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Prepaid water meter card based on internet of things

M Taufik*, A E Rakhmania and Y N Afnani

Department of Electrical Engineering, State Polytechnic of Malang, Sukarno Hatta Street No. 9 Malang, East Java, Indonesia, 65141.

*m.taufik@gmail.com

Abstract. Indonesian population has grown rapidly, as shown in Central Statistics Agency report that in 2018, Indonesia's population reached 265 million. Along with the increasing number of populations, water for daily needs is in high demand. A good monitoring and water management is needed to oversee the water usage efficiently. Currently, local water company still implements post-paid payment system that is time and human resources inefficient. In this study, we proposed the implementation of internet of things (IoT) in designing prepaid water meter card for real time water usage monitoring. The card could also be used to directly purchase water quota online via website. The proposed water meter used air vent valve system combined with the water flow sensor to measure the amount of user's water usage. Result shows that the proposed system could work properly with the error value of 2.84% measured from the difference between water flows read in conventional water meter with the measured value in our proposed water meter. The purchased quota will be directly deducted based on the amount of measured water usage. The process was done in real time environment and the data will be automatically stored in server. When user is running out of quota, solenoid valve embedded in the proposed water meter system will be automatically closed such that user have no access to water source.

1. Introduction

The increasing rate of Indonesian population in each year [1] caused the high demand in water consumption [2,3]. In 2018 where the population of Indonesia reached 265 million [1] caused the increasing number of water company customer up to 5% in each district compared to 2017 number of customer [3–6]. On the other hand, the number of water loss rate is also increasing and the company suffer greater loss. During 2015 – 2018 period, the number of water loss in Malang water company is increasing around 1% each year, from 18.33 until 20.31%. One of the major reason behind water loss rate is the traditional monitoring and customer management system [7]. Good monitoring and management such as increased security, service stability, resilience to disruptions and high performance are needed to reduce losses to the company [8,9].

Traditional water usage readings cause losses to companies and users due to frequent occurrence of misreadings. Customers also often neglect to pay the water bill such that many arrears occur. Users could not control water usage so the amount of monthly payment cannot be predicted. Moreover, current payment system, post paid payment is considered ineffective. Along with the rapid technology development such as Internet of Things (IoT), these problems could be overcome.

IoT is a scenario where an object has the ability to transfer data through a network without requiring human-to-human or human-computer interaction. IoT have been and still could be developed to be

implemented in many aspects in daily life to make human life easier [10]. This paper proposed a prepaid water meter card based on internet of things to overcome the problems raised in water management system. In this system, customer could monitor their water consumption and directly paid the appropriate amount using pre-paid system. On the other hand, water company could be able to real time monitor the water usage in each customer, remote controlling the water meter in customer house, reduce inefficient reading method, thus increasing their efficiency. Previous works about digital water meter in Rafik A and Yuniarto [11] implements pre-paid system, but failed to solve the existence of air in the valve that increasing the value of measured water consumption. Marais J M, et all [12] elaborated the topologies in implementing water meter applied in wireless sensor network, a scheme that is relatively small scale compared to the IoT. Instead of implementing IoT, proposed system in Thang V C [13] transmit the data using GPRS network. However, GPRS has lower data speed transfer and capacity compared to the IoT. Congestion would happen if there are many nodes transmit data simultaneously. On the other hand, our proposed system implements IoT that could allow many nodes could transmit data simultaneously. Cahyati C, et all only implemented water monitoring system without the payment method [14]. Wildani A N implements MCU ESP8266 to set up a prepaid water meter, however, the system still used code as prepaid voucher code which is inefficient and less secure [15]. Instead of changing the meter into fully digital by embedding sensor, Yang F, et al implement convolutional neural network to read data in analog meter then sent the data to sensor [16]. However, this method required high computational time and process for the system. Our proposed method implements water flow sensor to calculate water usage instead of the traditional one. Air vent valve was embedded to remove excess air in the water.

2. Methods

2.1. System design

Figure 1, shows the overall system block diagram.

