

# Fuzzy Logic and PID Implementation for Maintains PH Value on Hydroponics Assistant Based on IoT

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## Abstract

*Hydroponics is a method of planting crops through a medium of water that can live indoors or outdoors, hydroponics plants using NFT techniques (Nutrient Film Technique), where water and nutrients can circulate through plant roots. PH is the measurement of nutrient solution in acid or base state. Water pH can affect plant growth rates in hydroponic cultivation. PH cannot survive the stable value required for plant growth. In the previous study PH with value 8 make the plant dead. This research aims to design PH control using acid and base buffer solution. The PID method is the feedback mechanism control and minimizes the error value as setpoint and Fuzzy Logic used to maintain PH at values between 5.6 - 5.7. This model is used for PH in water to survive on good grades for plants. Observations show high PH values can damage plant growth. This research is used to maintain PH at the value of 5.6-5.7 for plant growth using PID and Fuzzy Logic method.*

**Keywords:** NFT, Hidroponics, PID, Fuzzy Logic, and PH

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## 1. Introduction

The global population is estimated at 9 billion by 2050, mostly urban dwellers, requiring an increase in agricultural productivity by 70%.[1] Villagers moving from rural to sustainable cities are expected to encourage the expansion of urban landscapes and accelerate the loss of cultivated land around the city. Coupled with land degradation and loss of soil fertility.[2] The rate of population growth in the city of Bandung according to the Central Bureau of Statistics is currently 0.37%-0.71% per year, in 2016 the population reached 2,490,622 Souls. Therefore the agricultural land in the city of Bandung decreased, from data on the number of agricultural businesses in Bandung has decreased to 34,803.00 Ha by 2015.[3] While agriculture is considered an important part of life for human beings because it is a fundamental source Of food, other raw materials to meet the needs.[4] Agriculture provides the most important commodities needed to meet the needs. A number of vegetables, fruits, nuts and spices all continue to be cultivated with a variety of techniques.[5] Hydroponic techniques have the type to overcome land problems in urban areas, one of which is NFT (Nutrient Film Techniques) that can be arranged vertically.[6] Hydroponics is a widely used and often used the technique for growing plants without soil, providing considerable control over the elemental environment around roots,[7] and is a plant growth system that provides more precise control over composition growth media.[8] Ease of system setup, cost of system growth and flexibility to characterize and crop material harvests continue to be improved in hydroponic systems.[9] Hydroponics uses nutrients as a solution that provides all the essential nutrients for plant development. Hydroponics can be controlled by utilizing the Internet of Things (IoT) or known by machines to machines referring to various devices (things) such as sensors, actuators and other devices.[10] This tool can generate, receive, convey information, through wired or wireless communications between the same or different devices of information to the internet.[11] In the IoT-based hydroponic development using PH, sensors are used to read the degree of acidity in water.[12]

The pH values are some very important chemical parameters.[13] Plants lose the ability to absorb different nutrients when the pH has different values. Plants have a certain pH that is optimal for them, generally, Although most plants prefer slightly acid growing around the environment. PH control is an important process because a small change of input gives a big change in output.[14] At the time of testing the PH sensor on the hydroponic plant the PH value reached 8 causing the plant to die and Research of Gent, Martin pH with a value below 4 has a negative effect on the plant [15] while according to research M Agus showed that the exact PH value for the plant values of 5.7-5.9, [16] and in Henrique's control the pH to an acceptable range of 5.5-6.5.[17]

So the purpose of this paper is to maintain the plant PH at the value of 5.6-5.7 using the PID method to obtain the value of 5.6-5.7 to maintain the PH, [18] and the Fuzzy method is used for the delay of giving acidic or alkaline solutions to water in hydroponics.[19] The results of the source code are uploaded to GitHub to allow users to interact or collaborate in code reviews. [20]

