



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOPMENT OF PORTABLE AIR CONDITIONING USING
THERMOELECTRIC COOLING DEVICE**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Automotive Industry and Robotics) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Automotive Industry and Robotics) with Honours. The member of the supervisory is as follow:

.....
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ABSTRAK

Dasawarsa ini, penghawa dingin bergerak telah diciptakan sebagai produk inovasi daripada penghawa dingin konvensional. Namun begitu, inovasi yang telah dilakukan adalah secara fizikal sahaja. Iaitu untuk memudahkan pergerakan berbanding penghawa dingin konvensional yang kedudukan statik pada sesuatu tempat. Manakala untuk sistem penghawa dingin, sistem yang digunakan tetap sama iaitu sistem mampatan wap. Sistem ini memberi impak yang negatif terutamanya kepada penipisan lapisan ozon. Hal ini kerana, sistem mampatan wap menggunakan gas Freon yang akan menyebabkan terhasilnya gas klorofluorokarbon dan sekaligus meninggalkan kesan kepada lapisan ozon. Situasi ini menjadi salah satu faktor untuk pengubahsuaian penyejuk udara bergerak kepada penghawa dingin bergerak menggunakan peranti penyejuk termoelektrik. Penggunaan modul penyejuk termoelektrik iaitu Peltier dapat menggantikan sistem mampatan wap yang digunakan dalam penghawa dingin. Selain daripada mesra alam, penggunaan Peltier dalam sistem penghawa dingin dapat menyumbang kepada penjimatan kos dan pengurangan penggunaan arus elektrik dan voltan yang tinggi. Untuk memastikan Peltier dapat memberikan kesan yang baik dalam sistem penyejukan, ia perlu digunakan dengan peranti penyejuk cecair iaitu 'waterblock'. Waterblock digunakan untuk menyejukkan air yang disalur keluar daripada Peltier. Ia memerlukan ruang yang kecil untuk tujuan pemasangan dan membantu untuk mencapai tahap penyejukan suhu yang tinggi. Secara keseluruhannya, dapat disimpulkan bahawa projek ini dapat memberikan keselesaan dan memuaskan hati pengguna.

ABSTRACT

Nowadays, portable air conditioner have been created as an innovation product of conventional air conditioner. However, it have been fabricated only in the physical state which is for easier mobility only but the air conditional system is still using the same system which is vapour compress system. The vapour compress system brings the negative impact effect especially on ozone depletion layer. This is because vapour compress system utilizes Freon gases which at the end will turn to release the cluorofluorocarbon which effect the ozone layer. This situation is a part of factors to come out with portable air conditioner with a thermoelectric cooling device. The use of thermoelectric cooling device which is Peltier replaced the current vapour compress system in air conditioner. Apart from environmental friendly, the use of Peltier in air conditioning system enables in reducing cost, current and voltage. In order to make Peltier effect device function, it need to be used with liquid cooling method which is waterblock. Waterblock is used in order to cool water out from a Peltier. It only requires much less space for installation and function to cool the specific system components to a greater degree. In short, this project will make the consumers feel more satisfy along with great comfortability.

DEDICATION

To my beloved parents

To my kind lecturers

And not to forget to all my fellow friends

I would like to give a special thanks for all their love, sacrifice, encouragement, and best wishes.

ACKNOWLEDGEMENT

I would like to thanks to all especially beloved parents for giving encouragement to complete this final year project. Not to forget also to my supervisor for the supports and guide and also to my fellow friends.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

P	-Power
V	-Voltage
I	-Current
TC	-Temperature Cool
TH	-Temperature Hot
SMD	-Sliding Mode Control
TEC	-Thermoelectric Cooling
RACs	-Room Air Conditioner
TEG	-Thermoelectric Generator
TEC	-Thermoelectric Cooler
Vdc	-Voltage direct current

CHAPTER 1

INTRODUCTION

1.0 Background

This project focused on the development of the Portable Air Conditioner using liquid cooling method with Peltier Effect. The Peltier is used as thermoelectric cooling. The Peltier cooler is a solid-state active heat pump which consume electric energy to transfer heat from one side of the device to the other side depends on the direction of the current. In theory, cooling effect occurs when an electric current passes through two conductors. A voltage applied to the free ends of two different material creates a temperature difference. The difference of the temperature will cause heat to move from one end to the other. Besides, the water block also is used as a liquid cooling method. To operate, the water block will absorb the heat from the water which have been passed through it. Due to that, it function is to allow to cool specific system components to a greater degree compared to air cooling method. It also used to make the portable air conditioner works with an efficient way and it much quieter than stuffing case full of air cooling method.

