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Peltier Module for Theremoelectric Heating and Cooling

Prof. D. S. Vidhya
Assistant Professor
Department of Electronics and Telecommunication Engineering
Don Bosco College of Engineering, Fatorda-Goa

Miss. Aditi Siddhinath Acharya
UG Student
Department of Electronics and Telecommunication Engineering
Don Bosco College of Engineering, Fatorda-Goa

Miss. Rowena Alesha Fernandes
UG Student
Department of Electronics and Telecommunication Engineering
Don Bosco College of Engineering, Fatorda-Goa

Miss. Preeti
UG Student
Department of Electronics and Telecommunication Engineering
Don Bosco College of Engineering, Fatorda-Goa

Miss. Anusha Ashok Sirsikar
UG Student
Department of Electronics and Telecommunication Engineering
Don Bosco College of Engineering, Fatorda-Goa

Abstract

In current scenario one of the major issue is power consumption. Also, with the use of refrigerants like Freon, Ammonia in air conditioning system for cooling purposes leads to harmful gas emission and global warming and other environmental hazards. These problems can be overcome by using thermoelectric modules. Efficient use of semiconductors can reduce power consumption thereby protecting the environment. These modules are compact in size, light in weight, highly reliable and no working fluid or moving parts unlike conventional systems. The need for different devices for heating and cooling is eliminated with the use of peltier module there by reducing cost and power consumption considerably.
Keywords- Peltier Module, Thermoelectric Module, Seebeck Effect, Peltier Effect, Thomson Effect

I. INTRODUCTION

The principle of operation of peltier modules is peltier effect. This effect creates a temperature difference by transferring heat between two electrical junctions. A voltage is applied across joined conductors to create an electric current. When the current flows through the junction of the two conductors, heat is removed at one junction and cooling occurs. Heat is deposited at the other junction and heating occurs.

A thermoelectric module consists of an array of p- and n-type semiconductor elements that are heavily doped with electrical carriers. The elements are arranged into array that is electrically connected in series but thermally connected in parallel. This array is then affixed to two ceramic substrates, one on each side of the elements as shown in the figure below.

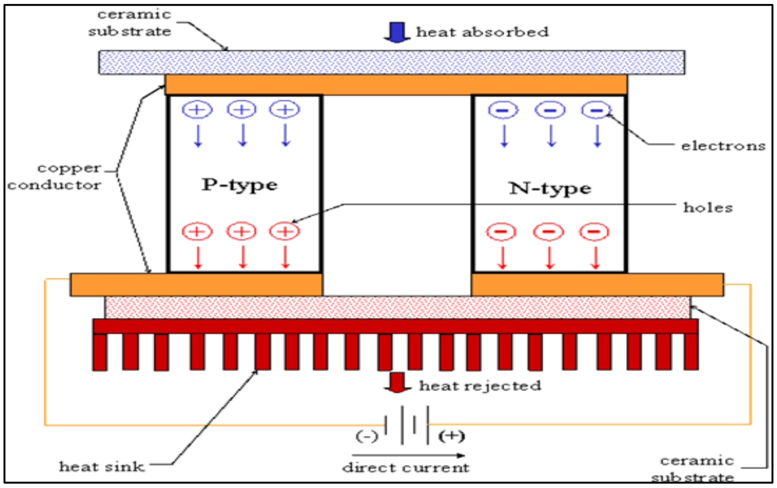

Fig. 1: Thermoelectric Module

When a voltage is applied to the free ends of the two semiconductors there is a flow of DC current across the junction of the semiconductors causing a temperature difference. The side with the cooling plate absorbs heat which is then moved to the other side of the device where the heat sink is. The cooling ability of the total unit is then proportional to the number of TECs in it. The cold junction and the hot junction can be reversed by simply reversing the direction that current flows through the device.

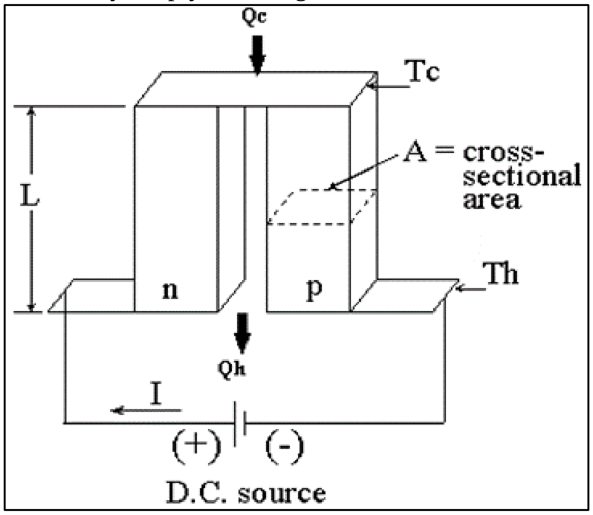

Fig. 2: thermoelectric couple

The figure above represents a thermoelectric couple. It shows some terms used in the mathematical equation:
L = element height
A = cross-sectional area
Qc = heat load
Tc = cold-side temperature
Th = hot-side temperature
I = applied current
Here are the basic equations:

$$Qc = 2 * N * [S * I * Tc - 1/2 * I^2 * R * L/A - K * A/L * (Th - Tc)]$$

$$V = 2 * N * [S * (Th - Tc) + I * R * L/A]$$

The first Qc term, S*I*Tc, is the peltier cooling effect. The second term,1/2*I^2*R*L/A, represents the Joule heating effect associated with passing an electrical current through a resistance. The Joule heat is distributed throughout the element, so 1/2 the heat goes towards the cold side, and 1/2 the heat goes towards the hot side. The last term, K*A/L*(Th-Tc), represents the Fourier effect in which heat conducts from a higher temperature to a lower temperature. So, the peltier cooling is reduced by the losses associated with electrical resistance and thermal conductance.

For the voltage, the first term, S*(Th-Tc) represents the Seebeck voltage. The second term,I*R*L/A represents the voltage related by Ohm's law

A. Seebeck Effect

If two junctions of thermo-couple are placed at different temperature, then an emf will be produced in thermo-couple which will be proportional to the temperature difference.

B. Peltier Effect

It is reverse of Seeback effect. According to this, when an electric current is passed through thermo-couple ,heat is evolved at one junction and absorbed at the other end i.e one end become hot while other become cold. The absorption and evolution of heat depends on the direction of flow of current.

C. Thomson Effect

The major difference between Thomson effect and other two is that in Thomson effect we deal with only single metallic rod and not with thermo-couple as in Peltier effect and Seebeck effect.
According to this effect, if a conductor has placed in varying temperature along its length and current is passed through it then it will absorb or evolve heat. Absorbing or evolving heat will depend on direction of current.
The four standard specifications for a module are:

1) The heat pumping capacity or Qmaxin watts.
2) The maximum achievable difference in temperature between the hot and the cold sides of the module known as the Delta Tmax or Tmax, usually represented in degrees Celsius.
3) The maximum input current in amps or Imax.

4) The maximum input voltage or Vmax when the current input is optimal (Imax).

1) Different uses of Peltier Module

Peltier modules are used for application that require heat removal ranging from milli watt to several thousand watts. They can be made for applications as small as a beverage cooler or as large as a submarine. Peltier elements are commonly used in consumer products for example they are used in camping, portable coolers, cooling electronic components and small instruments.

2) Peltier Module for Personal Heating or Cooling

According to path-physiologic the temperatures above 40 degree Celsius approximately could cause harm to the body. Even though the temperature ratings of most of the peltier modules are of high temperature range, the heat given out by the peltier module can be controlled by adjusting voltage supplied to the module so the module can be made to function which can be sustained by the body. The ultimate aim of using peltier module as a personal heating or cooling device is to reduce the energy consumption of buildings, by cooling and heating the individual and not the building, If the device stops one building from adjusting its temperature by even just one Celsius could save roughly 10o kilowatt-hours per month. A personal body heating or cooling device plays a crucial role in a situation wherein half of the occupants of a room are feeling hot, and half are feeling cold. Using this personal heating or cooling device(with the help of peltier module) thermal comfort can be provided to all the occupants having different body temperature needs simultaneously which would not have been possible in the case of a conventional heating or cooling device.

3) Applications of Thermoelectric Module

a) Case 1: Thermoelectric Cooling

The current in thermoelectric module causes heat transfer from the cold to the hot side due to the peltier effect, thereby creating a temperature difference. The temperature difference induces the opposite flow of heat by thermal conduction. The Joule heat is emitted in thermoelectric element. Cooling parameters depend on the properties of the thermoelectric material and the number of elements.

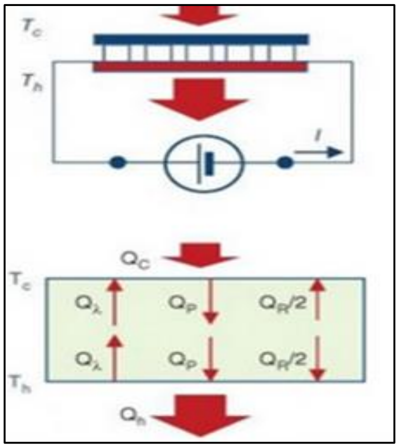

Fig. 3: Thermoelectric Cooling

b) Case 2: Thermoelectric Generation

In the presence of heat flux or temperature difference module, a thermo-EMF is generated in a module due to the seebeck effect. When the circuit is closed, there is a non-zero electric current. The current in the module causes the peltier heat transfer from the hot to the cold side. Generator parameters depends on the properties of the thermoelectric material, number of elements, and resistance of external load.

