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TABLE OF CONTENTS:-

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IOT BASED WATER LEAKAGE MONITORING SYSTEM

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ABSTRACT
Nowadays, water leakage has become one of the major issues in the water distribution system and it can cause a lot of water loss through water pipelines. Hence, it will give a financial loss if it cannot be identified at an early stage. The concept of real-time water leakage monitoring using the Internet of Things is presented in this project. The internet of things (IoT) is a key component of smart tracking, which uses wireless sensor technologies to link people and systems. The parameter used to analyse the water leakage in the pipeline is the water flow sensor. In this study, a water flow sensor is used to determine the rate of water flow via a pipeline in order to resolve any water-related concerns such as leakage and usage. The proposed system would concentrate on common housing pipes and would display collected data through a smartphone. Additionally, this project will build the case for the water flow sensor, as well as the full circuitry for all electronics needed. As a result, it shows that the system can function stably and give water flow rate readings with 98% accuracy. The system can also send real-time data to smartphones via the Blynk application and alert the users when leaks are identified using threshold data.

Keywords: IoT, water leakage, flow rate, Blynk, flow sensor.

INTRODUCTION

In recent years, Malaysia's water industry is plagued with ineffective water management. According to the World Bank, water management inefficiency has resulted in water losses of up to 50% in Pahang due to pipe leaks, while the national average is now at 35%, nearly three times that of developing nations. Additionally, the government intends to cut non-revenue water (NRW) to 25% by 2020 (*The Malaysian Leaky Pipe Story*, n.d.). This illustrates that pipe leakage is a significant concern in the water management system. Leaks that have remained undetected for a long period are one of the causes leading to the high NRW.

Recently, the development of IoT water leakage systems has been extensively studied by researchers (Mehta & Misra, 2019) presented a Leak Monitoring Device in 2019 that builds a nodal network of systems that continuously monitor the flow of water and may deliver timely alerts. The study used two water flow sensors to monitor the water flow rate and it will be located at both ends of the pipe. According to the research, if there is a changein flow rate at the pipe's ends, this might indicate that the pipe is leaking. Also, (Arya Vijayan& Mr. Raju Narwade, 2017) created a system that can detect pipe leakage by obtaining the inflow and outflow values. The study shows that If the differential between the two sensors exceeds 60 L/hr, a leak in the pipe has occurred. However, none of these researches discussesthe degree to which their various systems are accurate.

In this study, the proposed system will be monitoring the flow rate of water using TTGO Lora

Esp32 as the microcontroller and Wi-Fi as the communication protocol in the Internet of things (IoT). Therefore, it is predicted that this improvement will save time, costand most importantly it can monitor the flow rate at any places through the Blynk application on the smartphone (F Asra Noorain et al., 2020). The sensor used in this system is the water flow sensor and the overall system will be powered by a rechargeable battery and USB charging module. By focusing on the problem of water in the house, the system will be applied to standard housing PVC pipes ½ inches in diameter. Besides, all components will be placed in a compact casing that will be easy to install on-site.

METHODOLOGY

System Configuration

In this proposed system, Arduino IDE was used as a programming software to communicate with the microcontroller, sensor and IoT platform. In order to communicatewith the board, some libraries are required to be installed, such as ESP-32 and Adafruit SSD1306 library. The Adafruit SSD1306 library will enable the board to connect with the integrated 0.96-inch OLED screen for site monitoring purposes. Apart from that, the code for the water flow sensor will use an external interrupt function on signal pin 32. This is used to read the flow sensor's pulses. When the TTGO board detects a pulse, the pulse counter function is triggered to count the number of pulses. The water flow rates will be calculated using the equation (1) above, where the flow rate is pulse per minute divided by the calibration factor.

Then, the same flow rate will be delivered in real-time to the Blynk Server utilisingthe Wi-Fi protocol that is in the TTGO Lora board. A database will be established synchronously in the Blynk application for the purpose of monitoring the water flow rate on asmartphone. Lastly, when a leak is detected, the system will notify the user by sending a notification to their smartphone. The possible water leakage for this option is obtainedthrough the threshold method. The method classifies anything under a certain level of threshold flow rate as possible water leakage.

System Integration

After the IoT components were programmed, all components were integrated into onecomplete circuit to secure the connection during field testing. The schematic design of the hardware is illustrated in Figure 1.

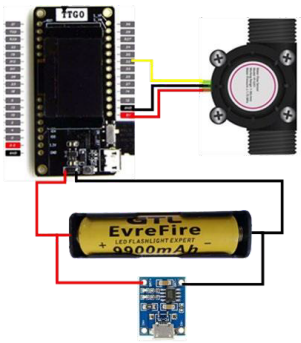

Figure 1. A schematic design for hardware

Next, the IoT-WLMS case was developed to integrate all components used as one compact device by using Autodesk Fusion 360. This ensures that all electrical componentsare shielded from any possible water spills and easy to install for site monitoring. Finally, the casing will fabricate by using 3D printing technology.

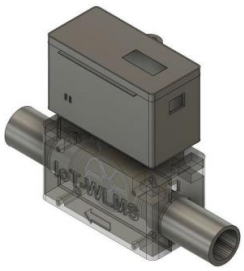

Figure 2. Designed casing using Autodesk Fusion 360

Experimental Setup

Sensor Calibration

During sensor calibration, the water flow rate produced by the sensor was comparedto the maximum flow rate offered by the water pump specification. A submersible aquarium pump with a power of 20W and a maximum flow rate of 15L/min was used to flow the water into the pipe and pass through the water flow sensor. The calibration factor was set to 3,4 and
5. This value will be entered in the coding respectively before the experiment is run. Finally, the data will be tabulated to illustrate differences and percentages of inaccuracy for various calibration factor values.

