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Design of Temperature Monitoring and Stabilization System Based on Microcontroller for Outdoor Jacket in Cold Regions

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Abstract: The design of a temperature monitoring and stabilization system on a microcontroller based cold region outdoor jacket by utilizing microcontroller technology, by ensuring user comfort while in a cold temperature environment. This research is shown specifically in cold areas, with the aim of preventing hypothermia commonly experienced by climbers or humans, who are active in cold areas. The results of the system research on outdoor jackets that can monitor and stabilize the user's body temperature automatically, especially in cold areas. This system uses an ESP32 microcontroller, which is equipped with the Blynk application to control and monitor temperature using a smartphone. When the ambient temperature drops below 20°C, the system automatically activates the carbon fiber heating pad to maintain a stable body temperature. The jacket is designed to function offline, where the system will rely on the temperature sensor to activate the carbon fibre heating pad if the temperature drops below 20°C. Test results show that the system works well, providing efficient results in power consumption, responsive to temperature changes, and effective in maintaining temperature stability. The resulting jacket is comfortable and safe so that it does not interfere with outdoor jacket users in various conditions.

Keywords: ESP32 microcontroller, outdoor jacket, temperature monitoring, temperature stabilization, hypothermia

1. Introduction

In the modern era, outdoor activities are increasingly in demand by many people. Activities such as hiking, camping, and mountaineering are part of extreme sports as climbers need skill, intelligence, and strength in climbing. Erratic weather conditions, especially in areas with extreme temperatures such as high-altitude mountains, can pose significant challenges to adventurers [1]. To avoid hypothermia, climbers usually carry equipment that can reduce unwanted risks such as carrying a jacket. Climbers often think of hypothermia as a common thing, but in fact it is very dangerous for humans so in climbing hypothermia is a big problem. Climbers who experience hypothermia can immediately experience symptoms such as loss of consciousness, a lot of silence when spoken to, to fatal things that can be dangerous, namely death when exposed to hypothermia [2].

Various technologies have been created to facilitate activities in climbing, one of the technologies that have developed is technology in the field of temperature monitoring. Based on this background, this research aims to design and design a temperature stabilization system on a microcontroller-based outdoor jacket, as a preventive measure against hypothermia. In this study the authors used a microcontroller as a control device for temperature stabilization and monitoring of outdoor jacket. The use of microcontroller as a smart jacket has the potential to increase the comfort of smart jacket users. By utilizing microcontroller, the author will make a final project with the title "Design of a monitoring and technology temperature stabilization system for outdoor jackets in cold areas based on microcontrollers". As a development, smart jacket can combine practical and effective technology. This research will have a positive impact on smart jacket users, to makes it easy for users to monitor ambient temperature of outdoor jackets. If the ambient temperature is below the average temperature, the heating device on the jacket will automatically warm up locally, which is useful for stabilizing the temperature inside the outdoor jacket [3].

This research aims to design a system to be able to display and stabilize the temperature effectively and to test the system that has been designed to see the performance results on the tool whether it is efficient, responsive and effective when used.

2. Materials and Methods

The design of this system will be carried out in research, the design of a temperature stabilization and monitoring system for outdoor jackets, with steps in the design that include. System design method, electronic design, tool design, and testing method.

2.1 System Design Methods

The system design methods are the application of the stages carried out to create a design, this method makes it easier for researchers to design a tool to be made. The system design is made in the form of a flowchart in Figure 1.

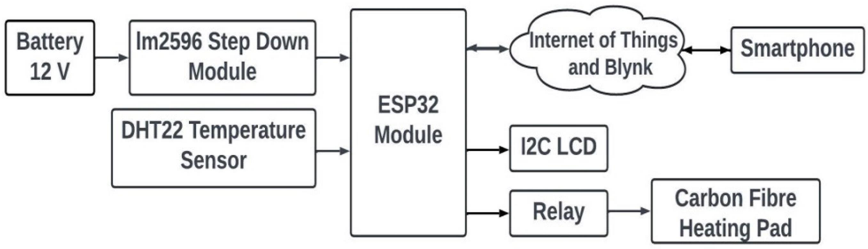


Figure 1. Block diagram of designed system

2.1.1 Electronic Design

This smart jacket requires a container for placing a program so that it can be run using a microcontroller. This design uses ESP32 as a microcontroller in the work system of this tool, because ESP32 is very easy and practical in its use. The electronic design can be seen in Figure 2 below.

