Remote Liquid Monitoring System

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Abstract- Automatic liquid level measuring and monitoring with a wide range applications in various field and industries, such as oil and gas, food and beverage industry, agriculture, as well as household and domestic instrumentation. The construction of an improved remote liquid level measuring and monitoring system, that will be synchronized through wireless radio frequency with python base stand-alone Graphic User Interface (GUI) software programme for an out-station monitoring. Using locally made liquid sensor for level evaluation, microcontroller for the firmware that will control the process, LCD for liquid level display, and Buzzer for alert at critical liquid levels. The enhanced liquid level monitoring system, is designed to monitor discretely the levels of liquid samples of all densities by generating a corresponding electrical resistance signal for levels of the liquid samples in a reservoir. Result obtained from the experimental evaluation of the device shows that increase in the level of water in the reservoir results into a corresponding decrease in the resistivity of the sensor. Values of the electrical signal is then transmitted through wireless radio frequency to a distant end out-station where it is interpreted and displayed on a friendly Graphical User Interface (UI) developed using Python programming language.

Indexed Terms- Liquid level, Microcontroller, Python, RF modules

I. INTRODUCTION

A thorough design process, development, construction, and implementation of the hardware and software components, as well as the instrumentation, of a real-time embedded system for online temperature and pressure measurements, online fluid flow monitoring, and automated fluid flow control system (Akpan & Osakwe, 2015) through the use of the Tiny Internet Interface (TInI) on an E10 socket. The construction was achieved using a reservoir, pipeline tubes, two pumping machines, two water level monitoring probes, two thermistors, and the signal conditioning system make up the seven main subsystems of the proposed real-time embedded system with other supportive component parts, and a pair of water level sensing, one-wire slave, and one-master interface circuits. Three circuits are connected to the alarm system, fluid pump controller power circuits, and TInI's bidirectional parallel input/output (I/O) port interface circuit. On the TInI, software is used for automated fluid flow monitoring and control, pressure and temperature measurements, and calibrations. Hardware is used for interfacing. and based on the lowest percentage errors, validation of the calibrated temperature and pressure sensor values against a conventional thermometer and Davi's Vantage Pro, respectively, yields satisfactory results. The methods suggested and put into practice in this design enable distant client computers to monitor fluid flow temperature and pressure through a variety of application protocols over a TCP/IP (transmission control protocol/Internet protocol) network. Ultimately, every Java software created for the online temperature and pressure monitoring system for the real-time embedded system for automatic fluid flow control and monitoring. A round polydimethylsiloxane silicone rubber diaphragm is inserted in a pair of fiber Bragg gratings (FBGs) in a fiber optic-based liquid level sensor system. They (Morais *et al*, 2022) describe the measurement principles of this sensor, which has a diaphragm construction measuring 45 mm in diameter and 2.2 mm in thickness. The diaphragm was put through loading and unloading liquid levels as well as compression tests in order to assess the linearity and sensitivity of the sensor. The force and liquid level increase tests demonstrated that a system with more linearity was produced by putting two FBGs

