

# Faculty of Electrical and Electronic Engineering Technology



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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

## DEVELOPMENT OF AUTOMATED HYDROPONIC SYSTEM MONITORING USING IOT MESH NETWORK BASED ON ESP8266

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#### DECLARATION

I declare that this project report entitled Development of automated hydroponic system monitoring using IoT mesh network based on esp8266 microcontroller is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



# APPROVAL

.....

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours



#### ABSTRACT

Hydroponic agriculture is a type of modern agriculture that allows for the production of healthy plants and vegetables. The majority of individuals nowadays want a garden in their homes. On the other hand, most individuals have trouble growing plants in their homes. It's due to a lack of available planting space at their home. Aside from that, they struggle to determine how much water the plants require and the existence of variable weather, which can cause the plants to wilt. An automated hydroponics system based on an IoT mesh network employing an esp8266 microcontroller was developed to address these issues. The IoT mesh now network, powered by an esp8266 microcontroller, will aid in collecting data collected by sensors, allowing for analysis. The hydroponics grower will have complete wireless management of the grow room atmospheric conditions, with user-inputted sensor thresholds that, if exceeded, will warn or take action as needed. Through the approaches adopted, integrated farming with an IoT mesh now network will be efficient for the automated hydroponic system.

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#### ABSTRAK

Pertanian hidroponik adalah sejenis pertanian moden yang membolehkan pengeluaran tumbuhan dan sayur-sayuran yang sihat. Majoriti individu pada masa kini mahukan taman di rumah mereka. Sebaliknya, kebanyakan individu menghadapi masalah menanam tumbuhan di rumah mereka. Ini disebabkan kekurangan ruang penanaman di rumah mereka. Selain itu, mereka bergelut untuk menentukan jumlah air yang diperlukan oleh tumbuhan dan kewujudan cuaca yang berubah-ubah, yang boleh menyebabkan tumbuhan menjadi layu. Sistem hidroponik automatik berdasarkan rangkaian jaringan IoT yang menggunakan mikropengawal esp8266 telah dibangunkan untuk menangani isu ini. Rangkaian rangkaian IoT kini, dikuasakan oleh mikropengawal esp8266, akan membantu dalam mengumpul data yang dimasukkan pengguna yang, jika melebihi, akan memberi amaran atau mengambil tindakan mengikut keperluan. Melalui pendekatan yang diterima pakai, perladangan bersepadu dengan rangkaian IoT kini akan menjadi cekap untuk sistem hidroponik automatik.

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#### **CHAPTER 1**

#### **INTRODUCTION**

#### 1.1 Background

In a well-managed hydroponic system, plants can be produced twice as quickly as in soil. Furthermore, because hydroponic farming takes place indoors in a climatecontrolled environment, farms can be established in areas where the weather and soil conditions are unfavorable. Hydroponics is a plant production technique that does not use soil and makes use of water and nutrient solutions only to grow plants. The deep flow technique and nutrient film technique are commercially used hydroponic systems to grow leafy vegetables. [2]. Most plant factories make use of hydroponics because of their added advantage of automated control of fertilization and irrigation which also saves labor. [3]. Indoor or greenhouse growing conditions keep the environment clean and control pests and diseases. [4]. The booming internet of things(IoT) is becoming an area of interest for researchers and industrialists. Increased plant yield and reduced maintenance cost can be observed in hydroponics employing IoT. [5]. The Internet of Things (IoT) is used in this project to create an automated hydroponic system. Sensors such as temperature and humidity sensors, water level sensors, and soil moisture sensors are used in IoT to monitor plants. The use of IoT has enabled the user to keep track of the hydroponic culture. The temperature sensor installed in the hydroponics system can detect temperature loss. It can measure the moisture content of the plant, which is crucial for its growth. It also includes a water level sensor that can check by the user if the water level falls below a certain level.

The user can check about the plant's condition if IoT is used in this project. As a result, the goal of this project is to create an IoT-based monitoring hydroponic system. This project will allow the user to keep track of plant health in real-time.

#### **1.2 Problem Statement**

One of the issues that might harm plants is unpredictably changing weather. Sea-level rise, extreme events, health, energy use, and water supply are the five key climate hazards that cities face. Extreme events and water scarcity are two of the five threats that pose the greatest threat to traditional farming systems. Droughts, heatwaves, windstorms, and floods make outdoor farming tough to grow.

Furthermore, the difficulty in monitoring the level of water when planting plants is an issue. Planting that did not self-water required daily attention to detect soil moisture and water as needed. Under and overwatering are also regular occurrences if the plants are not inspected frequently enough to determine if there is too much water. Watering the plant without knowing the volume of water is common. If the plant receives too much or too little water, it may wilt. It can also impact the plant's humidity.

Lastly, the main problem of this project is the difficulty in monitoring the plant's need and sand conditions from all over the area. The major challenge is to receive data from all the nodes to one access point. People who stay far away from their farming land are facing more difficulty in notifying the plant's conditions every day.

#### **1.3 Project Objective**

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This project aims to develop an Automated hydroponic system monitoring using an IoT mesh network to help people with indoor planting. The following objectives must be met in order to attain the goal.

- a) To design a web-based interface for status monitoring of indoor garden complete wirelessly with user-inputted sensor.
- b) To develop an IoT monitoring system based on several nodes connected to a mesh now network and deliver all the information collected by the sensors to hydroponic growers.
- c) Evaluate the functionality of an IoT monitoring system for hydroponics.



