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An Analysis Of Mini Control Timer System For PDAM Water Processing Using Wave Control Method

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ABSTRACT
In this study, a mini control timer system was analyzed in PDAM water treatment using the Control Wave method. In a water treatment system, timely control is very important to ensure optimal operational efficiency and water quality. The Control Wave method is applied to regulate and optimize the water treatment process more efficiently through automatic timer-based control. This system allows more flexible adjustments to variations in workload and operational conditions, thereby improving the overall performance of the water treatment process. which involves the development of a simulation model that describes the water treatment process with the integration of a Control Wave-based control system. The simulation results show that this method can improve energy efficiency, reduce downtime, and increase the stability of water treatment operations. In addition, the implementation of Control Wave in this mini control timer system has also been proven to be able to adjust to changes in operational needs dynamically, without sacrificing the quality of the processed water. The findings of this study provide a basis for further improvements in the control system in PDAM water treatment, especially in the use of automation technology to improve process reliability and efficiency.

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INTRODUCTION

A Clean water is a very important need in everyday life, used for activities such as washing, bathing, and drinking. In urban areas, clean water is often difficult to obtain, so it is necessary to process water resources from rivers or lakes into water that is suitable for use. For this reason, a water treatment plant is needed that can reduce contaminants and hazardous substances, so that it is safe for human health [1].

The development of electronic technology is currently experiencing very rapid growth. This development tends to lead to increased optimization of work speed and minimization. This means that electronic equipment and components are attempted to use materials and sizes that are increasingly smaller but have higher speed and work capabilities. Thus, one of the companies in Indonesia that manages water treatment plants is PDAM (Regional Drinking Water Company). PDAM carries out water treatment through three stages, namely natural sedimentation, clarification, and filtration [2].

Currently, PDAM still uses a conventional control system for water treatment, which makes the process less effective and efficient. Operators must monitor and control the process manually in the field, such as activating the pump by pressing a button, adjusting the pH mixing by manually opening the tap, and monitoring the water level. Operator error can hamper the water treatment process, which in turn also hampers the distribution of clean water to the community [3].

Therefore, an automatic and real-time water treatment plant control system is needed. According to Wang Xin, strengthening the supply of clean water with real-time monitoring is very important as a city infrastructure and a source of economic and social development [4]. According to Zhiyu Ye, one of the water treatment systems with automatic and real-time control uses a PLC (Programmable Logic Controller) as a control center. The advantages of using a PLC are the speed in determining output, ease of use, and real-time monitoring capabilities [5].

Thus, river water processing into clean water is needed using a PLC-based automatic control system to meet daily needs. In addition, this control system can also be used to monitor industrial processes that are controlled remotely, so that it can save costs, time and energy. In order for the research to be more specific, the author views that the problems raised need to be limited in terms of variables. The purpose is to make the writing more focused and not spread from the problem topic. The limitations of the writing problem are as follows:

This research will only cover PDAM water treatment installations that apply the Control Wave method. Water treatment installations with other methods will not be discussed. The focus of the research is on the use of automatic control systems based on Control Wave. Other control systems, such as SCADA or manual control, will not be analyzed in depth. The analysis will be carried out on a mini scale or pilot project, not on a full scale or the entire PDAM network. This is to facilitate initial testing and evaluation.

Research limitations include analysis of effectiveness, efficiency, and operational costs. Other aspects such as environmental, social, and legal regulatory impacts will not be the main focus. Data collection will be limited to a certain period set by the researcher. Historical data outside of that period will not be used in the analysis. This research will consider the limitations of available resources, such as budget, time, and access to Control Wave technology. These limitations can affect the results of the research and their interpretation. The influence and performance of human operators will be analyzed in the context of their interaction with the Control Wave system, but the training and skills aspects of operators will not be evaluated in detail.

This study will use data obtained from the Control Wave system and PDAM operational records. The validity and reliability of data outside these sources will not be further verified. The analysis will be based on the current environmental and infrastructure conditions. Significant changes in environmental conditions, such as natural disasters or policy changes, will not be considered in this study.