(0.99453N for force and 0.99163m for liquid level) in the diaphragm as opposed to using just one FBG. Temperature characterization was also carried out, and the results showed that the sensitivity was 10.29 pm/°C for FGB2 and 11.73 pm/°C for FBG1. When both FBGs were compared to uncoated FBGs, which typically had values of 9.75 pm/°C, the temperature sensitivity was improved. Hence, the suggestion for the FBG-based sensor system may measure force and temperature simultaneously in a small diaphragm-embedded system. For the chemical, cosmetic, pharmaceutical, and food sectors to ensure excellent product quality and optimize their production processes, in-line evaluation of fluids' rheological properties is essential, (Ricci *et al*, 2015) considered the combination of Pressure Difference (PD) and Pulsed Ultrasound Velocimetry (PUV) technologies in evaluation of the rheology of a fluid flowing in a pipe. PUV in particular has been revealed to be a non-invasive Doppler method that is capable of measuring the fluid's radial behaviour in velocity distribution or velocity profile. The flow velocity distribution is computed in post-processing on computers connected to minimum acquisition cards, which represent the majority of PUV systems that are now available to industries. A whole PUV system for in-line measurement consisting of the digital gadgets needed for the velocity profile computation on-board as well as the analog electronics needed for the ultrasound frontend were presented in their study. The system demonstrated a capacity of producing 45 profiles per second in real time and is fully programmable. It is now integrated into the Flow-Viz platform, and it's also recommended for industrial applications. The need for a sensor that can distinguish between layers of oil and water motivated a study (Leal-Junior *et al*, 2018) where they stated that, its desirable to have an intrinsically safe method for estimating the liquids interface level since crude oil reservoir containing large levels of combustible gasses that might cause explosions. In order to detect water and oil layers, their study describes the construction and characterization of an interface level sensor based on an FBG-embedded multi-diaphragm sensors system. Report of the two diaphragms' reactions to the water and oil layers were carried out and result presented, and it was found that the lower density of the oil relative to water reduced the diaphragms' sensitivity when water was replaced with it. The practicality of the optical sensor system suggested to measure the water-oil interface is demonstrated by tests that vary the interface of both water and oil. The sensors display a variation in its responses when the layers of water and oil are modified. Constant monitoring of the water level within storage tanks and reservoirs is one of the recommended methods of water management required in the world of growing human population. (Abo-Zahhad, 2023).) develop an embedded design of smart tank system that has remote pump control capability and can establish communication with the user. Additionally, this smart design of tank has a leakage detection subsystem that alerts the user to water waste in the event of a leakages. In the event that a leak is discovered or the tank is filled, this tank is intended to conserve water by shutting off the pump. The proposed system is a freestanding embedded system that can be applied to various kinds of tanks since it can adjust to the tank's volume. A microprocessor, an ultrasonic sensor, flowmeters, a GSM module, a water pump, a solenoid valve, and two flow meter sensors were put together in developing the suggested smart system. The water level is detected by an ultrasonic sensor, and the inward and outward flow rates are measured using flowmeters. The purpose of the GSM module is to link the user with the tank. Additionally, the user can send it an SMS with commands to manually control the system as an interruption. The designed prototype is tested to ensure that the procedure is followed correctly and the system functions as intended. For the input flowmeter sensor, output flowmeter sensor, and ultrasonic sensor, the sensitivity analysis test produced deviations from the simulation values of 1.65%, 2.2%, and 4.15%, respectively.

This study is aimed at constructing an improved remote liquid level monitoring system, that will be synchronized via wireless radio frequency with python base stand-alone User Interface (UI) software programme for out station monitoring. The hardware construction is developed using locally made liquid sensor for level evaluation, microcontroller for the firmware that will control the process, LCD for liquid level display, and Buzzer for alert at critical liquid levels.

II. MATERIALS AND METHODS

3.1.0 Materials

The following major components presented in the table were used in construction of the enhanced liquid level monitoring system

Table 3.1: Major components and model of our construction

S/N	Component	Model
1	liquid sensor	
2	liquid level encoder	PT2262
3	RF transmitter	433MH
4	RF receiver	433MH
5	liquid level decoder	PT2272L4
6	microcontroller	AT89C4051
7	LCD display	16 x 23
8	Buzzer	DC 3-24v

3.2.0 Method

The methodology employed in this construction research is an enhance means of monitoring liquid level of wide range of densities in a reservoir. Measuring instruments like this can find it applications in various field and industries, such as oil and gas, food and beverage industry, agriculture, as well as household and domestic instrumentation, a device that can discretely sense the level of a liquid remotely, irrespective of thermophysical properties and sends the level of the liquid through wirelessly means to a receiver for interpretation and display.

3.2.1 Proposed features of the Enhanced Liquid Level Monitoring System.

Wireless-based Radio Frequency (RF) Modules were added into the proposed liquid level monitoring system, which is designed to receive and transmit electrical signals of discrete liquid level obtained from sensors (probes) that is interfaced with a microcontroller that is programmed to trigger an alert device system for operators and user, and in addition to this enhanced monitoring system is a user interface screen integrated to the transmitter end to show the discrete status of the liquid level, status of which were displayed on the LCD screen with rapid and adequate feedback response.

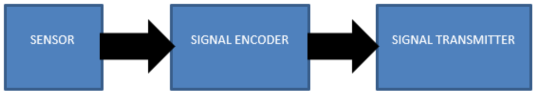


Figure 1: Proposed block diagram of remote liquid level monitoring system transmitter

The RF transmitter is used exclusively for the purpose of transmitting discrete electrical signals of liquid level generated by sensor output, and information of liquid level in the form of data packets to the receiving end through wireless radio frequency after proper field of communication has been duly established. data packets refer to the array of discrete electrical signal representing various liquid levels in a reservoir. before data transmission, a model of encoder chip (PT2262) transforms the data in a particular packet format that can be transmitted by the wireless RF Module. The wireless Module here is programmed to transmit the data packets at frequency of 443Mhz. We also used a simple wire antenna of length around 5cm to aid the operation of the transmitter and receiver modules. This module uses the Frequency Shift Keying (FSK) modulation algorithm, that means the packets of digital data from microcontroller are modulated with carrier waves before been transmitted.

