THERMOELECTRIC POWERED HIGH TEMPERATURE USING BOOST CONVERTER

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This thesis submitted to the senate of UTeM and has been accepted as fulfillment of the requirement for the Bachelor of Electronic Engineering (Industrial Electronic).

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I dedicate this work to

My father, Mohd Anuar Bin Abd Mubin and my mother, Rohana btYusof
for their endless love, support and encouragement.

And to all who have supported me throughout.

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ABSTRACT

This project introduces a green technology method to monitor power transformer health condition using heat energy harvesting technique through the Thermoelectric Power Generator (TEG).This project focused on the conversion energy stage from the transformer in electrical subsystem. The ambient heat energy from power transformer will be harvested from TEG. Since the TEG generates very small voltage within in 0.2V to 0.8V, therefore a boost converter is needed to increase the voltage output. The main objective of this project is to design the dc- to dc boost converter in order to increase and stabilize the voltage from TEG. This dc-to dc boost converter is able to increase the voltage from 0.8V up to 5V to power up the small electronic devices such as microcontroller circuit and driven sensors for monitoring purpose. The overall project is an alternative system using harvesting energy by reducing the manpower and eliminates the needs to replace battery.

ABSTRAK

Projek ini memperkenalkan kaedah teknologi hijau untuk memantau tahap keadaan suhu semasa pengubah kuasa menggunakan kaedah penuaian tenaga haba melalui Thermoelectric Power Generator (TEG).Projek ini menjurus kepada peringkat penukaran tenaga daripada pengubah pada. Tenaga haba sekeliling dari pengubah kuasa akan dituai dari TEG. Oleh kerana TEG menghasilkan voltan yang sangat kecil diantara 0.2V hingga 0.8V, maka peningkat voltan diperlukan untuk meningkatkan voltan. Objektif utama projek ini adalah untuk merekabentuk peningkat voltan arus terus untuk menaikkan dan menstabilkan voltan daripada TEG. peningkat voltan arus terus ini berupaya untuk meningkatkan voltan daripada 0.8V kepada 5V untuk menghidupkan alat elektronik yang kecil seperti litar mikro-pengawal dan alat pengesan untuk tujuan pemantauan .keseluruhan projek ini ialah sebagai sistem altenatif yang menggunakan penuaian tenaga dengan mengurangkan tenaga pekerja dan menghapuskan keperluan untuk menukarkan bateri.

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INTRODUCTION

1.1 Project Overview

Currently, the use of renewable energy technology and smart grid technology based technique has a vast potential in energy market. There is an increase in renewable energy source particularly in the applications of high energy levels in transmission and distribution [1].This is due to its advantages in term of green technology and environmentally friendly. In the distribution system, equipment like power transformer is still be the main component, although there has of new technology in the smart grid system.

Power transformers are the largest and probably the most expensive items of equipment in power systems. The main issue that need to be considered is health condition of power transformer. Obviously appropriate care and health monitoring of these assets are necessary in order to estimate and predict their live spans.The monitoring should be done over regular time intervals. Failure of power transformers may lead to excessive costs.

Historically, the way to monitor power transformer has started to evolve from typical monitoring technique to the use of sensor. In line with the green technology, the new development of using energy harvesting technology to power up sensors network for the monitoring purpose is proposed. The ambient heat energy from power transformer will be harvested from thermoelectric generator (TEG) to power up power electronic compensator and driven sensors.

1.2 Objectives

In order for the project to be successfully implemented, the following objectives are required to be achieved:

- To design the DC-to-DC boost converter in order to increase and stabilize the power from TEG.
- To analyze and study the characteristic of thermoelectric power generator (TEG) and output range produced from boost converter whether it capable to activated at least the small electronic devices.
- To demonstrate how boost converter can boost the electrical energy from the thermoelectric power generator (TEG) output.

