



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PIEZOELECTRIC ENERGY HARVESTING FLOOR MAT

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor's Degree of Electronic Engineering Technology (Telecommunication) with Honours

by

NUR LIYANA BINTI KAMARUL ANUAR

B071310283

910624-14-5770

FACULTY OF ENGINEERING TECHNOLOGY

2016

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **PIEZOELECTRIC ENERGY HARVESTING FLOOR MAT**

SESI PENGAJIAN: **2016/2017 Semester 1**

Saya **NUR LIYANA BINTI KAMARUL ANUAR**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

Cop Rasmi:

Alamat Tetap: No: 39, Jalan Ibu Kota 10,
Taman Setapak Indah 53100 Kuala
Lumpur.

Tarikh: _____

Tarikh: _____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled “Piezoelectric Energy Harvesting Floor Mat”
is the results of my own research except as cited in references.

Signature :

Author's Name : NUR LIYANA BINTI KAMARUL ANUAR

Date : 8 DISEMBER 2016

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor's Degree of Electronic Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

.....
PUAN.AZIEAN BINTI MOHD AZIZE
(Project Supervisor)

ABSTRAK

In this era of technology development, the main concern is the need to develop new energy sources. One of the sectors that have attracted much interest is devices that are able to convert other types of energy into electrical energy. The purpose of this "Piezoelectric Energy Harvesting Floor Mat" project is to develop a low-voltage electrical energy based on the concept of green technology. This project also will show that the presence of waste vibration energy might have some value to be used. Systems involved in this project is energy harvesting involves the conversion of dynamic compression of floors by people walking across piezoelectric materials into electrical energy, which exhibit electromechanical coupling between the electrical and mechanical domains. Mechanical vibration energy that results when people walk across received by the piezoelectric will generate a small electric energy, this electric energy also knows as a piezoelectricity and then the electricity will be connected to a voltage doubler circuit having a diode as a rectifier and convert an alternating voltage to a direct current voltage. When there is a direct current voltage, this voltage will be stored in the battery charger circuit which acts as a collector electric energy. Next, the recommendation area for this energy harvester circuit are at pedestrian, and this project had been connected with the traffic light.

ABSTRACT

Pada era zaman Pembangunan Teknologi ini, kebimbangan utama adalah keperluan untuk membangunkan sumber tenaga baru. Salah satu sektor yang telah menarik minat banyak adalah peranti yang dapat menukar jenis tenaga yang lain kepada tenaga elektrik. Tujuan terhasilnya projek "Piezoelectric Energy Harvesting Floor Mat" ialah untuk membangunkan tenaga alternatif elektrik yang bervoltan rendah berdasarkan konsep teknologi hijau. Projek ini juga akan menunjukkan bahawa kehadiran tenaga getaran yang terbuang secara sia-sia mungkin mempunyai beberapa nilai yang dapat digunakan. Sistem yang terlibat bagi projek ini adalah penuaian tenaga yang melibatkan penukaran tenaga getaran mekanikal yang terhasil apabila manusia berjalan kepada tenaga elektrik menggunakan komponen utama piezoelektrik, yang mempamerkan gandingan elektromagnetik iaitu antara domain elektrik dan mekanikal. Tenaga getaran mekanikal yang terhasil apabila manusia berjalan yang diterima oleh piezoelektrik akan menghasilkan tenaga elektik yang berskala kecil dan seterusnya tenaga elektrik ini akan disambungkan kepada litar pendua voltage yang mempunyai diod sebagai penerus dan menukar voltan ulang alik kepada voltan arus terus. Apabila terdapat voltan arus terus, voltan ini akan disimpan pada litar pengecas bateri yang bertindak sebagai pengumpul tenaga elektrik. Seterusnya, kawasan yang sesuai untuk penuai tenaga ini adalah di kawasan pejalan kaki dan project ini dapat disambungkan dengan lampu isyarat.

Specially dedicated to

My loving parents,

Kamarul Anuar bin Rahillah

and

Noor Huzaini binti Othman

My siblings,

Khairul Hidayat and Nur Afiqah

Who always stay by my side, give inspiration to me and
taught me that difficult roads often lead to beautiful
destinations.

ACKNOWLEDGEMENTS

In the name of Allah. First and foremost, I would like to thank Allah s.w.t for His blessing and help in giving me the strengths to complete this Final Year Project. I am deeply indebted to individuals who directly or indirectly, are responsible for this project.

