DESIGN OF THERMOELECTRIC ENERGY HARVESTER USING LTC 3108 BOOST CONVERTER

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Specially dedicated to my beloved parents, family members and fellows friend

APPRECIATION

First of all, praise to Allah S.W.T., because of His grace, I was able to implement my final year project till the end without any problems. I want to take this opportunity to express my appreciation to those who have helped me a lot throughout completing my PSM whether directly or indirectly. Special thanks to my family especially both of my parent who non-stop gave me morale supports and financial resources. Thanks also to my supervisor, Eng. Hazli Rafis Bin Abdul Rahim, for guiding me throughout getting an analysis and also gave some advice for my project. Lastly for my love, housemate and fellow friends, thank you so much for helped me out when I need an idea or something that related with my project. I express my gratitude for everyone that I not mention above and hope God will repay you well one day.

ABSTRACT

Renewable energy technique is the process of converting available ambient energy into usable electrical energy through the use of a particular material or transduction mechanism. Nowadays, the evolution of new technology which involving renewable energy technique and smart grid system has a huge potential in the energy market. In line with the current technology interest in the smart grid technology, power transformer health condition becomes one of the main issue need to be considered. The way to monitor health condition of the power transformer has started to evolve from typical monitoring technique to a new development of using energy harvesting technology to activate sensors network for the monitoring purpose. For this project, Thermoelectric Power Generator (TEG) is used to convert the heat energy get from the power transformer into small electrical energy in order to power up electronic devices that will triggering up the monitoring system. TEG only produces small electrical energy, so the boost converter is needed in order to increase the electrical energy from the TEG and get its maximum power point tracking (MPTT). The boost converter is a type of DC-to-DC converter which has a greater output than the input voltage. So, the result of this project will show us the small electrical energy, converted from the heat energy , range between 20 mV to 1.5V that is get from the TEG will be raised up until at least 5V using a boost converter. 5V is the minimum volts to trigger up the PIC circuit or any others small electronic appliance that has low power consumption.

ABSTRAK

Teknik tenaga boleh diperbaharui adalah proses menukarkan tenaga ambien yang sedia ada kepada tenaga elektrik yang boleh digunakan melalui penggunaan bahan tertentu atau mekanisme transduksi. Kini, perkembangan teknologi baru yang melibatkan teknik tenaga boleh diperbaharui dan sistem grid pintar mempunyai potensi yang besar dalam pasaran tenaga. Selaras dengan kepentingan teknologi semasa dalam teknologi grid pintar, keadaan transformer kuasa menjadi salah satu isu utama yang perlu dipertimbangkan. Cara untuk memantau keadaan transformer kuasa telah berubah mengikut peredaran masa sehinggalah penghasilan teknologi baru melalui penuaian tenaga untuk menghidupkan rangkaian sensor sebagai tujuan pemantauan.Untuk projek ini, penjana thermoelectric (TEG) digunakan untuk menukarkan tenaga haba yang diperolehi daripada transformer kuasa kepada tenaga elektrik kecil yang mampu menghidupkan alat-alat elektronik yang akan mencetuskan satu sistem pemantauan. TEG akan menghasilkan tenaga elektrik kecil, jadi penukar tingkat diperlukan dalam usaha untuk meningkatkan tenaga elektrik daripada TEG dan mendapatkan pengesanan titik kuasa maksimum (MPTT). Penukar tingkat adalah sejenis penukar DC ke DC yang mempunyai keluaran yang lebih besar daripada voltan masukan. Jadi, hasil daripada projek ini akan menunjukkan kepada kita tenaga elektrik kecil, ditukar daripada tenaga haba, julat antara 20 mV sehingga 1.5V yang didapati daripada TEG akan ditingkatkan sehingga sekurang-kurangnya 5V menggunakan penukar tingkat. 5V adalah volt minimum untuk menghidupkan litar PIC atau mana-mana perkakas elektronik lain yang mempunyai penggunaan kuasa yang rendah.

