ENERGY SCAVENGING WITH SHOE-MOUNTED PIEZOELECTRIC POWER GENERATOR

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Tajuk Projek : Energy Scavenging with Shoe-Mounted Piezoelectric Power Generator

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ABSTRACT

The intention of this project is to analyze the amount of electrical energy can be harvesting from piezoelectric power generator that installed in a shoe during walking or jogging and applied the generated energy to power up Light Emitting Diode (LED) that had been installed in a sport shoe and at the same time will provide a safety purpose to a user while walking or jogging in a night time. Moreover, the mechanical energy harvesting from human motion will be scavenging by using a piezoelectric and the generated energy where be analyzed. Furthermore, this project is about to study the energy produced by a piezoelectric during walking or jogging related with the maximum number of piezoelectric can be installed in a shoe with measured the energy produced. Besides, the connection of the piezoelectric in a shoe either in parallel or series connection also will the analyze from this project and the purpose of this analysis is to measure the optimum energy produced from a piezoelectric during walking or running associated the connection of the piezoelectric. In short, this project can save our environment because did not used any chemical substance to produce this project and make it this project is a green technology. The harvester from this project provides 5.53 mW during walking or jogging at a frequency of roughly 1.3 Hz. In a nutshell, a direct current (DC) power supply is built through integrating the harvester with a power converter circuit. This project should consist but not limited to the power generator and the power conditioning circuit.

ABSTRAK

Tujuan projek ini adalah untuk menganalisis jumlah tenaga elektirk yang dapat di tuai daripada penjana kuasa piezoelektrik yang telah dipasang di dalam kasut semasa berjalan atau berjoging dan tenaga yang terhasil digunakan untuk menghidupkan Diod Pemancar Cahaya (LED) yang telah dipasang dikasut dan pada masa yang sama memberiakn langkah keselamatan kepada penguuna semasa berjalan atau berjoging diwaktu malam. Tambahan pula, penuaian tenaga mekanikal daripada pergerakkan maknusia akan diperangkap mengunakan piezoelektrik dan kuasa yang terhasil akan dianalisis. Dan lagi, projek ini juga bertujuan untuk belajar tenaga yang dihasilkan daripada piezoelektrik semasa berjalan atau berjoging berkait dengan jumlah piezoelektrik yang dapat dipasang di dalam kasut dengan mengukur tenega yang terhasil. Selain itu, sambungan diantara piezoelektrik sama ada sambungan selari atau siri juga akan dianalisa daripada projek ini dan tujuan analisis ini adalah untuk mengukur tenaga pengeluar yang efisien semasa berjalan atau berjoging berkait dengan sambungan piezoelektrik. Secara ringkas, projek ini boleh menyelamatkan alam persekitaran kerana tidak menggunakan bahan kimia dalam penghasilan projek ini dan mejadikan projek ini berteknologi hijau. Hasil penuaian dari projek ini telah menghasilkan 5.53 mW semasa berjalan atau berjoging pada frekuensi secara kasar 1.3 Hz. Kesimpulannya, bekalan kuasa arus terus (DC) yang telah dihasilkan daripada gabungan tenaga penuaian bersama litar penukar kuasa. Perojek ini perlu terdiri tetapi tidak terhad kepada penjana kuasa dan litar kawalan kuasa.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Overview

Energy scavenging also known as energy harvesting or power harvesting but for is project is about mechanical energy harvesting or human motion also includes in an energy scavenging category. Harvesting mechanical energy from human motion is an attractive approach for obtaining clean and sustainable electric energy which are widely used for health monitoring, activity recognition, gait analysis and self-powered electronic system. This energy is maintenance free means that this energy no need to replace like a battery and make this energy is efficient to used. It is also a waste energy that produce by human in a daily life without notice that the waste energy can recycle to produce an electricity for specific purpose. This harvesting mechanical energy can be commercialized in many field such as wireless system sensor network and hazard warning system that can make our life easier. Harvesting mechanical energy are produced by a movement and can produced in the range of a mill-watt and up to a few of watts which can be used to power up a low power electronic device such sensor, semi-conductor component and light emitting diode (LED).

Piezoelectric was used in this project as a medium to convert mechanical energy into an electrical energy. Why piezoelectric is used is because the materials of

piezoelectric are capable to converting mechanical energy to electrical energy by mechanical stress or mechanical vibration. Piezoelectric are made up from ceramic materials and in basic sense when the ceramic materials are deformed, an electric charge will generate and this is called a piezoelectric effect. The ways to generate electricity is very simple but piezoelectric is very fragile and need to handle in care. The life time of piezoelectric is more longer than batteries and the price is cheaper that batteries and the most important things piezoelectric is relevant to replace batteries.

