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Development of Water Tap Control Systems and PDAM Cost Monitoring Based on IoT

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ABSTRACT
Management of the amount of water in daily life is very necessary in human life. As the amount water used is increased will impact the bill of payment. This research focus on how to manage the water flow by a series of instalation relate to Internet of thing (IoT). The objective is to control the valve using sensors that could monitor water usage every month. At the end, the bill of water will be displayed on PDAM website. Customer could login to the system and access the payment bill in the PDAM website from various platforms or gadgets. The sensor HC-SR04 manages the discharging solenoid valve reading the water level in the container. The YF-S201 sensor monitors monthly water usage costs based on the internet of things. The best performance of each valve is the first valve time steady = 414 s, rise time = 372.6 s, time delay = 207 s and steady state error = 2.53%. the second valve time steady = 144 s, rise time = 129.6 s, time delay = 72 s, and error steady state = 1.02%. The third valve time steady = 174 s, rise time = 151.2 s, time delay = 84 s, and steady state error = 1.04%

Keywords: *Solenoid Valve, Cost, Internet of Things, Water Level (cm)*

1. INTRODUCTION

Water consumption in daily life has important role for survival. The ability to manage the need for the amount of water used is very necessary in the sustainability of a life. In urban areas, clean water services are generally managed and provided by the government through the PDAM (Regional Drinking Water Company). PDAM is a regional-owned company engaged in the processing and distribution of clean water to various areas in an urban area [1, 2].

Based on the regulation of the Minister of Home Affairs no.23 of 2006. Regarding technical guidelines and procedures for setting the cost of drinking water at PDAM. The costs determined by PDAM-CM are to cover all production costs, operational costs, maintenance costs and administrative costs and are added with depreciation costs on the basis of acquisition value [3].
The Cilegon city government together with the Cilegon City DPRD drafted a local regulation on the cost of drinking water. Determined based on the regulation of the Mayor of Cilegon no.52 of 2016 with the lowest cost of Rp. 1,700 with a water volume of 0 - 10/m^3 and 1,800 when the water volume is more than 10/m^3 [3]. Water is a very important need for every life, especially humans. The water that flows will go through a device called a valve or water valve [4]. The water valve functions to close, open and/or hold the water flow manually. However, the use of the water valve is considered less efficient, especially in housing, hotels or home industries (home industry). Since after performing various activities user keep the water valve open. The situation caused a lot of water become waste and costs to be incurred will be enlarged. Research on the use of water valves or monitoring of water usage and the costs to be incurred has been carried out. There has been research that discusses the volume of water in the container and uses an electric motor to fill the container automatically based on the volume of water in the container based on IoT using android [5]. Other research discusses water level monitoring using ultrasonic sensors and comparing it with the volume of the container and LCD screen to display the status of the water level in the container [6]. Subsequent research related to water management systems discusses comparative analysis of water based on consumption by considering the number of consumers by calculating the volume of water in the tank and reading the flow of water consumed from the tank based on the internet of things [7].

2. METHODS

This section explained the research methodology used, in the form of a design that includes a measurement system block diagram, measurement flowchart and schematic of the device circuit on the board. This design focuses on the performance of the water valve control system. This system consists of hardware that is configured and integrated with software and the internet.

2.1. *The Block Diagram Research*

The block diagram of the water valve control system (figure 1) is needed to anticipate an error in the tool. It is also necessary to know that every element of all installed components can work according to the commands that have been given.

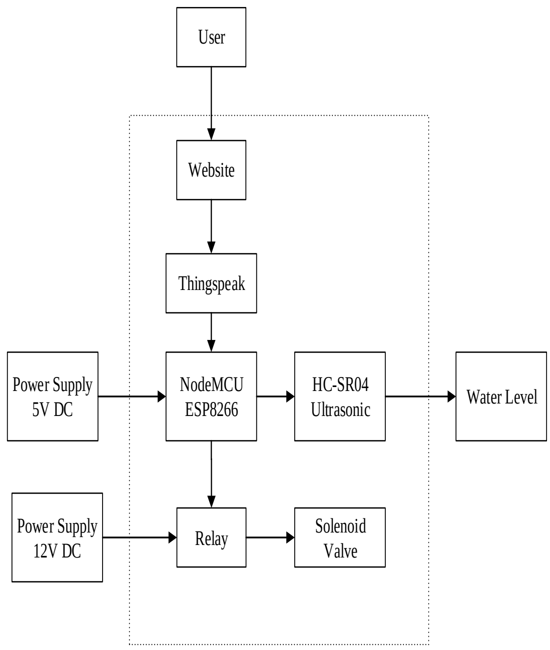


Figure 1. Water Valve Control System Block Diagram.

