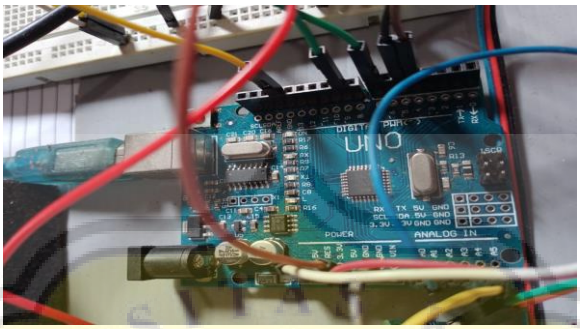
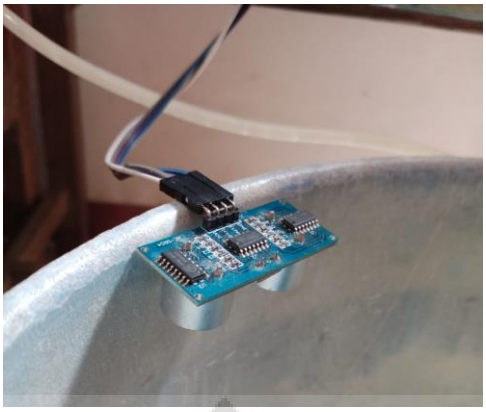
CHAPTER 4
ANALYSIS AND DESIGN

4.1. Hardware



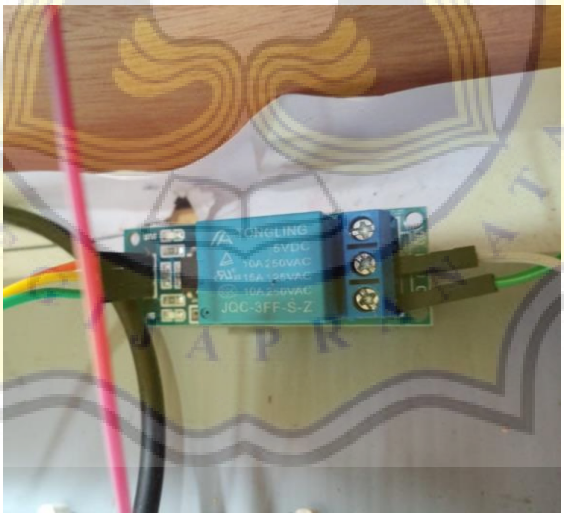
Picture 1: Arduino uno

As a microcontroller, Arduino Uno will execute all program code that contains fuzzy Sugeno logic including fuzzification, rule base, and defuzzification. Arduino will also process the twelve pre-programmed rules and the last stage is defuzzification to find out the final value which will be used as a pump delay. Arduino will also control the relay used to activate or deactivate the nutrition pump and water pump based on the result of the defuzzification value. Arduino Uno itself can accept voltages ranging from 6-20 volts and issue a maximum voltage of 5 volts which is enough to activate 2 output pumps, besides that Arduino Uno has 16 pins that are used to regulate the input and output of the system.



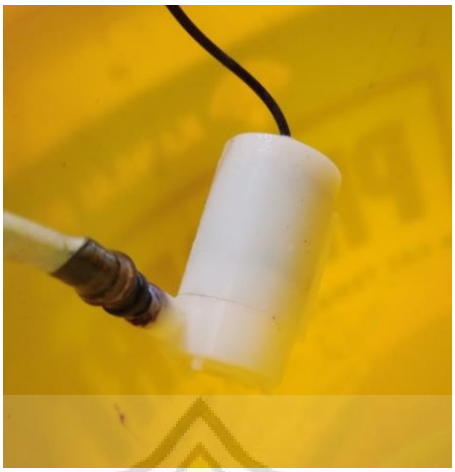
Picture 2: Ultrasonic sensor

Ultrasonic sensors are used to detect the water level in a hydroponic reservoir, this sensor uses reflected ultrasonic waves that are reflected in the object, namely water, and then the reflected waves are captured to further provide data to the microcontroller.



