UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF AUTOMATIC COOLING SYSTEM MODEL USING PELTIER THERMOELECTRIC COOLER FOR LIGHTNING DETECTION APPLICATION

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

by

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APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electical Mechanical Engineering Technology (Power Industry) with Honours. The member of the supervisory is as follow:

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ABSTRAK

Aplikasi Pengesanan Petir (LDA) adalah sistem yang terdiri daripada komponen elektronik yang sangat sensitif terhadap suhu ambien. Komponen elektronik tidak berfungsi dengan baik jika suhu terlalu tinggi. Selain itu, Sistem Pengesan Kilat menerima voltan tinggi sepanjang masa sehingga sebabnya ia mudah dipanaskan. Sistem penyejukan konvensional adalah mahal dan boleh menyebabkan pencemaran udara sebab itu tidak praktikal untuk digunakan dalam aplikasi pengesanan kilat. Oleh itu, untuk mengatasi masalah ini, penyejuk termoelektrik Peltier diperkenalkan kerana ia mempunyai bahan alternatif yang lebih baik. Matlamat projek ini adalah untuk membangunkan prototaip berasaskan mikrokontroler sistem penyejukan automatik untuk pengesanan kilat menggunakan modul Peltier termoelektrik dan untuk membangunkan sistem kawalan dan pemantauan untuk suhu dan kelembapan menggunakan ThingSpeak IoT yang boleh dikawal dan dipantau menerusi telefon pintar . Selain itu, objektifnya adalah untuk menganalisis suhu dan kelembapan prototaip sistem dengan persekitaran sekitar. Seperti yang dijangkakan, Peltier termoelektrik digunakan sebagai penyejuk penyejuk untuk kotak sejuk pengesan kilat dan suhu di dalam kotak sejuk di dalam modul dipantau menggunakan aplikasi telefon pintar.

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ABSTRACT

A Lightning Detection Application (LDA) is a system that consists of electronic components that are extremely sensitive to ambient temperature. Electronic components will not function properly if the temperature is too high. Furthermore, the Lightning Detection System receives high voltage most of the time, so that is why it is easily heated. The conventional cooling system is costly and can cause air pollution that is why it's not impractical to be used in a lightning detection application. Therefore, to overcome this problem a thermo-electric cooling Peltier is introduced because it has a better alternative material. The goal of this project is to develop a microcontroller-based prototype of an automatic cooling system for lightning detection using thermo-electric Peltier modules and to develop a control and monitoring system for temperature and humidity using ThingSpeak IoT that can be controlled and monitored via a smart phone. Other than that, the objective is to analyze the temperature and humidity of the system prototype with a surrounding environment. As expected, the thermo-electric Peltier was used as a refrigerant cooler for the lightning detector cooler box and the temperature inside the cooler box in the module was monitored using a smart phone application.

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DEDICATION

To my beloved parents

To my supervisor, Ts Maslan Bin Zainon

To my lecturers

And not forgetting to all dear friends.

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I would like to thank Allah S.W.T for His blessing because I was able to complete final year project. This project would not possible without considerable guidance and support. I would like to acknowledgement those who have enabled I to complete this project.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

The background of the project, the objectives, the problem statements, and conclusions will be described in this chapter. The structure of this report will be explained and full overview of the project will be given.

1.1 Background

In this modern era, a conventional cooling system which consists of compressor, condenser and a blower are used as cooling equipment to cool an enclosing area. Although the cooling system is good, the gas that was produced during the operations is CFC gas that can cause air pollution. The other disadvantage is the system is too huge to be placed in a small space such as lightning detection system. To solve this problem, a Thermoelectric Peltier module is a material that will be used in the lightning detector cooling system.

In thermoelectric materials, electrical energy can be transformed into thermal energy and from thermal energy it can be converted back to electrical energy. The Seebeck effect and the Peltier effect are two important thermoelectric effects that can enable the direct conversion between electrical and thermal energy. The Seebeck effect indicates the existence of an electric potential across a thermoelectric material subject to a temperature gradient.

