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Thermoelectric Mini Portable Fridge with Wireless Temperature Monitoring

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Abstract: Nowadays, to continue cooling food or medication during travel, people need a compact refrigerator that is easier to bring anywhere. Thus, the goal of this project is to build a Peltier thermoelectric mini-portable fridge, plus, the temperature can be monitored wirelessly. The fridge monitoring system consists of a DHT11 sensor, the HC-05 Bluetooth module, LCD, and Arduino Uno. The Arduino UNO is also programmed with minimal software called Arduino IDE, which programs the Peltier module's cooling temperature. The results show that when the time arises, the temperature decreases rapidly, and the humidity fluctuated. The saturation point increases as the temperature of the air changes. Before it becomes saturated, cold air can carry less water vapor, and hot air can retain more water vapor before it becomes saturated. The fridge needs to maintain a low temperature, which is a minimum of 7 °C in this project, the supply needs to have sufficient power to the heat sink, the fans, and the Peltier module.

Keywords: Thermoelectric, Heat Sink, Wireless Monitoring, Peltier

1. Introduction

In 1834, to establish refrigeration, Jean Charles Athanase reversed the movement of electrons in the Seebeck.s circuit. The Peltier Effect is known as this effect. The foundation of the thermoelectric refrigerator is this principle. In 1854, Scottish scientist William Thomson found that if a temperature difference occurs between any two points of a current-carrying conductor, depending on the material, heat is either produced or absorbed. If heat is absorbed by such a circuit, heat will evolve in the direction of the current or temperature gradient is reversed.

Thermoelectric refrigerator is often referred to as a thermoelectric cooler module, or the electrical component centered on a semiconductor that functions as a small heat pump is the Peltier module. The

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heat will be transferred from one side to the other via the module by supplying the Peltier module with a low voltage direct current (DC) power source. As a result, one module face will be cooled while simultaneously heating the opposite face. The Peltier modules' DC power mechanism allows electrons to change through the material of the semiconductor. Heat is absorbed in the cold end of the semiconductor material by the electron movement and discharged at the hot end [1][2].

People currently like outdoor sports, such as picnics, fishing, and bringing medication to village for medical purposes [3]. To continue cooling food or medication, they need a compact refrigerator that is easier to transport anywhere [4]. A mini fridge does not require much space especially for people who stay in an apartment or hostel. Moreover, drinks and foods that require low temperatures can be provided wherever you go with a portable mini fridge [5]. When buying wet food in the market, this fridge can help to bring stuff to home freshly. By having a mini fridge, everyone will be able to enjoy outdoor activities such as picnics and sunbathe or bring food and drinks either on holiday or to work [6].

In this work, a Peltier thermoelectric-based portable fridge with the wireless monitoring system is developed. The operating mode for the thermoelectric system starts with electrical power from the power supply, which is passed into the system causing the Peltier and Arduino to work. The components used for temperature monitoring in this project include Arduino UNO, jumper cables, HC-05, LCD, and the DHT11 sensor. The HC-05 Bluetooth module relates to the mobile phone to display the temperature and humidity data. While the system operates, the Peltier module creates different temperatures on both sides which cold side, and the other is the hot side. Therefore, the temperature can be determined in the Blueserial application on the mobile phone.

2. Materials and Methods

This section will explain the development of the thermoelectric mini-portable fridge that started with the block diagram of the main component in this project and the simulation using Proteus simulation with labeling. After the simulation process has been fulfilled and satisfied with the result generated, it moves to the hardware implementation. The operation of each type of component is also presented in the table.

