AN ANALYSIS OF SOLAR THERMOELECTRIC GENERATOR VOLTAGE GENERATION USING REAL TIME SIMULATION MODEL

FAIZ DANIAL BIN ROSLAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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FAIZ DANIAL BIN ROSLAN

This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2018

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UNIVERSI TITEKNIKAL MALAYSIA MELAKA
FAKULTIKEJUTERAANELEKTRONIK DAN KEJURUTERAANKOMPUTER

BORANGPENGESAHAN STATUS LAPORAN
PROJEKSARJANA MUDA II

Tajuk Projek : An Analysis Of Solar Thermoelectric Generator Voltage Generation Using Real Time Simulation Model

Sesi Pengajian : 2017/2018

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature	:	
Supervisor Name	:	Dr.Azdiana Binti Md Yusop
Date	:	1ST June 2018

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DEDICATION

For mom and dad

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ABSTRACT

This study is conducted to study the different spot in car which is back rear windshield, near window, on passenger seat and dashboard. Besides, to analyse the behaviour of voltage generation and thermal gradient of car waste heat when various conditions are applied; which consists of windows, brushless fan , sunshade , roofed car park , fan & ice and air-conditioned, enclosed cabin . The analysis of these behaviour is made possible by utilising a set of three thermoelectric generator (TEGs) with solar panel in each condition. Aside from those conditions, external load resistance are also introduced to the STEGs set to achieve the third objective of this study. The duration set to achieve the first objective is about forty-five minutes in total, second objective is thirty minutes whereas the duration for the third objective is ten minutes. At the end of the first objective, it is found that back rear windshield has the highest temperature. Next, at the end of the second objective, 3 pm – 3.30 pm has the highest thermal gradient and thus voltage generation for both day and night time. On the other hand, at the end of the third objective, the optimise value of load resistance to match with the internal resistance of the STEGs set is around 10 kΩ to 50 kΩ.

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ABSTRAK

Kajian ini dijalankan bagi mengkaji perbezaan tempat dalam kereata iaitu cermin belakang kereta, berhampiran tingkap, tempat duduk penumpang dan papan pemuka kereta. Selain itu, bagi menganalisis tingkah laku generasi voltan dan kecerunan terma haba buangan kereta apabila pelbagai keadaan digunakan; yang terdiri daripada tingkap , kipas tanpa berus , pelindung matahari , tempat letak kereta berbumbung, kipas bersama ais serta kabin tertutup berhawa dingin. Analisis tingkah laku ini menggunakan set tiga dalam penjana termoelektrik (TEGs) bersama panel solar untuk setiap keadaan. Selain itu, daripada keadaan-keadaan tersebut, rintangan beban luaran juga diperkenalkan kepada STEGs untuk mencapai objektif ketiga kajian ini. Tempoh yang ditetapkan bagi objektif pertama ini adalah empat puluh minit, tempoh untuk objektif kedua adalah tiga puluh minit manakala tempoh bagi objektif ketiga ialah sepuluh minit. Di akhir objektif pertama, didapati bahawa cermin belakang kereta mempunyai suhu paling tinggi. Seterusnya, 3 pm- 3.30 pm menunjukkan kecerunan terma yang paling tinggi dan generasi voltan untutk bacaan siang dan malam. Manakala, di akhir objektif ketiga, nilai optimum rintangan beban yang sepadan dengan rintangan dalaman STEGs adalah sekitar 10 kΩ hingga 50 kΩ

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ACKNOWLEDGEMENTS

First and foremost, I must acknowledge my limitless thanks to Allah , the Most Compassionate all praises be to Allah, for His help and bless because giving me a piece of mind and time that I can excellently complete this final project year. I would like to express my wholehearted thanks to my family especially toward both of my parents; Mr. Roslan and Mrs. Hajar for always giving me their generous supports and believe in me to complete this project well.