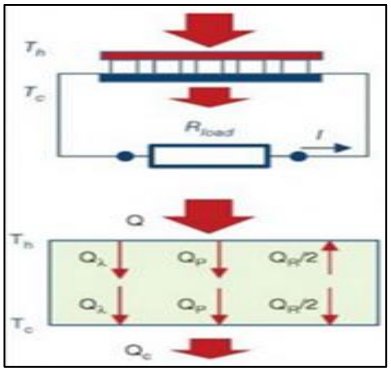

Fig. 4: Thermoelectric Generation

c) Case 3: Thermoelectric Heat Flux Sensor

In the presence of a heat flux a temperature difference appears on the module. The temperature difference generates a thermo-EMF due to the seebeck effect. The thermo-EMF is proportional to the temperature difference and the heat flux. The sensitivity to heat flux depends on the properties of the thermoelectric material.

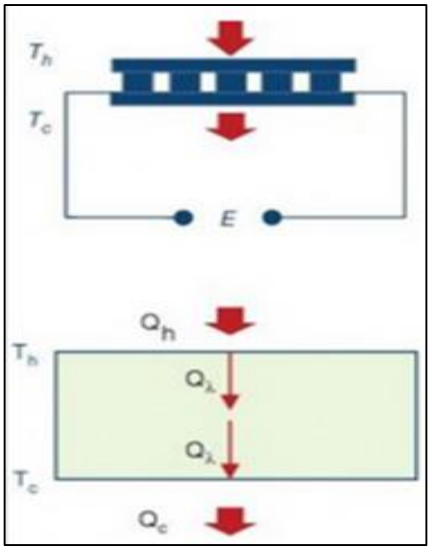

Fig. 5: Thermoelectric Heat Flux Sensor

In the first case it is peltier effect, in the third case it is seebeck effect.
Thermoelectric generation is based on the two opposite thermoelectric effects- the second case.

4) *Specifications of Different Thermoelectric Modules*

TEC series modules are made from premium grade custom ingots of Bi_2Te_3 thermoelectric material and perform significantly better in cooling applications than standard modules for high heat pumping capacity applications. Average cooling capacity is about 20% better with Delta Temperatures averaging 10°F to 15°F better than standard Chinese modules. The bonding materials are also all design for 190°C maximum hot and cold side operation well above the typical 90°C found in standard modules.

Table 1: Data obtained at hot plate temperature Th=27°C

Part Number	*Data obtained at hot plate temperature Th=27°C.*				*Dimension AxBxH mm*
	Imax (amps))	*DTmax(°C)*	*Vmax (Volts))*	*Qmax (watts))*	
TEC1-01703	*3.3*	*70*	*1.90*	*3.90*	*15x15x4.8*
TEC1-03103			*3.50*	*7.20*	*20x20x4.8*
TEC1-07103			*8.60*	*16.40*	*30x30x4.8*
TEC1-12703			*15.0*	*29.30*	*40x40x4.8*
TEC1-01704	*3.9*	*70*	*2.00*	*4.00*	*15x15x4.7*
TEC1-03104			*3.66*	*7.30*	*20x20x4.7*
TEC1-07104			*8.40*	*16.70*	*30x30x4.7*
TEC1-12704			*15.00*	*33.40*	*40x40x4.7*
TEC1-01705	*5.0*	*70*	*2.00*	*5.60*	*15x15x4.3*
TEC1-03105			*3.66*	*10.30*	*20x20x4.3*
TEC1-07105			*8.40*	*23.70*	*30x30x4.3*
TEC1-12705			*15.00*	*42.50*	*40x40x4.3*
TEC1-01706	*6.0*	*70*	*2.00*	*6.90*	*15x15x4.0*
TEC1-03106			*3.66*	*12.50*	*20x20x4.0*
TEC1-07106			*8.40*	*28.70*	*30x30x4.0*
TEC1-12706			*15.00*	*51.40*	*40x40x4.0*
TEC1-03108	*8.5*	*70*	*3.75*	*16.80*	*20x20x3.3*
TEC1-07108			*8.60*	*38.50*	*30x30x3.3*
TEC1-12708			*15*	*68.09*	*40x40x3.3*
TEC1-127085			*15*	*68.09*	*50x50x4.7*
TEC1-12710S	*10*	*70*	*15.80*	*85.0*	*40x40x3*
TEC1-12710	*10*	*70*	*15.80*	*85.0*	*50x50x4.8*
TEC1-07114	*14*	*70*	*8.40*	*65.90*	*44x44x4.6*
TEC1-12714			*15.80*	*118*	*50x50x4.6*
TEC1-12718	*18.5*	*70*	*15.8*	*156*	*50x50x4.1*
TEC1-12726	*26*	*70*	*15.8*	*220*	*50x50x3.6*

