FULLY AUTOMATED HYDROPONIC SYSTEM FOR INDOOR PLANT GROWTH

Abdul Hakim Bin Hussain, Nur Athirah Binti Mohd Isa,
Asilatul Hanaa Binti Azhar, Muhammad Faez Bin Sudin

Supervisor: Mr. Khairul Anuar Bin Juhari, Mr. Mohd Tajuzzaman Bin Hassanor
Advisor: Madam Siti Aishah Rusdan

***Abstract*: Hydroponic is one of the farming method without soil, but it uses water that contain nutrition. Nutrient solution is very important to define the successful of hydroponic cultivation. One of hydroponic technique is Drip Recovery system. Drip system uses nutrient solution to drain on the root area. pH level which is good for lettuce is 6.0-6.5, meanwhile the Electrical Conductivity (EC) level which is suggested is 0.8-1.2. Factor of pH and EC need to monitor 24 hours during the growth period. Hydroponic system requires wide area. However, in urban areas, the hydroponic greenhouse can't get a wide area only in one place. This system is used to solve the problem in the real time monitoring lettuce cultivation hydroponic. The method in this system contains communication, planning, modelling, construction, and socialization.**

INTRODUCTION

Growing certain plants and vegetables in remote areas such as deserts and the north and South Pole can be a challenge because of the extreme outside weather. Very few species of plants thrive in such situations and are often not used as a food source [1]. In this study, we created a system that can grow common plants and vegetables and can operate without depending on the outside climate. We achieved this by using a technique called Hydroponics. Hydroponics is a method of growing plants without using soil [2]. The system was automated using PLC (Programmable Logic Controller) and sensors to keep human intervention at a minimum. This way can improve reliability and allow remote monitoring and control if needed. The user is only required to plant a seedling and set initial parameters. Once done, the system is able to maintain the parameters and promote healthy plant growth.

METHODOLOGY

A. Project Design

Project begin with designing stage by using Catia V5 software below are the product specification of fully automated hydroponic growing stage.

1. Dimension: 1230mm x 625mm x 1310mm
2. Material structure:
   - Body Structure: Hardwood Plywood and Mild Steel Hollow
   - Water tank and Planting pot: Aluminum alloy
3. Weight : ±200kg
4. Power supply : 240 VAC
5. Additional feature : Touch screen HMI (Human Machine Interface)

<u>Design</u>

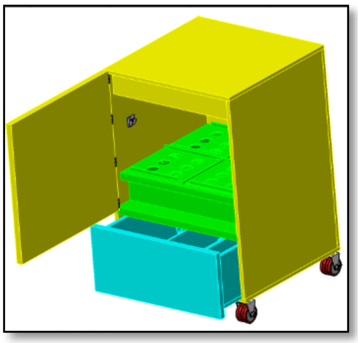


Figure 1 Product design

Table below shows the comparison design:

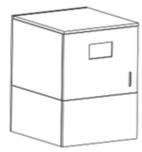
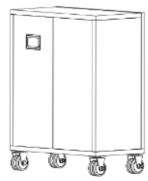
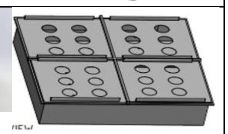
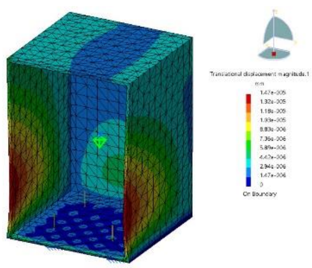
No	Part	Previous Design	Improved Design
1	Hydroponic Box		
2	Planting Pot		

Table 1 Design Comparison

<u>Product Design Analysis</u>

We have conducted analysis on important structure using Catia V5 analysis and simulation features to determine the reaction force on each of structure.



Load: 1500 N Von Mises Stress: 4.42e+003N.m2 Result: Good

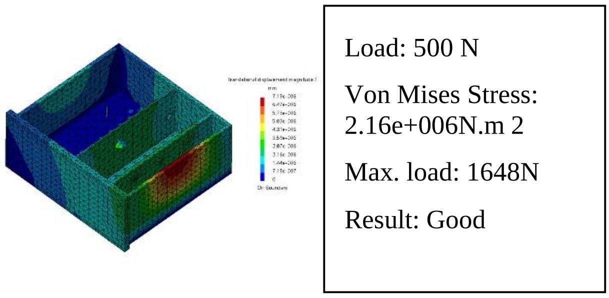


Figure 2 Von Mises Stress (Nodal Value) Analysis of Water tank

Based on the geographic above, it shows that the structure is very strong when the 150kg load force has been applied to the body structure while 50kg load has been applied to the water tank. The red color indicates that the critical part of the structure is due to the possibility of its relatively critical structure with the encumbrance that is implanted in the structure. Magnitude of displacement is a technical way of saying distance, as measured directly between the start point and the end point.