Secondly, to the person that I am most grateful to thank is the most kind heartedness supervisor, Madam Azien Binti Azizi and my Co-supervisor Mr.Fakhrullah Bin Idris for their cooperation, hard work and superior guidance in this project. Besides, I would like to appreciate to the panels with their advice, information and ideas for this project become abundance.

My admiration falls upon to the very important person in my life, Encik Kamarul Anuar bin Rahillah, my beloved father, and especially to my beloved mother, Puan Noor Huzaini, for their love and supporting me through all this years. Your pray, sacrifice and encouragement are really appreciated.

Last but not least, I wish to express my sincere thank you to all my friends for their contribution and ideas during the development of the project.

TABLE OF CONTENT

DECLARATION	iii
APPROVAL	iv
ABSTRACT	v
ABSTRAK	vi
DEDICATIONS	vii
ACKNOWLEDGMENTS	viii
TABLE OF CONTENTS	ix
LIST OF TABLE	xi
LIST OF FIGURES	xii
CHAPTER 1: INTRODUCTION	1-5
1.1 Background of the Project	1
1.2 Problem Statement	2
1.3 Objectives	3
1.4 Scope of the Project	3
1.5 Project Outline	4
CHAPTER 2: LITERATURE REVIEW	6-17
2.1 Introduction	6
2.2 Energy Harvesting	6
2.3 Method Used in Piezoelectric Element	9
2.3.1 Piezoelectric Energy Harvesting Shoe	9
2.3.2 Power-Generating Floor	10
2.3.3 Piezoelectric Bimorph model	11
2.4 Basic of Piezoelectric	12
2.4.1 Piezoelectric Transducer	13
2.4.2 Piezoelectric Principle	14
2.4.3 The Piezoelectric effect	15

	18 -27
CHAPTER 3: METHODOLOGY	
3.1 Introduction	18
3.2 Implementation of the project	18
3.3 Circuit Design	21
3.4 System of the Project	23
3.4.1 Piezoelectric	24
3.4.2 Voltage doubler circuit	25
3.4.3 Rechargeable battery	26
CHAPTER 4 : RESULTS AND DISCUSSION	28 - 43
4.1 Introduction	28
4.2 Piezoelectric sensor	28
4.2.1 Result tested between two sizes of piezoelectric	29
4.3 Voltage doubler Circuit	30
4.3.1 DC Voltage Doubler Circuit	30
4.3.2 DC Voltage Quadrupler Circuit	32
4.3.3 Compares between DC Voltage Doubler Circuit and DC Voltage Quadrupler Circuit	34
4.4 Testing the output voltage between Multisim and Hardware	35
4.4.1 Output Voltage measure by Hardware	36
4.4.2 Output Voltage measure by Multisim	39
4.4.3 Input and Output voltage	41
4.5 Storage Energy	43
CHAPTER 5 : CONCLUSION AND RECOMMENDATIONS	44 - 45
5.1 Conclusion	44
5.2 Recommendations	45
REFERENCES	46 - 47
APPENDICES	48 - 50

LIST OF TABLES

1.1	List of component to design a circuit	19
1.2	Features and Advantage of two size piezoelectric	29
1.3	Results of Output DC Voltage Doubler Circuit	31
1.4	Results of Output DC Voltage Quadrupler Circuit	33
1.5	Result of Input and Output Voltage from hardware	38
1.6	Result of Input and Output Voltage from Multisim Software	40
1.7	Compares of two types of battery	43

LIST OF FIGURES

Figure 1	Energy harvesting uses unconventional sources to power circuitry.	7
Figure 2	Diagram of a photovoltaic cell	8
Figure 3	Example of design Piezoelectric Energy Harvesting Shoe	9
Figure 4	“Power-generating floor” was installed at the ticket gates of train stations in Tokyo	10
Figure 5	A two layer piezoelectric material mounted as cantilever	11
Figure 6	Direct and Converse Piezoelectric Effects	12
Figure 7	A typical piezoelectric transducer	13
Figure 8	Piezoelectric effect with the help of a compression disk	14
Figure 9	The product of the acceleration and the seismic mass	15
Figure 10	Direct Piezoelectric Effect	16
Figure 11	The Entire Project Flow Chart	18
Figure 12	Flow Chart of Project Circuit Design	21
Figure 13	Block Diagram Of Project System	22
Figure 14	Simulation of Voltage Doubler Circuit	23
Figure 15	Nickel Cadmium (NiCd) Battery	26
Figure 16	Lead Acid Battery	27
Figure 17	DC Voltage doubler Circuit connection tested.	30
Figure 18	DC Voltage Quadrupler Circuit connection tested.	32
Figure 19	Line Graph plot of voltage against number of Piezoelectric	34
Figure 20	Project Hardware	36
Figure 21	Point to Measure Input and Output	37
Figure 22	Circuit tested in Multisim	39
Figure 23	Line Graph plot of Input Voltage against Output Voltage in Hardware and Multisim	41