Figure 1 describes the user setting the minimum and maximum limits for the water level in the container through the website. Then the command from the website will be saved and sent to Thingspeak to display a graph of the minimum and maximum water levels. This limit aims to open and close the water valve based on the water level that has been set through the website. The power supply required for the NodeMCU and the HC-SR04 sensor is 5V DC while the Solenoid Valve is 12V DC. The relay serves as a liaison between the NodeMCU and the Solenoid Valve.

2.2. *PDAM Cost Monitoring System Design*

This design focuses on the performance of the PDAM cost monitoring system. This system consists of hardware that is configured and integrated with software and the internet. The PDAM cost monitoring block diagram is required to anticipate an error occured in the equipment. It is also necessary to know that every element of all installed components can work properly according to the commands assigned. Therefore, a schematic working diagram is needed to get a picture of the actual performance of the tool. Figure 2. shows a block diagram of the PDAM Cost Monitoring system.

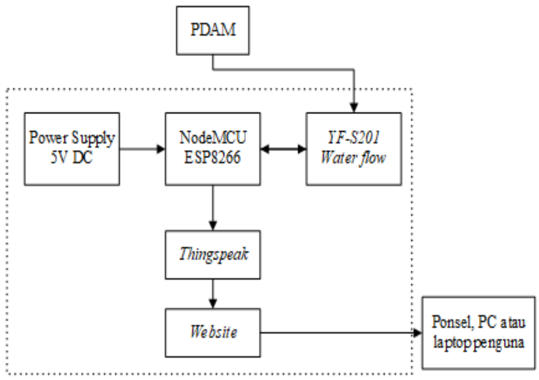


Figure 2. PDAM Cost Monitoring System Block Diagram.

In figure 2 water from PDAM flows through pipes to the YF-S201 water flow sensor. The water flow sensor will read the amount of water that passes through it. The size of the water discharge value read by the sensor is based on the swift flow of water. A lot of water discharge will be displayed on thingspeak in graphical form. The read water discharge will be converted into water volume. This is necessary to determine the amount of PDAM fees that will be paid. Then the water volume and PDAM fees that are read will be displayed on a website. Customer could access the payment bill in the PDAM website from various platforms or gadgets. The power supply used is 5V DC.

3. RESULTS AND DISCUSSIONS

This section describes the test results of the research each block diagram. This is necessary to determine the response and performance of the system that is working. After each section gets the test results, an overall test will be made to determine its condition and performance.

3.1. *Testing Ultrasonic Sensor HC-SR04.*

Testing the ultrasonic sensor HC-SR04 is divided into two parts, that is testing the amount of working voltage provided by the voltage source and the magnitude of the distance value generated by the sensor. Testing the working voltage of the sensor

using a multimeter by connecting the two multimeter probes to the Vcc pin and the GND pin of the sensor and comparing them with the sensor datasheet.
Testing the distance generated by the ultrasonic sensor is done by comparing the value of the distance generated by the sensor with the actual distance. Actual distance using a conventional meter. Meanwhile, the results of distance testing on the ultrasonic sensor HC-SR04 are shown in figure 3. Distance testing is carried out with a minimum distance of 2 cm. The distance of 2 cm is the minimum distance for the HC-SR04 sensor reading on the datasheet. In the HC-SR04 calibration test, eleven samples were taken with a comparison of the actual distance, the difference between the distances was 1 cm. The test was carried out twice with 3 sensors that have been programmed on the Arduino IDE software.

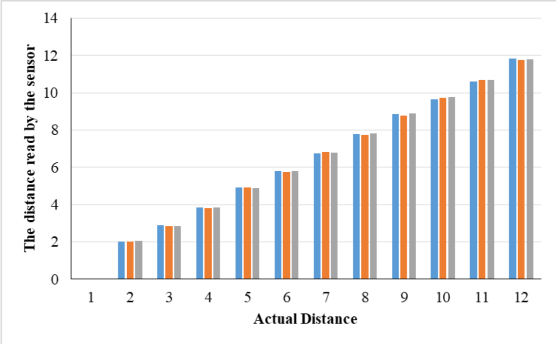


Figure 3. HC-SR04 ultrasonic sensor test chart.

