

Research Article

Grey Oyster Mushroom Automated System (GrOyMAS)

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Abstract: The grey oyster Mushrooms cultivation process is influenced by several factors such as ambient temperature, humidity, light and ventilation. The inconsistency of Malaysia's weather makes it challenging for this plant to maintain the ideal temperature for healthy growth and microbial avoidance. To address the issue of temperature and humidity for the development of grey oyster mushrooms, an automatic environmental control system for grey oyster mushroom houses has been developed. Thus, the main objective of the project is to design an automated temperature control system for the grey oyster mushrooms using the DHT22 sensor to measure and regulate the temperature and humidity, including transmitting the data to Arduino to automatically start the system when the temperature reaches 30 °C by misting or spraying. Here, to display the reading of the temperature and humidity of the mushroom home, the LCD interfaces with Arduino Proteus. The simulation is run in Proteus, and the code is created in the Arduino IDE. The main goal of this project is to develop a system to control the temperature and humidity in the grey oyster mushrooms house by spraying the interior sides of the mushroom production house; the attached water droplets will slowly evaporate, which will increase or maintain the humidity when it exceeds the temperature of the surrounding automatically. Therefore, with the operations of this circuit, the mushroom operator can avoid losses from the damage to the mushrooms. It is also relevant to help entrepreneurs toward technological entrepreneurship.

Keywords: Automated Temperature Control; Grey Oyster Mushroom; Water Droplet.



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1. INTRODUCTION

Grey oyster mushrooms, also known as *Pleurotus ostreatus* or tree oyster mushrooms, are a type of edible mushroom that belongs to the *Pleurotus* genus. They are native to North America and are commonly found growing on trees or logs in the wild. Grey oyster mushrooms have a grey or

brownish-grey cap, typically 3-10 inches in diameter. The flesh of the mushroom is white or pale grey and has a smooth, meaty texture. In 1960, the mushroom industry began to expand rapidly. Asian countries pioneered this industry. For example, China is the world's largest producer of mushrooms, but 95% of its output is destined for domestic consumption (Pocketbook, 2015). The global demand for fresh, dried, and processed mushrooms is increasing year after year, owing to their high potential in developing pharmaceutical, nutraceutical, cosmeceutical, and other downstream industries (Rosmiza & Hussin, 2017). This cultivation activity is growing and thriving due to high demand in the Malaysian market. The government recognizes the mushroom industry to have the potential to be developed as demand is increasing in tandem with the increase in population and consumption. The consumption of mushrooms per capita is expected to grow from 1.0 kg in 2008 to 2.4 kg in 2020. Besides, there were 648 mushroom entrepreneurs in Peninsular Malaysia in 2008. The demand for grey oyster mushrooms is increasing, but in Malaysia, the number of cultivators and production is decreasing. This is due to the inconsistent environmental condition with the high temperature of 32–35 °C and low humidity of 60%–70%. The higher demand for mushroom cultivation is an opportunity for entrepreneurs in Malaysia.

Grey oyster mushrooms are a popular choice for cultivation because they are easy to grow and have a fast growth rate. They can be grown on various substrates, including straw, sawdust, and wood chips, and are often used in commercial mushroom production. In addition to their use as a food source, grey oyster mushrooms have also been shown to have medicinal properties and are sometimes used in traditional medicine. The basic requirements for mushroom growth are a temperature of less than 30 degrees Celsius, relative humidity, carbon dioxide (CO₂), light, and adequate airflow in the mushroom house (Mazidi, Ibrahim, & Yaacob, 2020). The unpredictable Malaysia climate makes it difficult for the grey oyster mushroom to thrive, and the employee of the company can only check the temperature manually or set the timer for the water to spray to lower the temperature below 30 degrees Celsius for the mushroom to grow but ineffectively in term of workforce and bills. An automated system needs to be developed to increase production effectively. Hence, an automatic environmental control system for grey mushrooms house needs to be developed to control surrounding temperature to ensure the oyster mushroom thrives in an environment with optimum temperature and humidity. The main objective of this project is to create a system to control the temperature and humidity in the house of grey oyster mushrooms by spraying the interior sides of the mushroom production house; the attached water droplets will slowly evaporate, which will increase or maintain the humidity when it exceeds the temperature of the surrounding automatically.

