UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF ALTERNATIVE POWER SUPPLY TO CHARGE SMALL GADGETS

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

by

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I hereby, declare this report entitled "Development of Alternative Power Supply to Charge Small Gadgets" is the results of my own research except as cited in references.

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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:

Signature	:	…………………………………….
Supervisor's Name	:	SITI HALMA BINTI JOHARI
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ABSTRACT

The purpose of this project is to develop a portable thermoelectric power generator that using heat as a main source. The aimed group of this project is a hiker, climber, camper and any sorts them that need a portable power generator that can charge their small electronic gadgets while them doing their activity. The generation of electricity is based on the Seebeck Effect of Thermoelectric Generator (TEG) module. TEG module was used to generate electrical energy that operates until a maximum temperature of 230 ºC. The developed power generator is consisting of 1 TEG module, heatsink, boost converter and several important materials. The hot side of the TEG module was mounted on an opposite of the heat source. While the heatsink is installed on the cold side of the module with a cooling fans to provide a forced air cooling. To test the electrical generation of this project, candle is used as a heat source. Meanwhile, a multimeter is used to measure the current and output voltage of this device.

ABSTRAK

Tujuan projek ini adalah untuk membangunkan satu penjana kuasa termoelektrik mudah alih yang menggunakan haba sebagai sumber utama. Kumpulan sasaran bagi projek ini adalah pejalan kaki, pendaki, orang yang berkhemah dan lain-lain lagi yang memerlukan penjana kuasa mudah alih yang boleh mengecas alat elektronik kecil mereka sementara mereka melakukan aktiviti mereka. Penjanaan elektrik adalah berpandukan kepada Kesan Seebeck daripada modul termoelektrik Generator (TEG). Modul TEG digunakan untuk menjana tenaga elektrik yang beroperasi sehingga suhu maksimum 230 ° C. Penjanaan kuasa ini terdiri daripada 1 TEG modul, heatsink, boost converter dan beberapa alatan lain lagi. Sisi panas modul TEG ini dipasang bertentangan dengan sumber haba. Manakala heatsink pula dipasang di bahagian sejuk modul ini dengan kipas penyejukan untuk menyediakan penyejukan udara. Untuk menguji penjanaan elektrik eksperimen ini, lilin digunakan sebagai sumber haba. Manakala multimeter pula digunakan untuk mengukur arus dan voltan yang dijana pada bahagian keluaran alat ini.

DEDICATION

I would like to dedicate this thesis to my beloved mother, Fatimah Bt Abu Bakar and my family members. There is no doubt in my mind that without their continued support and encouragement I could not have completed this thesis.

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First praise is to Allah, the Almighty, The Most Gracious and The Most Merciful the one Whom always guiding us in our everyday life. I would like to express my appreciation to all whose guide me and provided me with possibility to complete my Projek Sarjana Muda. A special gratitude to my Project Supervisor Siti Halma Binti Johari, whose contribute in giving a guidance, suggestion and encouragement, helped me to align my project and writing the report. Furthermore I would also like to acknowledge and appreciate the staff and lab technician at Fakulti Teknologi Kejuruteraan for the cooperation given and knowledge sharing. It has helped me a lot in developing my project. Last but not least, many thanks also go to my fellow friends in BETE class and others who involved directly and indirectly in completing this project.

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TEG	-	Thermoelectric Generator
V_S	-	Source Voltage
V_O	-	Output Voltage
V_L	-	Inductor Voltage
I_L	-	Inductor Current
D	-	Duty cycle

CHAPTER 1

Introduction

This chapter will provide an overview about this project. It is divided into multiple sub-sections which is project background, problem statement, project objectives and scope.

1.2 Project Background

In present times, small electronic gadgets such as smartphone, camera, GPS device and others has become a norm nowadays. But one of the limitations of these gadgets is a power reserve. The battery of these gadgets can't stand for a long time when it was used extensively. Example like, smartphone nowadays can only stand an averagely for one day and a half before it dies. So, this has become a major problem for a people that always went for a camping trip, hiking or backpacking because usually these people went for places that didn't have an on-grid power supply to charging back their gadgets.

So, this is where this device can play an important part because this device is using a heat energy generated by fire as source and converting it into electricity. With this, it can be an alternative power supply while the main power source can't be reached. For this function, the voltage and current range of this device will suitable to be used by major small electronic gadgets nowadays.

