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Water Flow Control System by Online Based on ATmega328P Microcontroller

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Abstract

Monitoring water usage distributed by PDAM had been being done manually. It makes user's negligence in using clean water extremely hard to control. The negligence causes the waste of water in vain. The research aimed to be able to monitor the clean water usage and to control the water flow that was used so that the problem of wasting clean water in vain could be overcome. Water volume was measured by YF-S201 of which output was processed and sent by ATmega328P through SIM800L module. Measured water volume data could be viewed on a website. Control of the water flow was done by closing or opening a solenoid valve installed on water flow channel. The solenoid valve was controlled by a command sent from short message service (SMS) from users. Suitability between the water volume measuring result of the system and the reference obtained from the result of linear regression analysis was 99,99%.

Keywords: YF-S201 Water flow sensor, Solenoid valve, ATmega328P microcontroller, Database, SIM800L

1 Introduction

A safe, reliable, affordable, and easily accessible water supply is essential for good health [1]. This clean water is to be used for drinking, cooking, simple hygiene, etc. There are a number of different infectious agents detrimental to human health that grow in contaminated/unsanitary water which can cause several waterborne illnesses; such as cholera, hepatitis, typhoid, and diarrhea [2]. The existence of a clean water supply department is needed so the citizen gets the supply of clean water evenly. For example, in the country of Indonesia, the responsibility of providing clean water services is generally managed by the local government through the Regional Owned Enterprises (enterprises) by the Regional Water Company (PDAM) [3].

In the case of distributing the water by PDAM, it needs checking and monitoring process of the amount of water usage distributed to every single customer every month. In the case of water bill payments, PDAM still occupied manual officers to visit each customer's home to check the water meter and provide a monthly bill of water consumption fee to the customer. [4]. As well as PDAM does, the customer also looks into the measuring device that is installed in order to know their water usage. The monitoring process is only able to be done by coming directly to the place where the measuring device is installed. Hence, it is impossible to do monitoring if ones are away from the measuring device.

Customer negligence in using water is something that is not to be taken easily. One of the negligence examples happening rapidly is forgetting to close the tap water. This matter causes a big problem if a customer forgets to close the water tap and at the same time, the customer is going out of the house for a long period of time so that the water will be wasted with no meaning and the water usage bill will automatically increase.

Several researches have been done in order to find a solution of this problem. One of them is like what Fahmi et al. did in a journal titled "Clean water billing monitoring system using flow liquid meter sensor and gateway". In the research, the measuring of PDAM water usage used a water flow sensor where the sensor output was processed by microcontroller automatically and the output of that reading was sent to user via SMS gateway. However, the data that could be observed was monthly water usage. If someone for any different reason wanted to know the usage at certain time that had been passed, the data that were wanted could not be obtained. Moreover, the customer could not control the water flow in certain circumstances like forgetting to close the tap water while the customer was still far away from home and impossible to close the tap water by himself immediately.

Based on the previous explanation, it is important to make water flow control system that is able to be monitored from any distance and to display the water usage of which data is recorded and stored in a database. The control system intends to monitor water usage by online and to be able to close or open the water flow. The water usage is recorded by a water flow sensor and then the data recorded will be processed by ATmega328P microcontroller. The data will be sent to the database through SIM800L GSM Module. The data could be displayed on the web so that water usage from a related customer could be accessed anywhere and everywhere. The data that could be accessed is not only the data from which the web is accessed but also from the previous time as control to close or open the water flow is done by sending a command to ATmega328P microcontroller through Short Message Service (SMS).

2 Research Method

The research was done by doing some steps. The first one was started by designing the hardware and then creating the software. After the hardware and the software works properly as what they were meant to be, the step was carried on calibrating the system.

2.1 Hardware design

Designing hardware of the control system is started by making a printed circuit board (PCB) of the hardware and then all components needed on the PCB is placed. The control system hardware consists of several circuit blocks such as power supply block, a minimum system of ATmega328P, YF-S201 water flow sensor block, relay block, solenoid valve block and SIM800L GSM module block. Figure 1 shows block diagram of the control system.

