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Analysis of the Use of Digital Ultrasonic Based on Fuzzy Inference System to Get More Precise Water Discharge Measurement Results

Jamaaluddin Jamaaluddin[1,2], Izza Anshory[1,2], Ali Akbar[3], Khoiri[1], Mardiyono[2], Ahmad Fudholi[2,4],

[1] Department of Electrical Engineering, Universitas Muhammadiyah Sidoarjo, Jawa Timur, Indonesia
[2] Research Center for Energy Conversion and Conservation, National Research and Innovation Agency (BRIN), Indonesia
[3] Department of Mechanical Engineering, Universitas Muhammadiyah Sidoarjo, Jawa Timur, Indonesia
[4] Solar Energy Research Institute, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

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Abstract – *Water discharge measurement commonly used in Indonesia is based on a wheeled meter system. The management of water discharge to each house is regulated by the Regional Water Company (RDWC). However, the wheel meter system not only detects liquids, but also air. So that if the air passes, the meter also rotates. This research aims to measure water discharge in RDWC in Indonesia using ultrasonic. The use of ultrasonic is complemented by the use of Fuzzy Inference System (FIS). The initial stage of this research is to install an ultrasonic sensor device. This sensor is equipped with a display screen and data transmission system. So that RDWC officers and customers can easily monitor water. In addition to using microcontroller media, artificial intelligence technology is also used to make input and output data more precise. The main water measurement is done with the Ultrasonic Echosounder method. This research compares three water measurement systems, namely manual wheel, ultrasonic-based only, and ultrasonic-based with FIS. The comparison is done by measuring the water discharge every minute for nine minutes, and then the difference is indicated by the error value in the form of a percentage. The speed or flow of water is measured before the discharge measurement. The results showed a considerable difference between the manual and ultrasonic methods of 6.08%. In contrast, a minor error (3.74%) was observed in the comparison between ultrasonic-FIS and manual methods. In addition, the results of this study also illustrate the difference between the ultrasonic-FIS and FIS-only methods. Overall, these findings provide additional information regarding the applicability of ultrasonic-FIS and non-FIS methods compared to manual methods for water discharge measurement in Indonesia.*

Keywords: *Ultrasonic; Fuzzy Inference System; Water Debit; Water Flow*

Abbreviations

RDWC	*: Regional Water Company*
FIS	*: Fuzzy Inference System*
UNFIS	*:Un Fuzzy Inferece System*
NRW	*: Non-revenue water*
LCD	*: Liquid crystal display*
PWM	*: Pulse Width Modulation*
USB	*: Universal Serial Bus*
dToF	*: Time of Fligh)*
ICSP	*: In Circuit Serial Programming*
PIPEDIA	*: Pipe Diameter*
VELO	*: Velocity*
DEBIT	*: Water flow*
P	*: Water Pump.*
⊗	*: Stop Valve.*
M	*: Flow Meter Manual.*
SUS	*: Flow Meter Ultrasonic.*
BAK	*: Water tub*
VT	*: Sound Velocity dari material yang mengalir*
θT	*: Angle of transmitter beam*
K	*: Calibration factor*
VF	*: Flow velocity*
Δf	*: Doppler frequency shift*
VS	*: Sonic velocity of fluid*
fT	*: Transmitter frequency*
θ	*: Angle of fT entry into liquid*
K	*: Constant*
D2	*: Inner diameter of the pipe*

Symbols

m^3/mn	*: Cubic metres per minute*
m/s	*: Metres per second*

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I. Introduction

Clean water providers and customers have some problems on the presence of non-revenue water (NRW) This NRW occurs due to several conditions: Loss of water in the reservoir, unaccounted water consumption, leakage, damage to the customer's pipe, damage to the customer's meter, inaccurate readings on the customer's meter and damage to the customer's meter. Meanwhile, on the customer side, there is a lack of precision in billing with the water received [1][2]. This happens because there is air material (not water) that enters the meter and causes the meter to rotate, then the second cause is a leak in the customer line [3]. The problem can be formulated as how to make a clean water consumption meter that uses a digital electronic system with the provisions. The reading of the material in the pipe is water (not air), the value of usage can be read directly by the customer, can read up-to-date clean water usage data and can send usage data to the Regional Drinking Water Company (RDWC) office, digital measuring instruments that are made later have long durability that is not easily affected by weather and piping conditions at the customer.