#### 1.4 Scope of Project

The goal of this study is to grow plants using an Internet of Things mesh network to monitor an automated hydroponic system. The goal of this initiative is to assist those who are interested in indoor gardening at home. Several project scopes have been identified in order to achieve project objectives.

- a) This project allows for autonomous hydroponics environment monitoring using a variety of sensors such as temperature and humidity sensors, water level sensors, and soil moisture sensors. Users may watch their plants in real-time over the web.
- b) The system control unit is embedded with a Wi-Fi module and all the nodes will perform in a mesh now network to display the condition of the plant from different areas.
- c) The system is analyzed and investigated the functionality of the IoT monitoring system. UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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#### CHAPTER 2

#### LITERATURE REVIEW

#### 2.1 Introduction

This chapter looks at what has been achieved based on previous research. The automated hydroponic system, related work with this project, and development techniques to be used to design the mesh network hydroponic system will be described as subtopics. This chapter is jam-packed with information and research culled from the internet, books, and journal papers.

#### 2.2 Automated hydroponic system

An automated hydroponic system will help to solve the problem stated in Chapter 1, which is that there is a limited area for planting, especially for those who live in a city zone, unpredictable weather, and it is difficult to check the amount of water. People will be able to monitor their plants using smart technology in automated hydroponics that uses additional nodes in a mesh network, such as temperature and humidity sensors, soil moisture sensors, and water level sensors. [1]

Overall health and quality of life, physical strength, fitness flexibility, cognitive ability, and socialization are all advantages of automated hydroponics. Environmental studies have shown that interacting with plants improves our mental health and productivity and may even improve our empathy and compassion.

Furthermore, monitoring a hydroponics system using multiple nodes in a mesh network can offer reliable data. Finally, stress reduction is the only benefit of an automated hydroponic monitoring system using an IoT mesh network when people are in a room with a few containerized indoor plants.

#### 2.3 Type of Mesh Network Nodes

A mesh network is a network in which devices (or nodes) are linked together and branch off one another. These networks are designed to transport data efficiently between devices and clients. They assist organizations in maintaining a continuous connection across a physical place.



Figure 2.1 The Type of Mesh Network

Full mesh and partial mesh topologies are the two types of mesh topologies. When every node in a network has a circuit connecting it to every other node, it is known as full mesh topology. Full mesh provides the most redundancy, as network traffic can be routed to any of the other nodes if one fails. Backbone networks almost always use full mesh. Some nodes in a partial mesh network are structured in a full-mesh design, while others are only connected to one or two other nodes in the network. In peripheral networks coupled to a full mesh backbone, partial mesh topology is typical. Partial mesh topology is less expensive to implement than full mesh topology, but it provides less redundancy.

### 2.4 Related Work

The sensors, light-emitting diode lamps, water spray, and pump may effectively reduce CO2 levels and temperature while dramatically increasing water levels. [2] Hydroponic farming can also be better regulated in a greenhouse or indoor farming environment because of the surrounding conditions, according to the report. Hydroponic farming can also be better regulated in a greenhouse or indoor farming environment because of the surrounding conditions, according to the report. The unit area parameters are mechanically managed by ensuring that the plant receives all nutrients from the water solution. Furthermore, by utilizing IOT software, the cultivator can understand the conditions of plant growth and regulate the parameters remotely. This project used an Arduino microcontroller with three detector types: temperature sensor, pH detector, and LDR for each plant 1 and plant 2. A relay is utilized to automatically turn on and off the water supply to the pumping motor, and an ESP8266wifii module is used to communicate with the server via the internet of things.

The proposed project is about hydroponic farming, which is a method of growing plants without the use of soil or sunlight. [3] It is vital to building a farming system that is low-cost and easy to maintain and control critical variables such as light, water level, temperature, and humidity throughout the year. As illustrated in Figure 2.2, this project has been implemented as a NodeMCU microcontroller kit that can connect to the Wireless Sensor Network through the internet and measure humidity, temperature, and water level. The smart hydroponic farm's real-time data is collected using the sensors and other peripherals listed below. Blynk and ThingSpeak, two IoT-related platforms, were used in this project. API-based architecture is used to control and track the smart hydroponic farm.



Figure 2.2 Proposed Architecture

PlantTalk is a smart hydroponic plant factory system based on the Internet of Things. [4] PlantTalk, according to the business, can use a smartphone to configure connections for a variety of plant sensors and actuators. This project simplified the process of developing Python applications for plant-care intelligence on smartphones. The plant-care intelligence includes automatic LED illumination, water spray, and a water pump. The gardener may monitor sensor data in real-time via smartphone, but in this experiment, the user had to manually regulate the actuators. Figure2.3 shows the PlantTalk functional block diagram, which is connected to the control board through a few sensors and actuators. For agricultural surveillance, the sensors were critical. A temperature sensor, pH sensor, humidity sensor, CO2 sensor, O2 sensor, water level sensor, and timer are now included on the control board. This project also allowed them to integrate a camera into their smartphone apps, allowing them to remotely monitor the plants that the sensors and actuators were looking after. Using any smartphone's browser, the web based PlantTalk GUI may be used to link all plant IoT devices. The data is delivered from the control board to the PlantTalk server over Ethernet or Wi-Fi.