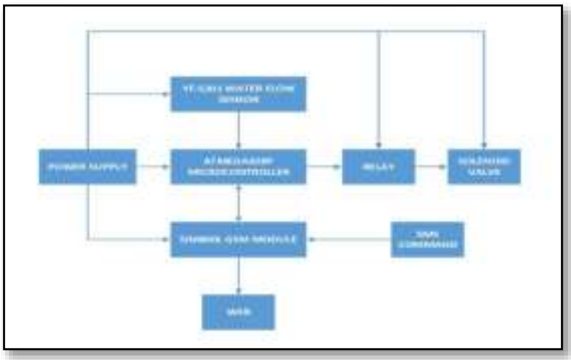

Figure 1. Block diagram of the research

The work procedure of the control system is mainly shown in figure 1. The procedure of the system is started from YF-S201 water flow sensor. YF-S201 water flow sensor has an integrated magnetic hall effect sensor that outputs electrical pulse with every revolution [5]. The sensor comes with three wires: red (5-24 V DC power) black (ground) and yellow (hall effect pulse output). By counting the pulses from the output of the sensor, we can easily calculate water flow. The pulse signal is a simple square wave so it's quite easy to log and convert into liters per minute using the following formula: Pulse frequency (Hz) / 7.5 = flow rate in liter/minute [6]. YF-S201 water flow sensor detects and measure water discharge that pasts through the sensor and then sends the measuring result to microcontroller ATmega328P. ATmega328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture [7]. This ATmega328P integrated chip consists of 28 pins [8]. ATmega328P microcontroller receives measuring result form YF-S201 water flow sensor which then is converted into the form of water volume. ATmega328P microcontroller sends the data converted to SIM800L GSM module. SIM800L is a quad-band GSM/GPRS module that works on 850MHz GSM frequency, EGSM 900MHz, DCS 1800MHz and PCS 1900MHz [9]. Sim800L integrates TCP/IP protocol and extends TCP/IP AT commands which are very useful for data transfer applications [10]. Figure 2 shows the physical form of SIM800L GSM module. SIM800L module is responsible for sending the data received from microcontroller to database server. The data could then be displayed on a website page.

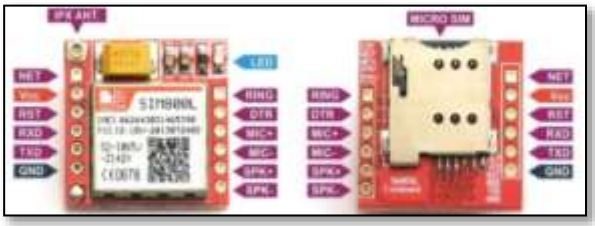

Figure 2. SIM800L module

SIM800L module also receives a command in SMS form. The command is used to close or open the water flow. In this research, it is done by closing or opening a solenoid valve installed on the water flow channel. Solenoid valve is used to regulate and switch liquid flows in continuous flow devices or for ejection of droplets or jets in non-contact dispensing application [11]. The solenoid valve is controlled using relay which works based on the signal received from the microcontroller. A relay itself is an electrically operated switch. It uses DC input of small voltage for triggering and is ideal to use with a controller [12].

After receiving the SMS command, SIM800L forwards the command to ATmega328P Microcontroller and then the microcontroller will send the signal to relay based on the command that has been given and finally the state of the relay will determine the state of the solenoid valve as well. The hardware circuit of whole control system is shown on Figure 3.

