Automatic Watering Monitoring System Using Solar Panel Resources at Agrapana Mushroom House Singosari District Malang Regency

Yoga Wishnu Wardhana[1], Farida Arinie Soelistianto[2*], Aad Hariyadi[3], Lis Diana Mustafa[4], Mochammad Junus[5]

[1,2,5]Digital Telecommunication Network Study Program, Department of Electrical Engineering, State Polytechnic of Malang, 65141, Indonesia.

[3,4]Telecommunication Engineering Study Program Department of Electrical Engineering, State Polytechnic of Malang, Malang, Indonesia

[1]djafrojack13@gmail.com, [2]farida.arinie@polinema.ac.id, [3]aad.hariyadi@polinema.ac.id, [4]lis.diana@polinema.ac.id, [5]mochammad.junus@polinema.ac.id

Abstrack— **Ear fungus (Auricularia spp.) is a cultivated mushroom widely grown in controlled environments using substrates such as sawdust or agricultural waste. Maintaining optimal humidity and temperature is essential to ensure efficient growth and high productivity. This study proposes the design and implementation of an Internet of Things (IoT)–based automatic watering system integrated with a Peltier cooling module powered by solar energy to support environmentally friendly cultivation. The system utilizes a soil moisture sensor to monitor the humidity level of the planting medium and automatically activates a water pump through a relay module when watering is required. Environmental data are processed in real time to maintain stable growing conditions, reducing dependence on manual monitoring. Additionally, the system provides SMS notifications to inform cultivators of watering activities, enabling effective supervision and timely intervention. The proposed solution aims to simplify environmental control, improve watering accuracy, and enhance cultivation efficiency. The results indicate that the IoT-based automatic watering system can optimize humidity regulation, accelerate mushroom growth, and reduce labor requirements, making it suitable for ear fungus farming applications.**

Keywords— Arduino Uno, Jamur kuping, Peltier, Pompa air, Relay

I. INTRODUCTION

Wood ear fungus or also called (Auricularia auricula) is a species of wood fungus belonging to the heterobasidiomycetes class which has high nutritional and economic value [1], [2]. The nutrients in wood ear fungus include protein, fat, carbohydrates, niacin, Ca, K, P, Na, and Fe. In terms of (taste, aroma, and appearance), wood ear fungus is indeed less attractive when served as food or main menu ingredients [3]. However, this wood ear fungus will be more attractive when served as a food supplement and this wood ear fungus is known as a food thickener and poison neutralizer [4]. Wood ear mucus is thought to be able to neutralize dangerous compounds or also called toxins found in food [5]. Wood ear fungus is also useful for treating heart disease (coronary heart disease) by reducing blood viscosity so that it can prevent blockage of blood vessels, especially in the brain [6], [7].

The Internet of Things is an extraordinary development in the fields of electrical engineering, information and communication technology [7]. All industrial sectors focus on the internet, which is a global network of computers connected using a series of standard protocols to serve billions of users worldwide [8]. This technology has developed and been applied in various aspects of agriculture, IoT utilizes internet connectivity to connect several electronic devices such as microcontrollers and several supporting sensors [8]. One method that has been done is to create an automatic sprayer that can be set at certain times for spraying [9].

Agrapana Mushroom House located in Kavling Graha Tunggul Ametung Block K62-63, Tejosari, Candirenggo, Singosari, Malang, is one of the businesses engaged in the cultivation of wood ear mushrooms [10]. This Mushroom House has an area of 120 square meters with a building length of 12 meters and a width of 10 meters, providing enough space for cultivating mushrooms in large quantities. In the cultivation process, this mushroom house uses 10,000 baglog planting media, which is a common media used for planting wood ear mushrooms [11], [12].

However, despite having quite large potential, Agrapana Mushroom House still faces challenges in terms of operational efficiency, one of which is the watering method which is still done manually [13]. Manual watering certainly requires a lot of time and energy, and can affect the quality and quantity of mushroom production. This is one of the factors that need to be considered in increasing production efficiency and the quality of mushroom cultivation at Rumah Jamur Agrapana [14], [15].

