“Energy Harvesting Using Piezoelectricity”

Seminar Report

Submitted in the partial fulfilment of requirement for award of degree
Of
Bachelors of Technology
In
Electronics and Communication Engineering
Presented at

University School of Information and Communication Technology
Guru Gobind Singh Indraprastha University
Sector 16C, Dwarka, New Delhi

SUBMITTED BY:

Rahul Singh Thakur(08316412812)

B.Tech (Electronics and Communication Engineering) – 8th Semester

University School of Information and Communication Technology

ABSTRACT

Energy consumption is a major problem everywhere, solutions to which are given in a number of ways. The concept is to capture the normally lost energy surrounding a system and converting it into electrical energy that can be used to extend the lifetime of that system's power supply or possibly provide an endless supply of energy to an electronic device which has led to power harvesting. One of the most interesting methods of obtaining the energy surrounding a system is to use piezoelectric materials. There exists variety of energy harvesting techniques but mechanical energy harvesting happens to be the most prominent. This technique utilizes piezoelectric components where deformations produced by different means are directly converted to electrical charge via piezoelectric effect. Subsequently the electrical energy can be regulated or stored for further use. The proposed work in this research recommends Piezoelectricity as an alternate energy source. The motive is to obtain a pollution-free energy source and to utilize and optimize the energy being wasted. Piezoelectric materials have a crystalline structure that provides a unique ability to convert an applied mechanical strain into an electrical potential or vice versa. These two properties allow the material to function as a power harvesting medium. In most cases the piezoelectric material is strained through the ambient vibration around the structure, thus allowing a frequently unused energy source to be utilized for the purpose of powering small electronic systems.

The project is using piezoelectric materials which convert the mechanical stress into electric charges. This is possible due to the gap in the material and because of dipole-dipole interaction. As soon as the stress is applied on the surface, the dipole interaction increases causing an effective charge and using various techniques this charge can be converted into electricity. The unit cell is symmetrical in piezoelectric crystals. Normally the piezoelectric crystals are electrically neutral, the atoms inside them may not be symmetrically arranged but they are electrically neutral.

Reverse piezoelectric effect is also possible that is, the pressure can deform the crystals if we apply the potential difference across them. The conversion of electricity is useful as it can generate power which can be used further.

CONTENTS

LIST OF FIGURES

INTRODUCTION

Piezoelectricity is the charge which accumulates in certain solid materials (such as crystals and ceramics) in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure. Piezoelectricity was discovered in 1880 by French physicists Jacques and Pierre Curie. The Piezoelectric effect is understood as the linear electro-mechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry. The piezoelectric effect is a reversible process in those materials exhibiting the direct piezoelectric effect. For example, PZT (Lead Zirconate Titanate) crystals will generate measurable piezoelectricity when there static structure is deformed by about 0.1% of the original dimension. Conversely those same crystals will change about 0.1% of their static dimension when an external electric field is applied to the material. The most common piezoelectric material is quartz. Certain ceramics, Rochelle salts, and various other solids also exhibit this effect.

A piezoelectric transducer comprises a "crystal" sandwiched between two metal plates. When a sound wave strikes one or both of the plates, the plates vibrate. The crystal picks up this vibration, which it translates into a weak AC voltage. Therefore, an AC voltage arises between the two metal plates, with a waveform similar to that of the sound waves. Conversely, if an AC signal is applied to the plates, it causes the crystal to vibrate in sync with the signal voltage. As a result, the metal plates vibrate also, producing an acoustic disturbance. Piezoelectric transducers are common in ultrasonic applications, such as intrusion detectors and alarms. Piezoelectric devices are employed at AF (audio frequencies) as pickups, microphones, earphones, beepers, and buzzers.
In wireless applications, piezoelectricity makes it possible to use crystals and ceramics as oscillators that generate predictable and stable signals at RF (radio frequencies).