Several previous studies have researched the ultrasonic working process, which converts ultrasonic signals into electrical signals. The flow velocity is calculated by analyzing the electrical signal to measure the flow [4]. Another researcher presented a dToF (Time of Flight) ultrasonic method for flow measurement, mainly applied to large-diameter flow meters by incorporating high-power digital signal processing devices [5]. This research proposes a dToF ultrasonic water meter that can be applied to small diameters and consumes low power [6]. Meanwhile, Catak presented a discussion on the calibration of ultrasonic flow meters that can improve readings over time. This tool is promising in minimizing flow measurement errors. Another researcher designed a high-precision ultrasonic flowmeter based on the cross-correlation method. Simulation of the ultrasonic wave propagation process during flow measurement and the cross-correlation algorithm implementation process were run using COMSOL Multiphysics 5.6 and Python software [7]. J Senthil Kumar conducted a comprehensive review research on improving accuracy in flow rate measurement using reconfigurable systems and deep learning approaches. This study also discusses the reduction of uncertainty in single-path and multi-path ultrasonic flow meters [4][8]. In this research, additional treatment is given as above, namely by providing an artificial intelligence system in the microcontroller program. This artificial intelligence gives the lowest error rate results. The artificial intelligence system used in this research uses a Fuzzy Inference system and a remote data transmission system using the internet of things using modbus.

With the use of artificial intelligence and remote data transmission using the Internet of Things, it is expected that there will be precise water discharge measurements in the measurement process. Of course, this is different from using a manual water discharge measurement tool (using a pinwheel). The use of the Internet of Things in carrying out the remote measurement process will make it easier for RDWC officers. Officers do not need to come to the place to be measured, but simply monitor at the RDWC office for the water usage data that has been sent. From this data, it can be used directly to assess how much payment must be made by the customer.

II. Method

The design of this clean water flow meter uses an Arduino microcontroller which functions as an input signal processor in the form of ultrasonic sensor readings for clean water flow measurements and outputs in the form of LCD readings and data transmission. Processing on this microcontroller is done by coding using artificial intelligence, namely the Fuzzy Inference System. The data sending device uses the Internet of Things Modbus system. The explanation regarding this ultrasonic sensor is that it is a remote sensor that emits ultrasonic waves with a frequency of 40,000 Hz. The receiver installed on this tool will invert the signal sent by the transmitter [9][10]. In principle, this sensor will convert the mechanical quantities generated by the piezoelectric motion into electrical quantities. The firing time of the waves and the reception of the waves are then converted into the desired unit by the programmer, such as distance or volume [11].

Arduino is one type of microcontroller board. It has 14 digital input and output pins, 6 of which can be used for PWM output. 6 analog inputs, 16mHZ crystal oscillator, USB connection [12]. Powerjack ICSP header and reset button on the arduino board. Arduino Uno has an important role to control the sensors used in the designed tool.

The IoT device used for this research is using the NodeMCU ESP8266 as the main microcontroller which sends the results of the input that goes to the HLW 8012 sensor which is displayed on a 20x4 LCD and forwarded by NodeMCU to the user's smartphone via the Blynk application where the application has been programmed with using a data interface that can display the necessary requirements. The system also has a remote switch consisting of electronic components, namely the NodeMCU ESP 8266 which has a 2-channel relay output that is used to disconnect and connect the flow of electrical energy according to user orders through the Blynk application that has been made [11][13].

In some previous studies, Nadagoudar [14] conducted research on measuring water discharge using neural

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networks. The results of his research show that by using a neural network, the error value ranges from 0.174 to 0.235. These results indicate a better error because the analysis is still a planning design and includes additional algorithm elements. Meanwhile, Solioz and Mudry [15] measured water discharge using machine learning. The results obtained using machine learning get an error value close to the 10% value. This shows that the use of machine learning has a greater error value when compared to using FIS. In another section, Hussein and Agbinya [16] conveyed that several artificial intelligence can help measure water discharge: Support Vector Machine, Artificial Neural Network, Markov Chain, and Ensemble Modeling [16]. This research uses artificial intelligence to do water discharge forecasting. The application will illustrate that the use of artificial intelligence will be increasingly massive in measuring and forecasting water discharge [17][18]. In this research, the artificial intelligence that will be used is Fuzzy Inference System (FIS). FIS is quite widely used in the production process, control process, and forecasting process [19][20][21].

Fuzzy inference system is a reasoning process using fuzzy input and predetermined fuzzy rules to produce fuzzy output [22][23]. The main structure of the type-1 fuzzy logic system is shown in Figure 1: The Fuzzy method was introduced by Ebrahim Mamdani in 1975. This method is called the Mamdani or Max-Min method; there are five stages to get the output, namely [24][25]: Formation of Fuzzy sets (input and output variables). Operation Membership Functions. Implication function application (Implication), in general, the Min function is used. Rule composition (Aggregation). Affirmation (Defuzzification).

