Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF AN AUTOMATIC WELCOMING SIGNAGE USING PIEZOELECTRIC GENERATOR.

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Bachelor of Electrical Engineering Technology with Honours

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A project report submitted
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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours.

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Supervisor Name : DR. AZHAN BIN AB. RAHMAN

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DEDICATION

I dedicate this final year project to my beloved parents for never ending prayers and moral support.

I would also like to dedicate it to my supervisor Dr. Azhan Bin Ab Rahman for the guidance and critical comments throughout the project.

ABSTRACT

Piezoelectric materials are those that can be used to turn environmental vibrations into electrical energy. After that, The stored energy will be used to power other gadgets. Piezoelectric power generation in microscale devices can provide an alternate power source for certain types of sensors or actuators. A piezoelectric generator is a component that converts vibrations energy into electrical energy. A milistructure of bi-morph piezoelectric material will be used in this project. This material will be used to convert vibrations in the environment into electrical energy. On the ground, a piezoelectric generator is used. where it will absord the vibration from people walking or running in order to convert to electrical energy. Human being always produce vibration when on the ground when moving, and then can use piezoelectric to produce electrical energy. This electrical energy then will be used to power electronic components such as LED or any gadgets that required electrical input power. It will transform vibration energy to electrical energy using the piezoelectric concept. In this project, the piezoelectric will convert vibration energy from people walking to an electrical energy and will light up the welcoming signage.

ABSTRAK

Bahan yang boleh digunakan untuk mengubah getaran persekitaran menjadi tenaga elektrik dikenali sebagai piezoelektrik. Selepas itu, tenaga akan disimpan dan digunakan untuk menghidupkan peranti lain. Penjanaan kuasa piezoelektrik dalam peranti skala mikro dapat menyediakan sumber kuasa alternatif untuk jenis sensor atau aktuator tertentu. Penjana piezoelektrik adalah peranti yang mengubah getaran menjadi tenaga elektrik. Mististruktur bahan piezoelektrik bi-morph akan digunakan dalam projek ini. Bahan ini akan digunakan untuk mengubah getaran di persekitaran menjadi tenaga elektrik. Penjana piezoelektrik dilaksanakan di lantai atau tanah, di mana ia akan menyerap getaran dari orang yang berjalan atau berlari untuk menukar menjadi tenaga elektrik. Manusia selalu menghasilkan getaran ketika berada di atas tanah ketika bergerak, dan dengan itu dapat digunakan untuk menghasilkan tenaga elektrik menggunakan piezoelektrik. Tenaga elektrik ini kemudian akan digunakan untuk menggerakkan komponen elektronik seperti LED atau sebarang alat yang memerlukan kuasa input elektrik. Ia akan mengubah tenaga getaran menjadi tenaga elektrik menggunakan konsep piezoelektrik. Dalam projek ini, piezoelektrik akan menukar tenaga getaran dari orang yang berjalan ke tenaga elektrik dan akan menyalakan papan tanda kedatangan.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

V	-	Volt
µ	-	Micro
W	-	Watts
Hz	-	Hertz
mm	-	millimetre
m	-	milli
kWh	-	Kilowatt-hour
s	-	Second
F	-	Farad

LIST OF ABBREVIATIONS

$FTKEE$	-	Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik
$MOSFET$	-	Metal-Oxide-Semiconductor field-effect transistor
LED	-	Light-emmiting diode
STM	-	Scanning Tunneling Microscope
AFM	-	Atomic Force Microscope
$WWII$	-	World War 2
$CMOS$	-	Complementary Metal-Oxide-Semiconductor
$MEMS$	-	Microelectronic Mechanical Systems
$PEM\ IEH$	-	multimodal hybrid piezo-electromagnetic insole energy harvester
$NO2$	-	Nitrogen Dioxide
SnO2	-	Tin IV Oxide
$OWECs$	-	Oceanic Wave Energy Converters
$PISD$	-	Pipeline Inner Spherical Detector
HPS	-	High-pressure sodium
ppb	-	Parts per billion

CHAPTER 1

INTRODUCTION

1.1 Background

In Malaysia, Nonrenewable energy sources such as coal, gases, and fuels are the primary sources of electricity generation (M. S. N. Samsudin, M. M. Rahman, 2016). This source produces a large amount of carbon dioxide, which will raise greenhouse gas concentrations and cause global warming. Furthermore, the declining availability of these fuels and gases had prompted the world to seek out another source of energy. Thus, one of the alternative energies that will ensure 'green' energy is piezoelectricity (Abadi, Darlis and Suraatmadja, 2018).