## 2. Related Works

Research of Oluwayesi Proportional-Integral-Plus (PIP) controller for optimal results based on the State-Model Dependent Parameter (SDP) was developed to control the nonlinear and variation of time that greatly varies the process of neutralization pH Since the pH invariant process is not available.[21] The pH control process involves a prototype model in which acid and base streams are mixed into a Continuous Stirring Reactor.[22] pH requires state measurement for plant implementation.[23] Measurement of pH control is very useful in different applications such as agriculture, food processing, biochemical processes and industrial applications. [24] The control objective is to regulate the pH of the outward neutral solution, by manipulating the flow of the basic solution, (NaOH), mixed with the acid solution, (HNO<sub>3</sub>), compensating for the possibility of changes in the buffer stream, (NaHCO<sub>3</sub>), which is considered an unmeasurable disturbance.[25] Strong neutralized neutralization control process simulation has been performed, and good control performance is achieved.[26] The ph-process system was developed adequately in terms of the supposed application of designing a better form of controller. the general method for obtaining dynamic equations for the neutralization process of PH in a continuous stirred tank, some point appears in developing neutralization of PH.[27] In maintaining the pH size constantly with the default rate on industrial processes. There is a difference in classification for the pH process. As we know the acid is divided into two groups, weak or strong, so a categorization based on the weakness or strength of the acid has been used and the other one is on the output current.[28] It is important to treat these chemical wastes to acceptable pH levels, i.e., the ideal PH is in the number 7. We propose pH 5-11 as the optimum pH range for the processing, reuse, and disposal of ash samples.[29] At the plant the neutralizing process of pH is used to neutralize chemical waste products that may arise as a result of some manufacturing process before releasing them to the environment. This is primarily to protect the environment by making safe-running water for marine and agricultural applications, and by avoiding damage to corrosion-related infrastructure.[30] For direct measurements in different literature, models have been presented to illustrate the dynamic behaviour of ph processes with batch type models.[31] A PH neutralization is required to exhibit highly nonlinear behaviour and its control is challenging in the hydroponic process and can not be controlled effectively with a conventional PI controller. [32] The heavy nonlinear presence in the neutralization process of pH makes the problem of pH control difficult and challenging. Furthermore, the optimum control is very nonlinear. The system requires setting up various parameters with appropriate evolutionary algorithms (EA). This paper presents an unlimited, continuous and single genetic algorithm (GA).[33] From the idea of S. Tu PH (4.5 - 8.0) is used to understand individual and interactive effects. plants and P and As uptake are influenced by these factors. Phosphorus is inhibited As the uptake at all for the Fern crop has a PH value of 5.87.[34] Adjustment to PH was performed using 1 mol / L KOH or 1 mol / L HNO<sub>3</sub>. [35]

The fuzzy system in general basically consists of four components: membership function (fuzzification), fuzzy rule base, defuzzification and fuzzy output. In fuzzification, numerical input and output variables are converted into linguistic or adjective terms, and the corresponding degree of one or more of several membership functions is determined.[36] Fuzzy Logic is used to control