1.2 Problem Statement

This project will be implemented to overcome several problems that arising which is:

- Needs of an alternative power source to charge small electronic gadgets while went for a camping trip, hiking or backpacking for a several days.
- Problem of needs of an off grid power source to charge an important electronic gadgets like smartphone and etc. when a disaster happen. Example like flood, earthquake and others.
- Need of a power supply when the main power source fails.

1.3 Project Objectives

The objective of this project is:

- To study whether heat energy can be a reliable power source.
- To develop an alternative power supply when the main power source can't be reach or fails.
- To analyze the electricity generated by thermal energy.

1.4 Scope

The work scope of the project is that this project will be based on how to transform heat energy into an electrical power. This project will analyze whether this heat energy can be reliable and will it usable for a long time. This project also will analyses what is the voltage and current range that is suitable to be used to charge a small electronic gadgets. This project will be implemented only for gadgets that use DC voltage.

CHAPTER 2

Literature Review

2.1 Introduction

This chapter will provide an overview of what research that has been done in completing this project. In completing this project, there are several research that has been done to collect a suffice data that needed to develop this small power generator. The content of the research consist of thermoelectricity, Peltier and Seebeck effect and other important materials needed.

2.2 Thermoelectric

Thermal energy is a product of other form of energy such as electrical energy, mechanical energy and chemical energy. The process that transforms electrical energy into thermal energy is called joule heating. This is the process which causes the wires to heat up when current pass through them. This is the basis of toasters, electric stoves and other appliances that uses the same concept. While thermoelectric effect is the conversion of temperature differences to an electric voltage. Figure 2.1 shows a thermoelectric power generation concept. A thermoelectric module will generate a voltage when there is a temperature difference on each side.

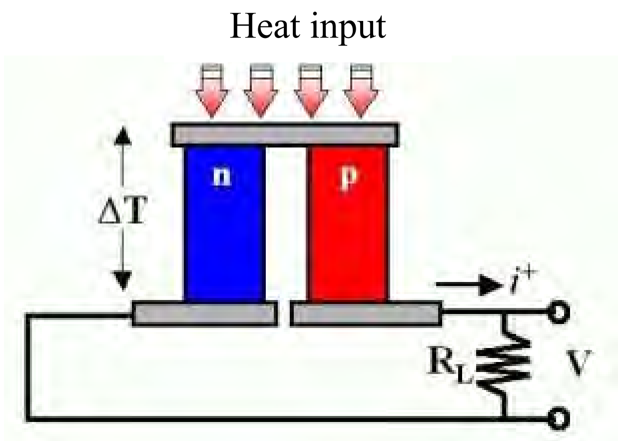

Figure 2. 1 : Thermoelectric Power Generation Concept

Thermoelectricity can be used for electric power generation (Seebeck effect) or for heating/cooling applications (Peltier effect). Electric power generation has not only been very successful for specialized applications such as satellites, but also to generate electricity at remote places using gas heaters and to make use of wasted-heat sources at low temperature. Cooling applications have only succeeded in low power applications such as camping coolers and small (hotel) refrigerators. For higher thermal power other cooling technologies overcome thermoelectricity by attaining better performance and lower prices.

2.3 Peltier Effect

Peltier effect is the existence of cooling or heating at a junction of two different conductors. This effect is named after French physicist Jean Charles Athanase Peltier who discovered this effect in 1834(Effects, 2003). Peltier Effect is the reverse of Seebeck Effect. This term is used to develop a cooler for microelectronic devices like microcontrollers and computer CPU. Although Peltier cooler is not very efficient as some other types of cooler, they are accurate, easy to control and easy to adjust.

2.4 Seebeck Effect

Seebeck Effect is first discovered by German Physicist Thomas Johann Seebeck in 1821. In his observation, Seebeck reported for the first time on his observation that a magnetic compass needle is deflected when the junctions in a closed loop of two dissimilar metals or semiconductors are at different temperatures, at a session of the Berlin Academy of Sciences on December 14, 1820(Velmre, 2007). This due to a metal responded to temperature difference in a different ways thus creating current loop and magnetic field. He called it "*Thermomagnetism*". Danish Physicist, Hans Christian Ørsted detects the mistake and change the term to "*Thermoelectricity*" due to electrical current involved. The temperature difference produces a voltage that can drive an electric current in a closed circuit afterward.