CHAPTER 1

INTRODUCTION

1.1 Background of the Project

Nowadays, we are in an era of increasing energy costs and decreasing supplies of fossil fuels, other than that we are also with an emphasis on protecting the environment and creating a renewable source of energy are a sustainable form of having become vital now. This is because the energy is used in our daily life and one of the energies that we use every day is electric energy. Electrical energy is used to power electrical or electronic devices.

Around us, there are a variety of renewable sources for generating new energy sources such as mechanical vibrations produced when people walk across. The vibrations can be generated into electric energy by a piezoelectric device. Piezoelectric devices are implements that use materials exhibiting piezoelectric effects. "Piezo," in Greek, means "pressure," which explains that when you apply pressure to piezoelectric materials, you get an electric energy[1]. It is show that the presence of waste vibration energy might have some value.

The energy that yields from the piezoelectric sensor device is known as piezoelectricity. Piezoelectricity is a form of coupling between the mechanical and the electrical behaviours of ceramics and crystal belonging to certain classes[2]. This piezoelectricity concept is same as an Electromagnetics (EM) meaning which is known as the study of electric and magnetic phenomena.

But there is electric energy that produces by each piezoelectric is only in a few volts, to make this project is an energy harvesting it needs more volts. Voltage doubler circuit had applied to this harvesting energy so that the voltage that had produce is in more voltage. Besides that, battery charger circuit also had applied to

this harvesting energy it is because this battery charge circuit can storage an electric energy that had produced by voltage doubler. To know whether the electric energy from this Piezoelectric Energy Harvesting Floor Mat is enough to power such a small electronic devices, it will be testing to a simple traffic light circuit.

1.2 Problem Statement

In our daily life, thing that we are usually do is walking. Went we walking there are a dynamic compression on every steps we walking. Without we know, this dynamic compression is very useful to use.

A dramatic consumption of energy supply is high demand for the daily uses. So we need to think a renewable energy solution that can be used in the energy generated by the natural environment, ecosystem, humans and animal, which can help to constraints energy source in the future.

Other than that we are also an emphasis on protecting our environment. So, there is a concept that we can develop a new technology of renewable energy based on green technology concept. The goal of this technology is to provide a remote source of electric power and to recharge storage devices, such as batteries and capacitors. The concepts have ecological ramifications in reducing the chemical waste produced by replacing batteries and potential monetary gains by reducing maintenance costs.

In addition, there are many research activities in developing a new energy sources which are renewable, reliable and efficient. Nowadays, there are many countries have show their support towards “green technology” and renewable energy concept. Even for the developing countries such Malaysia, the government had show their support by implementing some rules and laws regarding the environment concept. However, those supports can only be seen as some kind of camping as to realize the concept into the citizen mind.

Beside, the “technology” terms are also not being implemented much as there are not so many products with green technology concept are produced. Therefore, this project is proposing for developing a device that capable for generating low-voltage electric energy and can be renewable.

By developing the “Piezoelectric Energy Harvesting Floor Mat” it utilize the dynamic compression to be applied at the sidewalk and pedestrian for generating electric energy. The electrical energy can be used for powering electrical appliance and facilities such as traffic light. Plus, this project perhaps could be implemented to aid hawkers and stalls especially at the market for their electrical use.

1.3 Objectives

There are three main objectives of this project. These objectives serve as guides and milestones to the project in order to have a clearer view of the target results. The objectives of the project are as follow:

- I. To study an alternative electric power source based on green technology concept.
- II. To know how piezoelectric can generate electrical energy.
- III. To design device that can harvest energy from dynamic compression.

1.4 Scope of the Project

To start implant this project, there are several thing that need to plant which knows as scope. This is because to know the limit of the project, the following below is scope of this project.

The first scope of this project is to produce an energy harvest based on dynamic compression by walking. This mat will absorb dynamic compression energy by using piezoelectric transducer.

Next, voltage doubler had been used to receiver of voltage that piezoelectric transducer has produce. And then, voltage doubler circuit also used to change AC Voltage to DC Voltage and also double the input voltage.