Several issues have been identified due to the manual method of controlling the temperature and humidity in the mushroom house. For example, the operators find it difficult to control the temperature in the mushroom house, so regular monitoring is required to ensure the temperature is always at an appropriate level. Next, suppose the temperature in the mushroom house exceeds the temperature suitable for cultivation. In that case, the operator will manually reduce the temperature by spraying water on the floor, walls, and even wood blocks. This will cause water wastage and the risk of disease and insect attacks due to mushroom houses in damp conditions. Also, mushroom yields become of poor quality and small, and the weight of mushrooms becomes light due to the operator's negligence to control the mushroom house's temperature manually. An automated system needs to be developed to increase production effectively.

The project objectives are the actions that we took to achieve the aim that intends the betterment of the problem statement, such as: -

- (i) To develop an automated system to control the temperature of the grey oyster mushrooms production house.
- (ii) To improve the production of grey oyster mushrooms with optimum moist condition.

2. METHOD & MATERIAL

Project work normally involves time, people, and materials. The first step is to identify the problem in the industry. Next, clarify and study the problems or issues. Explaining how the problem came to attention, how it has been framed, the size of the problem, and the cause of the problem can help to ensure that the problem warrants attention and take the appropriate options for addressing the problem are considered (Cikarge & Arifin, 2018,). After that, project members visited the industry (Sinar Syukrawie Enterprise) area to get to know better the mushroom house's surrounding for the project's implementation. There are two important things that the project members should do during the visit to the industry, which is to get the full picture of the industry's mushroom house surrounding and the size of the mushroom house and plan to buy the material such as PU Pipe, mist, etc. after success develop the circuit. Besides that, the project members also get exposure to the daily work there. The workers explained to the project members the content of the mixture for the mushroom and the life span of the grey oyster mushroom. The workers also described the best duration for harvesting grey oyster mushrooms and the optimum cultivation conditions.



Figure 1. Site Visiting by our project members.

Next, a Gantt Chart is prepared for the project members to work efficiently. The resources can be used effectively if the Gantt Chart is prepared because Gantt Chart will show the project's timeline so that it can easily see how and where resources are being utilized. Gantt Chart also can display the project's progress, allowing project members to know if the project's progress is tallying with the planned progress. After preparing the Gantt Chart, the project members need to research the information about the mushroom house through articles, eBooks and the Internet. Then, useful data about the project is collected by the project members, such as the suitable temperature and humidity sensor, the LCD used, and the type of relay and valve used to control the water pump. These data can help project members identify issues and understand the theories to design the circuit needed for the project. Furthermore, the data collected also can help project members organize and optimize the quality of work, gain valuable insights, predict trends, prevent risks, save time, and make better decisions. After the data collection, the project members must decide on suitable sensors and actuators for the circuit. For example, the comparison between DHT11 and DHT22. The DHT22 outshines the DHT11 in every aspect. The DHT22 temperature range, temperature accuracy, and humidity range to humidity accuracy are far greater than DHT11.

Table 1. Comparison between DHT11 and DHT22.

	DHT11	DHT22
Temperature Range (°C)	-20 to 60	-40 to 80
Temperature Accuracy (%)	±2	±0.5
Humidity Range (RH)	0 to 95	0 to 100
Humidity Accuracy (%)	±5	±2
Cost (RM)	4.9	13

Table 1 above shows the comparison between DHT11 and DHT22. So, DHT22 was chosen as the temperature sensor in the project. Furthermore, the datasheet of the sensor and actuator that has been searched is investigated to analyse the components' functionality further. This action will save the project member time in connecting the circuit since the project member already has basic knowledge of the component. For example, Relay Module 5V Pinout in the datasheet. It shows the Normally Closed (NC), Common Contract (CC), Normally Open (NO), Input, Ground, and VCC of the relay. The data sheet will show in detail each of the pins. Moreover, the next step is to identify the risks of each component, including Arduino. Prevent the circuit exposure to water or liquids when the power switch is ON; otherwise, the circuit will have a short circuit. Besides that, when changing the wire or plugging off the cables, ensure the power is turned OFF. Ensure that the power supply matches the current-voltage component, which is 12V to 12V and 5V to 5V. After that, there are a few precautions for the soldering process, which are to make sure that the soldering iron does not damage any component by overheating and ensure the soldered point doesn't touch any other pin or components of the circuit to prevent the unnecessary or incorrect connection between components which can cause a short circuit. Besides that, the user of the soldering iron should never touch the element or tip of the soldering iron because the temperature is about 400°C. The soldering iron must always be returned to the soldering iron stands and never put down on the workbench.

