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Hydroponic Pest Control System with Internet of Things Application

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Abstract: Hydroponics is becoming increasingly popular because it allows for the production of fresh food closer to major cities. People want "safe" food that was grown in a responsible, sustainable way and is free of chemical pesticide residues. Many insects cause problems that far exceed the benefits of using pesticides responsibly. Pesticide use is discouraged and rarely necessary in hydroponic gardening. Insects have a variety of effects on our quality of life. To address the issue, a pest control system must be developed. Pest control systems assist users in controlling their hydroponic gardens in order to maximize crop production and prevent pest attacks. The system will include internet of things (IoT) capabilities to make it more user-friendly. Arduino IDE, as well as Wemos D1 microcontroller, are necessary to code the system in this paper. Furthermore, the consumption of this system also been analyzed to ensure that the user is aware on their power usage. It is found that the total energy usage by the system is 136.4 watts. The daily energy consumption is 3.2736 kWh, while the monthly consumption is 98.208 kWh. Next, the total financial cost for the complete development of this project is RM 315.90. It is also an innovative target for low-cost systems and global sustainable development.

Keywords: Pest Control, Energy Consumption, Hydroponic, Pesticides, Wemos D1.

1. Introduction

Hydroponics is gaining popularity since it allows for the production of fresh food closer to large cities. People's interest in how their food is produced has grown dramatically during the last decade. More people desire "safe" food that was grown in a sustainable, thoughtful manner and is free of pesticide residues. Hydroponic is the process of growing plants without soil, plant roots flooded or moist with nutrient-rich solutions in inert material [1]. Large hydroponic installations exist throughout the world for growing flowers, and vegetables like salad and capsicum. However, pest control is a problem with this way of growing plants.

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Pest control, in the form of pesticides, is frequently a necessary measure [2]. Many insects provide problems that significantly surpass the risks of using pesticides responsibly. Insects have a variety of effects on our quality of life. If pests are not effectively controlled, they can pose a hazard to public health and the environment, as well as have major negative economic consequences [3]. Pesticide use is discouraged and rarely essential in hydroponic gardening practice. Plants that are weak or diseased are more likely to be attacked by pests. Plants produced under hydroponics are more pest resistant than those cultivated on soil, yet they are not immune. So, to overcome the problem, pesticide control must be developed. The internet of things (IoT) can be used to overcome pest management issues. The IoT ecosystem is made up of web-enabled smart devices that use embedded systems including processors, sensors, and communication hardware to gather, send, and act on data from their surroundings. People may use the internet of 2 things to live and work smarter, as well as acquire complete control over their life. The IoT will give the hydroponic user a control and monitoring system. Once the technology is implemented, the user will not have to worry about their plant and will have to perform less effort [4].

2. Materials and Methods

Materials and methods describes the processes and tools required to design hardware and software. Following the completion of the hardware component, the development of hardware with software components to achieve the required function will begin. The software is hardcoded and cloud-hosted. The Arduino IDE supports hardcoding. The Arduino IDE is a popular IDE for developing IoT projects because it supports a wide range of controller boards. Finally, a database was required for this project to store the data transmitted by the sensor. Figure 1 shows the block diagram for hardware development.

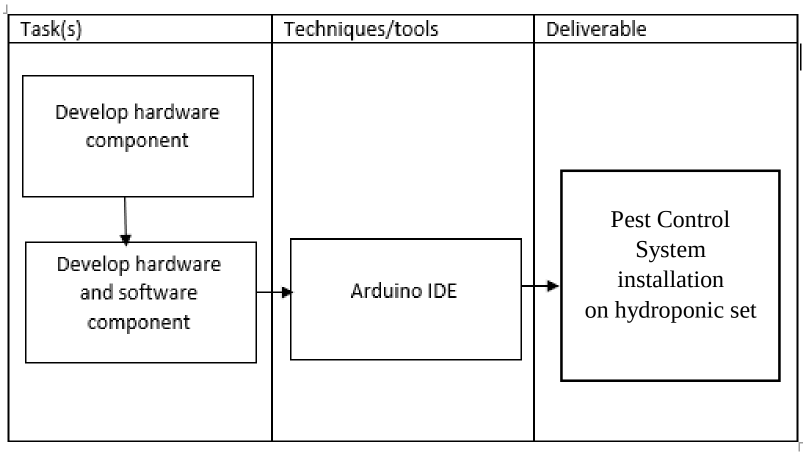


Figure 1: Block diagram for hardware development

2.1 Hardware Component

To begin the hardware development phase, the major component of this project was chosen first. The project's key components are a WeMos D1 mini module, ultrasonic sensor, LCD, relay and submersible water pump.

