International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 05, May 2017
ISSN: 2455-3778
http://www.ijmtst.com

Hybrid Energy Generation from Acoustic and Pressure Waves using Piezoelectric Transducers

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To Cite this Article
S.Hemila Haland, G.Gowri, M.Sowndhariyaa and K.Divyaparkavi, "Hybrid Energy Generation from Acoustic and Pressure Waves using Piezoelectric Transducers", International Journal for Modern Trends in Science and Technology, Vol. 03, Issue 05, May 2017, pp. 178-182.

ABSTRACT

In many crowded areas like railway stations and auditoriums the sound that will be produced and the human foot pressure will be wasted. In our project we have used sound energy and pressure energy as the sources for power generation. This energy generated due to mechanical vibrations on Piezoelectric material can be stored on a battery and can be used to power part of the railway platform lightings and displaysystem thus reducing the dependency on grid and also helps in energy conservation. This project uses two sensors, one is the pressure sensor which converts the hand pressure into electrical energy and the other is the sound sensor which converts the sound energy into electrical energy. The electrical energy that is obtained from both the pressure sensor and the sound sensor can be stored in a common battery or it can be directly given to loads.

KEYWORDS *– piezoelectric material, sound energy, pressure energy, electric power*

I. INTRODUCTION

At current in the earth the primary essential for endurance of all organisms is energy. Everything what ensues in the surrounding is the expression of flow of energy in one of the forms. In this firm moving world trivial country like Bangladesh, where population is greater than its territory, there the recent power generation has become inadequate to satisfy their demands. Hence to overcome this difficult we need to implement the techniques of optimal utilization of conventional sources for preservation of energy. At present, a great deal of research effort has been focused to finding ecological and renewable sources of energy.

Till now, fuel is aiding as the main source of electric power. Fuel incineration produces heat which in turn yields electricity through an electro-mechanical process. Minerals like coal, gas, diesel and uranium are generally used as fuels as per fuel ignition chamber. These mineral sources are limited in earth and hence these sources are diminishing day by day because of using it extensively. So, searching is on for renewable sources of electric power that can attain the demand of future. Solar & wind energy have previously been selected as a source of renewable source of energy, and are now being broadly recognized as one of the alternatives for fossil fuels. However their accessibility and adherence to natural factors such as weather conditions. However a largely ignored and more eagerly existing source of energy is available in the form of acoustic and pressure energy.

Acoustic waves as an another source of energy has a enormous potential that has been left mostly untapped as we progress further towards using Renewable and sustainable sources of energy. Source of acoustic energy to provide a viable electronic source in a vehicle, transforming the acoustic waves into electrical energy. The creation

of energy through sound can thus decipher into formation of electrical energy by one of the most eagerly available form of pollution. The consumption of waste energy from intervallic pressure is very much appropriate and it can be made possible for utilization. The piezoelectric ceramic convert the mechanical pressure into electrical energy and this energy can be generating power. Later, any vibrating material can be used for generating power. This is an effective use of vibration which cannot be futile.

II. PIEZOELECTRIC EFFECT

The word piezoelectricity means electricity ensuing from pressure. Piezoelectricity is the charge that gathers in certain solid materials stress. Piezoelectricity is the ability of some materials (notably crystals and certain ceramics) to engender an electrical potential in rejoinder to applied mechanical stress. This may cause the separation of electric charge across the crystal lattice. If the material is not short circuited, the applied charge persuades a voltage across the material.

The word is derived from the Greek word 'pizo' or 'piezien', which means to squeeze or press. Piezoelectricity was discovered in 1880 by French physicists Jacques and Pierre Curie. The conversion of mechanical energy into electrical energy one is generally accomplished by converters alternator type or ordinarily known dynamo. But there are other physical phenomena including piezoelectricity that can also exchange mechanical actions into electricity. The phenomenon that produces an electric charge when a potency is applied to piezoelectric material is known as the piezoelectric effect.

The piezoelectric effect is the ability of certain materials to generate an electric charge in rejoinder to applied mechanical stress and reverse process is also conceivable. The piezoelectric effect exists in two domains, the first is the direct piezoelectric effect that designates the material's ability to transmute mechanical strain into electrical charge, the second form is the reverse effect, which is the ability to change an applied electrical potential into mechanical strain energy.

