FINAL PROJECT – EE184701

Fuzzy Logic Controller Design with a Combination of Internet of Things (IoT) at Water Tank Level Control System

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Bachelor Program of Electrical Engineering
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TUGAS AKHIR – EE184701

Perancangan Fuzzy Logic Controller dengan Kombinasi Internet of Things (IoT) pada Water Tank Level Control System

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Surabaya

2022

VALIDITY SHEET

Fuzzy Logic Controller Design with a combination of Internet of Things (IoT) at Water Tank Level Control System

FINAL PROJECT

Submitted to fulfil one of the requirements

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Department of Electrical Engineering

Faculty of Intelligent Electrical and Information Technology

Sepuluh Nopember Institute of Technology

By : **Mochamad Rafif Firdiansyah**

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SURABAYA
December, 2022

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STATEMENT OF ORIGINALITY

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Hereby declare that the Final Project with the title " FUZZY LOGIC CONTROLLER DESIGN WITH A COMBINATION OF INTERNET OF THINGS (IOT) AT WATER TANK LEVEL CONTROL is the result of my work, is original, and is written by following the rules of scientific writing.
If in the future there is a discrepancy with this statement, then I am willing to accept sanctions following the applicable provisions at the Sepuluh Nopember Institute of Technology.

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ABSTRAK

Perancangan Fuzzy Logic Controller dengan Kombinasi Internet of Things(IoT) pada Water Tank Level Control System

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Mohamad Abdul Hady, ST., MT

Pada bidang industri banyak penerapan sistem kontrol level tangki air Namun masih banyak hal yang tidak dapat dikontrol dan dipantau dari jarak jauh. dan kinerja dari sistem kontrol level tangki air ini, tidak begitu baik pada bidang industri. Pada penelitian yang sebelumnya, hanya bisa monitoring saja, masi belum bisa dikendalikan dalam IoT tersebut. Dapat kita lihat bahwa sistem IoT juga telah berkembang pesat di era saat ini. Pengontrolan level air pada level tangki air juga jarang dikontrol melalui IoT. Sedangkan jika kita ketahui, salah satu fungsi dari IoT sendiri adalah untuk alternatif lain bagi kita di bidang industri jika kita ingin menyimpan data dan mengontrol suatu sistem dari jarak jauh. Dan ini bisa menghemat waktu juga, dan waktu respon yang diberikan bisa dibilang hampir tidak ada delay. Untuk mengatasi masalah ini, diperlukan bantuan Adam TCP 5000 pada plant aslinya dan menggunakan kontroler untuk mengontrol tangki air. dan ada beberapa software tambahan untuk mendukung hal tersebut yaitu dengan simulink dan juga python atau bahkan dalam tugas akhir ini menggunakan software matlab dan juga simulink di dalamnya. Penggunaan beberapa komponen tersebut menurut teori yang telah dipelajari dapat mendukung IoT pada sebuah plant tangki air. Dalam penelitian ini, hasil yang diharapkan dapat menjadi acuan bagi kehidupan kita dan industri untuk menggunakan kontrol dan mengamati tanaman dari jarak jauh. Dalam percobaan ini, menggunakan kontroler logika fuzzy. Untuk hasilnya sendiri, hasilnya bisa dibilang bagus, walaupun kita bisa menggunakan metode PID juga. Karena itu memiliki hasil yang stabil. Tetapi untuk proses internet nya sendiri sudah dapat berjalan dengan baik dan bisa memberikan input membership function didalam mqtt tersebut

Kata Kunci— Adam, Matlab, Water Tank,IoT

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ABSTRACT

Fuzzy Logic Controller Design with a Combination of Internet of Things (IoT) at WaterTank Level Control System

Student Name / NRP	**:**	**Mochamad Rafif Firdiansyah / 07111942000013**
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Abstract

In the industrial are, many application of water tank level control system But there are still many things that can't becontrolled and monitored remotely. and the performance from this water tank level control system, that's not to good for industry. From the previous research, there still just for monitoring but not for input internet processing. We can see that the IoT system has also developed greatlyin today's era. Controlling the water level at the water tank level is also rarely controlled throughIoT on the IoT platform. Meanwhile, if we know, one of the functions of IoT itself is for otheralternatives for our in the industrial sector if we want to store data and control a system remotely. And this can save time too, and the response time given can be said to have almost no delay. To solve this problem, you need the help of Adam TCP 5000 on the original plant and use a microcontroller to control the water tank. and there is some additional softwarefor support this, namely with simulink and also python or even in this simulation using Matlab software and also Simulink in it. The use of some of these components, according to the theorythat has been studied, can support IoT in a water tank plant. In this research, the expected resultscan be a reference for our lives and industry to use control and observe plants remotely.in this experiment, using fuzzy logic controller. For the result itself, the result can call good result, although we can be used method of PID also. Because that's have stable result. In the other side, for internet processing it self, there have been control remotely. and it can be work well, and also can input some membership function based on what we want inside of mqtt.

Keywords: : ***Adam, Matlab, Water Tank, IoT***.

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PREFACE

Praise and gratitude the authors pray to God Almighty because of His grace, the authors can complete research and final assignment with the title " **Fuzzy Logic Controller Design with a combination of Internet of Things (*IoT*) at Water Tank Level Control System** " well.

While completing this research and thesis, there were many obstacles and obstacles that the writer faced. However, many parties helped the author in solving these problems. With their support, the author can more easily complete this final report. So, the author would like to thank:

1. God Almighty, namely Allah SWT, always gives strength, health, smoothness, and ease for to servants.
2. The writer's family, especially my father, my mother, and my brothers who always provide material and non-material support.
3. Mr Eka Iskandar, S.T., M.T. and Mohamad Abdul Hady, ST., MT. as supervising lecturers I and II who have provided a lot of knowledge, advice, and motivation in completing this final project.
4. Then to all the electrical engineering lecturers whom I cannot mention one by one who has taught many things during this course and the staff of the electrical engineering department so that I feel a lot of the convenience and benefits of studying at the electrical engineering department.
5. The big family of the Automation and Control Laboratory Assistant and the System and Cybernetics Laboratory Assistant who always support, accompany and assist the author in completing this final report.
6. My friends, especially Faris Zuhairi, Aqil Nur Hadi, Hamzah Nur Azzam, and Said Rafif Ramadhan who always provide support and motivation.
7. All parties that cannot be written down one by one who has helped in completing this thesis.

In completing this thesis, the author realizes that the results that have been done are still not perfect and there are many things that must be improved. So suggestions, criticisms, and input from all parties can help the writer to develop this research further.

Surabaya,19 Desember 2022

Penulis

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1. CHAPTER 1 INTRODUCTION

1.1 Background

In this developed era, automation in the industry has developed in many ways. And we also really feel when automation helps our daily lives. One example is automation in the industry. Many of them use automation to help humans to easier work in some side. In fact, there are lots of examples that we can take around us for automation, because it can make it easier for us in many ways.

For the purpose itself can help industry area. Because in this case, it is much easier for us in the industry side. not only monitoring, but there are several examples in IoT that can be monitored remotely. We can control the plant remotely, wherever it is, it can be monitored remotely via our smartphone. [1]

Indeed, currently quite a lot of people use the internet of things system in their industry area. Because that we know if some of area in the industry isn't safe for all of human. Maybe that was caused by chemical contamination and the water tank is one of the most important that industry uses very oftenin in some condition. That's not just because of chemical industry, maybe it can be caused, the accessed goes to that water tank, isn't friendly. Maybe at high position or somewhere who were hard for come inside. So it can be very helpful for this part.

There are still many in the industry area, some irregularities in the use of the water tank level. There is still the occurrence of forgetting to close the control level, causing the level of tank to leak. Although this final project is focused on the industrial zone, it can be developed again with another method also. Even though, some components can be different than we used in this part. But it can be represented how industrial works.

For support this final thesis, can be realized we need some component. It can be some different with real component we used in real industry, but this is one of the closer components we used for this real plant in the industry. And we can be understood the condition of every single part we used. From the condition of controller. Because this is one of the most component, we need to run this process. We had been known, there have a lot of type for controller. So for standard controller in the industry, it can be used ADAM. For ADAM itself, there have several types. In this part we can use ADAM TCP-5000. The reason of using this controller because that's good enough for run our plant. Because in this final thesis, we used PCT-100.

1.2 Problem Formulation

In the industrial area, there is still not a massive controlling system that can be driven by *IoT*. Meanwhile, we know that the *IoT* field has developed very rapidly in this advanced era. This is also very easy for humans if they want to control remotely. It can also help to streamline the available time and maintain a database on a system. Even though we know if the condition of *IoT* right now, have several noises and delay.it caused by the connection wireless normally have some caused like that. Sometimes the condition of internet, can be unstable in occasionally.

