UNIVERSITI TEKNIKAL MALAYSIA MELAKA

AUTOMATIC COOLING SYSTEM USING PELTIER THERMOELECTRIC COOLER FOR LIGHTNING DETECTION APPLICATION WITH SMART CONTROL AND MONITORING SYSTEM

This report submitted in accordance with requirement of the UniversitiTeknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Electrical Engineering Technology (Industrial Power) (Hons)

by

MUHAMMAD ROZAINI BIN ROZLAN

B071310391

911017075533

FACULTY OF ENGINEERING TECHNOLOGY

2016

DECLARATION

I hereby, declared this report entitled "Automatic Cooling System Using Peltier Thermoelectric Cooler for Lightning Detection Application with Smart Control and Monitoring System" is the results of my own research except as cited in references.

Signature : ....

Author's Name : MUHAMMAD ROZAINI BIN ROZLAN

Date : ....

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

....

(MASLAN BIN ZAINON)

ABSTRAK

LDS ialah satu singkatan dari Lightning Detection System yang menggunakan komponen elektronik yang sensitif. Komponen elektronik ini sangat sensitif kepada sebarang perubahan suhu persekitaran yang boleh mengakibatkan komponen ini tidak berfungsi seperti yang dikendaki. Disebabkan komponen-komponen elektronik ini terlalu sensitif kepada suhu persekitaran, komponen ini perlu mempunyai sistem kotak penyejukan yang dapat melindungi komponen-komponen ini daripada terdedah kepada perubahan suhu cuaca yang tidak menentu. Sistem penyejukan konvensional tidak begitu praktikal untuk digunakan sebagai sistem penyejukan pengesan kilat kerana ia menggunakan elemen-elemen yang tidak mesra alam. Oleh itu, Termoelekterik Peltier adalah alternatif yang terbaik untuk dijadikan bahan penyejukan sistem pengesan kilat. Tujuan projek ini adalah untuk mereka bentuk dan membina satu sistem penyejukan secara automatic dengan menggunakan Termoelektrik Peltier untuk sistem pengesan kilat dan membangunkan satu aplikasi telefon pintar untuk memantau suhu, voltan dan arus elektrik yang digunakan dengan menggunakan aplikasi MIT App Inventor. Selain itu, prototaip sistem ini dibangunkan untuk menyediakan satu bentuk alat latihan pendidikan kepada institusi pengajian serta masyarakat. Hasilnya, kotak pengesan kilat ini akan menggunakan Termolektrik Peltier sebagai bahan penyejukan untuk mengawal suhu didalam kotak pengesan kilat dan akan dipantau dengan menggunakan aplikasi telefon pintar.

ABSTRACT

Lightning Detection System (LDS) is a system that uses sensitive electronic components. The electronic components are very sensitive to any ambient temperature changes, it will cause the components not operated as intended. Since the electronic components are too sensitive with the ambient temperature, these components should have a cooling system box installed to protect them from uncertain weather changes. The conventional cooling system is not very practical to be used as a lightning detector cooling system because it uses too many elements and not environmentally friendly. Therefore, the thermoelectric cooling material is a better alternative for the lightning detector cooler box. The aim of this project is to design and build an automatic cooling system for lightning detection system using thermoelectric Peltier module and to develop a smartphone application to monitor the reading of temperature cooling system and power consumption using MIT App Inventor software. Other than that, this system prototype is developed to provide a form of educational training tool for academic institutions and community. As a result, the lightning detector cooler box will use the thermoelectric Peltier as a refrigerant cooler and the temperature inside the cooler box will be monitored using a smartphone application.

DEDICATION

To my beloved parents

To my supervisor, Mr. Maslan Bin Zainon

To my lecturers

And not forgetting to all dear friends.

ACKNOWLEDGEMENT

Assalamualaikum Warahmatullahi Wabarakatuh.

Firstly thank you to Allah S.W.T who gives me strength and patience to enable me successfully complete this project. Peace and blessings be upon Muhammad S.A.W, the true Messenger of Allah for his beautiful bond of lovers to his sunnah.

I would like to take this opportunity to express my thankfulness to my supervisor, Mr. Maslan Bin Zainon, for his guidance, valuable assistance and motivation in helping me to complete this work successfully. Thank you.