Figure 2.3 PlantTalk functional block diagram

The pH, water level, ambient temperature, and relative humidity are all constantly monitored in this project to give the ideal environment for plants to flourish in. [5] Irrigation is controlled by water and nutrient input. Sensor-collected data and cloud-based technologies serve as the backend, allowing users to store, manage, apply, and share information through the internet. This project used the Raspberry Pi to collect data from the server and relay data from the temperature and humidity sensor, pH level sensor, and water level sensor. To monitor system nutritional conditions, a water pump was used to control machine water inflow, as well as temperature and humidity sensors. Data from hardware control systems is received by Firebase in two modes: real-time and batch time. Following that, data from the Firebase cloud service is gathered and displayed on a website app. The software was designed to be user-friendly on both desktop and mobile platforms. In a nutshell, a command acquired from Google Firebase, a cloud service that enables real-time sensor logging, is used to monitor components in the hydroponics system using the Raspberry Pi.

Their project explains how hydroponic farmers and the Cyber-Physical Social System collaborate (CPSS). [6] A CPSS is a collection of physical and social systems that are broadcast through the internet or over a network. To combine all sensors, the Raspberry Pi must be utilized doing the introduction of the CPSS hypothesis, hydroponic farmers were able to collaborate. A light sensor, a temperature sensor, a moisture sensor, and a nutrition sensor are among the sensors used. Furthermore, the Telegram conversation was used as a social media platform for interactions between farmers and between farmers and Bots. A Bot is a Python-based telegram bot that communicates between sensors and farmers.

A model gardening system with soil moisture, temperature, water sensor, growing light, and Android is included in IoT Planting for the Elderly. [7] This design used the Arduino Uno Wi-Fi, which has an inbuilt Wi-Fi module, as seen in Figure 2.4. The sensors are connected to the Arduino via the DHT22 soil moisture and water detector. Temperature and humidity have been measured using the DHT22. The water sensor was also employed to monitor the water level, and soil moisture was used to determine volumetric water content at the root level of the soil stack. The grow light and water pump with power supply are shown in Figure 2.4, which provide light for the photosynthesis cycle and water to the plant, respectively. To save data, this project used cloud technologies and PHP MySQL.



Figure 2.4 IoT Planting Components

Title	Author	Category	Focus Area	Control Board	Type of Sensor
Automating and Analysing Greenhouse Hydroponic Farms using IoT	(Keerthana, S. Devika, K.Sathiyadevi ,S. Priyanka, 2018)	Hydroponic	-	Arduino	<ul> <li>Temperature</li> <li>pH</li> <li>LDR</li> </ul>
at M	LAYSIA MC.				
A Novel Approach forSmart Hydroponic Farming Using IoT	(Rajkumar et al., 2018) ل مايسيا RSITI TEF	Hydroponic	Home (	NodeMCU	<ul> <li>Humidity</li> <li>Temperature</li> <li>Water Sensor</li> </ul>

Table 2.1 Comparison of previous work

PlantTalk: ASmartphone- Based Intelligent Hydroponic Plant Box	(LD. Van et al., n.d.)	Hydroponic	Home	Arduino ESP8266 ESP-12F	•	Temperature pH Humidity CO2 O2 Water Level
NOT Hydroponics Management System	(Aliac & Maravillas, 2019)	Hydroponic		Raspberry Pi	•	Temperature Humidity pH Water Sensor
IoT Planting: Watering System Using Mobile Application for the Elderly	(Lekjaroen et al., 2016)	Non- hydroponic	) ٽيڪ MALAY	Arduino Uno پور سيې SIA MELAK		Temperature Humidity Soil moisture Water sensor

Several scientists are also working on hydroponic and non-hydroponic plants. Arduino, NodeMCU, and Raspberry Pi all employ a variety of control boards in their designs, even though they are two different sorts. The microcontroller is a crucial component in the project's development. A sensor will be built into the microcontroller. We also make use of a range of sensors that might help the plant flourish. Sensors for temperature, humidity, pH level CO2 level, O2 level, water level sensor, and LDR are some of the sensors used in the facility. The data from the sensor will be transmitted to the cloud, where it will be analyzed.

Title	Author	Type of Notification	Ту	pe of Control Board
			•	Gizduino
Air Pollution and Particulate	(Caya et al.,	Email	•	Raspberry Pi 2
Matter Detector Using	2018)			
Raspberry Pi with IoT Based				
Notification				
			•	Arduino
Automatic Home Appliances	(Shingala &Patel,	SMS		
and Security of Smart Home	2017)			
with RFID,SMS, Email, and	>			
Real-Time Algorithm Based				
on IoT				
Design Alternatives for End User Communication in IoT Based System Model	(Anvekaretal.,n.d.) EKNIKAL MAI	بیونر س <sup>Elegram</sup>	او دم	Raspberry Pi
Healthcare based on IoT	(Gupta et al.,2016)	SMS	•	Raspberry Pi
usingRaspberry Pi				
Home Automation using Telegram	(P.N.V.S.N Et al.,2017)	Telegram	•	Raspberry Pi

