THERMOELECTRIC GENERATOR TO POWER AND CHARGE MOBILE DEVICES

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DECLARATION

I declare that this thesis entitled "THERMOELECTRIC GENERATOR TO POWER AND CHARGE MOBILE DEVICES" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any degree.

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APPROVAL

I hereby declare that I have checked this report entitled "THERMOELECRTRIC GENERATOR TO POWER AND CHARGE MOBILE DEVICES" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours.

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DEDICATIONS

To my always encouraging, ever faithful parents, Zaimah Binti Rahim And Emran Bin Ismail.

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ABSTRACT

Energy change utilizing waste heat recuperating abilities, explicitly thermoelectric generator (TEG) innovations has progressed during ongoing years. It is used in the elective energy industry which is sought after from many aspects. Prior research shows that TEG as a waste heat collecting technique is reachable. The primary goal of this research is to design the thermoelectric generator which utilizes elective sources of energy that can be utilized to harness and keep electricity. The produced electrical power will be utilized in various applications, for example, to power and energize the cell phones. This is reachable with the utilization of Seebeck effect. Thermoelectric generators (TEGs) are semiconductor-based devices that harvest heat to supply electricity. The fundamental model of this investigation (prototype) as a thermoelectric generator will comprise of aluminum sheet, DC-DC buck converter and thermoelectric cooler (TEC1-12706) that will be utilized as a generator. The cold and hot sides of the thermoelectric cooler device will give the temperature difference which is utilized to deliver electricity. This report additionally talks about the standards of the thermoelectric effect.

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LIST OF SYMBOLS AND ABBREVIATIONS

TEGs	Thermoelectric generator
TEM	Thermoelectric module
TE	Thermoelectric

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CHAPTER 1

INTRODUCTION

1.1 Background

As of now, the electrical power supply to charge the cell phone is one of the significant components in human daily life. The cell phone assumes a significant job in an individual's everyday schedule. The electrical power is generated from a generator in remote areas that required high maintenance costs and too loud in sound. Solar energy, nuclear energy, wind energy, and hydro energy are another option of environmentally friendly energy that can be used. Nonetheless, solar energy is restricted and relies upon the climate and geography while hydro energy and wind energy have their own impediments, making them insufficient for more extensive use. Nuclear energy can supply sufficient measures of energy but creates dangerous waste that is unsafe to the climate. Thermoelectric is the most ideal approach to generate electrical power. It changes thermal energy over to electrical energy utilizing a variety of thermocouples.

A thermoelectric generator to power the gadgets such as a cell phone, in general, can be depicted as a little power plant that the ability to create output voltage by changing thermal energy to electrical energy. The hot aluminum with the utilization of a flame source like a candle was used to put the thermoelectric module (TEC1-12706) on it. The cold water in the bread tin is utilized to cool the opposite side of the thermoelectric module to produce electricity using the temperature difference between the hot side and cold side. The voltage and current generated from the thermoelectric module will rise as well when the temperature of the hot plate rise. Further insight regarding the thermoelectric generator will be clarified in Section 2 and 3.

1.2 Motivation

The energy issue and the requirement for elective sources are the most significant and basic issues for all nations to diminish their petroleum derivative utilization. Thus, environment-friendly power sources are the one that can help to discover an answer for this issue. It is critical to look for new elective sources that stand apart as naturally practical arrangements, to change the energy framework and consequently limit the climate sway, by organizing the replacement by inexhaustible sources.

Transportation, oil refinery, steelmaking, concrete plants, and petro-chemistry are monstrous waste heat to be recuperate in Taiwan region which relate with the CO_2 outflow that is hurtful to our current circumstance. Therefore, energy saving was taken by Taiwan government and ozone depleting substance decrease as a significant approach to react to the outrageous worldwide atmosphere change[1].

Then again, the need to discover new energy assets and various choices and alternative for power generation due to expanding request on energy worldwide. Thermoelectric devices have been examined generally over the most recent twenty years. As there are no mechanical moving parts, TE devices are dependable energy converters and have no clamor or vibration. TE devices are light in weight and have little size. As refrigerators, they are well disposed to the environment as CFC gas, or some other refrigerant gas is not utilized. Because of these favorable circumstances, thermoelectric devices have discovered a huge scope of utilizations and numerous works have been repotted on thermoelectric cooling/heating and power generation[2].

