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Effective Water Leakage Detection System

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Abstract

Water leakage is a pervasive issue that can lead to property damage, increased utility costs, and adverse environmental impacts. This project aims to develop a cost-effective water leakage detection system that utilizes advanced sensor technology to identify leaks. By employing a network of flow sensors and smart programs, the system will provide early alerts to homeowners, enabling swift responses to prevent further damage. The successful implementation of this project could lead to significant savings, increased property longevity, and a reduced environmental footprint, ultimately contributing to a more sustainable future. A water flow leakage detector is designed to detect the leakage of water to significant savings, reduce water leaks, reducing wastage, costs, and environmental impact. Relay module, buzzer, water flow sensor, Arduino UNO, and LCDI2C display are used. The water leakage detection system utilizes two flow sensors to compare water flow rates in different sections of a plumbing system. The Arduino UNO processes the readings from both sensors, continuously monitoring for discrepancies. If one sensor detects a significantly higher flow rate than the other, indicating a potential leak, the system activates a buzzer to alert users and displays the flow rates and warning messages on the LCD, such as Leak Detected. This approach provides real-time monitoring and alerts without shutting off the water supply, allowing users to address the issue proactively.

Keywords: Arduino UNO, water flow sensor, leakage, flowrate, automation

Introduction

Around 150 to 250 gallons of water are used for household purposes in our daily lives. Water management in townships is an important concern, particularly in heavily populated countries like Oman, the UAE, and Saudi Arabia, where people face challenges due to poor water resource management. Issues such as pipe spillage, excessive water usage, and contamination result in improper utilization of water. Additionally, pipe leakage can cause flooding in streets, which impacts public transportation. A literature survey reveals that the development of microcontrollers and monitoring devices has been employed to address this problem. An IoT-based water monitoring system uses flow sensors to measure flow rates and provides alerts when a leak is detected, including its location through cloud computing technology. However, while many projects focus solely on leakage detection, it is crucial to also stop the water flow once a leak is identified. This project proposes a solution by connecting a relay to control a solenoid valve associated with the pipeline. The proposed system incorporates the following key features: (a) leakage detection, (b) flow rate monitoring, and (c) automatic shutting off of water flow when a leak is detected. [1]

Literature Survey

This literature survey explores various Arduino-based leakage detection systems developed for water, gas, and liquid leakage scenarios. The study on water leakage detection utilizes moisture sensors and flow meters integrated with Arduino to provide real-time monitoring. It demonstrates effective detection of residential and industrial pipeline leaks, offering a cost-effective solution but is limited by environmental factors like humidity (Kumar et al., 2020) [1]. Gas leakage detection systems employ MQ-series gas sensors along with GSM modules to alert users via SMS. These systems ensure rapid detection of gases like methane and propane, enhancing safety, though scalability for industrial setups remains a challenge (Sharma et al., 2021)[2].Liquid leakage detection in industries leverages capacitive sensors and Arduino to identify hazardous liquid spills effectively. This method provides accurate detection in industrial environments but involves high initial setup costs (Patel et al., 2019) [3]. For smart homes, water leakage detection systems combine Arduino, IoT platforms, and smartphone apps to monitor usage and send alerts. These systems are user-friendly and integrate well with smart home setups but rely heavily on stable internet connectivity (Ahmad et al., 2022)[4].