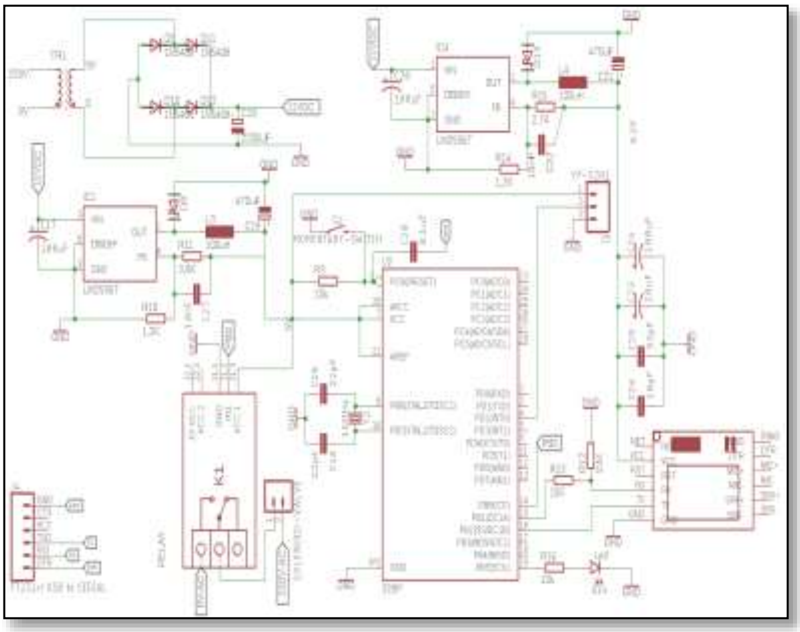

Figure 3. Whole hardware circuit

2.1 Software design

The software of program in this control system consists of two main components such as; program burnt into the ATmega328P microcontroller and the program existing on the WEB side. The program burnt into microcontroller is responsible to process data of sensor reading result and send them to a database server. Furthermore, the program existing in the microcontroller is also functioned to control the relay. At the same time, the program existing on WEB is responsible to store data sent from microcontroller and display them on WEB page.

3 Result and Analysis

3.1 Result

The research produces a water flow control system by online based on ATmega328P microcontroller. The control system mainly consists of 2 main components such as hardware that was responsible for being a measuring device and controlling the water flow and software that was responsible for being interface for users. The hardware and software of the control system is shown on Figure 4 and 5 respectively.

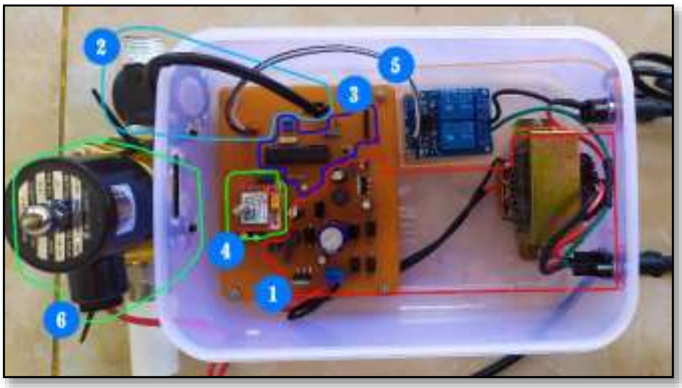

Figure 4. Hardware of the system

Figure 4 shows the whole device of the water flow control system by online based on ATmega328P microcontroller. The device consists of several parts. The first one is a power supply responsible for supplying power needed so that every single part of the device could work correctly. The second is YF-S201 water flow sensor that is responsible to measure the water volume passing through the sensor. The third is ATmega328P minimum system. This circuit is a main control of all hardware of the system. The minimum system does several works such as receiving signal from the sensor, processing data from the sensor and then converting it to water volume and ordering SIM800L module to send the data to server. Moreover, minimum system of this control system is also responsible to control the relay based on the user command sent through SMS. The fourth is SIM800L GSM module circuit responsible for sending measure water volume data to server. The fifth is relay module that is responsible for controlling solenoid valve state based on the user command sent through SMS. The sixth is solenoid valve responsible for closing or opening the water flow.

Figure 5. Interface of the System

The interface of water flow control system by online based on ATmega328P microcontroller is shown on Figure 5. The interface is a website displaying the result of measured water volume from hardware of the system. The interface based one Figure 5 consists of several website pages. The first page is registration page. The registration page is used to register account that could later be used to enter the index page that shows the measured water volume. The second page is a login page that is used to enter the index page. Entering the index page is done by entering username and password data from account that has been registered and verified by the system developer. The third page is index page. The index page is a page that displays the measured water volume data. The page consisted of two types of pages which are the page that displayed the data at the current time and the page that displays all data that had been stored since the device was turned on.

3.2 Analysis

The control system was the result of coordination between hardware and software. Hardware of the system was started from power supply that provided two types of direct current (DC) voltages that are 5V and 4V. 4V DC which were used by GSM Module since the GSM module needed a maximum of 4.2V [13]. Regulator used was switching regulator that used LM2596 ADJ Integrated Circuit. Switching regulator method was more power efficient (often 75% to 98%) than linear voltage regulation (which dissipates unwanted power as heat) [14]. First the water flow sensor detected the water volume passing through it and produced an output in the form of electrical pulse. The output was then connected to ATmega328P microcontroller using digital pin 2.

Microcontroller processed the data from sensor output to become measured water volume. Then, the data were sent to the database through SIM800L GSM module. The sending process was controlled by the program that had been burnt on ATmega328P microcontroller. SIM800L GSM module communicates with microcontroller by using RX pin of SIM800L that was connected with PB1 pin or digital pin 9 of ATmega328P and using TX pin of SIM800L that is connected with PB2 pin or digital pin 10 of ATmega328P. The data that had been sent could be accessed by all device that was able to connect to the internet through any browser such as personal computer (PC) or even smartphone.