1.3 Problem statement

These days, with the quick improvement of the worldwide economy, there are an ever-increasing number of convenient electronic products that have been made, for example, cell phones, tablets, and advanced cameras. They all should utilize batteries to work, yet the limit of an implicit battery is restricted and not enormous enough to be utilized for a significant stretch of time. For instance, when individuals making a trip to remote places such as jungles or mountains, where it is typically hard to track down a power source to charge these gadgets. Along these lines, the battery can run out of intensity at any time. There is an elective method to take care of this sort of issue, which is by utilizing convenient electronic devices such as power banks. Be that as it may, the power limit is restricted. Subsequently, by having hardware that can utilize heat energy to create electricity and produce DC voltage, these gadgets can be charged. As a little force plant for gadgets, this is especially helpful during crisis time.

1.4 Objective of the study

The primary objectives of this project are:

i) To analyse the thermoelectric generator which uses alternative source of energy.
ii) To develop the thermoelectric generator system prototype.
iii) To produce 5V output voltage with USB port to power mobile devices.

1.5 Scope

The thermoelectric generators (TEGs) used in this project are type TEC1-12706. TEGs have 127 semiconductor couples in a size of 40mm x 40mm x 3.8mm. Aside from that, the TEGs have an internal resistance of 138 and a maximum working temperature of 138°C. This TEG's maximum voltage and current are 15.4V and 6.4A, respectively. The TEC1-12706 performance curves are shown in Appendix A.

For technique of prototype, use a solid system to measure the temperature from a flame source such as candle and cold water. Then, use aluminum plate and bread tin to conduct heat from a flame source and cold water. Next, use DC-DC buck converter to convert generated voltage from thermoelectric generator to power and recharge mobile devices

For data collection, the infrared thermometer was utilized extensively in this project to measure the temperature of a flame source as well as the temperature of cold water placed in an aluminium bread tin.

CHAPTER 2

LITERATURE REVIEW

2.1 Thermoelectric effect

In 1822, Seebeck, who first found the thermoelectric effect and noticed an electric flow when one junction of two dissimilar metals, jointed at two places, was heated while the other junction was kept at a lower temperature. A typical multi-couple thermoelectric power module is shown schematically in Figure 2.1: n-type and p-type semiconductor thermos elements are connected in series by highly conducting metal strips to form a thermocouple[3].

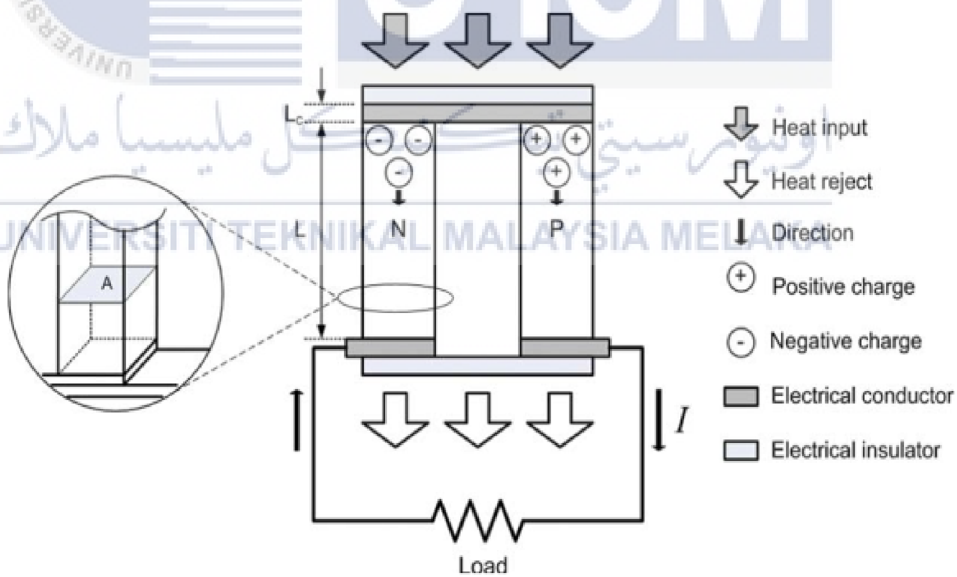

Figure 2.1: Schematic of single Thermoelectric Couple[3]

Based upon an improved theoretical model when the module is worked with a matched load, are given by[3]:

$V_o = \dfrac{\alpha N(T_h - T_c)}{1 + 2rL_c/L}$	(1.1)
$I_o = \dfrac{\alpha A(T_h - T_c)}{2\rho(L+n)(1+2rL_c/L)}$	(1.2)
$P_o = \dfrac{\alpha^2}{2\rho} \text{ x } \dfrac{NA}{(L+N)(1+2rL_c/L)^2} \text{ x } (T_h - T_c)^2$	(1.3)

Where n =2 ρ c/ ρ, r = λ / λc, α is the Thermoelectric material Seebeck coefficient (V/K), ρ is electrical resistivity (Ω cm), ρc is electrical contact resistivity, N is the number of the thermoelement in the module, A is the cross-sectional area of the thermoelements $(mm)^2$, L is the length of the thermos element (mm), Lc is the thickness of the contact layer (mm), Th is the temperature at the hot side, Tc is the temperature at the cold side, λ is the thermal conductivity of the thermoelement and λ c is the thermal conductivity of the contact layer[3].