Next, the project members need to set the budget for the project. With a well-planned budget, the projects can stay intact and be completed. Budgeting is a complex process, however, as budgets can be fixed or flexible. This will depend on the prices the stores give and negotiations between the project members and the store owner. Once the budget is calculated, the project members need to determine how much money can be spent on each component. A budget allows those in charge of purchasing to determine how much of the available funds can be allocated to the constituent elements of the project itself. This will provide the opportunity to decide whether the project can be completed with the available budget. Next, the project members must construct the schematic diagram in Proteus Professional Simulation Software. The voltage input decided is equivalent to 12V and 5V. The sensor used is 1(one) piece of DHT22 sensor. The output is the water flow from the valve, 3(three) pieces of LED which are D4, indicate power ON, D1 and D2 indicate relay whether ON or OFF, and LCD 16x2 displays the DHT22 reading. Then the microcontroller used is Arduino UNO. Another component is the 12V Relay which controls the switch ON and OFF the valve, diode, and transistor. The potentiometer is used to control LCD brightness. The schematic diagram is shown in Figure 2. After drawing the schematic, the Arduino coding was written in C and C++ Language. C and C++ Language are among the most powerful and easy-to-learn languages. Then, the Arduino coding was verified to ensure there were no errors, and the coding was uploaded into the Proteus Professional to test if the circuit functioned as the expected outcome. When the temperature is below 30°C, the relay is OFF, the LED Relay indicator and Power indicator turns OFF, and the valve OFF will make no water flow. When the temperature is above 30°C, the relay is ON, the LED Relay indicator, Mist System, and Power indicator turn ON, the valve will be ON, and water will flow.

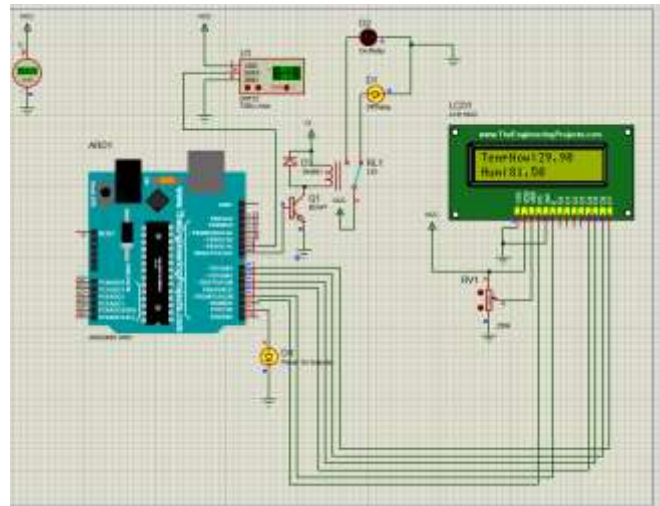


Figure 2. Schematic Diagram.

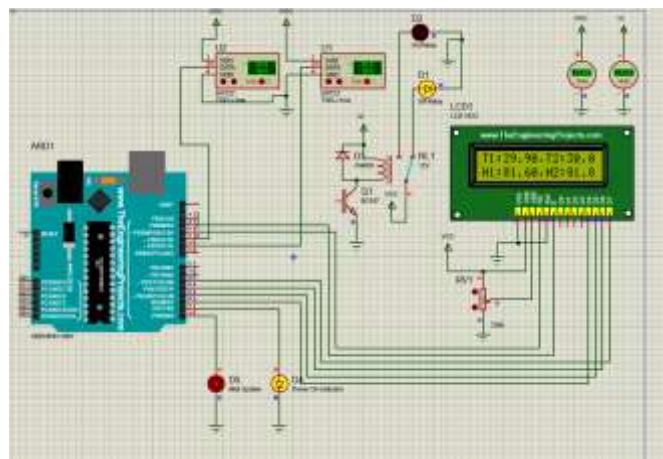


Figure 3. Modified Schematic Diagram.

Next, the simulated circuit is prepared; one more DHT22 sensor for a more accurate temperature reading and the LED indicator for Mist System need to be added to the circuit. The LCD requires to display both DHT22 sensors' readings. The modified circuit is shown in Figure 3 on the schematic diagram. All the sensor and components have been connected according to the schematic in Figure 3, but there is no output display at LCD. At first, the LCD is speculated to burn, so another LCD (2pcs) was bought, and one-piece header was soldered into LCD, but the same result was obtained as the previous LCD did. Then, another method was used, which the Arduino Basic Coding was uploaded into Arduino to display the most basic content, which involved Arduino and LCD only. However, the LCD still didn't show anything. Then, the timer for the system was set to turn on in 5 seconds to test the functionality of the LCD. After troubleshooting and researching through the Internet, an online article was found that stated that there might be a wire jumper connection problem. So, all the wire jumpers replaced those connected to LCD and the LCD turned to function programmed in Arduino. The jumper wire connection problem is due to the copper inside the jumper being oxidized.

