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DEVELOPMENT OF PROGRAMMABLE CONTROLLER FOR AQUAPONICS FERTILIZATION SYSTEM

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This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Industrial Electronic) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a fractional satisfaction of the prerequisites for the level of Bachelor of Electronic Engineering Technology (Industrial Electronic) with Honours. The member of the supervisory is as follow:

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Supervisor Name : *TS. SHAHRIZAL BIN SAAT*

Date : 04/02/2021

DEDICATION

I dedicate my thesis to my family and friends. A special feeling of gratitude to my loving parents, Jusili and Jaimis whose words of encouragement and push for determination ring in my ears. My brothers, Azraqul and Arsyad that have never left my side and are very special while giving guidance.

I also dedicate this thesis to my many friends who have supported me, guide me and also help me throughout the process. I will always appreciated all they have done, especially Mark for helping me develop my technological skills, Maria for the many hours of proofreading, and Ganesh for helping me to construct a programming code which give me a big headache.

I dedicate this work and give special thanks to my best companion Aira for being there for me throughout the entire bachelor degree program. You have been my best cheerleader.

ABSTRACT

An aquaponics fertilization system has been used for agricultural long before. It is a combination of hydroponics system and aquaculture where the excess food or waste from the fish become the nutrient for the plants while the plants consume the nutrients which cleanse the water and recirculated back to the aquaculture. To maintain a high quality products produced from aquaponics system, the nitrate produced in the aquaculture part need to be monitor and controlled. So this thesis is focused on creating a system that can control the parameters of aquaponics system by using Arduino micrcontroller to monitor and control pH and temperature as well as integrating the project into IoT monitoring system. So, basically, there are two tanks used as the main hardware which is the aquaculture tank and hydroponics tank. The water pump will pump water from the fish tank to the hydroponics tank and then the water from the hydroponics tank will flow back into the fish tank via overflow pipe. The water pump will only turned ON when the water level inside the hydroponics tank is empty or low. The pH and Temperature value inside the fish tank must also in its range which is 6 – 8 ppm and 18 – 30 ºC in order to turn the water pump ON. The pH and Temperature sensor is placed inside the fish tank because the process of turning the ammonia from fish waste into nitrate by the bacteria for the plants nutrient occurs in it. The sensors and actuators are controlled by the Arduino microcontroller and the data is also send to Blynk app for monitoring by using a smartphone. From the results gathered, The sensors used is also very stable, quite accurate with an average of 0.04 and 0.06 percentage of error, and also very consistent. As a result, pH and temperature value can be monitored and maintained to ensure good quality products produced.

ABSTRAK

Sistem persenyawaan akuaponik telah lama digunakan untuk pertanian. Ini adalah gabungan sistem hidroponik dan akuakultur di mana lebihan makanan atau sisa dari ikan menjadi nutrien bagi tanaman sementara tanaman memakan nutrien yang membersihkan air dan disirkulasikan kembali ke akuakultur. Untuk mengekalkan produk berkualiti tinggi yang dihasilkan dari sistem akuaponik, nitrat yang dihasilkan di bahagian akuakultur perlu dipantau dan dikendalikan. Jadi tesis ini difokuskan pada pembuatan sistem yang dapat mengawal parameter sistem akuaponik dengan menggunakan mikrokontroler Arduino untuk memantau dan mengendalikan pH dan suhu serta mengintegrasikan projek ke dalam sistem pemantauan IoT. Jadi, pada dasarnya, terdapat dua tangki yang digunakan sebagai perkakasan utama iaitu tangki akuakultur dan tangki hidroponik. Pam air akan mengepam air dari tangki ikan ke tangki hidroponik dan kemudian air dari tangki hidroponik akan mengalir kembali ke tangki ikan melalui paip limpahan. Pam air hanya akan dihidupkan apabila paras air di dalam tangki hidroponik kosong atau rendah. Nilai pH dan Suhu di dalam tangki ikan juga harus berada dalam kisarannya yaitu 6 - 8 ppm dan 18 - 30 ºC untuk menghidupkan pam air. Sensor pH dan Suhu diletakkan di dalam tangki ikan kerana proses mengubah amonia dari sisa ikan menjadi nitrat oleh bakteria untuk nutrien tumbuhan terjadi di dalamnya. Sensor dan penggerak dikendalikan oleh mikrokontroler Arduino dan data juga dihantar ke aplikasi Blynk untuk pemantauan dengan menggunakan telefon pintar. Dari hasil yang dikumpulkan, Sensor yang digunakan juga sangat stabil, cukup tepat dengan rata-rata 0,04 dan 0,06 peratus kesalahan, dan juga sangat konsisten. Hasilnya, nilai pH dan suhu dapat dipantau dan dipelihara untuk memastikan produk berkualiti dihasilkan.