Industrial gas safety systems integrate multiple MQ sensors into a centralized monitoring setup, ensuring workplace safety by detecting variations in gas concentrations. While scalable for medium-scale industries, these systems consume significant power during continuous monitoring (Singh et al., 2020) [5]. Environmental leakage detection for irrigation systems employs Arduino and moisture sensors to identify underground leaks, reducing water wastage in agricultural settings. These systems promote sustainability but require regular maintenance in harsh environments (Zhou et al., 2021)[6].Pipeline leak detection systems utilize ultrasonic sensors with Arduino to monitor changes in sound waves, effectively identifying leaks in high-pressure pipelines. This non-invasive method is suitable for industrial applications but is constrained by high sensor costs and sensitivity to external noise (Li et al., 2023)[7]. IoT-enabled gas leak detection systems extend functionality by using IoT platforms to log data and provide real-time alerts, making them scalable for smart city applications. However, their performance depends on reliable internet access (Gupta et al., 2022).[8]Finally, water leak detection systems integrated with AI algorithms demonstrate enhanced accuracy in detecting and predicting leaks. These systems combine predictive capabilities with real-time monitoring, but they demand advanced sensors and higher computational resources (Verma et al., 2023)[9]. Together, these studies highlight the versatility and effectiveness of Arduino-based systems in addressing leakage detection challenges across various domains.

Flowchart

The flowchart of our project is shown in figure 1. This system consists of an Arduino UNO, water flow sensor, Relay, solenoid valve, LCDI2C display, Buzzer and power supply unit. This proposed methodology can monitor the flow rate, identifies the leakage and then control the operation of the total system.

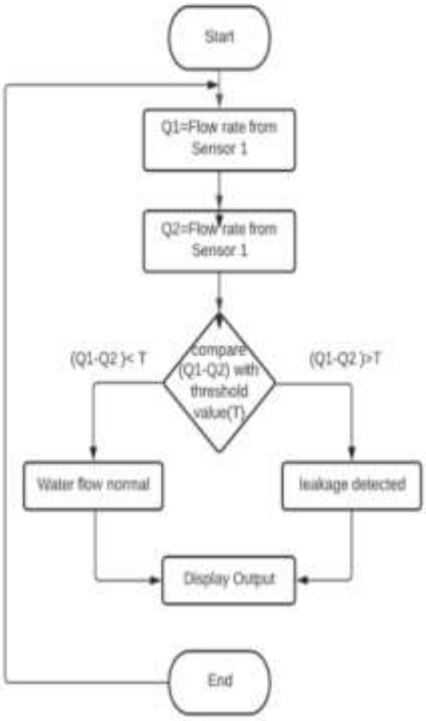

Figure 1. Flowchart

Proposed Methodology

The core principles of leakage detection focus on monitoring water distribution in a specific street by utilizing two strategically placed sensors, labeled A and B, on the main water pipeline, as depicted in Fig 1. Under normal operating conditions, when the pipeline is intact and there are no leaks, both sensors will register the same water flow level, indicating a balanced distribution system. However, in the event of a leak occurring between the two sensors, the flow rates will begin to differ. This variation serves as a crucial indicator of potential issues within the pipeline. As soon as the sensors detect this imbalance, they send a control signal to activate the solenoid valve, effectively closing it to mitigate further water loss and maintain the integrity of the distribution system.

Block Diagram

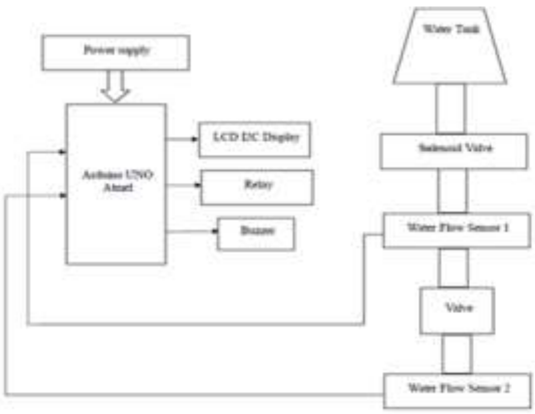

Figure 2 Block Diagram

In the block diagram, the power source is connected to the Arduino in order to provide it with the energy necessary to work. Two flow sensors are connected in the pipeline. A valve is connected in between the flow sensors. Two flow sensors will measure the flow rates at two locations and send that to Arduino. Arduino compares the flow rate and finds the difference. The measured values are displayed in the LCDI2C.If there is some difference, a buzzer will activate and make sound to alert about the leak. Also the message will be displayed in display element. The solenoid valve will close and cut the water supply.