*Corresponding author

Based on the explanation above, the development of an automatic spraying tool and a sprayed water cooler is carried out which is expected to save costs and be environmentally friendly because the tool to be used will be powered by sunlight (solar panels) [16]. If the development of this tool can be realized and commercialized, this will make it easier and more efficient in terms of electricity for entrepreneurs in the agricultural sector, especially the cultivation of wood ear mushrooms [17].

II. METHOD

Overview of research method is depicted in Fig. 1.

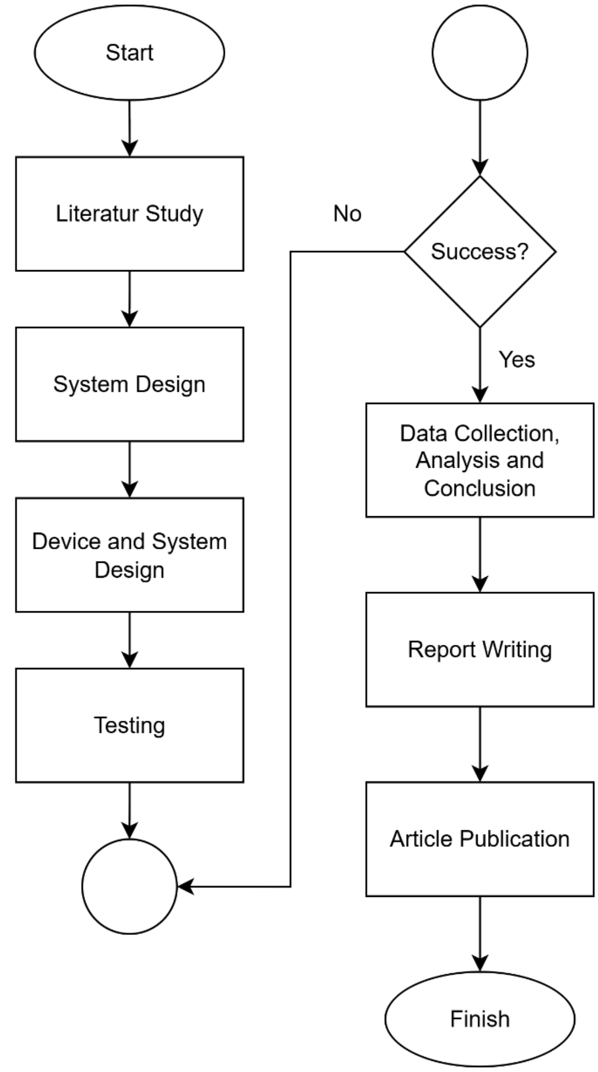

Figure 1. Research Methodology Flowchart

A. Research Design

1) Literature Study

At this stage, a literature search is carried out that is in accordance with the research to be developed. The search for literature references can be in the form of journals, articles, or theses that have been published regarding automatic plant watering devices. Researchers can use literature that was published a maximum of 5 years ago, this is because technology updates continue to exist every year.

2) System Design

At this stage, planning is carried out on the system design and prototype. At this stage, a simulation is carried out first regarding the prototype design that is developed, then system planning so that it can be connected to the prototype that will be developed.

3) Tool and System Design

After planning and simulating the automatic mushroom plant watering device, the next stage is product design and implementation of this tool.

4) Tool and System Testing

At this stage, testing is carried out on the prototype, software and connectivity between the two. The parameters that have been made are used to test the products made, these parameters include accuracy of the watering schedule, charging the solar panel to the battery, GSM module connectivity, and the suitability of the data that appears. If one of the parameters made fails, the researcher repeats the product design stage.

5) Data Collection, Analysis, and Conclusion

At this stage, data collection is carried out. Then continued to analyze the data that has been obtained. Furthermore, conclusions are obtained after the product works according to desire.