At the beginning of this project, the portable air cooler is used to fabricate the system to be an air conditioner system. The original system of air cooler use the system which called water distribution system. The system is an active system since it uses an electricity driven water pump to re-circulate the water back up to the top of evaporative pads. But, using this system, the flaws is it only can produce the air with limited temperature since it only depends on the system an water only as cooling

agent without addition in other components of cooling. Besides, the air cooler also prove ineffective in humid conditions.

1.1 Problem Statement

Nowadays, the consumers are burdened with high cost electric bills since the existing of portable air conditioner now also results in the higher uses of electricity and voltage. This is because current portable air conditioner use a Heating, Ventilation and Air Conditioning (HVAC) system which requires high electric and voltage to be functioned. The HVAC system is responsible for providing fresh outdoor air in order to dilute interior airborne contaminants. In this system, the “Freon Gas” have been used. When the Chlorofluorocarbons (CFCs) escape from the air conditioner unit, it will rises up to the atmosphere and break apart and release chlorine atom and effect the depletion of ozone layer. Besides, CFC also responsible in absorbing heat in the atmosphere then sending some of the absorbed heat back to the surface of the earth and automatically contribute to the Global warming effect.

1.2 Objective

In this project, Peltier have been used as a thermoelectric modules. The concept is almost similar to the current unit but has been change from gases to water as a cooling agent. The water in the system will be cooled using the Peltier cooling effect with the aid of water block as liquid cooling method.

- a) To compare existing cooling system that uses air cooling system with liquid cooling system in terms of cooling capacity.
- b) To develop the portable air conditioning system using water as cooling agent.
- c) To improve the efficiency of the system by having specific system components to cool to a greater degree than use fan.

1.3 Project Scope

The scope of this study is:

- a) To design the effective circuit for reduce current and voltage usage using Arduino.
- b) To build an outdoor unit that uses thermoelectric cooling device.
- c) To create an eco-green technology by using water as cooling agent.

1.4 Project Significance

This project focused on the replacement of vapour compression system to the thermoelectric cooling effect. The Peltier is used to modify the existing cooling system that uses gases to a cooling system using water from the Peltier effect. A Peltier cooler is a solid-state active heat pump which transfer heat from one side of the device to the other with consumption of electric energy depending of the direction of current. In order for cooling effect to occur, an electric current need to pass through to two dissimilar conductors. A voltage applied to the free ends of the conductors creates a temperature difference. This temperature difference will cause heat to move from one end to the other. Consuming of Peltier effect in the portable air conditioning system can reduce the cost of project, maintenance and electricity bills compared to existing cooling system. Instead of eco green technology, Peltier modules also contribute towards society growth.

1.5 Thesis Outline

In this project, the water is used as a coolant. The applying of the Peltier effect in this project will be discussed later in the topic such as introduction, literature review, research Methodology, result, discussion, conclusion and for further development in order to improve the function or efficiency of the project.

Chapter 1 basically is an introduction of the project. In this chapter, the main idea about the background and objectives of the project will be discussed. The full design and basic concept of the project will be focused in this chapter. The overview of the entire project also will be discussed in this chapter to show proper development of the project.

Chapter 2 is about the literature review and the methodologies for the development of the Portable Air Conditioners use water as a coolant applying the Peltier effect. This includes the future project development that can be added in this project.

