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# Development of an SMS-based accurate notification system for improved pipeline leakages

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**Abstract:**

In this study, an SMS-based accurate notification system for improved pipeline leakages is developed. Monitoring the flow rate of petrol and gas through pipe lines has been made easy through the use of hall effect water flow sensor normally connected within the pipe channel. The hall affect flow sensor is designed to generate pulses as the fluid passes through it and transmits these pulses to the ATMEGA328p micro-controller embedded within the admits UNO module used in this research. An additional 16x2 Alphanumeric Liquid crystal display (LCD) is incorporated in the design to persistently display quantities and variables like the volume and flow rate of the fluid in liter/minute (L/M). these results are consistently collated and the moment a decline or drop in the flow rate is perceived by the microcontroller, an error notification is forwarded via SMS to the user through the registered phone number providing information on the drop-in flow rate experienced. This research funds strong relevance in numerous applications ranging from gas factories water board stations amongst other areas where the flow rate of fluid is needed and a means of dissemination of a fact condition is required.

**Keywords:** Pipeline Leakage, Notification System, Leakage Detection, SMS

## 1. Introduction

The effective management and maintenance of pipelines are crucial for ensuring the safe and reliable transportation of fluids such as oil, gas, and water. Pipeline systems are subject to various risks and potential failures, including leaks, corrosion, and mechanical damage, which can lead to environmental hazards, disruptions in supply, and significant economic losses. To mitigate these risks and enhance the efficiency of pipeline maintenance, the development of an improved and accurate notification system is essential. Traditionally, pipeline maintenance has relied on periodic inspections and manual monitoring, which can be time-consuming, costly, and prone to human error. These conventional approaches often result in delays in identifying and responding to maintenance issues, increasing the chances of accidents or breakdowns. To overcome these limitations, there is a growing need for a more advanced and automated notification system that leverages cutting-edge technologies to detect, analyses, and to communicate pipeline maintenance requirements promptly. [1] Using wireless sensor networks, a data collection system for irrigation and gas pipelines is described. The design outcomes from the experimental prototype of a wireless sensor-based network for gathering pressure data for watering systems and gas pipelines were reported by the authors in this paper. The system's foundation consists of Telos B motes arranged in a WSN with an appropriate network protocol that also offers data control and aggregation.

The [2] research was presented. A study titled "Smart Pipes: Smart wireless sensor networks for leak detection in water pipelines" examined wireless smart sensor networks, which the authors claimed to be a practical method for keeping track of subterranean water pipes' pressure and, consequently, leaks. Their advantage over other widely used leak detection techniques is that they have some degree of redundancy, allowing for continuous monitoring without human involvement and preventing individual bad nodes from making the entire system obsolete. Smart wireless sensor networks with ultra-low power consumption can operate without maintenance for long periods of time. They can now be used with both traditional and cutting-edge power sources as a result [3] "Oil and Gas Pipeline Monitoring during COVID-19 Pandemic via Unmanned Aerial Vehicle" research was presented. He discussed the idea of using drones to conduct inspections and recording video and pictures in order to find potential hazards before they become serious. He also provided details of a survey that professionals in the oil and gas sector had undertaken to determine the functional and non-functional requirements of the suggested system. In [4], reliable solution was developed in the study titled "Remote Pipeline Monitoring Security System" for the wireless monitoring of the pipelines for various parameters that were embedded together. Remote monitoring was used to wirelessly monitor the pipelines in real time and report to the control center whenever a value was found that was higher than the threshold value. These pipelines underwent remote monitoring, which meant watching them from a distance. Temperature, relative humidity, dew point, liquefied petroleum gas leakage, liquefied petroleum gas leakage rate, liquefied petroleum gas leak rate, movement of persons around the facility, fire, and smoke are the variables that are tracked. A monitoring device was created and built to keep track of these parameters. To provide a reliable method of remotely monitoring the pipelines, a monitoring device for these parameters was designed, built, and software in the C programming language was created to communicate with the hardware.[5]

[6] The principles and approaches are in "Recent Advances in Pipelines Monitoring and Oil Leakage Detection Technologies: Approaches". analyzed the state-of-the-art accomplishments of various leak detection and localization systems and conducted research on pipeline leak detection technology. The best leak detection technique for a given operating environment was chosen using comparative performance studies as a guide. The location of sensors in pipeline monitoring is then brought to the attention of additional study. Before a complete real-time leakage detection in the pipeline can be realized, research gaps must be filled.