# Table 2.2 Comparison of notification

Energy-Efficient IoT- Enabled Fall detection system with Messenger-Based Notification	(Moretti etal., 2017)	Telegram	•	Raspberry Pi 3
IoT Based Home Security System Using Raspberry Pi with Email and Voice Alert	(Rani et al.,2018)	Email	•	Raspberry Pi 3
Internet of Things (IoT) for building Smart Home System	(Malche,2017)	Email	•	Arduino Nano
IoT based Smart Home Automation System using Sensor Node	(Singh et al.,2018)	sms ومرسيتي	•	NodeMCU ESP8266 Arduino Uno
UNIVERSITI TER IoT Based Smart Agricultural Device Controlling System	(NIKAL MALA) (Abagissa et al., 2018)	(SIA MELA SMS	eK.	Arduino Mega

#### 2.5 Development Techniques

In the IT sector, the Internet of Things is a new paradigm shift. "Internet of Things" is made up of two words: "Internet" and "Things." [11] There is no uniform explanation of the Internet of Things that is adequate for the global user community. Academics, researchers, practitioners, inventors, developers, and businesspeople are just a few of the groups that have defined the term. "A robust and open network of intelligent devices capable of self-organizing, sharing information, data, and resources, reacting and acting in the face of environmental events and changes," is the best definition for the Internet of Things. There are numerous advantages to IoT or connection. Machine-to-Machine communication is made possible via the Internet of Things. As a result, the physical systems can stay connected, allowing for absolute transparency with lower inefficiencies and improved quality. Because of the interaction and control of physical things with wireless infrastructure electronically and centrally, there is a lot of automation and control in the work. Without human involvement, machines can communicate with one another, resulting in faster and more timely output. Finally, the Internet of Things is incredibly efficient and time saving. As a result of the machine-to-machine contact, efficiency is improved, and precise results can be obtained rapidly. This results in significant time savings. This frees up people's time to pursue other creative endeavors rather than doing the same activities every day.

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#### 2.5.1.1 Internet of Things (IoT)

The Internet of Things is a new paradigm change in the IT world. The phrase "Internet of Things" is made up of two words, the first of which is "Internet" and the second of which is "Things". [11] There is no uniform explanation of the Internet of Things that is adequate for the global user community. Academics, researchers, practitioners, inventors, developers, and business people are just a few of the groups that have defined the term. "A robust and open network of intelligent devices capable of self-organizing, sharing information, data, and resources, reacting and acting in the face of environmental events and changes," is the best definition for the Internet of Things. There are numerous advantages to IoT, which include connectivity.

Machine-to-Machine communication is facilitated by the Internet of Things (IoT). As a result, physical systems can stay connected, allowing for comprehensive transparency while reducing inefficiencies and improving quality. Furthermore, there is a significant amount of automation and control in the work as a result of the interaction and control of physical items with wireless infrastructure electronically and centrally. Without the need for human involvement, the robots can communicate with one another, resulting in more rapid and accurate output. Finally, the Internet of Things is extremely time-saving and efficient. Efficiency is improved as a result of machine-to-machine communication, and precise results can be achieved quickly. This results in significant time savings. This frees up people's time to pursue other creative endeavors rather than doing the same activities every day.

#### 2.5.2 Thingspeak

Thingspeak is a web-based open API IoT source information platform that can store sensor data from a variety of "IoT applications" and display the sensed data in graphical form on the web. Thingspeak communicates with the host microcontroller via an internet connection that acts as a 'data packet' carrier between the connected 'things' and the Thingspeak cloud, which retrieves, saves/stores, analyses, observes, and works on the sensed data. The word 'Channel,' which has fields for data, location, and status for various sensed data, is the most important component of Thingspeak functioning. Once channels have been constructed in 'Thingspeak,' data can be incorporated, or the information can be processed and seen. [12]

There are several advantages to using Thingspeak, but the most essential feature that sets it apart from its competitors is the ability to build public channels, which encourages a sense of community. Using spline charts, the API makes it very simple to visualize the data obtained. As a result, it is more aesthetically appealing and easier to examine collected data than other open-source APIs.

Furthermore, while uploading data to the API, Thingspeak has a problem in that it only allows one update per channel every fifteen seconds. We assume the upload limit was imposed because of thepotential for excess bandwidth consumption, which would result in greater costs for ThingSpeak as a non-profit business.

#### 2.5.2 Black box Testing

There is no need to examine the code in black box testing because it is based on the requirements specifications. Only the tester knows the set of inputs and predictable outputs, therefore this is entirely based on the consumers' point of view. Black box testing is important in software testing since it helps to validate the system's overall functionality. Black box testing is done from the standpoint of the end-user. From the start of a software project's life cycle, black box testing is performed. All members of the testing team must be involved from the start of the project. The fundamental benefit of black-box testing is that it eliminates the needfor testers to have specific programming language knowledge, as well as knowledge of the implementation. Another advantage of black-box testing is that it aids in the detection of inconsistencies or ambiguities in requirements specifications. [13]

# 2.6 Summary

The past study on the issue of this project was discussed in the Literature Review chapter. By completing some work, we can find that numerous efforts have been made to develop IoT in hydroponics. Various strategies have been used in the hydroponic system. There is also a notification that the data can be provided to the user.

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#### **CHAPTER 3**

#### METHODOLOGY

#### 3.1 Introduction

This chapter discusses the proposed methods for developing an IoT-based hydroponic system. The methodology describes the approaches and techniques used to complete the project by the project's goals. In general, approaches and techniques in specification, design, programming, and testing were elaborated.