Circuit Diagram

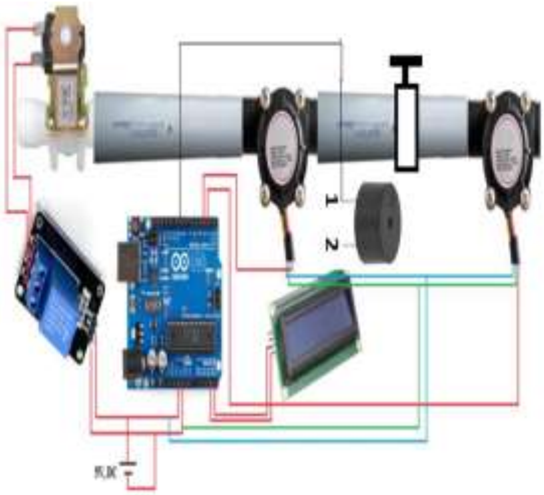

Figure 3 Circuit Diagram

The Figure 3 shows the circuit diagram of effective water leakage detection system using Arduino UNO. The water storage tank is connected to a 24 V solenoid valve via a pipe. The outlet of this solenoid valve leads to a PVC pipe. At the other end of the PVC pipe, a YF-S201 water flow sensor is installed, which then connects to additional PVC pipes. A second water flow sensor is placed at the end of this second PVC pipe. The flow rate is determined using the formula Q = ¼ (Pipe Diameter)^2 * Velocity. The readings from both water flow sensors are displayed on an LCD. The solenoid valve is a normally open (NO) type and is controlled by a normally closed (NC) 24 V relay. The digital pins 2 and 3 of the Arduino are connected to the two water flow sensors, while the A4 and A5 analog pins are linked to the LCD display. The entire system is powered by an RPS. The connection diagram can be found in Fig. 3. The pipe has a diameter of 1 inch, and the flow velocity is 4 m/sec.

Result and Discussion

An effective leakage detection system is essential for conserving resources, reducing operational costs, and ensuring environmental and public safety. Water, oil, and gas pipelines often suffer from undetected leaks, leading to significant waste, increased energy usage, and costly repairs. Early detection prevents contamination, limits non-revenue losses, and extends the lifespan of aging infrastructure. It also mitigates risks of explosions or environmental disasters, ensuring compliance with regulatory standards. By reducing water wastage, pollution, and greenhouse gas emissions, a well-implemented system not only enhances efficiency but also ensures reliable service and customer satisfaction, while minimizing legal and financial risks.

6.1 Arduino UNO Testing

To test your Arduino Uno (figure 4), begin by connecting it to your computer using a USB cable. Make sure that the necessary drivers are installed, which may happen automatically. Next, open the Arduino IDE. In the Tools menu, select "Arduino Uno" under the "Board" option, and then choose the appropriate port under "Port." Now, locate the Blink example by navigating to File > Examples > 01. Basics > Blink. Click the upload button (represented by a right arrow icon) to upload the code to your board. Once the upload is complete, the built-in LED on the Arduino should start blinking, indicating that everything is set up correctly.

Figure 4 Testing Arduino UNO

6.2 Testing of Buzzer

To begin, connect one wire to the GND pin on the Arduino UNO. Next, attach the other wire to the D9 pin. (Figure 5) Once you have made these connections, open the Arduino IDE and upload the program you've prepared. After the upload is complete, click the reset button on the Arduino board. You should then hear a sound, confirming that the setup is working correctly.