Radio Frequency Identification (RFID) and mobile sensors based on MICA were combined in the study published in "Remote pipeline monitoring using wireless sensor networks" [7, 11] to enable effective remote pipeline monitoring. A prototype model was developed that enables actuators to react to detected anomalies while allowing a topology-aware robot agent to sense desired parameters. The system's cost and scalability were shown through thorough testing, but additional study is required to track the effects of fluid on mobile sensors. [8] developed a wireless sensor network of mobile sensors that may be employed inside the water pipelines in their study titled "Mobile sensor networks for optimal leak and backflow detection and localization in municipal water networks." A mixed integer nonlinear optimization problem is used to solve the placement of sensors and beacons in a single joint formulation. It was determined that the disjoint method was an effective and reliable solution for solving the sensor and beacon placement problem in WDSs due to the joint formulation's time complexity. In a later project, algorithms will be extended to WDSs with dynamic pipe flow rates.

In their article "Operation of remote mobile sensors for security of drinking water distribution systems [9] examined a mobile water sensor that can wirelessly capture and send data as it is being constructed and manufactured. Several test results showed that adding inline observatory systems to online monitoring systems was an effective strategy to boost security and reduce the mean time of threat detection.

In the 2015 publication by. [10] Four wireless sensor network (WSN) methods for detecting leaks, including magnetic induction-based WSN for underground pipeline leakage detection and localization, were reviewed in "Sensors for Fluid Leak Detection. Sensors". Due to its low attenuation, this technology offers an inexpensive monitoring system and low power consumption for underground wireless communications. Even so, there is still room for improvement in terms of communication range, effectiveness, and dependability.

In a paper titled "Leak detection in gas pipeline by acoustic and signal processing" published in 2015, [11] discussed the fundamental wave propagation in gas pipelines and various techniques that exposed the signal's hidden information through the simulation of synthetic signals. In the pipeline system, wave propagation caused friction to be created, which was a key factor in the leak detection process. The results showed that the optimum method for detecting gas pipeline leaks is to use acoustic signal as the wave propagation and Hand-Held terminals (HHT). To quickly detect leaks, properly estimate their location, and manage the reduction of false alarms, more simulations and tests must be performed.

In 2013 [12, 13] Introduced four Wireless Sensor Network methods for leak detection in "Wireless Sensor Networks for Leakage Detection in Underground Pipelines". The use of WSNs with magnetic induction technology for locating and detecting subterranean pipeline leaks was discussed. This approach used magnetic induction for underground wireless communications, which looks to be efficient due to its low attenuation and provided a low-cost monitoring system and power usage. Despite the fact that this research introduces the theoretical framework for MI-based, the solution is limited to liquid pipelines. For effective leakage detection that offers accurate and real-time detection, Wireless Signal Networks (WSN) and underground to above ground WSN were also suggested methods. Only point measurements of the soil's characteristics can be provided by the WSN, and the data must first be processed before being sent. To effectively increase its communication radius and resolve the current problems, it will need to put in a lot of future work.

"Wireless and Mobile Technologies for the Internet of Things [13] presented a cloud-based trust management scheme (CbTMS), which was also suggested for use in networks for mobile crowd sensing (MCS) in order to detect Sybil assaults. The proposed CbTMS framework may manage trust and conduct reputation checks to validate the MCS network's nodes. To find suspicious Sybil nodes, it combines two systems, namely the Characteristics Checking Scheme (PCS) and the Trust Credit Assessment (TCA). While TCA was suggested for determining how trustworthy the suspicious Sybil nodes were, PCS was also suggested for passively monitoring the traits of the suspicious Sybil nodes, such as time, density, and topology in the MCS.