1.3 Problem Limitation

There are several variables used in this system. One of them is reducing the delay because there are still several things that can cause it to happen. And, within the scope of this problem, only perfecting existing methods from past research. As well as maintaining all existing

databases in a system so as not to leak anywhere.

1.4 Purpose

In this study, we will discuss a system that can detect input and output. obstacles in the development of the times such as the use of *IoT* in microcontroller tools are still not too massive. Therefore, more *IoT* systems are needed in this case to make it easier for existing engineers and to minimize delays in the micro controller device due to certain causes because it uses the wireless system. And, how to show the result of the water tank in an MQTT and can be control also used our phone.

1.5 Benefits

The benefits that this research can take are as follows:

1. Get settings from modeling water tank level in process control trainer.
2. Knowing the process of using the water tank level.
3. Get simulations and programs from the system settings on the water tank level
4. Connect with IoT.

CHAPTER 2 LITERATURE REVIEW

2.1 Previous Research Results

In previous research, it hasn't been done for IoT system. But that makes the difference is in this part using internet based on control system So it means, from previous research, it can be make using thingspeak. But in this one, I will be using another internet protocol that's MQTT and it can make more easier and also human friendly. And also, you can control input membership from your phone.

2.2 Basic Theory

2.2.1 P&ID Water Tank

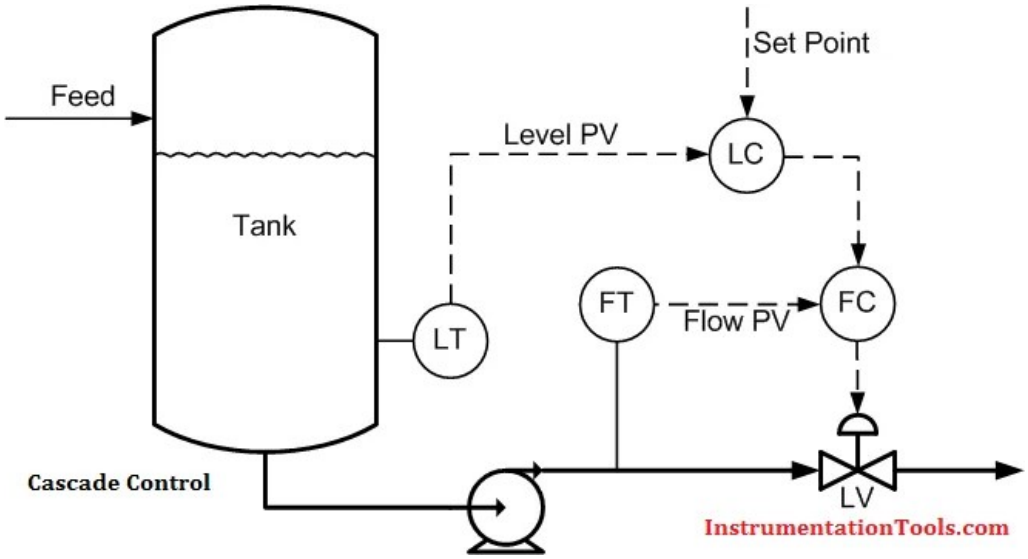

Figure 2.1 P&ID Process Control Trainer

From there we can understand if there are some parts used in this plant. First, wecan know the condition of the tank. When the storage of tank is not in the same conditionin picture above, so the condition will be follows. It means, if the position of water storage is below of set point, the level control will be open and give an instruction of pump to be pumping the water into water storage tank. Until reach a sensor in level controller, it will be stop and this condition will be running cycle. the value of setpoint itself, based on our needed and the position you located in the tank. Some sensors are used in this part like position sensor. thefunction of this part is for know when the exactly position of the water inside the tank. And it can give signal into pump and valve.[6]

2.2.1 Flow Chart of System

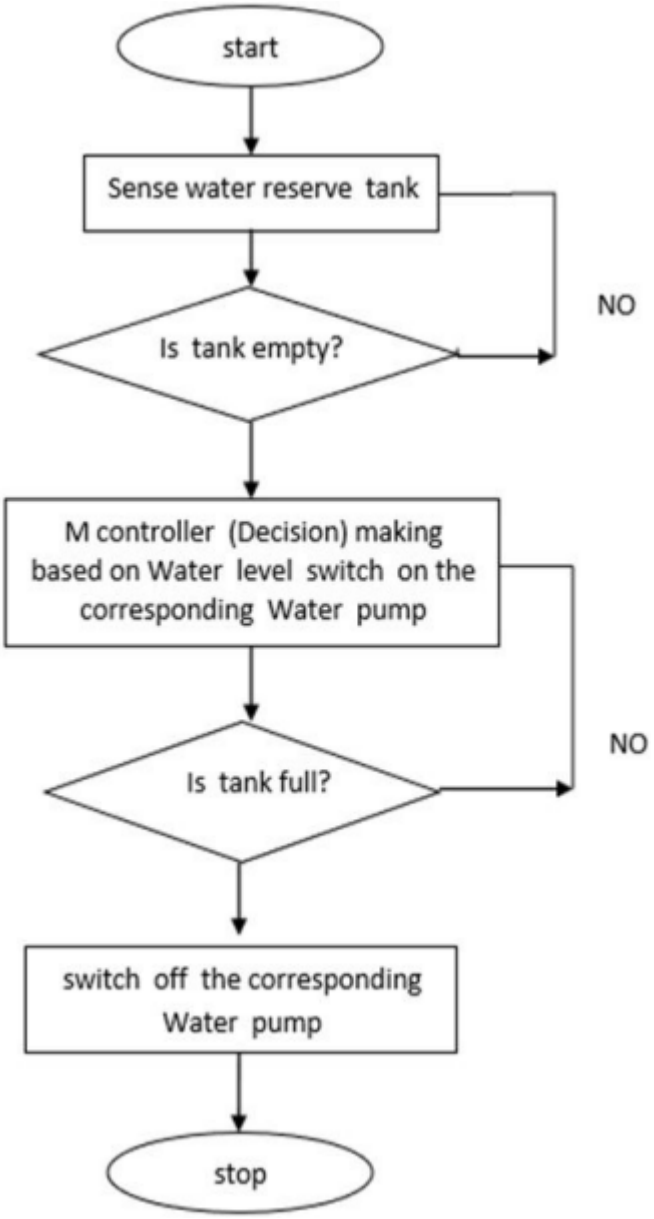

Figure 2.2 Flow Chart of System

shows a block diagram of the system. In the picture above discusses the system between water tank level and some sensor and then it will be connected in IoT using IoT-enabled MQTT protocol to carry out monitoring and analog input voltage remotely with the hope of seamless communication pause (no delay). And then we can be known if in this block diagram, we can be more understand how many sensors we used in this part and make sure all that things is work well. [4]

2.2.2 Water Tank

Figure 2.3 Water Tank Level

For the water tank level itself, the definition of A water garage tank is a field for garage of water for home and business uses. Water garage tanks are to be had in lots of shapes and sizes. They may be vertical, horizontal, underground and potable, and may be crafted from plastic, steel, fiberglass, stone, or concrete. Water tank leakage and corrosion in addition to bacterial boom are threats to the tank. It can be used for some purpose. It means, that's like in industrial and also another purpose for our home [15]

2.2.3 Process Control Trainer (PCT-100)

2.4 Figure of Process Control Trainer 100

The PCT-100, Process Control Trainer, is a fully integrated, self-contained benchtop apparatus consisting of a Process Module, and a Control Console with a built-in power supply. Windows-based software with full control and data acquisition is included. A few experiments in process control are included covering Flow, Level, Pressure, Temperature.

The PCT-100 control console is easily connected to a PC using the USB connection or to a PLC using D type connectors. The console has a mimic of the process module on the front and includes fault switches, and test points from all the transducers. Level is measured using a 0 to10v Magneto strictive sensor; pressure is measured using a Gage 0 to 5bar sensor and Flow using A turbine flow rate sensor. PT1000 are used to measure temperature in both the sump and process tank. A diverter valve can be used to direct the liquid through a forced air-cooling process to cool the liquid in the system. Two proportional valves are used to control flow into and out of the process tank, a manually adjustable needle valve is used to add disturbances to the system and a pressure relief valve fitted for safety.

