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Smart Internet of Things System for Hydroponic

Muhammed Yusuf Mazlan[1], Siti Amely Jumaat[1]*,

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

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Abstract: A hydroponic system is a kind of plantation that uses water as the medium rather than soil. To assist in the development of urban agriculture, a large variety of smart automatic watering solutions have been introduced. These systems, however, are still not included in the action to apply controller water nutrient level, which is essential for boosting overall plants growth. In this paper, the technology is built by combining a typical farming system with a web interface for monitoring the status of the hydroponic system. First, the prototype was built, developed, and tested, and sensor was collected the data and analyze the results on a cloud-based web page through a mobile application. Next, the system is provided with LED indicators to show the current status of water nutrient level solutions to regulate supply chains. By producing the product from an outdoor plant, the user will be able to develop hydroponic plants in their home, requiring just a little amount of space. Lastly, the data collected consists of water level has been analyzed. According to the results, when the value of water is empty, LED blue and LED yellow will turn off, and LED red will turn on, with the LCD displaying "Water level: Low". When the water level is full, LED blue turn on while LED red and LED yellow turn off includes the LCD indicator "Water level: High". The system is operational 24 hours a day and power consumption is 22.86 Watt. These results showed that the product worked as expected and the overall cost of this project is RM1111.40.

Keywords: D1 Wemos Mini, Water Level, Hydroponic, HC-SR04, LCD Display, Relay 5V Module.

1. Introduction

Farming has been a human tradition since the beginning of time. With technological advancement, this farming activity has grown significantly. As a result of technological advancements, farming activities are changing in a variety of ways. Changes in plant types and planting methods start with the goal of the farming activity itself. The hydroponic farming method is one of them. Hydroponics is a

**Corresponding author: amely@uthm.edu.my*

crop cultivation method that does not use soil as a growing medium, instead relying on nutrient-rich water or minerals [1]. The term "Hydroponics" comes from the Greek word "Hydroponos," which means "water with power" [2]. Using the hydroponic planting method, farmers can directly carry out and monitor environmental control, nutrition, and water conservation [3]. This hydroponic method can be done vertically in a small space, such as a garden or seating area, involving little space. Hydroponic growing media must meet the following requirements: be water absorbent, allow for air circulation, and be inexpensive [2].

Despite the many benefits and conveniences that hydroponic technology provides, many farmers continue to use traditional farming methods in the midst of the covid-19 pandemic [4]. The Internet of Things (IoT) technology can be applied to this hydroponic system to help farmers carry out their responsibilities in the midst of the COVID-19 pandemic. Monitoring and controlling activities, as well as plant care that can be done anywhere and at any time, are among the benefits gained from the use of IoT in hydroponic farming activities. IoT is a network of physical objects or "things" that have been embedded with electronics, software, sensors, and connectivity to collect and exchange data [5]. The use of IoT devices is rapidly increasing nowadays. IoT is widely used in all sectors, including residential, industrial, and educational. The system in this project will use Arduino as its primary programming to monitor and control the water nutrient level. This is due to its adaptable, user-friendly hardware and software. The code is much easier to understand, and there are numerous examples to work with. It can send data directly to the farmer by combining the D1 wemos mini module.

2. Materials and Methods

Materials and methods define the procedures and tools required to develop hardware and software. When the hardware component is completed, the development of hardware with software components is proceeded. The software is hardcoded and hosted on the cloud. Hardcoding is supported by the Arduino IDE. Because it supports a large selection of controller boards, the Arduino IDE is a popular IDE for designing IoT applications. Lastly, a database was required for this project to store the sensor's data. The block diagram for hardware technique development is shown in Figure 1.

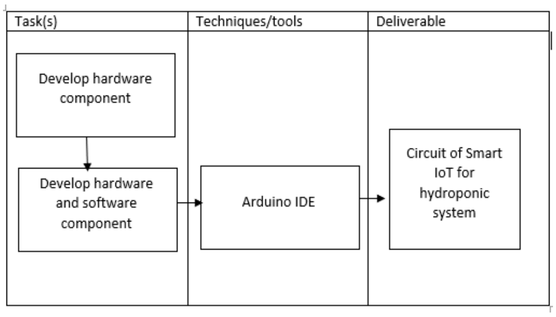


Figure 1: Details development of hardware phase

2.1 Hardware Component

A. WeMos D1

The Wemos D1 small is a low-cost "tiny Arduino with WIFI." It is built around the ESP8266 and features one analogue port and eleven digital connections. Micro USB is used to program it (or remote flash via WIFI). It is compatible with the Arduino IDE, micropython, and NodeMCU. It can be powered by 5V or 3.3V. All ports have logic levels of 3.3V. There are numerous example sketches included with the Arduino IDE. This makes it relatively simple to do what you want. They are compatible with the TMP36, DS18B20, RasPiO InsPiRing RGB LEDs, PIR motion sensors, and the BME280 barometric pressure/temperature/humidity sensors. Figure 2 shows the Wemos D1 mini microcontroller [5].