Picture 3: Relay

Relays are used to turn on or turn off the electric current that drives the nutrient pump and water pump. This study uses a single channel relay to facilitate the arrangement of the relay circuit, it also has a voltage of 5V relay to match the input voltage on the microcontroller.



Picture 4: Mini water pump

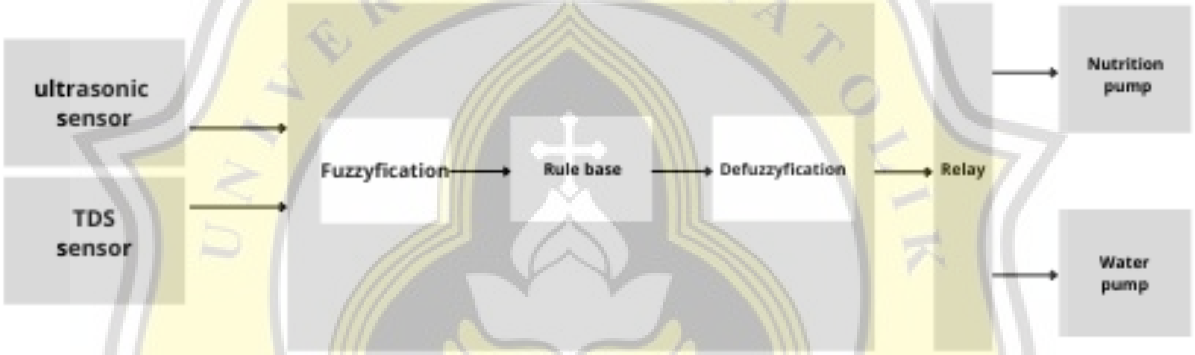
The pump is used to suck the nutrient solution and water which will then be mixed automatically in the nutrient reservoir. The pump used has a voltage of 6 volts which is compatible with the Arduino Uno microcontroller.

Picture 5: LCD 16x2

The 16x2 LCD is utilized to display the value of PPM, water level, as well as the output of the two pumps, namely dead, fast, medium, and long, with this LCD, the monitoring or controlling process will be much more convenient.

4.2. Fuzzy Algorithm

The algorithm used in this project is fuzzy with the Sugeno method, there are 3 main stages in the fuzzy algorithm, namely f*uzzification*, r*ule base*, and *defuzzification.* In *Picture 6* it is explained that the ultrasonic sensor and TDS sensor will enter the fuzzification process to determine the membership value of each input, then enter the rule base that has been formed so that the system runs properly and the last stage is defuzzification to find out the final value, this final value used as a delay on the relay then the relay works to turn off or turn on the pump according to the delay value that has been obtained.

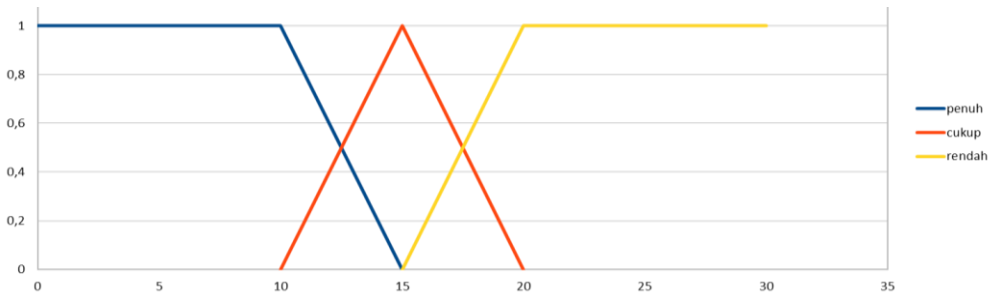


Picture 6: System design

4.2.1. Fuzzification

1. Membership Water level variable

Variable water level consists of 3 sets including full, adequate, low. In full water conditions, a parameter range of less than 15 is given. Then insufficient water conditions, a range of 10 to 20 is given. Then in low water conditions, a range greater than 20 is given.