1.3 Problem Statement

Current development to monitoring the health condition of transformer is using infrared thermography (IRT).This technique has been developing by TNB Berhad. But there are some disadvantages by using this type of technique which are images can be difficult to interpret accurately when based upon certain objects, specifically objects with erratic temperatures, although this problem is reduced in active thermal imaging. Besides that, if temperatures are very close in range, infrared imaging can lead to misreading information taken in from the camera; objects can become indistinguishable. The current technology in thermography only allows for imaging to be applied to surface temperatures. The downside to thermography is the price tag that is associated with thermo-imaging equipment. This equipment is rarely used by anybody other than large companies, public services, or educational institutions due to the price that it costs to purchase equipment.[2]

Based on this problem, the new technique has been introduced to overcome the problem by using the thermoelectric generator which is 100% green technology and affordable price.

1.4 Scope Of Project

This project focused on stabilize and boost the output voltage from TEG .This project primarily covered on the several parts, which are:

- Identify the characteristics of Thermoelectric Power Generator (TEG)
- Designing DC- to- DC Boost Converter

All the parts above will function in one system in order to convert energy from thermal energy to electrical energy and to stabilize the power using boost converter.

1.5 Project Significant

- This system can be operate in an autonomous and self-powered manner.
- This system can increase the very low voltage in order to power up the macro scale devices.
- This system using energy harvesting technology to power up sensors network, thus it environmental friendly.

CHAPTER II

LITERATURE REVIEW

Literature review is important in providing a broad view on the field of this project and the objectives and scope of this project had been identified. This chapter provides the summary of literature reviews on key topics related to the DC-DC boost converter, Thermoelectric Generator (TEG) and also type of intergrated circuit (IC) that used in this project.

2.1 Infrared Thermography (IRT).

The project from TNB is developing transformer monitoring method by using the infrared thermography (IRT). Infrared thermography (IRT) method used a Thermographic cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 9,000–14,000 nanometers or 9–14 µm) and produce images of that radiation, called thermograms. Since infrared radiation is emitted by all objects above absolute zero according to the black body radiation law, thermography makes it possible to see one's environment with or without visible illumination. The amount of radiation emitted by an object increases with temperature; therefore, thermography allows one to see variations in temperature. When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds; humans and other warm-blooded animals become easily visible against the environment, day or night. As a result, thermography is particularly useful to military and other users of surveillance cameras.

The appearance and operation of a modern thermographic camera is often similar to a camcorder. Often the live thermogram reveals temperature variations so clearly that a photografh is not necessary for analysis. A recording module is therefore not always built-in. but there are some disadvantages using infrared thermography (IRT) which are:

- Quality cameras often have a high price range, cheaper are only 40x40 up to 120x120 pixels.
- Images can be difficult to interpret accurately when based upon certain objects, specifically objects with erratic temperatures, although this problem is reduced in active thermal imaging.
- Accurate temperature measurements are hindered by differing emissivity and reflections from other surfaces.
- Most cameras have ±2% accuracy or worse in measurement of temperature and are not as accurate as contact methods.

- Only able to directly detect surface temperatures.