SIM800L GSM module of the hardware system was not only sending water volume data to server but also receiving command from user in the form of SMS. The SMS command received by SIM800L was then forwarded to microcontroller to be processed further. The SMS command was a command to control the relay state that would determine whether the solenoid valve would be opened or closed.

Software existing on the control system consisted of 2 main components such as controller program of the microcontroller and the program of storing the data in the database and displaying them on the website. Controller program of the microcontroller uses C programming language while the other one used PHP and HTML programing language.

The process was continued to calibration process. Calibration of system was done by comparing water volume in the range of 1 liter to 80 liters from the measuring result of the system and the water volume reference measured by measuring cylinder 1601. Before that, customizing value of calibration factor variable from the program that converts the electric pulse of the sensor to water volume data was done. The customization was done in order to get the closest result from the reference. Figure 6a, 6b, 6c and 6d show the graph of determination of calibration factor data.

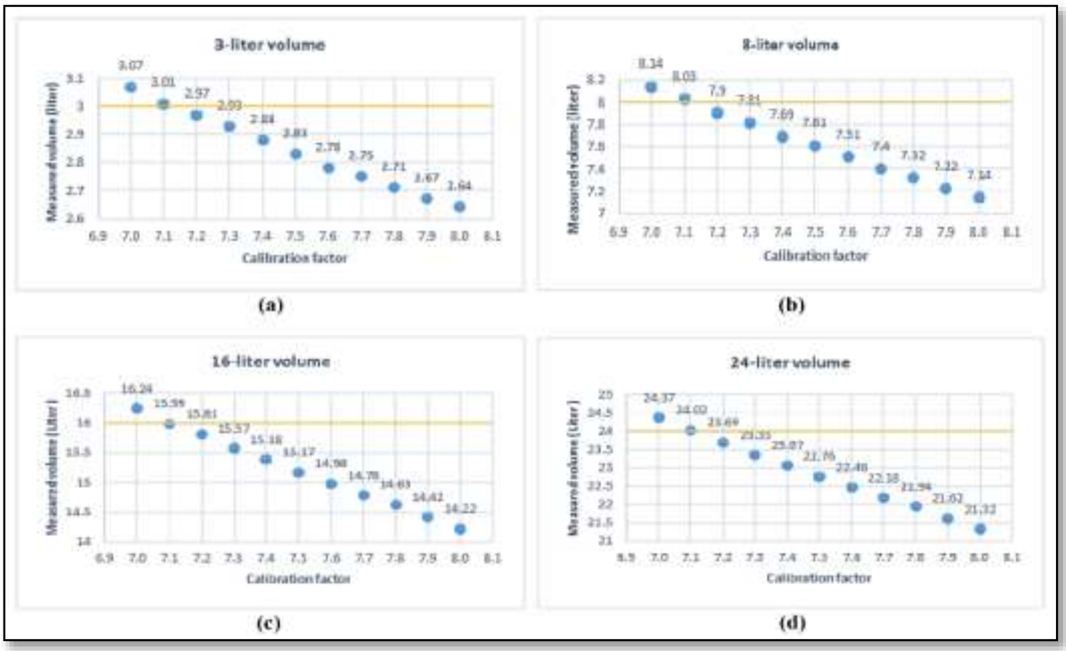

Figure 6. Measuring result for: (a) 3-liter volume, (b) 8-liter volume, (c) 16-liter volume, (d) 24-liter volume

This customization was done by changing the value of calibration factor variable in the range 7.0, 7.1, 7.2 until 8.0 for each measurement of 3, 8, 16- and 24-liters water volume. The choice of this range was based on the previous research that had been done by Prathyusha and Ramamurthy in 2015 that used 7.5 of calibration factor. So that this research took 5 intervals above and below in order to get the most suitable calibration factor value for this research. Calibration factor based on the graph that enable to obtain the closets result from reference water volume was 7.1. So that calibration factor variable was set to be 7.1

The next step was to calibrate the measurement device from this control system. The calibration was done by comparing the water volume from the measuring result of the system and reference water volume. The measurement was done within range 1 to 80 liter with 1 liter rose in each measuring. So that 80 data had been obtained. The calibration data were then plotted into linear regression graph of the ratio between measured water volume and the reference water volume. The graph is shown in Figure 7.