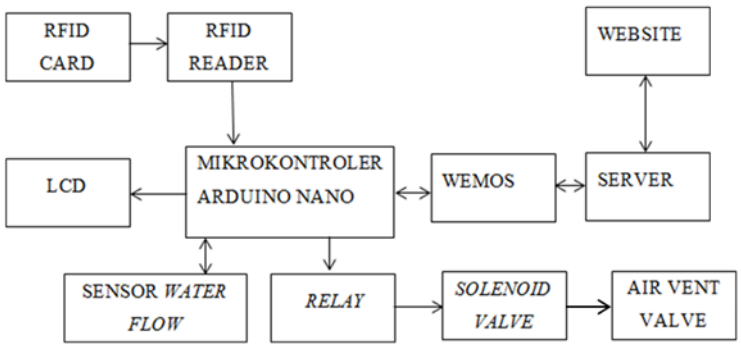

Figure 1. System block diagram.

User uses RFID card to detect the customer's ID number. Arduino Nano will check ID number and water quota on the server though wemos. If the user has quota then solenoid valve opens, the water in the pipe will be flowed through the air vent valve to remove the air bubbles. Water will be directed to solenoid valve and detected by water flow sensor. The measured data will then be sent to Arduino Nano to be converted into water volume and reducing user' water quota. Solenoid valve will automatically be closed and water supply is stopped when user' quota is empty. In website, user could monitor their remaining quota, water consumption, and also quota top up such that they do not need to go to certain outlets to buy water quota.

2.2. Implementation

Figure 2 shows the RFID card circuit that is used to check customer's ID and their remaining quota. RFID is connected to Arduino Nano that acts as data processor. Complete circuit is shown in Figure 3.

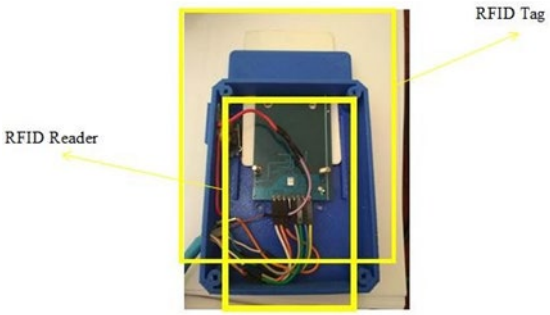

Figure 2. RFID card circuit.

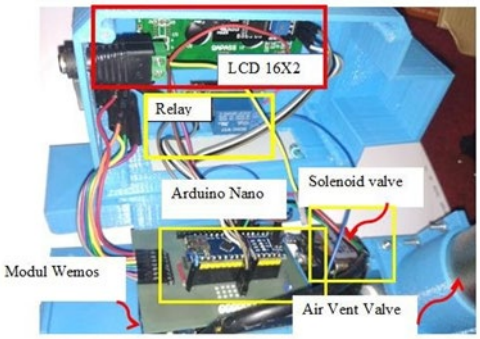

Figure 3. Implemented circuit.

2.3. Water flow sensor calibration

Before testing the system, water flow sensor must be calibrated in order to get the correct data. Water flow sensor was installed in serial with the conventional water meter. Water will be passed calibrated conventional meter before flowed through water flow sensor. The sensor output which is in the form of frequency was sent to Arduino Nano to be converted into volume. During the process, the calibration factor is set such as the value read by sensor is similar to the readout value of conventional meter.

Figure 4. Water flow sensor calibration set up.

3. Results and discussion

3.1. Air vent valve feasibility

Air vent valve is used to remove excess air in water inside the pipes, such that the water flow sensor could detect 100% water flow without any air inside the water. Air vent valve is installed before water flow sensor. To test the feasibility of air vent valve, first we need to install the water flow sensor and air vent valve in parallel with the traditional water meter. 2 liters of water is then flowed through the pipes. In conventional meter, waterflow that was detected still contained air inside it. In our proposed system, water was flowed through the air vent valve to remove the air before flowed to the digital meter. The number displayed on the proposed system is then read and compared to conventional meter. In our proposed system, the read value was always lower than in conventional meter, since we remove the excess air in the water.

Figure 5. Air vent valve feasibility testing set up.