Figure 2:Proposed block diagram of remote liquid level monitoring system receiver

The wireless RF Module at the receiving end is configured as the receiver gets the packets of data bytes sent by the transmitter, decoded by the decoder chip (PT2272L4) and the data is stored in the microcontroller after processing. Stored data packets after been processed by the microcontroller chip (AT89C4051) is then sent as electrical signal for it to be displayed on LCD. The wireless RF receiver is designed to detect the data packets transmitted as electrical signal by a particular phase locked loop (PLL) with frequency of about 443Mhz as carrier wave frequency. Similar antenna type as in transmitter is used to tune the particular carrier wave. Our RF receivers consist mostly of Buzzer and LCD display and a micro controller chip, mechanical switch device and other associated circuitry.

3.2.2 Operation principles of enhanced remote liquid level system.

A wireless field connection must be created between the RF module of circuit at the transmitting end and circuit at the receiving end, which constructed to be positioned within 60-100 meters apart for most efficient operation. When both circuits are switched ON the respective field connections is established. That is, the receiver circuit scans as it searches for electrical data signals from the circuit at the transmitting end to enable continuous synchronization of data between both ends. Communication between microcontroller and the sensor of the liquid level monitoring system are both placed in the same field. The liquid level sensor is placed in position where all levels of liquid samples are detected. As the liquid content in the reservoir reduced to lower threshold limit, a signal is sent by the microcontroller of the receiving end to trigger a buzzer that alerts the user, while it displays on the LCD screen. The liquid level signal from the sensor will be displayed on the LCD at the transmitting end, and on the software User Interface (UI) interfaced with the receiving end.

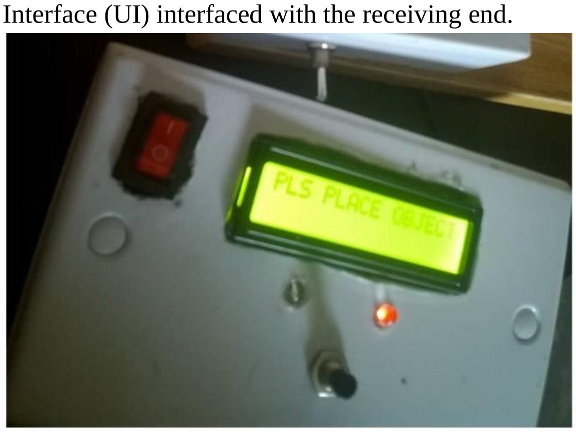


Figure 3: showing liquid level status of null displayed on a LCD screen.

The Microcontroller controls the operational pattern of the whole monitoring system. It is also used to interpret electrical signal from sensors, as the sensors detects a no-liquid condition the microcontroller will trigger the buzzer to alert operators. The data packets are further processed and transmitted through wireless RF modules to the receiving end, which receive and transmitted data packets of liquid level monitoring system for display on the User Interface (UI) programme written with Python.

3.2.3 Description of Major blocks of our enhanced liquid level monitoring system.

1. Sensing Unit: This unit Consist of sensors that detects all level of liquid content in a reservoir by measuring the resistivity of the liquid, in this case water. The metallic conducting materials used as probe sensor to detect the liquid levels, operates on ohms law of changing resistance to the proportional change in current at constant voltage. A metallic strip is what a liquid-level sensor essentially is. The metallic strip's resistance varies with the reservoir's liquid level. Because water enhances the conductivity of metallic strip, resistance will be higher at low liquid levels and lower at high liquid levels. The liquid-level sensor's resistance change is measured by the micro-controller. Prior to RF transmission, this variation in resistance is utilized to activate or switch on the signal encoder chip.

2. Microcontroller Unit: This unit consists of a microcontroller that is made up of several components for decision making and gives instruction to determine when liquid update is to be done. through the RF Module, the microcontroller communicates data bytes of liquid level from the sensor unit. After being decoded, the received data packet is kept in the RAM memory addresses. The information is received in a packet that represents the liquid level condition in the precise format that was sent by the transmitter. The microcontroller then divides up each piece of data. For instance, a liquid-level monitoring system or the status of the water level might be processed and then shown on the LCD, and also been sent to the receiving end for UI display. The Firmware algorithm that runs in the microcontroller run with the following cycle;

i. To checks and compares the converted signal from the sensor with predefined threshold values.

ii. And, initiating subroutines that are executed to either trigger or de-trigger the buzzer. The microcontroller is interfaced with the sensor to receive inputs which determine the energizing or de-energizing of the buzzer.