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The next one is Peltier effect which is the absorption of heat into one end of a thermoelectric material and the removal of heat from the opposite end because of a current flow across the material. (Benziger B, Anu Nair P & Balakrishnan P,2015)

1.2 Problem Statement

A Lightning Detection Application (LDA) is a system that consists of some electronic components that are extremely sensitive to the ambient temperature. Deterioration to the electronic components of the system are caused by high temperature. Furthermore, the Lightning Detection System is swiftly heats up because the system received a huge voltage. Due to that problem, the system needs a cooling system to preserve the components because of the uncertain weather changes. Besides that, most of the cooling systems available in the market do not have a monitoring system that is capable to check the temperature changes. This automatic cooling system project will be focusing on using thermoelectric Peltier, an Arduino Mega, and ThingSpeak IoT Application which can monitor the temperature.

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1.3 Objectives

The main objectives of this project are:

(a) To develop a microcontroller-based prototype of an automatic cooling system for lightning detection using thermoelectric Peltier modules.

(b) To develop a control and monitoring system for temperature and humidity using ThingSpeak IoT that can be controlled and monitored via a smart phone.

(c) To analyse the temperature and humidity of the system prototype with surrounding environment.

1.4 Project Scope

To achieve the project's objectives, the project scope has been carried out. Basically, the objective of this project is to create a prototype of an automatic cooling system using a thermoelectric Peltier module that can be controlled by an Arduino microcontroller. All hardware has a condition which is to control the temperature changes in the lightning detection system in the box. Then, the temperature change needs to be monitored thus, the ThingSpeak IoT will be used for the purpose of monitoring.

The prototype will be placed in a high-rise industrial building. Besides that, this prototype can show the understudies of the ThingSpeak IoT as a

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simple system to observe the temperature changes within the automatic cooling system box.

1.5 Conclusion

This chapter describe the objectives, project background, problem statements and scope of the project. Other than that, this chapter also discusses the problems that need to be solved and how the project is going to be conducted.

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CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

An Automatic Cooling system using a Thermoelectric Peltier, an Arduino Mega and MIT apps inventor that are used for monitoring and controlling purposes will be reviewed in this chapter. The main sources of the study were taken from articles, case studies, journals and websites. Each source that is relevant to the project scope is taken.

2.1 Thermoelectic Peltier Device

Peltier Module is one of the primary components of cooling systems that will be used in this project. Peltier Module Device contains two side surfaces which is cool side and hot side. The thermoelectric is formed by two dissimilar metals in the closed loop. The needle of the compass will be deflected when different temperature is present at the two metal held.

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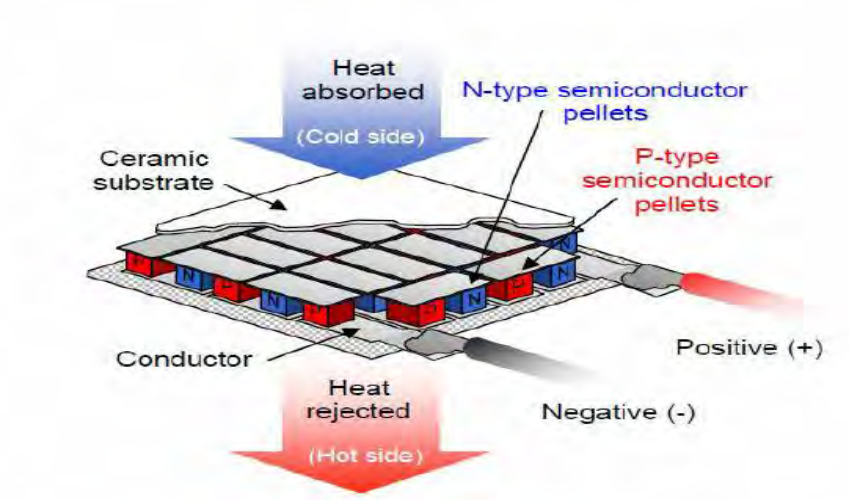

Figure 2.1: The Peltier Device diagram

The electric current will move between two conductors and it will cause a heating and cooling condition which is call thermoelectric cooler. The temperature when the voltage is connected to the free ends of the dissimilar material will be different. Peltier cooling operations is to make heat move from one end to the next end with a completely difference temperature. A numerous of p and n sort semiconductor components that consist of two difference conductors will be included to run of the thermoelectric cooler. The components are bound of two ceramic plates that are divides into electrical and thermal. If it is connected in series, it will be electrically while parallel connection is thermally. At the same time, when the temperature decrease at the cold side, and the heat is increase it will bought to the cooler by the process of electron movements and it discharges on the inverse side with is hot side.