System Performance Testing

System performance testing is conducted to determine the performance in monitoring the water flow rate in the pipeline. A prototype is designed to test the system performance by using PVC pipe ½" and connected to the existing pipe with 4 faucets. In this test, the developed system will monitor various water flow rates in order to determine the present condition of water flow at the site. Furthermore, the system's reliability will be validated via data transmission between the hardware and the IoT platform. Finally, leakage simulations will be conducted to determine the values for the threshold data that will be included in the final coding. The design of the prototype is shown in Figure 3.

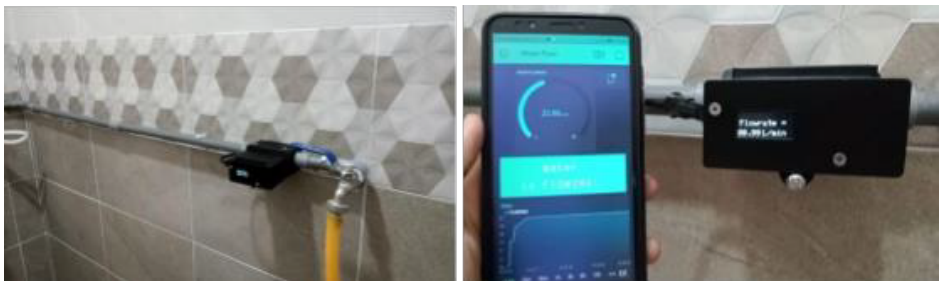

Figure 3. Water Flow Monitoring

RESULT AND DISCUSSION

Sensor Calibration

Table 1 shows the water flow sensor's percentage error at various calibration factors when the pump flow rate is kept at a maximum constant of 15 L/min.

Table 1: Percentage error at various calibration factors

Calibration factor,c	Water flow rate, Q (L/min)	Percentage error (%)
3	22.22	48.13
4	16.67	11.13
5	13.33	11.13

The table above shows that the most accurate value for 15 L/min of flow rate is between calibration factors of 4 and 5. Therefore, the interpolation formula can be used in order to get the value between two points, where;

$$c = 4 + (15 - 16.67)\frac{(5-4)}{(13.33-16.67)} = 4.5$$

Hence, the calibration factor of 4.5 was inserted in coding and the result shows thatthe sensor flow rate was 14.81 L/min. The error percentage, in this case, is 1.26% and has an accuracy of 98.74 % from the actual value. This finding was in agreement with (Rajurkar et

al., 2017) findings, who also used a 4.5 of calibration factor for this flow sensor. The error might have been due to pump error and losses in the pipeline

System Performance Testing

Next, the prototype is tested at various conditions of water flow. Figure 4 shows the graph for flow rate conditions during a given interval.

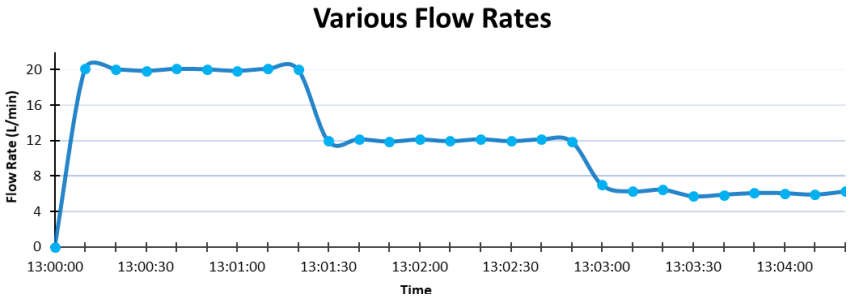

Figure 4. Graph of water flow rate at various conditions

The figure above shows that when no water is flowing, the flow rate is zero, and whenthe water is free to flow, the flow rate steadily rises to a constant value. The maximum flow rate during the testing is about 20.99 L/min, and at this stage, only one faucet was open. Then, the flow rate starts to decrease about half of the maximum point when two faucets were opened simultaneously. Meanwhile, when the opening faucets were increased to 3-4, the minimum flow rate was between 6.5 to 5.5 L/min. This shows that when the opening faucets are increasing, water pressure starts to drop. Hence the flow rate will also be decreasing.

From the minimum value of the flowrate, a 2 mm hole was made to consider that the pipe was leaking. As a result, the threshold data were obtained between $0< Q \leq 5$ L/min. The possible water leakage only shows a pulse when the flow rate is between threshold values for more than 5 seconds. The system will alert the users by sending a notification when leakageis detected. The possible leakage value of 5 L/min is acceptable, as the research from(Marinoski et al., 2014) stated that the average flow rate for one water fixture in low-income households is about 6 L/min.

Next, testing is done by placing the transmitters (device) and receivers (Blynk apps) ata certain distance. The experimental results show that transmitting data from transmitter to receiver rarely experiences delays in the range of 0.1km to 14km. This indicates that the sensor data was successfully sent to the receiver so that the Blynk dashboard could display it in real-time.

CONCLUSION

In this study, the development of an IoT Based Water Leakage Monitoring System was conducted and investigated at ½ inch PVC pipe. As a result, the system can communicate successfully between microcontroller, sensor and IoT Platform that utilises the Arduino IDE software and the Blynk application. Experimental testing of the sensor in measuring the flow rate of water shows that this system provides performance accuracy of more than 98% from

the actual water flow rate. The results also show that the developed system is very reliable in real-time monitoring, since the data transmission between receiver and transmitter does not show any delay during the testing session. In addition, the findings show that the pipeline's possible water leakage might occur if the flow rate is below 5 L/min. Finally, the implementation of the Internet of things (IoT) is necessary as water flow through pipelines can be observed at any time from anywhere, which can save money and time.

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