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INTRODUCTION

1.1 Background

There are many types of agricultural activities that provides human their needs of food like vegetables. One of the most used technique for agriculture is Aquaponics. Aquaponics refers to a system which is a combination of aquaculture and hydroponics where aquaculture is a term used for raising aquatic animals such as fish or prawns in a tank, while hydroponics is a term for cultivating plants in water. In a normal aquaculture, waste produced by the fish raised in the tanks will accumulate in the tanks. The waste produce inside the fish tank is in the form of ammonia, NH3. Then, the nitrifying bacteria will broke down the ammonia into nitrites and subsequently into nitrates that is good for fertilizing plants. High concentration of by-products inside the tank will result in high toxicity for the fish and can harm the fish if the water is not regulated. So, that's where hydroponics system come in, the water is pumped into the system and the water containing nitrate will be utilized by the plants as nutrients and then recirculated back to the fish tank.

This project is focusing on creating an automated system for the fertilization of aquaponics. The amount of nitrate inside the aquaculture tank is monitored by ammonia sensor where if the amount reach a specific amount then the water pump will start pumping water to the hydroponics section for the plants and stops when the amount of ammonia in the aquaculture tank reach a specific amount. pH and Temperature sensor is also used in the aquaculture section to check whether the situation is good or not. This is because, the breakdown of ammonia into nitrate needs a suitable pH and Temperature.

1.2 Problem Statement

In these days, Aquaponics system is not unusual agriculture technique anymore. This technique has already been done in a large scale but with a larger risk of loss by a lot of farmers around the world. The main problem that can risk great loss is the ammonia content in the aquaculture tank. Many farmers often overlook the ammonia content that is produced in the tank which needs to be monitored always. This can lead to high toxicity in the aquaculture tank and kills not only the fish but also the plants.

Other than that, the water pump used to circulate water from fish tank to the plants consumed more energy because once it is turned ON, it will only turned OFF when it is time to harvest the fish and the plants so it consume more energy and can lead to higher maintenance.

1.3 Research Objectives

The main aim of this research is to propose an automated aquaponics fertilization system. Specifically, the objectives are as follows:

i) To study and research on how Aquaponics fertilization system works based on research article produced and published on the internet.

ii) To develop an automated Aquaponics fertilization system by monitoring and controlling pH and temperature value using programmable controller Arduino.

iii) To reduce the risk of production loss and low quality products by controlling and maintaining the pH and temperature value using Arduino microcontroller.

1.4 Scope of Research

The scope of this research are as follows:

i) Research, study and analyse the data in any article or information on how aquaponics fertilization system works from the internet as well as journal.

ii) Analyse all the data gathered from research and determine the methodology that will be used to develop an automated aquaponics fertilization system that can monitor and control pH and temperature value to ensure high quality production from the system.

iii) Design a program for the Arduino microcontroller which act a as brain for the whole system to maintain the pH and temperature value so that the process of nitrification in the aquaculture tank which will provide the plants enough nutrients for growth.

1.5 Contribution of Research

Contributions of this thesis is to develop the agricultural sectors into a more advanced sectors where the products produced will be in higher quality due to continuous monitoring and controlling the Aquaponics parameters. Other than that, due to advancing civilization, the medicine sectors is also developing into a higher stage so, mortality rate is decreasing while birth rate increase each year. Based on that, the demand for land and food increased. The alternative is Aquaponics which used only water as the medium of growth while producing foods. So, Aquaponics is a great contribution for the civilization in allowing more land for the people and also food supplies.

1.6 Thesis Outline

Based on the objectives previously presented and on the approach proposed before, this thesis is made up of five (5) chapters, where chapter 1 presents the background of the study, research problems, objectives, scopes, contribution and significance of the research. In chapter 2, literature review, this chapter focused on the overview of the current agricultural technique which is Aquaponics system efficiency nowadays. Moreover, this chapter present numerous previous literature of reference and data for Aquaponics fertilization system. Chapter 3 will explain the methodology of this project where the flow project, flow process and also hardware that will be used is explained and selected.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This project's literature review target is on how the Aquaponics fertilization system operates to maintain a good environment for the aquaculture and the hydroponics to produce high quality output. For the system to be maintained automatically, an Arduino controller is required which is connected to a pH sensor, temperature sensor and also water pump to control the aquaculture nitrate products produced from the fish excretion and food waste for the hydroponics nutrient and water flow from aquaculture tanks to the hydroponics section. The parameters used includes Temperature and pH where the objective will be achieved by controlling the parameters by using Arduino controller.

2.2 Current Research

2.2.1 An Automated Solar-Powered Aquaponics System towards Agricultural Sustainability in the Sultanate of Oman

The following is a previous literature review which is studied and discussed below. The main objective that has been taken into consideration is the researchers is developing a good water recirculation system which will ensure enough nutrient will flow to the plants grow beds and clean water recirculated back to the aquaculture tank. Due to that, the researchers then create a block diagram of the Aquaponics control and monitoring system so that the whole process can be seen in a bigger picture and determine what is needed to make this project succeed. Based on the article, the methodology used was there are two sectors which is hydroponics sector and aquaculture sectors. In the hydroponics section, the sensor used is air temperature, relative humidity, light, water, temperature, and pH sensor while in the aquaculture tank section, the

sensors used is water level, water temperature, pH, DO, EC, TDS, and SAL sensors. The sensors will send signal to the microcontroller Arduino MEGA through a signal conditioning circuits. The microcontroller then receive the signal and send instructions to the actuators through the driver circuits where the actuators are water pump, aeration pump, warmer lamps, greenhouse light, exhaust fan, evaporative cooler, and fish feeder. The microcontroller also sends signal to the owner's smartphone by Wi-Fi through GSM shield for monitoring process. Other than that the parameters data can also be monitored in a laptop by using NI LabVIEW software.