Figure 2.2 shows a thermoelectric that is composed of materials of different Seebeck coefficient (p-doped and n-doped semiconductors), configured as a thermoelectric generator. If the load resistor at the bottom is replaced with a Voltmeter, the circuit then functions as a temperature-sensing thermocouple.

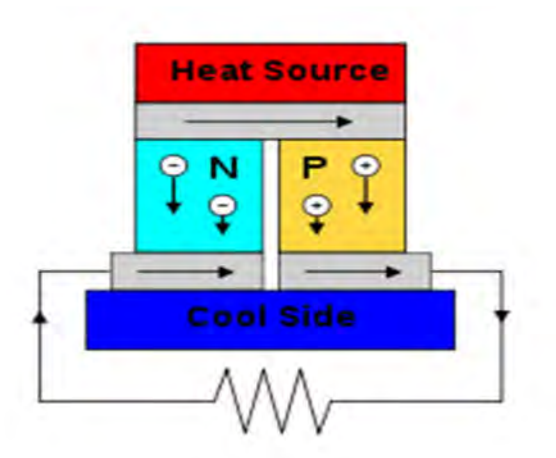

Figure 2. 2 : Seebeck Effect Concept

The voltage produced is proportional with temperature difference between the junctions. This is proved by the equation 2.1 below.

$$V = \alpha\,(Th - Tc) \qquad (2.\,1)$$

V = Voltage difference

a = Seebeck coefficient

Th = Temperature at hot junction

Tc = Temperature at cold junction

Seebeck Coefficient:

$$V = \alpha\,(Th - Tc) \qquad (2.\,2)$$

$$\text{Seebeck Coefficient} = \frac{\text{Electrical potential difference}}{\text{Temperature difference}}$$

Table 2.1 shows the Seebeck coefficients for some metal and alloys. Based on the table, each metal has different Seebeck coefficients. While table 2.2 shows the Seebeck coefficients for standard thermocouple.

Table 2. 1: Seebeck coefficients for some metal and alloys, compared to platinum(Lasance, 2006)

Metals	**Seebeck Coefficient (µV / K)**
Antimony	47
Nichrome	25
Molybdenum	10
Cadmium	7.5
Tungsten	7.5
Gold	6.5
Silver	6.5
Copper	6.5
Rhodium	6.0
Tantalum	4.5
Lead	4.0
Aluminum	3.5
Carbon	3.0
Mercury	0.6
Platinum	0
Sodium	-2.0
Potassium	-9.0
Nickel	-15
Constantin	-35
Bismuth	-72

Table 2. 2: Seebeck Coefficients for Standard Thermocouple(Lasance, 2006)

Type	**Couples**	**Seebeck Coefficient (µV / K)**
E	Chromel-Constantan	60
J	Iron-Constantan	51
T	Copper-Constantan	40
K	Chromel-Alumel	40
N	Nicrosil-Nisil	38
S	Pt (10% Rh)-Pt	11
B	Pt (30% Rh-Pt (6% Rh)	8
R	Pt (13% Rh)-Pt	12

Table 2. 3: Seebeck coefficients for some semiconductors(Lasance, 2006)

Semiconductors	**Seebeck Coefficient (μV / K)**
Se	900
Te	500
Si	440
Ge	300
n-type Bi_2Te_3	-230
p-type $Bi_{2-x}Sb_xTe_3$	300
p-type Sb_2Te_3	185
PbTe	-180
$Pb_{03}Ge_{39}Se_{58}$	1670
$Pb_{06}Ge_{36}Se_{58}$	1410
$Pb_{09}Ge_{33}Se_{58}$	-1360
$Pb_{13}Ge_{29}Se_{58}$	-1710
$Pb_{15}Ge_{37}Se_{58}$	-1990
$SnSb_4Te_7$	25
$SnBi_4Te_7$	120
$SnBi_3Sb_1Te_7$	151
$SnBi_{2.5}Sb_{1.5}Te_7$	110
$SnBi_2Sb_2Te_7$	90
$PbBi_4Te_7$	-53

2.5 Thermoelectric Generator (TEG) Module

Solid state thermoelectric generators (TEGs) are devices that can convert thermal gradients to electrical power through the Seebeck effect(Annapragada, Salamon, Kolodner, Hodes, & Garimella, 2012). These devices are reliable, low noise and low cost, but suffer from low conversion efficiencies (Min & Rowe, 2002). Thermal energy is an energy that is wasted in the form of heat for a vast variety of everyday situations ranging from exhaust pipes in cars, to heat generated on a microprocessor to even heat generated by the human body. Any device that can transform that heat into electrical power could potentially be very useful, provided that the obtained power is sufficient for practical applications. But some changes need to be made to improve the output power of any thermoelectric generator. Figure 2.4 shows a real TEG module which has two sides, cool side and a hot side.