Energy harvesting is a technique for generating electricity from the energy in the environment for example solar energy, wind energy, energy of the gas, vibration, flows of a liquid and many more (Elahi, Eugeni and Gaudenzi, 2018). Electromagnetism, photovoltaic thermoelectric and the four energy extraction technologies that receive the greatest attention among energy conversion technologies are piezoelectric technologies. Nevertheless, energy generated by numerous items, such as machine vibrations, motion, or any other type of mechanical energy that isn't being captured. Therefore, the source of energy is distributed and as a result wasted. Piezoelectric materials are used to collect wasted energy and convert it to electrical energy as an effective technique to make use of this energy loss. Because the amount of pressure applied is directly proportional to the electrical energy created, piezoelectric materials play a significant role. The practical use of the piezoelectric principle has the potential to make a significant impact by lowering electricity consumption costs. The use of piezoelectric materials to harvest energy from walking or running on specific area to light up a welcoming signage is a topic that truly reflects my curiosity. As the movement of busy area for example in shopping mall or in front of Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik (FTKEE) entrance, the capacity to gather this energy for the least amount of money would be a huge step toward cleaner energy creation. and greater efficiency.

Waste vibration energy must be turned into electrical energy using a piezoelectric generator and stored in a capacitor or battery. When the piezoelectric generator fails to create any energy, the capacitor or battery serves as a backup power supply for the charger. Most of this is based on the piezoelectric principle, which is a direct effect that may transform mechanical or vibration energy into electrical energy. Any moving object would be used as the source of vibration. In conjunction with that, walking or running has been chosen as the source of vibration. When utilised correctly, piezoelectrics offer various advantages, including the fact that they produce no harmful emissions and have a high voltage and current. The circuit for this project will designed to charge a battery and light up welcoming signage. This project prototype is built to protect against harm caused by high vibration such as footsteps, have a high efficiency in absorbing any moving things that is cause by vibrations, and be compact enough to be carry anywhere.

1.2 Problem Statement

More gasoline and gas are burned to create energy in today's fast-paced world. This is because of the growing number of population and more electricity demands around the world. These non-renewable energy sources are rapidly decreasing, and the world needs new energy options. One of the alternate energy sources is piezoelectric. Any type of vibration can be used to generate energy. One of the sources is vibration from us walking or running and the footsteps that can creates vibration. This vibration is a type of energy known as motion energy. Rather than just losing this energy, piezoelectric components can be used to harvest it and transform it into electrical energy. Simple electricity has been produced using piezoelectric energy to power microelectronic devices such as metal–oxide–semiconductor field-effect transistor (MOSFET) and power electronics equipment. However, the piezoelectric yet to be used in car or device that requires high voltage. The piezoelectric can only be used for small applications due to the low voltage produces. This project will investigate the power generated by the piezoelectric effect and create an application that can convert vibrations from walking or running into electrical energy. Piezoelectric energy also needs a lot of piezoelectric devices to generate high energy.

1.3 Project Objective

The following are the project's objectives:

I. To develop a piezoelectric generator to generate electricity from vibration.
II. To identify and investigate the voltage and current generated by the piezoelectric effect.
III. To identify the piezoelectric effect.

1.4 Scope of Project

I. To study the piezoelectric concept, characteristics, and the effect. In this project, the behaviour of the voltage and current provided by the piezoelectric element will be highlighted.
II. Design a prototype where vibration from a footstep is sufficient to cause the piezoelectric part to generate voltage and current and light up LED signage.

1.5 Thesis organization

The thesis's outline will detail the construction of an automated welcoming signage system based on a piezoelectric generator. The project introduction, literature review, methodology, results, and discussion, as well as the project conclusion and possible recommendations, are separated into five chapters. The first chapter will introduce the piezoelectric generator, which is currently used for electric storage or generation. It also contains the project's problem statement, objectives, and scope. Then, in chapter two a more detailed research is conducted to write the literature review and background studies. The research methodology section of chapter three explains how the project was created. The results of the experiments are then summarized and addressed in Chapter four to form an analysis. Finally, chapter five brings the overall project to a close. It will summarize the thesis' key points from chapter one to chapter four. After that, a further suggestion is made for the project's improvement in preparation for future study.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is essentially a high-level overview of the project and its goals. It is also a study of the variations and similarities between different authors' points of view. Books, dissertations, journal publications, and other written content, whether physical or electronic, are used to conduct the research. The analysis provides an overview of the research field and its implementation, as well as its benefits and limitations.