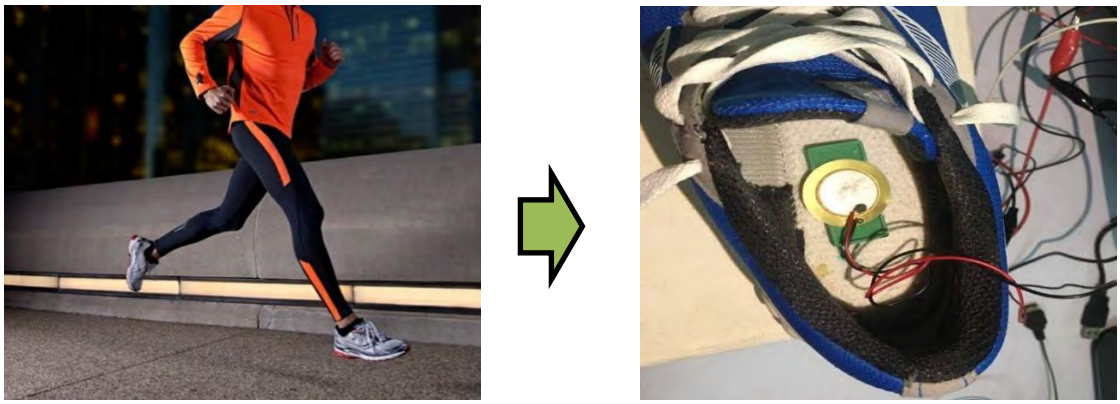

Figure 1.1: Electrical energy is generated from mechanical energy by using piezoelectric.

In this chapter is about the purpose of this project in roughly which Energy Scavenging with Shoe-Mounted Piezoelectric Power Generator. Besides, this chapter will tell about objective, problem statement and scope of the project.

1.2 Problem statement

Piezoelectric can be able to generate an electricity by itself when there are absent of mechanical stress applied on the piezoelectric. Hence, some of the problem have been occur when handling this project that dealing with mechanical harvest energy and piezoelectric and the problem have been stated bellow:

a) The problem of this study is to analyze the power output from the piezoelectric with related the number should be installing in shoe and the connection of the piezoelectric also a problem in this study that should be aims to answer.
b) Because of the global warming todays was triggered inspiration to design an eco-friendly power generator that using clean energy or energy scavenging as a medium to produced electrical power.
c) The generated electricity from mechanical harvest energy that produce by a piezoelectric replace batteries to reduce the pollution of environment and human health if using batteries.
d) The power output generated from piezoelectric cannot be predicting because it produces unstable power output means that the generated electricity sometimes high sometimes low. The generated electricity is in Alternating Current (AC) which is unregulated voltage and to apply this generated electricity in a circuit application a Direct Current (DC) is required.
e) The voltage generated from piezoelectric is very high but the current is very low and this means it cannot be able to power up or charge high power consumption electronic device such as a smart phone because it required 5 watts to operated meanwhile this piezoelectric can able to produce only a mill-watt.

1.3 Objective

1.3.1 To analyze the amount of generated power can be harvesting from human motion using piezoelectric.

i Human motion is a mechanical energy which is one of the energy scavenging from the environment. To investigate the amount of generated power from human motion piezoelectric was used as a medium to scavenging the power from human motion.
ii These parts also include the number of piezoelectric used to maximize the power from human motion.

iii The generated power should be relevant to use in circuit application.

1.3.2 To design a prototype that provide a safety precaution for user when walking or jogging at a night.

i The power generates when human used this shoe mounted with piezoelectric during walking or jogging and from the motion it will produced a mechanical stress that piezoelectric will response to produce electricity.

ii The generated power will power up 5 pieces of red LED as a warning light when user used this prototype jogging at the night day and at the same time will give a safety precaution to the user and can help to prevent an accident.

1.3.3 To analyze the connection of the piezoelectric installed in a shoe.

i The connection of piezoelectric in a shoe are the most important things to boost the power generated either in parallel or series connection that will give the most optimum power generated.

ii The space in the shoe is limited so to produce a larger power generated the connection of piezoelectric become a key role instead to add the number of the piezoelectric installed is a shoe for this scope.