Figure 2: Wemos DI mini microcontroller.

B. Liquid Crystal Display (LCD)

A 16x2 LCD is a core component that is widely used in various devices and circuits as it is inexpensive and the programming is simple. As a result, there is no restriction on presenting unique characters and animations. A 16x2 LCD can display 16 characters per line, and there are two lines. On this LCD, there are two registers: command and data. The command registers save the instructions sent to the LCD by the command. A command issued to the LCD to do a task such as moving the pointer, managing the display, or cleaning the screen. Figure 3 shows the LCD 16x2 pin configuration [6].

Figure 3: 16x2 LCD display pin configuration.

C. HC-SR04 Ultrasonic Sensor

The HC-SR04 is a low-cost, easy-to-use distance measurement sensor with a range of 2cm to 400cm (about an inch to 13 feet). Two ultrasonic transducers help compensate the sensor. The transmitter sends out ultrasonic sound pulses, while the receiver receives for reflected waves. It is basically a SONAR that is used in tanks to identify underwater things. Figure 4 shows the HC-SR04 ultrasonic sensor.

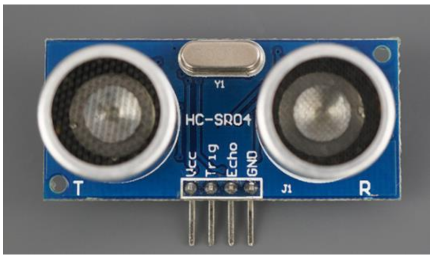


Figure 4: HC-SR04 Ultrasonic Sensor

D. Relay 5V Module

A relay is an electromechanical component that acts as a switch. DC powers the relay coil, allowing contact switches to be opened or closed. A coil and two contacts such as ordinarily open (NO) and usually closed (NC) are often included in a single channel 5V relay module (NC). Figure 5 shows the relay 5V module.

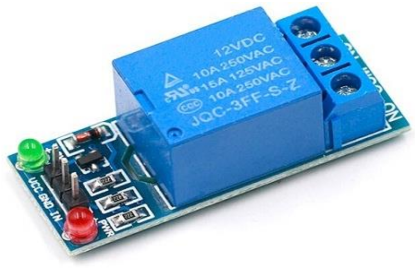


Figure 5: Ultrasonic sensor.

3. Results and Discussion

3.1 Project Design

Before creating the hardware for this project, it is important to understand the component arrangement. Sketch Up Pro 2020 software was used to create the three dimensional (3D) model design of the hydroponic system to ensure that it will be more realistic when making hardware in the future. Figures 6 illustrates the 3D model from differing viewpoints of the design.