6) Report Preparation

At this stage, a report is prepared containing the overall results of the research.

7) Article Publication

At this stage, an article is published as one of the outputs of this research.

B. System Design

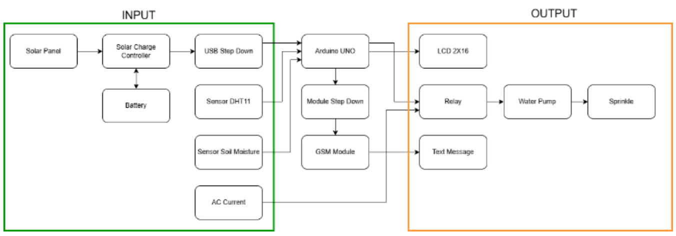

Figure 2. System Block Diagram

The block diagram shown in Fig. 2 illustrates the overall architecture of the proposed automatic watering and monitoring system. The system is powered by a solar panel that functions as a battery charger and serves as the primary energy source for all system components, including the Arduino Uno, soil moisture sensor, DHT11 sensor, 16×2 LCD, relay module, water pump, and GSM module. The Arduino Uno acts as the central microcontroller or main control unit responsible for executing programmed instructions and coordinating communication among all connected components. The soil moisture sensor continuously measures the humidity level of the planting medium and transmits this data to the Arduino Uno for processing. In addition, the DHT11 sensor is used to monitor ambient room temperature and humidity conditions. The measured values from both sensors are displayed in real time on the 16×2 LCD, allowing local monitoring of environmental conditions. The relay module functions as an electronic switch that controls the operation of the water pump based on sensor readings and predefined threshold values. Furthermore, the GSM module serves as a remote monitoring interface by sending SMS notifications to the mushroom cultivator whenever watering activities are initiated or completed.

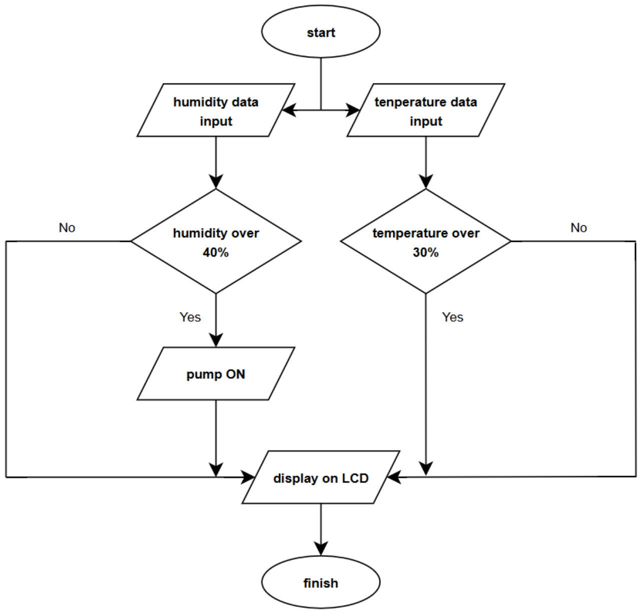

Figure 3. System Workflow Flowchart

Fig. 3 illustrates the system workflow through a flowchart that explains the sequential data processing and control mechanisms implemented in the proposed system. The workflow begins with the solar panel charging the battery, which serves as the primary power supply for the entire system. Once sufficient power is available, the battery energizes the Arduino Uno, initiating the system startup process. During this stage, the Arduino Uno performs an initialization routine to ensure that all connected components, including the soil moisture sensor, DHT11 sensor, relay module, LCD, and GSM module, are properly configured and ready for operation.

After initialization, the system enters a continuous monitoring mode. The soil moisture sensor periodically measures the humidity level of the planting medium and transmits the data to the Arduino Uno, while the DHT11 sensor simultaneously records ambient room temperature conditions. The Arduino Uno processes these sensor readings and compares them with predefined threshold values that represent optimal environmental conditions for ear fungus cultivation. When the measured soil moisture level falls below the specified threshold, the Arduino Uno activates the relay module, which functions as an electronic switch to turn on the water pump and initiate the automatic watering process. Likewise, when the recorded temperature exceeds the allowable limit, the control system can activate the water cooling mechanism to help stabilize the growing environment.