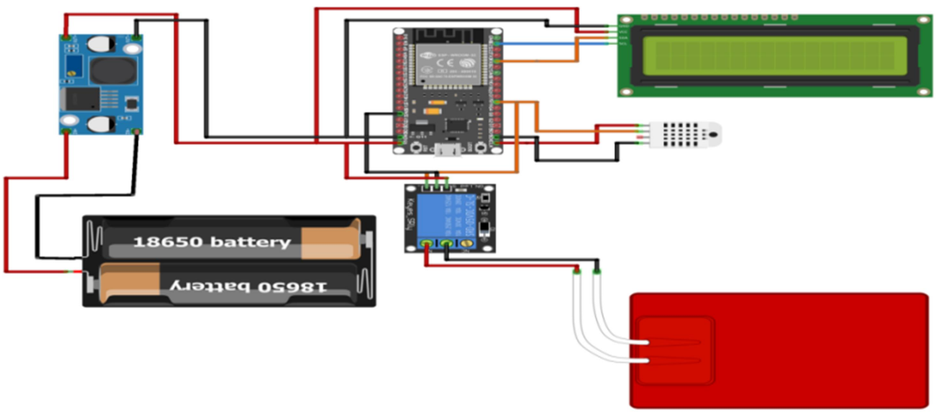


Figure 2. Electronic circuit design

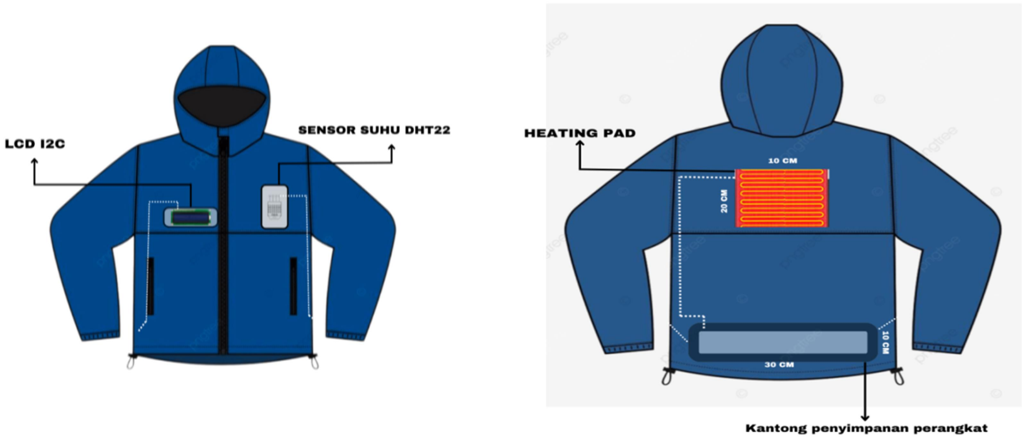
The electronic design is specifically designed in accordance with the design of the control system in the design of monitoring and temperature stabilization systems in outdoor jackets in cold regions based on microcontrollers. The electronic design can be divided into several parts, namely:

1. ESP32 module which functions for the controller of all research tools.
2. The design of the Dht22 temperature sensor functions to read the temperature in the surrounding area which will be displayed on the Blynk application and Lcd I2C, then will provide data to the relay to turn on the heating pad.
3. Carbon Fiber Heating Pad design functions as a local heater that is connected to the relay.
4. I2C LCD design that functions to display temperature data and humidity data from the DHT22 temperature sensor.
5. Relay design that functions to turn on and off the carbon fiber heating pad.
6. LM2596 module which functions to reduce the voltage on a 12 volt battery will be reduced to 5 volts as needed.
7. A 12 V battery which functions as a source of electricity in the research design of this tool.

The 12-volt lithium battery that has been assembled with a series circuit system, used as an electric current in this research system design, this battery can also be recharged. The LM2596 step down module functions to reduce the voltage from 12V to 5V to be input to the ESP32, then the DHT22 temperature sensor functions to read the temperature, which will be displayed to the I2C LCD and Blynk application connected via ESP32 wifi. To stabilize the temperature inside the jacket, using a carbon fiber heating pad that functions as a local warmer. Relay functions for automatic system. Temperature sensor data sent by ESP32 where the temperature is below 20°C, will send to the relay so that the system automatically works.