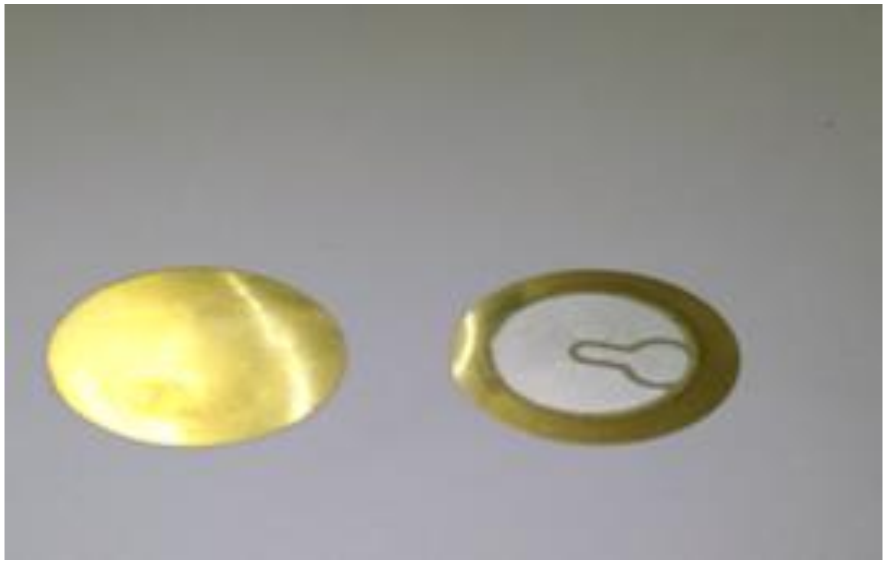

Fig. 1

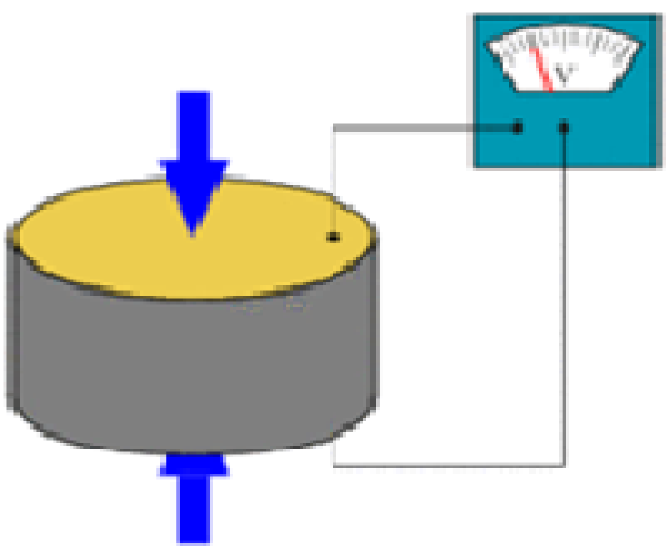

Fig. 2

HISTORY

The direct piezoelectric effect was first seen in 1880, and was initiated by the brothers Pierre and Jacques Curie. By combining their knowledge of pyro electricity with their understanding of crystal structures and behaviour, the Curie brothers demonstrated the first piezoelectric effect by using crystals of tourmaline, quartz, topaz, cane sugar, and Rochelle salt. Their initial demonstration showed that quartz and Rochelle salt exhibited the most piezoelectricity ability at the time. Over the next few decades, piezoelectricity remained in the laboratory, something to be experimented on as more work was undertaken to explore the great potential of the piezoelectric effect. The breakout of World War I marked the introduction of the first practical application for piezoelectric devices, which was the sonar device. This initial use of piezoelectricity in sonar created intense international developmental interest in piezoelectric devices. Over the next few decades, new piezoelectric materials and new applications for those materials were explored and developed. During World War II independent research groups in the United States, Russia, and Japan discovered a new class of synthetic materials, called ferroelectrics, which exhibited piezoelectric constants many times higher than natural materials. This led to intense research to develop Barium Titanate and later Lead Zirconate Titanate materials with specific properties for particular applications.