2.2.3.1 Model of Tank in PCT-100

The main component inside of this model of tank is the valve control itself. And wecan assume it as an capacitor because they have similar systems. When the condition of filling the tank like an fill something then the process of give output like an discharge of an capacitor. And also we can get the tank area using equation 2.1 [5]

$$C = \frac{Changge\ ooo\ Water\ Volume}{Changge\ on\ Water\ Level}$$

$$C = \pi d Tank\ cross - sectional\ area = \frac{\pi d^2}{4} = A \qquad (2.1)$$

When we want to modeling the tank, it will be start from mass balance law. So we can looking like equation below, where the position of water debit in side will be have an error with the water coming inside. So it will be have symbol of Q. the value will be like equation 2.2

$$Q_{in} - Q_{out} = Q \qquad (2.2)$$

And then we can make an connection between an debit and also water tank inside of tank like equation 2.3

$$Q = Av = A\frac{dh}{dt}$$

The next one we can

$$Q_{in}(s)R - H(s) = RCsH(s) \qquad (2.3)$$

$$Q_{in}(s)R = H(s)(1 + RCs) \qquad (2.4)$$

$$\frac{H(s)}{Q_{in}(s)} = \frac{R}{RCs + 1} \qquad (2.5$$

So this is for parameter plant model

Table 2.1 Table of Plant Model

Symbol	Definition	Unit
Qin	Discharge of incoming water tank	*cm3 / s*
Qout	Discharge of water coming out of the tank	*cm3 / s*
Q	Water discharge in the tank	*cm3 / s*
H	Water level in tank	*cm*
A	Tank floor area	*cm2*
a	Pipe diameter	*cm*
H	The current water level at the operating point	*cm*
Q0	Current outflow rate conditions at the operating point	*cm3 / s*
R	Resistance control valve	*s / cm2*
C	Tank capacitance	*cm2*
L	Long pipe	*cm*
θ	Delay time	Second

2.2.2 IoT System (MQTT)

Figure 2.5 IoT Application

The Internet of Things (IoT) is a system of ‘connected things’. The things generally comprise of an embedded operating system and an ability to communicate with the internet or with the neighboring things. One of the key elements of a generic IoT system that bridges the various ‘things’ is an IoT service. An interesting implication from the ‘things’ comprising the IoT systems is that the things by themselves cannot do anything. At a bare minimum, they should have an ability to connect to other ‘things’. But the real power of IoT is harnessed when the things connect to a ‘service’ either directly or via other ‘things’. In such systems, the service plays the role of an invisible manager by providing capabilities ranging from simple data collection and monitoring to complex data analytics.[12]

Furthermore, the protocol functions on a server-client system where the server, called a broker, pushes updates to MQTT clients. The clients won’t send messages directly to each other, instead relying on the broker for this. Every MQTT message contains a topic, organized in a tree-like structure, to which the clients can subscribe or publish. The broker receives published messages from clients that contain a certain value or command and relays the information to every client that has subscribed to that specific topic. As can be seen, the MQTT protocol was designed for asynchronous communication, where subscriptions or publishing to or from different entities take place in a parallel order. The protocol is also able to provide reliable transfers by choosing between three types of reliability mechanism, also called Quality of Service (QoS).[14]

When compared to other protocols like HTTP, the MQTT protocol has a considerably smaller footprint, making MQTT, as stated above, much more suitable for resource-constrained environments. Although the MQTT protocol has many advantages, not every MQTT-based broker has similar or comparable abilities for entity authentication or encryption. Eclipse’s open-source application, called Mosquitto, is able to provide most of standardized features of the MQTT protocol, such as SSL/TLS and client certificate support. The Mosquitto broker, by default, does not provide security for its messaging scheme and authentication information is

sent in plaintext; therefore, it requires security mechanisms to protect the transferred information.

MQTT features different security mechanisms, but most of them are not configured or provided by default, such as data encryption or entity authentication. Authentication mechanisms, such as using the physical address of the device (MAC), exist and are controlled by the broker by registering a device's information once it tries to connect. Access authorization can be done by the broker using a mechanism called an Access Control List (ACL). The ACL, as the name implies, contains records of information such as the identifiers and passwords of the different clients that are allowed to access different objects and can also specify what functions the client can perform on these.

2.2.3 Fuzzy Logic Controller

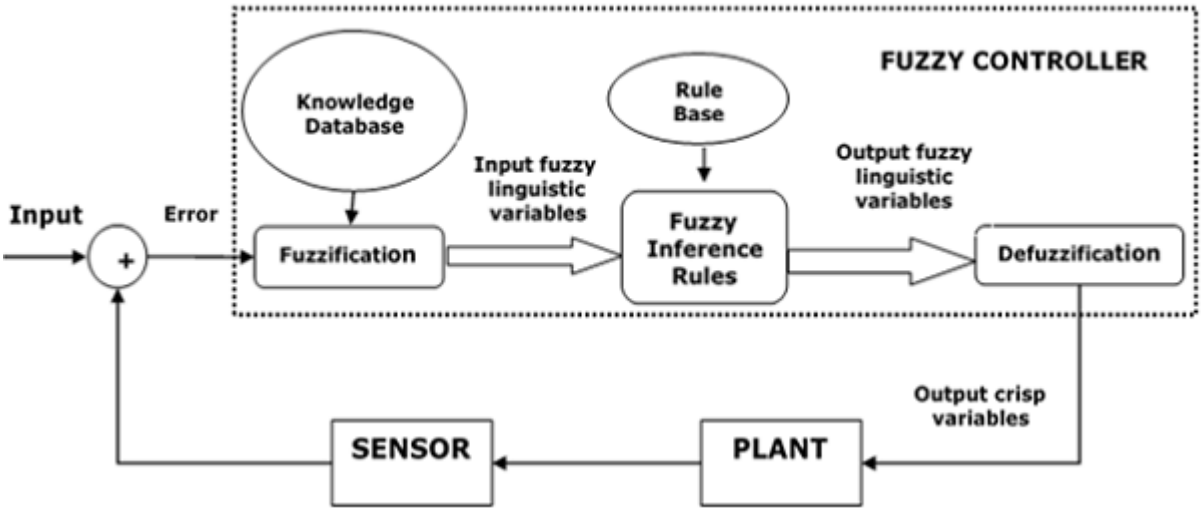

Figure 2.6 Fuzzy Logic Controller

Fuzzy logic, which is the logic on which fuzzy control is based, is much closer in spirit to human thinking and natural language than the traditional logical systems. Basically, it provides an effective means of capturing the approximate, inexact nature of the real world. Viewed in this perspective, the essential part of the fuzzy logic controller (FLC) is a set of linguistic control rules related by the dual concepts of fuzzy implication and the compositional rule of inference. In essence, then, the FLC provides an algorithm which can convert the linguistic control strategy based on expert knowledge into an automatic control strategy. Experience shows that the FLC yields results superior to those obtained by conventional control algorithms. In particular, the methodology of the FLC appears very useful when the processes are too complex for analysis by conventional quantitative techniques or when the available sources of information are interpreted qualitatively, inexactly, or uncertainly. Thus, fuzzy logic control may be viewed as a step toward a rapprochement between conventional precise mathematical control and human-like decision making, as indicated by Gupta.

Before we start the implementation in this final task, we can understand the condition of the plant. There are some reasons why we choose this method. That can be caused, while we should be known the model and also the objective function formulated in precise term. By applying fuzzy sense for control, we can use mortal moxie and experience for designing a regulator. The fuzzy control rules, principally the IF- also rules, can be stylish employed in designing a regulator.

While designing fuzzy control system, the following six introductory hypotheticals should be made The factory is observable and controllable − It must be assumed that the input, affair as well as state variables are available for observation and controlling purpose. Actuality of a knowledge body − It must be assumed that there live a knowledge body having verbal rules and a set of input- affair data set from which rules can be uprooted. Actuality of result − It must be assumed that there exists a result. 'Good enough' result is enough − The control engineering must look for ' good enough ' result rather than an optimum bone . Range of perfection − Fuzzy sense regulator must be designed within an respectable range of perfection. Issues regarding stability and optimality − The issues of stability and optimality must be open in designing Fuzzy sense regulator rather than addressed explicitly.

