The development of prepaid water meters based on AT89S52 Microcontroller

I G Nurhayatia, I W Sutaya and K U Ariawan

1Department of Industrial Technology, Faculty of Engineering and Vocational Ganesha University of Education, Bali, Indonesia

Corresponding author: gede.nurhayata@undiksha.ac.id

Abstract. A prepaid water meter is a device for controlling the volume of customer water usage with a water pulse system. Currently, the prepaid water meter implements a card system as a storage area for customer water pulse data by filling it via a keypad. This research aimed to develop a prepaid digital water meter using EEPROM memory as a storage area for customers' water pulses by filling it with a remote control based on the AT89S52 microcontroller. The research method is carried out by developing hardware and software, as well as testing the overall system performance. The results showed that the prepaid water meter system worked well to control the work of the solenoid valve in adjusting the volume of water consumption according to the number of water pulses in the EEPROM memory. Also, the system worked well in the process of recharging water pulses on prepaid water meters via remote control.

1. Introduction

The water meter is a device that functions to measure the volume of water[1]. The use of an analogue water meter requires a water meter recording officer to record the amount of water usage of the customer each month by directly visiting the customer's house. Difficulty recording the customer's water meter occurs when the house owner is not at home, so the recording is carried out with estimation. This causes the water usage payment does not follow the actual water consumption volume. In addition to this, the use of analogue water meters provides post-paid services, so that customers can be subjected to fines if they are late in making payments. Without full control by customers with post-paid services can causes customers unable to regulate their water usage. To solve this problem, it is necessary to develop an analogue water meter, so that it can convert the service to prepaid. With prepaid water meters, it is not necessary for field officers to record customer water meters and gives customers the freedom to fully regulate their water usage.

Several researchers attempted to develop prepaid water meters. AsepSaefullah et al[2] developed a token-based digital water meter recording system via the internet so that it does not require field officers. However, this research still applies a post-paid service system, by providing a receipt according to the results recorded on the database server. MochamadSubianto et al [3]developed a token-based prepaid water meter system via the internet based on Arduino Uno. M Taufik et al [4] designed a prepaid water meter using the internet for the purchase and refill process based on identity on the RFID card. The study in this research had a process for entering the token number into the customer's water meter via the keypad button based on the internet-based token number test. The weakness of this research is that if the internet network is disrupted, the token testing process and customer water usage data recording...
will certainly fail. Nyayu Latifah Husni et al. [5] designed a water meter system using data information from a water flow sensor to record a customer's water usage and convert it into the price the customer has to pay. The design of this water meter system only converts metered data into a price to be paid and does not give customers the freedom to control their water use. Mohamed Hussein Khalil Ahmed [6] has developed a GSM-based prepaid water meter but used a keypad to recharge by entering a pin code obtained from a water company. The use of a keypad only allows the filling of water pulses to be done directly near the water meter and also has an impact on the dimensions of the water meter development. In this research, the use of the keypad is replaced by using an infrared remote control so that recharging can be done remotely.

From some of the above studies, this research developed an analogue water meter into a digital water meter with an offline prepaid service system without using the internet network. In the development of this prepaid water meter system, water usage by customers depends on the limit on the number of water pulses which are entered in the prepaid digital meter system so that customers can fully regulate their water usage. In the development of this prepaid digital water meter, the identity of the customer, and the number of water pulses are stored in EEPROM memory. Then each customer is given a token number according to the ID number to enter the value of the water pulse via the remote control. The water pulse data on the EEPROM from the prepaid digital meter is used by the microcontroller to control the solenoid valve. With the development of this research, it is hoped that it can improve the water meter system with prepaid services to provide freedom for customers in fully controlling their water use.

2. Methods

2.1. Block Diagram System Design

This research is applied research to develop a product in the form of a prepaid water meter prototype based on the AT89S52 microcontroller [7]. The development in this research is started from the system design as shown in Figure 1.

![Block Diagram System](image-url)
Figure 1 shows when the system started to operate. The microcontroller began to read the number of customer water pulses stored in the EEPROM memory and displayed the remaining information of the customer’s water pulses on the LCD screen. If the system still has water pulses, the microcontroller will open the solenoid valve so that the water flows out of the water source to the customer’s water channel. As long as the customer uses water, the microcontroller will measure the volume of water that has been used through a flow sensor. Furthermore, the microcontroller will update the number of water pulses in the EEPROM memory according to the amount of water consumption by reducing the number of customer water pulses. If the number of customer water pulses has reached the minimum limit of water pulses, the system will issue a voice signal to remind the customer that the water pulse will run out soon. If the number of customer water pulses has run out, the system will close the solenoid valve and inform the customer on the LCD screen to immediately refill the pulse.

2.2. Hardware System Design

Based on the block diagram system design, the hardware design obtained is shown in Figure 2. From this figure, it can see the relationship between one component and another to form a system unit.

![Hardware system design](image)

**Figure 2.** Hardware system design.

TSOP4383 [8] infrared sensor component functions to receive data signals from the remote controller to enter the token number. The data on the amount of water pulse recharging entered via the remote control is stored in the EEPROM AT24C02 memory [9]. Besides, this EEPROM memory also functions to store changes in the number of water pulses when a customer is using water. An LCD type M1632[10] functions to display information related to system operation such as token filling information, the number of water pulses when using water. The component of the flow sensor type G 1/2 [11] functions to measure the speed of water flow so that it can see the amount of water flow that flows. This flow sensor produces an output signal in the form of a square wave voltage whose frequency corresponds to the water flow speed. The solenoid faucet component with the AQT15SL model [12] is a
faucet for 1/2 "pipe dimensions where the valve will open or close according to the presence or absence of a 12 volts voltage applied to the coil of the solenoid.