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Literature Review

Transmitter

A transmitter is a tool used to convert changes in sensing elements from a sensor into signals that can be translated by the controller. An electronic transmission system is a transmission using electrical signals to send signals. In general, the range used for this transmission is in the form of a voltage of 1-5 VDC or 0-10VDC and in the form of a current of 4-20mA. A transmitter is a device used to measure physical variables such as pressure, temperature, flow, and level, then convert this information into signals that can be forwarded to the control system for further processing. In the context of a water treatment system, the transmitter plays an important role in ensuring that the process runs efficiently and effectively. And the types of transmissions

1. Pressure Transmitter (Pressure Transmitter)
   Where Function: Measures pressure in the water treatment system, either in pipes, tanks, or other equipment. And Working Principle: Generally uses a pressure sensor that converts physical pressure into an electrical signal that can be read by the control system.
2. Temperature Transmitter (Temperature Transmitter)
   Where Function: Measures water temperature at various stages of processing. And Working Principle: Using a temperature sensor such as a thermocouple or RTD (Resistance Temperature Detector) to detect temperature changes and send the appropriate signal to the control system.
3. Flow Transmitter (Flow Transmitter)
   Where Function: Measures the flow rate of water in the treatment system. And Working Principle: Various technologies can be used, including turbines, electromagnetics, and ultrasonics, to measure flow and send data to the control system.
4. Level Transmitter (Level Transmitter)
   Where Function: Measures the level or height of water in a tank or treatment container. And Working Principle: Can use radar, ultrasonic, or hydrostatic pressure technology to detect fluid levels and send this information to the control system.

Role of Transmitters in Water Treatment Systems and Control Wave

Transmitters provide real-time data on the physical conditions within a water treatment system. This information allows operators to continuously monitor the process and take corrective action if necessary. Data from the transmitter is used by an automated control system, such as a PLC (Programmable Logic Controller), to regulate various aspects of water treatment, such as turning pumps on or off, regulating chemical flows, and maintaining optimal pressure and temperature and Reliability and Efficiency: The use of transmitters increases the reliability and efficiency of water treatment systems. By minimizing manual intervention and relying on accurate measurements, the risk of human error can be reduced, and the water treatment process becomes more consistent. And Transmitters help ensure that the treated water meets established quality standards. With close monitoring of critical variables, potential contamination or process failures can be detected early and prevented.

Control Wave is a control method that uses wave signals to control and monitor processes. This method can be used in automatic control systems to improve efficiency and reliability. Some important aspects of the Control Wave method include:

1. Continuous Monitoring: The ability to continuously monitor process parameters and detect changes in real-time.
2. Adaptive Control: The ability to adjust control actions based on detected process conditions, thereby maintaining process stability and quality.
3. System Integration: The ability to integrate with various sensors and actuators,

Ultrasonic Sensor

An ultrasonic sensor is a sensor that utilizes ultrasonic wave emissions. This ultrasonic sensor consists of an ultrasonic transmitter circuit called a transmitter and an ultrasonic receiver circuit called a receiver. The output of this sensor is a pulse whose width represents the distance. The pulse width varies from 115μs to 18.5 ms. The ultrasonic ping parallax sensor consists of a 40KHz signal generator chip, an ultrasonic speaker and an ultrasonic microphone. The ultrasonic speaker converts the 40 KHz signal into sound while the ultrasonic microphone functions to detect the reflection of the sound.

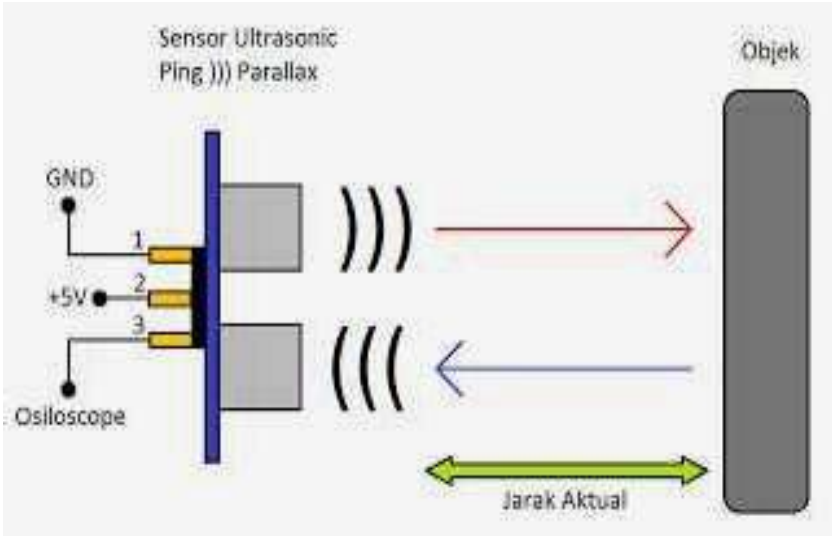

Figure 1. Illustration of how ultrasonic sensors work

DAC (Digital to Analog Converter) is an electronic circuit that functions to convert digital signals/data into analog signals. The system receives digital data as input signals and then converts them into analog voltages or currents. Digital data can be presented in various codes, the most commonly used being in the form of pure binary code or decimal code in binary form (Binary Code Decimal/ BCD).

