UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF PORTABLE AIR CONDITIONING USING PELTIER EFFECT FOR SMALL AREA USES

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

by

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930427-08-6554

FACULTY OF ENGINEERING TECHNOLOGY

2016

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SESI PENGAJIAN: **2016/17 Semester 1**

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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 Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow:

.....

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ABSTRAK

Dalam era globalisasi ini, suasana dunia semakin panas dan semua orang berasa panas dan mudah berpeluh berbanding dengan suasana yang sebelumnya. Oleh itu, masyarakat ini amat membimbangkan perkembangan pembangunan penghawa dingin mudah alih yang dapat membawa bersama-sama oleh pemilik dari satu tempat ke tempat lain. Dalam projek ini, ia menggunakan mudah alih bekalan kuasa DC untuk menyambung kepada penukar rangsangan untuk menaikkan voltan dan arus elektrik demi membekalkan bekalan voltan and arus elektrik kepada prototaip penghawa dingin mudah alih. Penukar rangsangan yang menggunakan ATtiny85 telah berjaya meningkatkan voltan daripada 4.62V kepada 13.2V tetapi arus elekktrik masih tidak cukup untuk membekalkan arus elektrik kepada penghawa dingin mudah alih tersebut. Penghawa dingin mudah alih tersebut adalah terdiri daripada modul Peltier, pelepas haba dan kipas. Demi mengumpulkan data, penghawa dingin mudah alih telah disambung dengan mudah alih bekalan kuasa DC dan penukar rangsangan. Dengan bekalan voltan dan arus elektrik yang secukupnya kepada modul Peltier dan dibantu oleh pelepas haba dan kipas, penghawa dingin mudah alih dapatlah berfungsi. Modul Peltier adalah alat kawalan arus di mana apabila kenaikan arus elektrik, efisien akan menurun semasa maxima arus elektrik dibekalkan kepada modul Peltier. Selain itu, penghawa dingin juga berfungsi dengan bantuan kesan Peltier yang mengalir arus elektrik melalui persimpangan dua logam yang berlainan dan dengan itu membebaskan haba. Dengan peredaran udara, suhu penghawa dingin adalah sejuk.

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ABSTRACT

During the hot whether, everyone is feeling hot due to the weather that are become hotter and hotter compared to previous. Thus, it is important to develop a portable air conditioner that able to bring along from one place to another place. In this project, it used a DC portable power supply to connect to a boost converter in order to step up the input voltage and current to supply to the prototype of portable air conditioner. The boost converter that using the ATtiny85 had successfully boost the voltage from 4.62V to 13.2V but the current was too small and insufficient to supply to the portable air conditioner.The portable air conditioner was made up of Peltier module, heat sinks and fans. In order to collect the data, the portable air conditioner was connected to the portable DC power supply and boost converter module. With the sufficient of voltage and current supply to the Peltier module and the aids of the heat sink and fans, the portable air conditioner can be functioning. For the Peltier module, it is a current control device where when the current increases, the efficiency decreases while maximum cooling occurs at some specific current. Besides, the air conditioner also works with the aids of the Peltier effect which the electric current flows through the intersection of two dissimilar metals as well as liberated the heat. With the air circulation of the neutral air, the temperature of the air conditioner at the cold side is cooler.

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DEDICATION

This thesis is dedicated to my beloved parents, supervisor and friends for their help and guidance to complete the final year project successfully.

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ACKNOWLEDGEMENT

First of all, I would like to convey my gratefulness to my supervisor, Mr A. Shamsul Rahimi Bin A. Subki for giving me such the valuable chance to have my final year project under his supervision. Without his supervision, encouragement and patient, this project would never have been completed on time. Besides, I appreciate all the assistance, motivation and precious discussion throughout the project. Although he is being extremely busy with his jobs and duties; he still managed to lead me along, apart from giving me the best ideas to each challenge that I faced. I would also like to show appreciation to all of my friends for their support when I faced any problems and difficulty in finishing this project. Last but not least, I would also like to give my special appreciation to my family for the continuous support and attention in my study life. Their endless support has extended to me throughout my study life and general life.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

A	-	Ampere
AC	-	Alternating Current
C	-	Capacitance
℃	-	Degree Celcius
D	-	Duty Cycle
DC	-	Direct Current
f	-	Frequency
I	-	Current
IC	-	Integrated Circuit
I/O	-	Input / Output
kW	-	Kilowatt
L	-	Inductance
mW	-	Milliwatt
P	-	Electrical Power Supplied
PCB	-	Printed Circuit Board
psi	-	Pounds Per Square Inch
PWM	-	Pulse Width Modulation
Q	-	Heat Absorption Per Unit Time
Q1	-	Heat to be Pumped
Q2	-	Heat Dissipated to the Ambient
R	-	Resistance
r	-	Voltage Ripple
S	-	Seebeck Coefficient
s	-	Seconds
SMPS	-	Switched-mode Power Supply
T	-	Temperature
TEC	-	Thermoelectric Cooler
TIM	-	Thermal Interface Material