I am grateful to some people, who worked hard with me from beginning till the completion of the present research particularly my supervisor Dr. Azdiana Binti Md Yusop, who always making her time for me and guiding me. Besides that, I owe a deep debt of gratitude to our university for giving me an opportunity to complete this project. I also want to express my thanks to Mrs. Hafizah, the technical staff of Fundamental Electronic 2 Laboratory as well as all my friends for giving me endless supports, knowledge and how to face throughout this whole year. After all, I had learned so much and gain very nice experience that maybe useful one day. Thank you.

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LIST OF SYMBOLS AND ABBREVIATIONS

C	:	Celcius
K	:	Kelvin
m	:	Mili
s	:	Second
TEC	:	Thermoelectric Cooler
TEG	:	Thermoelectric Generator
TEM	:	Thermoelectric Module
USB	:	Universal Serial Bus
V	:	Volt
W	:	Watt
ZT	:	Figure-of-Merit
STEG	:	Solar-Thermoelectric Generator

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LIST OF APPENDICES

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CHAPTER 1

INTRODUCTION

This chapter shall explain in details regarding this study as well as the root factors of why it is conducted. Besides that, all the scope of works and general methodologies taken toward completing this study are also explained briefly in this chapter.

1.1 Introduction

Solar convert the sun's energy into electricity. Unfortunately, there is still some limitations of solar photovoltaic technology for not able to respond to the infrared light which occupies a high proportion of the energy and power fluctuations caused by weather. Thus, instead of sticking with the old mindset of complaining on the solar limitation, it would be a far greater deed and more earth-friendly if the wasted heat is used to increase the output power efficiencies.

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Solar thermoelectric generator (STEGs), which converts solar energy first into a terrestrial heat source and then into electricity via a thermoelectric generator can even absorb the whole solar radiation spectrum with the ideal selective absorbing coating, thus it provide a higher utilization efficiency of infrared light. Even when the sun is partially blocked by clouds due to delayed thermal response, solar thermoelectric generator still enables the continuation of the output power generation.

By applying different condition and ran through different time in a same day, the voltage generation and thermal gradient of STEGs are analysed. Apart from that, the load dependent analysis is also characterized by introducing a load resistor to the STEGs.

1.2 Problem Statement

When a solar exposed under a direct sunlight, it is a normal occurrence for the solar photovoltaic for not able to respond to the infrared light. In a way of supporting current uprising green campaign, a system which capable in converting the waste heat energy from solar into useful electrical energy by hybrid with thermoelectric in other means for increase output power efficiencies might be a good idea.

However, the output of those STEGs can never be predetermined as it is depending on thermal gradient between both hot side and cold side of the TEGs. Thus, a few conditions are set in order to study the behavior of the voltage generated by thermal gradient of each condition. Besides that, a load dependent analysis is needed to monitor the loading effect onto the voltage generation of the STEGs.

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1.3 Objectives

1. To investigate the performance of solar thermoelectric generator under real meteorological condition.
2. To characterize the load depends on analysis of waste heat.
3. To analyse the voltage generation and thermal gradient of waste heat.

1.4 Scope of Work

This study is completed by achieving a few scope of works which consists of preliminary study on related information of STEGs, study of thermal accumulation and distribution, analysis on voltage and thermal gradient of waste heat, and load dependent analysis of waste heat.

The preliminary study on related information of STEGs is basically only consisted of gathering information on basic concept of STEGs, energy harvesting utilizing STEGs, as well effects affecting the performance STEGs.

Study of thermal accumulation of waste heat is done by measuring the open-voltage of one TEG directly using a digital multimeter. Ten data are collected at random time within one day duration which each consisted measured (highest) voltage from one spot.

Analysis on voltage generation and thermal gradient of waste heat can be further classified into two; which are the effect of different conditions and effect of different time of a day. To study the effect of different conditions, six other conditions are set aside from basic configuration where the thermal gradient and voltage generation from each condition are recorded. Meanwhile, to study the effect of different time of a day,

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the basic configuration is conducted in eight different time slots within 8.00 am to 5.30 am (of the next day); where the thermal gradient and voltage generation for each respective slot are also proceed.

Last but not least, load dependent analysis of waste heat is done with ten different values of load resistance are being introduced to the basic configuration. For each of load resistance, a total of 10 minutes duration is set and voltage generated by each load resistance is recorded.