A. WeMos D1

The WeMos D1 is an Arduino-compatible board with the built-in ESP8266 Wifi Module. It is WiFi-enabled based on the ESP8266 chip. The board looks like an ordinary Arduino Uno board. The dimensions and the pin layouts are also the same. The board is compatible with all the existing shields for Arduino [5]. Figure 2 shows the input and output pin for the WeMos.

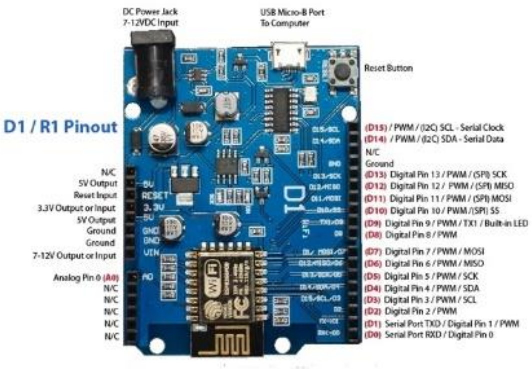


Figure 2: WeMos Pin, Input and Output.

B. Relay Module

The single channel relay module is a convenient board that can be used to control high voltage, and a high current load such as motor, solenoid valves, lamps, and AC load. It is designed to interface with a microcontroller such as Arduino, PIC and etc. The relay terminal (COM, NO, and NC) is being brought 14 out with a screw terminal. It also comes with a LED to indicate the status of the relay [6]. The relay used to turn 'ON OFF' for the pump. Figure 3 shows a picture of 1 channel relay module.

Figure 3: Channel Relay Module

C. I2C Liquid Crystal Display

The I2C is a type of serial bus, which uses two bidirectional lines, called SDA (Serial Data Line) and SCL (Serial Clock Line). Both must be connected via pulled-up resistors. The usage voltages are standard as 5V and 3.3V. It must be soldered together, the I2C adapter soldered onto the board, the wiring becomes easy where only four pins have to connect. The LCD display works with 5 Volts. This LCD will display the current parameters for the project. Figure 4 shows the I2C LCD soldered.

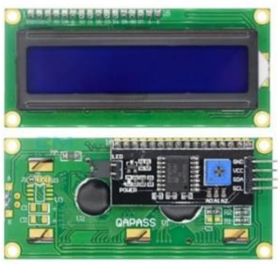


Figure 4: I2C LCD soldered.

D. Ultrasonic Sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has traveled to and from the target) [7]. Figure 5 shows the ultrasonic sensor utilized in the project. This sensor is used for detects pesticide levels in tanks.

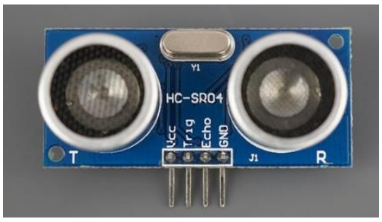


Figure 5: Ultrasonic sensor.

E. Submersible Water Pump

Submersible pumps are used to transport fluid from one location to another and totally immersed in the fluid or medium being pumped. This type of pump has a hermetically sealed motor that is close-coupled to the pump body, which is encased in a water-tight enclosure to prevent liquid entrance and damage to the motor. Submersible pumps operate by utilizing the fluid's head to drive it forward. Because it uses no energy, this pumping method is incredibly efficient. Besides, to prevent overheating, the motor of a submersible pump is cooled by the fluid around it [8]. Figure 6 shows the submersible water pump utilized in the project. The water pump helps in pesticide dispersion through the nozzle and host.