2.1.2 Mechanical Design

The design of the outdoor jacket concept design is made using the Canva application, so that it is easy to understand in designing an outdoor jacket design. The design of the front and back of the outdoor jacket can be seen in Figure 3. The mechanical design of the outdoor jacket uses the Canva application, this design is annotated with all the places of parts such as the main components of the microcontroller, temperature sensor, Lcd I2C, and carbon fiber heating pad.



(a) (b)

Figure 3. Outdoor jacket design (a) Front view (b) Back view.

2.1.3 Software Design

The stages carried out, on the design of the system. Design of a temperature stabilization and monitoring system on a microcontroller-based outdoor jacket. The algorithm of application program for designed sytem was shown in Figure 4.

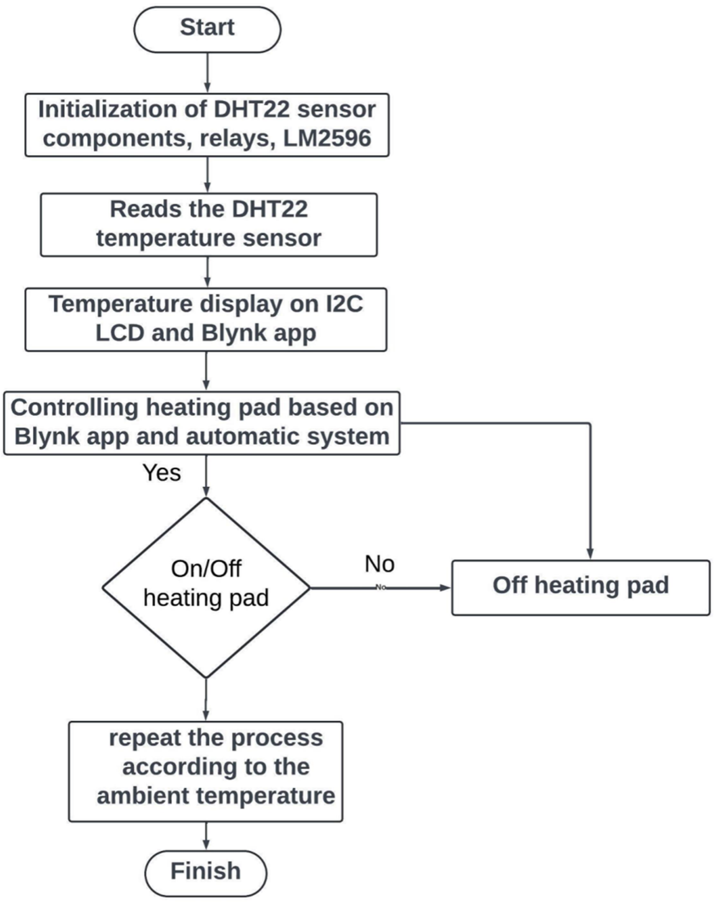


Figure 4. Algorithm of Application for Designed Sytem

2.2 Testing Methods

The data analysis method used in design research, using a microcontroller as a control tool for this research. Then the accurate level of the monitoring system and temperature stabilization on the microcontroller-based outdoor jacket will be tested. In the data analysis method there are several stages, namely collecting data in the form of a temperature sensor, blynk application, carbon fiber heating pad, battery then there is data collection, namely the calibration of the temperature sensor in calculating the average during the test period.

3. Results and Discussion

3.1 Prototype of System

The protototype of monitoring and temperature stabilization system on microcontroller-based cold-region outdoor jacket is divided into mechanical design, electronic design and program design. Mechanical aspects in the monitoring system and temperature stabilization in microcontroller-based outdoor jackets, mechanical aspects are very important to support system performance including design elements and physical structures designed to ensure that the jacket can function optimally. The electronic design is specifically designed in accordance with the design of the control system in the design of monitoring and temperature stabilization systems in outdoor jackets in cold regions based on microcontrollers. The prototype realized of system was shown in Figure 5 and the jacket with installed system was shown in Figure 6.

