SELF-POWERED VEHICLE BRAKING MONITORING SYSTEM USING THERMOELECTRIC GENERATOR

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"I admit that this report is the result of my own work except summaries and excerpts that each of them I have explained the source."

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Date :

"I / we hereby declare that I have read this in my / our work is sufficient in scope and quality for the award of the Bachelor in Electronic Engineering (Telecommunication Electronic)."

Signature :
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Date :

Dedicated to my beloved family for your love, guidance and supports.

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ABSTRACT

Sometimes the road accident happened is out of control, but most of the time, life of victim in the accident can be saved by sending an immediate alert signal to seek help. Usually, before accident happens, emergency brake is being applied and therefore the heat generated can be recovered and converted into electrical energy by using thermoelectric generator (TEG). However, the challenge of energy conversion using TEG is very low and the output voltage may not sufficient to operate an electronic device for sending the signal. The objective of this project is to provide a solution for this problem. Therefore, the solution which is being proposed in this project is designing a self-powered vehicle braking monitoring system using TEG and power conditioning circuit. The power conditioning circuit used is a DC-DC boost converter. The development of this DC-DC boost converter is using LTC3108 to boost up the voltage generated by TEG from conversion of heat from disc brake. From the experiment result, it shows that the output voltage of TEG which is 5V after DC-DC step up and it is sufficient to power up the RF transmitter without the use of battery. The RF transmitter will send signal to RF receiver to activate an alarm and send an email with GPS location to base station.

ABSTRAK

Kadang-kala kemalangan berlaku tanpa kawalan, tetapi kebanyakan masa. nyawa mangsa boleh diselamatkan dengan menghantar isyarat amaran dengan segera untuk meminta bantuan. Biasanya, sebelum kemalangan berlaku, brek kecemasan telah dipijak dan oleh itu kepanasan dari brek cakera boleh ditukarkan kepada tenaga elektrik dengan menggunakan penjana termoelektrik (TEG). Walau bagaimanapun, cabaran tenaga tukaran dengan menggunakan TEG sangat kecil dan voltan keluaran mungkin tidak mencukupi untuk broperasi satu peranti elektonik yang menghantar isyarat. Objektif projek ini adalah memberikan satu cara penyelesaian untuk masalah ini. Oleh itu, cara penyelesaian telah dicadangkan untuk projek ini dengan merekakan satu kenderaaan sistem pemantauan brek yang berkuasa sendiri dengan menggunakan TEG dan litar penyaman kuasa. Litar penyaman kuasa yang digunakan adalah DC-DC boost converter. Perkembangan DC-DC boost converter itu adalah menggunakan LTC3108 untuk meninggikan voltan keluaran yang dihasilkan oleh TEG dari kepanasan yang dari brek cakera. Keputusan eksperimen menunjukkan voltan keluaran dari TEG iaitu 5V selepas peningkatan DC-DC dan mencukupi untuk menguasakan RF pemancar tanpa menggunakan bateri. RF pemancar itu akan menghantar isyarat kepada RF penerima untuk menghidupkan alarm dan menghantar emel dengan lokasi GPS kepada stesen pangkalan.

TABLE OF CONTENTS

LIST OF TABLES

NO **TITLE** **PAGE**

LIST OF FIGURES

NO TITLE PAGE

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

In this chapter, the details of my project which is Self–Powered Vehicle Braking Monitoring System Using Thermoelectric Generator will be explained. Besides, objectives, problem statement, scope of project, project methodology, project planning and chapter organization also will be explained.

1.1 Project Background

Nowadays, energy harvesting technique has becomes widely use in the energy applications. Energy harvesting is the process which the energy being lost such as light, waste heat or movement is captured from the environment and stored as a useful energy source for applications.

Every vehicle needs engine to operate while the engine needs battery to work. However, sometimes the engine does not work due to the battery destroyed and it causes the delay of sending signal. Thus, alert system is very important to save the life

when accidents occur. This is due to some victims may unconscious for very long time. Battery needs to maintain and change for every two years. Besides, battery is toxic, non- biodegradable and cannot be decomposed. Thus, battery can cause environmental pollution.

TEG is a device that converts heat into electrical energy when there is presence of temperature gradient. Thermoelectric technology is environmentally friendly as it reuse the waste heat to produce electrical energy. There are many benefits of TEG. For instance, small size, high reliability and long lived as compared to conventional electrical power generators. However, TEG provides low efficiency ratings which is about 5% to 10%.