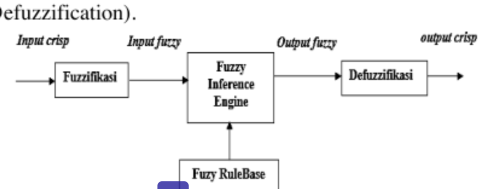

Figure 1. Fuzzy Inference System

In this study, the Fuzzy Inference System (FIS) has 2 input variables and 1 output variable. The input variables are pipe cross-section and water velocity, and they have a water debit output variable. The pipe cross-section variable has 3 membership sets: Big, Middle, and Little. The water velocity variable also has 3 membership sets, namely Low, Middle, and High. The water discharge variable also has 3 membership sets, namely Low, Middle, and High. The membership function graph for the pipe diameter, water velocity, and water discharge variables is shown in Figure 2-4.

For pipe Diameter membership operations are as follows:

- Little with a range of values: 0 to 0.75 (dim)
- Middle with a range of values: 0.5 to 1 (dim)
- Big with a range of values: 0.75 to 1 (dim)

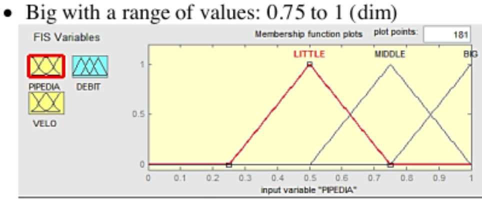

Fig. 2. Membership Set in Pipe Diamater. (X-axis=Pipe Diameter; Y-axis=Membership Function)

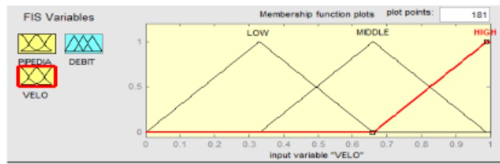

Fig. 3. Membership Set at Water Speed. (X-axis=Water speed; Y-axis=Membership Function)

As for the membership operation, the water speed is as follows:

- Fast with value range: 0 to 0.66 (m/s)
- Medium with a range of values: 0.33 to 0.99 (m/s)
- Slow with value range: 0.66 to 1 (m/s)

The graph is shown in Figure 3.

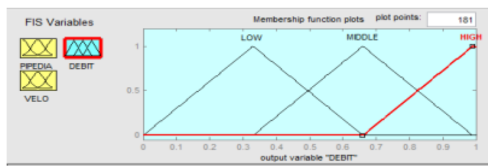

Fig. 4. Membership Association on Water Debit. (X-axis=Water Flow; Y-axis=Membership Function)

For water debit membership operations are as follows:

- Height with value range: 0 to 0.66 (m^3/mn)
- Medium with a range of values: 0.33 to 0.99 (m^3/mn)
- Low with a range of values: 0.66 to 0.99 (m^3/mn)

In the process of using Artificial Intelligence, the input used is the pipe's diameter and the water's speed. These 2 variables will be sorted according to their operational set [26]. The grouping on the set of FIS variables is processed so as to produce an analysis output in the form of water discharge. So, with this, the results obtained will be more precise. This prototype will be tested and compared with the manual water meter measurement system widely used today.

To operate the membership function value, it is necessary to create a fuzzy rule base. This Fuzzy Rule base provides rules to produce the desired Fuzzy value [27].

In Figure 5, the Fuzzy rules are shown with the following details:

Rule 1: If PIPEDIA is small and VELO is small, then DEBIT is small.

- Rule 2: If PIPEDIA is small and VELO is medium, then DEBIT is small.
- Rule 3: If PIPEDIA is medium and VELO is small, then DEBIT is medium.
- Rule 4: If PIPEDIA is medium and VELO is medium, then DEBIT is medium.
- Rule 5: If PIPEDIA is large and VELO is small, then DEBIT is medium.
- Rule 6: If PIPEDIA is large and VELO is medium, then DEBIT is medium.
- Rule 7: If PIPEDIA is small and VELO is large, then DEBIT is medium.
- Rule 8: If PIPEDIA is medium and VELO is large, then DEBIT is medium.
- Rule 9: If PIPEDIA is large and VELO is large, then DEBIT is large.

The rule table shows the relationship between PIPEDIA and VELO inputs and the DEBIT output. Each cell in the table represents the DEBIT output resulting from a combination of PIPEDIA and VELO levels [14].

The linking rule used is ('And' or 'Or'), which will affect the way the rule is evaluated. This value is assigned based on experience or previous research [28]. The next part is to assign a certain weight to the rule, which affects the strength of the rule's influence on the final result. In practice, this fuzzy logic system can be used to control processes involving PIPEDIA and VELO to produce a desired DEBIT output, such as in pumping systems or fluid flow regulation, by making complex decisions based on linguistic and uncertain inputs[20][29][30][31][32].