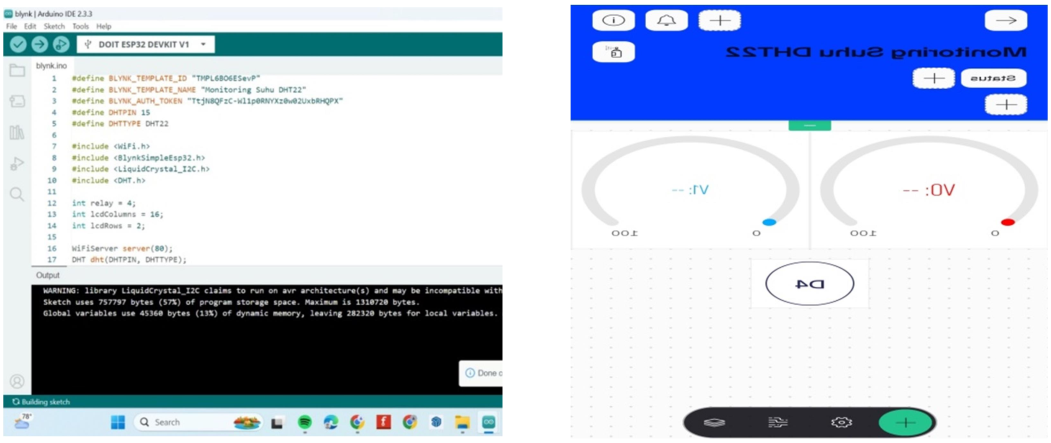
(a) (b) (c)

Figure 5. Prototype of System (a) Electronic devices in opened case (b) Electronic devices in closed case (c) Electonic devices with intalled carbon fiber heating pad

Figure 6. The jacket with installed system

3.3 Application Program for System

The temperature monitoring and stabilization system program is made in accordance with how it works, the program or command used to run the component uses two software, namely, Arduino IDE software and Blynk software. The following is the display of the two software. Arduino IDE Software is an application to create programming sketches and is used to program microcontrollers, testing this arduino program is done to find out whether the program made is running as it should. The Blynk app is for Android OS and and iOS in order to control Arduino, NodeMCU, Raspberry Pi and the like over the Internet. Blynk is not limited to some type of microcontroller that is already supported with the selected hardware. NodeMCU is controlled with an Internet connection via WiFi. Blynk is made online by connecting to the Internet of Things. The design of the arduino IDE program and blynk application is shown in Figure 7.



(**a**) (**b**)

Figure 7. Arduino IDE program and blynk application (a) Front view (b) Back view.

3.4 Battery Testing

In testing this 12 Volt DC battery using a digital multimeter tool. This battery is equipped with a charger module on the battery that makes it easy to recharge the battery, with a DC voltage output, a battery with a capacity of 9000 MaH can last 1 hour to 1.5 hours depending on how long we charge the battery. The test results are presented in Table 1 and Figure 8.

Table 1. Battery test results

No	Time	Voltage
1	08.00	12.00 V
2	08.05	11.59 V
3	08.10	11.59 V
4	08.15	11.57 V
5	08.20	11.40 V
6	08.25	11.00 V
7	08.30	10.45 V
8	08.40	9.43 V
9	08.45	9.25 V
10	08.50	9.21 V
11	08.55	8.50 V
12	09.00	7.81 V