After that, the 5V Relay Module and 12V valve were connected to the circuit. The 12V valve is directly connected to AC to DC Adapter 12V 2A, and 5V Relay Module is connected to DC Step Down Converter 12V to 5V and is also connected to AC to DC Adapter 12V 2A. After that, modify the coding when the temperature is below 30°C, the relay is OFF, the LED Relay indicator and Power indicator turns OFF, and the valve is OFF will make no water flow. When the temperature is above 30°C, the relay is ON, the LED Relay indicator, Mist System, and Power indicator turn ON, the valve will be ON, and water will flow. Then, the code is uploaded into Arduino UNO and the circuit is tested by making

the DHT22 temperature sensor detect the temperature and sending the temperature data to Arduino UNO. Then, all the LED's position is rearranged to the A0 (power ON OFF indicator), A1 (Mist ON indicator), A2 (Relay OFF indicator), and A3 (Relay ON indicator). When the relay is connected to the circuit, the relay is not functioning as expected, so the problem was suspected as previously where the wire jumper was oxidized. After all the wire jumpers were replaced, the relay functioned as programmed. The circuit runs according to expected outcomes. The schematic diagram after the LED position was rearranged is shown in Figure 4. The reason LED was rearranged is to make the project member easily connect the Arduino pin; if the distance of the pin is packed, the jumper wire will be hard to plug in and out the pin during troubleshooting.

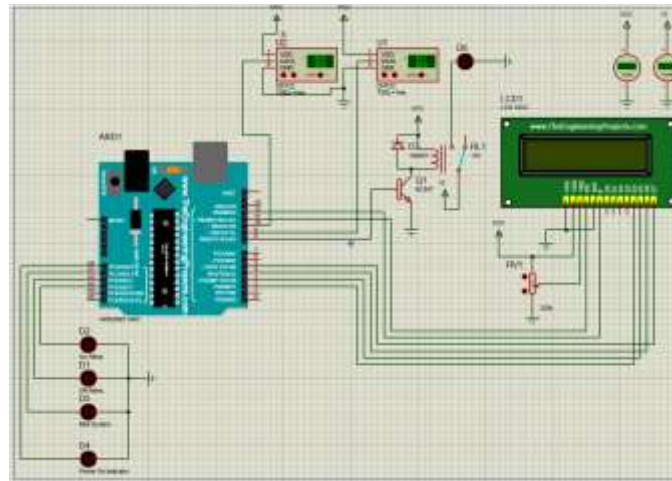


Figure 4. Schematic Diagram After Rearrange LED Position.



Figure 5. (a) Location Plan of Mushroom House(left) and (b) Size of Mushroom House(right).

The installation of the project will be done in house number 6. The length of the required pipe and wire was calculated according to the location plan and size of the mushroom house in Figure 5 (a) and (b). The calculation included the size of the mushroom house and the distance between the water pump (mushroom house number 4) and the electric supply (mushroom house number 5) to the mushroom house. After that, the resistor 220Ω was added to each of the LEDs through the project team member's discussion. The resistor was added by soldering into the circuit. The reason is the brightness of the LED is too high and the LED is easily burned or corrupted. So, the resistor was added to limit the current in the LED. Then, the resistor was also added to the schematic circuit diagram. The modified schematic circuit is shown in Figure 6 (a) and the resistor is soldered at the LED positive polarity into the circuit is shown in Figure 6 (b).

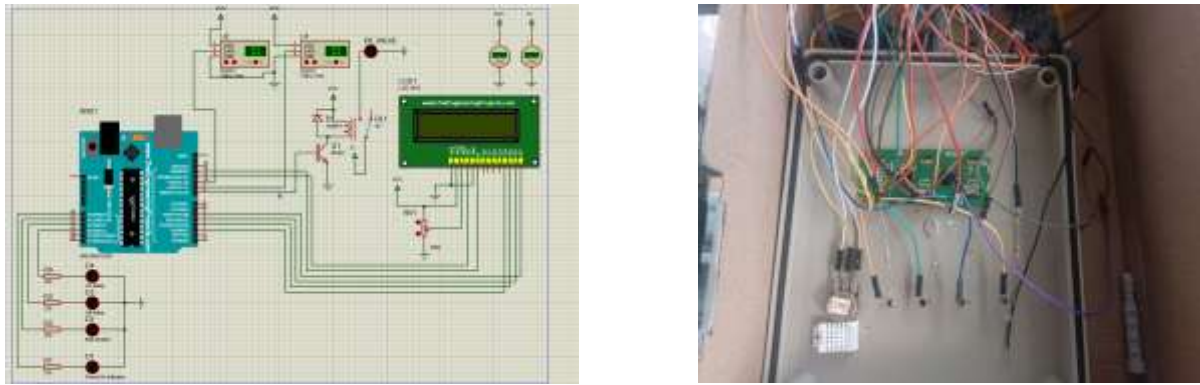


Figure 6. (a) Schematic Diagram with Resistor 220Ω (left) and (b) Resistor was Soldered (right).