To act this mat as energy harvester, battery charger circuit had applied to this project to store the voltage from voltage doubler circuit. This circuit had charge the battery until 12 DC Volt and at the same time this circuit also is apply the electric energy to switch on LED.

Lastly, this device also can be portable and easy to bring, this is because it can aid hawkers and stalls especially at the market for their electrical use.

1.5 Project Outline

This project outlines will briefly explain about the organization of the report that divided with the several chapters to make more clearly and structured. There will involve with five chapters that involved in Introduction to the Project, Literature Review, Methodology, Expected Result and Conclusion.

Chapter 1 is the Introduction for overall project concepts. This chapter will make clear about the Project Background, Problem Statement, Objectives and lastly the Scope of the project. The important of this chapter is it will be guideline for the whole projects analysis and researches.

Chapter 2 is the Literature Review of the project that covers the previous studies, researches and finding that related to the project. From this chapter the theory and application that discussed use inside researches will be references along the project

process. There are some researches and finding that related to the project be explain in this chapter.

Chapter 3 is the Methodology of the project which presented all the steps, projects flow chart, and block diagram. The projects process show how it works and will be discussed on this chapter. The design of the system will be included in this chapter.

Chapter 4 is the results from both simulation and experiment. The simulation software uses is Multisim to test the circuit. The overall results will be purposed in this chapter. The simulation and calculation result will proceed to the analysis.

Lastly, Chapter 5 is concluded the objectives that stated before. The conclusion is based on the result obtained at Chapter 4. In addition, it also will have discussion and also on recommendation for future work from the researches and result.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this section, there were an idea and hypotheses about in how the piezoelectric worked to get an electric energy. Other than that, this section additionally will investigate and comparison between the available projects, researches, and studies. Besides that in this section there is also show how piezoelectric elements incorporated with the vibrations created by people walking across it into electric power. Literature review work as the initial process of generating ideas about the projects provides extra understanding and valuable information.

2.2 Energy Harvesting

The expressions of "power harvesting" or "energy scavenging" are likewise used to describe the same process. This process is based on a concept that is the process in which energy is captured from a system's environment and converted into usable electric power.[4] Or in other words, energy harvesting also know as energy that collected from the instrument's immediate environment, offering perpetual operation with no connection to the grid and minimal or no maintenance requirements.[5]

Based on Figure 1 there are examples of energy source for energy harvesters is present as ambient background and is free. Ambient motion is one of the main sources of energy for harvesting and a wide range of motion-powered energy harvesters. Examples energy source include light (captured by photovoltaic cells),

vibration or pressure (captured by a piezoelectric element), temperature differentials (captured by a thermo-electric generator) radio energy (captured by an antenna); and even biochemically produced energy (such as cells that extract energy from blood sugar).[4]

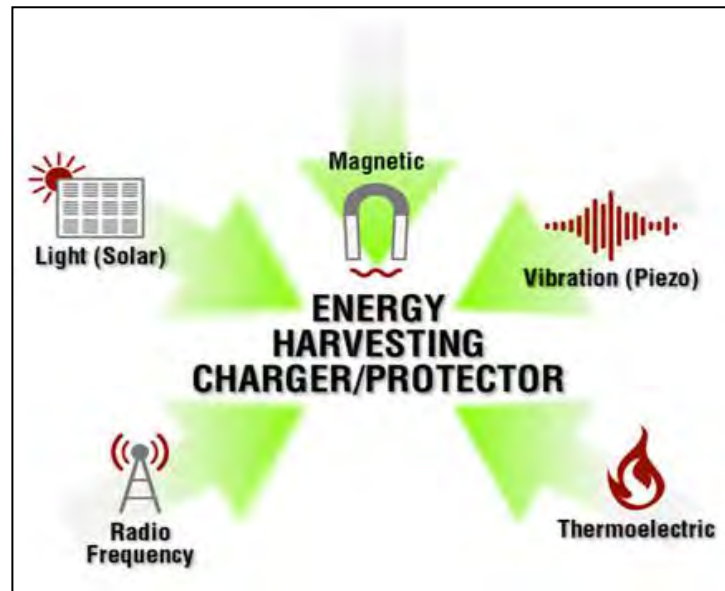


Figure 1 Energy harvesting uses unconventional sources to power circuitry.[4]

The most common sources of energy available for harvesting are vibration (or motion), light and heat. The transducers for all of these energy sources have three characteristics in common:

- Their electrical output is unregulated and doesn't lend itself to being used directly for powering electronic circuits
- They may not provide a continuous, uninterrupted source of power
- They generally produce very little average output power, usually in the range of $10\mu\text{W}$ to 10mW .