2.1 Block diagram of the main component

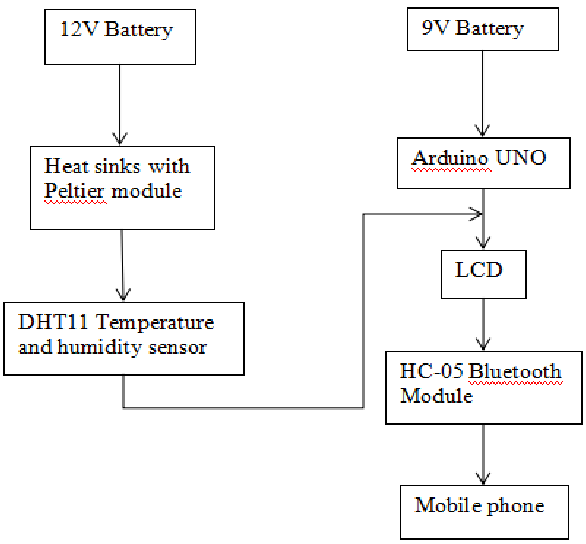

Figure 1: Main components block diagram

Based on the block diagram shown in Figure 1, the power supply represents the 12 V battery connected with the heat sinks with a Peltier module and the 9 V battery connected to Arduino UNO. The supply is different because heat sink with a Peltier module used more power in this experiment. There is a sensor connected to the Arduino UNO, which is a temperature and humidity sensor. The output is the LCD to display the temperature and humidity data and the HC-05 Bluetooth module to display temperature and humidity data in the mobile phone.

2.2 Components of the thermoelectric mini-portable fridge

The components required in the circuit with their functions are listed below in the Table 1:

Table 1: Main components and its function

Components	Functions
1. The DHT11 temperature and humidity sensor	To test the ambient air, it uses a capacitive humidity sensor and a thermistor and spits out a digital signal on the data pin at Arduino UNO.
2. HC-05 Bluetooth module	Its communication via serial communication, which makes a simple way to interface with the mobile phone and the program created in the Arduino IDE. It easy to monitor the temperature and humidity after programming it.
3. Liquid Crystal Displays (LCD)	A mixture of two states of matter, the solid and the liquid, is a liquid crystal or LCD. To create a visible image, the LCD uses a liquid crystal. After delivery, the temperature and humidity data will be shown.
4. Arduino UNO	The Arduino could be an ATmega328 board based on a microcontroller. Arduino has 14 input and output pins, which are typically used as PWM output by 6 pins, 6 analog input and 16 MHz quartz oscillator, the USB link, an impact Jack, and a button. The Arduino can support a microcontroller that can be USB-connected to a device. It uses the HC-05 Bluetooth module to monitor the temperature and humidity data.
5. Heat sinks with cooling fans	To accelerate the rate of heat absorption from the room to the cold side of the thermoelectric module, heat sinks are used. The heat sink, however, is becoming too hot. This occurs when the refrigerator runs for longer periods at maximum capacity.
6. The Peltier module	It acts as a tiny heat pump. Heat can be moved from one side of the module to the other by adding the DC power source to the Peltier module. This produces a warm and cold side. It used for cold the refrigerator.

2.3 Circuit of monitoring temperature and humidity

Based on Figure 2, the complete simulation of the monitoring temperature and humidity was shown. In this study, the DHT11 has three pins which are an output pin, an input pin, and a data pin. The output pin goes to power, the input pin goes to the ground and the data pin goes to the A0 pin of the Arduino UNO. The LCD has 16 pins, however, only 10 pins are uses in this circuit which are the VSS pin goes to the ground. The VDD pin goes to power with the resistor to limit the voltage division in the circuit. The VEE pin is the contrast adjustment, to maintain the brightness of the LCD, two resistors were used and connected to power and ground. The RS pin goes to pin 2 of the Arduino UNO. The RW pin got to the ground. The E pin goes to pin 3 Arduino, and pins of D7, D6, D5, D4 connected to PD7, PD6, PD5, and PD4 pins of Arduino. The HC-05 Bluetooth module has 5 pins, however, in this simulation needs two pins only which are RW and TW that are connected to PD1 and PD0 of Arduino.