The wiring process is to have the plug at the mushroom house to make the mushroom house have electricity. Next, the Arduino is installed inside the cover box. All the connections such as the valve, DHT22 sensor, DC Step Down Converter 12V to 5V, AC to DC Adapter 12V, and LCD 16x2 are connected inside the Arduino cover box. In addition, the DHT22 temperature sensor is connected to the design places by placing the pin wire from the Arduino cover box. the installation of the Arduino Cover Box is shown in Figure 7 (a). The installation of the DHT22 temperature sensor is shown in Figure 7 (b).



Figure 7. (a) Installation of The Arduino Cover Box (left) and (b) Installation of The DHT22 (right).

The flowchart of the project is shown in Figure 8. First, when the power source 12V is turned ON, the LED A0 power indicator will turn ON. The DHT22 will read the surrounding temperature and humidity. After reading the temperature and humidity, the LCD 16x2 will display the temperature value and humidity percentage. After that, there will be a selection happen. When the selection is 'Yes', the temperature is 30 degrees Celsius or exceeds 30 degrees Celsius, the 5V Relay will turn ON which means that the 12V valve also turns ON. When the relay was ON, the LED A3 will turn ON to indicate the relay is turned ON. At the same time, the Mist system is turned ON to lower the surrounding temperature, the LED A1 will turn ON to indicate the Mist system is turned ON. Then, water will be sprayed through the nozzle. After that, continue reading again the temperature through the DHT22 sensor. When the selection is 'No', the temperature is below 30 degrees Celsius. The 5V Relay will turn OFF which means that the 12V valve also turns OFF. When the relay was OFF, LED A2 will turn ON to indicate the relay is turned OFF. There is no water sprayed. The sensor continues to read the surrounding temperature. The Mist system will continue turned on until the temperature is below 30 degrees Celsius.