Picture 7: Fuzzyfication membership water level

$$1, x \leq 10$$

penuh $$= \frac{15-x}{15-10}, 10 \leq x \leq 15$$

$$0, x \geq 15$$

$$0, x \geq 10 atau x \leq 20$$

cukup $$= \frac{x-10}{15-10}, 10 \leq x \leq 15$$

$$\frac{20-x}{20-15}, 15 \leq x \leq 20$$

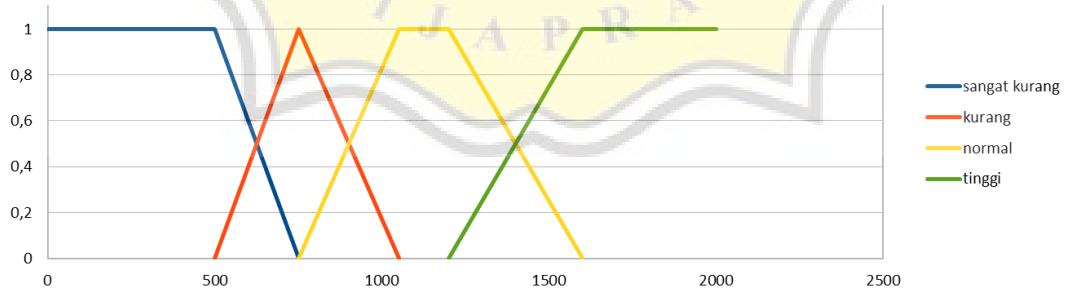
$$0, x \leq 15$$

rendah $$= \frac{x-15}{20-15}, 15 \leq x \leq 20$$

$$1, x \geq 20$$

2. Membership Nutrition Variable

The nutrition variable consists of 4 sets of which are very poor, lacking, normal, high. In conditions of very poor nutrition, a parameter range of less than 750 is given. Then in conditions of poor nutrition, a parameter range of 500 to 1050 is given. Then in conditions of normal nutrition, a parameter range of 750 to 1600 is given. Then in a state of high nutrition, a parameter range greater than 1600 is given.