Throughout the watering and cooling processes, the Arduino Uno continuously monitors sensor feedback to prevent overwatering or excessive cooling. Once the desired moisture and temperature levels are achieved, the relay is deactivated to stop the water pump or cooling system. At the same time, the GSM module is triggered to send SMS notifications to the user, providing real-time information on system status, watering duration, and operational conditions. This workflow ensures efficient resource utilization, autonomous operation, and reliable remote monitoring, thereby improving overall system effectiveness and cultivation management.

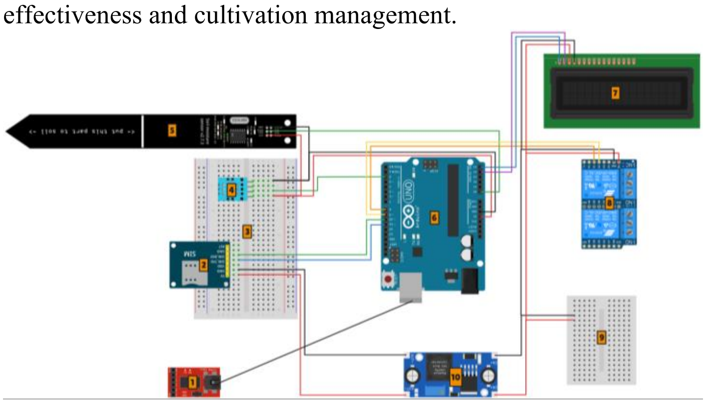

Figure 4. Circuit Diagram Schematic

The components installed on the client side as shown in Fig. 4 can be stated as follows:

- USB step down modul
- GSM modul
- Breadboard
- DHT11 sensor modul
- Soil moisture sensor
- Arduino uno
- LCD I2C 16x2
- Relay 2 channel
- Mini breadboard
- Buck step down module

In the design of the tool, a framework model of the shape to be made will be used. The design made will be a reference for the author regarding the layout of the device to be used and can be used as a design prototype for the device component box. The component used in this research shown in Fig. 5; it consist of solar panel 50wp, solar charge controller, battery 12v 12Ah.