[14] "Pipeline Monitoring System by Using Wireless Sensor Network" In this study, a sensor network platform for pipeline system monitoring was described. They covered how sensor networks can locate and quantify bursts, leaks, and other irregularities in pipeline systems in their paper. According to research, active sensing technologies like Lead Zirconate Titanate (PZT) for simultaneous actuation and sensing can be used to detect faults over a wide region. For the purpose of creating and monitoring guided waves that travel along the pipes, PZT sensors can be installed on the curving surface of the pipelines. In order to attain adequate performance for real-time monitoring, we will talk about approaches to cope with the Lamb wave dispersive propagation.

## I. METHOD

*Design and system description*

This design is done using the Arduino UNO having embedded within it, the ATMEGA328P microcontroller which constitutes the brain of the entire design. Other fundamental components employed in the design are the YFS201 water flow sensor, 16x2 Liquid Crystal Display (LCD), SIM8OOL GSM module and ESP8266 Wi-Fi module.

The assembly of these components were used to monitor the flow of fluid, through the pipes. As the fluid flows through the pipes and through the water flow sensor, pulses are generated dependent upon the rate of flow and pressure of the flowing fluid and then consistently sent to the microcontroller. This information regarding the rate of flow is furthermore, progressively communicated to the user through SMS text messages through the registered phone number and then results of the rate of flow also uploaded on the Think Speak cloud environment where they can be accessed from anywhere in the world.

This method is employed as a prototype which with no doubt, is sufficient enough to be used as a model for monitoring pipe lines in different regions and locations. Multiple units of these can be scattered around different region where the rate of flow of fluid, in this case petroleum is to be measured and the data disseminated. These multiple units are tagged as seen below for different regions.

- Unit 1
- Unit 2
- Unit 3
- Unit 4
- Unit 5
- Unit 6
- Unit 7
- Unit 8
- Unit 9
- Unit 10

These units represent duplicated version of these design proximate in ten different regions where the data was collated both through the SMS received from each of them and the database in the environment which provides up to data information on the condition or rate of flow of the fluid in the pipe lines.

**Features of Flow Sensor:**

Model: YF-S201

Sensor Type: Hall effect

Working Voltage: 5 to 18V DC (min tested working voltage 4.5V)

Max current draw: 15mA @ 5V

Output Type: 5V TTL

Working Flow Rate: 1 to 30 Liters/Minute

Working Temperature range: -25 to +80℃

Working Humidity Range: 35%-80% RH

Accuracy: ±10%

Maximum water pressure: 2.0 MPa

Output duty cycle: 50% +-10%

Output rise time: 0.04us

Output fall time: 0.18us

Flow rate pulse characteristics: Frequency (Hz) = 7.5 * Flow rate (L/min)

Pulses per Liter: 450

Durability: minimum 300,000 cycles

*Arduino uno*

This is the brain of the entire design; it determines the operation of the entire system by managing the information received from the water flow sensor and projecting resultant feedback both on the LCD and SIM800L GSM module. It receives consistent data from the flow sensor on the flow rate of the fluid and adequately relates that to the user through the registered phone number encoded within the program as expected. This Arduino UNO module has embedded within it the ATMEGA328P microcontroller which is the main processing unit in the module.