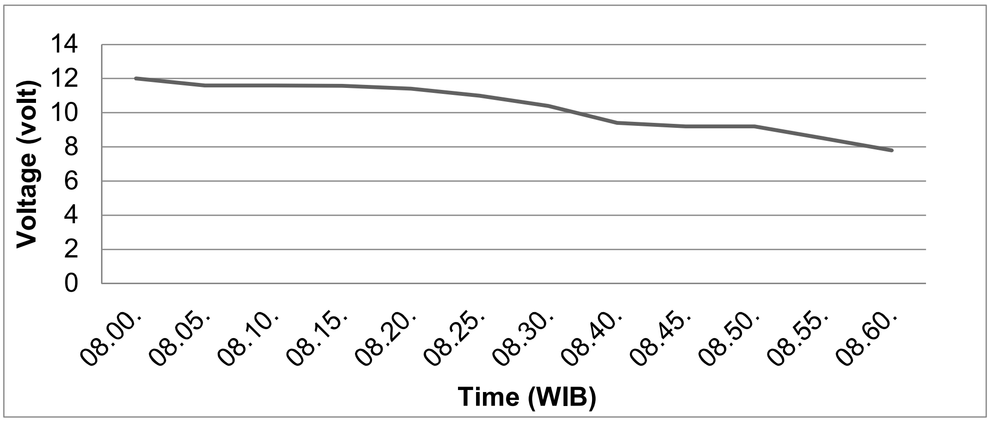


Figure 8. Voltage of Battery graph

3.5 The LM2596 Module Testing

In testing this LM2596 Module using a digital multimeter measuring instrument. This adapter requires an input voltage of 12 Volts DC with a DC voltage output. The test results can be seen in Table 2 and Figure 9.

Table 2. LM2596 test results

No.	Time	Voltage
1	09.00	5.21 V
2	09.10	5.21 V
3	09.20	5.21 V
4	09.30	5.19 V
5	09.40	5.18 V
6	09.50	5.18 V
7	10.00	5.19 V
8	10.05	5.20 V
9	10.10	5.15 V
10	10.20	5.16 V

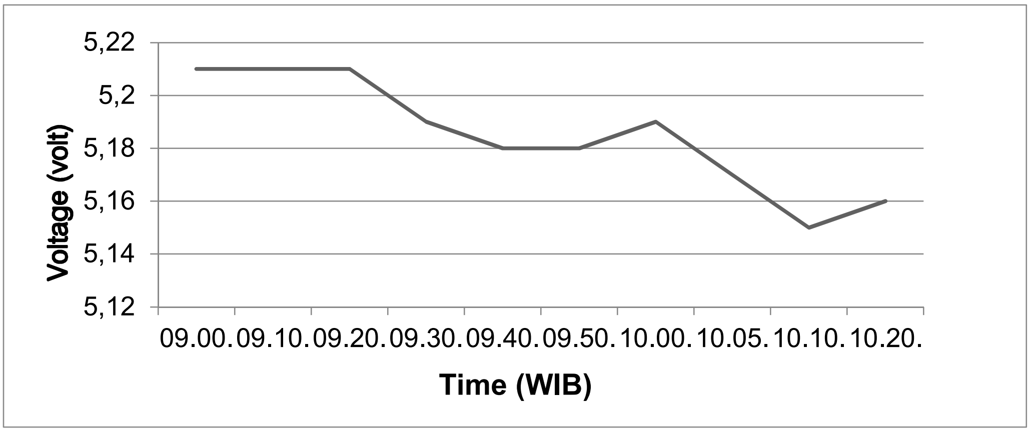


Figure 9. The LM2596 testing graph

3.6 The DHT22 Temperature Sensor Testing

Testing the performance of the DHT22 temperature sensor is done by exposing the temperature sensor to the actual environment, then the reading of the DHT22 temperature sensor is compared with a digital thermometer. This data collection is taken in the actual environment as a research site. The test results can be seen in Table 3 and Figure 10.

Table 3. The DHT22 temperature sensor test results

No.	Temperature (°C)		Error(%)
	Temperature sensor DHT22	Thermometer	
1	19.7	19.8	1
2	19.0	19.0	0
3	20.1	20.0	1
4	19.3	19.7	4
5	18.8	19.0	2
6	18.9	19.0	1
7	19.8	20.0	2
8	17.5	17.8	3
9	18.3	18.5	2
10	18.4	18.7	3

The temperature observation from the DHT22 sensor results in a temperature of 19.70ºC, while the temperature observation from the thermometer results in a temperature of 19.80ºC. This indicates that the DHT22 sensor can still be tolerated.