Figure 5. Electrical Diagram Schematic

III. RESULTS AND DISCUSSION

A. Result of The Implementation of Automatic Springklers

Figure 6. Automatic Watering

Figure 7. Left of View

Figure 8. Right of View

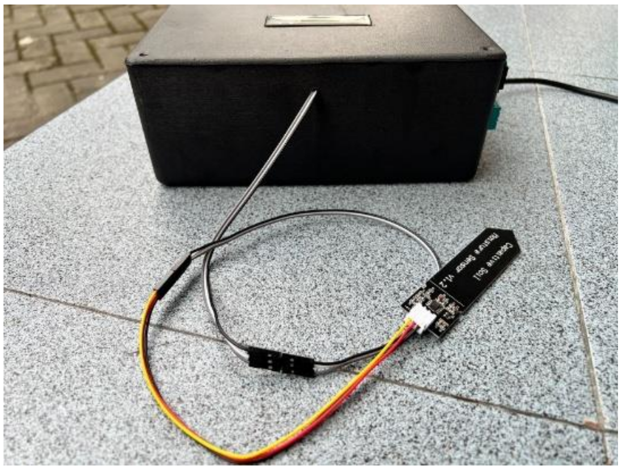

Figure 9. Top of View

Fig. 6 - Fig. 9, show hardware implementation in this research. In this system there is a box measuring 14.5mm x 21.5mm x 8.5mm which is used as an automatic watering control device in the Agrapana Mushroom House. On the left side of the box there is a hole that functions as a cable path as a power source for this device. On the right side there is a hole that functions as a circuit breaker from the water pump and water cooler to the 2 channel relay. Inside the box there is an Arduino Uno microcontroller that plays a role in controlling the entire system, the soil moisture sensor plays a role in providing humidity data to the Arduino Uno so that it can provide a trigger to relay 1 to turn the water pump on or off, the dht11 sensor plays a role in providing temperature data to the Arduino to display on lcd 16x2, the i2c 16x2 lcd plays a role in displaying data taken by the sensor, the 2 channel relay plays a role in disconnecting and connecting the electric current to the water pump and water cooler, the GSM Sim 800L module functions as a notification sender in the form of SMS to the destination number which will provide notification regarding the watering status. The specifications of the automatic sprinkler design results are as follows:

- Tool box measuring 21.5cm x 14.5cm x 8.5cm
- Arduino uno ATMega 328

- Soil moisture sensor
- DHT11 sensor
- I2C 16x2 LCD
- GSM Sim800L module
- 5V 2 Channel Relay
- USB Step Down 5V 3A
- Adjustable Buck Step Down Module

B. Device testing

a. Solar Panel Testing

Figure 10. Solar Panel Testing

The battery charging test with solar panels aims to determine how long it takes to charge a 144-watt battery capacity which shon in Fig. 10. The test was carried out 5 times in 5 days of testing with hot weather conditions. The test results can be seen in Table 1.

TABLE I
SOLAR PANEL TEST RESULT

No	Time	Temp (°C)	Humidity (%)	Voltage (V)
1	3 hours 2 minutes	34	49	14,2
2	2 hours 7 minutes	36	39	14,4
3	2 hours 9 minutes	35	57	14,3
4	2 hours 8 minutes	36	55	14,4
5	3 hours 3 minutes	35	58	14,3

Known :
Battery capacity 12V 12Ah = 12V x 12Ah = 144Watt
Total device load 3,2283Watt
Solar panels 50WP
Question :

1. How long does it take to fully charge the battery?
2. How long can the battery last to power all the device components?

Answer :

1. Battery 12V 12Ah = 144Watt
   Solar panels 50WP
   144/50 = 2,88hour
   So the battery charging time with a capacity of 144 watts takes 2.88 hours until the battery is fully charged.
2. Battery 12V 12Ah = 144Watt
   Device power = 3,2283Watt
   144/3,2283 = 44,6hour
   So a battery with a capacity of 144 watts will run out in 44,6 hours by providing power to all devices that require 3,2283 watts of power.

b. Soil Moisture Testing

Figure 11. Soil Moisture Test

Figure 12. Soil Moisture Test (Relay Off)

Figure 13. Soil Moisture Test (Relay On)

Soil moisture sensor testing was carried out by taking a comparison of the humidity data of the planting media with dry conditions and humid conditions. The proof of experimental result is shown in Fig. 10-Fig. 13. Test results obtained a humidity level in dry planting media conditions of 55% and in humid planting media 78%. The test results can be seen in Table 2.

TABLE II
SOIL MOISTURE TEST RESULT

No	Temp (°C)	Hum (%)	Soil (%)	Pump
1	26,80	85	55	On
2	26,80	85	78	Off
3	27,10	94	55	On
4	25,40	81	79	Off
5	26,20	92	56	On

The test results conducted with 5 trials obtained results with an average temperature in the range of 25°-27°C. The humidity level in the test obtained an average result in the range of 85%-94% and the water pump successfully turned on at a humidity level below 60% and the pump would turn off if the humidity condition reached above 78%.

c. DHT11 Sensor Testing

Figure 14. Sensor DHT11 Test

Figure 15. Sensor DHT11 Test (Relay Off)

Figure 16. Sensor DHT11 Test (Relay On)

