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Portable beverage cooler using the thermoelectric and microcontroller

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ABSTRACT

Design and Build Portable Beverage Coolers Using Tec1-12706 Modules and Microcontrollers aims to design and build a beverage cooling system using the TEC1-12706 pitier thermoelectric module based on the arduino uno microcontroller so that it becomes one of the alternatives in the application of environmentally friendly cooling systems and testing the device. Peltier's cooling ability is affected by the cooling process on the heat side emitted by Peltier, because if the heat is not absorbed or cooled, Peltier's performance will not be optimal. Peltier testing was carried out in an open room for 4 minutes with an ambient temperature of 29ºC, the test results on the cold side of Peltier were obtained a maximum temperature of -4.9ºC, while Peltier testing on the hot side obtained a maximum temperature of 32.2ºC. Peltier was able to reach a low temperature of -4.9°C in 2 minutes and 20 seconds but rose again to -4.2°C after 4 minutes of running. To cool 1 bottle of mineral water (300 ml) for 30 minutes can produce a temperature of 18.69ºC. To cool 2 bottles of mineral water (600 ml) with the same time, namely 30 minutes, can produce a temperature of 22.31ºC. And to cool 3 bottles of mineral water (900 ml) with the same time, namely 30 minutes, it can produce a temperature of 25.06ºC. More and more drink objects will be added.

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1. INTRODUCTION

The cooling system plays an important role in today's society. In Indonesia, which has a tropical climate, almost every house can be found equipment that uses a cooling system. In households, the cooling system is used in AC, refrigerators, freezers and dispensers. This equipment has a function to store various types of food, drinks, vegetables and fruits so that they last longer and stay fresh [1]-[3]. In the development of this cooling system, humans are aware of the dangers caused by the use of chemicals in it, one example is the use of refrigerants. Refrigerants are chemicals that can damage the structure of the O3 (ozone) layer if they decompose in the air. If this continues to be allowed, refrigerants or global warming can cause symptoms of poisoning in humans due to inhaling air from the gas. The effects that usually arise are swelling of the throat, difficulty breathing, severe sore throat, loss of vision, burning of the eyes, nose, lips and tongue, burns to the esophagus, vomiting blood, blood in the stool, severe abdominal pain, abnormal heart rhythm and blood circulation.

In addition, the effects of inhaling this gas can cause abnormal heart rhythms. Abnormal heart rhythms are heart rhythms where the rhythm is not normal. The heartbeat may be too fast or even too weak. So that it can cause death. Therefore, a cooling system is needed that no longer relies on refrigerants, but uses environmentally friendly technology. Human efforts to overcome the use of refrigerants that can damage the ozone layer are by replacing other chemicals that are not harmful or by methods that do not require chemicals [4]-[6]. Thermoelectrics are components that can replace the function of refrigerants. Thermoelectrics are the relationship between heat energy and electrical energy that occurs between two different types of metals [7]-[10]. The thermoelectric effect is developed in a device called a Peltier element. The use of this Peltier element can be designed in a system that can replace conventional systems and is more environmentally friendly. Examples of Peltier applications are as mini refrigerators, aquarium coolers, ice boxes, panel box coolers, and others [11]-[17]. Based on the description above, in this paper a beverage cooling system is designed and built which will become the latest technology for thermoelectric beverage cooling which is cheap, affordable and does not damage the environment in the air..

2. METHOD

Blog diagram of the Design of Portable Beverage Cooler Using Peltier Based on Microcontroller is shown in Figure 1. The description of each block is: The 220 Volt AC mains source will be converted to 12 VDC voltage, The 12 VDC voltage source will supply thermoelectrics, 2 fans outside the cooling chamber, and 1 fan inside the cooling chamber, and Arduino. When turned on, several components will work except for 1 fan in the cooling chamber. After the DS18B02 sensor detects a change in temperature and is exactly at the specified temperature set-point, the microcontroller in the Arduino will turn on 1 fan in the cooling chamber through the cooling driver. Figure 2 shows the hardware schematic of proposed system.