Definitions:I – Input Amps to the TEC (in Amps)
Imax – Input Amps that produce the maximum DT [DTmax] (in Amps)
Qc – Amount of heat that can be absorbed at the cold side face of the TEC (in watts) Qmax – Maximum amount of heat that can be absorbed at the cold side. This occurrs at I = Imax and when DT = 0. (in Watts).
Th – Temperature of the hot side face of the TEC (in °C)
Tc – Temperature of the cold side face of the TEC (in °C)
DT – Difference in temperature between the hot side (Th) and the cold side (Tc). dT = Th-Tc (in °C) DTmax – Maximum difference in temperature a TEC can achieve between the hot side (Th) and the cold side (Tc). This occurs at I = Imax and when Qc = 0. (in °C) Vmax – Voltage at I = Imax (in Volts)

II. CONCLUSION

By comparing peltier modules to different conventional heating/cooling devices, peltier module has better power saving capability. Also it is possible to control the output of a peltier module by adjusting the voltage supply which is a requirement in case of human use. Peltiers modules are less bulky hence are portable and user friendly. They are environment friendly as they do not contribute to any environmental hazards. Although Peltier modules have a lesser lifetime and reliability it overcomes major shortcomings of most of the conventional heating/cooling devices such as power consumption and portability and the same module is capable of both heating and cooling, it therefore serves as a convenient option for various heating and cooling applications.

REFERENCE

[1] Ajit N. Kumar ; Dr. Jitendra A. Hole ; “A Review on use of use of Peltiereffects” , International Journal of Science , Spirituality, Business and Technology , May 2014
[2] Benziger B, Anu Nair ,Balakrishnan P , “Thermoelectric Air conditioners using peltier modules” , International Journal of Mechanical Engineering , May 2015
[3] Maekawa, N.; Komatsu, T.; Murase, S.; Tsuzaki, M.; Iwamoto, H.; Okada, H.; Sagawa, M.; Inoue, H., "Peltier module for commercial use," Thermoelectrics, 1998. Proceedings ICT 98. XVII International Conference on , vol., no., pp.535,538, 24-28 May 1998 doi: 10.1109/ICT.1998.740435
[4] https://books.google.co.in/books?id=U9g1DwAAQBAJ&pg=PT435&dq=thermoelectric+module-+peltier&hl=en&sa=X&ved=0ahUKEwi2p-vZ7obaAhUaR48KHZCNBx4Q6AEIJDAA#v=onepage&q=thermoelectric%20module-%20peltier&f=false
[5] https://books.google.co.in/books?id=knDn-mfg6vMC&pg=PA187&dq=thermoelectric+module-+peltier&hl=en&sa=X&ved=0ahUKEwjshcCO8YbaAhWKMo8KHZVHAXA4ChDoAQgoMAE#v=onepage&q=thermoelectric%20module-%20peltier&f=false
[6] Gurevich, Yu.G.; Logvinov, G.N.; Fragoso, O.A.; del RioV, J.L., "Lowest temperature at thermoelectric cooling," Electrical and Electronics Engineering, 2007. ICEEE 2007. 4th International Conference on , vol., no., pp.369,372, 5-7 Sept. 2007 doi: 10.1109/ICEEE.2007.4345042.
[7] Michael Ralf Starke, Thermoelectrics for Cooling Power Electronics, The University of Tennessee, Knoxville,2006
[8] ChakibAlaoui, Peltier Thermoelectric Modules Modeling and Evaluation, International Journal of Engineering (IJE), Volume (5) : Issue (1) : 2011
[9] Tsung-Hsin Hung, Construction and Analysis of Personalized Air-conditioning System, National Chin Yi University of Technology, Taichung City 41170, Taiwan.
[10] Limei Shen, Investigation of a novel thermoelectric radiant air-conditioning system, Energy and Buildings 59 (2013) 123–132.
[11] Hyeung-Sik Choi, Development of a temperature-controlled car-seat system utilizing thermoelectric device, Applied Thermal Engineering 27 (2007) 2841–2849
[12] Judith Koetzsch& Mark Madden, Thermoelectric Cooling for Industrial Enclosures, Rittal White Paper 304.
[13] ReinhardRadermacher, BaoYang, Integrating Alternative and Conventional Cooling Technologies, ASHRAE Journal, October 2007.