Picture 8: Fuzzyfication membership nutrition value

$$1, x \leq 500$$

sangat kurang $= \frac{750-x}{750-500}, 500 \leq x \leq 750$

$$0, x \geq 750$$

$$0, x \leq 500$$

kurang $= \frac{x-500}{750-500}, 500 \leq x \leq 750$

$$\frac{1050-x}{1050-750}, 750 \leq x \leq 1050$$

$$0, x \leq 750$$

$$\frac{x-750}{1050-750}, 750 \leq x \leq 1050$$

normal $= 1, 1050 \leq x \leq 1200$

$$\frac{1600-x}{1600-1200}, 1200 \leq x \leq 1500$$

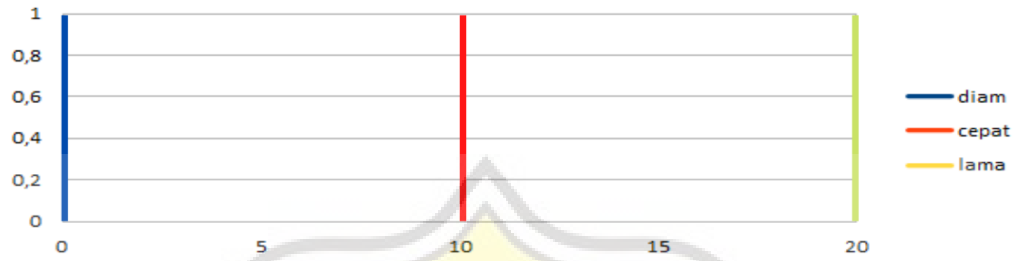
$$0, x \leq 1200$$

tinggi $= \frac{x-1200}{1600-1200}, 1200 \leq x \leq 1600$

$$1, x \geq 1600$$

3. Membership Water Pump Duration

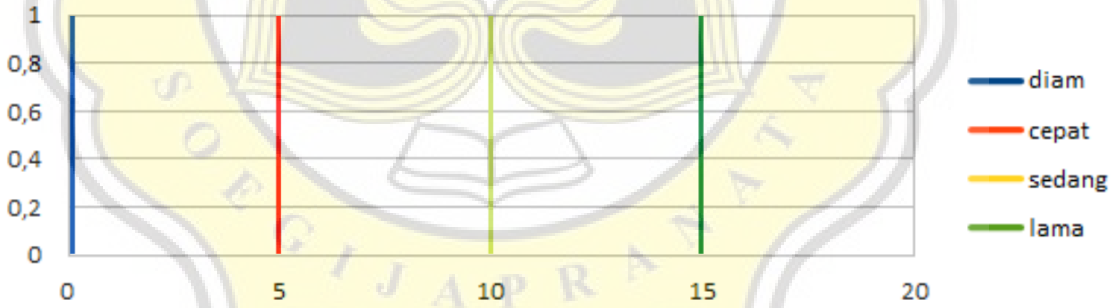
The duration of the water pump is divided into three, namely silent 0 seconds, fast 10 seconds, and long 20 seconds. The water pump will turn on when the water condition in the nutrient reservoir is low.



Picture 9: Fuzzyfication membership water pump duration

4. Membership Nutrition Pump Duration

The duration of the nutrient pump is divided into four, namely silent 0 seconds, fast 5 seconds, medium 10 seconds, long 15 seconds. The nutrient pump will turn on when the nutrients are at very low and low levels.



Picture 10: Fuzzyfication membership nutrition duration

4.2.2. Rule Base

Water / Nutrition	Sangat kurang	Kurang	Normal	Tinggi
Penuh	Diam / cepat	Diam / diam	Diam / diam	Cepat / diam
Cukup	Cepat / lama	Cepat / sedang	Cepat / diam	Cepat / diam
Rendah	Lama / lama	Lama / sedang	Lama / diam	Lama / diam

Table 1: Rule Base table

At the rule base stage, the minimum value of the two rule parameters is searched for example in the first rule containing silence and long, the silent parameter contains a value of 0.8 and the old parameter contains a value of 0.2 then the value that will fill the first rule is 0.2. Through two sensor inputs and two outputs, 12 rules are formed which include :

1. If the water is *penuh* and the nutrients are *sangat kurang* then the water pump is *diam* and the nutrient pump is *cepat.*
2. If the water is *cukup* and the nutrients are *sangat kurang* then the water pump is *cepat* and the nutrition pump is *lama*.
3. If the water is *rendah* and the nutrients are *sangat kurang* then the water pump is *lama* and the nutrient pump is *lama*.
4. If the water is *penuh* and the nutrients are *kurang*, then the water pump is *diam* and the nutrient pump is *diam.*
5. If the water is *cukup* and the nutrients are *kurang* then the water pump is *cepat* and the nutrient pump is *sedang*.
6. If the water is *rendah* and the nutrients are *kurang* then the water pump is *lama* and the nutrient pump is *sedang.*
7. If the water is *penuh* and the nutrition is *normal* then the water pump is *diam* and the nutrient pump is *diam.*
8. If the water is *cukup* and the nutrition is *normal* then the water pump is *cepat* and the nutrient pump is *diam.*
9. If the water is *rendah* and the nutrition is *normal* then the water pump is *lama* and the nutrient pump is *diam.*

10. If the water is *penuh* and the nutrient is *tinggi* then the water pump is *cepat* and the nutrient pump is *diam.*
11. If the water is *cukup* and the nutrient is *tinggi* then the water pump is *cepat* and the nutrient pump is *diam.*
12. If water is *rendah* and nutrients are *tinggi* then the water pump is *lama* and the nutrient pump is *diam.*

4.2.3. Defuzzification

The last stage is defuzzification, which is changing the output fuzzy set into crisp output. The method in this calculation is the Sugeno or Weight Average (WA). Defuzzification is carried out twice, namely first to determine the value of defuzzification in nutrients and then to determine the value of defuzzification in water. This defuzzification value will be used as a delay to start the pump. The formula for defuzzification of the Sugeno model is as follows.

$$output = \frac{(a1*z1)+(a2*z2)+(a3*z3)+\ldots..(an*zn)}{a1+a2+a3\ldots\ldots an}$$

a_n = Rule value to ...n

z_n = Output value to ...n