ON/OFF Control System

In a two-position (on/off) control system, the actuation element only has two fixed positions. This on-off control is widely used in industry because it is cheap and simple. The control signal will remain in one state and will change to another state depending on the positive or negative error value.

u(t) = control signal e(t) = error signal u(t) = U1 , e(t) >0
= U2 , e(t)<0

Two-position controllers are commonly found in electrical components (relays) and pneumatic components (valves and cylinders). An illustration of an on-off controller is as follows:

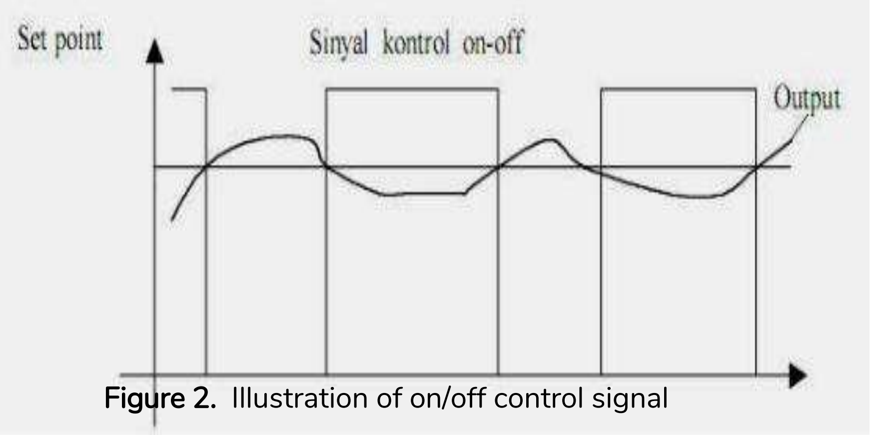

Figure 2. Illustration of on/off control signal

From the figure it can be observed that if the output is greater than the set point, the actuator will be off. The output will drop by itself until it touches the set point again. At that time, the control signal will return to on (actuator on) and return the output to its set point.

Terminal Block

A terminal block is a place where the electric current stops temporarily, which will be connected to another component or outgoing component. The function of this component includes connecting to other additional components (as a jumper), saving cable usage, protecting against shorts where they stop at the terminal and not damaging the outgoing component. In making electrical panels, terminal blocks are one of the main components because they have great benefits. Terminal blocks have great advantages in making electrical panels, because all the power that flows to the terminal block can be connected to other components to make the electrical panel work properly thanks to the terminal block. Terminal blocks also have the ability to control and regulate electrical circuits. After that we can use the terminal block to assemble circuit components and use the terminal block to create a circuit that can be connected from one electrical network to another. Inside the terminal there are incoming and outgoing. Incoming is the incoming current connector, while outgoing is the outgoing current connector.

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Figure 2. Terminal Block

Benefits of terminal blocks, namely:

1. As a connector / jumper if there are additional components.
2. Cable usage is not wasteful.
3. Safety if there is a troubleshort.
4. If there is a short circuit, the current is immediately cut off at the terminal before reaching the main component.

The support is made of hard material such as plastic. Or ceramics that electrically insulate adjacent blocks. Conductor paper is made of copper and other corrosion-resistant metals that are compatible with copper. Terminal blocks must be installed in a safe, stable and waterproof location. Designers have developed the following terminal blocks: Household, industrial, electronic and many other uses.

METHOD

The following is a block diagram of the design of a water level and pressure control system.

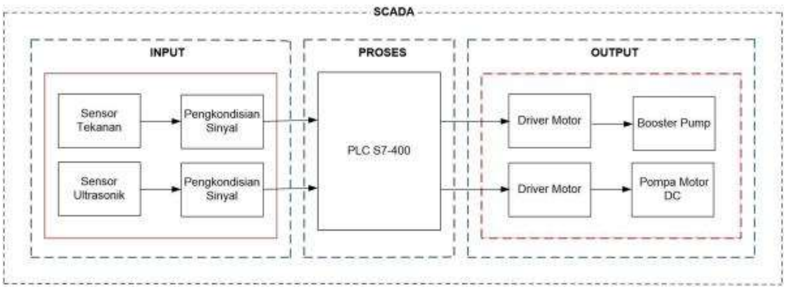

Figure 3. Block Diagram

From the block diagram above it can be explained as follows: The pressure sensor is a pressure transmitter and the height sensor is HC-SR04 as input to the PLC S7- 400 Because the S7-400 PLC input requires a voltage of 1-5VDC, a signal conditioner is used. This signal conditioner uses a program from the Arduino Uno, so that the output from the Arduino Uno will later enter the input of the PLC S7-400.PLC S7. This is the controller it contains.