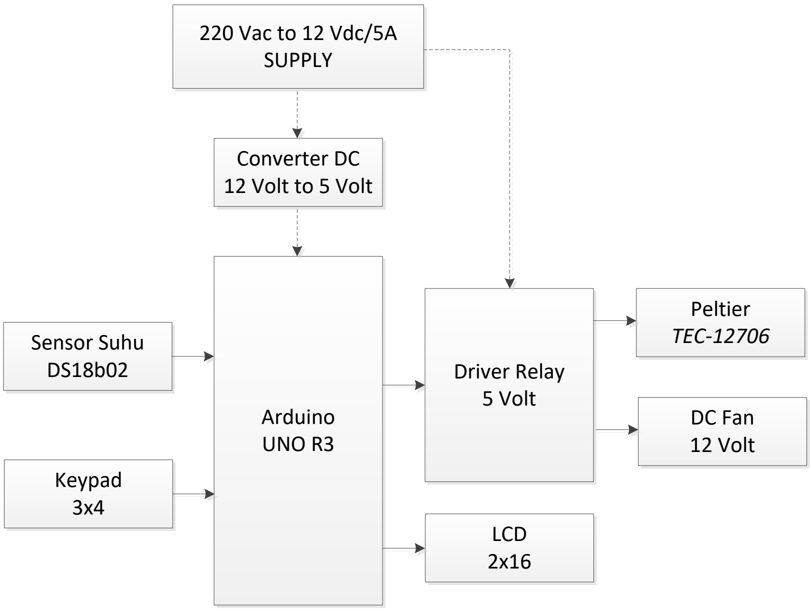

Figure 1. Diagram block of proposed portable beverage cooler

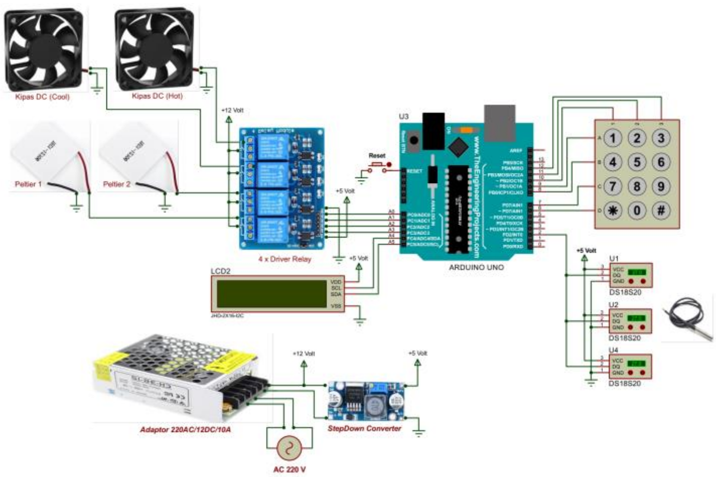

Figure 2. The hardware schematic of proposed system.

In designing software, Arduino uses its own software that is provided on the official Arduino website. The language used in software design is C/C++ with several additional libraries for designing this cooling device. In the Arduino IDE software, there is a kind of black message box that functions to display status, such as error messages, compile, and upload programs. At the bottom right of the Arduino IDE software, it shows the configured board along with the COM Ports used [18]. To clarify the design of the tool, the following is a flowchart for designing a portable beverage cooler system in general, including how it works to cool the cooling device to the desired temperature. A flowchart is the logic or sequence of program instructions in a diagram [19]. Figure 3 shows the flowchart of the proposed system.