One significant example of the use of piezoelectric crystals was developed by Bell Telephone Laboratories. Following World War I, Frederick R. Lack, working in radio telephony in the engineering department, developed the “AT cut” crystal, a crystal that operated through a wide range of temperatures. Lack's crystal didn't need the heavy accessories previous crystal used, facilitating its use on aircraft. This development allowed Allied air forces to engage in coordinated mass attacks through the use of aviation radio.

WORKING OF PIEZO

- Initially the charges in a piezoelectric crystal are balanced even if they are not symmetrically arranged.
- The effect of the charges cancel out each other, leaving no net charge on the crystal. This means that the electric-dipole moments cancel each other.
- If the stress is applied on the crystal, the forces becomes unbalanced.
- Now net effective charge is produced and the dipole moments no longer cancel out each other and the net positive and negative charges appear on opposite faces and that's piezoelectricity.

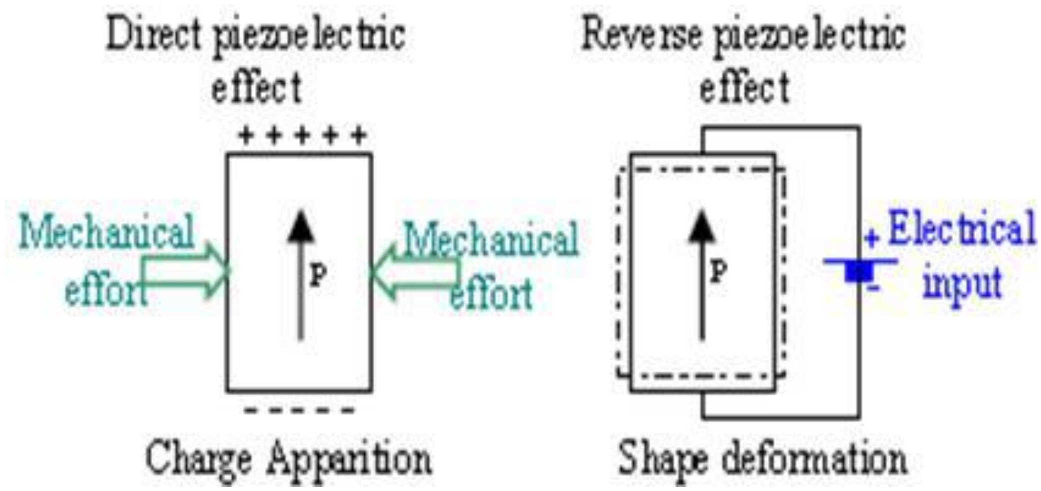

FIG. 3

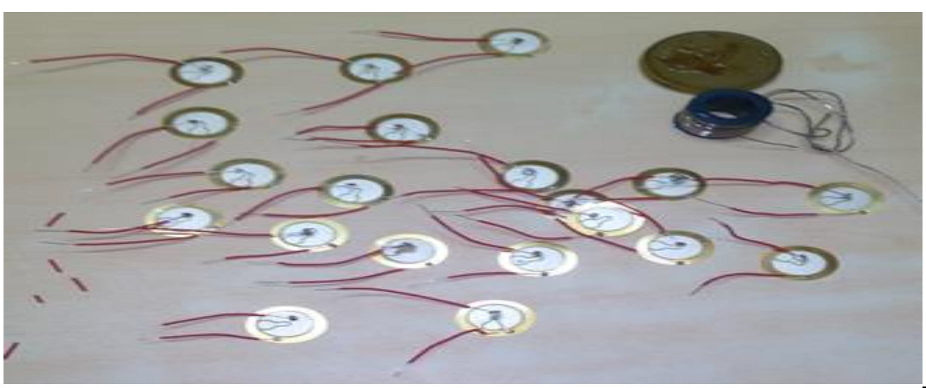

FIG. 4

FULL WAVE RECTFIER

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as **rectification**. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury arc valves, copper and selenium oxide rectifiers, semiconductor diodes, Silicon controlled rectifiers and other silicon-based semiconductor switches. Historically, even synchronous electromechanical switches and motors have been used.