With the following rules: Rule Number: Numbers 1 to 9 indicate different rules. Each rule may combine the PIPEDIA and VELO inputs in a different way to generate the DEBIT value. Membership Function: The rule uses different membership functions (triangular and trapezoidal) to determine the membership level of the input value. Yellow indicates a higher level of activation of the rule, while grey indicates no activation or low activation. Input: 'Input: [0.5 0.5]' below indicates that the current input being analyzed is 0.5 for PIPEDIA and 0.5 for VELO.

This study was initiated by designing the diagram block, then tool installation, and finalized by tool testing phase. The design of a clean water flow meter using an Ultrasonic sensor has a block diagram design as shown in Figure 5.

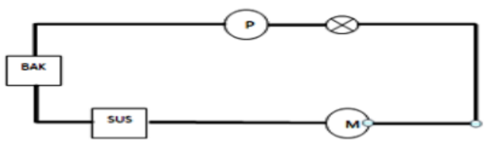

Fig. 5. Research Block Diagram

Caption:

P = Water Pump.

⊗ = Stop Valve.

M = Flow Meter Manual.

SUS = Flow Meter Ultrasonic.

BAK = Water tub.

In the block diagram, the initial process of using an ultrasonic sensor to measure the water level in the pipe input to Arduino. Arduino will process the input data by entering the FIS logic. Besides processing with FIS, Arduino also accepts input of water velocity and pipe cross-sectional area. After the process on the Arduino, an output appears in the form of a water discharge per unit time. With the calculation process, the value of water usage will be obtained. This research also uses a communication device, namely by using NodemCu as a transmitter circuit to send real-time data that can be received by Android or other receiving devices.

The tools used to conduct this research are: ultrasonic sensor, Arduino, LCD, NodemCu. On Arduino, coding must be done to operate the system. The Arduino operation will combine input and FIS analysis processes and produce output in the form of water discharge. The Flow Chart of the system inputted to the Arduino system is shown in Figure 6.

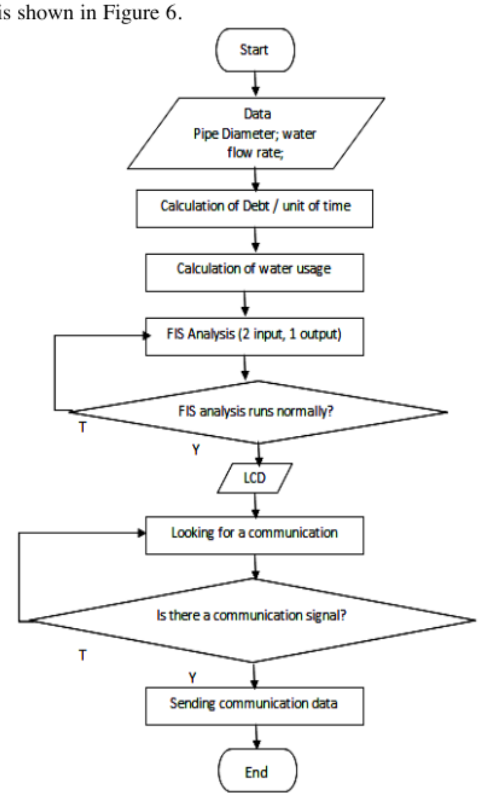

Fig. 6. System Flow Chart In This Experiment

The block diagram of how the system works is shown in Figure 7. The ultrasonic flow meter works based on speed, where the ultrasonic waves are transmitted by the transducer which is passed by the flowing media so that the ultrasonic device obtains the flow velocity. The ultrasonic flow transmitter will capture and process the signal from the sensor or transducer by providing the measured average flow velocity of the medium. Ultrasonic flow meters utilize the ultrasonic sound vibrations generated by the transducer to measure the flow rate of liquids. There are two types of ultrasonic flowmeters: Doppler and Transit Time [28][10]. Ultrasonic flow meters are ideal for measuring all types of liquids or liquids that are homogeneous and do not depend on the conductivity of the liquid.

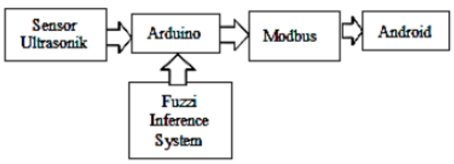

Fig. 7. Experimental Block Diagram

The next step of the process is to evaluate the surface view. Surface view in fuzzy logic has several main functions: It assists in visualizing the relationship between inputs and outputs in a fuzzy system. It is very useful for understanding how various inputs affect the output. Surface View allows the analyst to see how changes in the input variables affect the output variables. It helps in decision-making and fuzzy rule tuning. They are used to identify and fix problems in fuzzy logic. For example, if the output does not change according to expectations when the input changes, they can be identified by viewing the Surface View. They are used to evaluate the effectiveness of fuzzy models, particularly in handling complex and uncertain data. In the context of education and training, Surface View is used to teach basic concepts of fuzzy logic and how fuzzy systems work.