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V	-	Voltage Difference
Π	-	Pie
%	-	Percentage
τ	-	Torque
μ	-	Micro

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CHAPTER 1
INTRODUCTION

1.0 Introduction

Recently, the weather seemed to be hotter and hotter compared to previous. Thus, everyone is feeling hot and have a great concern on the development of a portable air conditioner. Hence, in order to solve the problem, many researchers are trying to find an alternative air conditioner technology in order to replace an inconvenient air conditioner. But nowadays, many of the air conditioners are using AC power supply to power up the air conditioner. Instead, a system of using the Peltier effect is needed for the air conditioner to be functioning.

The Peltier effect is where heat is liberated or absorbed when an electric current flows through the junction of two different metals. The heat is absorbed in the hotter intersection point while the heat is liberated at the colder intersection point when the electric current is flowing in the same direction. The Peltier circuit is as shown in the Figure 1.1.

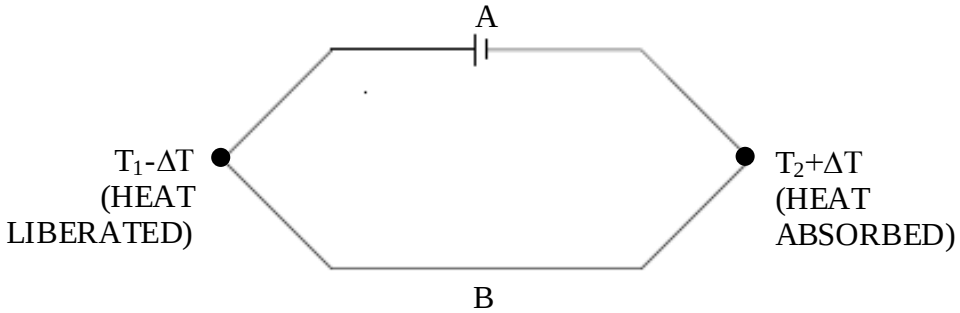

Figure 1. 1: Peltier Circuit

This impact is unique in relation to the development of heat depicted toward Ohmic (I^2R) losses. This impact will be reversible, high temperature constantly advanced as current flows in a direction across the intersection point, and absorbed when

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the current in the reverse direction. The junction or also known as the intersection point is the origin of a Peltier voltage. When current is flows across the junction which in the opposite direction of the voltage, a heating action happens. The intersection point is cooled, if the current is flows in the direction of the Peltier voltage,

The Peltier effect is defined by:

$$Q = \Pi_{AB} \bullet I \tag{1}$$

Where Q is the heat absorption per unit time, Π_{AB} is the Peltier coefficient, and I is the current.

While the two dissimilar metals are in contact with electrical, the electrons of a metal with fewer electrons bound flow out to the higher number of electrons bound's metals. This phenomenon known as Fermi level among the two dissimilar metals. The Fermi level represents the differentiation in energy within the conduction band of a metal. The conduction band is the band among the two energy levels which in use by electrons and those that are not occupied.

When the two dissimilar metals which have different Fermi levels are place in contact, the electrons flow from the metals that have a higher altitude to a lower altitude until the electrostatic potential changes and brings the two Fermi levels to the same value. This electrostatic potential can also be known as the contact potential.

With this, when the current flows through the intersection point of the two dissimilar metals or also known as the junction of the two dissimilar metals, it causes in either a forward or reverse bias which also cause the temperature to be changed which results in a temperature gradient. The cold plate's temperature can be cooled by tens of degrees if the temperature of the hotter intersection point is maintains low by dissipating the generated heat.

The Seebeck effect is a occurrence of a difference in temperature between two different electrical conductors or semiconductors which produce a voltage difference between the two substances. Two types of wires that having different Seebeck coefficient connects to form a junction where it can be used to determine the thermoelectric power. For example, if electrical conductors or semiconductors are iron and copper, and if one of the intersection point is kept in a cold region while the other is

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kept in a hot region, current flows from copper to iron across the hot junction. The Seebeck circuit is as shown in the Figure 1.2.