Chapter 3 will discussed about the design of this project development. In this chapter, it will explain about the overall flow of the project and guidelines in order to make sure the project progress flow in the track and achieve the objective of the project.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

A literature review is a summary of the research which obtained from previous journal and chapter. The proposed of this chapter is to present the knowledge and ideas that have been established on a topic. In this project, it have mains part to investigate. There are Peltier, Temperature Controller, and Air Conditioner system. Peltier method is most important part used in order to create hot and cooling air. Moreover, the sensor also used as a device to detect a temperature in the air conditioner. The main objective are the use of Peltier Technology in air conditioner system by modifying the existing portable air cooler into the air conditioner system which uses water from Peltier effect.

2.1 Components of heating and cooling

In order to achieve the air conditioner system, the review is based on literature review which will be discussed in detail in this chapter. For the heating and cooling system, the research is mainly on Peltier, Temperature controller and air conditioner system.

2.1.1 Peltier

Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfer heat from one side of the device to the other,

with consumption of electric energy, depending on the direction of the current. In Peltier module, it consists of a number of thermocouples sandwiched between two dissimilar materials. Single thermocouple consists of one n and one p-type semiconductor material and are electrically connected in series but thermally in parallel. For the cooling mode, the direct current passes from the N to P type semiconductor material. Then, the temperature of TC (cold junction) of the interconnecting conductor decreases and the heat is absorbed from the environment. It occurs when electrons pass from a low energy level in P type material through the interconnecting conductor to a higher energy level in N material. The absorbed heat is transferred through the semiconductor materials by electron transport to the other side of the junction TH and released as the electrons return to a lower energy in the P type material.

According to the article title “Peltier Module for Commercial Use”, the objective is to create a support part in the electrode in order to absorb substantially strain on the chips and design the required life. This is due to substantially strain on the Peltier module’s chips effect by the temperature difference between hot and cold electrode. The thick electrode pattern is used to absorb strain and to release the stress of DBC method and bar ingot is used to ensure high strain and arrange crystal axis. As a result, the more thickness of support part module effect on the better cooling and heating cycle test and more long life module. To conclude, reliable module for commercial use is proposed based on temperature map and the values on mounting force. Figure 2.1 below shows the Peltier’s cooling thermocouple.

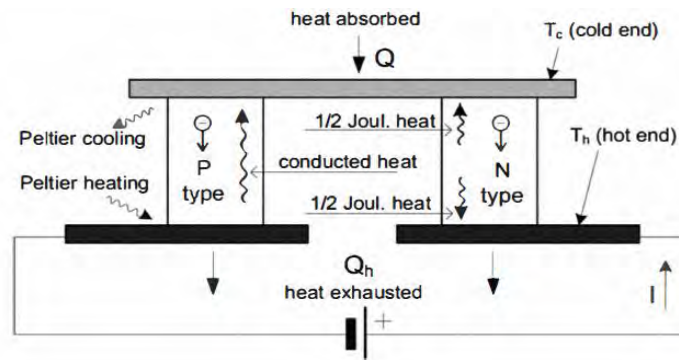


Figure 2.1: Peltier's cooling thermocouple

2.1.2 Temperature Controller

A temperature controller is a device that used to control a heater or other equipment by comparing a sensor signal with a set point and performing a calculations according to the deviation between those values. It control the temperature so that the process value will be the same as the set point, but the response will differ due to the characteristics of the controlled object and the control method of the Temperature Controller. Temperature controller also is needed in any situation requiring a given temperature be kept stable. The simplest example of temperature controller is a common thermostat. For instance, a hot water heater uses a thermostat to control the temperature of the water and maintain it at a certain commanded temperature. It is also used in oven. When a temperature is set for an oven, a controller monitors the actual temperature inside of the oven. If it falls below the set temperature, it sends a signal to activate the heater to raise the temperature back to the set point. Other than that, Thermostats are also used in refrigerators. If the temperature gets too high, a controller initiates an action to bring the temperature down then keep the temperature in a stable condition.