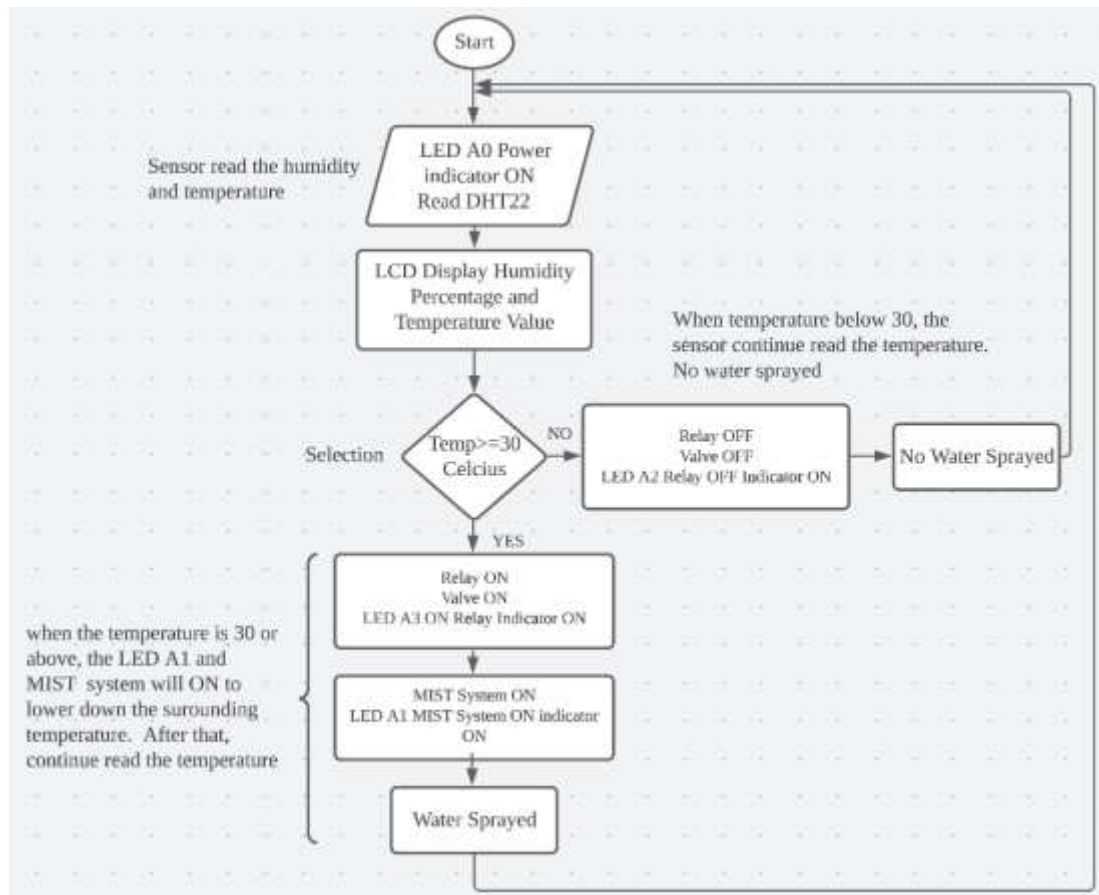


Figure 8. Flowchart of The Project

The block diagram in this project is shown in Figure 9. The input is AC to DC Adapter 12V 2A, DC Step Down Converter 12V to 5V, and DHT22 temperature sensor. The output is water flow, A0, A1, A2, A3 LED, and LCD Display 16x2. The Adapter 12V is connected to DC Step Down Converter 12V to 5V and both are connected to 5V Relay Module. Then, the water flow is controlled by a valve connected to 5V Relay Module. The 5V supply from DC Step Down Converter is connected to two pieces of the DHT22 temperature sensor. The sensors are connected to the microcontroller which is Arduino UNO and connected to output LED and LCD 16x2.

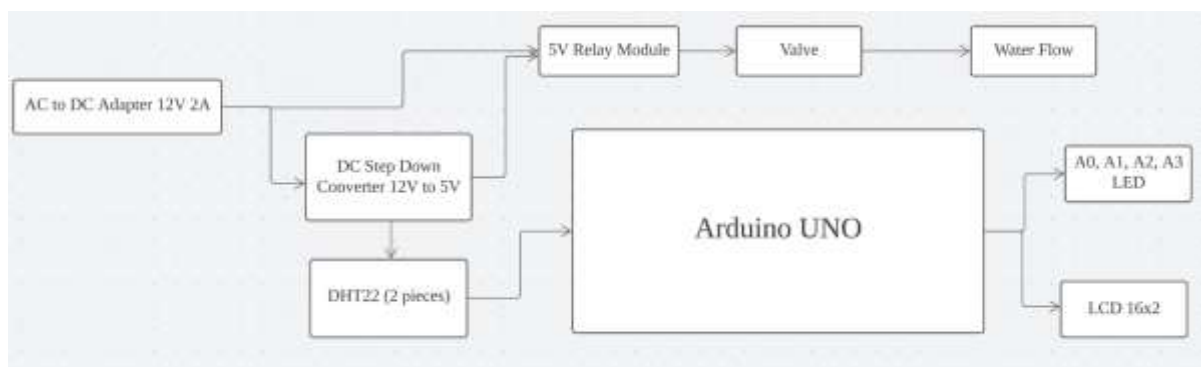


Figure 9. Block Diagram of The Project

3. FINDINGS

The result analysis of the project as well as the applications of the circuit is discussed. Data and results collected are recorded and discussed in this chapter. This project is mainly to create an automation system for the growth monitoring of grey oyster mushrooms. The temperature sensor used DHT22 to monitor the surrounding temperature and relative humidity and automatically turn on the mist system when it is necessary.

3.1 Simulation Result

Proteus Professional is used as the simulation software for the Grey Oyster Mushroom Automated System. At first, the LCD starts to show the 'System starts in 5' shown in Figure 10 and counts until 1. The LED indicator for Power on (D1) and no relay (D3) on lights up. In this system, DHT22 functions as the temperature and humidity sensor and passes the data to Arduino. The data of 2 DHT22 is shown in LCD 16x2. The BC547 is used as current amplification and the 1N4001 is to ensure the current flow in one direction, which is from GND to VCC.