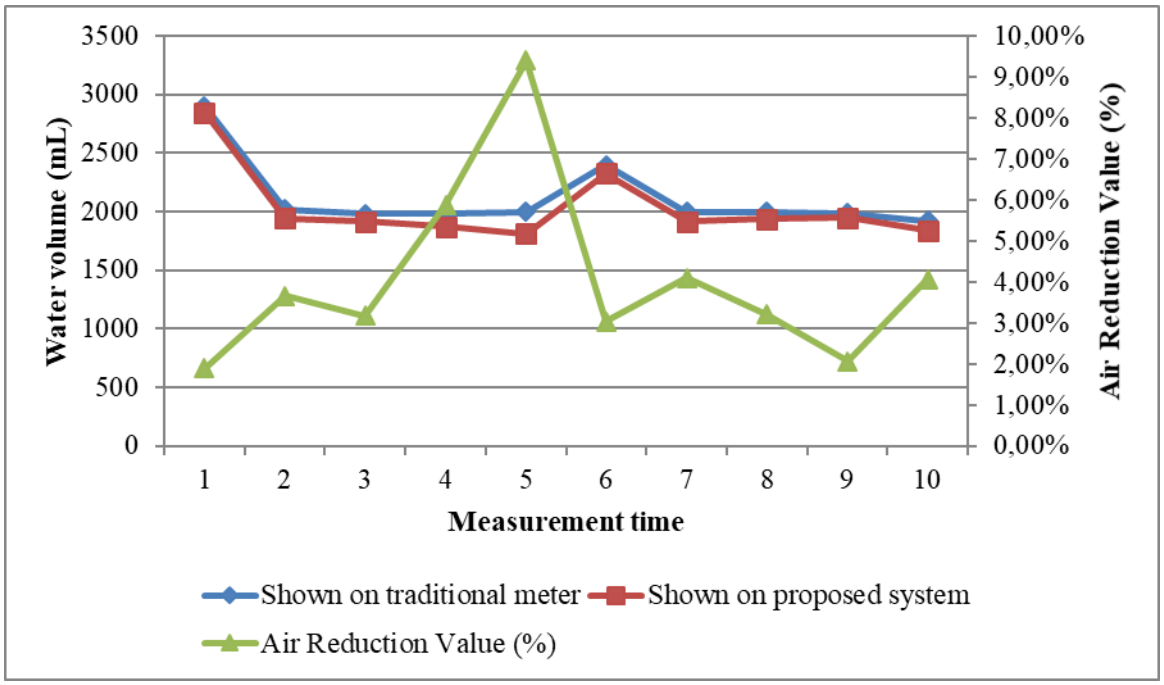

Figure 6. Air vent valve feasibility results.

Figure 6 shows the feasibility result of air vent valve system. In traditional meter, the average water flow value is 2120 mL while in our proposed system is 2036.5 mL. It proves that in our proposed system, the air is successfully removed from the water flow, thus the value detected by the water flow sensor is smaller than the traditional one with the average air reduction value reached 4.05%.

3.2. Water flow sensor accuracy result

Figure 7 shows the accuracy result of water flow sensor. The volume shown in proposed meter is compared with the value obtained in traditional meter. Set up and measurement steps is similar with air vent valve feasibility results. Average error obtained from ten experiments are 0.82% which means the installation of water flow sensor in our proposed system is accurate.