2.2.4 Adam TCP-5000

Figure 2.6 ADAM TCP-

We also known the function of Adam TCP-5000 is for controller the plant based on what we want. So, in this my final project for undergraduate program, I use this this controller to control water tank level actually is process control trainer in control system laboratory. The type I used is PCT-100. Some of the function use Adam TCP-5000 and also for the table 2.1 we can look the table specification of Adam TCP 5000, there's have from input output, until communication repeater distance based on official website from adam company [13]

Table 2.2 Table Specification of ADAM TCP 5000

Spesification ADAM TCP-5000	
Input I/O	8 I/O Slots for Up to 128 Points Data Monitoring and Control
Communication Protocol	Supports Modbus/TCP for Easy Integration
Ethernet Communication	1500 VDC isolation for Ethernet Communication
Software	AdamApax.net
Communication Port	10/100Base-T Auto-negotiation High-speed Communication Port
Architecture ARM (Architecture processor)	ARM 32-bit RISC CPU
Communication Repeater Distance	100 Meters

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2. CHAPTER 3 SYSTEM DESIGN

3.1 Method used.

In this final project, can using fuzzy logic controller method. The reason I chose this method is because it makes it easier and also efficient for this final project. But another method we use in this final project is to analyze the condition of water tank level and the final data when the sensor can run well.

3.2 Materials and equipment used.

Materials and equipment in this study will be used in the form of software. The required software includes:

1. Laptop. with minimum specification in intel five
2. Adam TCP 5000
3. PCT-100
4. MQTT.
5. Python

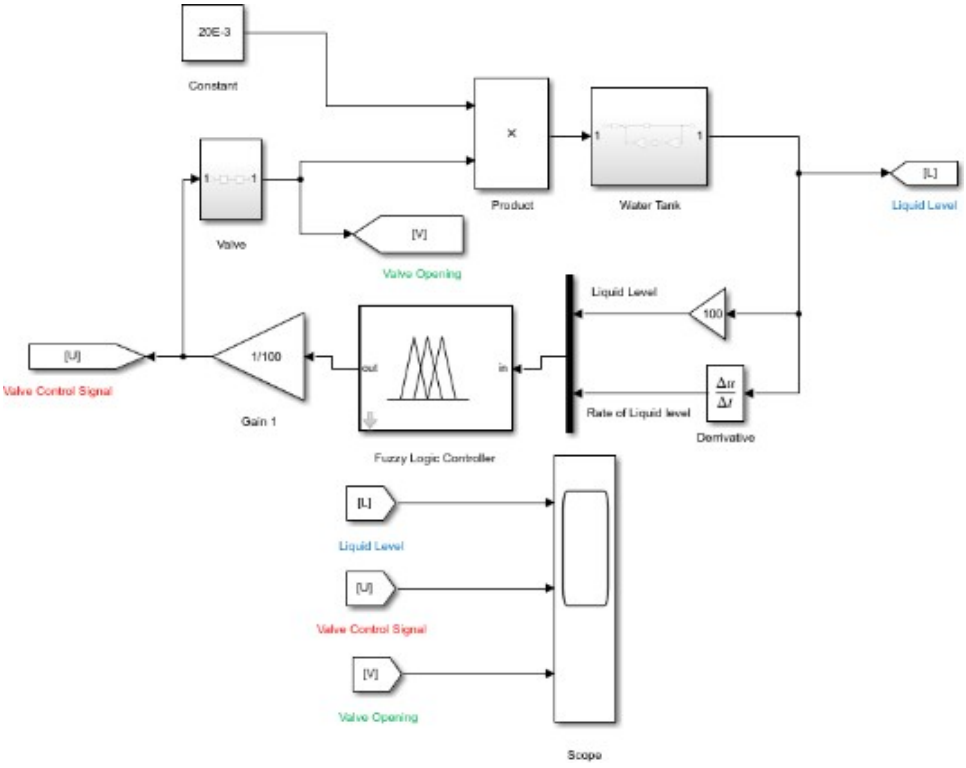
3.3 Order of research implementation

Meanwhile, in conducting this final project research will be carried out in several stages. Among them,

1. Literature Study

   In this literature study, you can learn various things related to Adam TCP 5000 and also connect the plant, the plant and the *IoT* system that will be used. This can be learned through various sources such as articles, journals, and others.
2. System Design

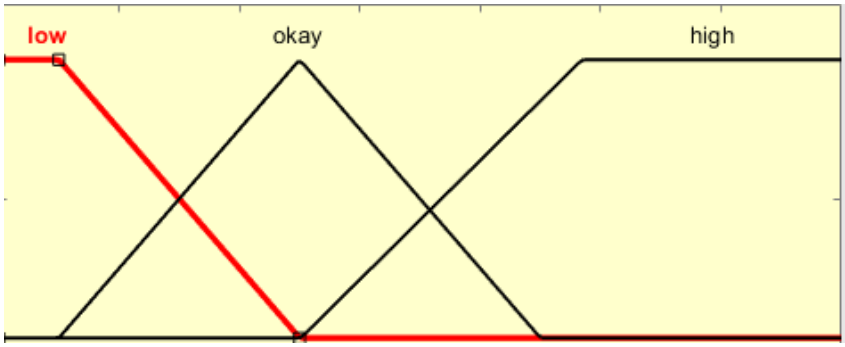
   For the design of the system itself, starting from simulation to real application in the field. Begin to understand the whole process from input to output. After making a flow chart on the system run, the next part we should understood how the system runs in the mqtt apps for giving input set point and monitoring by far distance. The next one is we should know how to connect between Adam TCP into the *IoT*.



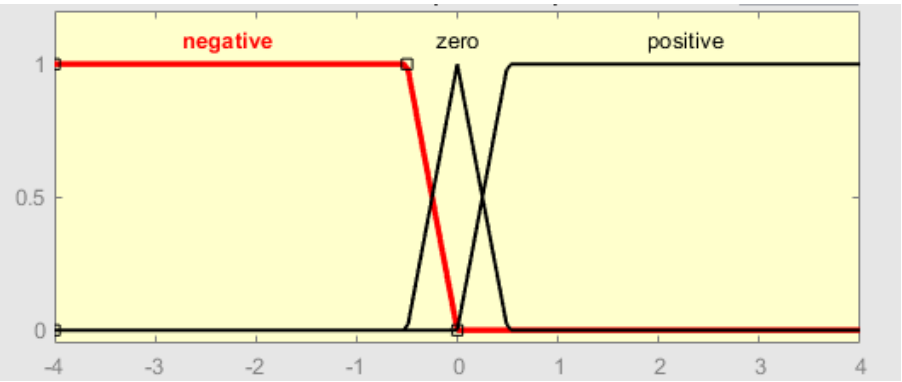
3.1 Block Diagram from this System

From this system above, we can look how fuzzy logic controller will be work. And the result will be shown in scope also. When we want to connect to the plant, it can be used as an reference for wiring also.

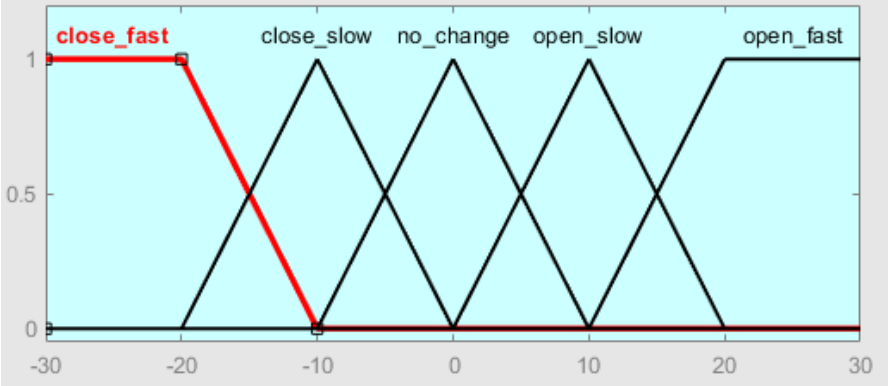
And we know that this fuzzy logic controller needed membership function to run and make a logic for what we think. And the picture below is membership function for this water tank.



3.2 membership function for level



3.3 membership function input rating



3.4 membership function for valve

And for the rule based will be like that

Table 4.1 Rule Based Fuzzy

	Low	Okay	High
Negative	OF	OS	CF
Zero	OF	NC	CF
Positive	OF	CS	CF

The meaning of OS is Open slow, next one for OF is open fast and CF is Close fast and then for CS is Close Slow and next one for NC itself is no change.

3. System Testing and Evaluation

For this stage, a simulation will be carried out according to what has been studied previously. In the early stages, we can test the data that has been obtained from the plant to the micro controller first. And then it will be sent to the cloud. But before that, Adam TCP 5000 is needed to control I/O on the simulator first. After that, the results can be monitored on MQTT Application on our phone.

4. Preparation of Final Project Report

The results of this research will be compiled in the form of a book. The contents of the book cover the research process from beginning to end.