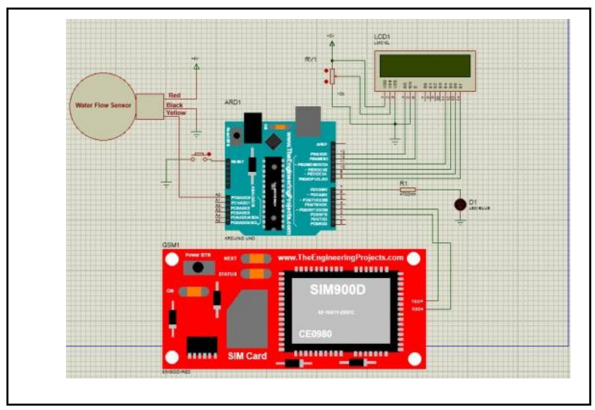


**Fig. 1.**Circuit diagram of a fluid sensor with SMS notification system

*SIM800L GSM module*

This module is configured and designed to transmit information received from the Arduino UNO on the condition and nature of flow of the fluid based on the cooling sequence and to the registered phone number encoded in the programming of the micro-controller through SMS. It has a VCC voltage input of 3.7v to 4.2v and is connected to the Arduino UNO through the transmitter and receiver pins (Tx and Rx).

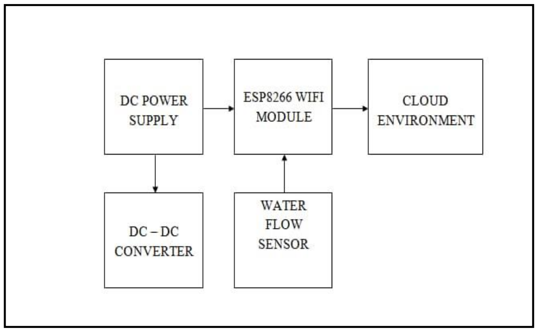


**Fig. 2.**Block Diagram of a Fluid Flow Sensor with Cloud Based Notification System

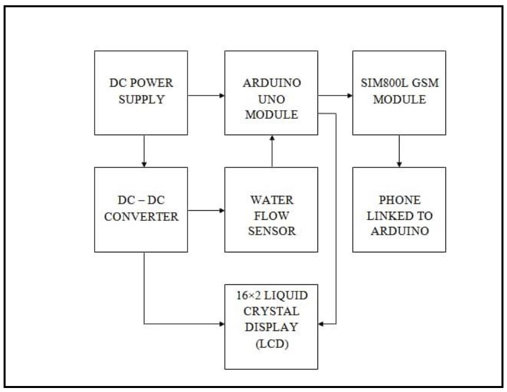


**Fig. 3.**Block Diagram of a Fluid Flow Sensor with SMS Notification System

*YFS – 201 water flow sensor*

This sensor transmits pulses consistent with the degree of rotation of its valves caused by flow of the fluid passing through it. As the fluid passes/flows through it, it carries a rotation of those value which in turn, causes the transmission of pulses sent to the Arduino UNO board to initiate certain working condition. The flow rate of the fluid is monitored by this sensor and then communicated to the microcontroller.

## II. Results and Discussion

The result of the flow is obtained as prepared in the code using the expression below,

X = pulse in (input, H GH);

Y = pulse in (input, Low);

This expression above depicts the time ON and time OFF of each pulse generated from the fluid flow sensor which is dependent upon how many liters of fluid or the fluid flowing through per minute

The TIME = X+Y i.e., for one complete cycle.

Frequency = 1000000/TIME;

Fluid (L/m) = Frequency /7.5; -flow rate

The above expression for the time and frequency is dependent upon the flow rate pulse characteristics of the YFS201 hall effect water flow sensor as seen below.

Flow rate pulse characteristics: frequency (Hz) =7.5xflow rate (L/m)

Liter/second (L/s) = FLUID/60;

Now, for every liter of fluid that flows through the pipe and by extension, the senor, it was observed that the flow sensor outputs 4.5 pulses, hence, 5 liters of fluid were used for demonstration and the results below were obtained from the LCD screen for every 0.5 liter. The graph in Figure 4 and 5 shows the results.

