DESIGN AND DEVELOPMENT OF BATTERY-LESS ELECTRONIC FLOOR BASED ON HUMAN FOOT STEP IMPACT FORCE

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Sesi Pengajian : 1 6 / 1 7

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Dedicated to my beloved mother and father, my siblings and my colleagues who had been support me to complete this project.

Signature :

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ABSTRACT

Nowadays, electronic technologies have been growing up so fast and required a lot of electrical power consumptions. Battery is the most convenient power source for these electronic devices and have becoming one of the most important things in everyday life. However too dependent on battery may not be the ultimate solution as battery has limited lifespan. So, energy harvesting is one of the alternative way in producing energy. Energy harvesting or also known as power harvesting which derived or capture from ambient energy. The major challenge for energy harvesting is low output and which may not be sufficient to power up electronic device. Therefore, this project is to design and develop a battery-less electronic floor based on human foot step impact force using piezoelectric. This project will recover the kinetic energy from human steps impact and convert into electrical energy via conditioning circuit involving rectifier. Piezoelectric has the ability to generate AC voltage when force is being applied. The project consists of one floor tile which is embedded with a combination of a series parallel of piezoelectric that is capable to generate more than 5-volt DC after rectified at a force given which is more than 200N and able to power up a transmitter circuit to send a bit of data to the receiver circuit.

ABSTRAK

Pada masa kini, teknologi elektronik telah berkembang dengan begitu pantas dan memerlukan banyak konsumsi kuasa elektrik. Bateri adalah sumber kuasa yang paling mudah untuk peranti elektronik dan telah menjadi salah satu perkara yang paling penting dalam kehidupan seharian. Walau bagaimanapun, terlalu bergantung kepada bateri tidak boleh menjadi penyelesaian muktamad dimana bateri mempunyai jangka hayat terhad. Jadi, penuaian tenaga adalah salah satu cara alternatif dalam menghasilkan tenaga. Penuaian tenaga atau juga dikenali sebagai penuaian kuasa yang diperoleh atau ditangkap daripada tenaga ambien. Cabaran utama dalam menuai tenaga ini ialah adalah keluaran tenaga yang rendah dan mungkin tidak mencukupi untuk memberi kuasa kepada peranti elektronik. Oleh itu, projek ini adalah untuk mereka bentuk dan membangunkan lantai elektronik tanpa bateri berdasarkan daya impak kaki manusia menggunakan piezoelektrik. Projek ini akan mengitar semula tenaga kinetik dari impak langkah kaki manusia dan ditukar kepada tenaga elektrik melalui litar pendingin melibatkan penerus. Piezoelektrik mempunyai keupayaan untuk menjana voltan AC apabila daya diberikan kepadanya. Projek ini terdiri daripada satu jubin lantai yang tertanam dengan gabungan selari siri piezoelektrik yang mampu untuk menjana lebih daripada 5-volt DC selepas ditukar arus pada tahap kuasa yang diberikan lebih daripada 200N dan mampu untuk menghidupkan litar pemancar untuk menghantar bit data kepada litar penerima.

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LIST OF ABBREVIATION

PZT	-	Piezoelectric Disk/Plate Type
AC	-	Alternating Current
DC	-	Direct Current
V	-	Voltage
I	-	Current
R	-	Resistor
W	-	Watts
u	-	Micro
K	-	Kilo
M	-	Mega
RF	-	Radio Frequency
TX	-	Transmitter
RX	-	Receiver
PCB	-	Printed Circuit Board
s	-	Seconds
kg	-	Kilogram
m	-	mili
cm	-	Centimeter

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CHAPTER I

INTRODUCTION

1.1 Project Overview

In this current era, energy harvesting is not a something new anymore. There are a lot of research done by researcher all over the world as the world now need to find a better and greener energy to be use. Energy harvesting technologies is growing and become an alternative way to generate energy where the demand of energy around the globe are increasing. As the world seek for greener energy and more efficient solution like solar cell and wind generator, piezoelectric is also one of the energy harvesting technology. In today's world, a lot of electronic stuff such as gadget and not to forget systems such as security system needs energy to power up them. Energy harvesting is one of the solution to provide energy and has the potential to replace batteries for small, low power electronic devices. The search for reusable and clean energy are getting serious as it is an alternative

way to enhance the use of environmental energy around us. There are a lot of energy being wasted around us as we are not aware of.

The main reason of this project is to harvest the energy by using piezoelectric which is embedded in a floor. Piezoelectric tile is designed to capture the wasted energy and resources. The energy is harvested from the impact of human foot step, then this energy is stored in an energy storage device for further use. From the impact of human foot step, the energy stored in the capacitor will power up the load circuit which is the transmitter circuit to send a bit of data to the receiver circuit. The system comprises piezoelectric installed at a strategic location and a wireless data transmission system. This system could be one of the way as a monitoring system as every step on the piezo count and store to send the data wirelessly. It will benefit the opportunity to improve city walkability and is hoped to improve the transportation system based on the pedestrian traffic.