CHAPTER 4
RESEARCH RESULTS AND DISCUSSION

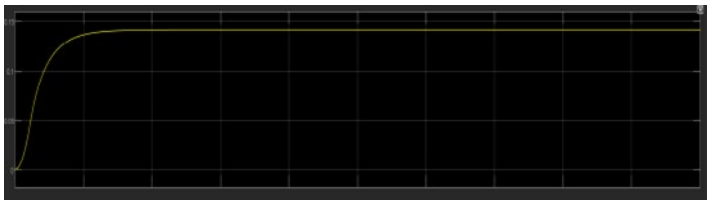
4.1 Research Result

For the first one we can know how to model system in this plant, it can be used.

$$\frac{H\ (S)total}{\text{ꕥ}n\ total} = \frac{1.753e^{-4.23s}}{109.921s + 1}$$

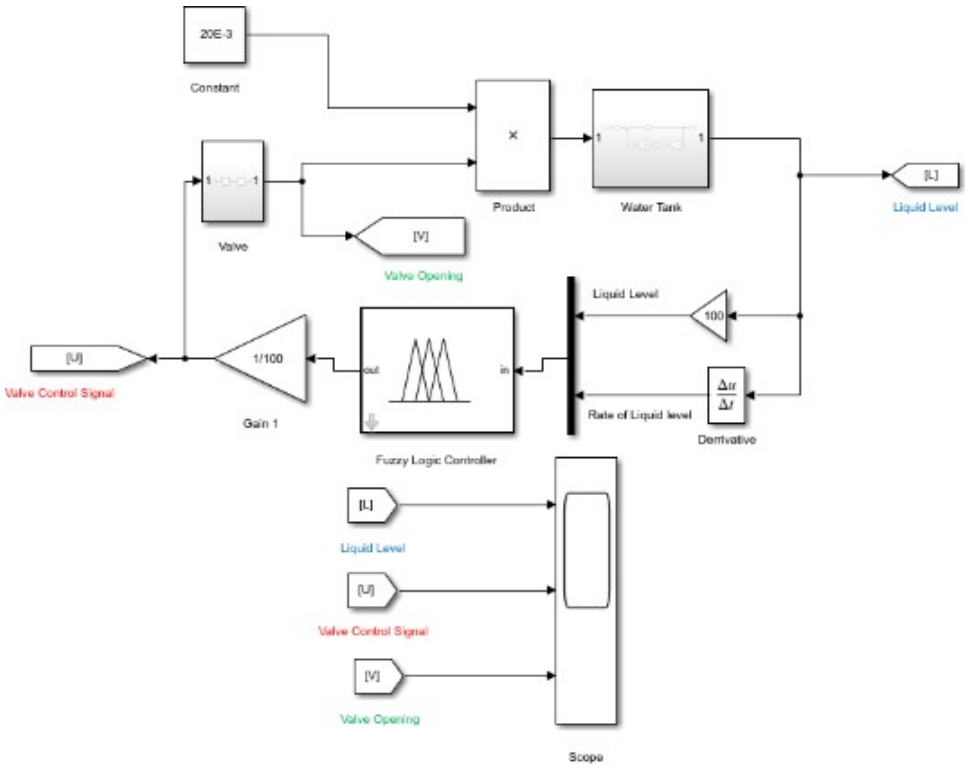
And then we can get the simulation and also implementation in real plant, inside our laboratory is PCT-100

So, from this one we can looking the result in this simulation using Simulink on matlab. So, the picture 4.1 , there have an picture shown from every single level,



4.1 experimental results at the level

4.2 Wiring



4.2 Diagram Block for water tank level

In this Simulink we can be known some part using in this simulation until the result can be shown on scope also. It can be added again if the result will have another overshot. Example is we can add some component like disturbance or something else.And from some journal I read said, it can be giving better result if we want to more experience again in this simulation

4.2 Result of Open Loop System in Implementation

And the chart below explains the relation between an ten volt from the flow and also the level output from open loop system.

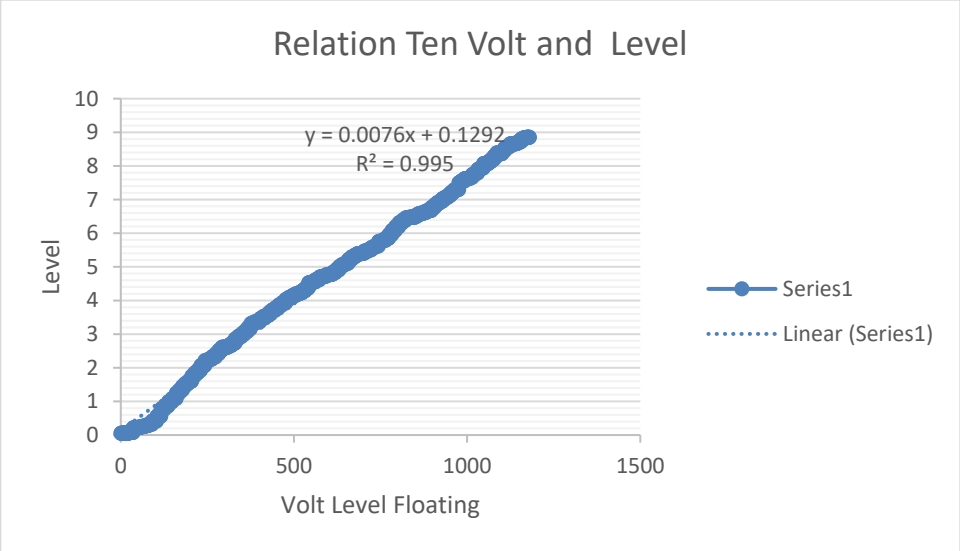


Figure 4.3 Diagram of Open Loop System in PCT-100

From the data Above we can look some value from variable in PCT-100 in laboratory also. So, from the first one we can get the data of valve voltage and also level. The voltage in this plant can be sent more than value show above, but in this plant just show until eight point eight. It can be caused, when we sent input more than that value it can be not good result and that caused the flow in this plant can be sent just two point seven liters per minute. So, when voltage gives more than that value, it can't send a good voltage.

The next one we can fine the value of y by using linear regression using this method:

$$y = mx + c$$

then we should be finding the value of m and also c

$$m = 1.7055517310856645$$

$$c = 4.80943785889385$$

So, the next one is when the condition in close loop system. In this part, after some trial and error, we can get the condition if the result is linear. Because when we get the result above, we set the set point in ten centimeters but the result still goes infinite until the value is goes to infinite. Thisis have several reason why this part still can't stop, maybe it can still be wrong in membership function.

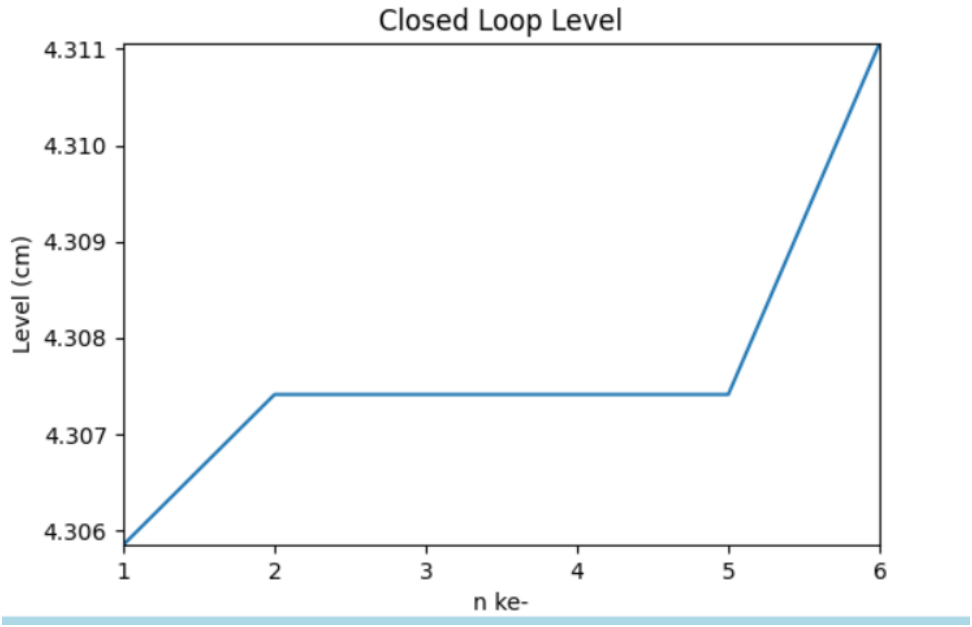


Figure 4.4 value of Close Loop System in PCT-100

There are several different values when the condition with disturbance or without disturbance. When this is with disturbance, the raise time will be more small value, but when without disturbance, the condition will be having big value. Because we can looking from implementation, when we give an disturbance, it will be goes faster than the others.in this part, I set the settling time 0.05

And actually there are several reasons why this goes to infinite, it can be caused the condition of the plant can't control for this method. Because when we use another method in PID Control, it can be running well. And it can be caused the condition of membership function is not so good, so the condition will be not so smooth. When in this part using manual tunning for fuzzy, this is needed long time to find the value with steady state. And when we look the result of another method, that have stable result also with more easier for implementation.

