SELF-SUFFICIENT ENERGY RECYCLING OF LAPTOP USING THERMOELECTRIC GENERATOR MODULE FOR ITS COOLING APPLICATION

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A very special dedication for my beloved family especially to my parent,

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ABSTRACT

In the past decade, there has been significant development in green technology which using energy harvesting system to power on electronic devices instead of using batteries. In this paper, the concept of using thermoelectric generator (TEGs) for converting the waste heat energy exerted from laptop into electrical energy is presented. The main focus of this project is to build an autonomous cooling system for laptop using TEGs whereas the speed of the cooling fan can be controlled by a microcontroller based on the temperature detected by temperature sensor. In addition, the microcontroller is powered on by the energy harvested from TEGs. The system with two voltage booster and supercapacitor has been designed for the supply of microcontroller. This work considers the laptop waste heat as the heat source, 4 thermoelectric generator (TEGs) attach with heat sink is placed under the laptop to generate electrical energy over time. The TEGs was tested with a laptop, it is able to produce 110mV by having 3ºC temperature differences. The primary booster manages to boost up the harvested energy to usable voltage level which is 3.3V and store it into a supercapacitor. The secondary voltage booster is able to boost up the voltage from 3.3V to 5V which is required to turn on microcontroller. The microcontroller can operate for about 30 seconds to control the cooling system if the capacitor is fully charged. Primary voltage booster will charge the supercapacitor overtime and roughly require 20 hours to charge the supercapacitor to 3.3V.

ABSTRAK

Dalam dekad yang lalu, teknologi hijau terus berkembang dan ia menggunakan sistem penuaian tenaga untuk bekalan elektrik peranti elektronik daripada menggunakan bateri. Konsep menggunakan penjana termoelektrik (TEGs) untuk menukarkan tenaga haba yang dikeluarkan dari komputer riba kepada tenaga elektrik dibentangkan. Fokus utama projek ini adalah untuk membina sistem penyejukan autonomi untuk komputer riba menggunakan TEGs manakala kelajuan kipas penyejuk boleh dikawal oleh mikropengawal berdasarkan suhu yang dikesan oleh sensor suhu. Di samping itu, pengawal mikro dihidupkan oleh tenaga dituai dari TEGs. Sistem dengan penggalak dua voltan dan Superkapasitor telah direka untuk bekalan mikropengawal. Haba yang dikeluarkan dari laptop sebagai sumber haba, 4 penjana termoelektrik (TEGs) bersama dengan sink haba diletakkan di bawah laptop untuk menjana tenaga elektrik dari masa ke masa. The TEGs telah diuji dengan komputer riba, ia mampu menghasilkan 110mV dengan mempunyai 3ºC perbezaan suhu. Booster voltan yang pertama berjaya merangsang tenaga yang dituai ke tahap voltan yang boleh digunakan iaitu 3.3V dan menyimpannya ke dalam Superkapasitor. Booster voltan yang kedua mampu merangsang voltan dari 3.3V ke 5V yang diperlukan untuk menghidupkan mikropengawal. Mikropengawal mampu beroperasi selama 30 saat untuk mengawal sistem penyejukan sekiranya kapasitor dicas sepenuhnya. Booster voltan yang pertama akan caj superkapasitor ke 3.3V dan ia memerlukan lebih kurang 20 jam.

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TEG	-	Thermoelectric Generator
EMF	-	Electromotive Force
DC	-	Direct Current
CMOS	-	Complementary Metal Oxide Semiconductor
SCR	-	Silicon Controlled Rectifier

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

This chapter will discuss all the overview about the energy harvesting using thermoelectric generator module of laptop for cooling application. It embraces of project background, the problem of the project, the objectives and the scope of project.

1.1 Project Background

In this technology era, almost everything is automated and everywhere is full with machine and electronic devices. Those machine and electronic devices expend a lot of energy to operate considering the amount and the operation duration. Therefore, green technologies take place and grow rapidly these years instead of fully depend on the energy generation from fossil fuel.

Thermoelectric power generator has emerged as a promising alternative green technology due to their distinct advantages. Thermoelectric power generation offer a potential application in the direct conversion of waste-heat energy into electrical power. The application of this alternative green technology in converting waste heat energy directly into electrical power can improved the overall efficiencies of energy conversion systems.

Since majority of the thermal energy produced by machine and electronic devices are dissipated as waste heat to the environment. This waste heat can be utilized further for power generation. By using thermoelectric generator, the technology for recycling of waste heat energy is implemented. The waste heat at the exhaust can be recycled and converted from heat energy into electrical energy.

In this project, Thermoelectric Power Generator (TEG) is implemented and captures the waste heat from the laptop. It will generate a small electrical voltage and increase with the temperature gradient. The output of TEG is normally low as millivolt, so a DC-DC converter will be used to step up the voltage to power up the microcontroller with sensor.

After the entire system completed, the system will be implemented at the laptop. The system will placed under the laptop that near to the exhaust and the energy will be generated based on the temperature gradient across the TEG. The energy harvested will be used to power up the microcontroller with temperature sensor. The temperature sensor will detect the temperature changes which indicate the laptop temperature. If the temperature goes beyond a certain point, the microcontroller will send signal to increase the speed of the fan and vice versa.

1.2 Problem Statement

In recent years, the environmental issues of emissions greenhouse gases and depletion of fossil energy source are increasing. In particular global warming and limitations of energy resources, the thermoelectric power generators have emerged as alternative green technology.

By using thermoelectric power generator, the waste heat energy can be directly converted into electrical power for any possible output device or system. Thermoelectric generator actually will generate different output voltage based on the temperature difference between both sides. But the output voltage generated from TEG is relatively small, therefore a ultra-low power voltage booster is required to boost up the voltage from TEG to usable voltage level and thus power on the microcontroller in this case.