With the displacement magnitude value, this allows for analysis of a movement from two different point points. Based on the result above, it shows that the critical value for translational displacement value is 1.47e-0005. By referring the above geographical guarantees, this proves that this structure is very strong with the weight it applies to it because the red area is very small compared with the blue area.

The result of the Von Mises Stress analysis on the hydroponic structure which is to check whether this design will withstand the load of structure with load of 1500N. It is shown that higher Von Mises Stress occur on the center and the both side end of the bracket with the maximum value of 4.42e+003. This is less than the yield point value of wood. This show that the design of the bracket is reliable. The color scale provides the range of the stress values that are present within the model for the given conditions.

B. System description

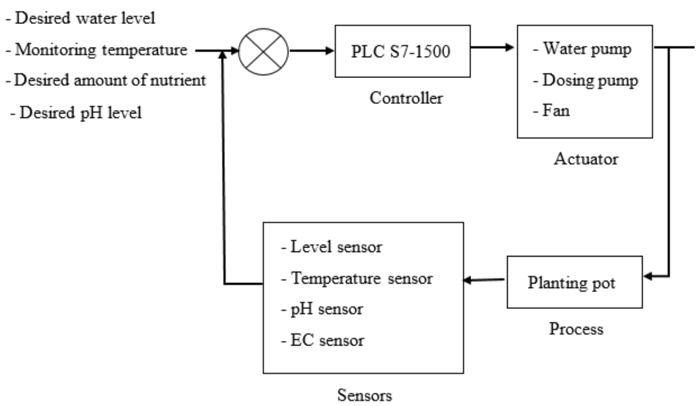


Figure 3 fully automated hydroponic closed loop description system.

Figure 3 shows the overall block diagram of a full automated hydroponic drip recovery system. Set point is the desired value that needed by the user. The set point will be the desired water level, the monitored ambient temperature in the box, the monitored temperature in nutrient solution, monitoring pH level and the desired amount nutrient intake. While PLC (Programmable logic control) is the brain that used to receive the information from the analyzation of the sensor and come out with an instruction in term of response (action) as the feedback. Then the action will be based on the actuator that will react towards the act received. Therefore, this closed system will completed the project development system.