Input MQTT

From the picture below, we can see the result from the internet processing. Because when we give the setpoint like below, the result will be like that. And from the recommendation in final defense, I got some points for internet processing itself. Because in this part, I give some addition. From the first one is, I just give input set point, for right now I can input membership output itself. Like the first one we can set the value of Close slow, Close fast, Open Fast, and also Open slow itself. It can be represented by the processing from this method itself.

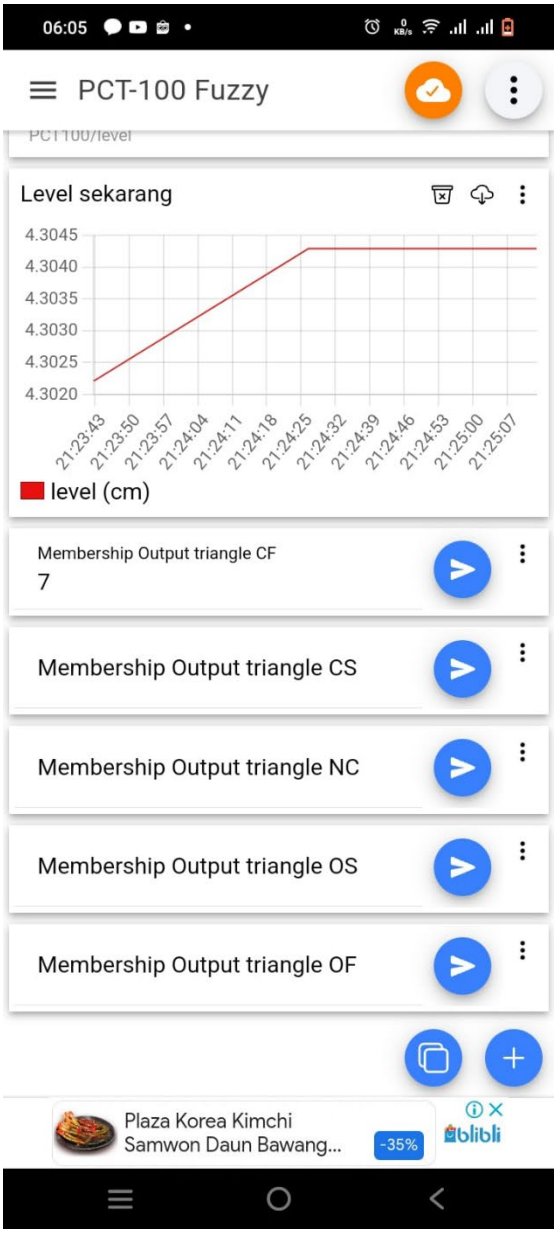


Figure 4.5 MQTT interface in Phone

In figure 4.7, shows the interface in our device using MQTT application. And when you want to input another value of membership function, it can be shown like figure 4.7. There are several inputs like Set point of level value and some value of membership. And for the next one I give another input for

membership function like figure 4.6. so, we can look from figure 4.6. and result will be like figure 4.6

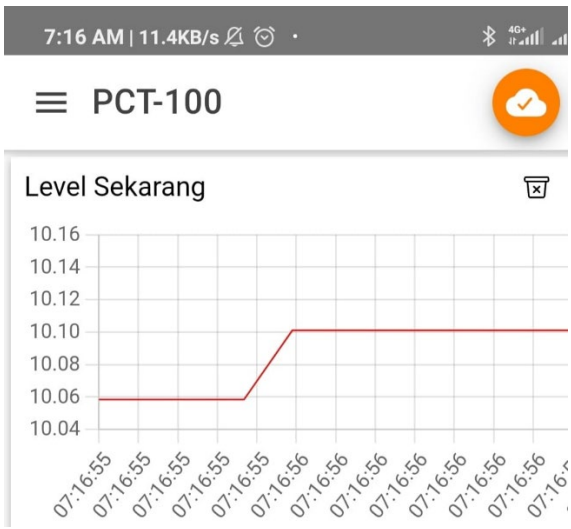


Figure 4.6 MQTT interface in Phone with different input membership

We can be looking the result when the graph in figure 4.6, this condition can be looking when we give set point in ten centimeters and the value of membership function I was set in high value, the result will be like graph that figure. Because we can understand, if the value of membership function is changed, it can have an effect in our value and there will be like that. actually for the picture in the user interface inside our phone, will be always like figure 4.6 and 4.5. that because every single seven seconds, there will be update the data inside our phone.

CHAPTER 5
CONCLUSIONS AND RECCOMENTADIONS

5.1 Conclusions

The research for this final project can contain some conclusions and we can be looking from another last research also with another method how will be the result also. And then how's the result from this method in this plant also. Because every plant has their own mathematical model and different results too.

So, from this final project, the result is the simulation using Simulink like the picture above have result with small overshoot using this membership like picture above and also block diagram above. And, from this experiment with method in implementation, we can know if the condition can be running well with this code inside. but maybe it can be caused of this plant had their own fuzzification and membership. But this is still linear, and I alwaystrain with new membership function but still show like the figure in chapter four. When we look at the result of this experiment, the PID controller has a better result than fuzzy logic controller. It can have several reasons, because every single plant have its own way to give an method.

5.2 Recommendations

For the next experiment, you can change another plant and it can be given a disturbance to make a better result and give another effect into the result. For the implementation, maybe it can be changed to an plant. Because there are several components in pump can't be controlled that caused of condition of that plant not so good enough for right now. And maybe it can give for IoT system. You can change the output, or you can give additional input for turning on and also turn off. So, you don't need to turn on your computer to turn on this part.

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[16]