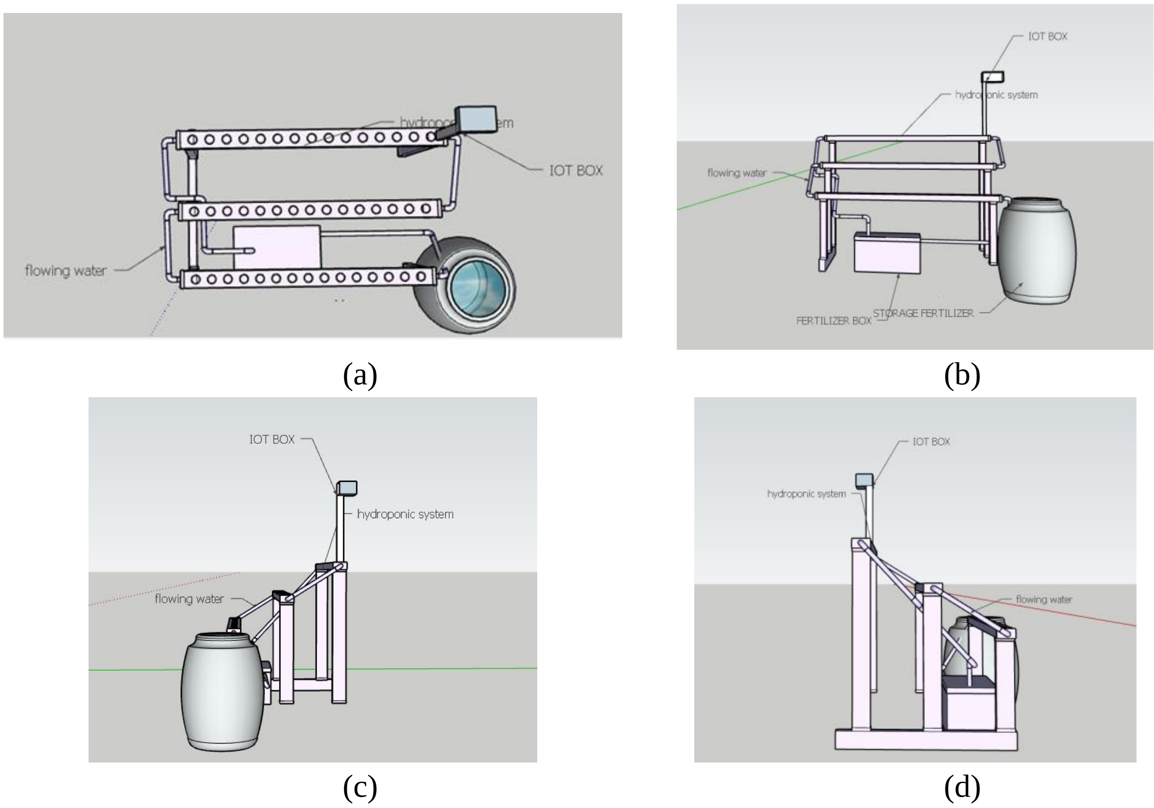
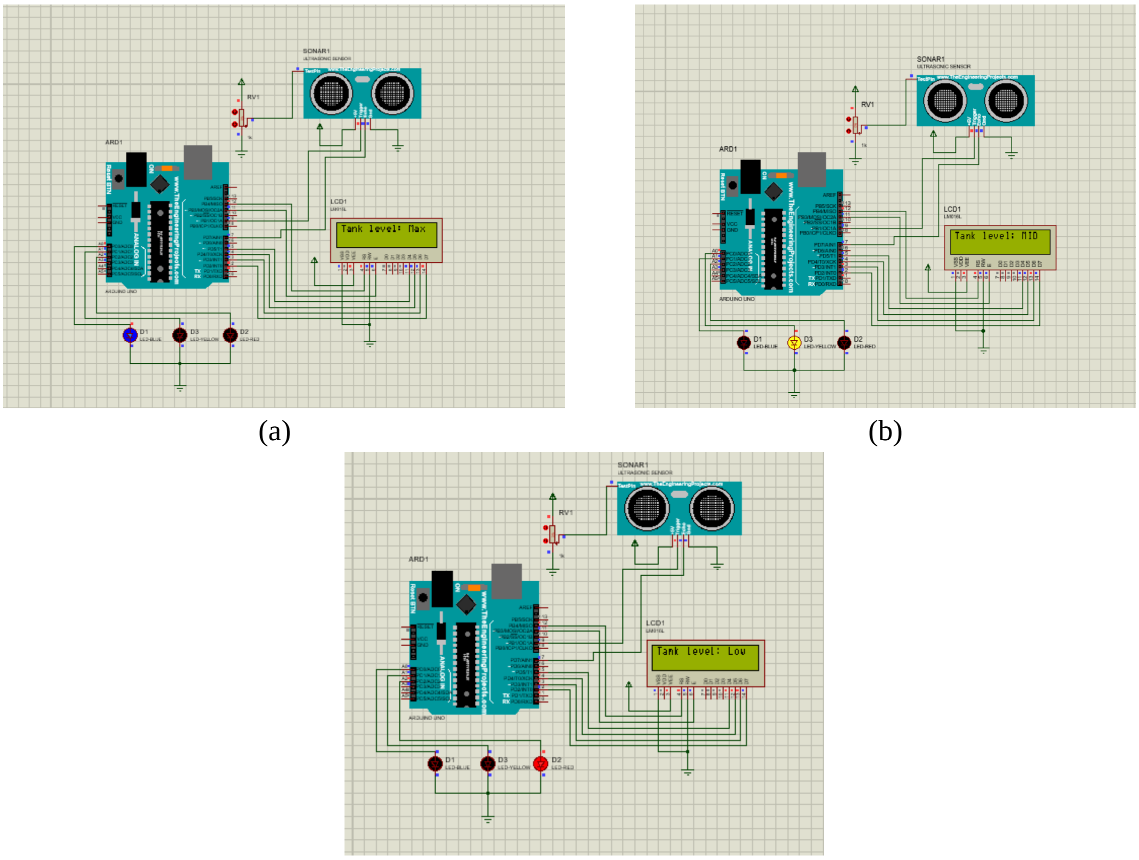


Figure 6: 3D model from (a) top view; (b) front view; (c) right view; and (d) left view of the project.