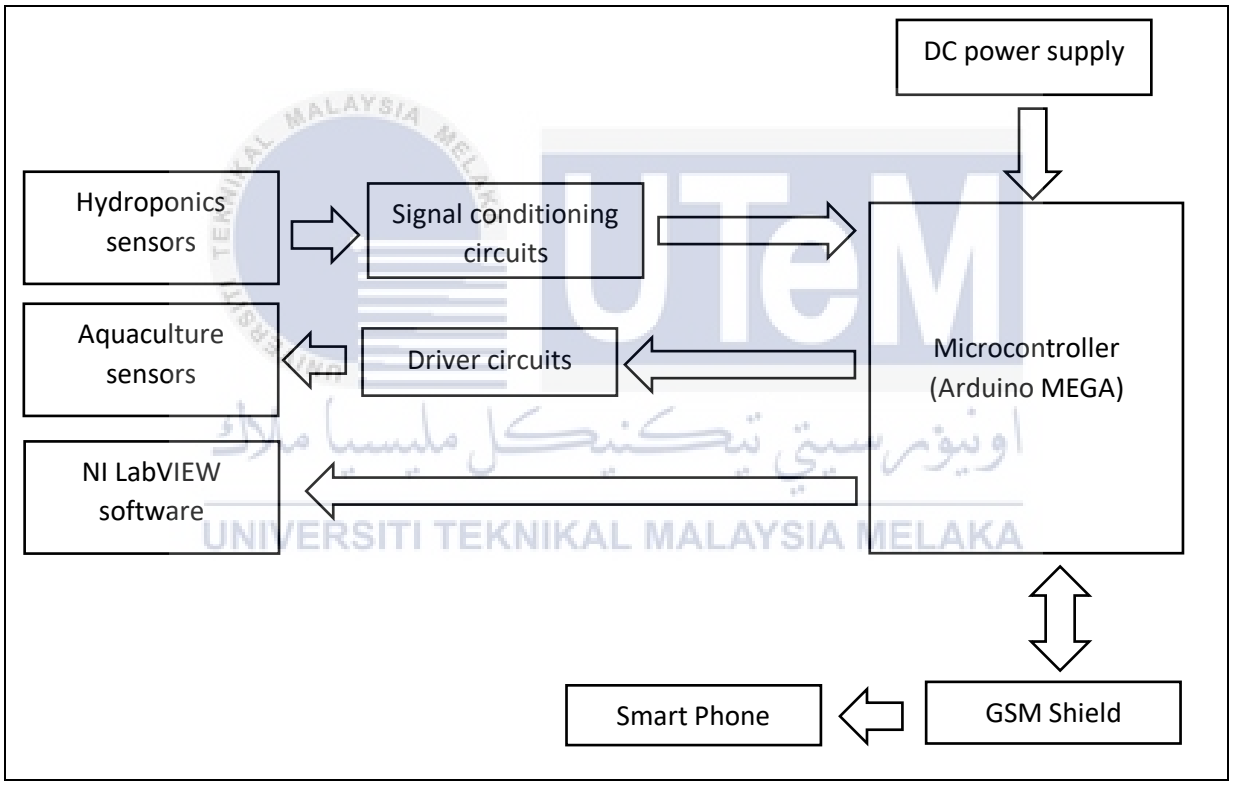

Figure 2.2.1.1: Block diagram of the Aquaponics control and monitoring system

This research is being carried out because two of the main sectors that provides food security in Oman are agriculture and fisheries. So the problems they faced when dealing with this sectors is the lack of fertile land and limited irrigation water which is a big problem for them. In order to overcome this obstacle, food production by using soil-less method of agriculture is being researched and it is being combined with technological and scientific researches. The parameter used is temperature, humidity, carbon dioxide level, light intensity, pH level, dissolved oxygen level and water level. The experimental data and analysis of results achieved by the researches is shown below by using figures and tables:

Table 2.2.1.1: Greenhouse control and monitoring system results in testing environmental parameters read from sensors, actuator status, GSM shield notification, and temperature

Greenhouse Control and Monitoring System									
	Environmental Parameters read from Sensors			**Status of Actuators**				**SMS from GSM shield**	**Outside Air Temperature using Thermometer (°C)**
Time	**T_{air} (°C)**	**Relative humidity (%RH**	**CO2 (ppm)**	**F**	**E**	**G**	**W**		
8.00	34	54	617	1	1	0	0	0	37.6
9.00	35	52	612	1	1	0	0	0	38.3
10.00	36	51	608	1	1	0	0	0	39.9
11.00	36	50	603	1	1	0	0	0	40.1
12.00	37	48	598	1	1	0	0	0	40.6
13.00	37	47	595	1	1	0	0	0	41.3
14.00	39	42	595	1	1	0	0	0	42.6