Braking is a process of deceleration of a vehicle and it leads to stop. It is an essential factor that will affect the safety of drivers and passengers while driving. The vehicle accident is a major public problem in many countries. This problem is still increasing due to driver's poor behaviors especially the driver will emergency brake in order to avoid the vehicles or obstacles. This phenomenon leads to accident occurs.

Thus, this project provides a solution for this issue which is designing a self-powered monitoring system that powered-up by TEG to monitor the behavior of the driver for reducing the accident cases. The self-powered monitoring system will be embedded in vehicle’s disc brake in order to convert the heat from the disc brake to electrical power. Whenever the vehicle being applied emergency brake, an accident alert system with IoT will activate the alarm for alerting the people surrounding to help the driver who injures or faints after sudden braked. The IoT system will also send the signal with GPS location via 1sheeld to the target receivers to notify them while the driver sudden brakes. The data will be saved as a record. The target receivers are able to identify the location of the driver and call for help immediately if the driver faces accident.

In conclusion, this project is useful in reducing accident cases and save life. Besides, this project is green technology in the electricity production for using waste heat as the input source. The TEG that being used in this project can replace the battery in terms of environmentally friendly. The reducing in battery usage can save the environment as the battery which is not biodegradable and cannot be decomposed is harmful to environment. The battery that contains chemical which is toxic can cause

harmful to the environment such as soil pollution and water pollution. This will cause hazardous to human health. This project is sustains due to the TEG can function whenever there is a heat provided and save the maintenance fee due to no need replace the battery. Thus, it is long-lived.

1.2 Problem Statement

TEG can be used where it can self-powered at the moment of emergency brake. TEG will detect the heat and the heat generated can power-up the device and send signal via IoT system. However, TEG may not sufficient to generate useful energy to power up complex system, so power conditioning circuit for TEG is needed to design to boost up the voltage. Therefore, a solution is provided which is by using TEG to power-up the small electronic components and send signal in a small range when there is a heat. TEG will not function when there is no heat.

1.3 Objectives

The three main objectives of this project are as the following:

1. To characterize the heat that generated by braking system and output voltage derive from TEG.
2. To design a power conditioning circuit to boost up electrical energy from TEG.
3. To test the performance of the alert system with IoT for the application of braking monitoring system.

1.4 Scope of Project

This project will focus primarily on the TEG on disc brake of motorcycle which only function when there is a sudden break but not work for all the time. Off-the-Shelf TEGs are used as thermal harvester. The functionality of this project only covered the TEG on the disc brake which generates the power by the heat from the disc brake and activate the alert system with sending email including GPS location to the receiver. Bicycle brake is used for clamping the disc brake instead of hydraulic pipe as long as the braking can generate heat. Three TEGs and a heat sink will be used in this project.

The power generated is around 0.01W to 0.04W. This project only apply in the model in lab and does not embedded in real vehicle. Braking system is not being study in the scope. Other aspects exclude from the scope will not be covered in this project.

1.5 Chapter Organization

This thesis consists of five chapters which are introduction, literature review, methodology, results and discussion and the last chapter is conclusion and recommendation. Each chapter will describe briefly about the details of this project.

Chapter 1 is the introduction of the project which includes explanation of project background, problem statement of project, objectives of project, scope of project and chapter organization.

Chapter 2 is the literature review of the project which will explain the knowledge including the theoretical background that related to the topic of this project from the studies and findings in journals. The main topic is about the thermoelectric generator (TEG). Moreover, comparison of the findings which is the output voltage of DC-DC boost converter will be analyzed in a table.

Chapter 3 will describe the methodology of the project. The process of designing the self-powered vehicle braking monitoring system will be explained step by step with flow charts and its concept will be explained based on a block diagram. In this chapter, the experiment setup and circuit testing will be explained too.

Chapter 4 will discuss about the results and discussion of the project. The output voltage and power of TEG will be analyzed in graphs and compared. The simulation and fabrication results of power conditioning circuit will be analyzed in this chapter. The results include the IoT system for application of the project will also be discussed.

Chapter 5 is the conclusion and recommendation of the project. The achievement of the project will be concluded in this chapter. The recommendation for further research and development for the improvement of this project in the future will be explained in recommendation part.