2.1.1 Seebeck effect

In 1820s, the German physicist Thomas JK. Seebeck is the first discovered the Seebeck effect. The efficiencies of the thermoelectric modules that work on Seebeck effect are around 5-10%. A typical material utilized in TEM is a two element of semiconductor bismuth telluride (Bi_2Te_3) that has high Seebeck coefficient such that the efficiency of generated voltage per unit temperature different is high (around a few tens hundreds μV per °C). P-type and N-type semiconductors that are connected by metallic interconnect produced TE elements. Temperature gradient on the two sides of the semiconductors generated a voltage. As appeared in Figure 2.2, the current will passes into P-type after cross a metallic interconnect and flow through the N-type element. Therefore, this current able to power a load. The TEM generated electrical energy from the thermal energy. As appeared in Figure 2.2, the P-type and N-type semiconductor elements are configured thermally in parallel, but electrically in a series circuit [4].

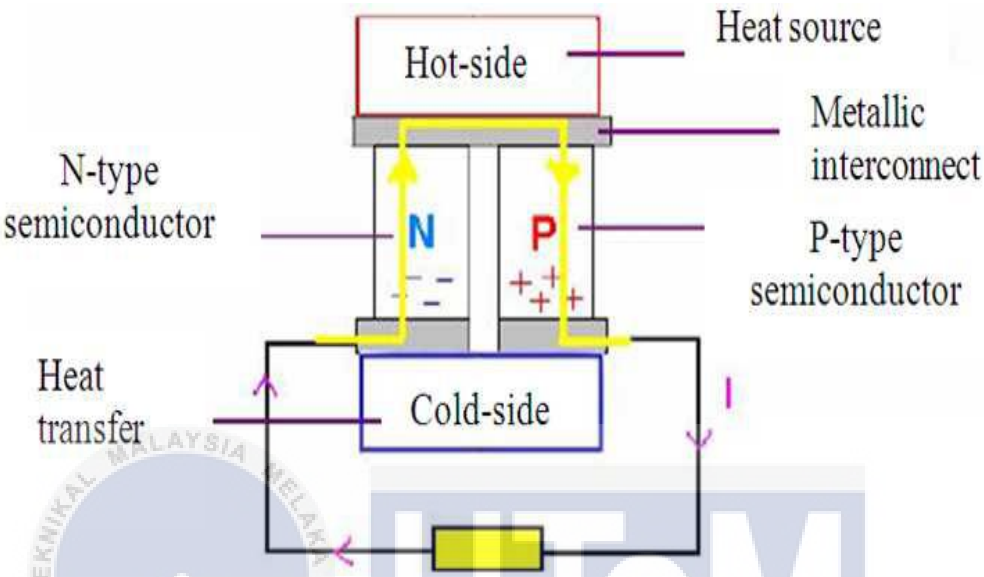

Figure 2.2: Operating principle of thermoelectric material[4]