1.4 Scope of works

For scope of works for this project are have several procedures that need to follow before making this project works. This project consists of 2 parts:

1.4.1 Part 1 (PSM 1)

i Study literature review about piezoelectric project.

ii Analyze the material, connection, size, and price related with the generate energy at the same impact of piezoelectric.

iii Investigate the generate energy using digital oscilloscope at the Research Lab II.

iv Select the appropriate result from the analyzed and investigation as the main component for this project.

1.4.2 Part 2 (PSM 2)

i Design the full bridge rectifier and the filter that can be able to convert an AC into a DC for circuit application.

ii Analyze the result that fulfills the requirement of application.

iii Develop a prototype of this project.

iv Test the prototype in real time for make it relevant to use.

1.4 Summary

In this chapter, the main purpose that needs to be perceived is the general understanding on the objective, problem statement and scope of project that would help the committees to have a better understanding the general idea about the Energy Scavenging with Shoe-Mounted Piezoelectric Power Generator. The Energy Scavenging with Shoe-Mounted Piezoelectric Power Generator will be explained deeper in the upcoming chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Background

Energy scavenging nowadays growth rapidly in supplying energy to applications is the process of measure amounts of energy from one or more clean energy sources, accumulating them and storing them for application usage. Besides, to power up a variety of low power consumption like sensor and control circuity for intermittent duty applications an energy harvesting can be perform all these functions. Mechanical stress from piezoelectric effect will induces an electric polarization proportional to an applied mechanical stress or mechanical strain proportional to an applied electric field. Several factors where include such the frequency constant of the piezoelectric element, mechanical properties of the material and the temperature and stress dependence of the physical properties will rely on the power output from the piezoelectric.

This chapter will discuss about the fundamentals, theories and concepts of this project in detail and study the background or literature review that relate with this project. Besides, various journals and articles had been referred during performing this project.

2.2 Theory

In this sub chapter will tell in roughly about the theory about background of energy scavenging environment like how the energy can be produced and the application of energy scavenging can be used in real time application, circuit application and help human in daily life works. Besides, this sub chapter also about the history of piezoelectric and how the piezoelectric works.

2.2.1 Energy scavenging

Energy scavenging can be known as a harvesting energy, harvesting power and ambient power which an energy produced by environment where the process by the energy is derivative sources such as thermal energy, wind energy, and kinetic energy which is external sources. All these things are clean energy that will not be harmful to the environment. This energy capable to captured and stored for low power consumption devices like a sensor, wireless sensor and a transmitter. This energy scavenging is generated a small of total power for low circuit application usage.

The operation for energy scavenging devices is translating ambient energy into electrical energy and this energy was extremely used in military and commercial sectors. There are many ways that energy scavenging can be apply to any application. High power consumption devices and deployed at remote location is assisting a huge system are the future application for the energy scavenging. Besides, there are another application of energy scavenging is in electronic devices usage where the energy scavenging devices can power up or can act as a charger for a smartphone, laptop and equipment for radio communication.

2.2.2 Piezoelectric

The history name of piezoelectric are comes from “Piezo” which means to squeeze where the term comes from a Greek term and electricity resulting from the pressure. Jacques and Pierre Curie a physicist from French are the person that responsible in encounter of piezoelectric at 1880. Piezoelectric substance are solid materials such as crystal and ceramics where the electric charge that accumulates in certain that will generate voltage in response to applied mechanical stress. The voltage, movements and forces generated by piezo material are very small and usually require amplification for circuit application in wearable electronic device. For example, a typical disc of piezoelectric ceramic will increase or decrease in size by only a small fraction of a millimeter. Piezoelectric materials are used in many applications despite this minor change of thickness.

There are many varied sizes and shapes of piezoelectric substances that can be used in piezoelectric sensors. Figure 2.1 shows the working of true precision springs that will be offer various advantages and disadvantages with the different element configurations. The arrows indicate how the material is stressed while the red section represents the piezoelectric crystals. By apply a high frequency pressure and force will makes some useful for compression design features in high rigidity. A disadvantage for this substance is sensitive to the thermal transients. The offset of narrow frequency range and low over shock survivability is the simplicity of the flexural design.