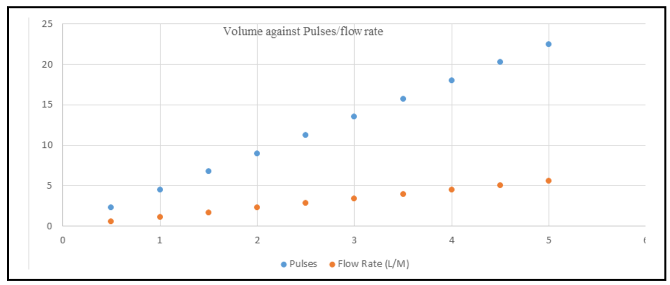


**Fig. 4.**Graph of Volume against Pulses/Flow Rate

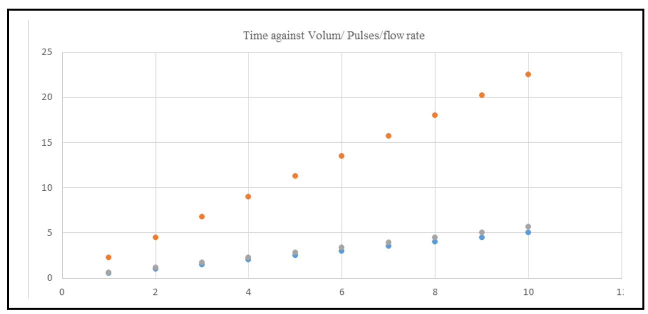


**Fig. 5.**Graph of Time against Volume/ Pulses/Flow Rate

*System testing*

The developed system was tested using functional testing method. A set of test cases was created based on the system

requirements. Figure 3.0 shows the text message alert during the testing process. The pressure drop text message was sent when the detected rate of flow dropped below the set parameter in the Arduino program. The message consists of the location or unit being monitored, time of monitoring and an indication of a drop in pressure or flow.


**Fig. 6.**Notification message via SMS


**Fig. 7.**Diagram of SMS Notification of the Pressure-Drop

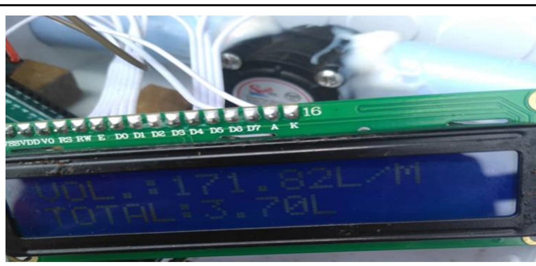


**Fig. 8.**Results displayed from the Liquid-Crystal Display (LCD)

*16 X 2 LCD display*

This liquid crystal display is saddled with the task of presenting a visual pipeline of the operation and condition of the Arduino UNO dependent upon the sequence of coding done in the micro controller. It takes a VCC voltage input of 5v and receives data from the Arduino UNO module through its Rs, E, D4, D5, D6, D7, pins and its backlight powered through a 5v voltage potential.

## II. Conclusion

In conclusion, the Development of an SMS-Based Accurate Notification System for Improved Pipeline Maintenance is a significant step towards enhancing the safety, efficiency, and reliability of pipeline infrastructure. By integrating remote sensing technologies, data analytics, real-time monitoring, machine learning, and a user-friendly interface. This system addresses the limitations of traditional approaches and offers several key benefits.

Furthermore, the integration of automatic capturing algorithms enhances the accuracy and reliability of the notification system. By developing robust models, the system can effectively differentiate between normal operational conditions and potential maintenance issues, minimizing false alarms and improving overall efficiency.

In the future, further advancements can be explored, such as the integration of advanced technologies like artificial intelligence and blockchain for enhanced monitoring, analysis, and security. Collaboration with industry stakeholders and wider adoption of the system will also be essential for its long-term success and widespread implementation. Overall, Development of an SMS-Based Accurate Notification System for Improved Pipeline Maintenance represents a significant advancement in the industry, offering a proactive approach to mitigate risks, optimize maintenance operations, and ensure the reliable functioning of pipeline infrastructure.

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