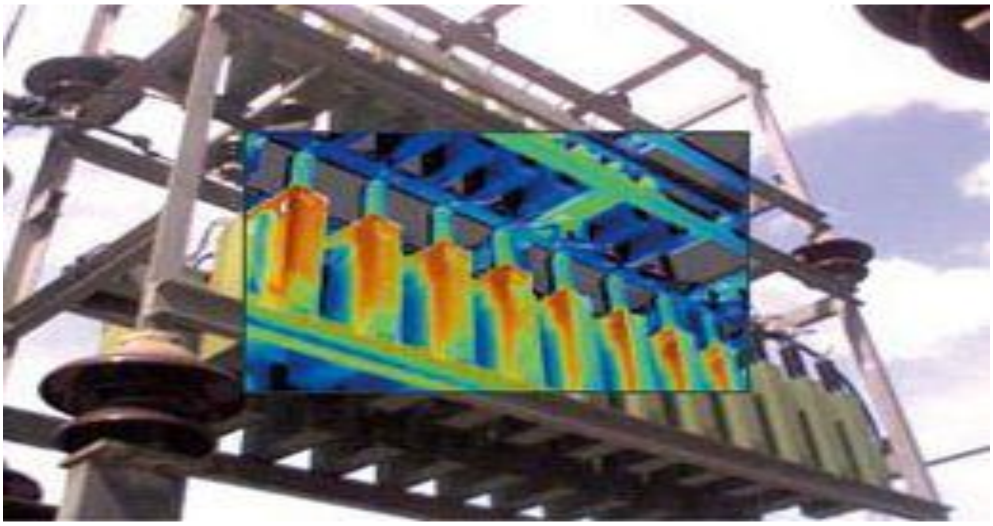

Figure 2.1: Transformer condition using IRT

2.2 Fundamental of Thermoelectric Generator

Thermoelectric generator (TEG) is a device that converts thermal energy directly into electrical energy [3]. A typical TEG structure is shown in Figure 2.2. Early TEG devices utilize metallic TE material, whereas more recently manufactured TEGs use alternating n- and p-type semiconductor materials. The TEG structure is consisting of thermoelectric materials which are sandwiched by two heat exchanger plates at its two ends respectively. One of the two exchangers has high temperature, and hence, it is called the hot side of the TEG. The other has low temperature and is called the cold side of the TEG. There are electrical-insulate-thermal-conductive layers between the metal heat exchangers and the TE material. The two ends of n- and p-type legs are electrically connected by metal

The thermal-electrical conversion is done by a phenomenon generally called as Seebeck effect [3]. TEGs are solid-state device, which means that they have no moving parts during their operations. Together with features that they produce no noise and involve no harmful agents, they are the most widely adopted devices for waste heat recovery.

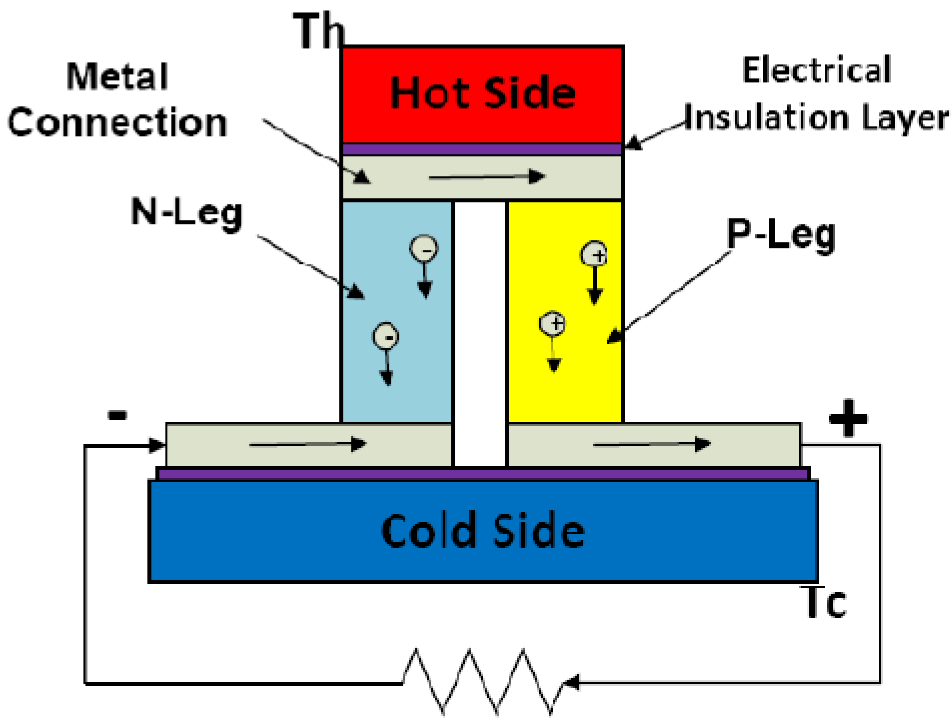

Figure 2.2 Simplified illustration of TEG

2.2.1 The Physics of Thermoelectric Generation

Seebeck Effect

Seebeck effect is the conversion of temperature differences directly into electricity [4]. In the basic version of TEG, the conductor materials used to generate Seebeck effect are two different metals or semiconductors. The term thermo power or Seebeck coefficient of a material is a measure of the magnitude of an induced thermoelectric voltage in response to a temperature difference across that material. The Seebeck coefficient has units of V/K, though it is more practical to use mV/K. The Seebeck coefficient of a material is represented by Sand is non-linear as a function of temperature, and dependent on the conductor's absolute temperature, material and molecular structure.