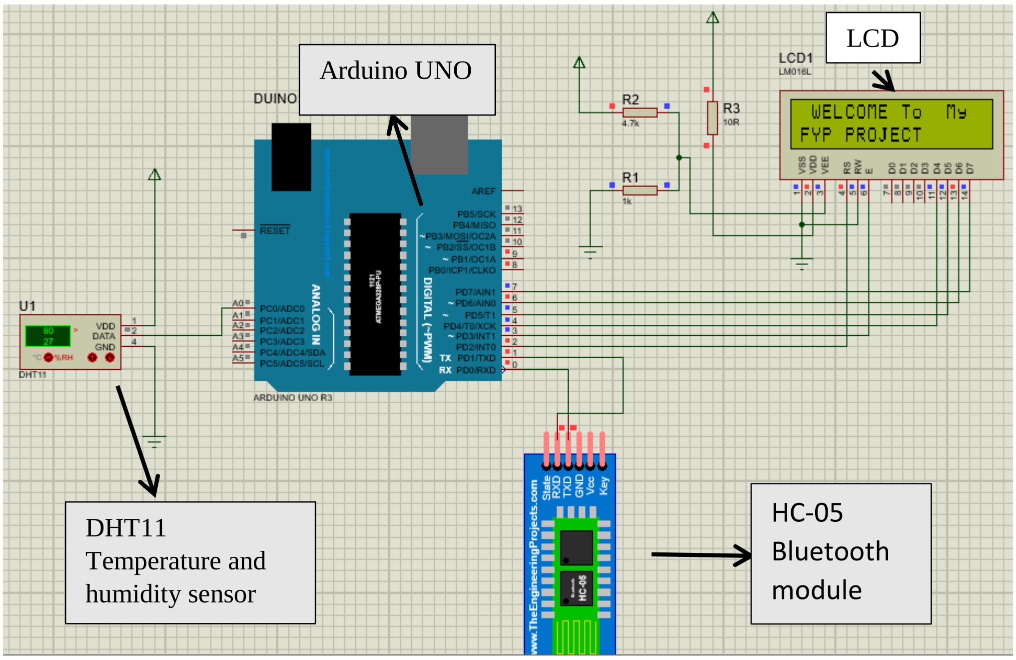

Figure 2: Simulation of monitoring temperature and humidity

3. Results and Discussion

In this section, the development of the thermoelectric mini-portable fridge with wireless temperature monitoring is discussed. To organize the collected data in a clear and summarized form, the project results in the table and graph. With a significant visual of the graph, the result analysis becomes more understandable.

3.1 Result and Analysis

Figure 3 shows the data of temperature and humidity at room temperature the mobile phone using Blueserial applications. This application is easy application as a need to program in Arduino IDE and interface in the mobile phone.

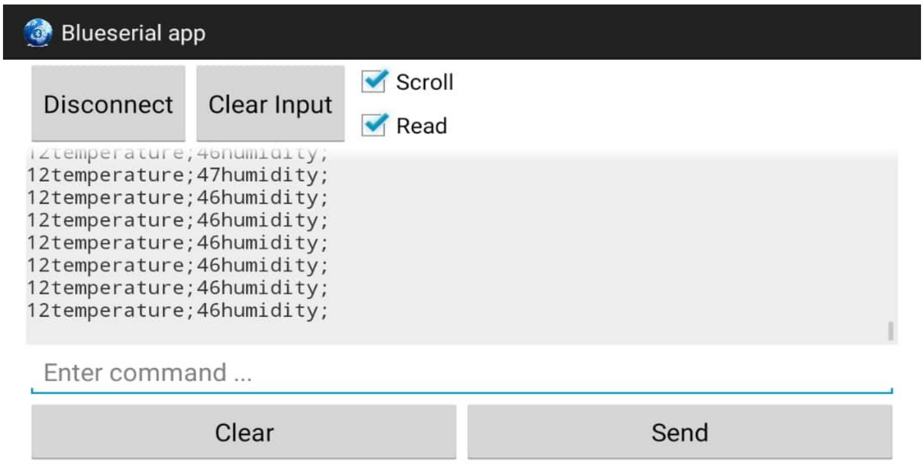

Figure 3: The data of temperature and humidity at room temperature using Blueserial application

The relative humidity is the volume of water vapor in the air as opposed to the saturation point of water vapor in the air. Water vapor tends to condense at the saturation point and to settle on dew-forming surfaces. The saturation point increases as the temperature of the air changes. Before it becomes saturated, cold air can carry less water vapor, and hot air can retain more water vapor before it becomes saturated. Relative humidity shall be expressed as a percentage. At 100.00 % relative humidity, condensation occurs, and at 0 percent relative humidity, the air is completely dry.