3.2 Circuit Design

Since Fritzing does not have simulation hardware, simulation was performed using Proteus software as an interface. The circuit consists of an Arduino uno, ultrasonic sensor, and a 16x2 LCD. The main encoding component, the Wemos D1 mini is replaced with an Arduino Uno. This is due to inadequate of a Wemos D1 mini library in Proteus. Even though it has been replaced, the system's coding remains unchanged. Figures 7 illustrates the circuit diagram for simulation ultrasonic sensor. It is observed that the LCD able show the water level condition.



(a) (b)

(c)

Figure 7: Circuit diagram of simulation ultrasonic sensor for (a) high; (b) medium; and (c) low water level situation

The simulation result of the water level sensor circuit is tabulated in Table 1. According to the results, when the value of water is empty, LED BLUE and LED YELLOW will turn off, and LED RED will turn on, with the LCD displaying "Water level: Low" to alert the user that the water level is low. When the water level is full, LED BLUE will turn on while LED YELLOW and LED RED turn off includes the LCD indicator "Water level: High" to notify users when the water level is high.

Table 1: Simulation Result.

WATER LEVEL	LED BLUE	LED YELLOW	LED RED	LCD
Empty	Off	Off	On	Tank level: LOW
Medium	Off	On	Off	Tank level: MID
Full	On	Off	Off	Tank level: HIGH

3.3 Blynk Application

Figure 8 shows Blynk template already installed on a mobile phone while Figure 9 shows a Blynk template already installed on a website. The Blynk application is used by the farmer as an interface to monitor and control the Hydroponic system. Each widget must be code connected and represented its system function as display and control.

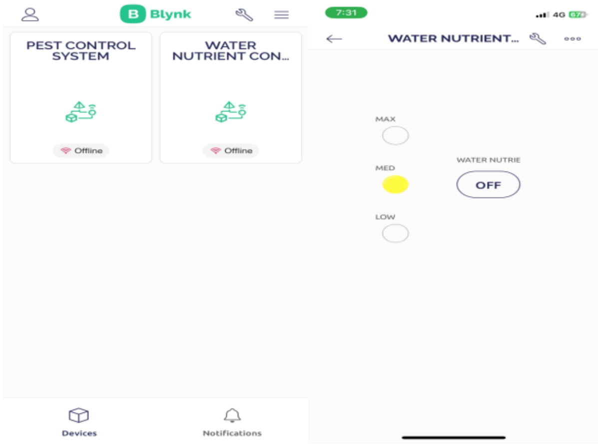


Figure 8: Blynk Application on a mobile phone

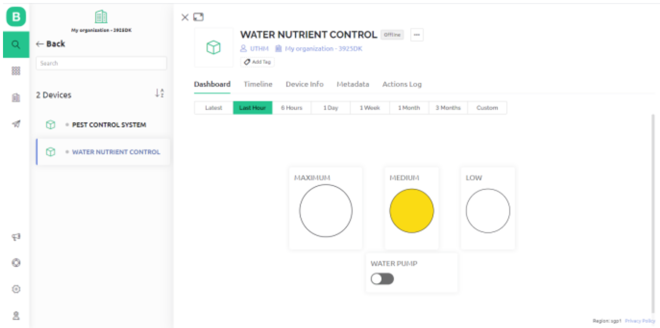


Figure 9: Blynk Application on a website

3.4 Arduino IDE

Arduino IDE is the primary code editing application for Arduino programming. That is where the code will initially check to see if there is a coding problem. The code will then be uploaded to the board. Figures 10 depict the code that was uploaded to the Arduino in Proteus to obtain the value of a water level. It has three detecting systems from sensors: high, medium, and low.