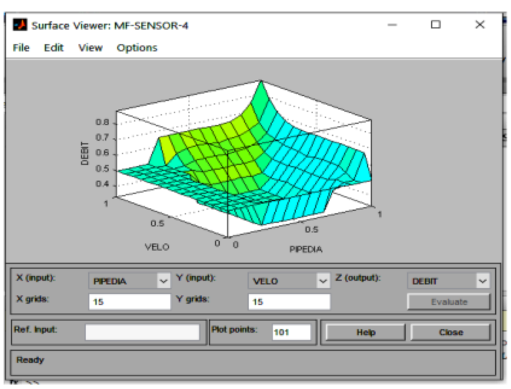

Fig. 8 Surface View

In Figure 8, it appears that the surface view has a: X-axis - PIPEDIA: This indicates that the pipe diameter (or the variable represented by 'PIPEDIA') is normalised between 0 and 1. Such normalization is often done in data analysis to simplify comparisons or when the actual value does not need to be known for the analysis being performed. As for the Y-Axis - VELO: It also has a range from 0 to 1, which indicates that the flow velocity (or 'Velocity') is also normalized. In a real context, this might represent a range of possible velocities from very slow (0) to very fast (1) flow conditions. For Z Axis - DEBIT: The values on the Z-axis vary from 0 to about 0.8. This indicates the discharge or volume flow of the fluid measured by the sensor. The maximum value of about 0.8 may indicate the maximum capacity or maximum measured discharge value in this system [33][34]. The surface graph shows how the discharge changes with variation in pipe diameter and flow velocity. The highest point on the surface may indicate the optimum combination of pipe diameter and flow velocity for maximum discharge. The shape of the surface graph indicates the type of relationship between pipe diameter, flow velocity, and discharge [27]. For example, suppose the surface tends to rise faster as it approaches high values on the X and Y axes. In that case, this indicates that increasing pipe diameter and flow velocity has a positive influence on discharge up to a certain point [35].

The Ultrasonic Doppler Flow Meter measures the shift in frequency, which is directly proportional to the flow rate. This value is multiplied by the internal cross-sectional area of the pipe to get the volumetric flow as shown below:

$$\Delta f = 2fT \sin\theta \cdot VF/VS \quad (1)$$

$$VF = \Delta f/fT \cdot VT/\sin\theta T = K\Delta f \quad (2)$$

Where

VT = Sound Velocity dari material yang mengalir
θT = Angle of transmitter beam
K = Calibration factor
VF = Flow velocity
Δf = Doppler frequency shift
VS = Sonic velocity of fluid
fT = Transmitter frequency
θ = Angle of fT entry into liquid

$$\text{Volumetric flow rate} = K \cdot VF \cdot D2 \quad (3)$$

K = Constant
D = Inner diameter of the pipe

This type of Doppler operation depends on the particles flowing in the liquid, therefore care needs to be taken to minimize the concentration and size of the solids or bubbles contained in the liquid. Likewise, to maintain the continuity of suspended solids, the liquid must flow at a fairly high rate [36][37]. The next stage is to conduct trials and measurements. The trial was carried out measuring water discharge using an annual meter, then using ultrasonic and using ultrasonic by the Fuzzy

Inference System. Test equipment is needed to compare the measurement results shown by research measuring instruments with conventional water meter measuring instruments. From the test results, it will be known the error rate of the system to improve its reliability further.

III Results and Discussion

The test results are obtained. In testing the ultrasonic sensor readings, what is done is to measure the water discharge (flow). Some component settings are required by entering pipe material values and pipe diameters. In the first test, the measurement of water discharge was carried out. Comparisons were made using ultrasonic and manual. In contrast, the second test was carried out by entering the Fuzzy Inference System. In the first test, the measurement results were obtained, as shown in Tables 1 and 2.

Table 1. Comparison of Ultrasonic and Manual Flow

TIME	Water speed (m/s)	
Minute	ultrasonic	manual
1	58.75	10.20
2	59.60	11.00
3	60.50	11.90
4	61.40	12.80
5	62.27	13.70
6	63.00	14.68
7	63.70	15.45
8	64.55	16.40
9	65.45	17.30
10	66.35	18.20
Sum	625.57	141.63
Average	62.56	14.16

In Table 1, it can be seen that the results of measuring water discharge by ultrasonic and manual measurements are almost the same. This shows that the measurement of water discharge using ultrasonic has a fairly good accuracy. The flow rate for each measurement when using ultrasonic measurements starts at 58.75. The manual flow meter shows numbers starting at 10.20 and increasing per unit time.