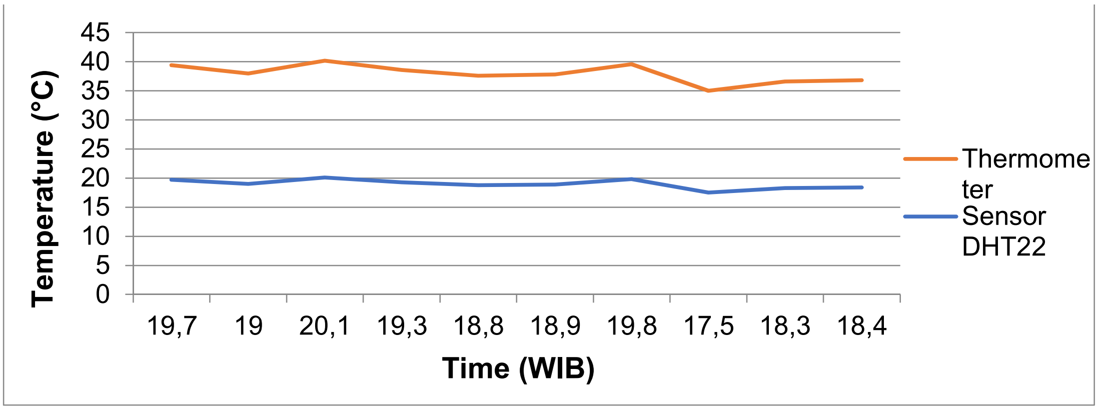


Figure 10. The DHT22 Sensor Graph

3.7 Testing of Carbon Fiber Heating Pad

Testing with an automatic system or offline and online using the Blynk application via Smartphone, the aim is to determine the success of the entire system, the use of energy consumption and the time needed to warm the appliance. The maximum temperature obtained in this study reached 43 ° C. In this study focused on sufferers of mild hypothermia symptoms, because the recovery time of people with hypothermia depends on the severity of hypothermia. In the recovery of mild hypothermia sufferers, the recovery process takes 20 minutes to 30 minutes. The temperature that can be accepted by people with mild hypothermia, ranging from 37 ° or 40 ° C, is not recommended to exceed 43 ° C to avoid the risk of overheating. Then the time needed to warm this tool is around 15 minutes to reach a temperature of 40 °C, with power from a 12 Volt battery, the battery can last up to 1 or 1.5 hours.

3.7.1 Online Testing

The online testing system can test with the online method by directly connecting with the Wifi module on the Esp32, when connected the device is monitored with the Blynk application which can turn on and off the carbon fiber heating pad. The results of the study are shown in Table 4 and Figure 11.

Table 4. Heating pad test results

No.	Time	Carbon fibre heating pad	
		Online conditions	Offline conditions
1	22.00	23°C	23°C
2	22.10	35°C	22°C
3	22.20	39°C	20°C
4	22.30	40°C	21°C
5	22.40	39°C	21°C
6	22.50	40°C	22°C
7	23.00	41°C	20°C
8	23.10	40°C	21°C
9	23.20	40°C	19°C
10	23.30	41°C	20°C

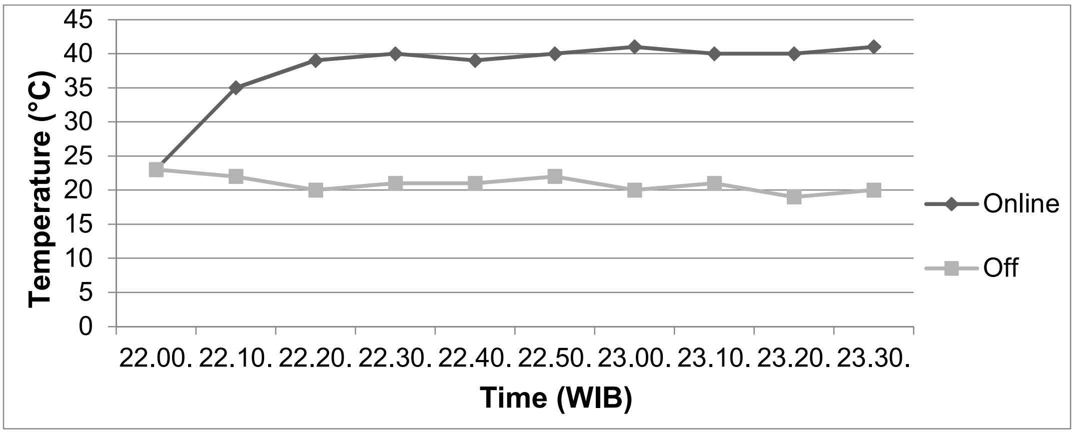


Figure 11. Heating pad graph.