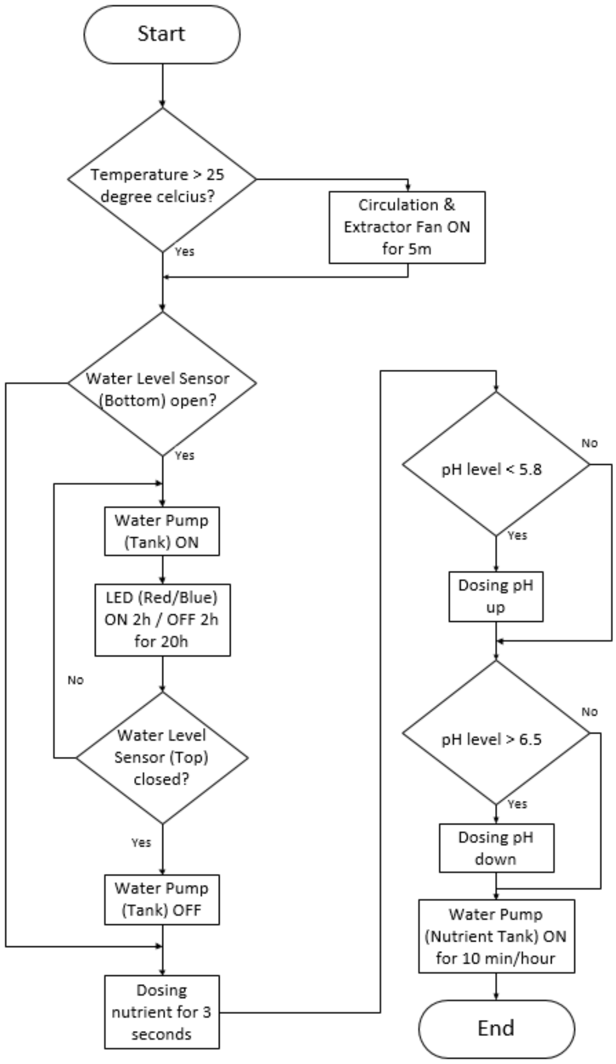


Figure 4 Process Flow Chart of the system

Figure 5 View of fully automated hydroponic system

C. Hardware development

Hardware is the physical components that have been merged together in order to build and form a fully automated hydroponic system for indoor plant growth

1. Hydroponic Component

Twenty four samples of Lettuce were placed in a Hydroponic tray (length 358mm, width 296mm, height 152mm) that constructed 10.8cm above the water and nutrient tank. The hydroponic tray was filled with three compartments that are water reservoir, nutrient solution tank and bottle storage. Depth of 419 mm and 95L. Hydroponic units were irrigated daily for 10 minutes at every hour .This system is using an unfiltered fresh water supply of 3L per irrigation. Irrigated water were retained in the hydroponic unit until it reaches the 0.5cm from the bottom tray level and drained back into the fish tank through a 15mm PVC pipe by gravity. All of the plant will grow in the medium basket while the plants root immersed in the water.

2. Light for Plant Growing

LED Growing light supplied to the plants was practically a daylight bulb. Benefits of LED Lighting. LEDs are extremely energy efficient and consume up to 90% less power than incandescent bulbs. Since LEDs use only a fraction of the energy of an incandescent light bulb there is a dramatic decrease in power costs. The usage of this light is affordable to be bought to replace the actual grow light. ON and OFF conditions of the light was depends on the timer that had been set. For this system, the time the light operates is at 10:00 am until 2:00pm and 7:00 pm to11:00pm per day.

3. Temperature Sensor (MALTEC-T) PT 100

Theoretical the plant require to be in a temperature between 24°C to 30°C to keep it growth and live well. The temperature maybe affected by the ambience temperature or the heat dissipate by the LED growing light. To monitor the temperature of the air temperature, Temperature sensor is placed near to the LED Growing light to check whether the heat dissipated from the LED light affect the ambience in the growing box. The extraction and circulation fan will active if the temperature detect the temperature more than 30°C.

4. Water Level sensor

Water level sensor was used to control the water level in the nutrient tank to constantly maintain at it set point required. The float sensor used to detect a minimum and maximum level of water in the tank. The float sensor act as a switch to be either in active high or in a active low that indicate discrete level measurement 1 or 0. It used to indicate the sufficient water level and insufficient water level in the tank as to avoid insufficient water level for the pump to operate.

5. pH sensor

The pH level in water solution to the Drip Water Recovery System is should be maintained to ensure the plant grows wisely. The suitable range pH level for plant is 6.5 to 5.8. The nutrient is supplied to the plant by mixture the water solution with fertilizer before started to grow the plant. After that, the suitable of pH value of the plant must be set up first by using a keypad button that connected with the pH controller. Once, the pH level was entered the system will automatically make a comparison between pH level value in water solution with range of suitable pH level value.

6. EC (Electro conductivity) sensor

Balancing nutrient solution is one of most important things when growing plants in hydroponics systems. EC sensor will tell us how much nutrients have in water. Conductivity is the ability of substance to carry the current. It is the reciprocal of resistivity. In liquid, we often use the reciprocal of resistance that is conductance, to measure the conductive capacity. The conductivity of water is an important indicator in the measurement of water quality. It can reflect the level of electrolytes present in the water. Depending on the concentration of the electrolyte, the conductivity of the aqueous solution is different

7. Touch screen HMI (Human Machine Interface)

This system used HMI type of 8.5cmx6cm to display the data of the system that consists of current stage of growth, the current date and time status, the measured temperature of PT 100, pH sensor reading and light status.

D. Software development

Software development is the process of designing, programming, testing, and bug fixing involved in creating a fully automated hydroponic system.