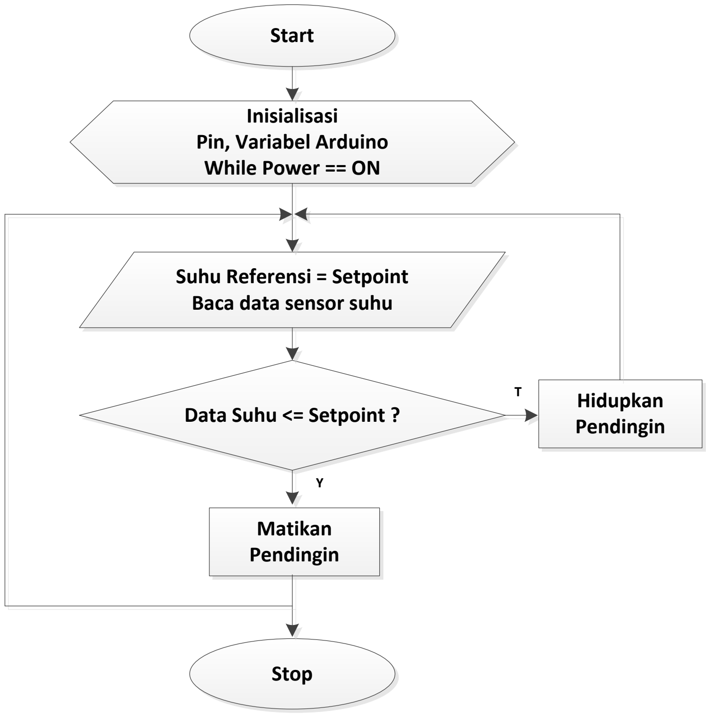

Figure 3. Flowchart of proposed system

Mechanical design, the cooling chamber is designed in a box shape made of styrofoam that can withstand temperature conditions from outside temperature conditions. The design of the box as in figure 3.3 by utilizing a factory-made styrofoam box that is easily available on the market. The size of the box is 26 × 18 × 40 cm with a thickness of styrofoam material used of 2.5 cm. Inside the box consists of 1 small Heatsink as a cold intermediary from Peltier, 1 fan as a cold distributor from the Heatsink into the cooling chamber and an empty space for the cooler, in addition to the space at the top there is a Heatsink that must be attached with Thermoelectric on the side that produces hot temperatures then above the large Heatsink 2 fans are placed to reduce the heat generated from the hot side of the Peltier and on the side of the thermoelectric part that produces cold temperatures 1 small Heatsink is also attached and below it is installed a small fan, namely 1 fan inside. While the control circuit is located outside the cooling chamber. In the initial process of designing and making the control, the amount of input required, the load, and the load of the material to be cooled, and the temperature to be produced are determined first. While for the mechanics, the type of material is determined for making the frame, the wall partition material, and determining the location of the Driver, Control Circuit and Microcontroller [20]. So that this design and construction are expected to provide safety for users (humans) and the tool itself.

For the upper wall section is not coated with aluminum foil, a hole is made the same size as the length and width of the Peltier/thermoelectric as a place for the thermoelectric, then at the bottom of the thermoelectric (cold side) 1 small Heatsink is attached and below that again 1 small fan is attached. above the Peltier/thermoelectric which is on the hot side, 1 large Heatsink is attached, then above the Heatsink 2 small and large fans are attached. The design of the cooling system such as the placement of the Heatsink and the fans is intended to reduce the hot temperature on the hot side of the Peltier and maximize the cold temperature produced by the cold side of the Peltier to cool the temperature in the box space. While for the placement of the driver circuit, controller circuit, voltage source (DC) is placed on the sides of the cooling space and placed in different places.

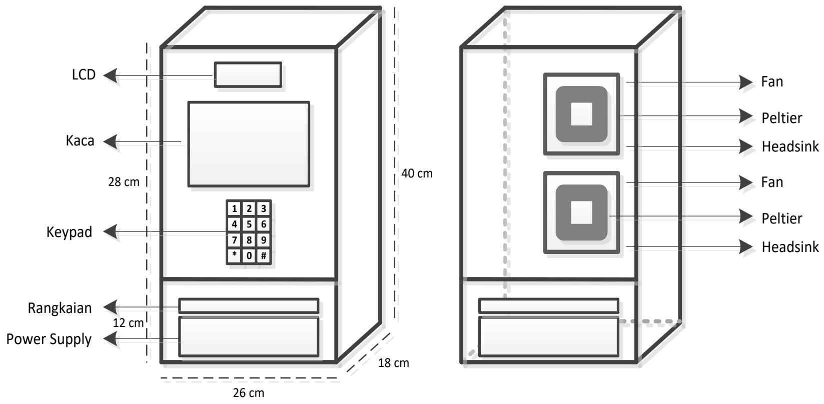

Figure 4. Mechanical design of a portable beverage cooler

In figure 4, 2 Peltier elements are located between the Heatsink and the coldsink. working when supplied with a 12 V dc voltage. When the element is working, each side of the element will remove heat and release heat. The Heatsink will focus on heat dissipation and the coldsink will focus on heat absorption. Fans C2 and C3 will accelerate heat dissipation while C1 will accelerate heat absorption. Fans C2 and C3 will blow air at temperature t0 (ambient temperature) to the Heatsink, so that the air coming out of the Heatsink is at temperature t1. Fan C1 will blow air at temperature t3 through the coldsink, so that the air coming out of the coldsink is at temperature t4. Over time, t3 will reach t4 so that t3 = t4.

3. RESULTS AND DISCUSSION

To ensure that the device can function properly and can work according to the desired capabilities, a test is carried out to turn on the LED using the output on the Arduino Uno. The LED used is a device that is already on pin 13 on the Arduino Uno board. If the LED blinks, the Arduino Uno board has been installed on the Arduino IDE software. The 16x2 I2C LCD test aims to determine the level of accuracy of the 16x2 I2C LCD to the serial monitor and see the 16x2 I2C LCD temperature sensor functioning properly. This test is carried out by connecting the 16x2 I2C LCD to the Arduino Uno using a jumper cable after which you can upload a sample program in the Arduino IDE software. Figure 5 show the LCD display.

