Development of a Cooling System Simulation Model using Thermoelectric Peltier based on Microcontroller

Givy Devira Ramady*, Ninik Sri Lestari, Hetty Fadriani, Rosyidin Sufyani, Andrew Ghea Mahardika, Rahmad Hidayat, Hermawaty
Sekolah Tinggi Teknologi Mandala, Bandung, Indonesia
*givy.d.ramady@gmail.com

Abstract. The development of technology can be seen from the increasing number of industries that are standing and especially industries that produce air-conditioning machines such as Air Conditioner (AC), Air Cooler and Chiller. As the name implies, AC has a function to condition the air in a room so that it feels cool, comfortable, and healthy. In operation, AC requires electricity, and almost all of its main components require electricity so that the cost of using flow electricity is the benchmark in efforts to save energy. At the tool and system design stage, an overall tool design is carried out to form a miniature air-conditioning system using a Peltier Thermoelectric. The purpose of designing this tool is to produce a tool that functions to cool a room, so that the temperature in the room is cool and maintained, with the performance of Peltier TEC1-12706 and also heatsink as a channel for cold air through fans indoor and outdoor, and displaying temperature. In testing the system there is a slight difference from the measurements of the results with the component datasheet. On the results of the power test on the 12 V.10A adapter without load, the average output is 12.11 V, not pure at 12 V because the voltage displayed on the AVO meter has an average difference of 0.92%. Whereas in the measurement of power by load, that is, with an average load of 12.05V because the voltage displayed on the AVO meter has a difference and the voltage already has a load and has an average error of 0.41%. The existence of this error is because the current entering the adapter is also unstable.

1. Introduction
In the modern era, many electronic tools are designed to make it easier and more comfortable for its users and inseparable from human life. The development of technology can be seen from the increasing number of industries that are standing and especially industries that produce air-conditioning machines such as Air Conditioner (AC), Air Cooler and Chiller. The cooling system (AC) is a system designed to stabilize the temperature air and humidity of an area or room. In addition, air conditioning has become a mandatory facility especially in hotel rooms, company workspaces, classrooms, or even in restaurants. As the name implies, AC has a function to condition the air in a room so that it feels cool, comfortable, and healthy. In operation, AC requires electricity, and almost all of its main components require electricity so that the cost of using flow electricity is the benchmark in efforts to save energy [1]–[3].

The impact of excessive electricity consumption or electricity waste, which by reducing fan speed by about 20 percent, can reduce power usage by up to 50 percent. In addition, there are still many AC uses whose control method uses the ON-OFF system, or also called conventional methods, such as AC LG S09LFG-2 (860 W), meaning that the Fan motor on the evaporator will OFF when the desired temperature has been reached and will be ON again after the temperature rises [4]. As a result, it will cause a large starting current, and also have an impact on the user the greater the electric power, the
efficiency and performance decreases, and the cooling process of the air conditioner used becomes slower [5]. Therefore, it is necessary to do a motor controller [6]. The evaporator fan is one of the components in the air conditioner, with the hope of increasing the performance of the air conditioner in addition to saving users of electric power [7]–[9].

In the development of household appliances, humans are aware of the dangers posed by the use of chemicals, one example is the use of refrigerants, which are chemicals that can damage the structure of the O3 (ozone) layer if decomposed in the air [10]. Thermoelectric is a component that can replace the function of refrigerants [11]. Thermoelectricity is the relationship between heat energy and electrical energy that occurs between two different types of metal. The thermoelectric effect was developed in a device called the Peltier element. The use of this Peltier element can be designed in a system that can replace conventional systems and is more environmentally friendly [12]–[14].

2. Material and Method

At the tool and system design stage, an overall tool design is carried out to form a miniature air-conditioning system using a Peltier Thermoelectric. The purpose of designing this tool is to produce a tool that functions to cool a room, so that the temperature in the room is cool and maintained, with the performance of Peltier TEC1-12706 and also heatsink as a channel for cold air through fans indoor and outdoor, and displaying temperature. The resulting temperature on the LCD Temperature Controller XH-W3001 screen.

This study uses a temperature microcontroller as the main microcontroller. This microcontroller will process the input and output data. The input from the tool that is built is a capacitive sensor as a temperature detector on the system air conditioner. The output of this system is to display the room temperature and ensure the room is cool. The system block diagram design that will be made is as follows as in figure 1.

Figure 1. Air Conditioning System Block Diagram

The microcontroller used is the Temperature Controller XH-W3001. This microcontroller will process input data and provide output to the Digital LCD screen. The way the system works is designed with the thermoelectric effect of the TEC1-12706 Thermoelectric module. This thermoelectric effect will cause one side of the module to become hot and one side becomes cold. The cold part is connected to the aluminium plate which functions to maximize the spread of cold. The hot side of the Peltier is connected to the heatsink which functions to dissipate the heat generated by the Peltier effect. The temperature sensor is used to detect the temperature produced on the side of the room. The temperature controller functions to adjust the relay so that it is connected to the Power Supply [15]. Temperature data in the hot and cold sections will be displayed on the Digital LCD. If the temperature
is measured by the sensor in the aerated section, the sensor will provide feedback to the Temperature Controller for disconnect the Relay to the power supply.