2.2 Background of piezoelectric

The ability of some materials to generate an electric charge when mechanical force is applied in figure 2.1 is known as the Piezoelectric Effect. Piezoelectric comes from the Greek words piezein, which means "to squeeze or press," and piezo, which means "push" (Uchino, 2010). The direct piezoelectric effect (the creation of electricity when stress is applied) is reversible, which means that materials that have the direct piezoelectric effect can also have the reverse piezoelectric effect (the generation of stress when an electric field is applied). When a piezoelectric material is subjected to mechanical stress, the material's positive and negative charge centers shift, producing an external electrical field. When the piezoelectric material is inverted, an external electrical field stretches or compresses it.

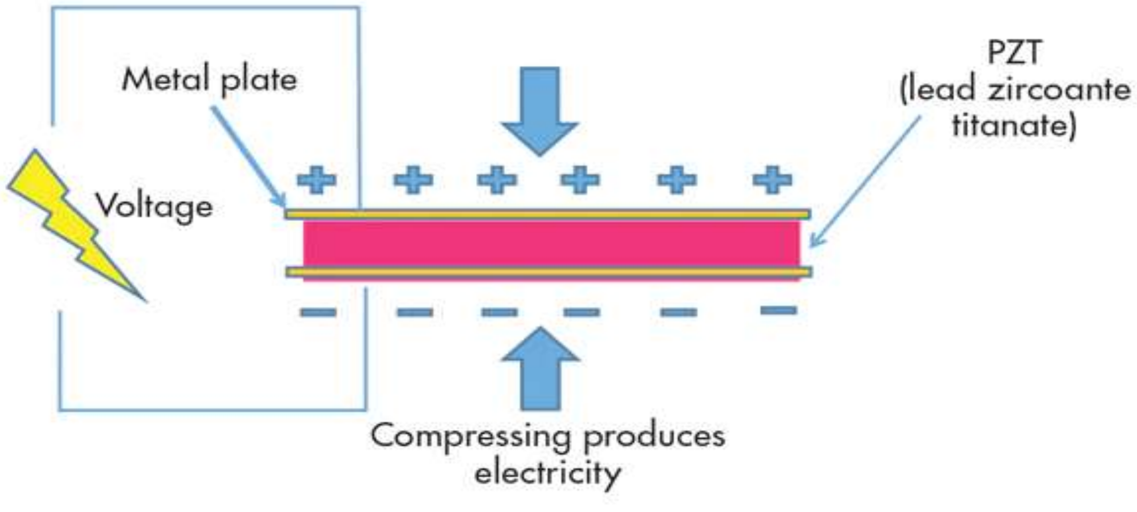

Figure 2.1: Piezoelectric is compressed to produce electricity (Carmen, 2016).

Sound creation and detection, high-voltage generation, electronic frequency generation, microbalances, and ultra-fine focusing of optical assemblies are all applications that benefit from the piezoelectric effect (Manbachi and Cobbold, 2011). It is also the backbone for a variety of atomic-resolution scientific tools like scanning probe microscopes (STM, AFM, etc). The piezoelectric effect is also employed in more daily applications, such as as an ignition source in cigarette lighters.

2.2.1 History of piezoelectric

The brothers Pierre and Jacques Curie were the first to note the direct piezoelectric effect in 1880 (Uchino, 2010). By integrating their knowledge of pyroelectricity with their understanding of crystal structures and behaviour, the Curie brothers demonstrated the first piezoelectric effect using crystals of tourmaline, quartz, topaz, cane sugar, and Rochelle salt. Quartz and Rochelle salt had the highest piezoelectricity potential at the time of their demonstration. Piezoelectricity remained a laboratory fascination over the following few decades, with more study being done to reveal the piezoelectric effect's vast potential. In figure 2.2, the sonar system, which was created in France during World War I by Paul Langevin and his colleagues, was the first practical application for piezoelectric systems. They developed an ultrasonic undersea detector consisting of a transducer and a hydrophone constructed of thin quartz crystal sandwiched between two steel plates (Uchino, 2010).