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Figure 4. Diaphragm DC Pump Motor

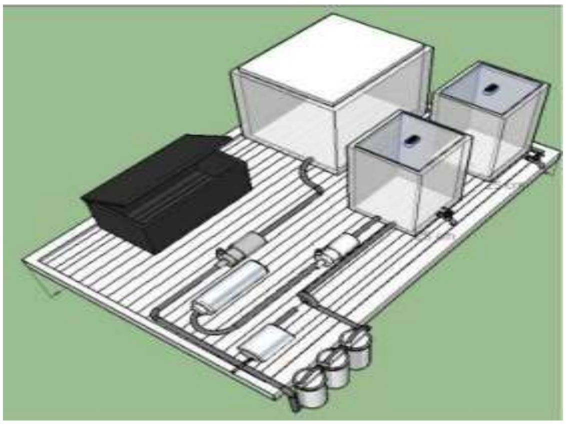

Figure 5. Dimensional Mechanical Design

Figure 6. Water level control design

In designing the mini plan there are several supporting components, namely tank 1, tank 2, tank 3, DC pump motor 1, DC pump motor 2, filters, reverse osmosis, pressure transmitter, HC-SR04, electrical box and hose. The tank height used in designing this water level control is 40cm with a maximum water height used of 36cm. So the HC-SR0$ ultrasonic sensor is used, because it measures water level by reflecting ultrasonic waves from the transmitter which will later be received by the receiver. The range of the HC-SR04 Ultrasonic sensor is around 2cm-400cm. Even though it already has an output of 5VDC, to be more optimal, a signal conditioner is still used so that the voltage output of the HC-SR04 ultrasonic sensor matches the input from the S7-400 PLC. The signal conditioner used is a program from the Arduino UNO, because the Arduino UNO output is in accordance with the S7-400 PLC input requirements. In its design, the HC-SR04 ultrasonic sensor will read water levels ranging from 2cm to 36cm. So when making a program on the Arduino UNO, when the sensor reads 2cm a 1VDC voltage signal will come out. Meanwhile, when the sensor reads 36cm, a 5VDC voltage signal will come out. If this has been fulfilled, then the output of the HC-SR04 ultrasonic sensor is in accordance with the requirements for the S7-400 PLC input.

The reverse osmosis process requires compressive power from a motor with large pressure. Before entering the membrane, the pressure of the water pressed by the pump needs to be known. So a pressure sensor is needed that has large pressure reading parameters. So when reading this water pressure sensor, use a pressure transmitter G1-1/4-12B-DC5V. This sensor is used because the reading of this sensor can read pressure up to 12 bar. Then, it is not easy to find a pressure sensor that can be used in salt water. The output voltage ranges from 0.5-4.5VDC, so a signal conditioner is needed to change the pressure transmitter's output voltage according to the input from the S7-400 PLC. In this pressure transmitter, the signal conditioner used is also a program from the Arduino UNO, because the output of the Arduino UNO is in accordance with the input requirements of the PLC S7 -400. In its design, this pressure transmitter will read water pressure ranging from 0Psi to 100Psi. So when creating a program on the Arduino UNO, when the sensor reads 0Psi a 1VDC voltage signal will come out. Meanwhile, when the sensor reads 100Psi, a 5VDC voltage signal will come out. If this has been fulfilled, then the HC-SR04 ultrasonic sensor output is in accordance with the requirements for the S7-400 PLC input.

RESULT

Testing and Analysis of the Water Level.

Sensor Testing the water level sensor is for find out that the signal output from the HC-SR04 sensor is in accordance with the input requirements of the S7 -400 PLC, namely producing an output signal in the form of a voltage of 1-5VDC. This test was carried out by measuring the output of the HC-SR04 sensor which had been given a signal conditioner, namely Arduino Uno, using a digital multimeter starting from 2 cm to 36 cm.