Besides, nowadays electronic devices are all around us. When electronic devices are operating, it eventually will produce heat when the electrical energy flows through wires with resistance. The electronic devices will get hot over time and the performance of the devices might drop. Therefore, installing a cooling system is a way to control the electronic device in its particular optimum temperature. With electronic devices operate in its optimum temperature, this ensures that electronic devices are always in its best condition and also prevent any overheat problem that might cause the electronic devices breakdown.

1.3 Objectives

The objectives of the project are:

1. To analyze the relationship between temperature gradient and output voltage generated from thermoelectric generator module.
2. To modify and use DC-DC converter to boost up small voltage (110mV) to a desired output voltage (5V) for powering microcontroller.
3. To design and develop a cooling application using thermoelectric generator module.

1.4 Project Scopes

To achieve the project objectives, a boosting circuit that using LTC 3108 IC chip, 0.9V-5V booster and super capacitor will be used for powering a microcontroller to control the cooling application. The voltage will be step up after go through primary and secondary boosting circuit. The boosted voltage (3.3V) will be stored inside super capacitor and secondary booster will boost to 5V to turn on microcontroller for controlling cooling application purposes.

1.5 Thesis Organization

This report consists of 5 chapters that describe the flow of this research in structure. First chapter will present about the background of the project, problem statement, objectives and the scope of the project.

Second chapter will discuss the literature review that comparing the idea and method of other researcher used to do the energy harvesting using TEG.

Third chapter is the research methodology which will introduce the method of conducting the analysis of this research in details.

Fourth chapter will reveal the result that obtained from the analysis and the discussion made through the output that obtained from the analysis made.

Last chapter will conclude all the overall progress from the beginning until the end of the project.

CHAPTER II

LITERATURE REVIEW

This chapter will review the concept, idea and synthesis obtained from the reference for project purpose. The details of energy harvesting using Thermoelectric Generator (TEG) will be further discussed.

2.1 Seebeck Effect

The Seebeck effect is discovered by Baltic German physicist, Thomas Johann Seeback. In 1981, Thomas Johann Seebeck found that a circuit with two dissimilar metals with different temperature junctions would deflect a compass magnet. The electron energy levels in each metal shifted differently and there is a voltage difference between the junctions and thus created an electrical current and magnetic field around the wires.

The Seebeck effect is the production of EMF, electromotive force. With junctions of two different conductors, the current and voltage can be produced and measured. Two junctions connected back to back are held at two different temperatures T_H and T_C and an EMF appears between their free contacts. The principle behind it obeys the equation below:

$$V = (T_H - T_C) \quad (2.1)$$

Where V is the voltage difference between two dissimilar metals, S is Seebeck coefficient, $T_H - T_C$ is the temperature difference between hot and cold junction.

Seebeck coefficient or thermoelectric sensitivity is affected by the change in material of metal, the EMF will be difference although the temperature difference is the same. Normally, Seebeck coefficient is usually a nonlinear function of temperature.

The concept of Seebeck effects is shown in Figure 2.1. The electrons at hot side have high momentum compared to cold side. Electrons tend to go where the energy is lower so therefore it will move from the hot side to the cold side which leads to transporting energy. This movement actually led to generation of electrical potential and the electrical potential is direct current (DC). If there is higher temperature difference, the electron will move faster and thus a higher electrical potential is produced.

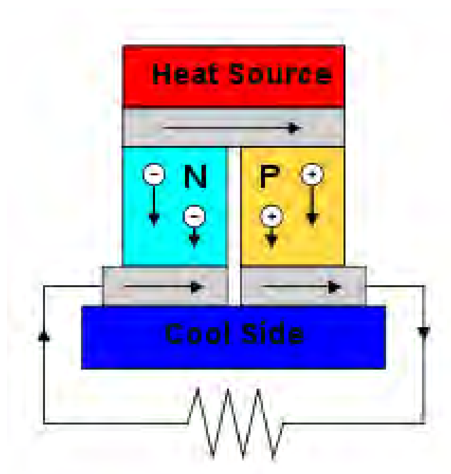

Figure 2.1: Thermoelectric circuit composed of p-doped and n-doped semiconductor with Seebeck effect

Seebeck effect is normally used in thermocouples to measure the temperature differences or to actuate the electronic switches that can turn the system on or off. Besides, thermoelectric generators (TEG) also apply the concept of Seebeck effect and act as a heat engine. In automobiles field, thermoelectric generators is used to increase fuel efficiency.

2.2 Peltier Effect

In 1834, French physicist Jean Charles Athanase Peltier discovered the Peltier effects. The Peltier effect creates temperature difference by applying a voltage between two electrodes connected to semiconductor material. The junction of dissimilar metals were heated or cooled, it is depending on the direction in which electrical current passed through them. Heat is generated by current flowing in one direction and heat is absorbed if the current is reversed.

The Peltier effect is defined by:

$$Q = (\Pi_A - \Pi_B) I \qquad (2.2)$$

Where Q is the heat absorption or generated per unit time, Π_A is the Peltier coefficient of conductor A, Π_B is the Peltier coefficient of conductor B and I represent the electric current.

Figure 2.2 shows the thermoelectric circuit composed of p-doped and n-doped semiconductor with Peltier effect. Peltier effect is the temperature difference generated by EMF and it is opposite of the Seebeck effect. It is the electric-current-driven transfer of heat from one material to another. One of the junctions will be cooled and the other junction will be heated as the electric current is maintained in a circuit of material consisting of two dissimilar conductors. A voltage is applied across joined conductors to create an electric current. When the current flows through the junctions of the two conductors, heat is removed at one junction and cooling occurs. The effect will be stronger if the circuit containing dissimilar semiconductors.