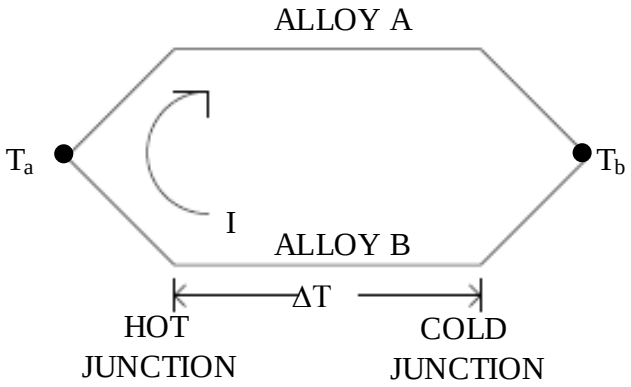

Figure 1. 2: Seebeck Circuit

The Seebeck effect is defined by:

$$V = \int_{T_1}^{T_2} S_B(T) - S_A(T) dT \tag{2}$$

Where V is the voltage difference, S is the Seebeck coefficient, and T is the temperature at the junction.

The Peltier module, also known as the thermoelectric module is an energy converter in solid state that consists of a cluster of the thermocouple that connects in series and thermally in parallel in an electrical circuit. A Peltier module is also able to transfer heat from one region to the other region using the Peltier effect. It functions when two heat sinks are pasted to its hot and cold parts for the heat transfer.

A Peltier TEC also acts as a temperature control with high efficiency. An active heat transport is produced when an electrical current flows through the Peltier TEC. The cooling effect of a Peltier TEC is proportional to current, but the internal heating due to I^2R losses is proportional to the square of the current. When current increases, the efficiency decreases while maximum cooling occurs at some specific current. The PWM produced by the regulated temperature of the microcontroller needed to be filtered so that the Peltier TEC sees relatively smooth current.

With this, a product that is small, portable and lightweight compared to the other products that we review was highlighted. In order to archive this target, the mechanism of the air flow through the air conditioner module and also the basic construction of the

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air conditioner module should be studied. The air conditioner module used the Peltier TEC module which using Peltier effect as the heat is liberated or absorbed when an electric current flows across a intersection point of two different metals. The construction of the Peltier air conditioner was as shown in Figure 1.3.

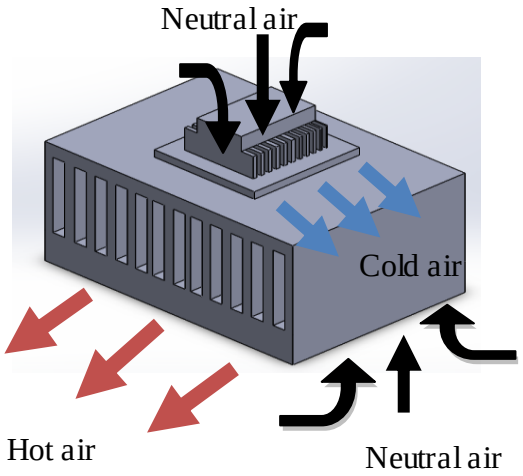

Figure 1. 3: Construction of the Peltier Air Conditioner

In order to fulfill the condition of a portable air conditioner, a boost converter needed to be designed to supply the voltage source to the air conditioner to be functioning well. Most of the air conditioners nowadays are still using the AC power supply but in this case, a design of DC to DC boost converter was used to provide a DC voltage source to the air conditioner to be functioning.

A boost converter is a DC to DC converter that boosts a lower DC voltage to a higher DC output voltage. It is also known as a step-up converter. A DC boost converter is also one of the classes of a switched-mode power supply (SMPS) which contain minimum of two semiconductors which are a diode and a transistor and at least one energy storage space element which are a inductor, capacitor, or both. To reduce the voltage ripple, r, filters made of capacitors are usually connected to a converter's output and input.

By using a boost converter in any application, it can increase the voltage value and reduce the cells that normally needed. Thus, it is more portable because by decreasing the number of cells, the weight of the cells can also be decreased and thus it is more convenient to bring anywhere. For example, a boost converter can step up an

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input voltage of 6V to an output voltage of 12V which means that we can obtain a higher output voltage by using a lower input voltage which passes through a boost converter. Below is the basic schematic of a boost converter:

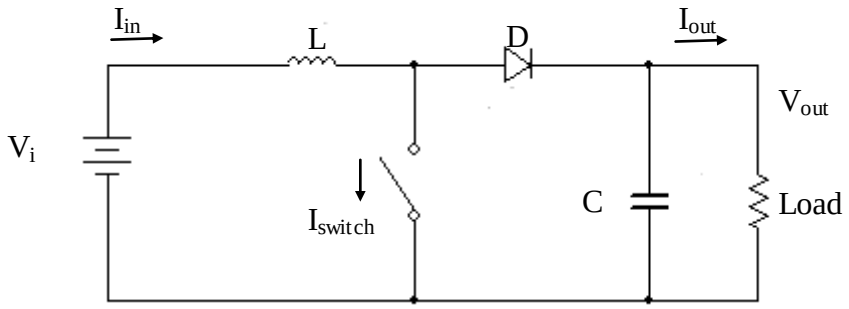

Figure 1. 4: Boost Converter

To drive a DC boost converter, the tendency of an inductor is the main principle to oppose the changes in current by providing and destroying a magnetic field.