These characteristics demand judicious power management if the source is going to be useful in powering wireless sensors or other electronics[6]. Energy harvesting from a natural source where a remote application is deployed, and where such natural energy source is essentially inexhaustible, is an increasingly attractive alternative to inconvenient wall plugs and expensive batteries[5].

Energy harvesting holds great promise for both low-voltage and low-power applications in a wide range of portable or mobile markets such as medical equipment, consumer devices, transportation, industrial controls and military.[7] An energy harvesting system generally includes circuitry to charge an energy storage cell, and manage the power, providing regulation and protection.[4]

Then, energy harvesting can allow electronics equipment to operate when there's no conventional power source, eliminating the need to run wires or make frequent visits to replace batteries. In addition, energy harvesting can be used as an alternative energy source to supplement a primary power source and to enhance the reliability of the overall system and prevent power interruptions.

Besides that, there are another type of energy harvesting that are commonly used which is Photovoltaic Energy Harvesting, Thermoelectric Energy Harvesting and Wind Energy Harvesting. All of this energy harvesting has their unconventional source to produce energy power.

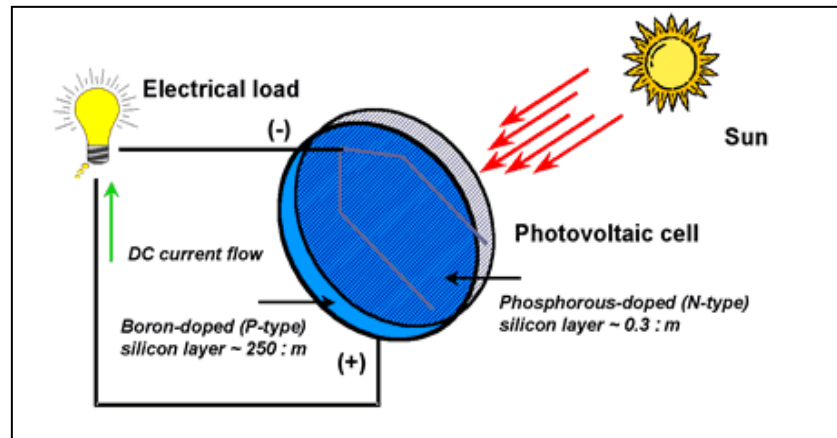


Figure 2 Diagram of a photovoltaic cell

Example of unconventional source for Photovoltaic Energy Harvesting is light, this Energy Harvesting system will operate when Photovoltaic collects light energy from the environment. Photovoltaic is a popular power source for consumer electronic devices, example of electronic device that use this power source including calculators, watches, radios, lanterns and other small battery-charging applications. Figure 2 show the diagram of photovoltaic cell.

2.3 Method Used in Piezoelectric Element

2.3.1 Piezoelectric Energy Harvesting Shoe

A project by Abu Darda' Bin Mohd Isham had developed a shoe as a efficiency of Energy Harvesting by using piezoelectric. The purpose of this project is to harvest the wasted energy from human walking and store it in battery. The energy inside the battery can be used for travellers in deep forest who needs source of light at night by light up torchlight. Piezoelectric had placed under sole of a shoe to create vibration. Figure 3 had show an example of design a Piezoelectric Energy Harvesting Shoe



Figure 3 Example of design Piezoelectric Energy Harvesting Shoe

The circuit had contain five piezoelectric, this is because if only use one piezoelectric is not enough to charge two battery 1.5V. Full wavebridge rectifier which contains four schottky diode had used to rectify a electric energy from alternating current(AC) to direct current(DC) that had been produce by piezoelectric. Battery and capacitor had use to act as a charging element.

Went tested had been done to this project it will find that the voltage had reached to 3.2V as a maximum value in 32 times knocked. After 32 times knocked, the voltage will drop until zero as the capacitor was discharging.[8]

2.3.2 Power-Generating Floor

A Demonstration experiment by Japan Railway Company had tested the “Power-generating floor” which is an environmentally friendly system that generates electricity by using the energy from the vibrations created by people walking on the floor. The piezoelectric elements incorporated inside the flooring transform pressure and vibration into electric power.