3.7.2 Offline Testing

In offline testing without connecting to the Wifi module on the ESP32, this test ensures that the system can operate without a signal in the surrounding location area without requiring a network connection. The test table and graph of offline test results can be seen in Table 5 and Figure 12.

Table 5. Heating pad test results

No.	Time	Carbon fibre heating pad	
		Offline conditions	Off condition
1	23.00	24°C	21°C
2	23.10	34°C	22°C
3	23.20	39°C	23°C
4	23.30	40°C	20°C
5	23.40	39°C	21°C
6	23.50	40°C	22°C
7	00.00	40°C	20°C
8	00.10	40°C	21°C
9	00.20	43°C	20°C
10	00.30	43°C	19°C

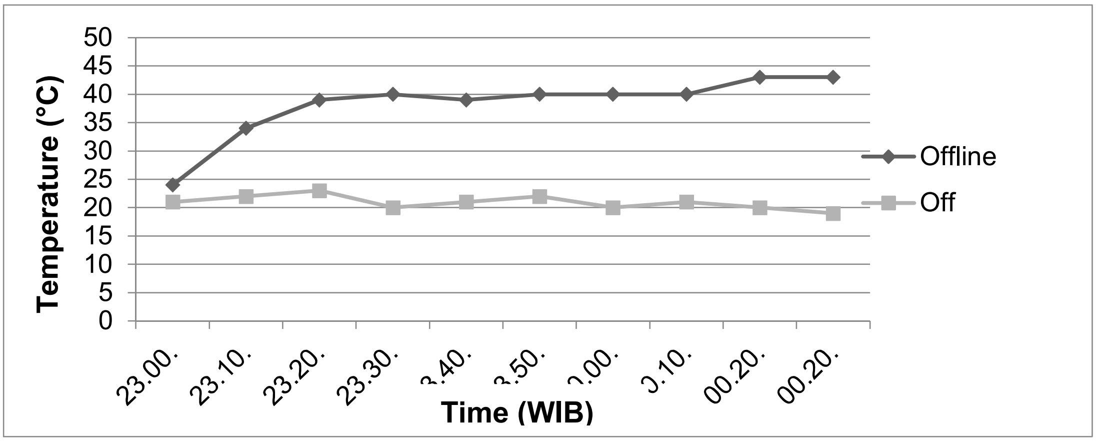


Figure 12. Heating pad graph

3.8 Testing of Blynk Application

Testing the Blynk application ensures that the microcontroller (ESP32) can connect to the Blynk application via a Wifi connection, then the DHT22 temperature sensor data will appear on the Blynk screen as a result of the Celsius temperature reading, then the humadity or humidity reading and the on/of button to turn on and off the heating pad. In the temperature observation from the DHT22 sensor through the Blynk application, the temperature result is 19.7ºC, while the temperature observation from the I2C LCD gets a temperature of 19.70ºC. This indicates that the Blynk application and the I2C LCD have no errors. The test results can be seen in Table 6.

Table 6. Test results of the blynk application

No.	Temperature sensor DHT22	
	Temperature (°C)	Humidity (%)
1	19.7°C	90%
2	19.1°C	96%
3	18.9°C	95%
4	18.8°C	95%
5	18.8°C	96%
6	19.0°C	93%
7	19.1°C	94%
8	18.9°C	95%
9	18.8°C	95%
10	19.8°C	91%

4. Conclusions

After testing and analyzing the data, the test results can be concluded. The design of this system is effective to display and stabilize the temperature, in the design of the tool is made as comfortable as possible so as not to interfere with the movement of the user. Furthermore, the monitoring system and temperature stabilization on microcontroller-based outdoor jackets show good system performance, in detecting and sending results connected to the Blynk application. Furthermore, the system must be connected to a wifi connection, so that users can control and monitor jackets online using the Blynk application. The system results can also operate in offline conditions, in offline conditions the system functions automatically by relying on temperature sensors. In offline mode, the system will compare the temperature in the environment with the temperature that has been inputted in the program. If the temperature is detected below 20°C, the carbon heating pad will automatically turn on.

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