1.2 Problem Statement

Advanced technical developments have increased the efficiency of devices in capturing trace amounts of energy from the environment and transforming them into electrical energy. In addition, advancements in microprocessor technology have increased power efficiency, effectively reducing power consumption requirements.

In the great majority of today's wearable or portable devices, the energy necessary for their operation is provided by batteries. Batteries are a significant fraction of the total size and weight of the system. As technology scales down, this fraction is expected to further increase. Also, what is very important is the requirement for proper maintenance of batteries, with the need to either replace or recharge them. This is a one of the critical problem and become the limitation to the computing paradigms like ubiquitous computing or system which involved sensors, in which there are dozens or hundreds of small systems with batteries to be maintain.

One possibility to overcome these power limitations is to extract (harvest) energy from the environment to either recharge a battery, or even to directly power the electronic device.

In doing this project, there are some problem that were faced during the completion of this project. One of them is to test the piezoelectric itself. The machine which is the actuator can only press one piezo at a time. So, the problem is when doing an experiment to test a combination of connection of piezoelectric. It cannot be done with the help of the machine thus it need to be done manually with real human impact foot step. There are a few questions that need to be answered which one of them is how many piezoelectric should be used in this project, what is the best rectifier diode that has less power requirement and low voltage drop. Furthermore, this project involved a wireless transmission of data. One of the intention of this project is where a power generated from the piezo will be go through the rectifier and the power will power up a transmitter to transmit the bit to be received by receiver. With this, come another problem which is to find a suitable transmitter and receiver circuit that has low power consumption and can be power up by the energy harvester.

1.3 Project Objectives

This project is developed to accomplish certain objectives such as:

- To design energy harvesting project by using piezoelectric.
- To develop an energy harvesting circuit converting AC to DC for power up electronic circuit.
- To test the performance of this system in a control environment in the lab for the application.

1.4 Scope of Project

The main purpose of this project is to build or to design piezoelectric flooring system where the floor is designed to harvest energy from human foot step impact. The scope of this project is divided into several parts which are components and equipment, limitation and application.

For the components and equipment part, piezoelectric is used which is bought in electronic shops and not being designed by me. The type of piezoelectric which is being used is the Lead Zirconate Titanate (PZT) disk/plate type. Where it is one of the world's most popular piezoelectric ceramic materials, which make it happen to develop energy when stress is put on it. This project also includes rectifier circuit and amplifier circuit. The purpose of rectifier circuit for this project is to convert AC to DC as the output from the piezo is AC. The design of the circuit that is used is taken from the previous research and being re-design and improve to get better output from it. This project also need amplifier circuit as the output from piezo is very small and need to be amplify for further usage. All this circuit is being printed on PCB.

There is some limitation of this project's prototype which one of them is that this project is limited to be test in the controlled area as in the lab. The designed is subjected to be a conceptualize design. Regarding also about the prototype of this project, it consists of one tile which is embedded with piezoelectric.

Furthermore, as mention earlier, this project is targeted to replace the use of battery in term powering up of low power electronic device. In this context, it means that this system can power up low power wireless device or system which is battery-less. The system itself will gain power through the energy that is harvested from the impact of human foot step.

1.5 Thesis Organization

This thesis organization describe about what are the topics discussed on each chapter of this thesis. Chapter 1 discussed about the introduction of the project where all the basic information regarding this project is been discussed. In chapter 1 also discussed about why this project been choose as well as the important elements such as problem statement, objective and scope of project.

Chapter 2 is the literature review where it discussed about the background study and previous researches related to this project. The findings about piezoelectricity is one of the element included in this section.

Chapter 3 is the methodology. In this section, it tells about the flow of this project from the start until the end of this project. The block diagram as well as the experimental set up regarding this project also included in this section.

Chapter 4 is the result and discussion where in this part it describes about the project result that has been done. It includes all the analysis related to this project. Furthermore, it also includes simulation and experimental result.

In the last chapter which is chapter 5 it tells about the conclusion and future recommendation for this project. What is achieved and what need to be improve for this project is also included in this section.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter 2 will describe about the literature study which involved during completing this project. In this chapter, some research needs to be done to find theory and information that can be used in this project. Therefore, the previous related work was understood to complete this project. All the components used in this project were studied first before move to another step to make sure the understanding of the characteristic and behavior of the components is in line with the intended output.

Energy harvesting has become of a growing interest in the last few years and research report number has kept increasing for the last decade. These research reports are viewed and studied to have better understanding to start this project.

2.2 Introduction to Piezoelectric

A piezoelectric is a device that measure the changes in pressure when force act on it. The word piezo itself means electricity resulting from pressure. It came from a Greek word which mean squeeze or press and electric or electron, which is also stands for amber – an ancient source of electrical energy [1].