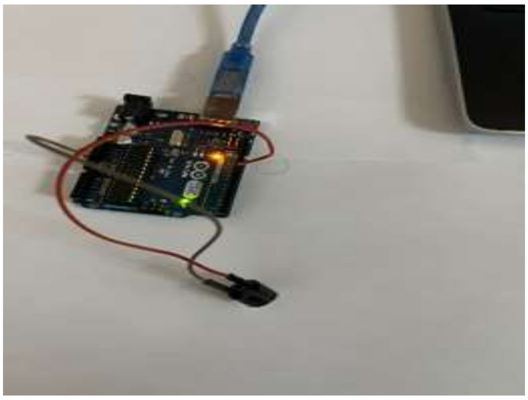

Figure 5. Testing of Buzzer

6.3 Testing of Water flow sensor

Connect the Flow Sensor to the Arduino Uno. (Figure 6) Wiring is Connect the flow sensor's signal (S) wire to a digital pin on the Arduino (e.g., pin 2 or 3). Connect the power (VCC) of the sensor to the 5V pin on the Arduino. Connect the ground (GND) of the sensor to the GND on the Arduino. Upload a Flow Sensor program and blow air through the sensor. Open the Serial Monitor in the Arduino IDE and check the flow rate values. The flow sensor counts pulses, which correspond to the amount of water passing through.

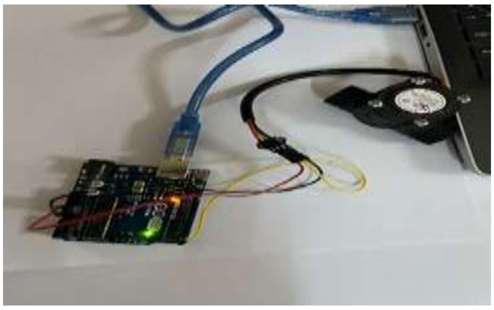

Figure 6. Testing of Water flow sensor

6.4 Testing of I2C LCD

Connect the Vcc and GND pins of the I2C LCD to the Vcc and GND pins on the Arduino. Then, connect the SDA and SCL pins of the LCD to the A4 and A5 pins on the Arduino, respectively, as illustrated in the figure below. Once all connections are made, open the Arduino IDE and enter the program code. Next, connect one end of a USB cable to the Arduino UNO and the other end to your computer. Follow the instructions to upload the code to the UNO. Finally, initiate the program by pressing the run button in the Arduino software.(Figure7)

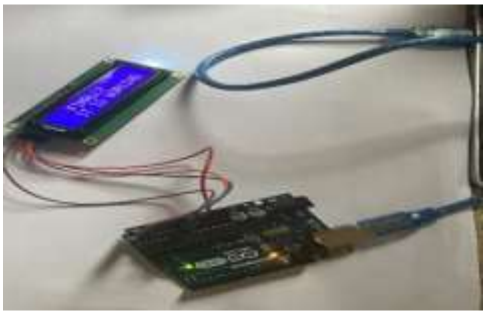

Figure 7. Testing of I2C LCD

6.5 Project Final Schematics

Figure 8 shows the final circuit assembly of the project. The final circuit assembly integrated all components successfully.

6.6 No Leakage Display

When there is no different of water between the two water flow sensor the lcd will shows no leaks. (Figure **9).**

