

Mini Refrigerator Using Peltier Module

Suvom Karmakar 021 221 027, Sazzad Hossen 021 221 026,
Naimur Rahman 021 221 043, Md.Noushadul Alam 021 211 018
Group - Influx Electric.

Contributing authors: skarmakar221027@bseeee.uiu.ac.bd;
shossen221026@bseeee.uiu.ac.bd; nrahman221043@bseeee.uiu.ac.bd;
malam211018@bseeee.uiu.ac.bd;

Abstract

Our project, "Mini Refrigerator Using Peltier Module," focuses on the development of a portable refrigerator unit utilizing the Peltier effect. While conventional compressor-based refrigerators excel in high cooling capacities, they suffer from decreased efficiency at lower capacities. In contrast, the coefficient of performance of Peltier-based units remains relatively constant across different cooling capacities, making them ideal for applications requiring lower cooling capacities. Additionally, the compact size of Peltier cooling units offers versatility and simplicity in control, allowing for easy adjustment of cooling rates by varying the applied current. Our fabricated portable refrigerator unit offers a sustainable, eco-friendly cooling solution.

Contents

1	Introduction	3
1.1	Objective	3
1.2	Principle	3
2	Material Selection and Rationale	3
2.1	Peltier Module	3
2.2	Heat Sink	4
2.3	Heat Sink Fan	5
2.4	Thermocol	5
2.5	Thermal Paste	6
2.6	PVC Sheets	7
2.7	DC Female jack	8
2.8	12V Power Supply	8
3	Working & Construction	9
3.1	Working	9
3.2	Construction	9
4	Schematic Diagram	9
5	Final Project	10
6	Benefits & Limitations	11
6.1	Benefits	11
6.2	Limitations	11
7	Cost Estimation	11
8	Power Consumption	12
9	Conclusion	12
10	References	12

1 Introduction

1.1 Objective

Refrigeration is the process of heat removal from a space in order to bring it to a lower temperature than surrounding temperature. In this context, my seminar topic, "Peltier cooling module" which works on thermoelectric refrigeration, aims to provide cooling by using thermoelectric effects rather than the more prevalent conventional methods like the 'vapor compression cycle' or the 'vapor absorption cycle'. There are three types of thermoelectric effect: The Seebeck effect, the Peltier effect, the Thomson effect. From these three effects, Peltier Cooler works on the Peltier effect; which states that when voltage is applied across two junctions of dissimilar electrical conductors, heat is absorbed from one junction and heat is rejected at another junction.

1.2 Principle

It works on the principle of the Peltier Effect.

Peltier Effect: The Peltier Effect is the phenomenon that the potential difference applied across a thermocouple causes a temperature difference between the junctions of the different materials in the thermocouple. The hot junction can be placed outside of an insulated area, and the cold junction can be placed inside the region. The Peltier Effect can be used to cool a region.

2 Material Selection and Rationale

2.1 Peltier Module

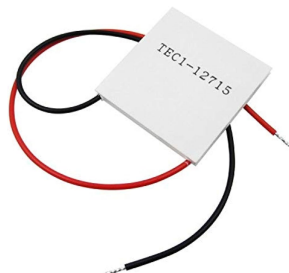


Fig 2.1: Peltier Module

Peltier modules are solid-state heat pumps that operate on the Peltier Effect. The heat pump is a thermodynamic system that transfers heat from the low-temperature body and gives out the same to the high-temperature body. The Peltier Effect, mini refrigerator operates according to the Peltier effect. The effect creates a temperature difference by transferring heat between two electrical junctions. A voltage is applied across joined conductors to create an electric current.

Peltier Module	Alternative Material
Chosen for its compact size and relatively constant efficiency at lower cooling capacities, making it suitable for portable and small-scale applications.	Vapor Compression Cycles: Complex system with moving parts and refrigerants, higher cost for small-scale applications.
Avoids the complexity of traditional cooling systems and the use of refrigerants, aligning with eco-friendly objectives.	Evaporative Cooling: Requires a constant water supply and is less effective in dry environments.
Provides precise temperature control without the need for moving parts or refrigerants.	Solid-State Coolers (Other Than Thermoelectric): Highly expensive and not suitable for small-scale applications.
Simple construction and operation, leading to lower maintenance costs.	Phase-Change Materials: Limited cooling capacity and require periodic replacement or regeneration.