My deepest thank to all lecturers who have thought me, directly or indirectly during these four years of studies. I will never forget all the precious knowledge learnt and gained.

Thank you.

TABLE OF CONTENTS

CHAPTER 2: LITERATURE REVIEW

CHAPTER 3: METHODOLOGY

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

CPC	=	Chlorofluorocarbon
DC	=	Direct Current
TEC	=	Thermoelectric cooler
T_C	=	Temperature cooling
T_h	=	Temperature hot
Q_c	=	Cooling load
I	=	Current
V	=	Voltage
ΔT	=	Temperature different
C_p	=	Specific heat of air
PIC	=	Programmable Integrated Circuit
CMOS	=	Complementary Metal-Oxide Semiconductor
EEPROM	=	Electrically Erasable Programmable Read-Only Memory
ADC	=	Analog Digital Converter
mW	=	Miliwatt

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will explain the background of this project, problem statements, objectives, and conclusions. The structure of this report will be described and a better overview of the whole project will be given.

1.1 Background

In a conventional cooling system, the system uses a condenser, compressor and blower to cool the surrounding area of the system. This system has many disadvantages such as CFC gas emissions that can pollute the air and the system is too large to fit into a small space such as lightning detection system. To overcome this problem, thermoelectric Peltier module was introduced as a material to be used in the cooling system lightning detector.

Peltier thermoelectric semiconductor is a material that offers several advantages over the conventional cooling systems. This Peltier is a solid-state device with no moving part, it is reliable, rugged and quiet. This semiconductor material does not release CFC which could deplete the ozone layer. This material is one of the alternatives that is more environmentally responsible than the conventional systems. Peltier generally is used in small size applications where the cooling demands are not too great, such as in the electronic components cooling system (Astrain and Vian, 2005).

To ensure the cooling system is running as required, a monitoring system is set up to monitor the ambient temperature inside the lightning detection cooling box. MIT apps inventor is an application used for monitoring purpose. This application can be connected using a Smartphone and the monitoring can be done remotely without the needs to be at the place where the lightning detector placed.

1.2 Problem Statement

Lightning detection system are uses a highly sensitive electronic components. Since the electronics components are too sensitive to the ambient temperature, these components should consist a cooling system that can protect the components from uncertain weather changes. Besides that, there is no monitoring system that is able to check the temperature changes. In order to avoid the problem of detecting lightning, an automatic cooling system using thermoelectric Peltier becomes important and helps to protect the electronics components from malfunctioning. This project will focus on an automatic cooling system using thermoelectric Peltier module, PIC16F877A microcontroller and MIT apps inventor software for temperature monitoring purpose.

1.3 Objectives

The main objectives of this project are:

(a) To design and build an automatic cooling system for lightning detection using thermoelectric Peltier module.

(b) To develop a smartphone application to monitor the reading of the cooling system temperature and power consumption condition.

(c) To develop a prototype as an industrial concept and as an educational training tool for academic institution (community).

1.4 Project Scope

In order to achieve the project objectives, the project scope has been carried out. Generally, the goal of this project is to design a prototype of an automatic cooling system using thermoelectric Peltier module and controlled by PIC16F877A microcontroller. Then, MIT Apps Inventor software will be developed to monitor the temperature changes inside the cooling system box using a Smartphone. All these hardware are selected based on their criteria and ability to control the temperature inside the lightning detection cooling box and monitor the temperature change using a smartphone application.

The prototype will be implemented in a high-rise industrial building. Other than that, this prototype is able to expose the understudies about the MIT Apps software as the easier system to detect the changes of temperature inside the automatic cooling system box.

1.5 Conclusion

This chapter explains about the project background, objectives, problem statements and scope of the project. In addition, this chapter discusses the problem to be solved and how the project is conducted.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter gives a review of an Automatic Cooling system using Thermoelectric Peltier, PIC16F877A microcontroller and the uses of MIT apps inventor for monitoring. The main source of the study was taken from journals, articles, case studies and websites. Each source is chosen according to the relevancy of the project scope.

2.1 Thermoelectric Peltier devices

According to the project, Figure 2.1 shows the Peltier module that will be used as the project cooling system. This Peltier module has two side surfaces. When the DC source applied to a thermoelectric cooler module, the heat will be transferred through the module from one side to the other.