Fig. 14 to Fig. 16 present the results of DHT11 sensor testing conducted in the planting room of the Agrapana Mushroom House to evaluate its performance in monitoring ambient room temperature. During testing, the DHT11 sensor measured temperature data in real time, which were processed by the Arduino Uno and displayed on the 16×2 LCD to provide users with direct information regarding environmental conditions in the cultivation area. Fig. 14 shows the initial testing condition in which the sensor successfully detected and displayed room temperature under normal conditions. Fig. 15 illustrates the system state when the relay is OFF, indicating that the measured temperature remains within the predefined optimal threshold and no control action is required. In contrast, Fig. 16 shows the relay in the ON state, which occurs when the detected temperature exceeds the specified limit, triggering the Arduino Uno to activate the relay and initiate the appropriate control action, such as operating the water cooling system. Overall, the results demonstrate that the DHT11 sensor operates reliably, accurately detects temperature variations, and effectively supports the automatic control mechanism needed to maintain stable environmental conditions for ear fungus cultivation.

TABLE III
DHT11 SENSOR TEST RESULT

No	Temp (°C)	Hum (%)	Soil (%)
1	28,10	85	56
2	31,20	85	56
3	27,10	94	55
4	29,40	81	79
5	26,20	92	56

The results in Table 3 obtained from 5 tests obtained fairly accurate sensor readings related to the data displayed on the 16x2 LCD screen to provide information to the user.

d. SMS Notification Testing

This test was conducted to determine the level of success and accuracy of this watering tool in sending notifications related to watering status in the form of SMS to land owners. The test results can be seen in Fig. 17 and detailed in Table 4.

Figure 17. SMS Notification Testing

TABLE 1
SMS NOTIFICATION TEST RESULT

Watering	Status Relay	Delay (ms)	Notification SMS
1	On	1-3	Penyiraman sedang berlangsung…
2	On	1-3	Penyiraman sedang berlangsung…
3	On	1-3	Penyiraman sedang berlangsung…
4	On	1-3	Penyiraman sedang berlangsung…
5	On	1-3	Penyiraman sedang berlangsung…
6	On	1-3	Penyiraman sedang berlangsung…
7	On	1-3	Penyiraman sedang berlangsung…
8	On	1-3	Penyiraman sedang berlangsung…
9	On	1-3	Penyiraman sedang berlangsung…
10	On	1-3	Penyiraman sedang berlangsung…
11	On	1-3	Penyiraman sedang berlangsung…
12	On	1-3	Penyiraman sedang berlangsung…
13	On	1-3	Penyiraman sedang berlangsung…

IV. CONCLUSION

Design and design this tool by providing hardware such as Arduino Uno, Soil Moisture Sensor, DHT11 Sensor, I2C 16x2 LCD, 2 Channel Relay, GSM Sim800L Module, Step Down Module. The use of solar panels for charging gets maximum results at 14.4 volts (in full condition) with an average time required of 3.2 hours at an outdoor temperature of 35 degrees Celsius. The use of soil moisture sensors in watering gets good accuracy results according to the soil moisture threshold that has been adjusted for the ear mushroom planting medium. The use of the dht11 sensor to provide data in the form of temperature to provide information data to users regarding room temperature in the Agrapana Mushroom House. The use of the GSM Sim 800L module can provide notifications in the form of SMS messages regarding watering status.

REFERENCES

[1] Subali Donysius, Hartanti Anastasia Tatik, and Canti Meda, "Improving The Economy Of The Community Of Manokwari, Papua Through Cultivation Of Ear Mushroom," Community Service, Vol. 5, No. 1, 2023.

[2] Asngad Aminah, Nugroho Dian, Khussyiria Milla Mifta, And Agustina Lina, "The Quality Of Natural Flavor Enhancers Of Edible Mushroom Combinations (Merang, Oyster, Kuping) With Variations In Temperature And Drying Time," Bioexperiment Journal Of Biological Research, Vol. 8, No. 1, Pp. 36–44, March. 2022.

[3] Edi Dhea Oksalia, "Potential Of Black Ear Fungus (Auricularia Polytricha) As Alternative Therapy For Diabetes Mellitus," Journal Of Health Science And Physiotherapy, Vol. 2, No. 1, Pp. 9–14, Jan. 2020.