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LIST OF ABBREVIATIONS

TNB – Tenaga Nasional Berhad

TEG – Thermoelectric Generator

V - Voltage

PIC – Programmable Integrated Circuit

IC – Integrated Circuit

DC – Direct Current

PWM – Pulse Width Modulator

SMD – Surface Mount Device

SMT – Surface Mount Technology

PMC – Power Management Circuit

PCB – Printed Circuit Board

I – Current

C - Celcius

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CHAPTER I

INTRODUCTION

1.1 Project Introduction

Renewable energy technique is the process of converting available ambient energy into usable electrical energy through the use of a particular material or transduction mechanism. Nowadays, the evolution of new technology which involving renewable energy technique and smart grid system has a huge potential in the energy market. Although the application of new technology in the smart grid system has evolved rapidly, devices such as power transformer is still be a major component in the power distribution system. Thus, in line with the current technology interest in the smart grid technology, power transformer health condition becomes one of the main issues considered.

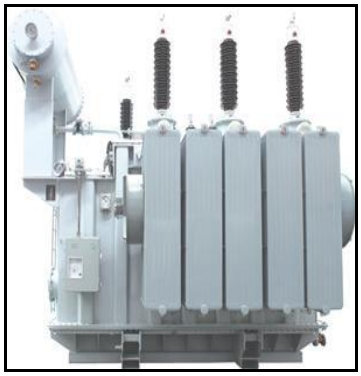

Figure 1.1: Power Transformer In Distribution System

In this situation, the health condition of power transformer is about how much the heat generate during the transformer operated. Heat is generated due to the high voltages that need to be step-up or step-down by the transformer. Overheat may cause minor or major damage to the transformer and this will affect the performance of the transformer and this also will lead to failure of the transformer. So to reduce and overcome this problem, we must have a device that could monitor the heat generate by the power transformer. This monitoring system will be used to inform the relevant authority, for example Tenaga Nasional Bhd. (TNB) or other electric supply company, whether the temperature of the transformer is in control or not. This will allowed them to make any maintenance before the transformer malfunction or get any another major damage.

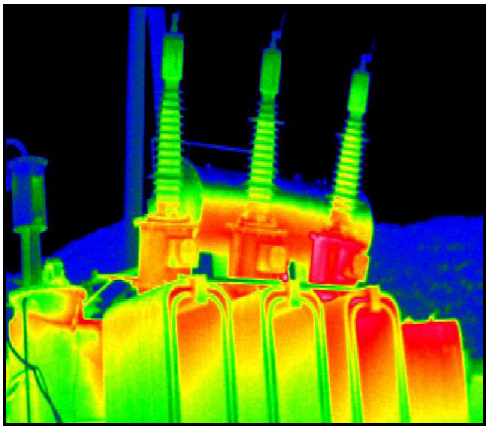

Figure 1.2: Hot Spot Measurement of High Voltage Transformer

The way to monitor power transformer has started to evolve from typical monitoring technique to a new development of using energy harvesting technology to activate sensors network for the monitoring purpose. The ambient heat energy obtained from the power transformer will be harvested to turn on power electronic compensator and driven the sensors.

In producing an auto monitoring system for the power transformer, the Thermoelectric Power Generator (TEG) can be used as a device which will generate a small electrical energy. Normally TEG will generate an electrical voltage between 20 mV to 1.5 V, depend from the heat generated. When the temperature increases, the voltage generated also increases. The output of TEG is normally very small and varies. This is because the output is depend on the temperature different between 2 different plate inside the TEG, so this small electrical energy need to be boost up to a higher level which can be used to triggering up the PIC circuit. Normally PIC usually need around 5V to 5.5V to be operated. Therefore, the input get from the TEG must be boost up at least 5V to let the PIC switch ON. There are two function of this PIC circuit in this situation. First, PIC circuit is used to triggering up the communication device such as Zigbee or Xbee to the user. Secondly, this PIC circuit reads the surrounding heat temperature using a heat sensor so that this temperature reading can be sent through the

communication device and be used by the user whether the temperature of power transformer is still in control or not.