Table 2. Comparison of Ultrasonic and Manual Flow Movements.

TIME	Debit (m^3/minute)		Deviation	Error (%)
Minute	Ultrasonic	Manual		
1	0.85	0.80	0.05	6.25
2	0.90	0.90	0.00	0.00
3	0.90	0.90	0.00	0.00
4	0.87	0.90	0.03	3.33
5	0.73	0.98	0.25	25.51
6	0.70	0.77	0.07	9,09
7	0.85	0.95	0.10	10.53
8	0.90	0.90	0.00	0.00
9	0.90	0.90	0.00	0.00
			Sum	54.71
			Average	6.08

Deviation: Manual – Ultrasonic

Error = (Deviation / Manual)x 100%

Table 2 shows that the numbers in the discharge column indicate the amount of water flowing. Measurement used ultrasonic and using a manual meter to calculate it by the designation of the flow rate in each minute minus the measurement in the previous minute. From the calculation results, an average error rate of 6.08% was obtained.

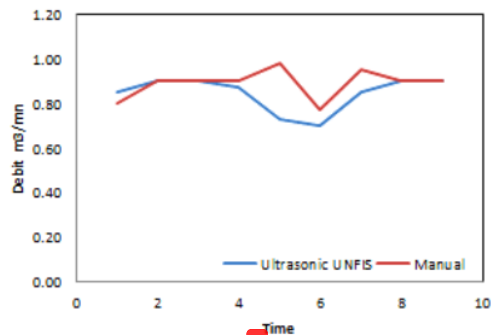

Fig. 9. Debit Measurement using Ultrasonic-UNFIS and Manual

In Figure 9, it can be seen that there are differences in the measurement of water discharge using ultrasonic and manual, but they are not far adrift. It can be seen in the graph that there are several increases in discharge, this occurs due to the influence of the water discharge used. The second cause is the performance of the water pump used. By incorporating Artificial Intelligence using the Fuzzy Inference System, the test results are obtained as shown in Table 3 and Table 4, with a graph as shown in Figure 10.

Table 3. Comparison of Ultrasonic and Manual Water Speed

TIME	Water Speed (m/s)	
(Minute)	Ultrasonic	Manual
1	67.30	19.50
2	68.28	20.45
3	69.31	21.47
4	70.27	22.45
5	71.19	23.38
6	72.23	24.34

TIME	Water Speed (m/s)	
(Minute)	Ultrasonic	Manual
7	73.21	25.29
8	74.27	26.23
9	75.22	27.19
10	76.15	28.13
Sum	717.43	238.43
Average	71.74	23.84

Table 3 shows the results of measurements of ultrasonic water discharge and manual measurements. The flow rate for each measurement when using ultrasonic measurement starts at 67.30. Manual flow measurement using a manual water meter with a mechanical system starts at 19.50 and increases per unit of time.

Table 4. Comparison of Ultrasonic-FIS and Manual Discharge Movements

Time	Debit (m^3/minute)		Deviation	Error
(Minute)	Ultrasonic-FIS	Manual		
1	0.98	0.95	0.03	3.16
2	1.03	1.02	0.01	0.98
3	0.96	0.98	0.02	2.04
4	0.92	0.93	0.01	1.08
5	1.04	0.96	0.08	8.33
6	0.98	0.95	0.03	3.16
7	1.06	0.94	0.12	12.77
8	0.95	0.96	0.01	1.04
9	0.93	0.94	0.01	1.06
			Sum	33.62
			Average	3.74

Deviation: Manual – Ultrasonic
Error = (Deviation / Manual)x 100%

Table 4 shows that the numbers in the debit column indicate the amount of water flowing. Measurement used ultrasonic and a manual meter to calculate it by the designation of the flow rate in each minute minus the measurement in the previous minute. From the calculation results, an average error rate of 3.74% was obtained.

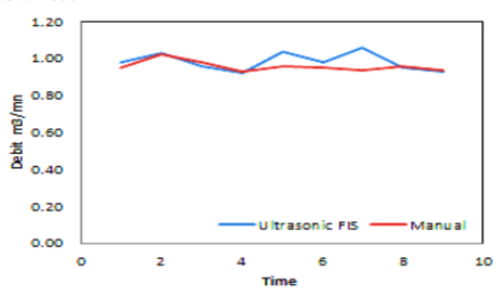

Fig. 10. Debit Measurement using Ultrasonic-FIS and Manual

In Figure 10, it can be seen that by using FIS, smaller error results are obtained. The magnitude of the difference in errors can be seen in Table 4. The comparison of errors between systems that do not use FIS and those that use FIS can be seen in the graph of Figure 11.