1. Ladder Diagram

Programmable Logic Controller (PLC) are used to design a ladder diagram for the system. By using Function Call, the system are divided into one testing mode and three system types. Each of them are controlled using memory input which are connected through Human Machine Interface. The system also includes interlocking which will prevent user from executing multiple function block at once. In the system, timer are used to control the duration of the output to be triggered at a specific time. Furthermore, the PLC can read temperature sensor which give a reading range from 4-20mA into analog input module. The module converts the signal and by adding NORMX and SCALEX block, the analog signal are converted into readable output. The system also used counter and comparator to count up the numbers of repeated cycle which will stop at the count of 10.

2. Human Machine Interface

When the system boot up, HMI will power on and initialize the main screen. In the main screen, user will have three options to choose which is monitor output, automatic start, and stop all. When the user press monitor output, user can test each actuator to check their functionality. Each test key are assigned to memory bit which will set bit when pressed and reset bit when released. When pressing stop all, all function block will reset and stop and the user will be taken to the main screen. Pressing automatic start will take the user to another screen which the user can select three different types of system that the user wants. Each system are specified their LED color, sequence and output timer. By selecting one system, user are unable to select another system without stopping the running system first. User will be taken to the screen where it will show what system the user chose and current temperature reading inside the hydroponic box. Monitoring output while the system running are still possible.

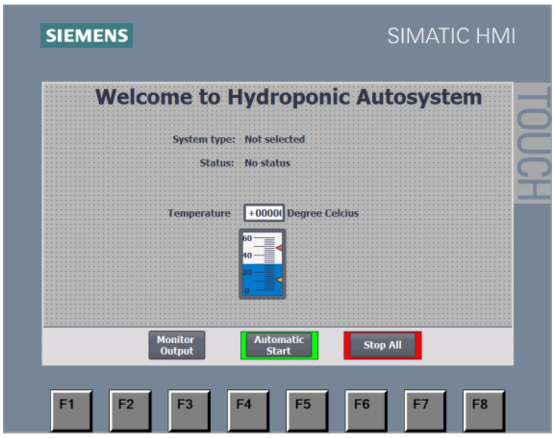


Figure 6 HMI startup screen

RESULTS AND DISCUSSION

PLC and the designated sensor network were placed on a hydroponic plant box. PLC received data from each sensor. Where the data was the amount of acidity / base water, water temperature and air temperature in the scope of the plant. After the system received the value of all sensors, indicating the crop conditions, then it was decided whether the condition of the plant normal or not normal. The system also displayed a graph of each sensor, and this graph was regularly updated for 10 minutes. Testing is done for one week per plant. The test results can be seen in Tables 4.1.

Table 2 : Sensor reading for plants (day 1-7, week 1)

Day	pH	Water temp (°C)	Air temp (°C)
1	-	-	28
2	-	-	30
3	-	-	29
4	6.20	29	31
5	5.93	29	31
6	5.93	29	20
7	5.75	29	29

Based on the Table 2 result, the water temperature sensor, air temperature, and pH always get stable average data in accordance with the environmental conditions of the plant. This result indicate that the sensor and the system were running well.

CONCLUSION

The prototype of the fully automated hydroponic Drip recovery system was tested to determine its performance. Especially in the full treatment, once the general strategy was defined, it took over and made decisions about when to apply water and how much water to apply. In the automated system, depending on the feedback of the sensor, and the set point that need to be achieved in every subsystem or variable that need to be controlled such as pH level, nutrient intake, and air temperature. Also, the software used to provide a monitoring and controlling in the project was simple and maintained the desired state for the full application.

REFERENCE

1. K. Kalovrektis, Ch. Lykas, I. Fountas, A. Gkotsinas, I. Lekakis, “Development and application embedded systems and wireless network of sensors to control of hydroponic greenhouses”, International Journal of Agriculture and Forestry 2013, 3(5): pp. 198-202.

2. Rajeev lochan Mishra1 and Preet Jain, “Design and implementation of automatic hydroponics system using ARM processor”, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 4, Issue 8, August 2015

3. Mamta D. Sardare, Shraddha V. Admane, ‘A review on plant without soil – hydroponics’, IJRET: International Journal of Research in Engineering and Technology ISSN: 2319-1163, Volume: 02 Issue: 03, Mar-2013

4. Velazquez, L.A., Hernandez, M.A., Leon, M. Dominguez, R.B., Gutierrez, J.M. “First advances on the development of a hydroponic system for cherry tomato culture”, IEEE 10th International Conference on Electrical Engineering, Computing Science and Automatic Control (CCE), September 30-October 4, 2013.