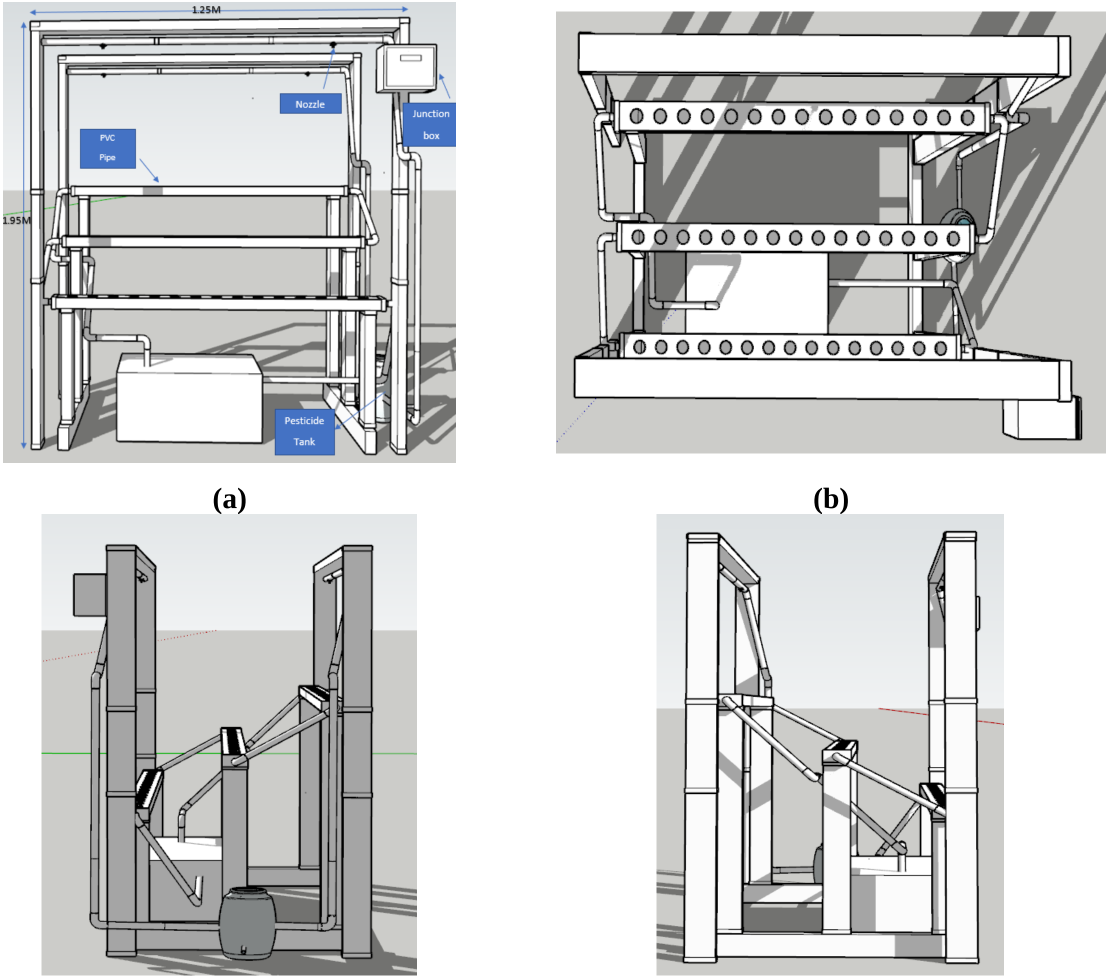
Figure 6: Submersible water pump utilized in the project.

3. Results and Discussion

This section explains and discuss the results and design of a 3D model for a hydroponic pest control system with an IoT application. Sketch Up Pro 2021 software was used to create the 3D model. To proceed with hardware development, the circuit connection in this project must be simulated using Proteus 8 Professional and Arduino IDE software. As a result, the outcome of this project can be executed.

3.1 Project Design

Sketch Up Pro 2021 can be used to create the project's design. Before creating the hardware for this project, it is critical to understand the component layout. The project's design is displayed in 3D to ensure that it more realistic when making hardware in the future. In this software, all of the primary components were designed in 3D. Figures 7 shows the 3D model from various perspectives.



(a) (b)

(c) (d)

Figure 7: 3D model from various perspectives: (a) front; (b) upper; (c) right and (d) left view

3.2 Circuit Design

A simulation circuit is used to test the operation of a circuit. This is where the Proteus 8 and Wokwi software are used to create the circuit and run Arduino code. The circuit's connections must first be verified. It can also be done in parts. Knowledge of upload sections and libraries is essential for these parts. After uploading the code to Arduino, the simulation can be performed with Proteus 8 and Wokwi. Figure 8 shows the successful completion of a full circuit simulation in the Wokwi simulator.

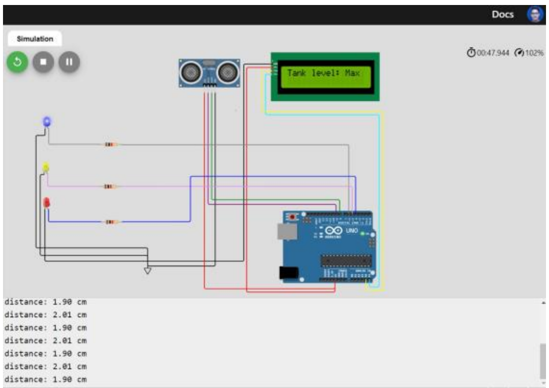


Figure 8: Circuit simulation for system operation.