As referred to Figure 4, the horizontal axis shows the time during the experiment which is two hours, and the vertical represents the humidity in percent and temperature in degree Celcius. The time rises steeply while the temperature decreases rapidly, and the humidity fluctuated. The result of temperature and humidity with time is recorded in the Blueserial application. The time increase, 3 minutes minimum and 12 minutes maximum. The temperature decrease, however, it takes a longer time to down the temperature as the heat sinks cooling fans need sufficient voltage when it operates. By the increase of the time, the voltage decreases because continue operation in longer time. Furthermore, the humidity unfortunately not consistent due to the surrounding air in the fridge and the room. In summary, the humidity depends on the temperature of the surroundings.

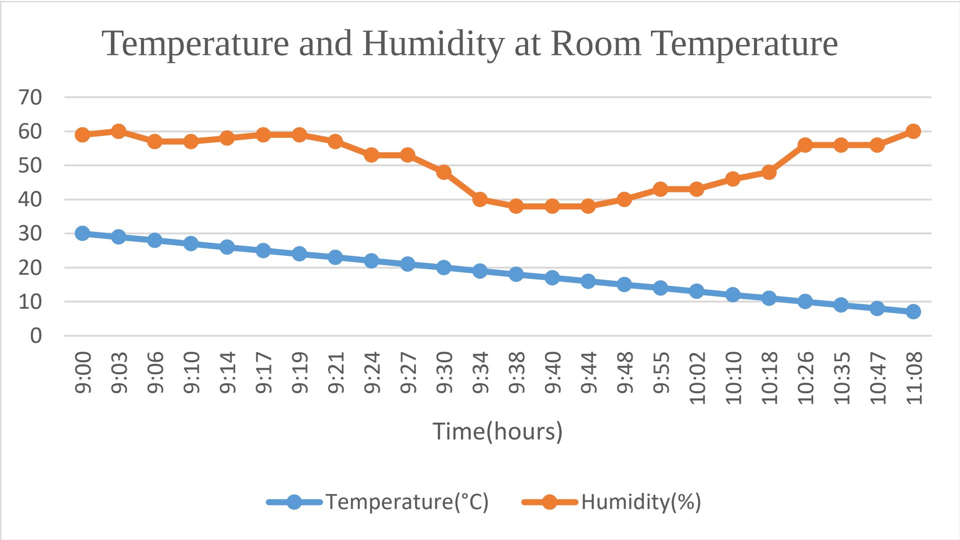

Figure 4: Graph of the temperature and humidity at room temperature against time

Figure 5 shows the data of temperature and humidity at the outdoor temperature in the mobile phone using Blueserial applications.

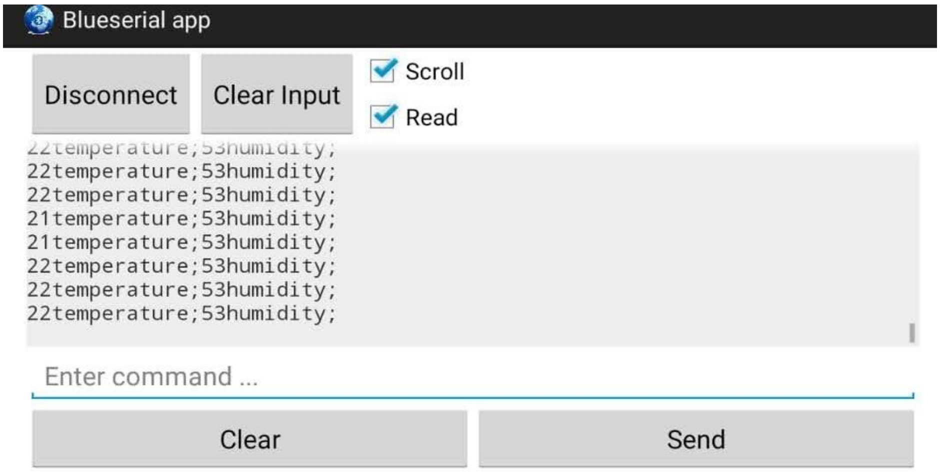

Figure 5: The data of temperature and humidity at outdoor

As referred in Figure 6, the horizontal axis shows the time during the experiment in one hour approximately and the vertical represents the humidity and temperature. The time rises steadily while the temperature decreases rapidly, and the humidity increase sustainably. The relative humidity increases if the water vapor content remains the same and the temperature decreases. The relative humidity decreases if the water vapor content remains the same and the temperature increases. This is because colder air does not take as much humidity as warmer air to become saturated.