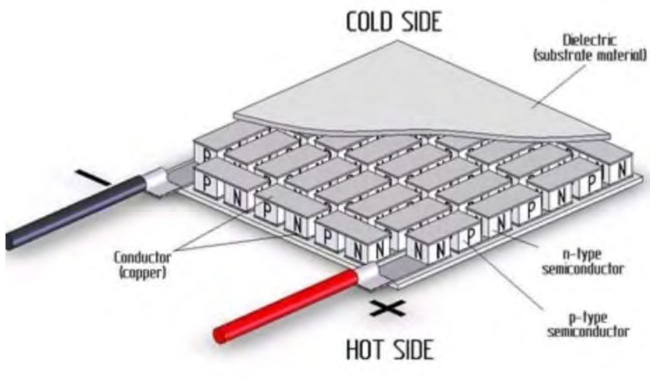

Figure 2.1: Peltier Module

2.1.1 Introduction

The thermoelectric refrigerator or also known as thermoelectric Peltier cooler is a semiconductor based electric component that functions as a small heat pump. When a DC source is applied to a thermoelectric cooler module, the heat will be transferred through the module from one side to the other Prof. Vivek R. Gandhewar et al (2013).

When the first surface is cooled, the other surface of Peltier modules will become heated. This phenomenon occurs when a change in polarity (plus and minus) DC voltage that causes heat to move in the opposite direction Raghied Mohammed Atta (2011).

A thermoelectric and mechanical refrigerator use the same fundamental theory of thermodynamic and refrigeration systems. In a mechanical refrigerator, a compressor raises the pressure of a refrigerant and sends it to the system. In the refrigerant chamber, the refrigerant boils and during the process of vaporizing, the refrigerant absorbs heat and caused the chamber to become cool. The heat is transferred to the condenser where it is then transferred to the environment from the condensing process Mayank Awasthi et al (2012).

For a thermoelectric cooling system, a doped semi-conductor material replaced the refrigerant, the condenser is replaced by a heat sink, and the compressor is replaced by a direct current power source. Direct current power that is applied to the thermoelectric cooler devices causes electron to move to the semi-conductor material. At the end of the cold semi-conductor material, the electron movement will absorb the heat, and expel at the hot end material. Since the hot end material is attached to the heat sink, the heat goes through from the material to the heat sink before transferred to the environment Onoroh Francis et al (2013).

2.1.2 Basic principles of thermoelectric devices

Referring to Jose Rui Camargo (2011), a thermoelectric cooler consists of a semiconductor material that is connected electrically in series and thermally in parallel. These thermoelectric and their electrical are mounted between two ceramic substrates as shown in figure 2.2.

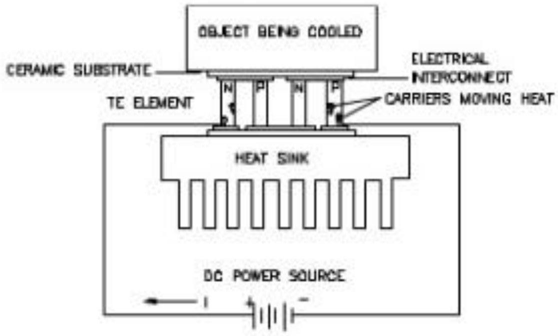

Figure 2.2: Schematic diagram of a thermoelectric cooler

Figure 2.3 shows the N-type and P-type thermoelectric materials are used in a thermoelectric cooler. This course of action causes the heat to move through the cooler in one direction while the electrical current moves forward and backward between the top and bottom substrates through every N and P element. N-type material is doped so that it will have a surplus of electrons (more electrons are needed to complete a perfect molecular structure). P-type material is doped so that it will have a shortage of electrons (less electrons are necessary to complete a perfect structure). Most thermoelectric cooling modules are manufactured with an equivalent number of N-type and P-type elements where N and P elements are paired to frame a thermoelectric. Heat flux is proportional to the magnitude of the DC electric current is applied. By changing the input current to zero, it is possible to control the temperature and heat flow.