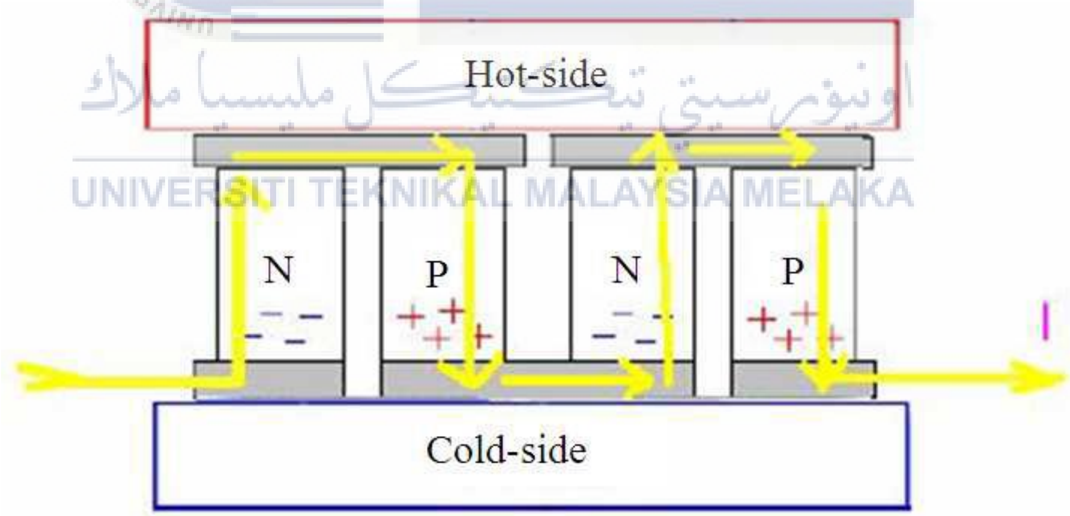

Figure 2.3: A two coupled thermoelectric elements[4]

TEM produced the total output electrical voltage that is series-adding of the voltage of each semiconductor. In a truly thermoelectric element, numerous such P-type and N-type semiconductors are utilized to bring the Seebeck voltage up to helpful levels. A two coupled thermoelectric element are appeared in Figure 2.3[4].

2.1.2 Peltier effect

The voltage between both electrode that connected to a sample of semiconductor material created temperature difference according to the Peltier effect shown in Figure 2.4. The heat move from one medium to another on a small scale and this phenomenon can be helpful[5]. Due to its accessibility and affordability, the developer utilized a TEC-12706 peltier device as a generator[3].

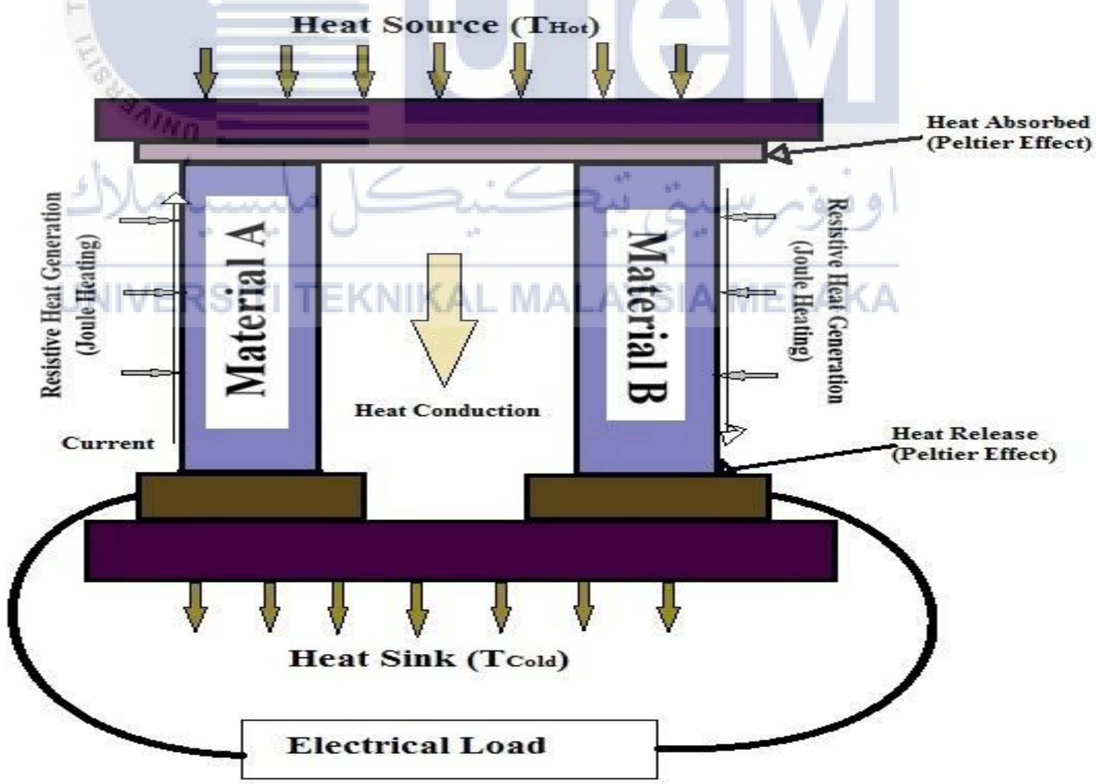

Figure 2.4: Thermoelectric generation[6]