According to the article “Design and Verification of Thermostat with Peltier Thermoelectric Modules”, high demand of crystal oscillators with measurements of frequency versus temperature characteristic have been lead to design a fast responses thermostat in order to control and stabilize a temperature

inside the chamber in the specific range. To achieve the objective, several steps which are designing the regulator, modelling of the thermostat with the PSD regulation and measurement on the prototype of thermostat was taken. In order to determine the regulator's parameter, the SIMple Control (SIMC) have been utilized. Next, since the required regulator is digital, the continuous PID regulator have been transform to the appropriate discrete regulator (PSD regulator). For modelling of the thermostat with the PSD regulator, the block diagram is used to represent the complete model. The models include several blocks, which represents different effects in the real hardware. Next, the model is used to optimize the temperature PSD regulation to the desired temperature profiles in the chamber and to investigate the different effects of error sources. After measured the temperature inside the chamber of the prototype, the result obtained shows that thermostat with PSD regulator able to perform fast reaction when the desired temperature changes and required a short period to stabilize the temperature within the small error. Therefore, developing of the thermostat with the PSD regulator able to optimize the parameters of the regulator according to the expected temperature profiles inside the chambers.

The proper control strategy effect the amount of energy used in air conditioning / refrigerator system. In presented work, the temperature controller which known as on/off controller have been used to maintain the temperature of air conditioning/ refrigerator with a certain range via switching the whole system on or off. However, it is unable to control the temperature oscillation amplitudes and frequent activations may lead to the excessive power consumption. Therefore, in order to overcome the problem of current controller, the Sliding Mode Controller (SMD) is used to handle high order, nonlinear system, and to be used under the constraint of limited sensor set. Sliding Mode Controller (SMD) also is used to handle with the large oscillation. But, the consideration about saving energy is not be taken. Due to that, an energy set-point optimizer is designed to be with Sliding Mode Controller in air conditioning / refrigerator system. The scope in this research paper is to compare the on/off controller and Sliding Mode controller to be used in in air conditioning /refrigerator system. From the result obtained by applying the on /off controller and Sliding Mode Controller with set-optimizer in air conditioning /

refrigerator system, it have been shown that the Sliding Mode Controller able to drive the temperature to the set point in a short period compared to the on/off controller. It also able to keep the temperature at the set point with a little oscillation. Thus, by using the Sliding Mode Controller with an energy set-point, the objective of the paper have been achieved.(Huang, Khajepour, Ding, Bagheri & Bahrami, 2016). Figure 2.2 below shows block diagram of presented work.

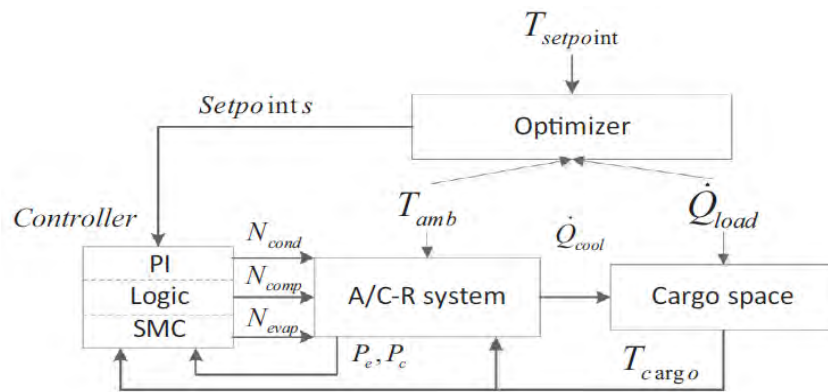


Figure 2.2: Block Diagram of presented work (Set-Mode Controller)

2.1.3 Air Conditioner System

Air conditioning units are designed to remove heat from interior spaces and reject it to the outside air. It is utilized in order to maintain the space at low temperature level by absorbing heat, and extract that heat into a higher temperature environment. The control of these condition is needed in order to get the humid and fresh air in an enclose condition.

In order to achieve the objective which are to obtain desired amount of cooling and reduce the amount of space to arrange the components in the air conditioning system, the Thermoelectric cooling which is Peltier Module have been used. Peltier Module have the specifications in terms of geometry, number of thermocouples, power rating, maximum voltage, current, and maximum temperature