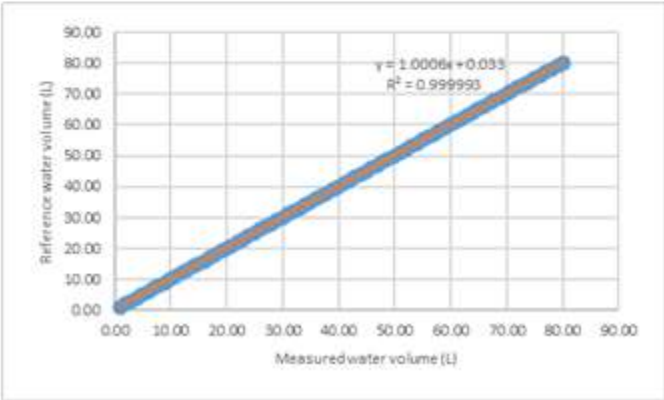

Figure 7. Regression graph of ratio between measured volume and the reference

The output result based on Figure 7 varies. So that it needed to customize the program burnt into microcontroller. The customization was done by inserting the gradient value of regression line obtained into the sub program that processed the output of the sensor. The next step was testing process. The test consisted of 2 steps which were testing the result of measured water volume and system respond of SMS command to control the solenoid valve.
The first step was done by comparing the measuring result within range of 1 liter to 80 liters. The data obtained from this test was processed by using linear regression analysis to know the compatibility between measuring result and the reference value.

The regression analysis aimed to create a model describing a set of experimental x and y data to predict unknown x values using created model [15]. The result of the linear regression analysis is shown on the graph of linear regression on Figure 8.

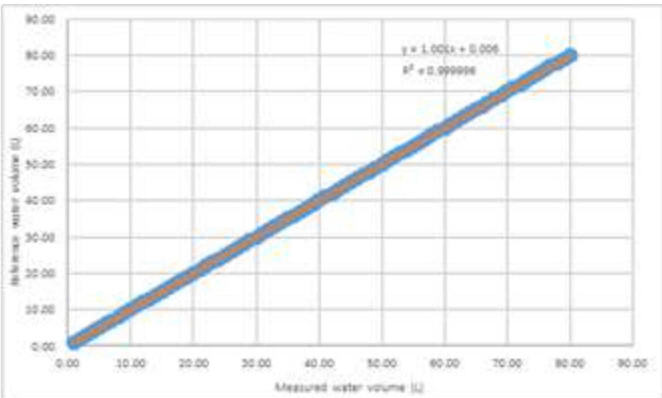

Figure 8. Comparison Graph between measured water volume and the reference

Figure 8 shows the comparison graph between measured water volume from this control system and the reference measured by using measuring cylinder 1601. The graph shows the linearity between x and y variable. This can be seen from determination coefficient (r^2) of the data has a high value which is 0.999996. The coefficient value shows that the compatibility between water volume measuring result from the system and the reference water volume is 99.99%.
The second test was to examine the system respond to control water flow that was done by opening or closing the solenoid valve. From the test having done Table 1 shows the result obtained.

Tab1e 1. The table of solenoid valve control respond result

No.	SMS Command	Solenoid Valve State
1	OPEN	Open
2	CLOSE	Close
3	Open	No change
4	Close	No change

The system responds based on Table 1 shows that solenoid valve will be opened when the system receives SMS command that consists of word “OPEN” and closed when the system receives SMS command that consists of word “CLOSE”. The system has been designed to respond to that two commands only. The command must be typed like that even from the capital form must be the same. If the system received the different command, even the capital difference, the solenoid valve state will not be changed. This can be seen in the result from table 1 that when the system receives command “Open” or “Close” which is not all capitalized the state of solenoid valve will not change at all.

4 Conclusion

Water flow control system by online based on ATmega328P microcontroller has been successfully made. The testing result of measuring water volume compared to reference volume measured by using measuring cylinder 1601 shows the suitable value. The compatibility is obtained from linear regression analysis of device testing data that is 99.99%. Water usage data could be accessed easily website from anywhere and everywhere as long as the place is reachable from coverage cellular network provider without having to look directly into the measuring device itself. Water flow control is done by opening and closing the solenoid valve. The control could be done from any distance because it is done by sending the command through SMS only.

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