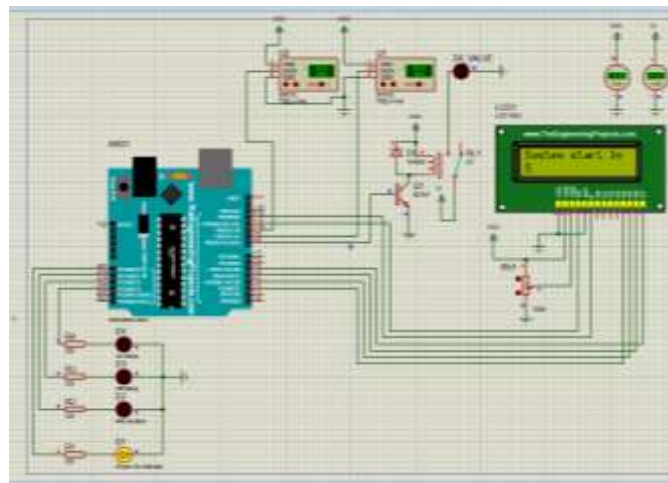


Figure 10. LCD showing 'System Starts in 5'.

When one of the DHT22 detected temperature exceeds or is equivalent to 30°C,

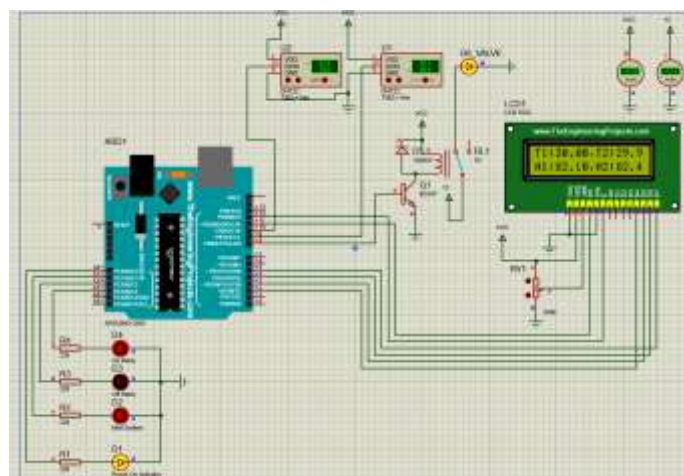


Figure 11. The temperature $\geq 30^{\circ}\text{C}$.

When the temperature $\geq 30^{\circ}\text{C}$, D3 Off Relay Indicator turns off, D4 On Relay and D2 Mist System turn on as shown in Figure 11. The Relay is connected to NO (Normally Open) and turns on the DC 5V Solenoid Valve (LED D6 is used as a substitution).

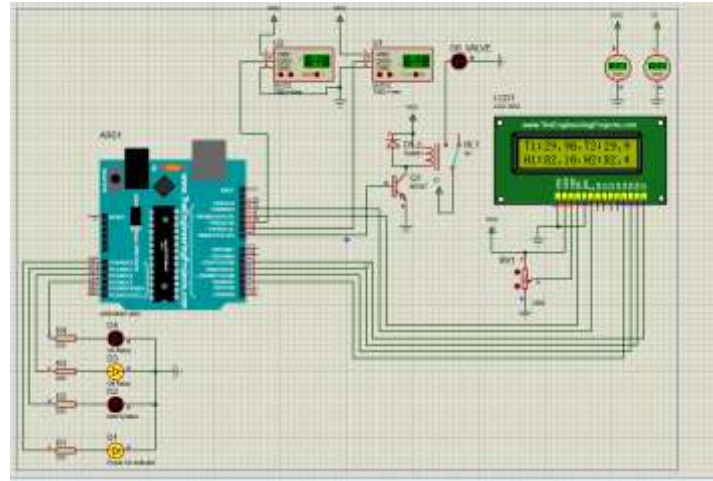


Figure 12. The temperature $< 30^{\circ}\text{C}$.

When one of the DHT22 detected temperature less than 30°C , D3 On Relay Indicator turns on, D4 On Relay and D2 Mist System turn off as shown in Figure 12. The Relay is connected to NC (Normally Connected) where there is no circuit and therefore doesn't have any output.

3.2.2 Prototype Operation

The Grey Oyster Mushroom Automated System starts to operate by showing "System start in 5" on the LCD 16x2 Display shown in Figure 13 (a). The countdown will start to count from 5 to 1. The LED indicator for the system on and relay turn-off (COM terminal of the relay connected to NC) will light up. At the same time, the 2 pieces of DHT 22 will start to detect the surrounding temperature and humidity and pass it to Arduino UNO. The data will be passed from Arduino UNO to LCD Display to display both temperature and humidity detected by the DHT 22 in Figure 13 (b).



Figure 13. (a) LCD Display "System starts in 5" (left) and (b) LCD showing the surrounding temperature and humidity (right).