2.2 Heat Sink



Fig 2.2: Heat Sink

A heat sink is a passive heat exchanger that transfers the heat by any device into a coolant fluid in motion. Then transferred heat leaves the device with the fluid in motion therefore allowing the regulation of the device temperature at physically feasible levels. A heat sink transfers thermal energy from a higher-temperature device to a lower-temperature fluid medium. The fluid medium is frequently air, but can also be water, refrigerants, or oil. If the fluid medium is water, the heat sink is frequently called a cold plate.

2.3 Heat Sink Fan



Fig 2.3: Heat Sink fan

Sometimes the heat sink itself becomes hot during the heat transfer to overcome this problem a device called a Heat Sink A fan is used for the removal of induced heat in the fins of heat sink. So these fans are attached to the fins of the heat sink and it cools down the heat produced in the heat sink.

2.4 Thermocol



Fig 2.4: Thermocol

The thermal casing is made of thermocol and is used for keeping cool inside and to store the storage beverages and food stuffings in the mini refrigerator. Thermocol is an insulator. So, it will help to cool inside the mini refrigerator.

Reasons for Choosing Thermocol	Reasons for Not Choosing Alternative Materials
Thermocol serves as an effective insulator, helping to maintain cool temperatures inside the device.	Other materials such as polyurethane foam or vacuum insulation panels may offer better insulation properties but are more expensive.
It is lightweight and easily moldable, making it suitable for shaping into the desired form for the application.	Alternative materials like aerogel insulation or mineral wool insulation may provide similar insulating properties but are more costly and less easily moldable.
Thermocol is readily available and cost-effective, reducing production costs.	While materials such as rigid foam boards or fiberglass insulation are available, they are typically more expensive and may not be as easily accessible.

2.5 Thermal Paste



Fig 2.5: Thermal Paste

Thermal paste, also known as thermal grease or thermal compound, is a heat-conductive material used to improve the thermal transfer between two surfaces in close contact. In the project, thermal paste is applied between the Peltier module and the heat sink to ensure efficient heat dissipation from the hot side of the Peltier module to the heat sink. The paste fills in the microscopic air gaps and irregularities between the two surfaces, providing a better thermal path and improving the overall cooling performance of the system.

2.6 PVC Sheets



Fig 2.6: PVC Sheets

Polyvinyl chloride (PVC) sheets were utilized as a durable and lightweight material for constructing the outer casing of the mini-refrigerator. PVC is a thermoplastic polymer that offers several advantages, including resistance to moisture, chemicals, and corrosion, making it suitable for the environment inside the refrigerator. Additionally, PVC sheets are relatively inexpensive and readily available, aligning with the project's goal of creating an affordable solution.

Reasons for Choosing PVC Sheets	Reasons for Not Choosing Alternative Materials
PVC sheets are durable and weather-resistant, making them suitable for outdoor applications.	Other materials such as cardboard or paperboard may not withstand outdoor conditions as well as PVC sheets.
They are lightweight and easy to work with, allowing for flexibility in design and installation.	Alternative materials like metal sheets or wood panels may be heavier and more difficult to handle, increasing installation complexity.
PVC sheets are cost-effective, reducing production costs without compromising quality.	While materials such as aluminum or fiberglass may offer similar properties, they are typically more expensive and may not provide significant advantages for this application.

2.7 DC Female jack



Fig 2.7: DC Female Jack

A DC female jack, also known as a DC power jack or a barrel jack, is a type of electrical connector used to provide a secure and convenient way to connect a DC power source to the mini-refrigerator. This component allows the Peltier module and other electronic components to be powered by an external 12V DC power supply.

2.8 12V Power Supply



Fig 2.5: 12V Power Supply

A power supply is an electrical device that supplies electrical energy to the electrical load. The primary function of a power supply is to convert one form of electrical energy into another. Here we're using a 12V power supply because it reduces the 220V AC input into 12V AC Output. Because we are using all components that are working with 12V of current.

3 Working & Construction

3.1 Working

Here the Mini Refrigerator works on the Peltier effect. We are using the thermocol casing on all sides. Because thermocol is a good conductor of heat, so it absorbs some heat coming from outside. We are placing Heat Sink and Heat Sink Fan on the top of the mini refrigerator. When the heat comes inside the heat sink transfers the heat by any device into a coolant fluid in motion. Sometimes the heat sink itself becomes hot during the heat transfer, then the heat sink fan is used to remove induced heat in the heat sink sink. So these fans are attached to the fins of the heat sink and it cools down the heat. Then the area inside the refrigerator must become cool.