Table 1. HC-SR04 Sensor Test Results

Distance (cm)	Voltage Sensors (V)	Distance Monitors (cm)	*Error* (%)
3	1,241	1.26	1.82
6	1,559	1.58	1.45
9	1,769	1.79	1.28
12	2,196	2.22	1.04
15	2,514	2.54	0.91
18	2,831	2.85	0.81
21	3,055	3.08	0.75
24	3,372	3.40	0.68
27	3.69	3.71	0.62
30	4.12	4.14	0.56
33	4.44	4.46	0.52
36	4.49	4.49	0.51
Erroraverage		0.91	

From the results of the test table, these are the results from the HC-SR04 1 and 2 ultrasonic sensors, because they use the same sensor so they were only carried out on one of the sensors. These results are direct readings from the tank from 2cm to 36cm which are compared with the readings on the Arduino UNO serial monitor which acts as a signal conditioner. This test was carried out to see whether the voltage produced by the HC-SR04 ultrasonic sensor was in accordance with the input on the S7-400 PLC which requires a voltage range of 1-5 VDC. From this test, the largest error was 1.82% and with an average error of 0.91% so that the performance of the HC-SR04 ultrasonic sensor was not disturbed.

Testing and Analysis of the Water Pressure Sensor Testing.

This is the case with the water level sensor, namely to find out that the output from the pressure transmitter sensor is in accordance with the input on the S7 -400 PLC, namely producing an output signal in the form of a voltage of 1-5VDC. This test is carried out by measuring the output of the pressure transmitter sensor which has been given a signal conditioner, namely Arduino Uno digital multimeter. The parameters on the pressure transmitter sensor range from 0-100 psi.

Table 2. Pressure Transmitter Sensor Test Results

Voltage (V)	Pressure (Psi)	Voltage AVO(V)	*Error*(%)
1.00	0	1.04	3.85
1.20	3	1.24	3.23
1.40	14	1.45	3.45
1.60	20	1.67	4.19
1.80	24	1.84	2.17
2.00	31	2.08	3.85
2.20	39	2.26	2.65
2.40	44	2.46	2.44
2.60	42	2.66	2.26
2.80	32	2.86	2.10
3.00	58	3.06	1.96
3.20	43	3.26	1.84
3.40	51	3.46	1.73
3.60	56	3.63	0.83
3.80	63	3.83	0.78
4.00	78	4.03	0.74
4.20	65	4.23	0.71
4.40	77	4.48	1.79
4.60	85	4.64	0.86
4.80	93	4.89	1.84
5.00	100	-	-
Error Average			2.06

From the results of the pressure transmitter testing, it was carried out by providing an input voltage from the power supply to the DC 2 pump motor with the range as in the table above. Then read the sensor output that has entered the signal conditioner using a multimeter. This aims to see whether the pressure transmitter output is in accordance with the needs of the S7-400 PLC. Meanwhile, the pressure results read by the pressure transmitter are read via the display on the LCD. The comparison of the input voltage results with the voltage read by the multimeter is not too big. Although an error value was still

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found that reached 4.19% and the average error was 2.06%, so it did not interfere with the connection with the S7 -400 PLC. And its performance is still within the scope of what can be said to be good.

Testing and Analysis of PID Control at Water Level

This PID control test at water level uses a design based on the Ziegler-Nichols method with an "S" shaped response curve. In calculations using the Ziegler-Nichols method, the values obtained are Kp=6.4667, Ti=36.01 and Td 8.99. In the designer, a set point value of 50 is given. The following is the response curve with the Kp, Ti and Td values:

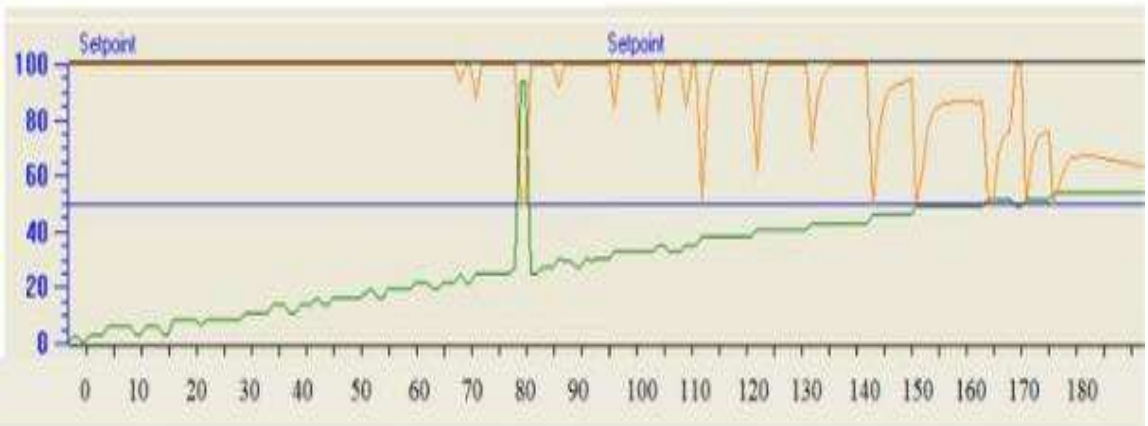

Figure 7. Response curve with Kp=6.4667, Ti=36.01, Td=8.99

From the results of the response curve above, it can be seen that the PID water level with values Kp=6.4667, Ki=36.01, Td=8.99 at setpoint 50 produces a delay time of 78 seconds, rise time of 79 seconds, settling time of 81 seconds and a steady state error of 4.03 %. For this reason, it is necessary to make several changes to the values of Kp, Ti, Td to get a better response. So a more suitable value is obtained, namely with the parameters Kp=6.4667, Ti=0, and Td=4.99. Following are the results of the response with changes in value:

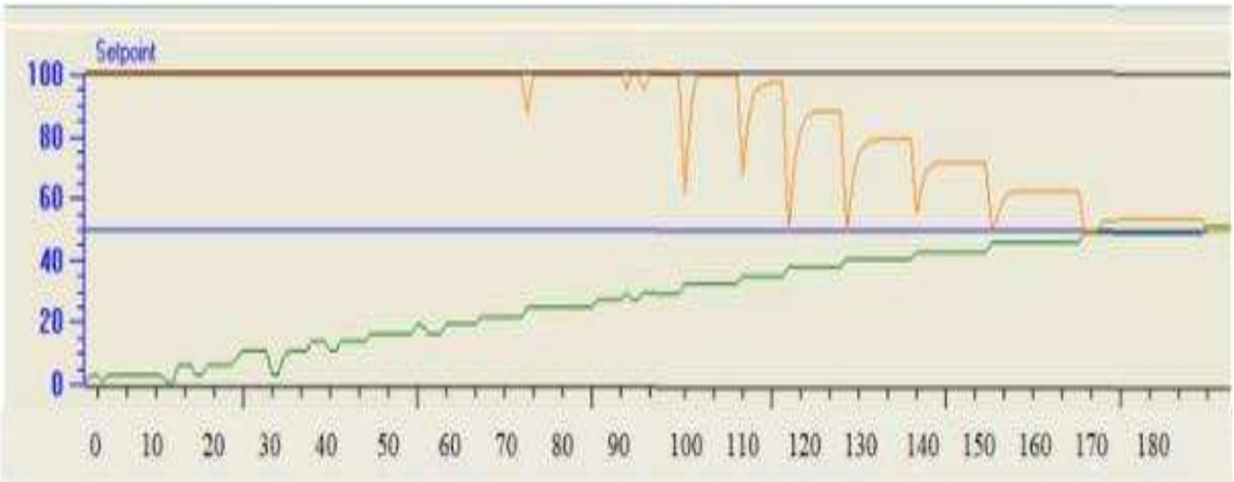

Figure 8. Response Curve with Kp=6.4667, Ti=0, Td=4.99

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The Kp value was left the same, namely 6.4667, because it was feared that it would increase overshoot if the value was increased. Meanwhile, the Ti value in the initial calculation was 36.01 and then changed to 0. This was done in order to reduce the steady state error and this was successful, initially the steady state error reached 4.03% and changed to 1.68%. However, this resulted in the settling time value increasing from 81 seconds to 190 seconds. Meanwhile, the Td value which was originally 8.99 was changed to 4.99, this was done to reduce overshoot and the second response curve was not that big.

Testing and Analysis of PID Control on Water Pressure

This PID control test on water pressure uses a design based on the Ziegler-Nichols method with an oscillating curve response. In calculations using the Ziegler-Nichols method, the values obtained are Kp=0.72, Ti=5.53 and Td 1.375. In the designer, a set point value of 40 is given. The following is the response curve with the Kp, Ti and Td values:

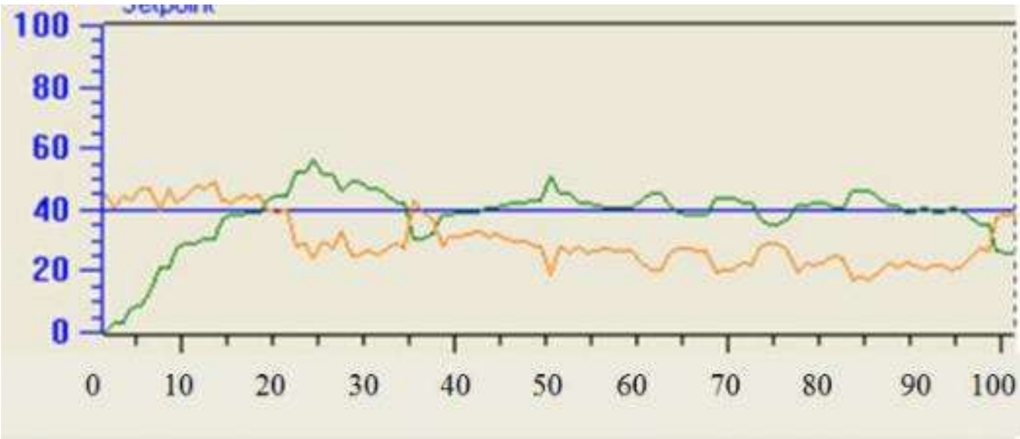

Figure 9. Response curve with Kp=0.72, Ti=5.53, Td=1.375

From the response curve above, it can be seen that the water pressure PID with values Kp=0.72, Ti=5.53, Td 1.375 at setpoint 40 produces a delay time of 8 seconds, a rise time of 14 seconds and a steady state error of 14.2%. For this reason, it is necessary to make several changes to the values of Kp, Ti, Td to get a better response. So we get more suitable values, namely Kp=3, Ti=0, and Td=1.6. Following are the results of the response with changes in value:

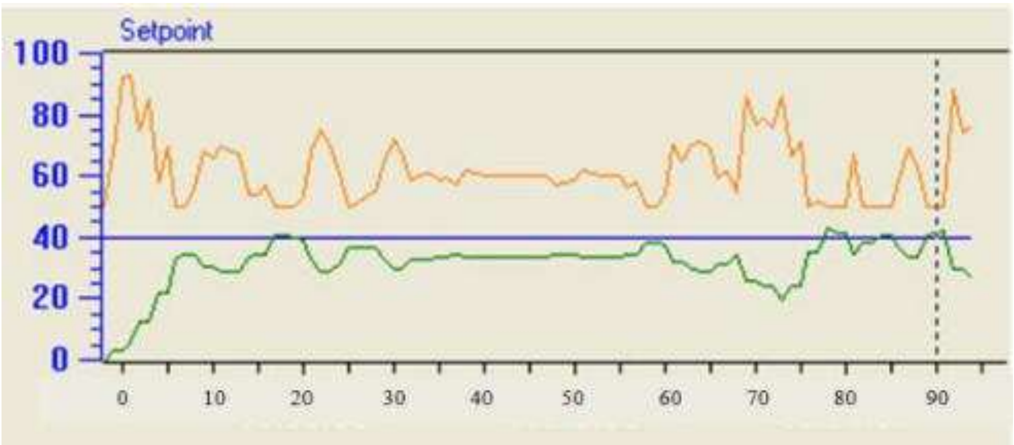

Figure 10. Response curve with Kp=3, Ti=0, Td=1.6

The Kp value, which was previously 0.72, was changed to 3. This was done so that the steady state error and rise time values decreased. The value of the steady state error has decreased, as has the rise time value which has also decreased. Meanwhile, the Ti value in the initial calculation was 5.53 and then changed to 0. This was done in order to reduce the steady state error and this was successful. Initially the steady state error reached 3.05% and changed to 1.03%. Meanwhile, the Td value which was initially 1.9 was changed to 1.6, this is done to reduce overshoot and the second response curve is not so large.

CONCLUSION

From the results of the explanation of the previous chapters and the tests and analyzes carried out using the Ziegler-Nichols PID method in the reverse osmosis process for controlling water level and water pressure, several conclusions can be drawn: *Mini plants*This uses control by a PLC S7-400 with SIMATIC MANAGER software, which uses the Ziegler-Nichols PID method. To create a SCADA system, the WinCC application is used. The water level sensor uses the HC-SR04 ultrasonic sensor. The water pressure sensor uses a pressure transmitter. The pump motor used is a diaphragm water pump motor. Reverse osmosis membrane with a capacity of 50 gpd which will reduce the salt content in sea water. In testing the output voltage used as the S7-400 PLC input from the HC-SR04 ultrasonic sensor produced a maximum error of 1.82% and the pressure transmitter produced a maximum error of 4.19%. Meanwhile, testing the driver and pump motor speed produced a maximum error of 1.23%. From the error results, it still provides good performance. The PID method for water level uses the Ziegler-Nichols curve "S" with a height range of 2-36cm which is given a set point value of 50. In the Ziegler-Nichols calculation, Kp = 6.4667, Ti = 36.01 and Td = 8.99. With these values, the performance response time is 78 seconds, rise time is 79 seconds, settling time is 81 seconds and steady state error is 4.03% and there are

REFERENCES

[1] A. Hasta dan R. Rulliyanto, “Penerapan Teknologi Komunikasi Nirkabel Berbasis Zigbee pada Sistem Pengendalian dan Monitoring Kelas,” *Jurnal Ilmiah GIGA*, jilid. 18, tidak. 2, hal.61–72, 2015.