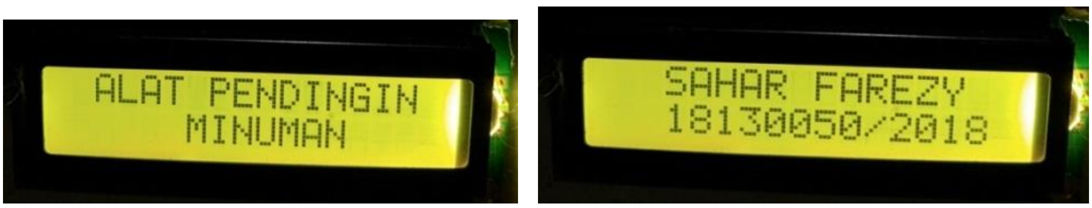

Figure 5. 16x2 I2C LCD test results

The test of the Peltier TEC-12706 module aims to determine the cold temperature produced by the Peltier TEC-12706 module and to see if the Peltier TEC-12706 module is functioning properly. This test is carried out by connecting the Peltier TEC-12706 module to the power supply using a cable. The test is carried out to determine the correct cooling method, the test is carried out in an open space for 4 minutes with an ambient temperature of 29ºC and to see the temperature changes on the cold side and hot side of the Peltier. The thermoelectric is placed in front of the Heatsink and the fan is placed behind the heatsink. The thermoelectric and fan are given a voltage of 12 Vdc 20A. Above the thermoelectric on the cold and hot sides, a thermometer is placed to see the measured temperature.

The test results with the Peltier cold side cooling method obtained a maximum temperature of -4.9ºC, while the Peltier test on the hot side obtained a maximum temperature of 32.2ºC. It is known in Figure 20 that the Peltier TEC-12706 module is still functioning properly. The Peltier TEC-12706 module test was carried out in an open room, where when water was dripped on the Peltier module, the water froze at a temperature of -0.3℃ when the room temperature was 29.1℃. Table 1 describes the test results.

Table 1. Peltier temperature changes

Component System Cooler	Time	Temperature Cold side (°C)	Temperature Heat side (Heatsink) (°C)	Current (A)	Voltage (V)
Peltier TEC-12706	0s	29.7	30.5	0.13	10.76
	20s	7.8	30.5	6.54	10.56
	40s	-2.5	30.5	6.01	10.58
	1 m	-4.7	30.7	6.01	10.58
	1.20	-4.2	30.8	6.00	10.59
	1.40	-4.8	31.0	6.00	10.60
	2 m	-4.8	31.2	6.01	10.60
	2.20	-4.9	31.5	6.01	10.59
	2.40	-4.5	31.6	6.00	10.58
	3 m	-4.8	31.8	6.00	10.60
	3.20	-4.5	31.9	6.00	10.58
	3.40	-4.5	32.2	6.01	10.60
	4 m	-4.2	32.2	6.01	10.58

Research result box cooler displayed in form tables and graphs for make it easier in reading and analyzing. In sequentially, result data study for box cooler without and with drink. Table 2 describes the results of testing the beverage cooler without drinks.

Table 2. Testing of the cooling device without drinks

No.	Time (Minute)	Room Temperature (°C)	Cold Side Peltier Temperature (°C)	Hot Side Peltier Temperature (°C)	Current (A)	Voltage (V)
1	0	28.87	28.31	29.88	0.16	10.78
2	1	25.25	18.12	31.88	6.56	10.56
3	2	24.81	13.50	33.25	6.12	10.58
4	3	23.87	12.19	34.44	6.06	10.59
5	4	23.00	11.63	34.44	6.04	10.59
6	5	22.19	11.38	35.69	6.05	10.58
7	6	21.50	11.13	35.50	6.04	10.58
8	7	20.94	10.88	35.56	6.03	10.58
9	8	20.50	10.75	35.50	6.03	10.59
10	9	20.19	10.75	35.31	6.03	10.59
11	10	19.87	10.63	35.44	6.03	10.59
12	11	19.62	10.69	35.38	6.03	10.59
13	12	19.50	10.63	35.56	6.03	10.59
14	13	19.37	10.63	35.63	6.03	10.58
15	14	19.25	10.63	35.50	6.03	10.58
16	15	19.19	10.56	35.31	6.02	10.59
17	16	19.06	10.38	35.25	6.01	10.59
18	17	19.06	10.25	35.13	6.01	10.59
19	18	19.00	10.44	35.44	6.02	10.59
20	19	19.00	10.38	35.31	6.01	10.58
21	20	18.94	10.44	35.19	6.02	10.58
22	21	18.94	10.38	35.06	6.01	10.58
23	22	18.94	10.38	35.19	6.01	10.58
24	23	18.87	10.38	35.13	6.01	10.59
25	24	18.87	10.31	35.13	6.01	10.59
26	25	18.87	10.25	35.31	6.01	10.59
27	26	18.81	10.25	35.25	6.01	10.59
28	27	18.81	10.44	35.13	6.02	10.59
29	28	18.75	10.50	35.06	6.02	10.59
30	29	18.75	10.50	35.19	6.02	10.59
31	30	18.69	10.44	35.13	6.02	10.59