[4] Zilham Adib And Gunawan Rahmad, "Potential Of Iot In Industry 4.0," JATI (Informatics Engineering Student Journal), Vol. 8, No. 2, Pp. 1932–1940, Apr. 2024.

[5] Sandi Ganesa Heru And Fatma Yulia, "Utilization Of Internet Of Things (Iot) Technology In

Agriculture," JATI (Informatics Engineering Student Journal), Vol. 7, No. 1, Pp. 1–5, Jan. 2023.

[6] Hermala Irvan And Darda Azqia Maulida, “Evaluation Of The Application Of Solar Hydroponic Systems Based On Iot To Increase The Productivity Of Horticultural Crops,” Syntax Literate Jurnal Ilmiah Indonesia, Vol. 7, No. 1, P. 232, Jan. 2022.

[7] Wulandari Sinta And Afriyanto Kevin Maulana, “Design Of Smart Reminder System And Integrated Agricultural Monitoring Based On Iot,” Journal Science Innovation And Technology (SINTECH), Vol. 3, No. 1, Pp. 7–14, Jan. 2023.

[8] Waluyo Sri, Wahyono Ribut Eko, Lanya Budianto, And Telaumbanua Mareli, “Automatic Control Of Temperature And Humidity In Oyster Mushroom (Pleurotus Sp) Cultivation Using A Microcontroller,” Agritech, Vol. 38, No. 3, Jul.2018.

[9] Ridwan Mohammad Yusuf, Nurpulaela Lela, And Bangsa Insani Abdi, “Iot System Application On Arduino Nano-Based Automatic Plant Watering Device,” Electronic Control, Telecommunication, Computer Information And Power System, Vol. 7, No. 1, Mar. 2022.

[10] Sari Tyas Kartika, Putri Dianing Novita Nurmala, Abduh Syamsir, And Widjaja Maulasukma, “Design Of Iot-Based Water Level Monitoring Prototype Using Solar Panels As A Source Of Electrical Energy,” Jetri Jurnal Ilmiah Teknik Elektro, Vol. 20, No. 2, Pp. 165–178, Feb. 2023.

[11] Ariep Jaenul, Mauludi Manfaluthy, Yordan Pramodja, And Febria Anjara, "Creation Of Backup Electricity Sources Using Internet Of Things (Iot) Based Solar Panels With Loads Of Lights And Electrical Equipment," Formosa Journal Of Science And Technology, Vol. 1, No. 3, Pp. 143–156, Jul. 2022.

[12] Muh. Ilcardi Ralda, La Ode Ahmad Barata, And Nanang Endriatno, "Automatic Dispenser Based On Arduino Uno," Piston Journal Of Technology, Vol. 7, No. 2, Pp. 23–28, Dec. 2022.

[13] M.U. Farooq, Muhammad Waseem, Sadia Mazhar, Anjum Khairi, And Talha Kamal, “A Review On Internet Of Things (Iot),” Int J Comput Appl, Vol. 113, No. 1, Pp. 1–7, March. 2015.

[14] Ali Nauman P.Hd., Muhammad Arbab Amjad, Yousaf Bin Zikria, And Yazdan A. Qadri, “Multimedia Internet Of Things: A Comprehensive Survey,” IEEE Access 08(00):8202, Vol. 8, Pp. 8202–8250, Jan. 2020.

[15] Zakariashvili Mariam, “From Virtual To Real Models – Arduino Uno,” Electronic Engineering, Vol. 7, Oct. 2023

[16] Dunbar Norman, “Alternatives To The Arduino IDE,” Arduino Software Internals, Pp. 163–217, Jun. 2024.

[17] Rahmany Rijal Surya, Aldo Jefri, And Halim, “Simulation Of The Use Of Roof Solar Panels In The Campus Environment Of Batulicin Polytechnic,” Scientific Journal Of Mechanical Engineering Kinematika, Vol. 8, No. 1, Pp. 74–84, Jun. 2022.