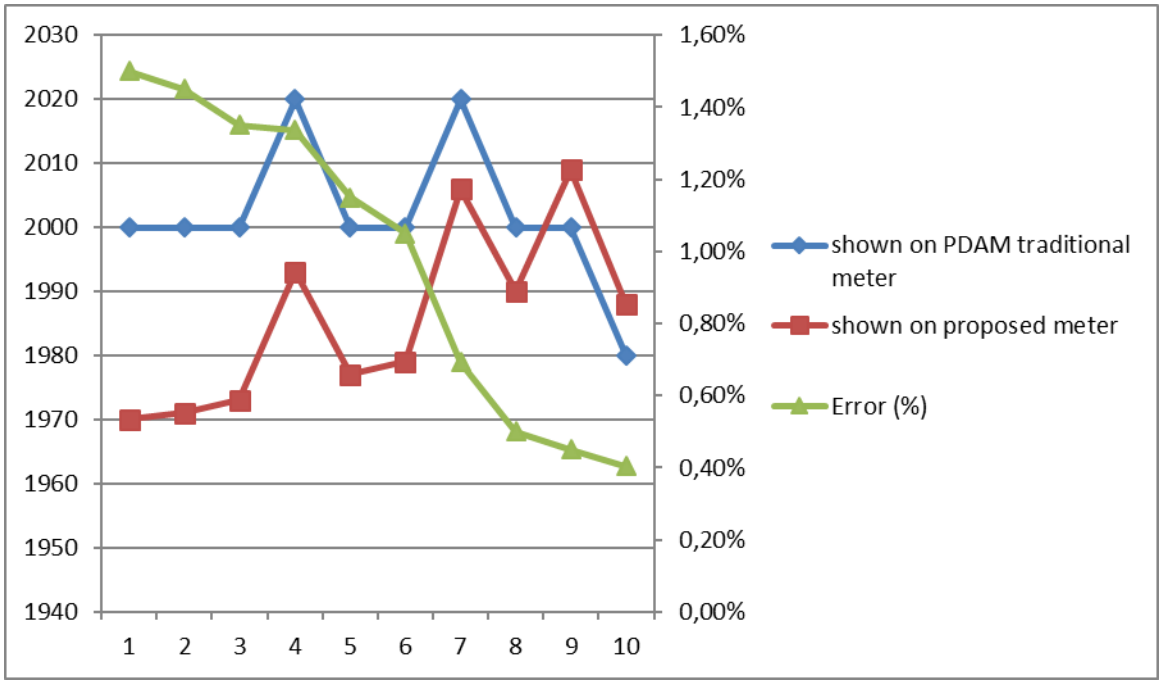

Figure 7. Water flow sensor accuracy results.

3.3. Water quota top up trial

Water will be flowed through customer pipes when customer has enough water quota. To reload the quota, customer only need to open the website and do the top up through user page. The payment is done by debit card or mobile and internet banking, so that users do not need to go to certain outlet to obatain water quota.

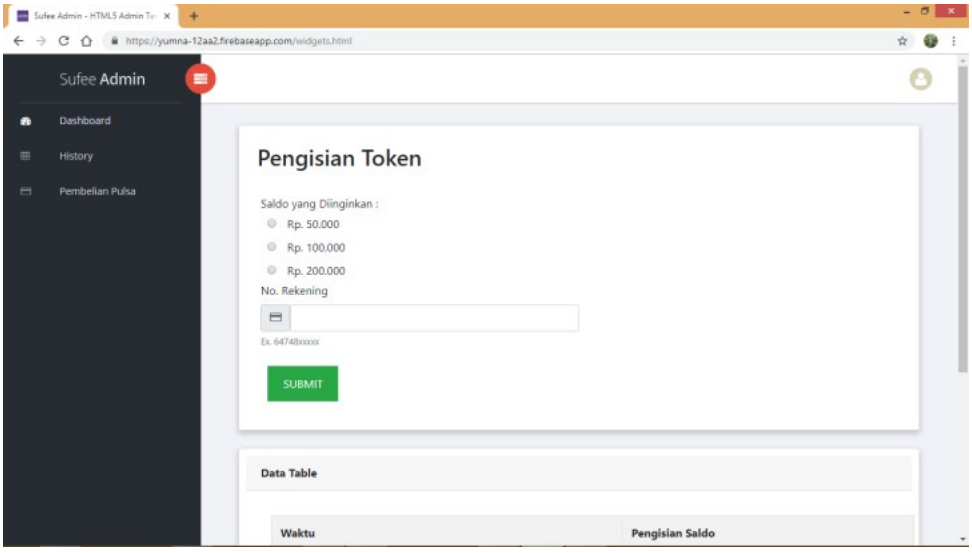

Figure 8. Water quota top up page.

All top up transactions done via the website were successfull, as shown in Table 1. User choose their desired top up amount, then the value is converted to water quota based on the existing tariff for each user.

Table 1. Water quota top up results.

Experiment number -	Test Time	Top up amount (Rp)	quota obtained (L)
1	20 March 2019 12:22	50.000	13529.41
2	30 March 2019 09:55	200.000	42941.17
3	18 April 2019 17:18	100.000	23333.33
4	18 April 2019 19:39	50.000	13529.41
5	19 April 2019 17:42	50.000	13529.41

4. Conclusion

Our proposed system, prepaid water meter card based on internet of things has been designed successfully. The card is used to check user ID and remaining water quota that could be successfully reload directly from website. Air vent valve is implemented to remove the excess air in the water that flows through the pipes in order to obtain a more accurate result on water flow sensor. Results shows that the installed air vent valve is feasible to use since it could successfully remove the excess air in the water. Water flow sensor is used to detect the volume of water that flow through the pipes. With the error of 0.82%, it proved that the implemented water flow sensor is accurate. Overall results show that our proposed system could work properly and ready to be implemented in daily life to help creating better water management system.

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