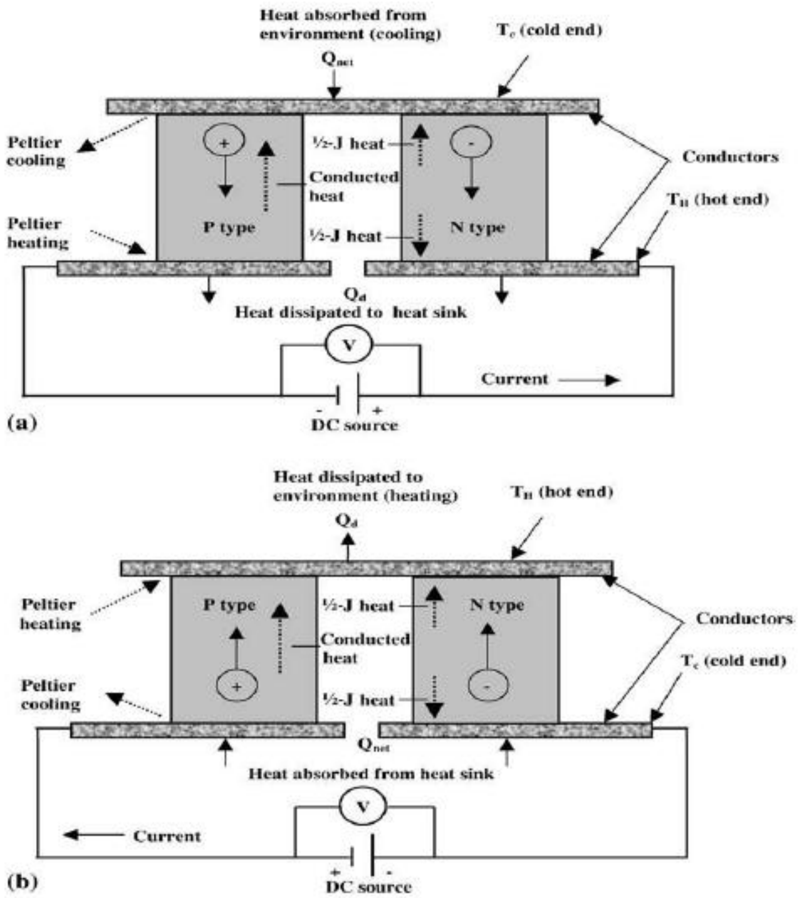

Figure 2.3: Schematic of thermoelectric module operation (a) cooling (b) heating

2.1.3 Parameters of a thermoelectric module

Referring to Prof. N.B. Totala et al. (2014), the appropriate thermoelectric for an application depends on at least three parameters. These parameters are:

- The cold side temperature (T_c)
- The hot side temperature (T_h)
- Operating temperature difference, the temperature difference between T_h and T_c.
- Heat load to be absorbed at the cool surface (QC).
- Operating current (I) and operating voltage (V) of the TEC

2.1.4 Cold side temperature

The required temperature can be considered the temperature of the cold side of TEC when the object to be cooled is in direct contact with the cold surface of the TEC. The aim is to cool the air flowing through the heat sinks. When this type of system is employed, the cold side temperature of the TEC is needed to be several time colder than the ultimate desired temperature of the air.

2.1.5 Hot side temperature

The hot side temperature (Th) is referring to the base of two factors. The first parameter is the temperature of the ambient air in the environment to which the heat is been rejected. The second factor is the efficiency of the heat sink that is between the hot side of TEC and ambient.

2.1.6 Temperature difference

The difference ΔT, between two temperatures Tc and Th is a very important factor. The difference temperature must be determined accurately if the cooling system needs to be operated as desired. This equation, $\Delta T = Th - Tc$ shows the actual ΔT. The system ΔT is not the same as the actual ΔT. The difference between the actual ΔT is the hot and cold side of the TEC. Instead, ΔT is the temperature difference between the ambient temperature and the temperature of the load to be cooled.

2.1.7 Cooling Load

An important factor needs to be calculated accurately is the amount of heat to be released or absorbed by (QC) on TEC cold side of the module. Qc is calculated by finding the product of mass flow rate of air, specific heat of air and temperature difference. ΔT is the temperature difference between the inlet and outlet temperature of the cooling system. The mathematical equation for QC is $QC = m\ Cp\Delta T$.