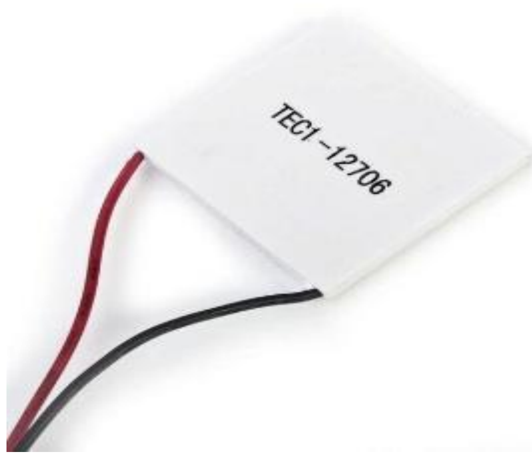

Figure 2.5: TEC-12706 thermoelectric cooler IC[3]

Figure 2.5 shows the type of thermoelectric cooler IC which is TEC-12706 and Table 2.1 represent the performance specification of TEC1-12706. The maximum voltage and current generated from this type of thermoelectric is 16.4V and 6.4A, respectively. When the hot side temperature reach to 25°C, the module resistance will be 1.98Ohms. for 50°C hot side temperature, the module resistance is 2.30Ohms.

Table 2.1: Performance specification of TEC1-12706[3]

Hot side temperature (°C)	25°C	50°C
Qmax (Watts)	50	57
Delta Tmax (°C)	66	75
Imax (Amps)	6.4	6.4
Vmax (Volts)	14.4	16.4
Module Resistance (Ohms)	1.98	2.30

2.2 Factor that affect the performance of TEGS

2.2.1 Thermoelectric materials

Research made by [6] conclude the supply of a high efficiency TE material at the loss due to conflicting material characteristics such as TEG have been to ineffective to be cost efficient to other applications. These issues are addressed to some restrict due to present of development of Nano innovation. Bismuth telluride or silicon germanium intensely doped semiconductor are the best performance. At long last, semiconductors are attractive to have base material that can be both P-type and N-type that can be utilized on both sides of the junctions. Commonly used thermoelectric materials are:

(i) Bismath-Titenium (Bi_2Te_3)
(ii) Zinc-Antimony (Zn_4Sb_3)
(iii) Lead-Tellurium (PbTe)
(iv) Silicon-Gallium (SiGe)
(v) Bismath-Antimony (BiSb)

As appeared in Figure 2.6, the proficiency of these materials shifts with temperature. Paper [6] can be conclude that Bismath-Titenium (Bi_2Te_3) has the highest efficiency and its temperature near to room temperature.

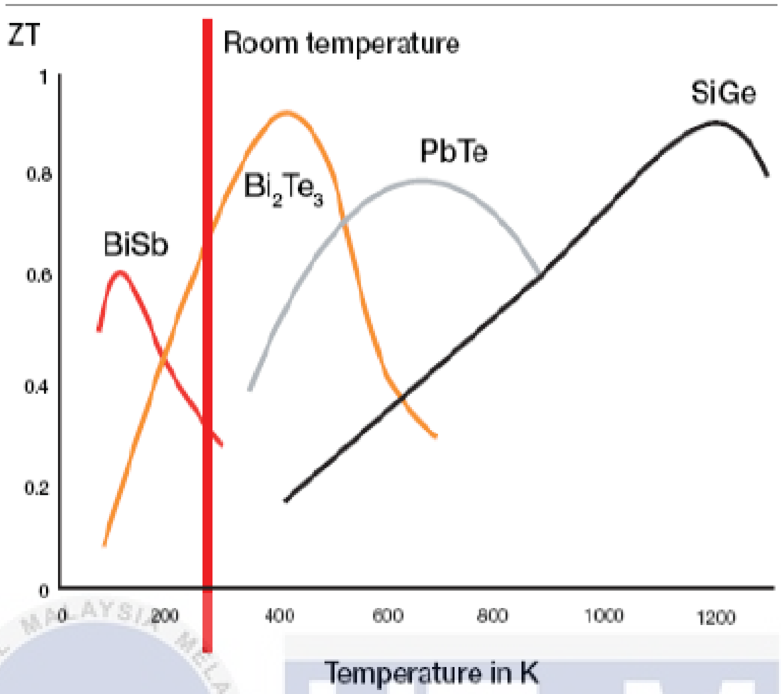

Figure 2.6: Efficiency of different TE materials[6]

2.2.2 Temperature different

Temperature difference between the hot and cold side of TEM are the other factors that affect the performance of TEGs. Therefore, it must research and analyses the temperature difference between hot and cold side of TEM.

Based on [3], the primary test was using the human body temperature as heat source at ambient room temperature and an aluminum heat sink as its cold side. This test produces the following outcomes.