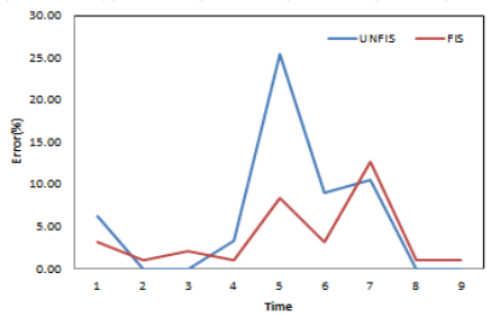

Fig. 11. Comparison Error UNFIS and Using FIS

The graph presented is titled "Comparison Error Un Fuzzy Inference System and Using Fuzzy Inference System." It compares the error values of two different systems or models: one that does not use a Fuzzy Inference System (UNFIS) and one that does use a Fuzzy Inference System (FIS). The graph shows that both systems have fluctuating error rates across 9 different measurements, labeled 1 through 9 on the horizontal axis. The vertical axis represents the error magnitude, and we can observe the following points: Both systems exhibit variability in performance, with errors rising and falling across the different instances. The UNFIS system (represented by a blue line) shows a particularly high error value at instance 5, which significantly exceeds any error value for the FIS system (represented by red line). Apart from the spike at instance 4, the FIS generally has lower error values than the UNFIS system, with error average 3.74 %. This comparison could be used to evaluate the effectiveness of implementing a Fuzzy Inference System in reducing errors within a given process or application. The data suggests that while the Fuzzy Inference System might not always provide a lower error rate, it could potentially offer a more consistent or stable performance, except for certain instances where the UNFIS outperforms significantly.

4. Conclusion

After conducting the research as above, the following analysis results were obtained: Water discharge measurement in Indonesia usually uses a wheeled meter system. This system, which is regulated by the Regional Water Supply Company (RDWC), has the disadvantage of being able to detect air in addition to liquid, so passing air also makes the meter rotate. In this research, an ultrasonic sensor is installed equipped with a display screen and data transmission system, allowing RDWC officers and customers to monitor water consumption easily. Artificial intelligence technology is also used to improve the precision of input and output data. The primary measurement of water was conducted using the Ultrasonic Echosounder method.

This research compares three water measurement systems: manual, ultrasonic-based only, and ultrasonic-based with FIS. A smaller error (3.74%) was observed in the comparison between the ultrasonic-FIS method and the manual method. Overall, these findings provide additional information regarding the feasibility of using ultrasonic-FIS and non-FIS methods compared to manual methods for water discharge measurement in Indonesia.

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AUTHORS' INFORMATION

Dr. Ir. Jamaaluddin, MM, was born in Surabaya, Indonesia, on October 17, 1970, graduated with the B.S. in Electrical Engineering from the Brawijaya University, Malang Indonesia, in 1992, M.S. in Magister Management of Muhammadiyah University of Yogjakarta in 2013 and Doctoral in Electrical Engineering, Institute Technology of 10 Nopember (ITS), Surabaya, Indonesia in 2020.

His main contributions are in Power Electrical Engineering and Artificial Engineering, solar radiation modeling and resource assessment, advanced solar photovoltaic systems (grid-connected photovoltaic, solar powered regenerative fuel cell, solar hydrogen production, thin film silicon solar cell) and advanced solar thermal systems (solar cooling, solar heat pump, solar assisted drying, combined photovoltaic thermal or hybrid collector).

He has been involved in many research and community services and has received funding from the Indonesian government more than 10 times with a funding value of more than IDR 1 billion. He has been a member of the Indonesian electro engineering forum since 2015 until now. He has obtained several simple patents and several awards in the academic field.

Dr. Izza Anshory, ST, MT, was born in Ponorogo, Indonesia, on December 9, 1975. He completed his undergraduate studies in electrical engineering at Universitas Brawijaya in Malang, and then pursued his master's and doctoral degrees in the same field at the Institut Teknologi Sepuluh Nopember (ITS) in Surabaya. Dr. Anshory showed great diligence and excellence throughout his education.

As an academic, Dr. Anshory has been active in research and scholarly publications. His research interests are focused on power systems, renewable energy, and artificial intelligence in electrical engineering. His work has made significant contributions to science and technology, especially in the fields of renewable energy and the application of artificial intelligence

The individual's research interests encompass the field of BLDC Motors, applications of Renewable Energy, and the domain of Artificial Intelligence.