Figure 3.1 depicted the four stages of the project's completion. The project's specifications were the initial phase. Background of study has been undertaken in the specification to determine the factors and variables to be employed in finishing the project. Background research was undertaken on a hydroponic system that will use IoT in this project. Design is the second phase. After the first phase is completed, this phase will begin. This chapter explains how to create a project prototype. The programming phase follows, in which the hardware and software components are developed. This stage also explains the technique and tools that will be used to merge the hardware and software components. Testing is thefinal stage of this project's development. This phase will describe the tasks that will be carried out during the testing phase.

#### 3.3 Design

Design is the next stage of the approach. Designing the system flow, developing the sensor node, and designing the circuit diagram are all part of this process. It will make it easier for the developer to complete the project.



Figure 3.3 Project estimation general process flow



Figure 3.4 Mesh network estimation general process flow

#### 3.3.1 Design Sensor Node

The second objective for Phase 2 is to create a block diagram for the sensor node. Microsoft Visio can also be used for the second job. The core aspect of IoT architecture is the design block diagram. This phase demonstrates how they work together to gather, store, and process data.

#### 3.3.2 Design Circuit Diagram and Schematic Diagram

Following the completion of the second work, the next task will be to create the circuit diagram and schematic diagram. The second portion of the assignment focuses on creating the schematic circuit diagram, which is accomplished using Fritzing. The schematic diagram of the hardware component prototype will be sketched and viewed using Fritzing.

#### 3.4 Programming

Last but not least, programming takes place before the final step. This procedure explains the strategies and tools needed to design hardware and software, as well as how to integrate hardware and software components.

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#### **3.5** Develop Hardware

#### 3.5.1 NodeMCU (ESP8266)

It is self-contained, a microcontroller with a CPU, memory, and peripherals can be used as an embedded system. NodeMCU is an open-source firmware and development kit for Internet-of-Things (IoT) device development and prototyping. It uses the ESP8266, a low-cost Wi-Fi chip with complete TCP/IP capabilities.



Figure 3.5.1 NodeMCU (ESP8266)

#### 3.5.2 Temperature and Humidity Sensor

To give temperature and humidity information, temperature and humidity sensors are used. These are the primary sensors that keep track of the system's nutrition. Because these sensors provide the cornerstone for the plant's growth, safety management, and maintenance, they must be exceedingly accurate.



Figure 3.5.2 Temperature and Humidity Sensor (DHT22)

## 3.5.3 Water Level Sensor

Water level sensors are used to monitor the number of substances that may flow. The sensors alert the operator to any potential property damage caused by a leak, as well as when a container is close to being emptied.



Figure 3.5.3 Water sensor level

# 3.5.4 Soil Moisture Sensor

The moisture content of the soil is sensed by the moisture sensor in the soil. It consists of two conductors, referred to as electrodes, that are separated by a smalldistance. It features Vcc, ground, and signal pins in addition to the digital pins, which produce a high or low output. The analog value proportional to the amount of soil moisture is given by the signal pin.



Figure 3.5.4 Soil Moisture Sensor

#### 3.5.5 LM 2596 buck module with display

The DC-DC Buck Converter (LM2596) with Display is a DC/DC stepdown voltage regulator that converts input voltage between 3.2V and 40V into a smaller voltage between 1.25V and 35V, capable of driving a 3A load with excellent line and load regulation.



# 3.5.6 Ads1115 analog to digital converter

The 16-bit chip ADS1115 is an analog to digital converter that processes the analog signal to digital data and sends it via I2C bus to the Raspberry Pi. The ADC module can be easily plugged on the GPIO header. So analog sensors and other accessories can be used.



Figure 3.5.6 Ads1115 analog to digital converter

#### 3.5.7 Develop Hardware with Software Component

The second job is to create hardware with software components. Following the completion of the hardware component, the development of the hardware with software components will begin to achieve the intended function. The software component is cloud-based and hardcoded. The ArduinoIDE allows for hard coding. Because Arduino IDE supports a wide range of controller boards, it is a popular choice for developing IoT projects. Finally, a database was required for this project to store the data transmitted by the sensor.

#### 3.6 Testing

The testing step is the final phase of the process. Sensor testing and sensor-cloud connectivity are two tasks that must be completed during this phase. The Black boxTesting approach is used to analyze the response time and offer a fully functional and useful project.

#### 3.6.1 Sensor Testing

The first task is sensor testing. After developing the hardware component, all the sensor components will be tested to know whether the sensor is functioning or not. Three different sensors will be tested are temperature and humidity sensor, water level sensor, and soil moisture sensor. The test will be conducted where the researchers will provide the stimuli to the sensor.

#### 3.6.2 Connectivity between Sensor and Cloud-Based

The second task is connectivity between the sensor and the cloud-based testing will be conducted after the sensor testing is perfectly working. This task will determine whether the connection between the hardware component and software components is correct. The researchers will check the individual connection between the sensor, database, and monitoring dashboard showing the data in statistics.

Table 3.6 The details of testing phase

Task(s)	Techniques/Tools	Deliverable
Sensor testing Connectivity between sensor and cloud-based	Blackbox Testing Method	Functionality and usefulness of IoT Based Hydroponic System

## 3.7 Summary

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Chapter 3 described the general what were steps taken in completing the prototype. The general phases have four phases which are specification, design, programming, and testing. The significance of methodology is to plant the research from the beginning of the project until the scope and objective are achieved. This methodology also gives guidance to the researchers to complete their projects as planned.