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2.1.1 Basic Principles of Thermoelectric Devices

Thermoelectric module is a device that consists of n-type andp-type semiconductors which have two connections which is series and parallel. These thermoelectric and their electrical are fixed in between of two ceramic substrates. (Allwin Jose1, Alan D'souza2, Sarvesh Dandekar3, Jitesh Karamchandani4, Pavan Kulkarni5, 2015)

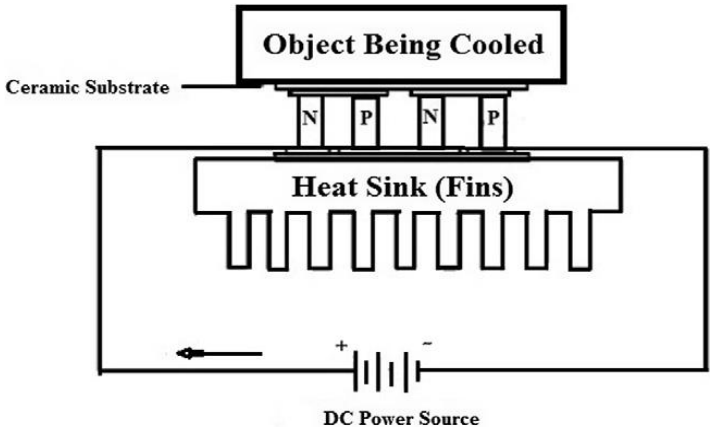

Figure 2.2: Direction of the electron in thermoelectric cooler

This module can transform heat energy to electricity using a principle known as the Seebeck effect. The electrons in the p-type semiconductor and the holes in the n-type semiconductor will shift from the heat source when heat is enforced to one of the thermoelectric generator's surface. The movement of holes and electron are the one that cause the

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production of electricity. The direction of the current is opposite to the flow of the electrons, and in the same direction as the movement of the holes.(Specifications, n.d.)

The positive and negative charge carriers in the pellet array will absorb the heat energy from one substrate surface and discharge it to the substrate at the opposite side when a DC voltage is enforced to the module. The surface where the heat energy is absorbed will become cold. The opposite surface where the heat energy is being removed will turn hot. Applying this simple way to "heat pumping," the thermoelectric technology is enforced to numerous widely-varied applications such as small laser diode coolers, portable refrigerators and liquid coolers.

2.1.2 Parameters of a Thermoelectric Module

I. Cold temperature Tc

II. Heat temperature Th

III. Charge, Qc

IV. Voltage, V. current, I

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2.1.3 Hot Side Temperature

The junction will be cooled when current flow through the thermoelectric cooler right to the top and it will cause some heat generation due to the Joule heating in both of the leg. This Joule heating is the same to the square of the current multiply with the electrical resistance of the leg and it lead to the backflow of heat. Thus, a small electrical resistivity is needed for thermoelectric (TE) materials. In order to lessen the backflow of heat from the hot junction to cold junction, materials with a low thermal conductivity are needed.

2.1.4 Cold Side Temperature

The operation for cold side temperature is the negative charge carriers in the n-type leg will move towards the bottom, or base, and the positive charge holes will move towards the base when the current flows across the legs. This will cause both electrons and holes carry heat away from the top junction to the bottom. The top junction is being cooled due to this. An externally generated temperature gradient is used to move the heat from the top to the bottom junction and this process will results in a voltage drop that is produced between the electrodes at the base.