The AT89C4051 IC microcontroller is the one being used. It's an ATMEL-made, standard 8051 microcontroller. It is a low-power, high-performance 8-bit complementary metal-oxide-semiconductor (CMOS) microcontroller that supports the industry-standard 8051 instruction set and pin-out. It also has

4K bytes of in-system programmable flash memory technology. Program memory may be reprogrammed in-system or using a traditional non-volatile memory programmer thanks to the on-chip flash. An event-driven software included into the microcontroller is used to activate or deactivate the buzzer, alerting the user to the liquid level. Pin 2 of the microcontroller chips, port p3.0, is constantly checked by the configured microcontroller chip. The microcontroller verifies the existence of liquid level data whenever it detects a low (0 to 1.875V DC) level and processes the signal to operate the outputs. Consequently, the program is run so that the microcontroller signals the buzzer to turn on anytime the liquid level is low if pin 2 of the microcontroller chip is low, meaning that the output from the valid data pin of the decoder chip is low, signaling a low no new data. The buzzer trigger keeps going for a few minutes until stopping, meaning that the microcontroller sends the buzzer to de-energize and switch off, and all of this is shown on the LCD screen. At this time, the output of the liquid level is low, indicating a low liquid level content. Until the microcontroller is switched on and inserted into an appropriately constructed circuit, the micro-code that has been burned into the chip is dormant. The primary purpose of the LCD display and buzzer alarm is to notify the user when the liquid level is low, allowing them to verify that the pump is working properly and that there is enough water in the designated field. A reset circuit, which makes sure the microcontroller is correctly initialized on power ON by starting from the beginning of the micro code within, is one of the basic circuits needed for the microcontroller in the main circuit to operate properly. As directed by the AT89C4051's manufacturer, the reset circuit is formed by R10 (10KΩ) and C3 (10μF).

3. RF module Unit: This unit consists of the receiver and transmitter sections which must be connected together through wirelessly means before field communication takes place. Where data packets of liquid level content are gotten and processed onto the display screen. RF modules are electronic component that is use to receive demodulate radio frequency (RF) signals, and to transmit modulated signals. They are also found in variety of applications such video, voice and data applications. RF modules consist of a physical antenna to receive transmitted signals and a frequency tuner to separate a specific signal from all of the other signals that the antenna receives. Detectors or demodulators extract information that was encoded, and to limit localized interference and noise before transmission. To transmit a new electrical signal properly, oscillators generate sine waves which are encoded and propagated as radio signals. RF modules are also classified based on requirement over coverage distance, and transfer rate of data packets. The wireless RF modules have a broad operating voltage range of 3 to 12 volts and are incredibly tiny in size. In essence, we were using a 433 MHz frequency band RF module. There is no power consumption by the transmitter. When broadcasting logic zero and regularly entirely suppressing the carrier, battery operation uses a remarkably small amount of power. Carrier is completely on to roughly 45mA with a 3-volt power source when logic one is communicated.

Wavelength; using the equation below

$$f = \frac{c}{\lambda} \quad 3.1$$

where c is the constant of the speed of light = $3x10^8$m/s, f is the Frequency of the electromagnetic wave at 433 MHz, λ is the wavelength of the electromagnetic wave given as

$$\lambda = \frac{c}{f} \quad 3.2$$

from equation 3.2, the value of the wavelength becomes

$$\lambda = \frac{3\times10^8}{433\times10^6} = 0.69m \quad 3.3$$

equation 3.3 is the theoretical wavelength of the electromagnetic wave. But from measurement, the wavelength of the electromagnetic wave emitted by our RF module is $6.9 \times 10^{11} m$ Frequency range, Distance between receiver and transmitter units when connection is established;

4. Liquid Crystal Display (LCD) unit: This unit displays liquid level monitoring system information feed to the microcontroller by the sensor, before been transmitted through the RF module. LCD is an integrated circuitry that has the ability of displaying alphanumeric characters and symbols. They are basically used as feedback displays, showing the condition of the monitoring system they are interfaced with. LCD renders lots of application in terms of providing useful interface for the user.

5. Power supply unit: This unit powers the whole system based on 9 volts DC battery. DC supply which is regulated to 5v to power the decoder and Buzzer, led/output and 5v to power the microcontroller.