CHAPTER II

LITERATURE REVIEW

In this chapter, the theoretical background about the review of self-powered, vehicle braking system, monitoring system and thermoelectric generator (TEG) from the studies and findings in journals will be explained. Besides, the critical reviews including comparison of the findings which are the output voltage, current and power with different temperature gradient from the journals will be also discussed.

2.1 Review of Energy Harvesting

There are various kinds of renewable energy such as wind energy, solar energy, heat energy and geothermal energy [1]. Energy harvesting has become more and more famous in many applications. It includes the conversion of energy from external sources like heat, wind and solar into useful energy source. The technologies that utilize the heat, wind and solar energy are famous for the used in industries by using TEG, wind turbines and solar power [2]. The device which powered-up by using

energy harvesting technology can be categorized as self-powered. Self-powered can be as a description about the machine which does not require an external source to work as it has its own energy source.

2.2 Thermoelectric Technology

Thermoelectric technology is categorized as an alternative and environmentally friendly technology in energy harvesting field by recovering waste heat into electrical energy by using thermoelectric generator (TEG) [3].

Thermoelectric technology is used for electricity generation. Thermoelectric power generators convert the thermal energy into the electrical energy. Thermoelectric is known as the science technology that involved electricity generation and cooling effect by using thermoelectric method. Thermoelectric technology uses the Seebeck effect and Peltier effect [4]. According to Seebeck effect and Peltier effect, thermocouples can be acted as heaters and coolers as well as TEG.

2.2.1 Seebeck Effect

Thomas Johann Seebeck discovered a thermal gradient was formed between two dissimilar conductors can produce voltage in 1821. Thermoelectric effect is a temperature gradient in a conducting material which produces heat flow and causes the diffusion of charge carriers. The flow of charge carriers to the low temperature region produces a voltage difference [5].

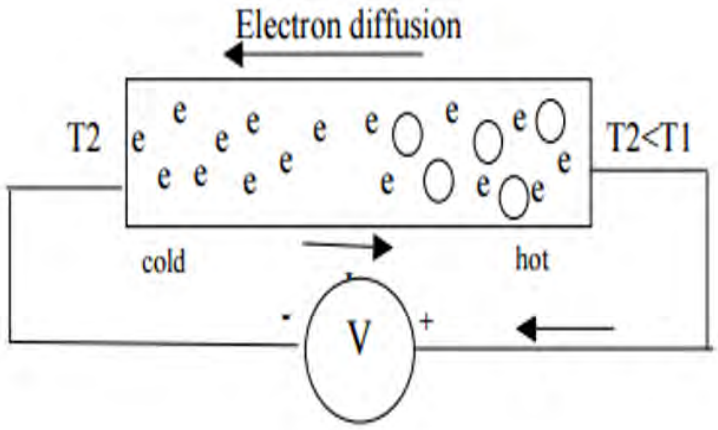

Figure 2.1: Electrons diffuse from hot to cold side of semiconductor leaving holes on cold side [5]

From Figure 2.1, while both ends of the conductor are held at different temperatures, the electrons at hot junction at higher thermal velocities diffuse to the cold junction. Seebeck realized that EMF was produced between both ends of the conductor by making one end of a metal bar colder or hotter than the other one. He conducted the experiment for testing. If there is a temperature difference between two electrically connected junctions which a junction is hot while the other junction is cold, a compass needle will be deflected by a wire which connected the two junctions. According to Lenz's Law, it showed that there is a changing emf V in a magnetic field in the circuit caused by the electron diffusion current. The magnitude of the emf V produced between both junctions depends on the material and on the temperature gradient, ΔT with Seebeck coefficient for the material [6]. The equation for Seebeck effect is as shown in the following [17]:

$$V \propto \Delta T \quad \text{---------- (2.1)}$$

2.2.2 Peltier Effect

Jean Charles Athanase Peltier discovered that electric current through the two dissimilar conductors' junction could act as a heater or coolant of the junction in 1834. The condition of heater and coolant are depend on the flow of current's direction. The heat is directly proportional to the current. The proportionality constant is defined as Peltier coefficient. Ideal thermoelectric material has high Seebeck coefficient and high electrical conductivity but low thermal conductivity. In order to maintain a high

thermal gradient at the junction, low thermal conductivity is required [7]. Generally, Peltier effect devices are used as coolers for microelectronic devices.

2.3 Thermoelectric Generator

Thermoelectric generator (TEG) is a device to convert the temperature differential from thermosyphon and the cooling system into electricity. This concept based on Seebeck effect which consists of a current loop being created by two metals joined in two places with a temperature differential between the junctions. The current loop is for providing electrical power [8].