2.1.8 The advantages of thermoelectric Peltier cooler

Referring to Prof. Vivek R.Gandhewar et al. (2013), thermoelectric cooling modules are solid-state cooler that combine both semiconductor innovations and electronic assembly method. In this way, thermoelectric cooling modules are solid-state, free of vibration, and free heat pump. They consist of primarily thermoelectric materials between the ceramic plates and have no moving parts. Some features of thermoelectric devices include:

I. Small size and weight
II. Ability to cool below ambient
III. No Freon's or other liquid or gaseous refrigerants required
IV. High reliability
V. Operation in any orientation
VI. Easy to clean the aluminum interior
VII. Eco-friendly, CFC free insulation

2.2 Related Previous Research

2.2.1 First design

Referring to a design Aditya Nandy et al. (2014), the design of the project used a semiconductor material which is Peltier modules. Total capacity of air containing water vapour varies depending on air temperature and humidity in the environment. More humid air will produce more water vapour. The humid air will be channelled through the first pump tube and go through the Peltier cold side to reduce the air temperature. When the air temperature decreases, the water vapour starts condensing. The water vapour that has evaporated is supplied to the Peltier (hot surface) for the purpose of cooling as shown in figure 2.4.

It is very important to ensure the Peltier module is not damaged due to extremely hot temperatures in (hot surface) Peltier. TC1046 temperature sensor is used and connected to the PIC16F872 microcontroller to control the system temperature and keeping the temperature of the circulating air above the water freezing point.

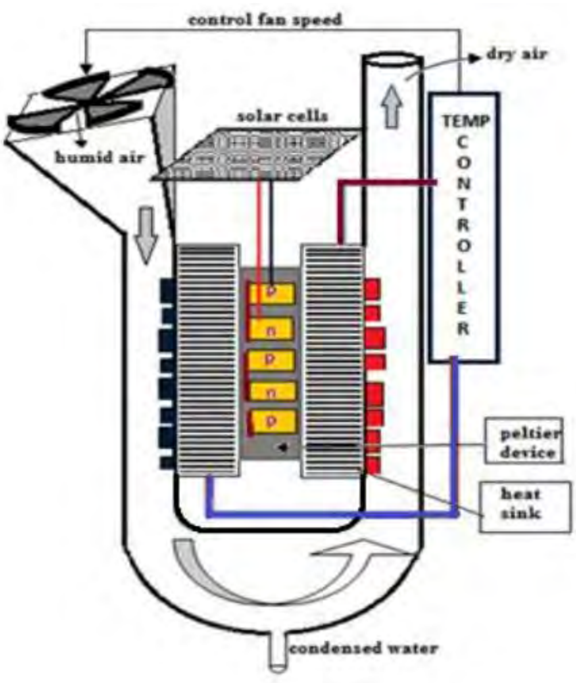

Figure 2.4: Atmospheric Water Generator

2.3 PIC16F877A as a Controller

2.3.1 Introduction

PIC16F877A is manufactured by Microchip is a CMOS-FLASH based 8-bit RISC microcontroller. It perfectly fits various utilizations from businesses and controlling home machines to advanced instruments, remote sensors, electrical entrance locks and security equipment. EEPROM memory makes it less requesting to apply microcontrollers to equipment where a never-ending limit of various parameters is required (codes for transmitters, motor speed, frequency controller, etc.). Insignificant exertion, low use, simple dealing and flexibility make PIC16F877A important even in the areas where microcontrollers are not even considered, for example; hour capacity, interface replacement in larger framework and the coprocessor application.

In system programmability of the chip (along with only two pins as part of the exchange of information) to make adjustments it considers the item, after collecting and testing has been completed. This capacity can be used to create a generation of mechanical production system, to store information accessed strictly alignment when the last test, or it can be used to improve programs on completed items. This 200 nanosecond instruction execution yet simple to-system which is just 35 single word guidelines that microcontroller packs Microchip's capable PIC® design into a 40 pin bundle. The PIC16F877A characteristic 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital converter, 2 catch/analyze/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I^2C™) transport and a Universal Asynchronous Receiver Transmitter (USART).