3.2. Testing Water Flow Sensor YF-S20.

Sensor testing is carried out to determine the working voltage of the YF-S201 water flow sensor and the pulse obtained in 1 L of water. The method used to determine the value of the working voltage of the YF-S201 Water Flow sensor is using a multimeter. The two multimeter probes are connected to the positive and negative poles of the YF-S201 Water Flow sensor. Meanwhile, for testing the value of reading the volume of 1 L of water and the pulse sensor water flow YF-S201. Ttable 1 is shown based on the datasheet of the water flow sensor YF-201 1 L Water volume = 450 pulses with error 5.01%.

Table 1. Pulse Test Results on Volume 1 L of Water.

Sample	Water Volume (L)	Pulse 1 L	Convert to debit (mL / Pulse)	Error (%)
1	1	427	2,341	5,1
2	1	428	2,336	4,9
3	1	424	2,358	5,8
4	1	426	2,347	5,3
5	1	425	2,352	5,6
6	1	427	2,341	5,1
7	1	427	2,341	5,1
8	1	421	2,375	6,4
9	1	430	2,325	4,4
10	1	431	2,320	4,2
11	1	425	2,352	5,6
12	1	429	2,331	4,7
13	1	431	2,320	4,2
14	1	424	2,358	5,8
15	1	430	2,325	4,4
Average		427	2,341	5,1

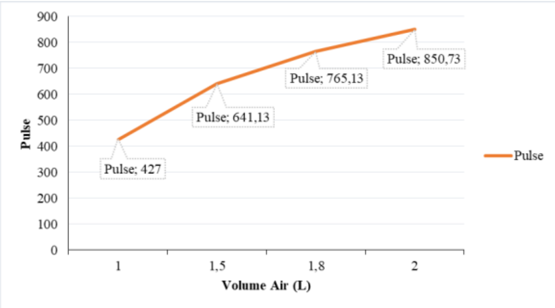


Figure 4. Graph of Sensor Output Pulse Against Water Volume.

The second test uses the value of the water volume, which is 1.5 L= 675 pulses with error 5.01%. The next test using the value of the water volume is 1.8 L = 810 pulses with error 5.5%. The last test using the value of the water volume is 2 L = 900 pulses with error 5.4%. After repeated testing to determine the magnitude of the pulse value in Volume 1, 1.5, 1.8, and 2 L. Then the increase in the volume value, the more pulse value that is read and generated by the water flow sensor. The accuracy resulting from repeated tests is 4 – 6% shown in figure 4.

3.3. 3.1 Testing PDAM Cost Monitoring System.

This test intend to determine the volume of water that has been converted from pulse readings based on the flow of water through the sensor. In addition, this test also aims to determine the cost of using water based on the volume of water produced.

3.1.2 PDAM cost monitoring test from 1 to 6 June 2021.

The results of this test were carried out on June 1 to 6 by comparing the data that had been read by the YF-S201 sensor and displayed on the website with manual calculations. Figure 5 shows the estimated costs from 1-6 June 2021.

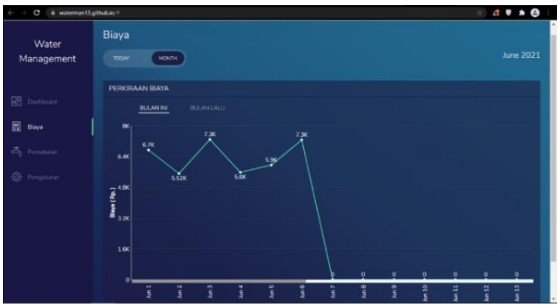


Figure 5. Estimated Cost and Water Usage Fees May - June 2021.

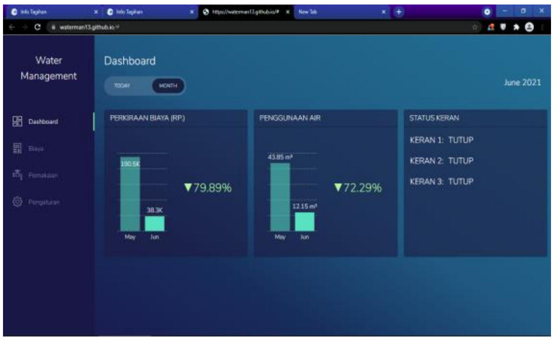


Figure 6. Estimated Cost and Water Usage Fees May - June 2021.