A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Full-wave rectification converts both polarities of the input waveform to pulsating DC (direct current), and yields a higher average output voltage. Two diodes and a centre tapped transformer, or four diodes in a bridge configuration and any AC source (including a transformer without centre tap), are needed. Single semiconductor diodes, double diodes with common cathode or common anode, and four-diode bridges, are manufactured as single components.

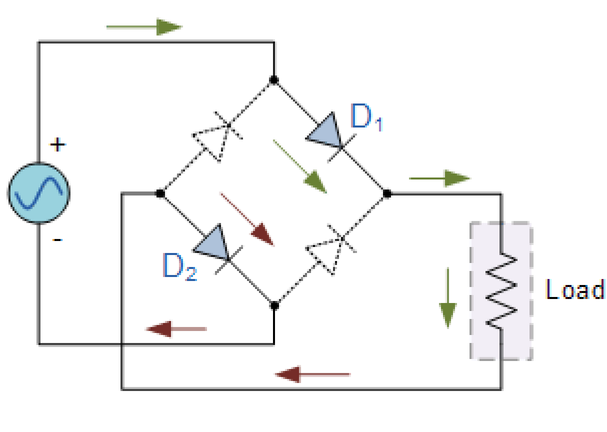

FIG. 5

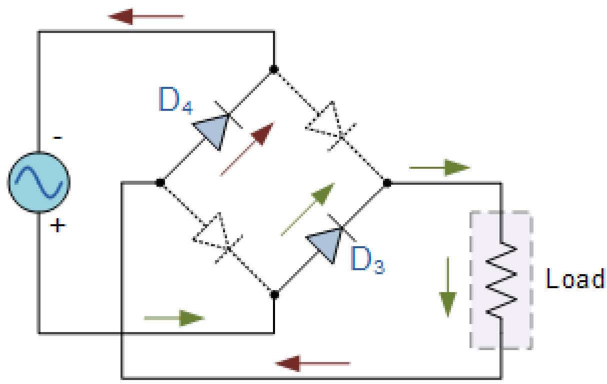

FIG. 6

The output obtained from the single wave and centre tap rectifier is not smooth so in order to make the output smooth the RC circuit has to be connected to the output of the waveform and the DC voltage is then stabilised. The ripple factor can be reduced by using the appropriate value of the time constant and the output can also be adjusted accordingly.