APPENDIX

Code for Close Loop System

```
import tkinter as tk
import matplotlib.pyplot as plt
from matplotlib.backends.backend_tkagg import FigureCanvasTkAgg
import time
import csv
from pyModbusTCP.client import ModbusClient
import random
from skfuzzy import gaussmf, trimf
import numpy as np
from paho.mqtt import client as mqtt_client

broker = 'test.mosquitto.org'
port = 1883

c = ModbusClient(host="10.0.0.1", port=502, auto_open=True,
auto_close=True)

header = ['n', 'volt_flow', 'input_level', 'volt_pot', 'timestamp']
f = open('dataRafif_FLC.csv', 'w', encoding='UTF8', newline='') # open
the file in the write mode
writer = csv.writer(f) # create the csv writer
writer.writerow(header) # write the header
timeSampling = 0.05 # dalam detik, min 0.05s
n = 0 # tidak boleh nol agar index tidak e[-1]
# --------INISIASI Variabel FLC----------
SP = 10 # SP level dlm cm
e=[0.0]
e_np = np.array([0,0])
# e[0]=0 # initial condition error, iterasi
de=[0.0]
de_np = np.array([0,0])
# --------- MQTT-----------------
def on_message(client, userdata, message):
    stringParameterMasuk = str(message.payload.decode())
    # rekam(rrr)
def on_connect(client, userdata, flags, rc):
    if rc == 0:
        print("Connected to MQTT Broker!")
    else:
        print("Failed to connect, return code %d\n", rc)
def on_disconnect(client, userdata, rc):
    print("Client Got Disconnected")
```

```
#-----plot data-----
def plot_data():
    # print("masuk plot data")
    global n,cond, arr_n, arr_volt_level, timeLast, sent
    if (cond==True):
        # print(cond)
        timeNow = time.time()
        # condition untuk sampling, jika sudah melebihi time sampling
        if True:
            n = n + 1
            # print("timeLast sudah bisa masuk")
            arr_n.append(n)
            volt_flow,input_level,volt_pot = kontroller()

            arr_volt_level.append(input_level)

            timeLast = timeNow
            ax.set_xlim(min(arr_n), max(arr_n))
            ax.set_ylim(min(arr_volt_level), max(arr_volt_level))
            # lines = ax.plot(arr_elapse, arr_volt_level, color='green')
            lines.set_xdata(arr_n)
            lines.set_ydata(arr_volt_level)
            # write multiple rows
            # print("v LT: " + str(volt_level) + " V")
            print("level: " + str(input_level) + " cm ; volt pump: " +
str(sinyal_level) + " VDC")
            writer.writerow([n, volt_flow, input_level, volt_pot,
timeNow-start_time])
            # print(arr_n)
            # print(arr_volt_level)
            time.sleep(timeSampling)
            canvas.draw()
        window.after(1, plot_data)
def plot_start():
    global cond, start_time, client
    global cf, cs, nc, os, of, stringParameterMasuk
    cond = True
    start_time = time.time()
    # s.reset_input_buffer()
    print("start mulai yaa")
    # return cond
    client = mqtt_client.Client()
    # client.username_pw_set(username, password)
    print("Connecting to MQTT Broker ....")
    client.on_connect = on_connect
    client.connect(broker, port)
    client.loop_start()
    SP = 0
    print("MQTT Connected")
```

```
    # --- Membership output: triangle--------
    cf = -20  # close fast
    cs = -10  # close slow
    nc = 0  # no change
    os = 10  # open slow
    of = 20  # open fast

    window.after(1, plot_data)

    stringParameterMasuk = "# Belum dapat string subscribe"

def plot_stop():
    global cond, sent
    cond = False

    print("sudah stop yaa")
    sent = c.write_multiple_registers(16, [0, 4096])
    f.close()

def kontroller():
    global volt_flow,input_level,volt_pot, sent,n, sinyal_level,
input_flow, e_np, de_np
    global cf, cs, nc, os, of
    regs = c.read_holding_registers(8, 8)  # format: (address,quantity).
quantity gabole lebih, tapi boleh kurang

    bit_flow = regs[0]
    volt_flow = 20*bit_flow/65535 - 10
    input_flow = 0.27*volt_flow # in lt/min

    bit_level = regs[1]
    # volt_level = (20 * bit_level / 65535 - 10)
    volt_level = 20*bit_level/65535 - 10
    input_level = 1.7055517310856645*volt_level + 4.80943785889385

    # bit_pot = regs[2]
    # volt_pot = (20 * bit_pot / 65535 - 10)
    # print(n)
    # e[n] = (SP - input_level)
    e.append(SP - input_level)
    # sum_e[n] = sum_e[n] + e[n]*timeSampling
    # de[n] = (e[n] - e[n-1])/timeSampling
    de.append((e[n] - e[n-1])/timeSampling)
    miu = 0
    perbandingan = 0
    total_miu = 0
    perbandingan_e = []
    perbandingan_de = []
```

```
    total_perbandingan = 0
    total_miu = 0

    efuzzy = np.array(e)
    defuzzy = np.array(de)

    # --- Membership input error level: triangle --------
    e_l = trimf(efuzzy, [-4, 1, 5])[n]  # error low
    e_ok = trimf(efuzzy, [1, 5, 9])[n]  # error okey
    e_h = trimf(efuzzy, [5, 9, 14])[n]  # error high
    if efuzzy[n] > 1:
        e_h = 1
    elif efuzzy[n] < 1:
        e_l = 1
    # --- Membership input error level: triangle --------
    de_n = trimf(efuzzy, [-1, -0.5, 0])[n]  # delta error negative
    de_z = trimf(efuzzy, [-0.5, 0, 0.5])[n]  # delta error zero
    de_p = trimf(efuzzy, [0, 0.5, 1])[n]  # delta error positive
    if defuzzy[n] > 0.5:
        de_p = 1
    elif defuzzy[n] < -0.5:
        de_n = 1
    # ---- Rule base -------------------------------------
    LTable_y = [[of, nc, cf],
                [of, nc, cf],
                [of, nc, cf]]
    # ---- perbandingan e, de untuk Center of Area
    perbandingan_e = [e_l, e_ok, e_h]
    perbandingan_de = [de_n, de_z, de_p]
    print("perbandingan_e: " + str(perbandingan_e) + " ;
perbandingan_de: " + str(perbandingan_de))
    for i in range(3):
        for j in range(3):
            # print(i)
            perbandingan = min(perbandingan_e[i-1], perbandingan_de[j-
1])
            miu = perbandingan * LTable_y[i-1][j-1]
            total_perbandingan = total_perbandingan + perbandingan
            total_miu = total_miu + miu
            print("perbandingan: " + str(perbandingan))
    outputvolt = total_miu / total_perbandingan
    print("outputvolt: " + str(outputvolt))
    sinyal_level= 0.586320532982868*outputvolt - 2.819872168774626  #
volt sinyal kirim level, level ke volt
    bit_uPID = 4096*sinyal_level/10 # volt ke bit 4096
    if bit_uPID > 4096:
        bit_uPID = 4096
    if bit_uPID < 0:
        bit_uPID = 0
```

```
    e.append(e[n])
    de.append(e[n])

    # print(bit_uPID)
    sent = c.write_multiple_registers(16, [int(bit_uPID), 0])  # list
bit pompa dan valve max.4096
    volt_pot = 69 # ntar hapus ya, ini ga kepake
    # ----send to MQTT-----------------

    result = client.publish("PCT100/level", str(input_level))
    status = result[0]
    if status == 0:
        print(f"Send level berhasil")
    else:
        print(f"gagal send level")

    client.subscribe([('PCT100/MFout/cf', 1),
                      ('PCT100/MFout/cs', 1),
                      ('PCT100/MFout/nc', 1),
                      ('PCT100/MFout/os', 1),
                      ('PCT100/MFout/of', 1)])
    client.on_message = on_message

    words = stringParameterMasuk.split('=')

    if words[0] == 'cf':
        cf = float(words[1])
    elif words[0] == 'cs':
        cs = float(words[1])
    elif words[0] == 'nc':
        nc = float(words[1])
    elif words[0] == 'os':
        os = float(words[1])
    elif words[0] == 'of':
        of = float(words[1])
    else:
        print("StringParameter Undefined")
    print("cf = " + str(cf) +
          " ; cs = " + str(cs) +
          " ; nc = " + str(nc) +
          " ; os = " + str(os) +
          " ; of = " + str(of))

    return volt_flow,input_level,volt_pot

cond = False
timeLast = 0
arr_n = []
```

```
arr_volt_level = []

window = tk.Tk()
window.title('GUI Closed Loop PCT-100')
window.configure(background = 'light blue')
window.geometry("700x500")

fig = plt.Figure();
ax = fig.add_subplot(111)
ax.set_title('Closed Loop Level')
ax.set_xlabel('n ke-')
ax.set_ylabel('Level (cm)')
lines = ax.plot([],[])[0]

canvas = FigureCanvasTkAgg(fig, master=window)  # A tk.DrawingArea.
canvas.get_tk_widget().place(x = 10,y=10, width = 600,height = 400)
canvas.draw()
# ----------create button---------
window.update();
start = tk.Button(window, text = "Start", font = ('calbiri',12),command
= lambda: plot_start())
start.place(x = 100, y = 450 )

window.update();
stop = tk.Button(window, text = "Stop", font = ('calbiri',12), command =
lambda:plot_stop())
stop.place(x = start.winfo_x()+start.winfo_reqwidth() + 20, y = 450)

# window.after(1,plot_data)
window.mainloop()

# greeting = tk.Label(text="Hello, Tkinter")
# greeting.pack()
```