A TEG is composed by an array of some thermocouples electrically which connecting in series and thermally in parallel. The TEG's performance is affected by temperature distribution of materials and thermal gradient which can be recovered between the hot and cold junctions of the thermocouples. The conversion efficiency and the output voltage of the TEG are limited by the reduced thermal gradient existing between body heat and environment [9].

TEG consists of various of thermoelectric elements that are connected electrically in series and thermally in parallel. The TEGs connected in series is to increase the generated voltage. The TEGs connected in parallel is to increase the thermal conductivity [16].

2.3.1 Structure of TEG

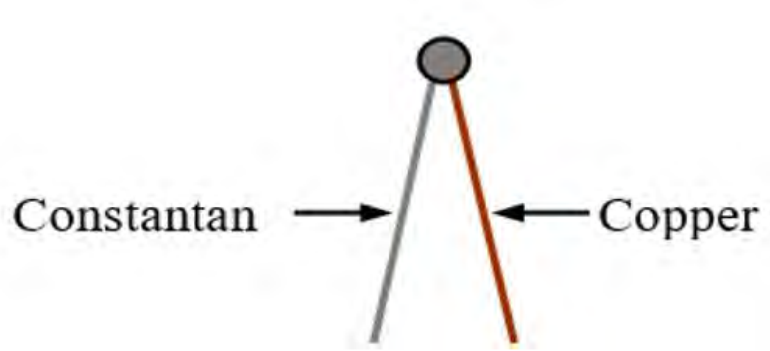

Figure 2.2: A T-type thermocouple [4]

TEG is a semiconductor device that creates a connection between thermocouple and TEG. Thermocouples are made up of two dissimilar metals. For example, T-type thermocouple is made up of copper and constantan as shown in Figure 2.2. When the thermocouple's junction is kept in the cold or heat condition, it produces a small voltage 40 μV/°C per one degree temperature change based on Seebeck effect [4].

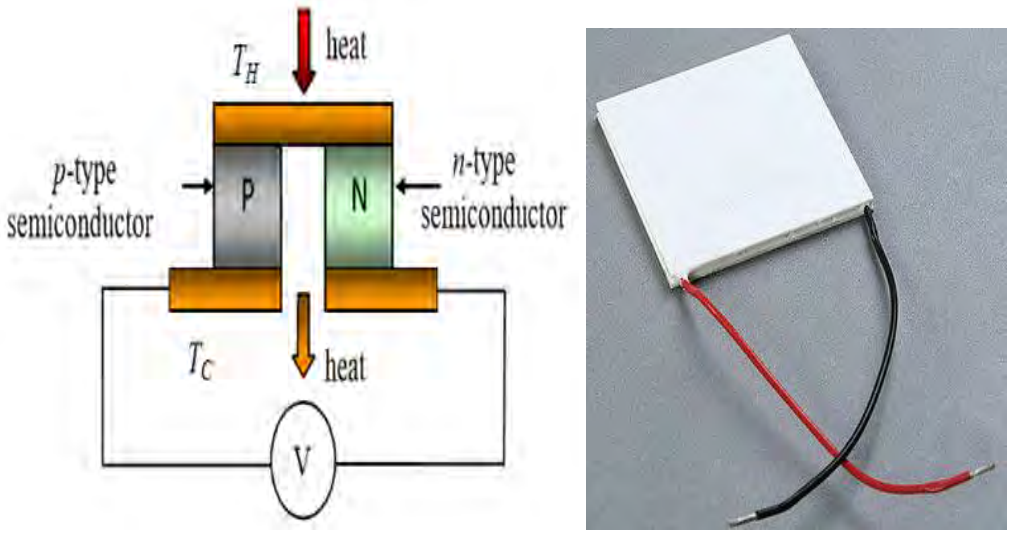

Figure 2.3: The structure of thermocouple and photograph of TEG [4]

From Figure 2.3 the thermoelement is forms with an end of p–type and n–type semiconductors. The photograph of TEG shows that it has two polarities. When there is a temperature gradient occurs between two surfaces, a voltage will be produced between the open ends. The voltage value is effected by temperature gradient and Seebeck constant. The equation of voltage value is

$$V = \alpha (TH - TC) \quad \text{---------- (2.2)}$$

where V is voltage of thermoelement, TH is hot side temperature, TC is cold side temperature and α is Seebeck coefficient [4].