Ali Akbar ST., MT., was born in Sidoarjo, Indonesia, on February 1973, graduated with the ST., in Mechanical Engineering from the Sepuluh November Intitute of Technology, Surabaya Indonesia, in 2000. MT., graduated in Magister Mechanical Engineering from the Brawijaya University in 2014.

He has been a member of the International Association of Engineers (IAENG) since 2010 until now. His main contributions are in the fields of Mechanical Engineering, Alternative Energy, Renewable Energy and Applied Mechanical Engineering. He has been involved in a lot of research and community service and has received funding from the Indonesian government. He has obtained several simple patents and several awards in the academic field.

Khoiri, S.Th.I, M.Pd.I was born in Mojokerto on 1 February 1979 and resides in Desa Bandung, Kecamatan Gedeg, Kabupaten Mojokerto. Khoiri is a dedicated professional with a passion for education, entrepreneurship, and community service.

His educational journey began with fervor, completing studies in MI, SMP, and SMEA Muhammadiyah in Ngoro, Mojokerto. He then earned both Bachelor's and Master's degrees from Muhammadiyah University. Currently immersed in the pursuit of a Doctoral Degree at IKHAC Mojokerto, Khoiri exemplifies a commitment to continuous intellectual growth. Khoiri wears multiple hats in his professional life. As a lecturer at AIK UMSIDA, he shapes young minds with dedication. Simultaneously, he is the owner of TOMBO AL KHOIR, showcasing

his entrepreneurial spirit. Notably, Khoiri is also an esteemed author, with works including "Rumus Langit," "Jebakan Langit," "Solusi Langit," and more. Beyond his professional roles, Khoiri actively engages with various organizations. From active involvement in IPM to participation in Pemuda Muhammadiyah Mojokerto, TS Surabaya, and PPKI Kyokushin Full Contact, his commitment shines through. Currently serving as the Vice Chief in PDM Kabupaten Mojokerto, Khoiri contributes significantly to the organizations he is a part of. Khoiri's story is one of continuous growth and community dedication, marked by a relentless pursuit of knowledge, a thriving entrepreneurial spirit, and a passion for literary expression. As he traverses the worlds of academia, business, and community service, Khoiri stands as a beacon of inspiration, embodying the transformative power of diverse pursuits and a commitment to positive impact.

Mardiyono was born in Kediri, December 6 1963. He completed his primary to secondary education in Kediri. Undergraduate/S1 education was completed at STESIA Surabaya and postgraduate/S2 was completed at UGM. Since 1993, he has been a Civil Servant (PNS) as a family planning counselor in Surabaya until 2000, after which in 2000 he joined as a researcher at the East Java BKKBN representative and was placed at the East Java KBN development center. Then since 2022 he has joined the Population Research Center of the National Research and Innovation Agency (BRIN).

Research activities related to population, family and family planning that have been carried out include those in charge of the Survey of Population and Family Planning Program Performance Indicators and the Research on the Development of a PKB Performance Model for the Bangga Kencana Program in East Java Province. Some published article publications include; Qualitative Study of Family Planning (KB) Village Program's implementation in East Java Province-Indonesia, Intrapersonal Factors Relationship in Adolescent Pregnancy .

Assoc. Prof. Ahmad Fudholi, Ph. D joined the SERI as a lecturer in 2014. He is Associate Professor in Universiti Kebangsaan Malaysia. He involved ~ USD 600,000 worth of research grants (42 grants/ project). He supervised and completed ~ 50 M.Sc and Ph.D students. To date, he has managed to supervise fifteen Ph.D.

His current research focus is renewable energy, particularly solar energy technology, micropower systems, solar drying systems, and advanced solar thermal systems (solar-assisted drying, solar heat pumps, PVT systems). He has published more than 400 peer-reviewed papers, of which 140 papers are in the WoS index (80 Q1, impact factor of 5-16), and more than 270 papers are in the Scopus index (84 Q1 and 90 Q2). He has a total citation of 5336 and an h-index of 34 in Scopus (Author ID: 57195432490). In addition, he has published more than 80 papers at international conferences. He has a total citation more than 7789, an h-index of 39, and documents more than 420 in Google Scholar.

He has been appointed as a reviewer of high-impact (Q1) journals. He has received several awards. He owns seven patent and two copyrights. He joined the BRIN as a researcher in 2020. He is the best of researcher from ~700 researchers OREM BRIN in 2022. He is World's top 2 % Scientists in 2021, 2022 and 2023. He can be contacted at email: a.fudholi@gmail.com; ahmad.fudholi@brin.go.id.

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