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### **CHAPTER 4**

#### **RESULTS AND DISCUSSIONS**

#### 4.1 Introduction

In this chapter, results and findings of this project will be discussed in detail. This will be done based on analysis and statistic of conducted evaluation. This chapter will be discussed the functionality evaluation which fulfills the requirements of objective three (3): To evaluate the functionality of IoT Monitoring Hydroponic.

However, objective one (1) and objective two (2) requirements had been fulfilled before proceeding with the testing phase. Figure 4.1 proved that objective (1): To design a web-based interface for status monitoring of hydroponic wick system has been fulfilled up to the requirements. Moreover, Figure 4.2 shows the prototype of an IoT monitoring system for hydroponics in a small space which fulfills the requirements for objective (2).



Figure 4.1.1 Dashboard IoT Based Monitoring Hydroponic System



Figure 4.1.2 Hydroponic System with completed prototype

## 4.2 Testing Description

The system is tested to ensure that it functions properly. The sensor data was collected during the testing period of seven days. The testing took place over the course of seven days, starting at 10 AM each day. Three soil moisture sensors, a water level sensor, and temperature and humidity sensors are used in the testing for each pot. Water level sensors and soil moisture sensors are the main testing areas for this project. However, this information will also be gathered for DHT22. Before testing a sensor to obtain the actual result, the expected result data for each sensor must be entered.

The DHT22 is the project's initial sensor to be used. The DHT22 is used to measure the environment's humidity and temperature. Temperature and humidity are crucial for maintaining a healthy plant since they have an impact on the growth of the plant. However, since temperature and humidity are unable to predict the predicted outcome, DHT22 does not have a specified task. The only purpose of temperature and humidity is for data collection. Water level is detected by the second sensor. The water level in the container will be determined by a water level sensor. The level of water must be measured first as an expected outcome before data collection may begin. The ruler will be used to gauge the water's level.

Soil moisture sensor is the final sensor. According to this sensor, the soil either "Moistures" or "Does Not Moisture." This sensor has been tested on new, dry soil before the testing phase ever began. This is done in order to assess if the soil need irrigation or not. The plant "Needs Watering" if the soil moisture sensor reading is greater than 533 and "Does Not Need Watering" if the reading is less than 533. The plant needs to be watered to see whether the soil moisture sensor is functioning properly or not if it displays more than 533 on that particular day.

The form that was to be completed as an expected outcome prior to the testing is shown in Table 4.1. Table 4.2 is the following table. The form that had to be completed during the testing is shown in Table 4.2. There are only 10 data to test when filling out the form.

Table 4.2.1 Expected Result form								
Allen		Day						
Temperature	Humidity	Water Level	Soil 1	Soil 2	Soil 3			
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Table 4.2.2 Form Testing

Day 1							
No.	Temperature	Humidity	Water Level	Soil 1	Soil 2	Soil 3	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

## 4.3 Result and Findings

The results for each pot's DHT22, water level sensor, and soil moisture sensor are shown in this chapter's subchapter. Each sensor's data will be displayed in its own separate table in table. The statistics in the table were gathered at 10 AM. Additionally, a graph was created to summarise all the data.

#### 4.3.1 DHT22 sensor

The data from the DHT22 sensor are shown in Tables 4.3 and Table 4.4. The data for temperature are shown in Table 4.3, while the data for humidity are shown in Table 4.4. The surrounding temperature and humidity are displayed in the tables.

	TEKNIN	-	LAKA	Table 4	<b>.3.1.1</b> Dat	a of Tem	perature			
Days	Data	Data	Data	Data	Data	Data	Data	Data	Data	Data
Days	1	2	3	4	5	6	7	8	9	10
1	30.7	30.4	30.1	30.9	30.4	30.3	30.3	30.3	30.5	30.8
2	31.4	31.7	31.6	31.7	31.2	31	31	31.5	31.9	31.6
3	-31	31.6	32	31.7	32	31.1	31.7	32	31.6	31
4	29.2	29.6	29.5	29.9	29.7	29.1	29.2	29.9	_ 30	30
5	129.3 E	<b>F29IT</b>	29.3K	29.2	29.2	29.6	29.5 E	29.1	29.3	29.7
6	30.5	30	31	30.3	30.9	30.3	30.5	30.5	30.5	30.9
7	31	31.8	31.6	31	31	31.9	32	31.7	31.5	31.9

Table 4.3.1.2 Data of Humidity

Days	Data	Data	Data 3	Data	Data 5	Data	Data 7	Data	Data	Data
1	82	82.2	82.1	82	81.9	82	81.8	82	81.9	81.4
2	90.4	90.1	90	90.5	90.4	90.8	90.5	90.8	90.3	90.9
3	94.8	94.1	94.4	94.3	94.3	94.5	94.4	94.6	94.8	94.8
4	93.3	93.3	93.1	93.9	93.2	93.2	93.8	94	93.5	93.8
5	94.3	94.4	94	94.2	94.6	94	95	94	94	94.4
6	90	90	90.6	90.4	90.4	90.2	90.8	90.8	90.9	90.8
7	79	79.2	79.2	79.2	79.4	79.1	79.4	80	79.9	80

The temperature graph of the DHT22 sensor is displayed in Figure 4.5. According to the graph, Day 3 had the highest temperature and Day 5 had the lowest. Additionally, the graph of temperature data displays increases and decreases. Throughout each day, the temperature changes. The range of temperature change, however, is between 0.1°C to 0.5°C.