Table 2 shows the time required for cool temperature in the tool cooler; there is a drink. The initial temperature of the room cooler is 28.87^0 C; after about 30 minutes, the resulting temperature is 18.69^0 C.

Table 3 describes the test results of beverage coolers filled with beverages with 2 cans load drink (378 ml). Table 3 show temperature room cooling of 20.25 ^{0} C for cool 2 cans drink (378 ml) with 30 minutes time .

Table 3. Testing of cooling equipment drink with 2 cans load drink (378 ml)

No	Time (Minute)	Room Temperature (°C)	Cold Side Peltier Temperature (°C)	Hot Side Peltier Temperature (°C)	Current (A)	Voltage (V)
1	0	28.35	29.36	29.02	0.13	10.85
2	1	26.54	13.67	31.26	6.57	10.54
3	2	25.96	12.98	32.42	6.13	10.58
4	3	25.06	12.19	33.81	6.04	10.58
5	4	24.44	11.00	33.25	6.03	10.58
6	5	23.62	9.94	33.44	6.02	10.58
7	6	23.00	9.81	33.81	6.01	10.58
8	7	22.56	9.81	33.81	6.02	10.58
9	8	22.19	9.88	33.75	6.02	10.58
10	9	21.81	9.81	33.75	6.01	10.58
11	10	21.56	9.88	33.88	6.01	10.58
12	11	21.37	9.88	34.00	6.02	10.58
13	12	21.31	9.88	33.88	6.02	10.58
14	13	21.19	9.75	33.81	6.01	10.58
15	14	21.06	9.81	34.00	6.02	10.58
16	15	21.00	9.69	34.06	6.01	10.58
17	16	20.94	9.50	34.13	6.01	10.58
18	17	20.87	9.50	34.00	6.01	10.58
19	18	20.81	9.63	33.81	6.01	10.58
20	19	20.75	9.63	33.75	6.01	10.58
21	20	20.75	9.69	34.06	6.01	10.58
22	21	20.69	9.75	34.50	6.02	10.58
23	22	20.69	9.75	34.44	6.01	10.58
24	23	20.62	9.56	34.19	6.01	10.58
25	24	20.56	9.38	33.88	6.01	10.58
26	25	20.56	9.31	34.00	6.00	10.58
27	26	20.44	9.31	34.06	6.00	10.58
28	27	20.37	9.31	33.69	6.00	10.58
29	28	20.37	9.19	33.75	6.00	10.58
30	29	20.31	9.19	33.88	6.00	10.58
31	30	20.25	9.19	33.88	6.00	10.58

4. CONCLUSION

Cooling capacity Peltier is affected by the cooling process on the hot side emitted by Peltier , because if the heat is not absorbed or cooled, Peltier performance will not be optimal. Testing Peltier is done in the room open for 4 minute with temperature environment 29^o C, results testing on cooling side cold Peltier obtained temperature maximum -4.9^o C, whereas testing Peltier on the side hot obtained temperature maximum 32.2^o C. Peltier is able to achieve temperature lowest -4.9°C on time 2 minute 20 seconds but back go on to -4.2°C after 4 minute executed. To cool 1 bottle of mineral water (300 ml) in 30 minutes can produce a temperature of 18.69^o C. To cool 2 bottles of mineral water (600 ml) in the same time, namely 30 minutes, can produce a temperature of 22.31^o C. And to cool 3 bottles of mineral water (900 ml) in the same time, namely 30 minutes, can produce a temperature of 25.06^o C. The more beverage objects to be cooled, the more time is needed, if the desired temperature is below 25^o C.

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