3.2 Construction

Firstly a box of thermocol is made of dimensions and then inside the box, we will arrange the small fan which is coming inside the box and then the Peltier module will be arranged on top of the small fan with the hot side being the upper side. On the top of the Peltier module, we can arrange a heat sink fan that absorbs heat from the heat sink. Now all the connections must be given carefully then we give input of 220V to the power supply by using strong wires. After that, only two wires will come outside from the box. These wires we want to connect these with the power supply in the Output places which gives 12V AC output.

4 Schematic Diagram

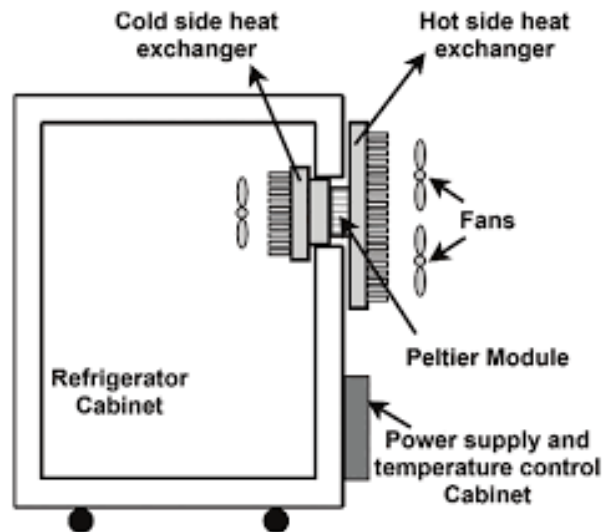


Fig 4.1: Schematic Diagram

5 Final Project



Fig 1: Front View



Fig 2: Back View

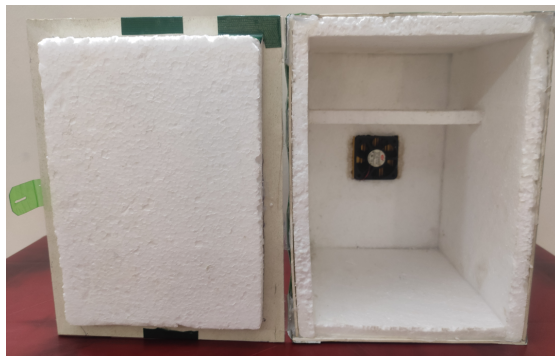


Fig 3: Full View



Fig 4: Inside View



Fig 5: Left Side View



Fig 6: Right Side View

6 Benefits & Limitations

6.1 Benefits

- These are eco-friendly refrigerators. No Chloro Fluoro Carbons.
- They are light in weight.
- They give fast temperature response.
- They are portable and small in size.
- They have no vibrations.
- They create no noise.

6.2 Limitations

- Only small-weight things will be kept inside the fridge.

7 Cost Estimation

Component Names	Price (BDT)
Peltier Module	300
Heat Sink (3)	180
Heat Sink Fan (2)	140
Thermocol	20
12V Power Supply	600
PVC Sheets	100
Female jack	10
Thermal Paste	100
Total	1450

8 Power Consumption

Table 1 Power Consumption

Component	Power Consumption
Peltier Module	40W
Heat Sink Fan 1	1.25W
Heat Sink Fan 2	1.25W
12V Power Supply	$\approx 5W$
Total	$\approx 47.5W$

The Peltier module is the main power-consuming component, requiring 40W to create the necessary temperature differential for cooling.

Two small heat sink fans are used, each consuming around 1.25W, to dissipate heat from the hot side of the Peltier module.

A 12V DC power supply is used to provide the required voltage to the Peltier module and fans. The power consumption of the power supply itself is approximately 5W.

The total power consumption of the mini-refrigerator is the sum of the power consumed by the Peltier module, heat sink fans, and the power supply, which is around 47.5W.

The power consumption may vary slightly depending on the specific components used, the ambient temperature, and the desired cooling performance.

9 Conclusion

A portable mini refrigerator prototype was designed and built which can be used for personal cooling. It was constructed by using thermocol with perfect dimensions. It was successful and the temperature readings were recorded. Cooling stabilizes within one hour once the switch is turned ON. It had been shown from testing results that the portable mini fridge is capable of cooling the can. All the components in the project had been tested individually and the results were found to be positive.

10 References

- <https://nevonprojects.com/mini-can-cooler-fridge-using-peltier/>
- https://www.researchgate.net/figure/Schematic-of-thermoelectric-refrigerator-25_fig5_360644590