[2] Alam, H., Lubis, Z., Adytia, B. S., Yuhendri, D., & Siregar, N. K. (2019). Rancang Bangun Alat Otomatis On/Off Ac Saat Mendeteksi Asap Menggunakan Sensor Asap Dan Notifikasi Alarm Berbasis Arduino. *JET (Journal of Electrical Technology)*, *4*(3), 172-177.

[3] Aryza, S., Lubis, Z., Indrawan, M. I., Efendi, S., & Sihombing, P. (2021). Analyzed New Design Data Driven Modelling of Piezoelectric Power Generating System. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, *4*(3), 5537-5547.

[4] M. Irsan, EB Stephen, dan A. Supriyono, "Perancangan dan Pembangunan Monitoring Ruang Server CCTV Menggunakan Raspberry Pi di Sekolah Pelita Harapan Lippo Village," *Jurnal SISKOM-KB (Sistem Komputer dan Kecerdasan Buatan)*, jilid. 2, tidak. 2, hlm. 23–29, 2019.

[5] DW DARA, M. AYU, dan KRTP Sari, "Sistem monitoring dan notifikasi kualitas udara terhadap karbon monoksida di ruang belajar berbasis IoT," *Jurnal Intensif*, jilid. 5, tidak. 1, hal.121–133, 2021.

[6] W. Dargie dan C. Poellabauer, *Dasar-dasar jaringan sensor nirkabel: teori dan praktik*. John Wiley & Putra, 2010.

[7] A. Guerrieri, G. Fortino, dan W. Russo, "Kerangka evaluasi untuk jaringan sensor nirkabel berorientasi bangunan," di *Simposium Internasional IEEE/ACM ke-14 tahun 2014 tentang Komputasi Cluster, Cloud dan Grid*, IEEE, 2014, hlm.670–679.

[8] Digi International, "Panduan Pengguna Modul Frekuensi Radio (RF) XBee®/XBee-PRO S2C DigiMesh® 2.4," 2022. Diakses: 10 Juni 2024. [Online]. Tersedia: https://www.digi.com/resources/documentation/digidocs/pdfs/90001506.pdf

[9] S. Bouckaert, E. De Poorter, P. De Mil, I. Moerman, dan P. Demeester, "Interkoneksi sensor nirkabel dan jaringan mesh nirkabel: Tantangan dan strategi," di *Konferensi Telekomunikasi Global IEEE GLOBECOM 2009-2009*, IEEE, 2009, hlm.1–7.

[10] Satria, B. (2022). IoT Monitoring Suhu dan Kelembaban Udara dengan Node MCU ESP8266. *sudo Jurnal Teknik Informatika*, *1*(3), 136-144.

[11] J. Riyanto, F. Nurlaila, H. Haerudin, dan BT Jarastino, "Perancangan dan Pembangunan Sistem Monitoring Kelas Berbasis Internet of Things di Universitas Pamulang," *Jurnal Informatika Universitas Pamulang*, jilid. 5, tidak. 4, hlm.483–489, 2021.

[12] T. Ghozali dan S. Mulyanti, "Jaringan Sensor Nirkabel untuk Memantau Suhu Ruangan Kelas,"*Jurnal Listrik*, jilid. 10, tidak. 2, hal.117–126, 2017.

[13] Tharo. Z dkk (2021), ANALISIS PERBANDINGAN KINERJA KWH METER PRABAYAR DAN PASCABAYAR. Prosiding Konferensi Nasional Social & Engineering Polmed (KONSEP), 2(1), 358-365.

[14] FZ Rachman, A. Armin, N. Yanti, dan Q. Hidayati, "Implementasi jaringan sensor nirkabel zigbee menggunakan topologi mesh untuk pemantauan dan pengendalian perangkat luar angkasa," *Jurnal Teknologi Informasi dan Ilmu Komputer*, jilid. 4, tidak. 3, hal. 201–206, 2017.