This project only covered up until the operation of TEG and the design a boost converter which used LTC3108 IC and also Surface Mount Device (SMD). This design of boost converter must be compact and able to step-up the voltage produce by the TEG which in range between 0.7V to 1.5V into a minimum output level which is at least 5V.

The LTC3108 is a highly integrated DC-DC converter ideal for harvesting and managing surplus energy from extremely low input voltage sources such as TEGs thermopiles and small solar cells. The step-up topology operates from input voltages as low as 20mV.

Using a small step-up transformer, the LTC3108 provides a complete power management solution for wireless sensing and data acquisition. The 2.2V LDO powers an external microprocessor, while the main output is programmed to one of four fixed voltages to power a wireless transmitter or sensors. The power good indicator signals that the main output voltage is within regulation. A second output can be enabled by the host. A storage capacitor provides power when the input voltage source is unavailable. Extremely low quiescent current and high efficiency design ensure the fastest possible charge times of the output reservoir capacitor.

The LTC3108 is available in a small, thermally enhanced 12-lead (3mm × 4mm) DFN package and a 16-lead SSOP package.

1.2 Project Objective

i. To design a compact DC-DC boost converter using LTC3108 IC and SMD in order to increase and stabilize the output voltage generated from the TEG.
ii. To demonstrate experimentally DC/DC boost converter using LTC3108.
iii. To analyze and evaluate the characteristic of TEG and output range produced from the boost converter whether it capable to supply a sufficient voltage and activated at least small electronic devices.

1.3 Problem Statement

i. TEG generated power which is varies, intermittent and limited, so the power management circuit (PMC) using DC-DC boost converter which use an LTC3108 and SMD component can be used to stabilize the power to the load and also extract maximum power.
ii. The needs of alternative power supply to power the sensor system to grant the effectiveness of the sensor system.
iii. The maintenance cost to change the battery is a big issue as batteries is known to have short lifetime
iv. A renewable energy is an energy that have a large potential in the market nowadays, so we need to design a new source of energy using a renewable energy to power up small or low voltage device by manipulating an energy harvesting technique

1.4 Scope of Work

i. Determine the output voltage that can be harvested from the TEG circuit based on temperature different from surrounding. This output voltage will be used as an input to the boost converter circuit.

ii. Developed circuit which is used to power up the PIC circuit that involving the TEG and boost converter using LTC3108 IC, SMD component and fabricated circuit . Where SMD component consists of resistor, capacitor and small transformer.

1.5 Report Overview

'*Design of Thermoelectric Energy Harvester using LTC3108 boost converter'* is the title of this report where it contains a combination of five chapters from the introduction of this project to the outcome, expected result and conclusion of this project. The report is written in detail on each of every step to take under consideration on the progression of the project.

Chapter 1 elaborate briefly what the project is all matter. Here clearly stated the background of the project, the objective, the scope of work of this project, brief description of methodology and the overview of each of the chapter contains.

Chapter 2 is some of the literature review from an article, paper work, book, website and all the written text that are related to the project topic. Where in this thesis, it is included a literature review on TEG, Boost converter, SMD component and LTC3108 as all of the materials is used in this project.

Chapter 3 is on the methodology of overall project. It will discuss about the project background and also project methodology. At project methodology we will discuss further the way how this project will going on. It is not limited to the hardware choose, it also discuss on the software implementation choose.

Chapter 4 will discuss about the result that had been obtain from the project such as the structure of the system, finished product and analysis taken. This chapter also we will discuss about the overall data that have been collected.

Chapter 5 will concludes the overall view of the project. This chapter will summarize the findings of the project, analysis achievement, potential of commercialization and suggest further research for the future.