$V = \frac{I}{f*C}$

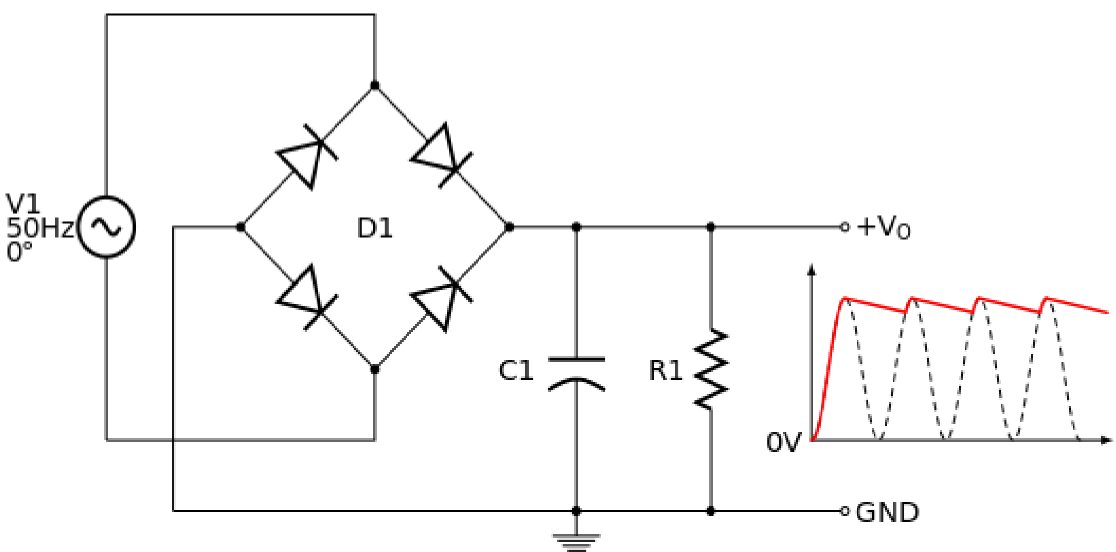

FIG. 7

CIRCUIT DIAGRAM

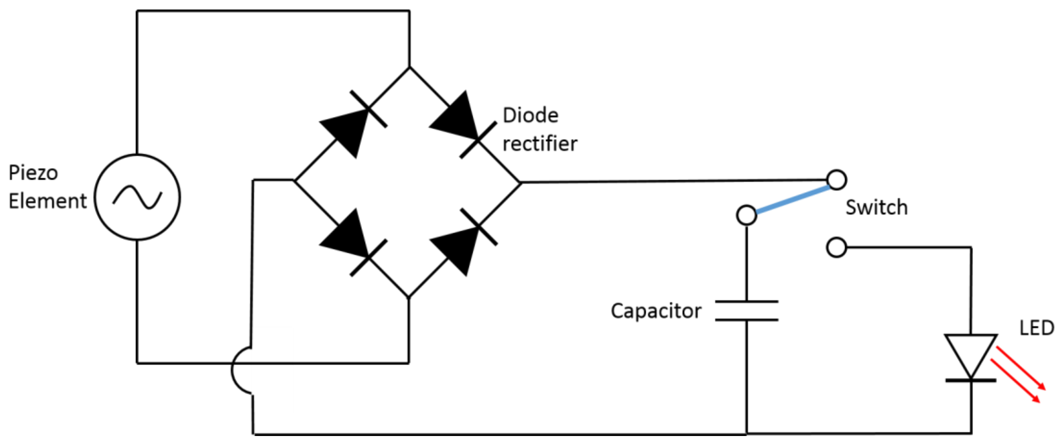

FIG. 8

The above circuit diagram shows the connections of piezo crystal and the full wave rectifier with a load or a led for the output. This circuit converts the alternating high low peaks of current drawn from the piezo crystal into a steady one which can be stored in the capacitors and further used by the LED.

CONCLUSIONS

The report illustrates the working of the Piezo element as an energy source from where electricity can be generated by applying stress to it. This phenomenon uses the dipole-dipole interaction as the back bone where the neutral crystal gets charged due to the pressure applied.

The average voltage generated by the piezo elements was sufficient to glow LEDs and varies with the impulse provided. The voltage from one piezo (averagely) lies between 1-2V.

The average voltage generated by connecting 3 or 4 crystals in parallel manner will generate a positive peak of 10-13V for a few microseconds. Continuously pressuring a bunch of crystal (for one minute) can generate 5-6V which can be stored in capacitors and further can be used for different purposes.

APPLICATIONS

- Piezo element can be used as a piezo transducer which can convert this electricity produced by the technique explained in the report.
- Power generating side walk- In this the piezo elements are laid underneath pavements, sidewalks, and speed breakers for maximum power generations.
- Power generating shoes- an initiative was started by Defence Advance Research Project Agency (DARPA) in which power is extracted from the soldier’s shoes.
- Gyms and workplaces- This technique can also be used to use the vibrations made by the machines in gym to get the electricity from them.
- People powered dance clubs- The night clubs where there are dancing floors there this technique can be of major use and can enough energy for the lighting of the same floor.
- Also this technique can be used in mobiles and keyboards where one has to apply pressure for touching or typing.

REFRENCES

http://www.piceramic.com/applications/piezo-energy-harvesting.html

http://bvicam.ac.in/bijit/downloads/pdf/issue4/10.pdf

http://www.ijera.com/papers/Vol3_issue5/CI35478482.pdf

https://en.wikipedia.org/wiki/Piezoelectricity

http://www.nanomotion.com/piezo-ceramic-motor-technology/piezoelectric-effect/

http://www.explainthatstuff.com/piezoelectricity.html

http://whatis.techtarget.com/definition/piezoelectricity