1.5 Methodology Brief Explanation

This project is started with doing a lot of relevant literature review and understand it before proceeding to analysis. Analysis 1 is to determine which spot has the highest temperature and yield the highest voltage output. The result from part 1, part 2, and part 3 is proceeded only with the same spot determined. The part 2 is will conduct to monitor the behavior of voltage generation and thermal gradient of waste heat when conducted in a different location as well as different time. At the same time, part 3 is to monitor the loading effect when a load resistor is introduced to the solar thermoelectric generator. The observation and result will be recorded for all part, then the study can proceed through analysis on overall data.

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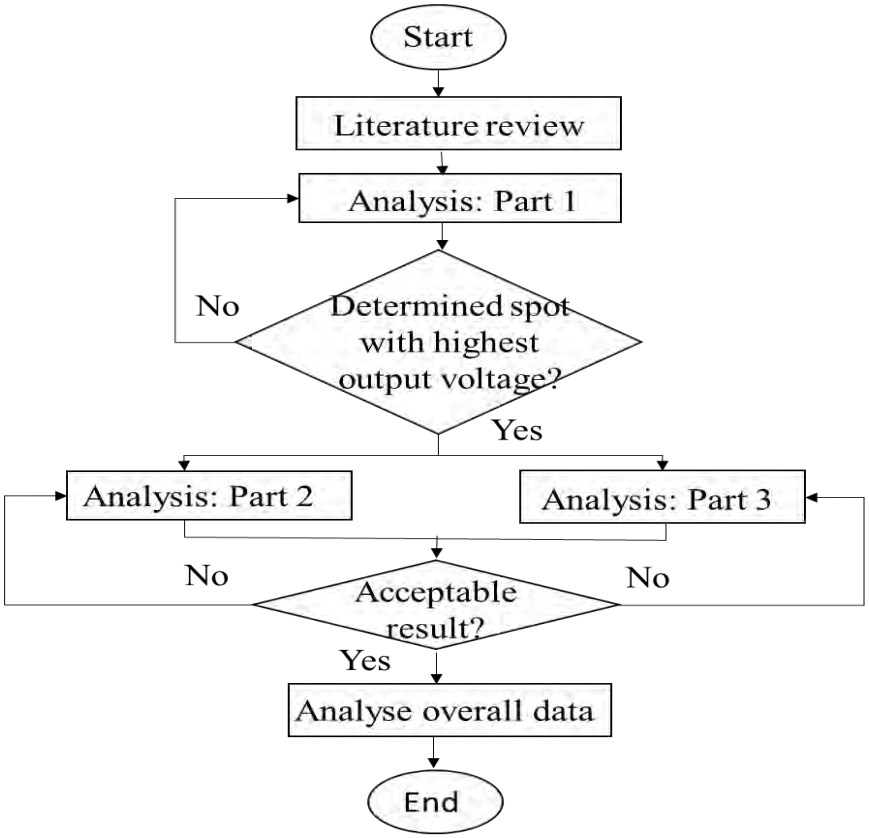

Figure 1.1: Flowchart of General Methodology

1.6 Thesis Outline

This thesis consists of five main chapters as outlined in the table of contents. The summarization of each chapter is as below:

Chapter 1 is regarding introduction. This chapter covered the introduction to the study. It represented the problem statement which leaded to this study, objectives needed to be achieved, scope of works, methodology and the thesis outline of this study.

Chapter 2 is consists of literature review. This chapter presented the brief explanation regarding solar thermoelectric generator which is main component for this

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study. All the information in this chapter are derived either from published journal or books chapter.

Chapter 3 represented methodology. This chapter shows the detail explanation on how the study is conducted. It is divided into three parts, where each part may has difference methodology and carried a different purposed.

Chapter 4 is for result and discussion. This chapter shows all the results obtained by conducting methodology in chapter 3.For each result, a detailed discussion is provided.

Last but not least, Chapter 5 is all-around conclusion. This chapter contained the summarization of the entire objectives, project achievements, as well as the recommendation for future work.

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