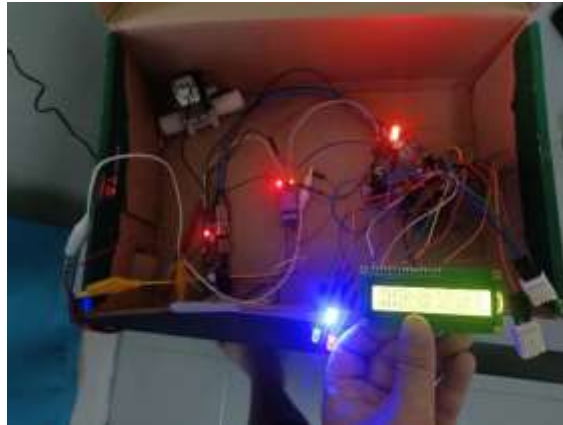


Figure 14. The circuit of the prototype

3.2.3 Circuit Operation in Mushroom House (Sinar Syukrawie Enterprise)

The installation of electrical power supply for the single base and the mist system is installed in the mushroom house of Sinar Syukrawie Enterprise using the T connector, C connector, Nozzle Mist Sprinkler, PU Tube 6mm and reducer 0.5 inches is connected to the solenoid valve. The circuit is put inside the box prepared to act as protection for the circuit. When the temperature exceeds 30°C, relay trigger to open the valve and the mist system is on the water will flow through the valve and the PU tube and begin to spray out through the nozzle mist sprinkler. Once the temperature is lower than 30°C, the solenoid valve will be closed, and the mist system will turn off.



Figure 15. (a) LCD showing 'System start in 5' in Sinar Syukrawie Enterprise (left), (b) Temperature <30°C (centre), and (c) Temperature ≥30°C (right)

The mist system starts to spray but it may not show clearly because the photo was taken during the evening as shown in Figure 16.



Figure 16. Mist System Spray

4. DISCUSSION

The result obtained from the prototype and the implemented hardware in Mushroom is the same as the expected output result of the system in the simulation. The automated system's desired outcome is to ensure water is automatically sprayed when the temperature exceeds 30 °C. The mist system stops pouring the water after the temperature decreases below 30 °C. Besides that, the LED indicator will automatically turn on and off depending on the temperature, except for the Power On LED, which is always on. When the temperature is below 30 °C, the LED indicator for Relay-Off will turn on, and the LED indicator for Relay-On and Mist System-On is turned on. The LED indicator result will be vice versa when the temperature is less than 30 °C.

The system used before this project was implemented in the mushroom house is a timer-based automated mist system that will spray the water every hour to ensure the temperature is lower than 30 °C. Water is wasted for this system because the water will be sprayed out even if the temperature is below 30 °C. When the DHT22 sensor is utilized, the mist system will only be turned on according to the temperature value from the DHT22 sensor. This will avoid the wastage of water and save the cost of the water utility bill. Besides that, the success percentage of mushroom cultivation will increase because the water will not spray water when the temperature is below 28 °C as the optimum growing temperature is between 28 °C and 30 °C. This will result in lesser losses for Sinar Syukrawie Enterprise.

5. CONCLUSION

In conclusion, the grey oyster mushroom automated system was successfully developed within the time frame set and met the study's stated goal at the outset. Developing this grey oyster mushroom automated system may assist agropreneurs in controlling mushroom houses more systematically and efficiently and reduce the rate of mushroom damage due to excessive watering. This proposed automated system can assist new or long-term agropreneurs in grey oyster mushroom cultivation. This system can assist agropreneurs in more systematically and efficiently controlling mushroom houses

and reducing the rate of mushroom damage due to excessive watering. Agropreneurs can more easily monitor and control the temperature and humidity in the mushroom house by using this system.

As for the recommendation part for Grey Oyster Mushroom Automated System, we can further improve by using solar energy instead of electricity to save energy. This is because this system uses direct current (DC) voltage on the microcontroller and the water pump. Furthermore, we can also insert indicators such as an alarm to alert the user that the system is in operation. Besides that, in the future, this IoT system can be applied to monitor the humidity and temperature of the grey oyster mushroom house. It would be helpful for agropreneurs to observe and be aware of the surrounding of the grey oyster mushroom house without going directly to the place.

Acknowledgments: The authors would like to thank Sinar Syukrawie Enterprise for the Research Project Collaboration and Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer, Universiti Teknikal Malaysia Melaka for providing the facilities to do the experimental analysis and work towards completing this research paper.

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