Coding for Open Loop System in PCT100

```
from pyModbusTCP.client import ModbusClient
import random
import matplotlib
import matplotlib.pyplot as plt
from matplotlib.figure import Figure
from matplotlib.backends.backend_tkagg import FigureCanvasTkAgg
import tkinter as tk
import time

start = time.time()
cond = False
# TCP auto connect on modbus request, close after it
```

```
c = ModbusClient(host="10.0.0.1", port=502, auto_open=True,
auto_close=True)
# SP NOISE POMPA & DRAIN VALVE
volt_pompa = 10  # max tegangan untuk pompa
volt_valve = 9
# SP OUTER LOOP (LEVEL yang DIHARAPKAN)\
SP_level = 10
#-----Main GUI code-----
root = tk.Tk()
root.title('Real Time Plot')
root.configure(background = 'light blue')
root.geometry("700x500") # set the window size
#------create Plot object on GUI----------
# add figure canvas
fig = Figure();
ax = fig.add_subplot(111)
ax.set_title('Serial Data');
ax.set_xlabel('Sample')
ax.set_ylabel('Voltage')
ax.set_xlim(0,100)
ax.set_ylim(-0.5,6)

def plot_data():
    global cond, data
    if (cond == True):
        a = s.readline()
        a.decode()
        if (len(data) < 100):
            data = np.append(data, float(a[0:4]))
        else:
            data[0:99] = data[1:100]
            data[99] = float(a[0:4])
        lines.set_xdata(np.arange(0, len(data)))
        lines.set_ydata(data)
        canvas.draw()
    root.after(1, plot_data)

def plot_start():
    global cond
    cond = True
    s.reset_input_buffer()
def plot_stop():
    global cond
    cond = False
# indent: tab/shift+tab, comment: ctrl+/
while True:
    # NOISE POMPA & DRAIN VALVE diabaikan, hanya noise pompa yang
dipakai
```

```
    bit_pompa = int(volt_pompa * 4096 / 10)  # mangubah besaran volt ke
bit max 4096

    # READ FEEDBACK SIGNAL-----------------
    regs = c.read_holding_registers(8, 8)  # format: (address,quantity).
quantity gabole lebih, tapi boleh kurang
    bit_flow = regs[0]
    volt_flow = (20*bit_flow/65535) - 10
    bit_level = regs[1]
    volt_level = (20*bit_level/65535) - 10

    # CONTROLLER OUTER LOOP/LEVEL

    # CONTROLLER INNER LOOP/FLOW

    # SEND CONTROL SIGNAL------------------
    sent = c.write_multiple_registers(16, [0, 0])  # list bit pompa dan
valve max.4096

    print(volt_level)

    end = time.time()
    elapsed = int(end - start)

    lines = ax.plot([], [])[0]
    canvas = FigureCanvasTkAgg(fig, master=root)  # A tk.DrawingArea.
    canvas.get_tk_widget().place(x=10, y=10, width=500, height=400)
    canvas.draw()
    # plt.plot(elapsed, volt_level)
    # plt.show()
```

Result of Open Loop System in PCT-100

n	volt flow	volt level floating	volt pot	timenow	10-volt pot	level (cm)
1	9.613.184	-296.177.615	9.946.593.423	1672578962	53.406.577	0
2	9.613.184	-296.177.615	9.946.593.423	1672578962	53.406.577	0
3	9.613.184	-296.177.615	9.946.593.423	1672578962	53.406.577	0
4	9.613.184	-296.177.615	9.946.593.423	1672578962	53.406.577	0
5	9.613.184	-296.177.615	9.946.593.423	1672578962	53.406.577	0
6	9.613.184	-296.177.615	9.946.593.423	1672578962	53.406.577	0
7	9.613.184	-296.177.615	9.946.593.423	1672578963	53.406.577	0
8	9.613.184	-296.177.615	9.946.593.423	1672578963	53.406.577	0
9	9.613.184	-296.177.615	9.946.593.423	1672578963	53.406.577	0

10	9.613.184	-296.177.615	9.946.593.423	1672578963	53.406.577	0
11	1.516.594.186	-296.177.615	9.946.593.423	1672578963	53.406.577	0
12	1.516.594.186	-292.210.269	9.946.593.423	1672578963	53.406.577	0
13	1.516.594.186	-292.210.269	9.945.677.882	1672578963	54.322.118	2
14	1.516.594.186	-292.210.269	9.945.677.882	1672578963	54.322.118	2
295	8.257.419.699	545.815.213	739.345.388	1672578988	260.654.612	5.661
296	8.257.419.699	545.815.213	739.345.388	1672578988	260.654.612	5.661
297	8.257.419.699	545.815.213	739.345.388	1672578988	260.654.612	5.661
298	8.257.419.699	545.815.213	739.345.388	1672578988	260.654.612	5.661
299	8.257.419.699	545.815.213	739.345.388	1672578988	260.654.612	5.661
300	8.268.711.376	545.815.213	739.345.388	1672578988	260.654.612	5.661
301	8.268.711.376	645.609.216	739.345.388	1672578989	260.654.612	5.661
302	8.268.711.376	645.609.216	739.345.388	1672578989	260.654.612	5.661
303	8.268.711.376	645.609.216	7.383.688.106	1672578989	2.616.311.894	5.682
304	8.268.711.376	645.609.216	7.383.688.106	1672578989	2.616.311.894	5.682
305	8.268.711.376	645.609.216	7.383.688.106	1672578989	2.616.311.894	5.682
516	8.244.602.121	2.739.757.382	5.773.556.115	1672579010	4.226.443.885	9.252
517	8.244.602.121	2.739.757.382	5.773.556.115	1672579010	4.226.443.885	9.252
518	8.244.602.121	2.739.757.382	5.773.556.115	1672579010	4.226.443.885	9.252
519	8.244.602.121	2.739.757.382	5.773.556.115	1672579010	4.226.443.885	9.252
520	8.244.602.121	2.739.757.382	5.773.556.115	1672579010	4.226.443.885	9.252
521	8.244.602.121	2.739.757.382	5.773.556.115	1672579010	4.226.443.885	9.252
522	8.244.602.121	2.739.757.382	5.773.556.115	1672579010	4.226.443.885	9.252
523	825.070.573	2.739.757.382	5.773.556.115	1672579010	4.226.443.885	9.252
866	8.207.675.288	5.711.604.486	3.425.497.826	1672579043	6.574.502.174	14.459
867	8.207.675.288	5.711.604.486	3.410.543.984	1672579044	6.589.456.016	14.492
868	8.207.675.288	5.711.604.486	3.410.543.984	1672579044	6.589.456.016	14.492
869	8.207.675.288	5.711.604.486	3.410.543.984	1672579044	6.589.456.016	14.492
870	8.207.675.288	5.711.604.486	3.410.543.984	1672579044	6.589.456.016	14.492
871	8.207.675.288	5.711.604.486	3.410.543.984	1672579044	6.589.456.016	14.492
872	8.207.675.288	5.711.604.486	3.410.543.984	1672579044	6.589.456.016	14.492

963	8.194.552.529	6.645.456.626	2.720.531.014	1672579055	7.279.468.986	16.022
964	8.194.552.529	6.645.456.626	2.720.531.014	1672579055	7.279.468.986	16.022
965	8.194.552.529	6.645.456.626	2.720.531.014	1672579055	7.279.468.986	16.022
966	8.194.552.529	6.645.456.626	2.720.531.014	1672579055	7.279.468.986	16.022
967	8.203.707.942	6.645.456.626	2.720.531.014	1672579055	7.279.468.986	16.022
968	8.203.707.942	672.449.836	2.720.531.014	1672579055	7.279.468.986	16.022
969	8.203.707.942	672.449.836	2.702.525.368	1672579056	7.297.474.632	16.062
970	8.203.707.942	672.449.836	2.702.525.368	1672579056	7.297.474.632	16.062
971	8.203.707.942	672.449.836	2.702.525.368	1672579056	7.297.474.632	16.062
1018	8.184.481.575	7.179.522.393	2.256.656.748	1672579061	7.743.343.252	17.050
1019	8.184.481.575	7.179.522.393	2.256.656.748	1672579061	7.743.343.252	17.050
1020	8.184.481.575	7.179.522.393	2.256.656.748	1672579061	7.743.343.252	17.050
1021	8.184.481.575	7.179.522.393	2.256.656.748	1672579062	7.743.343.252	17.050
1022	819.546.807	7.179.522.393	2.256.656.748	1672579062	7.743.343.252	17.050
1023	819.546.807	725.459.678	2.256.656.748	1672579062	7.743.343.252	17.050
1098	8.185.702.296	79.375.906	1.634.699.016	1672579071	8.365.300.984	18.429
1099	8.185.702.296	79.375.906	1.634.699.016	1672579071	8.365.300.984	18.429
1100	8.180.514.229	79.375.906	1.634.699.016	1672579071	8.365.300.984	18.429
1101	8.180.514.229	8.011.444.266	1.634.699.016	1672579071	8.365.300.984	18.429
1102	8.180.514.229	8.011.444.266	1.555.657.282	1672579071	8.444.342.718	18.604
1173	7.824.673.838	8.653.543.908	1.151.598.383	1672579079	8.848.401.617	19.500
1174	7.824.673.838	8.653.543.908	1.151.598.383	1672579079	8.848.401.617	19.500
1175	7.824.673.838	8.653.543.908	1.151.598.383	1672579080	8.848.401.617	19.500
1176	7.824.673.838	8.653.543.908	1.151.598.383	1672579080	8.848.401.617	19.500
1177	7.824.673.838	8.653.543.908	1.151.598.383	1672579080	8.848.401.617	19.500
1178	7.824.673.838	8.653.543.908	1.151.598.383	1672579080	8.848.401.617	19.500
1179	7.295.490.959	8.653.543.908	1.151.598.383	1672579080	8.848.401.617	19.500
1180	7.295.490.959	871.061.265	1.151.598.383	1672579080	8.848.401.617	19.5