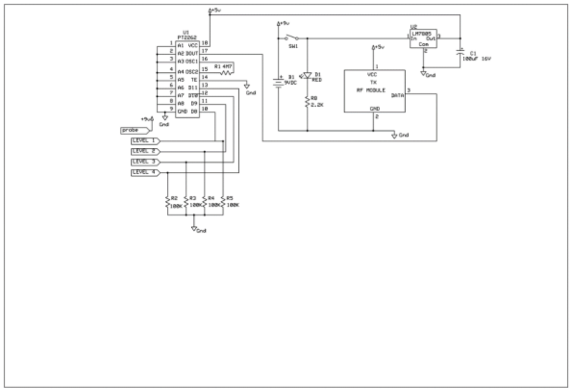


Figure 4: circuit diagram of our transmitter

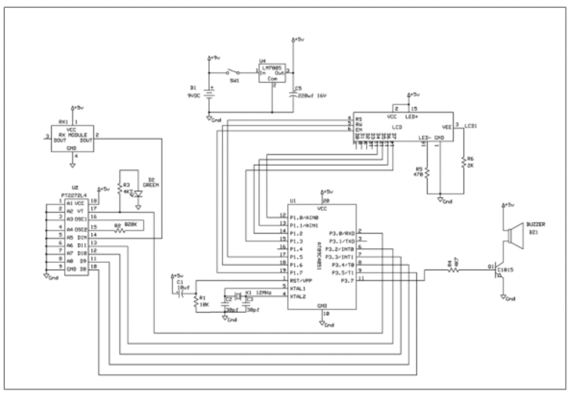


Figure 5: circuit diagram of our transmitter

5. User Interface (UI) unit: this is the software unit that enable operating user at a distance end to monitor liquid levels in the reservoir on a Graphical User Interface. This software application is developed using Python framework. No operation is enabled from this end just a visual observation of the liquid levels in the reservoir.

- Experimental Testing

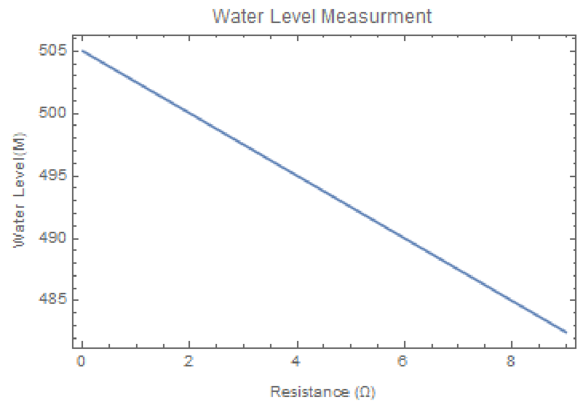
The sensor is positioned in the reservoir in such a way that it produces a resistance value at a particle liquid level. And the upper and lower set point of the level at 100L and 0L produces a corresponding resistance value of 0Ohms and 200Ohms respectively, becomes the defining standard for our calibration.

Numerical results of successive increase in water level, and its corresponding value of resistance obtained shows the linear relationship given as

$$y = -2.5x + 505 \quad 3$$

where y is the liquid level, x is the resistance value.

The following profile of water level against resistance is presented



III. DISCUSSION OF RESULT

Result presented show how the linear decrease in water level as resistance of the sensor increases. Which also imply that, increase in the level of water in the reservoir results into a corresponding decrease in the resistivity of the sensor.

CONCLUSION

The enhanced liquid level monitoring system, can monitor discretely the levels of liquid samples of all densities by generating a corresponding electrical resistance signal for levels of the liquid samples in a reservoir, values of the electrical signal is then transmitted through wireless radio frequency to an end station where it is interpreted and displayed on a friendly User Interface (UI) developed using Python programming language.

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REFERENCES

[1] Akpan, V. A., & Osakwe, R. A. (2015). Real-Time Embedded System for Online Temperature and Pressure Measurements for Automated Fluid Flow Monitoring and Control.

[2] Morais, E., Pontes, M. J., Marques, C., & Leal-Junior, A. (2022). Liquid level sensor with two FBGs embedded in a PDMS diaphragm: Analysis of the linearity and sensitivity. *Sensors*, *22*(3), 1268.

[3] Abo-Zahhad, M. M. (2023). An Embedded Smart System for Water Monitoring and Leakage Detection of Storage Tanks. *Sohag Engineering Journal*, *3*(2), 110-121.

[4] Leal-Junior, A., Frizera, A., Marques, C., & Pontes, M. J. (2018, September). Water-oil interface level sensor based on FBG-embedded multi-diaphragms system. In *Optical Fiber Sensors* (p. TuE36). Optica Publishing Group.

[5] Ricci, S., Meacci, V., Birkhofer, B., & Wiklund, J. (2015, October). Embedded system for in-line ultrasound velocity profile detection. In *2015 IEEE International Ultrasonics Symposium (IUS)* (pp. 1-4). ieee.