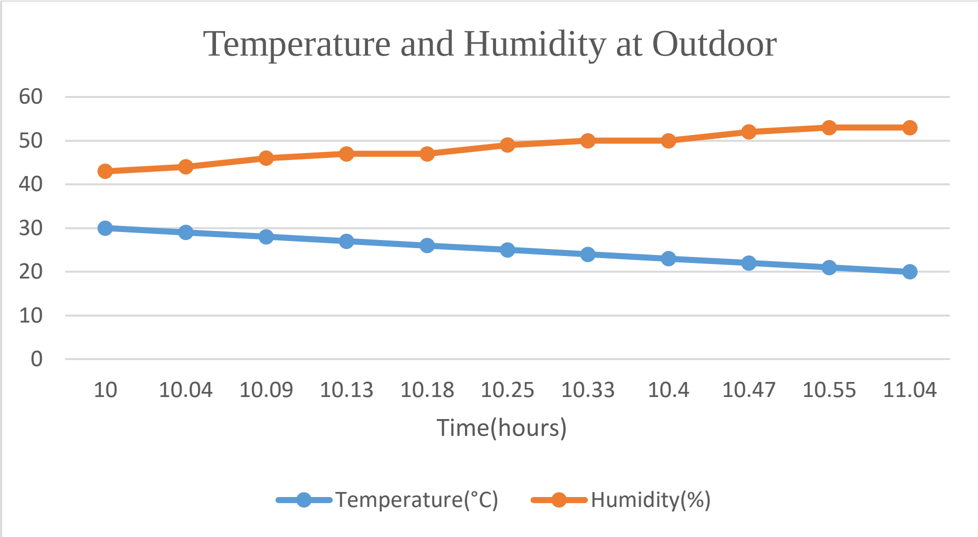

Figure 6: Graph of the temperature and humidity at outdoor against time

3.2 Experimental Results

The back view of the prototype of this project is shown in Figure 7, the top view of the prototype in Figure 8, the front view of the prototype in Figure 9, the inside view in the fridge is shown in Figure 10, during the experiment in the room shown in Figure 11, and during outdoor in Figure 12. In this phase, the HC-05 connected to the mobile phone to monitor the temperature and humidity data. The Arduino programmed the code to operate the DH11, HC-05, and LCD with a 9 V battery. The 12 V battery is supplied to the Peltier module and heat sink with cooling fans for the operation of this project. The supply of Arduino UNO with the Peltier module and fans are different because the Peltier module and heat sink with cooling fans used more power and need to have their own supply. The Peltier module will damage if the supply share with Arduino UNO.

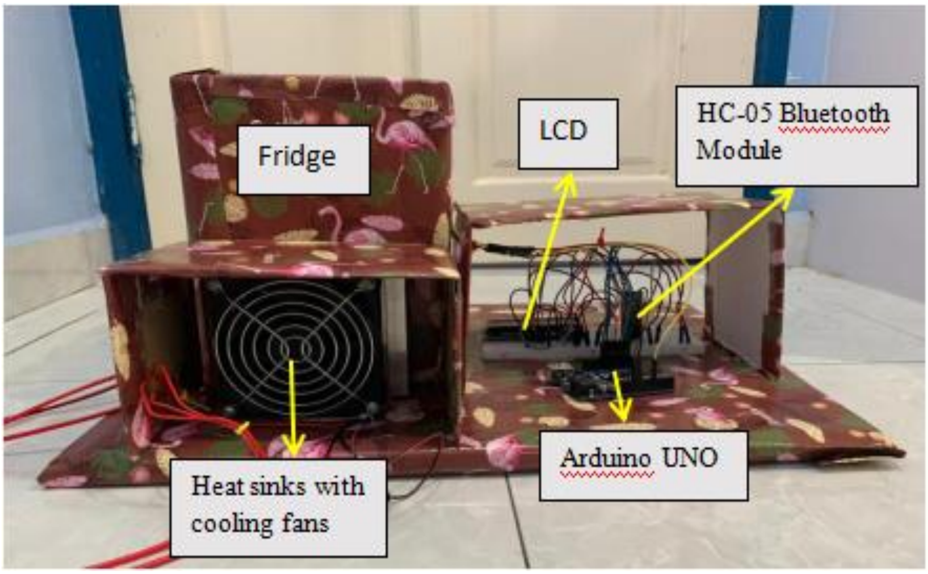

Figure 7: The back view of the prototype of the thermoelectric mini-portable fridge with a wireless temperature monitoring