3.3 Blynk Application

Figure 9 shows a channel template on a mobile phone using the Blynk app while Figure 10 shows a template with system-operating widgets. The position of widgets can be adjusted based on the needs, and there are many widgets available. Every widget used must be programmed in the Arduino IDE and linked through code to operate. Figure 11 shows a template for Blynk on a web server. This is the initial phase in developing an IoT platform before moving on to mobile phones. Each widget must be code-connected and represent its system function as display and control. Anyone with access credentials can log into the IoT platform. Additionally, it displays the current status of the hardware and server either online or offline.

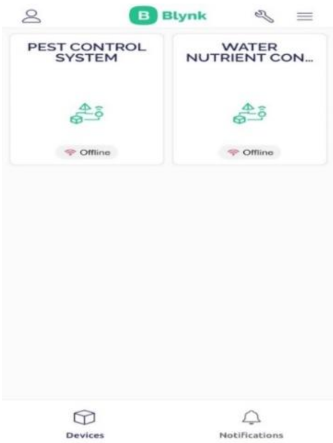


Figure 9: Blynk channel template on a mobile phone.

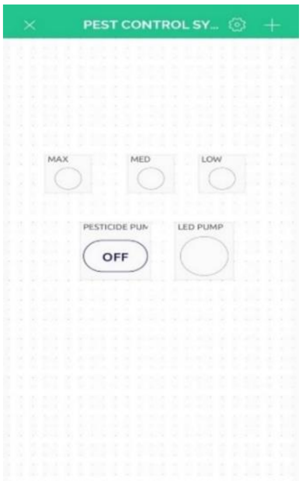


Figure 10: Blynk template operation on a mobile phone.

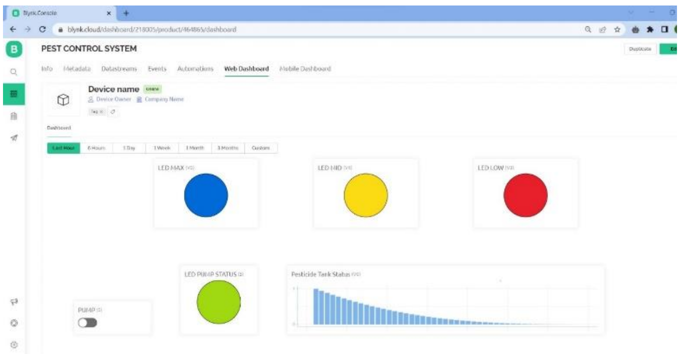
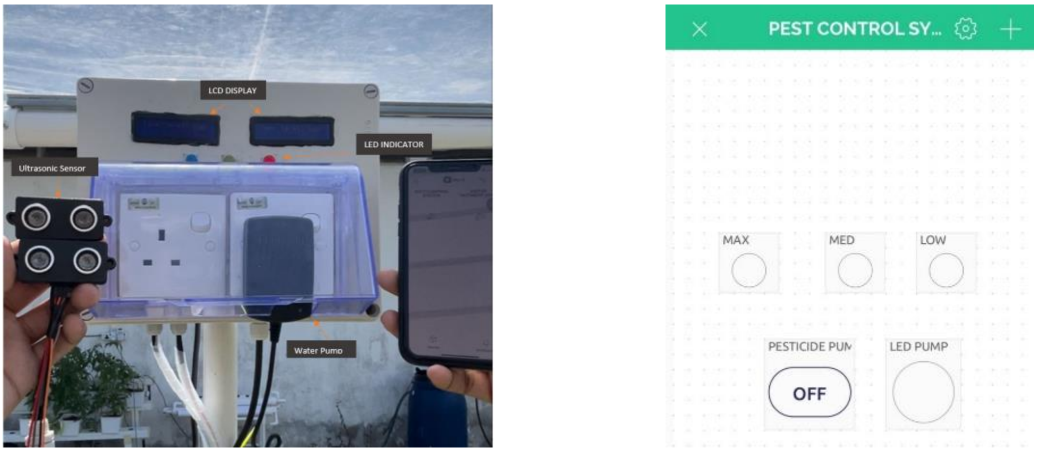


Figure 11: Blynk template on a web server.