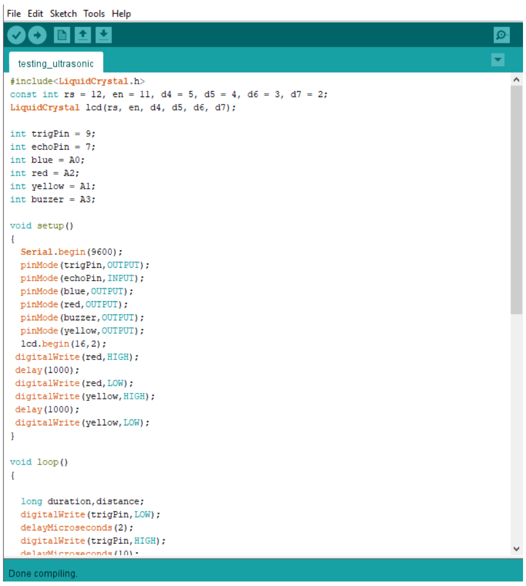


Figure 10: Coding for water level

3.5 Hardware Development

3.5.1 Monitoring System

This monitoring system includes an ultrasonic sensor that detects water level and nutrient levels as shown in Figure 11. Following that, Table 2 shows the ultrasonic sensor connection for the monitoring system.

Figure 11: Ultrasonic Sensor.

Table 2: Circuit connection of ultrasonic sensor and D1 wemos.

HC-SR04 ULTRASONIC	D1 Wemos
VCC	5V
GND	GND
ECHO	Pin Digital 1
TRIGGER	Pin Digital 2

The LEDs will light up according to the water nutrient level, which is blue for the maximum tank, yellow for the medium tank, and red for the empty tank. Figure 12 shows the LED Red, Yellow, Blue used in this project. Table 3 shows the connection LED with Wemos D1. The Red LED connects to digital pin 3 through a resistor and ground. The Blue LED connect to digital pin 4 through a resistor and ground. Lastly, the Yellow LED connect to digital pin 5 through resistor and ground.

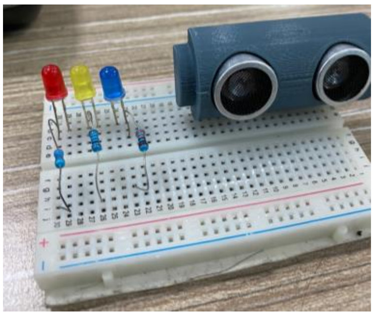


Figure 12: LED Red, Yellow, Blue

Table 3: Circuit connection of LED and D1 wemos.

LED (INDICATOR)	D1 Wemos
YELLOW	Pin Digital 5
RED	Pin Digital 3
BLUE	Pin Digital 4

3.5.2 Control System

Figure 13 shows the relay 5V while Table 4 list of relay connection with Wemos D1. When the Wemos D1 is connected to D6 pin is set to LOW, the 5V relay connected to it turns on, and when it is set to HIGH, the relay turns off. Given that the neutral wire passes through the relay's NC and COM, D6 pin is set HIGH to turn on the water pump and D6 pin LOW to turn it off.

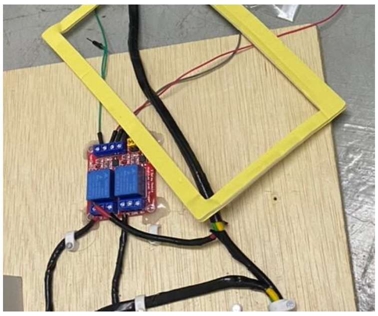


Figure 13 Relay 5V

Table 4: Shows the connection relay with Wemos D1

RELAY PIN	D1 Wemos
GND	GND
VCC	5V
IN	Pin Digital 6

Ultrasonic, relay, and LCD are configured in one system, with the system controlled by Wemos D1. This monitoring system will be valuable in many applications, especially hydroponic systems, because the sensors will be operated and also displaying a compilation of data to the users. Figure 14 shows the entire monitoring and control system setups.

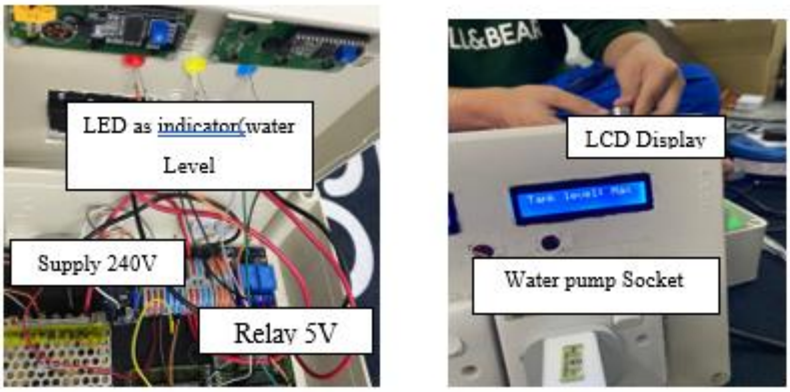


Figure 14: Complete configuration of monitoring and control system.