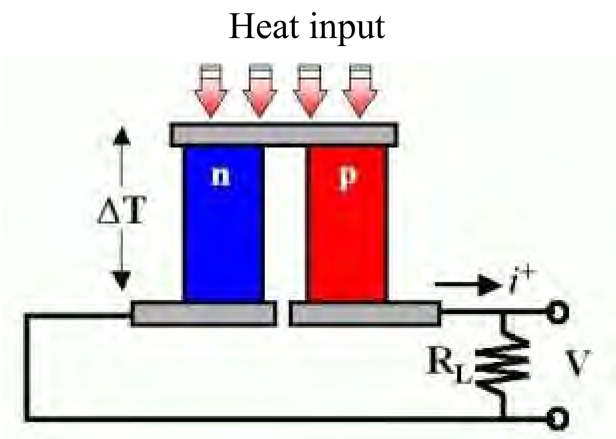

Figure 2. 3 : Thermoelectric Power Generation Concept

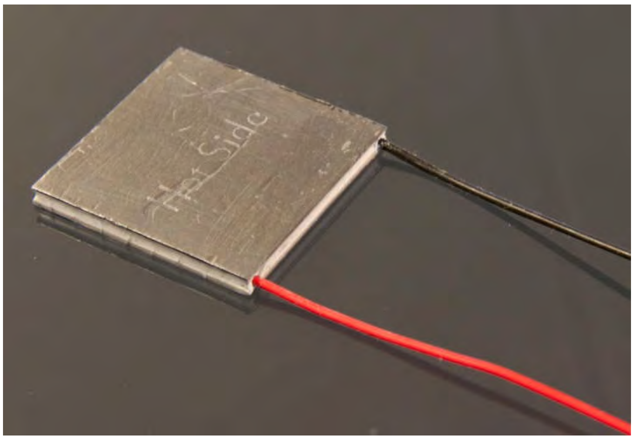

Figure 2. 4 : Thermoelectric Generator Module

Figure 2.5 shows a construction of TEG module. this TEG module consist of n-type semiconductor and p-type semiconductor. Other than semiconductor, TEG module also consist of metal conductors and ceramic insulator. Nowadays, TEG module are made from a highly doped semiconductors consisting of Bismuth Telluride(Bi_2Te_3), Lead Telluride(PbTe), Calcium Manganese Oxide(CMO) or a combination of all those. These depends on the temperature.

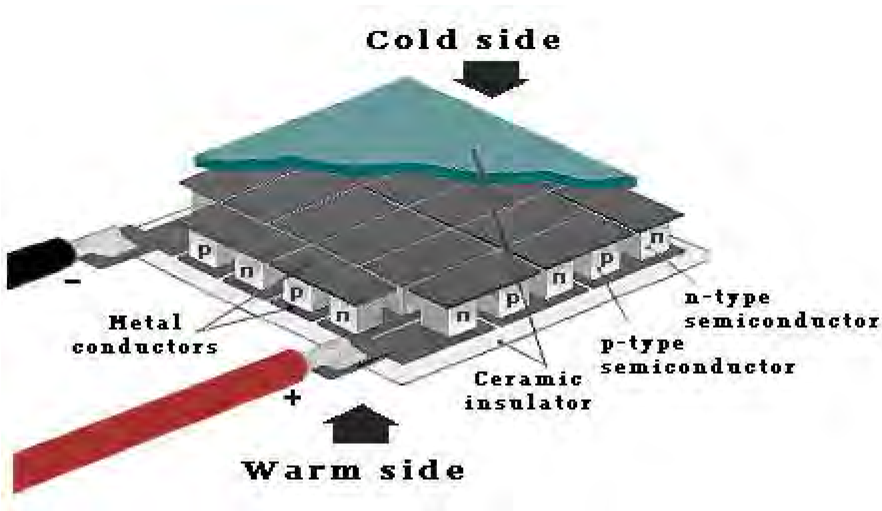

Figure 2. 5 : TEG Construction