3.3 Hardware Implementation on Hydroponic System.

This section is intended to assist users in understanding the project's current status. It applied on both hardware and Blynk application. The control box has LCD I2C that displays the project's current status. It also has three LED lights that indicate the amount of pesticide in the tank based on ultrasonic sensor readings. An ultrasonic sensor is used to detect the distance for pesticide levels in the tank. It will activate the LED indicator after a certain distance. The template project for the Blynk application includes three LED widgets that are synchronized with on hardware and perform the same function. Figure 12 shows display parts for the monitor section on hardware and Blynk template while Table 1 tabulated the LED legend for the system.



(a) **(b)**

Figure 12: (a) LCD and LED display on the control box; and (b) Monitor LED indicator on Blynk template.

Table 1: LED indicator legend.

Led (Indicator)	Level Pesticide Tank
Blue	Maximum
Yellow	Medium
Red	Low

3.4 Result control and analysis System Consumption

The control section focused on controlling the system's submersible water pump. Using the Blynk application, a relay is used to turn on and off the load. The relay has been synchronized with switch button widget on Blynk so that the user can easily control it. Following that, the water pump will deliver the pesticide to the plant via the nozzle and host. Figure 13 shows a basic hydroponic set and also the installed hydroponic set with a pest control system. Meanwhile Figure 14 shows a nozzle delivering the insecticide (neem oil) in vapor over hydroponic plants through the Blynk application which covers a total of 16 pots.

The load consumption measured for the pest control system is tabulated in Table 2. The value is obtained using a digital multimeter. For voltage values, connect the multimeter in parallel with the system's voltage supply. The current value is obtained by connecting the multimeter series to the circuit. Assume that the system operates 24 hours because it features users to apply pesticides through Blynk application. Then, simply multiply the voltage and current values to get the power for the system. Table 2 tabulates the system's energy consumption over time. If the duration of usage increases, so does the energy consumption. Besides, the TNB tariff charge was computed based on consumption to estimate the monthly and yearly bills for the system. Table 3 tabulates an estimated cost generated by the TNB simulator calculator on the TNB website [9].

(a) **(b)**

Figure 13: (a) Basic hydroponic set and (b) the installed hydroponic set with a pest control system.

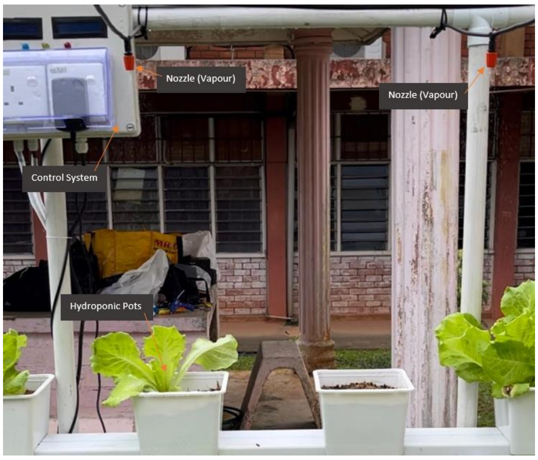


Figure 14: Nozzle Part on Hydroponic.

Table 2: Data load consumption measured.

Loads	Voltage(V)	Current (A)	Hours	Power (W)
Pest Control System	12	2.2	24.0	26.4
Water Pump	24	4.5	0.5	110.0
		Total		136.4

Table 3: Energy consumption for system.

Duration of Energy Usage	Times(Hours)	Days	Power for system(kW)	∑ Energy Consumption (kWh)	TNB Tariff Bill (RM)
Daily	24	-		3.2736	0.14
Months	24	30	0.1364	98.208	19.45
Annual	24	365		1194.864	233.40

4. Conclusion

In conclusion, the proposed internet of things (IoT)-based pest control system has proven to be a very effective way for the user to manage hydroponic farming. The ability to remotely turn on pesticides from a device, the users are able to effectively manage pest infestations without the need for manual labor. This system has several benefits for both the user and the environment. The advantage for the user is the ability to quickly and easily apply pesticides can save time and labor costs. It can also help to reduce the amount of pesticides used, as the system allows for precise application rather than blanket spraying. As for the environmental perspective, the use of this system can help to reduce the risk of pesticides drifting into unintended areas, which can be harmful to wildlife and other non-target organisms. It can also help to prevent the overuse of pesticides, which can lead to the development of pesticide resistance in pests. Overall, the development of pest control systems using IoT has been a success, providing a cost-effective and environmentally-friendly solution for farmers engaged in hydroponic farming.

Acknowledgement

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