In Figure 4 had shows that this “Power-generating floor” was installed at the ticket gates of train stations in Tokyo where there is high traffic of people walking. Other than that, this “Power-generating floor” was using the electricity generated to cover a portion of the electrical output for such station facilities as automatic ticket gates and electroluminescence displays.



Figure 4 “Power-generating floor” was installed at the ticket gates of train stations in Tokyo

Went this “Power-generating floor” was tested in 2 months, it had production of electricity reached a maximum of 10,000 watt-seconds per day (equivalent to the electricity needed to light a 100W light bulb for 100 seconds). [9]

2.3.3 Piezoelectric Bimorph model

As we know, piezoelectric is materials that can be used as a means of transforming ambient vibrations into electrical energy that can be stored and used to power other devices. The energy produced by these materials is too small and directly power to electrical device. However, if the material is use in a large scale and in a collective power as storage, it is shown that the small energy is just a turning point to harvest slightly large electrical energy.

In this paper by Mahmoud Al Ahmad and Amro M. Elshurafa et al, show a method to find the maximum power transfer conditions in bimorph piezoelectric-based harvesters is proposed. This paper show how there had using piezoelectric bender generators. A bending element could be mounted in many ways to produce a generator.

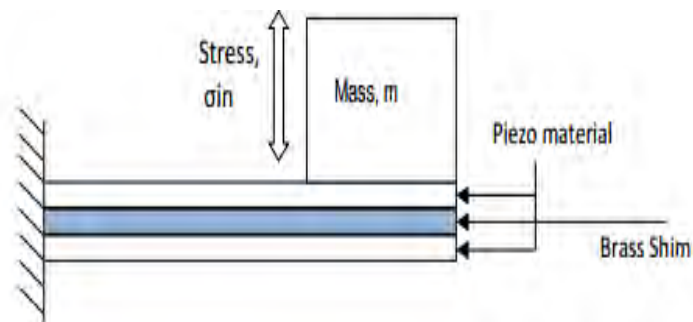


Figure 5 A two layer piezoelectric material mounted as cantilever

One of the ways is connecting two piezoelectric beams that are separated by a shim which also called the piezoelectric bimorph. Figure 5 shows that a two layer piezoelectric mounted as a cantilever beam with a mass placed on the free end. This type had chosen for two reasons. First, for a given force input, the cantilever configuration results in the highest average strain, and the power output is closely related to the average strain developed in the bender. Piezoelectric also preferred as they efficiently convert mechanical stress or strain to an electrical voltage or charge without any additional power. [10]

2.4 Basic of Piezoelectric

Basically, there are three basic vibration-to-electric energy conversion mechanisms which is electromagnetic, electrostatic and piezoelectric.[3] Piezoelectric are materials that can make power when subjected to a mechanical anxiety. They will likewise work backward, producing a strain by the use of an electric field. Or in other word, piezoelectric is knows as crystals which get a charge when compressed, twisted or distorted are said to be piezoelectric.

The piezoelectric effect exists in two domains, the first is direct piezoelectric effect that describes the material's ability to transform mechanical strain into electric charge, the second form is the converse effect, which is the ability to convert an electrical potential into mechanical strain energy. There are two types of piezoelectric signals that can be used in technological applications. These two types of piezoelectric signals had show in Figure 6.

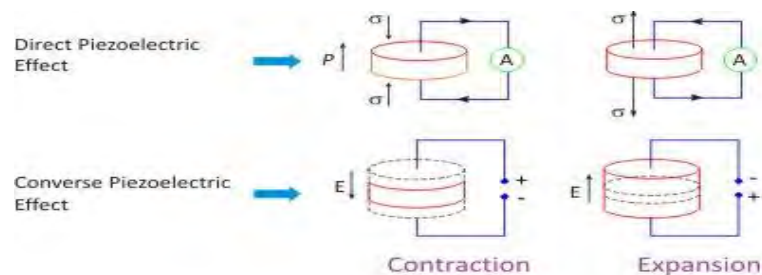


Figure 6 Direct and Converse Piezoelectric Effects

The direct piezoelectric effect that describes the ability of a given material to transform mechanical strain into electrical signals and the converse effect, which is the ability to convert an applied electrical solicitation into mechanical energy. This direct piezoelectric effect is more suitable for sensor applications, where the converse piezoelectric effect is most of the times required for actuator applications [6]. The piezoelectric materials that exist naturally as quartz, which possess properties for the production of electricity in very small quantity, however compare to quartz an artificial piezoelectric materials such as PZT(Lead Zirconate Titanate) present advantage characteristics of generating more electricity[7].