the process of pH (Non-linear process). Fuzzy refers to the fact that the logic involved can deal with concepts partially true.[37] In the pH process, the pH sensor is immersed in water.[37] In previous research the fuzzy system was used to model and control complex nonlinear systems for their excellent ability to approximate nonlinear systems.[38] Fuzzy PID controller tunes PID three parameters with a fuzzy controller. Note the oil temperature error  $e$  and the error change rate PH as the input variable, and  $K_p$  (proportional gain correction),  $K_i$  (integral gain correction),  $K_d$  (gain correction derivative), which adjusts the parameter value of PID, as the output variable. Thus the overall fuzzy controller is two input systems and three outputs.[39] On the other hand, when applied to field-adjusted PIDs, which are the result of standard sites.[40] Fuzzy Logic Controller allows designers to design and build controllers by forming statements of IF-THEN in the form of statements. The Fuzzy Logic Controller structure contains four main sections as follows: Fuzzification, inference mechanisms, ground rules and defuzzification, in which the fuzzification section is used to convert real input to fuzzy input.[41] A standard fuzzy PID controller, which is formed using a PID fuzzy controller with an integrator and an addition unit at the output.[42] Many PID controllers based on nonlinear optimization are also proposed for various applications.[43] Proposed modified genetic algorithm for optimizing parameters of multi-objective PID controller and Testing it in revolving pendulum system.[44] To test the performance of fuzzy controllers such as PID, both simulations and experiments of various aqueous acid solutions showing buffer conditions comprising acetic acid and propionate neutralized in a single CSTR with sodium hydroxide having molar concentration  $[\text{NaOH}] = 0.2 \text{ Mol / L}$ . [45] For that process with large delay, nonlinearity, etc, it's not easy for conventional PID to achieve the desired performance. The Fuzzy Controller adjustment does not rely on an accurate mathematical model and has a major advantage in solving uncertainty.[46] To build a digital control system model with a fuzzy PID controller in the SIMULINK modelling package, we will transfer from the Sources sub-category to the two-block model window. Constant and one Step block, generating the unit step function; Mathematical Operations - Sum comparison blocks and two Gain blocks.[18] Fuzzy Logic is used to control the process of pH (Non-linear process). The term fuzzy cannot be expressed as "true" or "false" but as "partially true".[19] The input of the fuzzy PID controller is the error  $e$  and the pH level change error, after the fuzzy, output,  $K_p$ , and  $K_d$  processing that make the PID controller adjust its own parameters according to the error and error rate different from the system.[47] [48]

In the previous study PH with value 8 make the plant dead. This research aims to design PH control using acid and base buffer solution. Methods in journals that prior to only use one method to maintain the value of PH is the method of PID. This research combines two methods namely PID method which is control mechanism of feedback and minimizes error value as setpoint so that PH can survive at value 5,6 - 5,7 and Fuzzy Logic which is used to give time delay on tool not to do giving buffer solution repeatedly. This model is used for PH in water to survive on good grades for plants. Observations show high PH values can damage plant growth. This research is used to maintain PH at the value of 5.6-5.7 for plant growth using PID and Fuzzy Logic method.

### 3. Research Method

PID control has a simple structure, tuning parameters, and easier operation, but for controls cannot be better. The neutralization process PH has nonlinear, time lag, and other features to adjust the PID. PID control.[44] Research of Zhang, the control algorithm chosen for optimal PH is the PID controller.[25] We can guarantee the system to maintain the stability of PH. The PID control algorithm can be expressed as follows:[42]

$$u(t) = K_p + \left( e(t) + \frac{1}{T_i} \int e(t)dt + T_d \frac{de(t)}{dt} \right)$$

Atau

$$u(t) = K_p + \left( e(t) + K_i \int e(t)dt + K_d \frac{de(t)}{dt} \right)$$

$u(t)$ = signal output PID control

Kp= konstanta proporsional

Ti= Time integral

Td= Time derivative

Ki= Constanta integral

Kd= Constanta derivative

e(t) = Signal error

Thus, the PID control override function (in domain s) can be expressed as follows:[18]

$$G_c(s) = K_p + \frac{K_i}{s} + K_d(s)$$

the model may be approached as first orders inertia. The PH value of the neutralization control process is carried out in the aeration tank, while the aeration tank in the waste treatment process can enter the next processing stage.[43]

Fuzzy Logic is used to control the process of pH (Non-linear process). The term "fuzzy" refers to the fact that the logic involved can deal with concepts that can not be expressed as "true" or "false" but as "partially true". In the pH process, the pH sensor is immersed in a solution or a liquid whose pH must be measured. The Output of the pH sensor is in terms of Voltage (0-100 mV). This voltage is calibrated in terms of pH. The voltage of the pH sensor is given as input to the fuzzy controller. An appropriate membership function is selected, and the rule is formed within it. Membership functions are classified into values according to the process.[19]

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