2.3. Software System Design

Based on the hardware development in Figure 2, a software design is needed to regulate the work operations of the hardware as shown in Figure 3.

![Flowchart of software system design](image)

**Figure 3.** Flowchart of software system design.

The flow chart in Figure 3 works when the system is first turned on. The system will initialize the data variables. Then the system starts to read the number of water pulses stored in the EEPROM memory. If the number of water pulses runs out, the system will display information to inform customers to refill their water pulses. Conversely, if the number of water pulses is still there, the information on the number of water pulses will be displayed on the LCD screen and the solenoid valve will open. If the customer is using water, the system will measure the water flow volume that comes out of the water meter. In the above system design, where every measurement of water volume is more than 100 mL, the water pulse will be reduced and stored back in the EEPROM memory. During water usage, if the number of water pulses has reached the minimum pulse limit, the system will activate the bell and generate a sound signal to inform the customer to top up the water pulse. If the water pulse has run out, the system will automatically move the solenoid valve to close the water flow. As long as the customer is using water, the water pulse refilling process can be done via the remote control to update the number of water...
pulses. In this process, the solenoid valve will remain open so that it does not affect the ongoing water use process.

2.4. Implementation

Figure 4 shows the results of the prepaid water meter packaging design. The water flow sensor and the solenoid valve components are packed in one place. The placement of the two components is made like there is curve in the pipe to obtain more minimalist dimensional shape when compared to a connection with a straight pipe.

Figure 4. Prepaid water meter prototype design.

Figure 4 shows the placement of the IR sensor components, EEPROM memory, microcontroller, and solenoid driver as well as the buzzer circuit on the printed circuit board. Meanwhile, the LCD is not installed in a printed circuit board, so it required a cable connection to be placed on the panel box. The entire series of hardware can be put in the packaging box along with the water flow sensor components and the solenoid valve.

3. Result and discussion

3.1. IR sensor reading results

Based on the testing of the prepaid water meter system, the results of testing the infrared sensor performance data are in the form of remote control button code identification as shown in Figure 5.

Figure 5. The result of reading the remote control button code
Figure 5 shows the process of testing the remote control code data reading program used to enter water pulse data. First of all, the remote control code reading program was embedded in the AT89S52 microcontroller, then the circuit was turned on which was indicated by the LCD screen on. Then the remote control was pointed at the infrared sensor and pressed a few buttons from the remote.

3.2 Token Test Results
Refilling of water pulses was done by using a remote control to enter the token number which was purchased from the water company online. Deni Lumbantoruanet al [13] uses encryption and decryption with a substitution model. The token in this system is designed with a data width of 12 digits in the form of an encrypted data code as shown in table 1. Meanwhile, the decryption process was carried out by changing customer ID position and water volume as shown in table 2.

Table 1. Encryptions of 12 digits token code

| Date | Month | Year | Volume | ID Customer |
|------|-------|------|--------|-------------|
| 2 digit | 2 digit | 2 digit | 3 digit | 3 digit |
| A | B | C | D | E | F | G | H | I | J | K | L |

Table 2. Decryption of 12 digit token code

| ID Customer | Volume | Date | Month | Year |
|-------------|--------|------|-------|------|
| 3 digit | 3 digit | 2 digit | 2 digit | 2 digit |
| J | K | L | G | H | I | A | B | C | D | E | F |

Figure 6. The result of encryption and decryption of the token program

Token number input via a remote control can be done while the water meter is operating. Figure 6 (a) shows one of the token numbers that has been entered into the system via the remote control. If the number of digits entered is less or more than 12 digits, the system will reset the screen and ask to re-enter the token. Conversely, if the token number is correct, the token data will be decrypted by the system as shown in Figure 6 (b).
3.3 Water Flow Sensor Reading Results
Figure 7 shows the software testing process in reading water volume through a water flow sensor. This figure shows the information on the measurement results of water flow rate (Q) of 16.67 mL/s and the results of measuring water volume of 0.499 liters for 30 seconds. These results indicate that the software worked well in measuring water volume. The results of this test are used to monitor the volume of water consumption by customers.

![Figure 7. The results of testing the water flow sensor program](image)

3.4 Solenoid Valve Test Results
Figure 8 shows the performance of a solenoid valve in regulating water flow based on the condition of water pulses number stored in the EEPROM memory. The solenoid valve will open so that water flows if there is still a water pulse value in the memory.

![Figure 8. The results of testing the solenoid valve control program](image)

As long as the water pulse is still above 1 m3 volume which is indicated by the green indicator, the LCD screen displays only water pulse data. Meanwhile, if the water pulse is below the volume of 1 m3 indicated by a yellow indicator, the LCD screen will display warning information to the customer that the pulse will run out soon. In this condition, the solenoid valve is still open. Then, if the water pulse in
memory has run out, which is indicated by a red indicator, the LCD screen displays information that the water pulse has run out and advises the customer to refill the water pulse immediately.

4. Conclusions
Based on the results of the test and discussion above, it can be concluded that the performance of the hardware and software on the AT89S52 microcontroller-based prepaid water meter worked well. The infrared remote control successfully replaced the keypad function in filling water pulses in the system. Water pulse data on prepaid water meter successfully stored on EEPROM memory to limit the solenoid valve operation. It is hoped that the result of the development of this prepaid water meter will give customers the freedom to control their water usage.

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