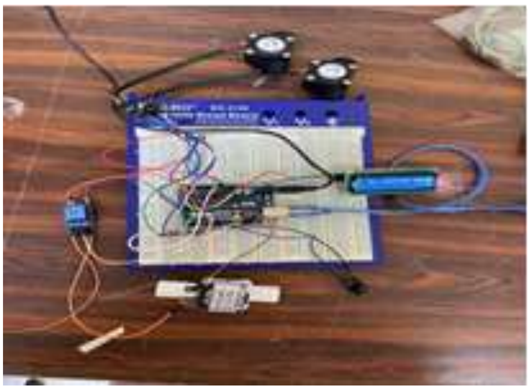

Figure 8. Final Assembly of Components

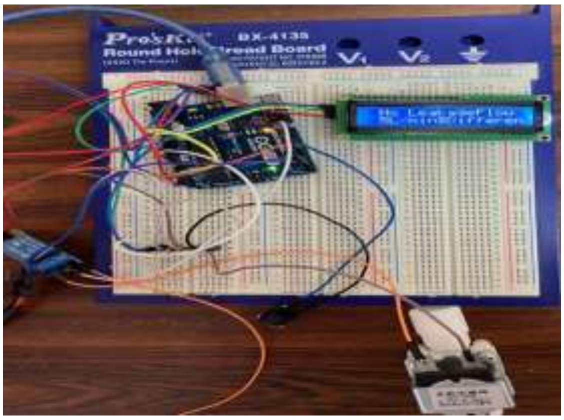

Figure 9. No Leakage Display

6.7 Leakage detection

When there is different water between the two water flow sensor the lcd will shows leaks and buzzer will make sound then the solid valve will close Figure 10. The result of serial monitor is shown in figure 11.

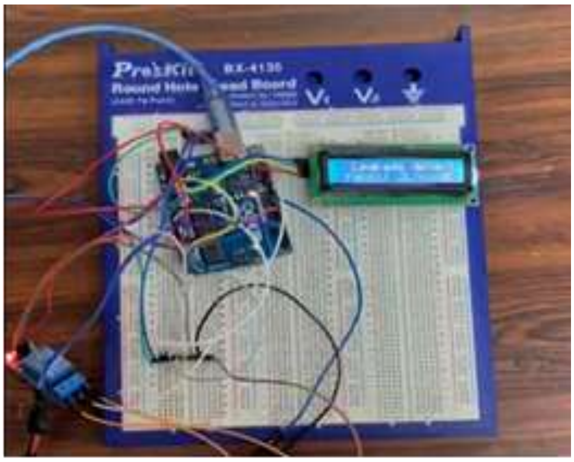

Figure 10 Leakage Display

```
No Leak
Flow rate: 0L/min        Flow rate: 0L/min
Difference: 0L/min
Leak
Flow rate: 39L/min       Flow rate: 0L/min
Difference: 39L/min
Leak
Flow rate: 23L/min       Flow rate: 0L/min
Difference: 23L/min
Leak
Flow rate: 33L/min       Flow rate: 0L/min
Difference: 33L/min
Leak
Flow rate: 17L/min       Flow rate: 0L/min
Difference: 17L/min
```

Figure 11. Final Circuit Serial Monitor

6.9 Project Model

After testing the circuit completely, we have created a model of our project as shown in figure 12

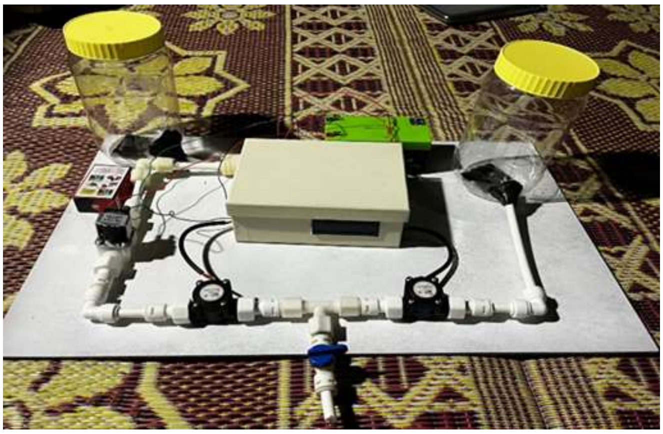

Figure 12. Final Model

Conclusion

The project on water leakage detection using an Arduino Uno, two flow sensors, a buzzer, and a solenoid valve effectively addresses the issue of water wastage caused by leaks. By integrating flow sensors, the system continuously monitors water flow and triggers a buzzer alarm when irregularities or unexpected flow patterns are detected, indicating a potential leak. Once a leak is confirmed, the solenoid valve activates to shut off the water supply, preventing further wastage. This setup enhances water conservation and reduces the risk of costly water damage. Utilizing the Arduino Uno provides a cost-effective and reliable solution for detecting and managing water leakage, ensuring improved efficiency and timely action to mitigate water loss.

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