Figure 8: The top view of the prototype of the thermoelectric mini-portable fridge with a wireless temperature monitoring

Figure 9: The front view of the prototype of the thermoelectric mini-portable fridge with a wireless temperature monitoring

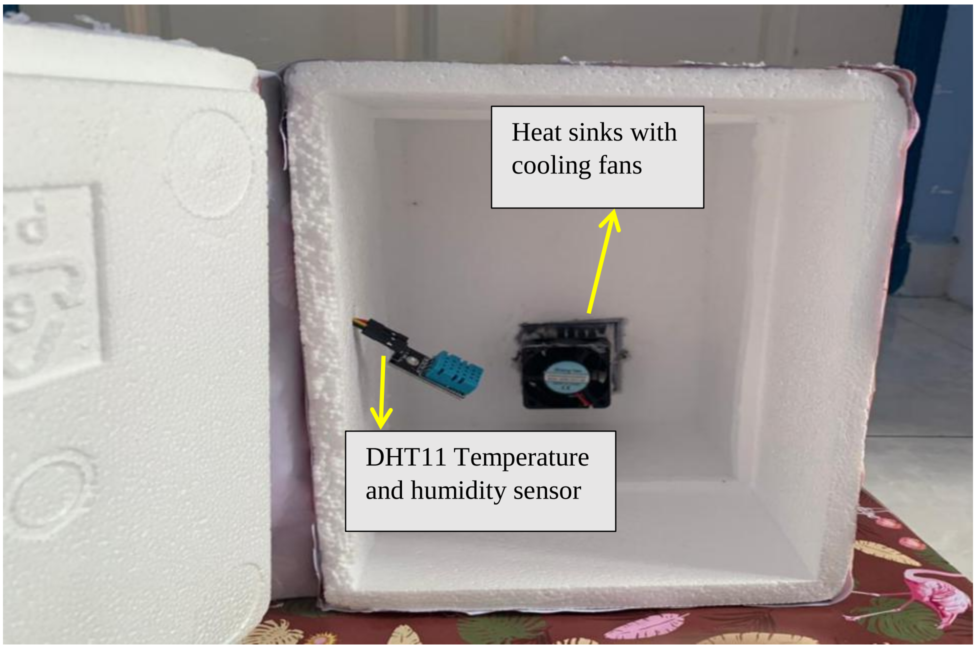

Figure 10: The inside view of the prototype of the thermoelectric mini-portable fridge with a wireless temperature monitoring