The graph in Figure 4.6 displays the data on humidity. The graph indicates that Day 7 has the lowest humidity. Additionally, Day 3 has the greatest humidity statistics. The data are somewhat changing during the course of a day, according to Figure 4.2's data. Less than 1% of the data changes per day.



Figure 4.3.1.2 Humidity Chart

This investigation has shown that the DHT22 sensor is capable of detecting ambient temperature and humidity. The reason for this is that neither the temperature nor the humidity will vary by more than or less than 0.5°C. The sensor can be used to demonstrate that temperature and humidity sensors are effective because the changes in the data are marginally different.

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# 4.3.2 Water Level Sensor KNIKAL MALAYSIA MELAKA

The predicted value for the water level sensor is displayed in Table 4.5. The sensor used to gauge the water level in a hydroponic container is called a water level sensor. Before turning on the sensor, which is used to calibrate for water level, the predicted value is taken. Additionally, a ruler is used to establish the predicted value. Additionally, Table 4.6 displays the data that the water level sensor's 7-day data collection yielded. The sensor's data are measured in millimetres (mm).

Days	Expected Result
1	35
2	34
3	34
4	33
5	32
6	32
7	31

 Table 4.3.2.1 Expected Result for Water Level

 Table 4.3.2.2 Data of Water Level

Dave	Data	Data	Data	Data	Data	Data	Data	Data	_Data	Data
Days	1	12LA	1 S1.3	4	5	6	7	8	9	10
1	38	37.9	35.7	35.1	35.1	34.9	35.2	35.2	35.1	35.1
2	35.4	36.7	35.4	35.4	37.1	36.8	34.7	34.7	34.7	34.7
3	36.9	35.2	34.5	34.5	34.1	34.3	34.5	34.4	34.4	34.4
4	33.8_	37.3	33.8	33.4	33.8	33.8	34.1	33.8	33.8	33.8
5	34.7	37.6	33.7	33.2	33.2	33.5	33.2	33.2	33.2	33.2
6	38.2	35.5	32.9	32.9	32.2	33.1	33.1	33.1	32.9	32.9
7	33.3	37.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
	2	y all	alle		2	20,0	رسيج	اويبوم		
		4.0	44		1.1	-		14		

The graph in Figure 4.7 is based on the data in Table 4.6. The maximum data for the water level, 38.2 mm, is displayed on Day 6. The data can vary quickly for each day of the week. The water level sensors change the most on Days 6 and 7, from 33.2mm to 38.2mm and 37.5mm to 32.3mm, respectively. Day 6 and Day 7's changes are 5mm.



Figure 4.3.2.1 Water Level Chart

This research shows that the water level sensor is not working properly. According to observations made during the testing phase, if there are water waves on the container, the level of water can change quickly. Because of this, the water level might occasionally shift quickly. Additionally, the sensor position must be upright to obtain an accurate result. Additionally, the sensor occasionally struggles to recognise the true value when slowly submerged in water.

#### 4.3.3 Soil Moisture Sensor

In this project, there are three hydroponic pots. For the soil in tiny hydroponic pots, three soil moisture sensors had been tried. The anticipated outcome for each sensor is displayed in Table 4.6. All of the anticipated results show that the soil is "Wet." This is so that the soil in the miniature hydroponic pot may be fertilised using the nutrient solution used in this hydroponic project. That implies that the soil should be "Wet." If there is no nutrient solution in the container, the soil moisture sensor will turn "Dry."

Days	Soil 1	Soil 2	Soil 3
1	Wet	Wet	Wet
2	Wet	Wet	Wet
3	Wet	Wet	Wet
4	Wet	Wet	Wet
5	Wet	Wet	Wet
6	Wet	Wet	Wet
7	Wet	Wet	Wet

Table 4.3.3.1 Expected Soil Moisture

The results of the soil moisture sensor for tiny pot 1 are reported in Table 4.8. Most of the data in this table indicate that the plant in the pot is "Wet." Only two statistics from Day 2 suggest that the plant is "Dry," nonetheless.

Days	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8	Data 9	Data 10
1	480	490	494	480	489	484	493	490	493	484
2	472	492	527	517	512	522	536	538	524	522
3	438	441	440	439	440	442	438	441	451	451
4	430	432	495	480	457	464	467	456	438	473
5	456	481	530	531	518	509	481	501	486	501
6	476	477	484	485	483	477	490	483	490	483
7	488	501 **	496	497	488	509	494	492	499	506

Table 4.3.3.2 Data of Soil Moisture 1

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The summarised data for soil moisture sensor is shown in Table 4.9. The data is lower than 533 on Day 2, Day 4, and Day 5. The plant is 'Dry,' according to this indication. However, it appears that the soil is damp for the majority of the day.

Davs	Data									
Days	1	2	3	4	5	6	7	8	9	10
1	450	453	455	460	460	455	453	459	457	452
2	522	532	511	530	532	505	492	523	532	564
3	473	479	478	487	483	479	473	478	476	480
4	481	518	514	535	546	541	532	529	504	534
5	476	525	506	484	500	534	504	480	493	496
6	403	405	414	412	405	418	407	405	417	417
7	456	459	481	484	464	469	469	463	467	488

Table 4.3.3.3 Data of Soil Moisture 2

The data from the soil moisture sensor for the small pot are summarised in Table 4.10. The plant is 'Wet,' as anticipated. In comparison to other days, the plant is "Dry" on Days 4 and 6. Additionally, Day 1 has the lowest data, which implies "Wet."