3.3.2 Recapitulation of Water Usage and Estimated Costs for May 2021

This test was conducted in May by comparing the data that has been read by the YF-S201 sensor and displayed on the website with manual calculations. The results of the May test recapitulation are shown in Figure 6.

3.4. Testing of the Water Valve Control System.

The test of this circuit is carried out to determine the water faucet control system for the water level in a container and the response time when the water faucet will automatically open or close based on the maximum or minimum water level in the container.

Testing the response time on the water valve no. 1, it is carried out to determine the value of rise time, delay time and steady state error. The set point used is 15 cm. The set point is the condition of the water valve closing. The test results of the response time are shown in Figure 7.

Testing response time valve control no. 1 with a set point of 15 cm in Figure 7. water valve control produces a time steady value = 414 s, a rise time value = 372.6 s, a delay time value = 207 s and a steady state error value = 3.13%.

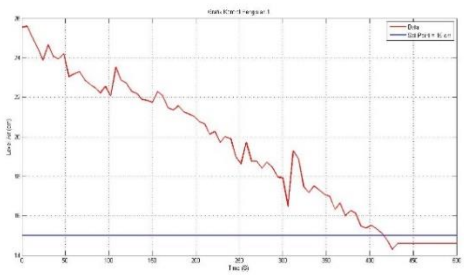
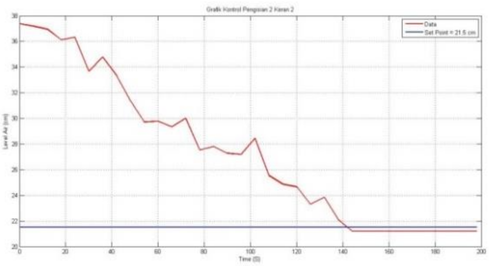
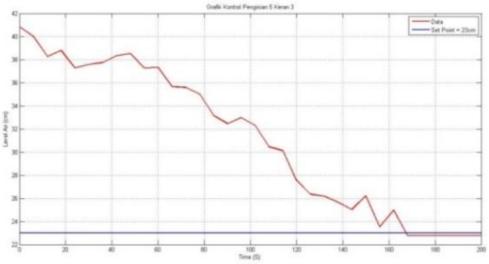


Figure 7. Result testing response time on the water valve no. 1

In testing the water valve control system no. 2 and 3, it was carried out to determine the value of rise time, delay time and steady state error. The set point used for valve no. 2 is 21.5 cm. The set point is the condition of the water valve closing. The test results of the response time are shown in Figure 8.



(a) the water valve no.2



(b) the water valve no.3

Figure 8. Result testing response time on the water valve no.2 and 3.

Testing response time valve control no. 2 with a set point of 21.5 cm in Figure 8a, water valve control produces a time steady value = 144 s, a rise time value = 129.6 s, a delay time value = 72 s and a steady state error value = 1.04%. In testing the water valve control system no. 3, it was carried out to determine the value of rise time, delay time and steady state error. The set point used for valve no. 2 is 23 cm. The set point is the condition of the water valve closing. The test results of the response time are shown in Figure 8b.

4. CONCLUSION

Based on research that has been done can be concluded as follows:

1. A water valve control system has been successfully built using three proximity sensor units to detect and calculate the water level by calibrating the sensor with a 30 cm ruler as a conventional meter with each sensor having an error of 2.75%, 2,96%, and 2.76%.
2. The water valve control system has been successfully carried out using the website with each water valve being set to automatic mode by changing the mode to on and changing the maximum and minimum limit values according to the height of the container.
3. The water valve control system managed to get the best performance from the three valves with the first valve time steady = 414 s, rise time = 372.6 s, time delay = 207 s, and steady state error = 2.53%. In the second valve the best performance is time steady = 144 s, rise time = 129.6 s, time delay = 72 s, and error steady state = 1.02%. In the third valve the best performance is time steady = 168 s, rise time = 151.2 s, time delay = 84 s, and error steady state = 1.04%.
4. The PDAM cost monitoring system was successfully created by getting the smallest error value of 3% on June 1 and the largest on June 6th. The magnitude of the error value on June 5 and 6 was due to the accumulated volume value calculated by the sensor while the real value was calculated manually using the difference in usage for 1 day.

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