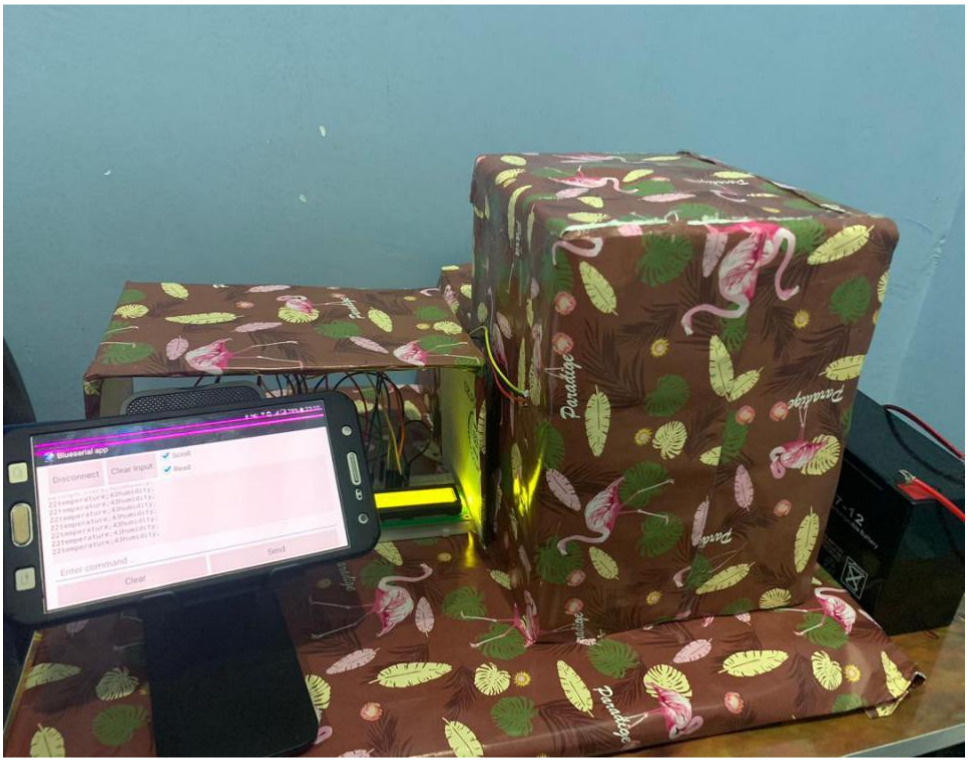

Figure 11: The prototype was being tested in room

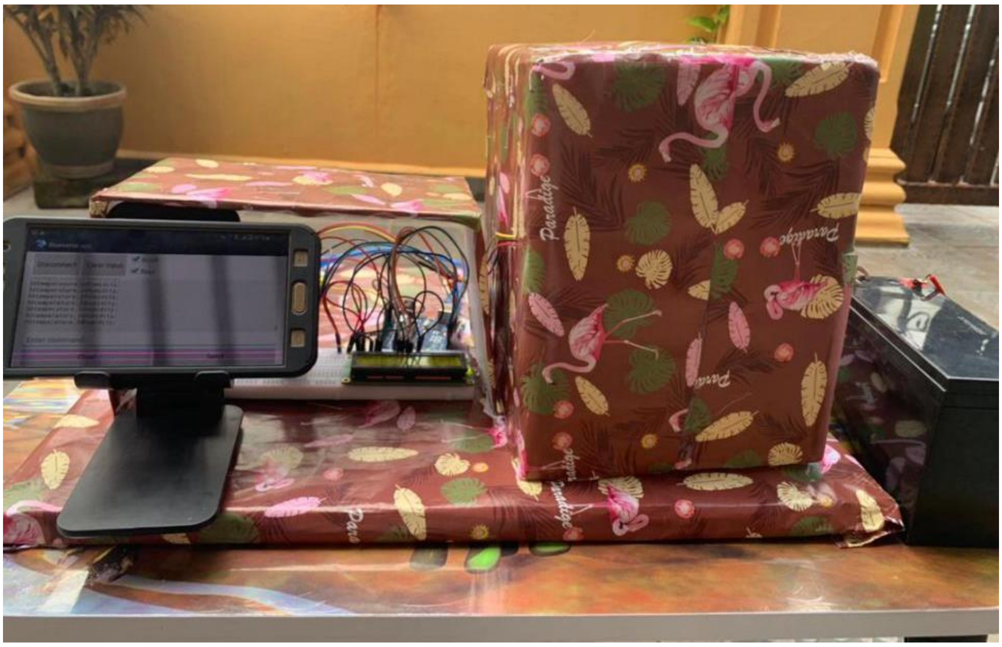

Figure 12: The prototype was being tested at outdoor

4. Conclusion

The thermoelectric mini-portable refrigerator with wireless temperature monitoring was successfully developed. It can be inferred from this project that the supply needs to be adequate to supply the voltage to the heat sink with cooling fans and to operate the Peltier module to obtain the minimum temperature of the mini-portable refrigerator. In conclusion, all the targets are completed and confirmed by recorded evidence. By adding more functions to this framework, some features can be upgraded for this scheme. The recommendation for system improvement is to upgrade the monitoring feature in the Blueserial application so that the user can control the system's current, power, and voltage status and decrease the power consumption for system activity by adding deep sleep functions that simply sleep the system when no action is needed.

For future work, add another set of the heat sink, the fans, and the Peltier module for faster cooling and reduce power usage for the system operation by introduced deep sleep functions that simply sleep the system when no actions are required.

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