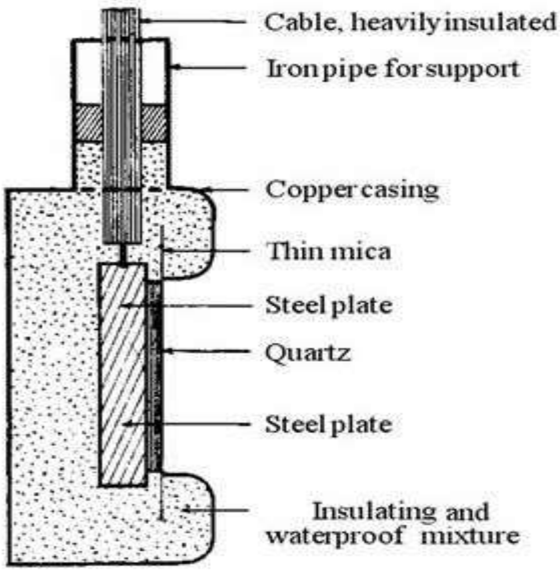

Figure 2.2: Cross sectional view of first ultrasonic detector by Paul Langevin (Cyprien, 2019).

This early use of piezoelectricity in sonar inspired an interest in piezoelectric devices all across the world. For the next few decades, new piezoelectric materials and uses were investigated and established. During WWII, scientists in the United States, Russia, and Japan developed ferroelectrics, a new class of man-made materials with piezoelectric constants several times higher than natural piezoelectric materials. Despite the fact that quartz crystals were the first commercially exploited piezoelectric material and are currently utilised in sonar detecting applications, scientists sought out other materials. Because of this extensive research, two materials with extremely particular characteristics suitable for specific applications were developed: barium titanate and lead zirconate titanate (Uchino, 2010).

2.2.2 Piezoelectric materials

When mechanically deformed, some materials, such as ferroelectrics, exhibit polarisation changes because their crystal structure lacks a centre of symmetry (strain). When mechanical strains are applied to piezoelectric materials, they produce electricity. The type of material used in piezoelectric energy harvesting has a big impact on how well it works. As a result, a wide variety of materials have been investigated for piezoelectric energy harvesting, including inorganic, organic, and composite materials. Many natural and man-made materials show piezoelectric properties in varying degrees. Berlinite (structurally identical to quartz), cane sugar, quartz, Rochelle salt, topaz, tourmaline, and bone are some naturally occurring piezoelectric minerals shown in figure 2.3. (The apatite crystals in dry bone give it some piezoelectric qualities, and the piezoelectric effect is assumed to operate as a biological force sensor). Man-made piezoelectric materials include barium titanate and lead zirconate titanate, as seen in figure 2.4.

(a) (b)

Figure 2.3: Example of natural piezoelectric material: (a) Quartz (JJ Harrison, 2009) and (b) Berlinite (DMGualtieri, 2012)

(a)

(b)

Figure 2.4: Type of man-made piezoelectric material: (a) Barium titanate (Materialscientist, 2009) (b) Lead zirconate titanate (Piceramic, 2021)

2.2.3 Advantages and disadvantages of piezoelectric

The benefits of piezoelectric energy harvesting are numerous (Covaci and Gontean, 2020). It has high energy and power density. It also has simple structure and good scalability. It is easy to suit and mount in high-density electronic devices due to its small dimensions. Then piezoelectric also does not require the use of an external voltage source. When a force is applied to a piezoelectric material, it produces a voltage. External power is not required for piezoelectric materials. Piezoelectric and hybrid materials can be combined to provide a wide range of voltages. Piezoelectric transducers are available in a variety of forms. Most piezoelectric materials can be designed in a variety of shapes and sizes, making them extremely useful in a variety of applications and fields. Energy collecting structures can simply incorporate piezoelectric transducers. Curie temperatures are high in many piezoelectric materials (the temperature at which piezoelectricity is lost in materials).

Considering their many benefits, piezoelectric energy harvesting technologies have a few limitations (Covaci and Gontean, 2020). One of the downside is when compared to other harvesting techniques, such as thermoelectric, the power harvested is modest. Piezo materials create very little electric charges despite being self-creating, demanding the need of a high impedance connection to connect them to an electrical interface. Rectification, maximum power extraction, and output voltage regulation are all requirements for piezoelectric harvesters. Piezoelectric energy harvesters are not necessarily suited for use