Figure 2.1: Piezoelectric Disk

Figure 2.1 above shows the picture of a piezoelectric which is ceramic plate type. The piezoelectric effect is a molecular phenomenon which can be seen at the macroscopic level as a change in electrical potential that is created when a piezoelectric is deformed. The first research and experiment was conducted in mid 1800s by Carl Linaeus and Franz Aepinus. The observation and experiment was not truly understood and until it was continued by the French's physicist, Jacques and Pierre Currie in 1880. The piezoelectric effect contained a special material property that exists in many single crystalline materials. An example of crystalline materials are Quartz, Rochelle salt, Topaz, Tourmaline, Cane Sugar etc. In addition, there are two types of piezoelectric effects, which are direct piezoelectric effect and converse piezoelectric effect. As mention earlier, for the direct piezoelectric effect, the electricity is produced when stress is applied to it. Whereas for the converse piezoelectric effect, stress/strain is produced when and electric field is applied.

Direct piezoelectric effect: $D=e^{T}S + \alpha^{s} E$ (2.1)

Converse piezoelectric effect: $\{T\}=c^{E} S – eE$ (2.2)

D is the electric displacement control, T is the stress vector, e is the dielectric permittivity matrix, c^E is the matrix of elastic coefficients at constant electric field strength, S is the stain vector, α^s is the dielectric matrix at constant material strain and E is the electrical field vector.

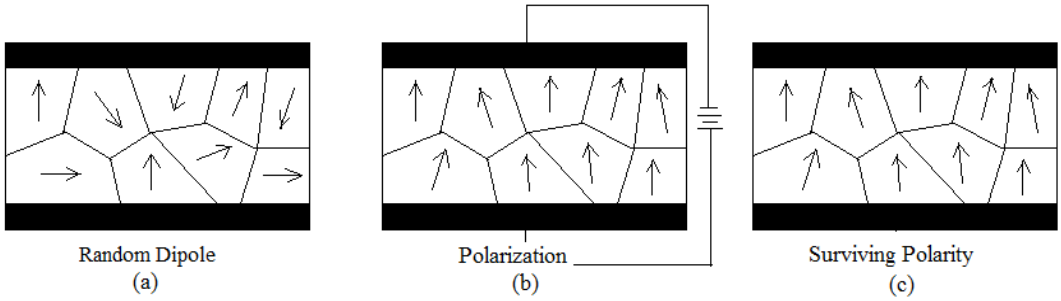

Figure 2.2: Polarization of ceramic material piezoelectric effect.

As what we already know, piezoelectric has the capability of creating a net voltage across the material when they are stressed. In [2] Initially, before the polarization electric dipole takes place, the direction of the molecules is randomly aligned where it is shown in figure 2.2(a). This phenomenon is happened in crystal which it is understood to has no center of symmetry [2]. When a strong electrical field is applied, the direction of molecules changes within the material which the electric dipoles re-orient themselves as shown in figure 2.2(b). When there is no electrical field, as shown in figure 2.2(c) the dipoles will maintain their orientation and the material then exhibit the piezoelectric effect. In regard to this, an electrical voltage can be recovered along any surface of the material when the material is subjected to a mechanical stress.

The output power from a single piezo is extremely low. Therefore, to tackle this problem, previous study has been done where it combines a few piezo in term of its connection to be tested. The kind of connection need to investigate to give optimum output. In [3], they connected 3 PZT in series, parallel and series parallel combination to test the outcomes. As the forces and stress is applied on these connection, the voltages corresponded were observed and noted.

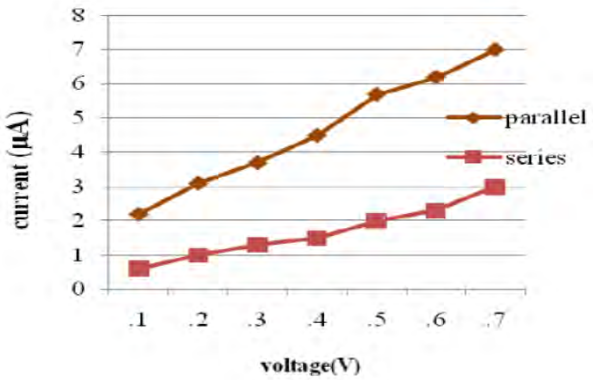

Figure 2.3: V-I graph of parallel and series connection [3].

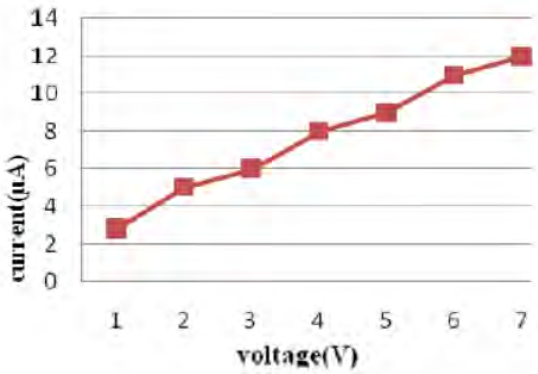

Figure 2.4: V-I graph of parallel and series combination [3].

From the graph, they obtained it shows that series connection obtained low current yet the voltage is good. As for the parallel, the current readings are good but the it has poor voltages reading. And the last combination is the series-parallel combination which has great voltage as well as the current is better than the previous connections.