Boost converter can function in two modes which are continuous mode and discontinuous mode. For the continuous mode, the current that flows through the inductor will not equal to zero. While for the discontinuous mode, at one point of time, the current that flows through the inductor become zero due to the using up of energy by the load.

Besides, the switch of the DC boost converter is normally connected to a MOSFET which receive the Pulse Width Modulation (PWM). PWM is a manner to send signal which is in varies from a given set signal. PWM can change the duty cycle of a square wave to vary the power supplied. PWM varies due to the signal that gets the duty cycle and averages of the power signal as output. The bigger is the duty cycle that produced by the PWM, the bigger is the output signal. This can be seen in Figure 1.5.

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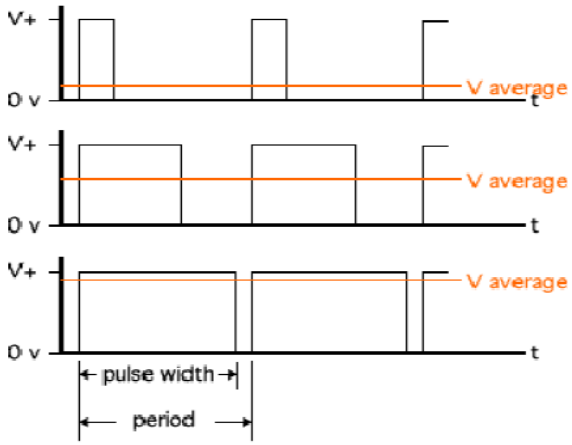

Figure 1. 5: Variation of Duty Cycle

In this project, an Arduino Uno will be used to generate the PWM. An Arduino is a software company where this software is in open-source which can get the sources from internet. An Arduino is a microcontroller board designs, produced by several vendors and used different types of microcontrollers. This system provides sets of digital and analog I/O pins that can interface to various development boards and other circuit. The Figure 1.6 shows the hardware of an Arduino Uno R3.

Figure 1. 6: Arduino Uno R3

An Arduino Uno R5 has 14 digital input or output pins. There are six pins have built in PWM function. The pins that do not have built in PWM function can still be used for PWM but must used in another way.

There are two ways to generate the PWM by using an Arduino which are AnalogWrite and DigitalWrite. AnalogWrite have it own square wave that already had generated and the AnalogWrite is easier to determine the value to get the required duty cycle. The disadvantage of the AnalogWrite is it will have a same frequency as what is

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already set for the pin. In other way, the DigitalWrite needs to calculate the required duty cycle but it lets for the changes of frequency.

The programming that used in an Arduino is C language which is a basic language that normally used in programming field. C language is a standard programming used for compiler and a boot loader that perform on the microcontroller.

In addition, there is an alternative way of designing a boost converter which use microcontroller ATtiny85 as a switch control. The circuit design of boost converter using the microcontroller ATtiny85 follows the topology of the basic boost converter. ATtiny85 is a microcontroller that can be program by using the Arduino Uno. By using the ATtiny85, it can provide a faster pulse width modulation (PWM) compare to power Mosfet or BJT. Besides, ATtiny85 can save a few changes and make a smaller design. The most excellent order for setting up the chip to be used with the Arduino IDE is on the MIT, High Low Tech. The chips work alike to the Arduino Uno with some restrictions. When using an ATtiny85, a breadboard or circuit of a design is used. Different with an Arduino Uno, which has the pins at the headers numbered to go with the pin numbers in the Arduino IDE, then the ATtiny85 is wires to the actual physical pins. The numbers of analog pins are different with the digital pins at the same physical location. For example, both of the digital pin 2 and the analog pin 1 are the physical pin 7 while the physical pin 6 is also same as the Digital pin 1 and it has no analog input. This is due to the design of the chip and not caused by the Arduino software. The pin numbers are based on how port B and the ADC is mapped. Pin 7 is PB2 (digital pin 2) and ADC1 (analog pin 1).

Figure 1. 7: ATtiny85

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