3.6 Hardware Implement on Hydroponic System.

After finishing the monitoring system configuration, the system was installed on a hydroponics system. Figures 15 depicts the before and after implementation of the monitoring and control system for the hydroponics system, respectively.

The outdoor testing was conducted at SMK Yong Peng in Batu Pahat on December 3, 10, 17, and 24, 2022 which water nutrient levels was measured in real time. The water nutrient level result is shown in Tables 5 while the plant's progress week by week is presented in Figures 16. The end outcome will be continuous as long as the microcontroller receives power supply and internet connection. As a result, the water level nutrient from the first to the third week shows no large different. It was quite low because it had been raining for three weeks at SMK Yong Peng. Week 4 shows a decrease in the water's nutrient level. The water nutrient level changes from high to medium.

(a)

(b)

Figure 15: (a) Before and (b) after implementation of the monitoring and control system

Table 5: Water nutrient level result.

Date and Week	Time	Water level (water nutrient Box)
3 December 2022 (Week 1)	10.00 a.m	High
10 December 2022 (Week 2)	9.45 a.m	High
17 December 2022 (Week 3)	10.30 a.m	High
24 December 2022 (Week 4)	12.00 p.m	Medium

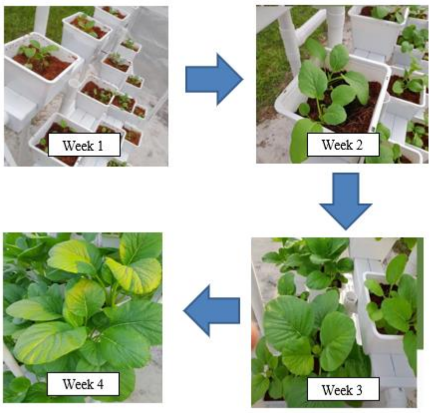


Figure 16: Progress of Plant Result.

3.8 Load consumption and project cost

Table 6 and 7 show the data load consumption measured and energy consumption for system, respectively.

Table 6: Data Load Consumption Measured

Voltage (V)	**Current (A)**	**Power (W)**
12.7	1.8	22.86

Table 7: Energy Consumption Measured.

Duration of Energy Usage	Time (Hours)	Days	Power of System (kW)	Energy Consumption (kWh)
Daily	24	-	0.02286	0.54864
Months	24	30	0.02286	16.4592
Annual	24	365	0.02286	200.2536

Meanwhile, Table 8 shows the overall cost of the project based on the list of hardware and electrical components. The overall cost of this project is Rm1111.40, which also includes the RM 950 hydroponic set system.

Table 8: Cost of The Project.

No	Component	Quantity	Cost (RM)	Total (RM)
1	Hydroponic Set	1	950.00	950.00
2	Ultrasonic sensor	1	7.50	7.50
3	Breadboard	1	4.50	4.50
4	D1 Wemos mini	1	32.50	32.50
5	Female To Male Jumper	2	3.50	7.00
6	Male To Male Jumper	2	3.50	7.00
7	I2C Serial LCD	1	5.00	5.00
8	LED Red Yellow Blue	3	0.30	0.90
9	16x2 LCD	1	28.00	28.00
10	2 Channel Relay Module	1	7.00	7.00
11	Junction Box	1	28.00	28.00
12	Tank	1	34.00	34.00
Total				1111.40

4. Conclusion

In conclusion, this project achieved the initial goal of developing an IoT monitoring system for hydroponics that can be used to monitor the plant in a tiny space and at any time by applying an Ultrasonic sensor and a Relay 5V Module. To monitor and operate the system, the web application made usage of the Blynk application platform. This project also met the second goal of testing and evaluating the performance of a hydroponic control and monitoring system employing a microcontroller and a sensor. By producing the product from an outside plant, the user will be able to develop hydroponic plants in their home, requiring just a little amount of space. Lastly, the data collected consists of water level has been analyzed. These results showed that the product worked as expected.

Acknowledgement

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