 Table 4.3.3.4 Data of Soil Moisture 3

Days	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8	Data 9	Data 10
1	387	400	393	394	388	390	390	400	399	396
2	437	442	437	443	439	442	443	437	437	439
3	387	396	392	400	395	389	388	395	395	389
4	489	544	532	543	534	522	539	523	492	487
5	402	411 **	413	415	<b>409</b>	404	414	414	410	417
6	432	535	527	545	540	538	523	510	494	498
7	423	443	442	439	433	442	435	424	444	455

Figure 4.8 displays the compiled information for Soil 1, Soil 2, and Soil 3's soil moisture on the micro pot. Tables 4.7, 4.8, and 4.9 are the foundation for the graph. Most of the value changes every day. Although most of the data are changing, the values are not changing very quickly.



Figure 4.3.3.1 Soil Moisture Chart

According to the investigation, each pot has three soil moisture sensors that can determine whether the soil is damp or not. As a result, the data will decrease and show that the plant doesn't require watering. The soil could stay wet for a very long time. Therefore, soil that has been watered directly will continue to be damp the next day.

#### 4.4 Benchmark Test

	ON	OFF	OFF	ON	OFF	OFF
	Mesh Node 1	Mesh Node 2	Mesh Node 3	Sensor 1	Sensor 2	Sensor 3
Days	Soil Moisture 1	Soil Moisture 2	Soil Moisture 3	Soil Moisture 1	Soil Moisture 2	Soil Moisture 3
1	480	450	387	459	-	-
2	472	522	437	523	-	-
3	438	473	387	478	-	-
4	430	481	489	529	-	-
5	456	476	402	480	-	-
6	476	403	432	405		-
7	488	456	423	463	-	-

 Table 4.4.1 Soil moisture under mesh hydroponic and wick system hydroponic.

The table above shows the two different project of hydroponic which is the mesh hydroponic set and the hydroponic wick system. Both projects used soil moisture sensors to find the soil moisture level, there have been used three soil moisture sensors which fixed in three different pots. The mesh hydroponic set is shown that whenever one of the nodemcu is a failure we can still get the soil moisture data because all three nodemcu have been connected as a mesh system. The hydroponic wick system is also used three esp node but it does not work as a mesh system which can send data of the soil moisture when it's complete in well working condition. The advantage of this project is we can see that the nodemcu is very useful to get the data even when there is one of the esp nodemcu failures.

#### 4.5 Conclusion

The results for each pot's DHT22, water level sensor, and soil moisture sensor are shown in this chapter's subchapter. Each sensor's data will be displayed in its own separate table in table. The statistics in the table were gathered at 10 AM. Additionally, a graph was created to summarise all the data.



#### **CHAPTER 5**

#### CONCLUSION

#### 5.1 Introduction

The summary of the IoT Based Monitoring Hydroponic System will be covered in this chapter. Additionally, this chapter will cover suggestions for this system's improvement. As a result, it will serve as a helpful reference for a developer who will work on this project in the future.

#### 5.2 **Project Contributions**

To make it easier for users to monitor their hydroponic plants, our research developed the IoT-Based Monitoring Hydroponic System. The environment's temperature and humidity may be checked by the user, which is crucial for plant growth. Additionally, hydroponic plants place more emphasis on soil moisture and water content. It is crucial for the user to be aware of the water level in order to keep the soil moist. Using the sensor, the user may determine the temperature, humidity, water level, and soil moisture for each pot. DHT22 sensors were utilised in this project to measure temperature and humidity as well as water level and soil moisture.

There are also online tools available for consumers to keep an eye on their hydroponic plants. The data from the sensor is sent to Thingspeak's database as soon as the user turns on the esp8266. The user can also read the data on the graph and be aware of the most recent data. As a result, the user is likely aware of any increases or decreases in sensor data.

## 5.3 Conclusion

In conclusion, the first goal of this project, which was to design a web-based interface for tracking the status of an indoor garden, has been accomplished. Utilizing Matlab Thingspeak, the web application was developed using the Windows platform. The second goal of the project, to create a prototype IoT monitoring system for hydroponics in a small space and at any time to monitor the plant, was also accomplished. By creating the prototype in a small area, the user will be able to cultivate hydroponic plants in their home with little room needed. The third and last goal of this research is to test the functionality of IoT monitoring for hydroponics. This was verified by the use of sensors. These outcomes demonstrated that the prototype performed as intended and consistently.

#### 5.4 Project and Limitations

There are a few problems and limitation of this project throughout the process of developing and testing. The problems and limitations are listed as follows:

i) DHT22 sensor which read the temperature and humidity of surrounding does not have the expected value. This cannot be done for testing DHT22 sensor.

i) The water level sensor found very difficult in determine the level of water.

### 5.5 **Recommendation for Future Work**

Numerous tasks had to be done in order to reach the project's goal during the development of this prototype. In order to finish this project, it was produced within the time constraints set forth. Future project improvements that can be suggested to create a better system in the future include:

i) Provide the other sensor such as light sensor and pH sensor. Both sensors are needed for hydroponic plant growth which light sensor required for the plant to get the amount of light and pH sensor for having the correct pH of nutrient solution.



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