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2.2 Arduino

Arduino is an open-source platform used for building electronics project. It also one of the most popular physical programmable circuit boards because easy to handle compare to previous programmable circuit. Arduino also consists two part with is physical programmable circuit board and piece of software or IDE (Integrated Development Enviroment) with only run in Pc. The coding that be used in Arduino is C language.

2.2.1 The Arduino Mega Specification

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). Arduino Mega 2560 has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16D analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It consists everything required to support the microcontroller. To begin, simply link it to a computer with a USB cable or power it with a AC-to-DC adapter or battery. The Mega is suitable with some shields designed for the Arduino Duemilanove or Diecimila.

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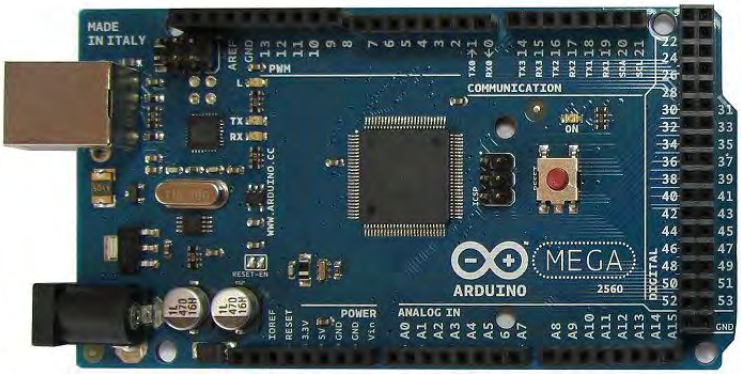

Figure 2.3: The top view of Arduino Mega

2.2.2 Pin Configurations

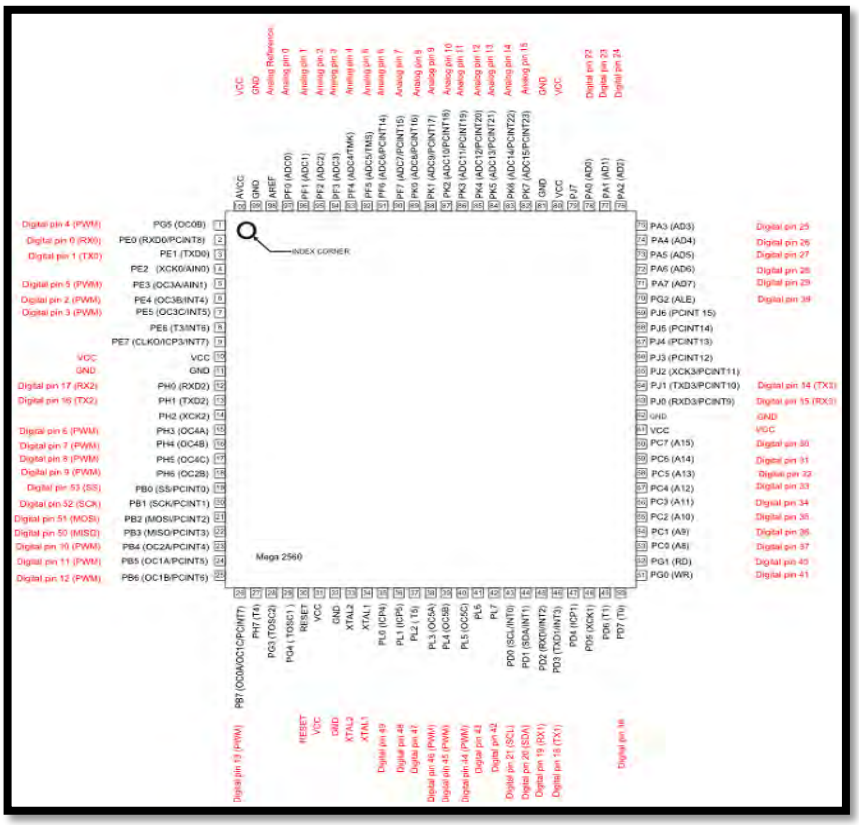

Figure 2.4: Detailed Pin IC in ATMEGA 2560

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