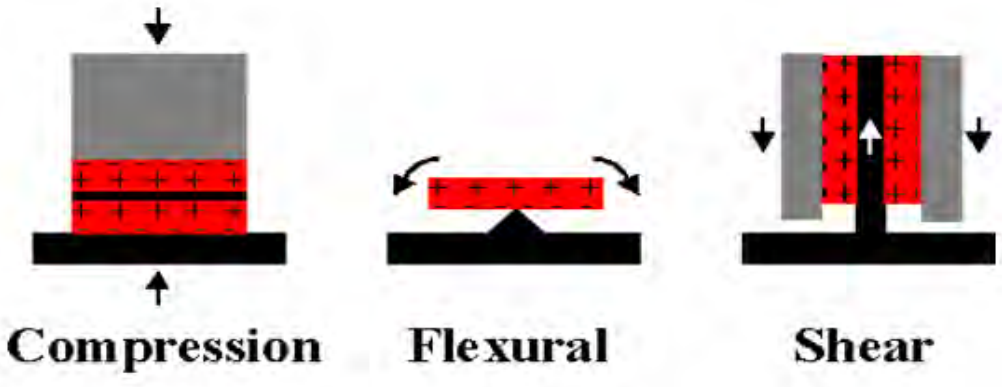

Figure 2.1: Material configurations of piezoelectric.

An electric charge that produced from the piezoelectric is always associated with the electric field. A test particle with an accelerating force (F) will experience small charge (Q) was placed near a concentration of charge due to the field. The electric filed (E) value of the location is a vector or the ratio (F/Q). For a strain, when a rod of length (L) is stretch to a new length (L + ΔL), so the strain ratio in the rod is (ΔL)/ (L). Convenience of visualization is a dimensionless measure of compression often stated as "millimeter per meter" or stretching. In additional, a tension for tensile strength will break by a sample of solid material, the stress that measured in Newton/m^2 or psi.

2.3 Literature review

In 1980 until nowadays, piezoelectric was become famous among the researcher to make a research on a piezoelectric because the potential of commercialization is very high. Today, piezoelectric was search for the commercial success by some Japanese efforts was attracted the attenuation in industry by many other nations and encouraged a new effort to create successful materials of piezoelectric. There is another country that measure of activity is the rate and origin of article publication in the piezo material and application area where there has been weighty increase in publication media rate such as book, magazine, newspaper and journal at Russia, China and India. Some advantageous and logically price actuators produced low power consumption with high in reliability and environmental harshness. The perfect of piezo products is under development by a researcher nowadays. At last quarter of the 20^{th} century the number of activity was increased based on judging that has been performed.

2.4 References

While for this sub chapter will tell about the past project that related with Energy Scavenging with Shoe-Mounted Piezoelectric Power Generator project.

2.4.1 Shoe-Mounted PVDF Piezoelectric Transducer for Energy Harvesting.

This project is about an energy harvesting research has been conducted with ceramic based piezoelectric transducer because their relatively large electrical response to mechanical excitation. However, notwithstanding their comparatively low piezoelectric coefficients, piezoelectric polymers too hold promise as energy harvesting material due to their flexibility and strength which make them ideal candidates for use in more diverse polymers must be utilized in the most efficient manner possible. With these factors, a novel prototype for a piezoelectric transducer to parasitically harness the energy of heel strikes is designed and examined. This system of multiple vertical PVDF unimorphs is contained in an insert that fits into the tick rubber heel of a sneaker. Efficiently and output test results along with comparisons to calculated values are given. The maximum power from the heel transducer is found to be 0.06 mW and improvements in efficiency are achieved. [1]

2.4.2 A Shoe-Embedded Piezoelectric Energy Harvester for Wearable Sensors

This paper is about harvesting mechanical energy from human motion is an attractive approach for obtaining clean and sustainable electric energy to power wearable sensors, which are widely used for health monitoring, activity recognition and gait analysis. Besides, a piezoelectric energy harvester for the parasitic mechanical energy in shoes originated from human motion. The harvester is based on a special designed sandwich structure with a thin thickness, which makes it readily compatible with a shoe. A consideration is given to both high performance and excellent durability. The harvester provides an average output power of 1 mW during a walk at a frequency of roughly 1 Hz. Furthermore, a direct current (DC) power supply is built through integrating the harvester with a power management circuit. The DC poer supply is tested by driving a stimulated wireless transmitter, which can be activated once every 2-3 steps with an active period

lasting 5 ms and a mean power of 50 mW. This work demonstrates the feasibility of applying piezoelectric energy harvesters to power wearable sensors. [2]

2.4.3 Energy scavenging with shoe-mounted piezoelectric

This journal is about to decreasing size and power requirements of wearable microelectronic make it possible to replace batteries with systems that capture energy from the user environment. The unobtrusive device was developing at the MIT Media Lab scavenging electricity from the forces exerted on a shoe during walking. Flexible piezoelectric foils stave to harness sole-bending energy and reinforced PZT dimorph to capture heel strike energy. [3]