![Circuit design schematic](image)

**Figure 2.** Circuit design schematic

As shown in Figure 2, the Temperature Controller as a microcontroller has several components and it is activated automatically, namely the LCD which is controlled by the relay connected to the supporting source component which functions to produce cold temperatures connected to the microcontroller. Waterproof sensor where this sensor is connected to the Interface sensor on the Temperature Controller which is connected to the NO pin as a voltage source and the Interface sensor as a media to control the Waterproof sensor. Then the Heatsink here functions to spread and blow cold air pressure in a room automatically.

| Hot Side Temperature (°C) | 25°C | 50°C |
|---------------------------|------|------|
| $Q_{\text{max}}$ (Watt)  | 50   | 57   |
| $\Delta T_{\text{max}}$ (°C) | 66   | 75   |
| $I_{\text{max}}$ (Ampere) | 6.4  | 6.4  |
| $V_{\text{max}}$ (Volt)   | 14.4 | 16.4 |
| Module Resistance (Ohm)   | 1.98 | 2.30 |

### Table 1. TEC1-12706 thermoelectric Peltier technical data

3. Results and Discussion

The tests carried out include taking primary data related to the maximum temperature parameters in a room, and to find out the test results, the authors compare the measurement results with a different temperature with a digital temperature controller that has been adjusted, namely at a temperature of 22 °C automatically off and at 27 °C automatically on. Testing of tools and systems is carried out to determine the level of success of the tools made including, gradual testing of the functions and performance of components/tools as well as testing the whole system.

Based on the results of testing the overall display when the waterproof temperature sensor detects the temperature, there is always a change in temperature on the LCD. In placing the waterproof sensor in the image above, it is only a simulation to measure the temperature that will be detected later. This tool uses a power supply system that is plugged into the 220 V switch so this tool will immediately be enabled and display a description on the LCD.
Table 2. Test result data on the system

| No | Time Temperature Sensor Waterproof (in minutes) | Temperature display on the LCD of the appliance |
|----|-----------------------------------------------|-----------------------------------------------|
| 1  | 1 – 2 minutes                                  | 30°C - 27°C                                   |
| 2  | 2 – 3 minutes                                  | 28°C - 26°C                                   |
| 3  | 3 – 4 minutes                                  | 25°C - 22°C                                   |
| 4  | 4 – 5 minutes                                  | 24°C - 21°C                                   |
| 5  | 5 – 6 minutes                                  | 23°C - 20°C                                   |

From the results of testing the tool for air conditioner readings, it was found that the application of a waterproof sensor to changes in coolant temperature resulted in a percentage of 95% because the accuracy of the reading from the waterproof temperature sensor was very accurate. Based on the description of the overall system test results above, it can be concluded that as a whole it can work well and accurately and has a low error rate.

No-load power measurement is carried out 5 times so that the data received is valid. It can be seen in table 3, the results of the power test on the 12 V 10 A adapter without average load produce an output of 12.11 V not pure 12 V because the voltage read on the AVO meter has a difference of 0.90% on average. The existence of this error is due to the unstable current entering the adapter.

Table 3. No-load power measurement result test

| No | Test | V-Out (Volt) | V-Out Read (Volt) | Error % | Difference |
|----|------|--------------|-------------------|---------|------------|
| 1  | 1    | 12           | 12.11             | 0.92    | 0.11       |
| 2  | 2    | 12           | 12.11             | 0.92    | 0.11       |
| 3  | 3    | 12           | 12.11             | 0.92    | 0.11       |
| 4  | 4    | 12           | 12.11             | 0.92    | 0.11       |
| 5  | 5    | 12           | 12.11             | 0.92    | 0.11       |

Measurement of power with load was also carried out 5 times. The results can be seen in the table 4 below, namely the average load of 12.05 V because the voltage read on the AVO meter has a difference, and the voltage has a load and an average error of 0.41%. The existence of this error is due to the unstable current entering the power supply.

Table 4. Load power measurement result test

| No | Test | V-Out (Volt) | V-Out Read (Volt) | Error % | Difference |
|----|------|--------------|-------------------|---------|------------|
| 1  | 1    | 12           | 12.05             | 0.41    | 0.05       |
| 2  | 2    | 12           | 12.05             | 0.41    | 0.05       |
| 3  | 3    | 12           | 12.05             | 0.41    | 0.05       |
| 4  | 4    | 12           | 12.05             | 0.41    | 0.05       |
| 5  | 5    | 12           | 12.05             | 0.41    | 0.05       |

4. Conclusions
Based on the stages of the tests carried out, it can be concluded that the entire circuit can work well and by the functions of each component. In testing the system there is a slight difference from the measurements of the results with the component datasheet. This difference is influenced by many factors, such as the measuring instrument used, the quality of the components, the tolerance for component values that are not appropriate, and the inaccuracy in measurement. On the results of the power test on the 12 V.10A adapter without load, the average output is 12.11 V, not pure at 12 V because the voltage displayed on the AVO meter has an average difference of 0.92%. The existence of this error is because the current entering the adapter is unstable. Whereas in the measurement of power by load, that is, with an average load of 12.05V because the voltage displayed on the AVO meter has a
difference and the voltage already has a load and has an average error of 0.41%. The existence of this error is because the current entering the adapter is also unstable.

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