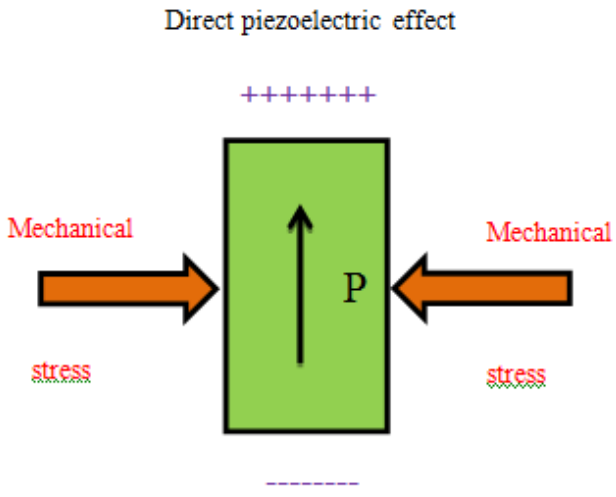


Fig 1.Change apparition

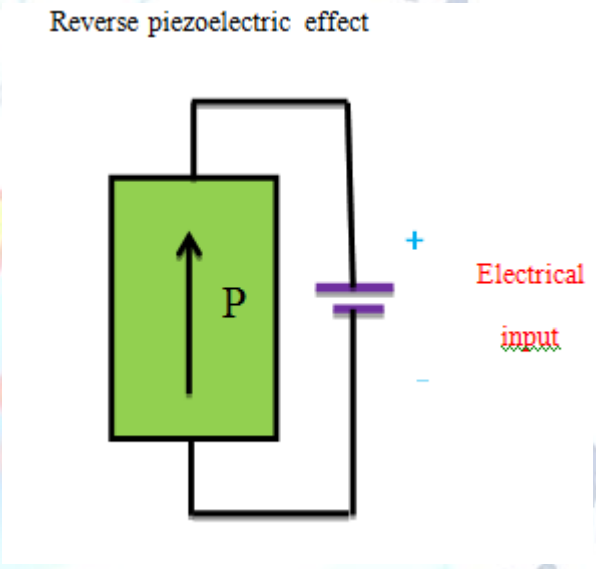


Fig 2.Shape deformation

The piezoelectric materials that exist naturally as quartz were not fascinating assets for the production of electricity, however synthetic piezoelectric materials such as PZT (Lead ZirconateTitanate) have present beneficial characteristics. PZT material exhibit greater sensitivity and higher operating temperature and also it is physically strong, chemically inert and relatively in expensive to manufacture.

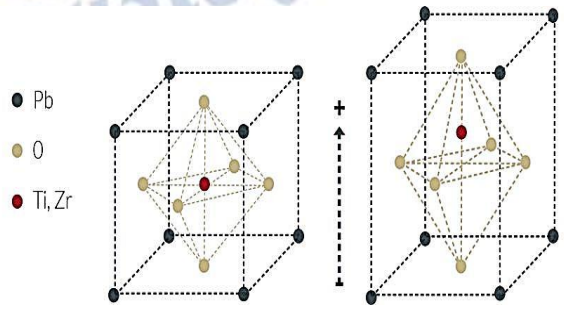
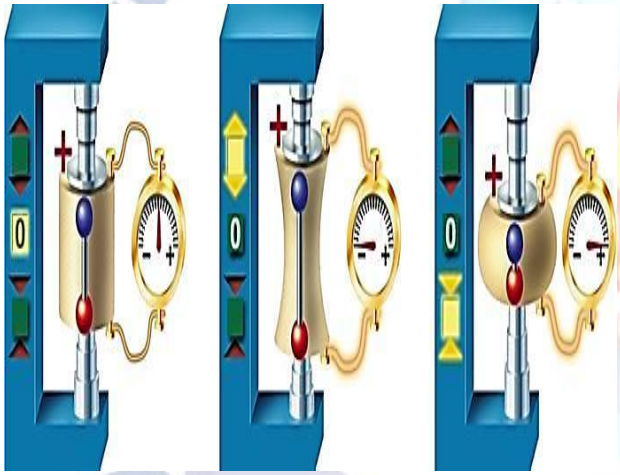


Fig 3. Piezo ceramic Crystal Structure

For example, lead zirconatetitanatecrystals will generate measurable piezoelectricity when their 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 inverse piezoelectric effect is used in production of ultrasonic sound waves. The maximum charge density which can be generated is about 0.275 C/m2once a PZT 5A element has produced a charge density of 0.275 C/m2as for the dynamic case, it is almost completely irreversibly depolarized.

The piezo emf generated across to surface of a piezoelectric material depends upon the type of force it is subjected to; i.e force is compressive or tensile. The following figures explain detail about it.



(a) (b) (c)

Fig 4.piezoelectric effect and polarization

In figure (b) when compressive force (squeezed) is applied to a piezo electric material, emf produced is +ve in nature (c) remaining the connection same if the material is subjected to a tensile force (strectched) then the polarity will be opposite (-ve). Of decisive importance for the piezoelectric effect is the change of polarization P when applying a mechanical stress. This might either be caused by a re-configuration of the dipole-inducing surrounding or by re-orientation of molecular dipole moments under the influence of the external stress. Piezoelectricity may then manifest in a variation of the polarization strength, its direction or both, with the details depending on: 1. the orientation of P within the crystal; 2. crystal symmetry; and 3. the applied mechanical stress.

The change in P appears as a variation of surface charge density upon the crystal faces, i.e. as a variation of the electric field extending between the faces caused by a change in dipole density in the bulk. For example, a 1 cm3 cube of quartz with 2 kN (500 lbf) of correctly applied force can produce a voltage of 12500 V.

Piezoelectricity is found in useful applications, such as the production and detection of sound, generation of high voltages, electronic frequency generation, microbalances, to drive an ultrasonic nozzle, and ultrafine focusing of optical assemblies. It is also the basis of a number of scientific instrumental techniques with atomic resolution, the scanning probe microscopies, such as STM, AFM, MTA, SNOM, etc., and everyday uses, such as acting as the ignition source for cigarette lighters, push-start propane barbecues, and quartz watches.

III. BLOCK DIAGRAM

When vibrations due to pressure or sound is applied to an object a negative charge is produced on the expanded side and a positive charge on the compressed side of the piezoelectric crystal. Due to the continuous change in pressure, there will be movement of charges inside the crystal which leads to flow of current.

Since developed power from piezoelectric crystal i.e both from sound and pressure, it is fed into a rectifier for AC to DC conversion. In order to increase the voltage level, the output from the rectifier is given to the boost converter. The output of this boost will be 20V-24V approximately.

The triggering pulses for this boost converter is given from pic micro-controller. The output of boost converter can be directly connected to a load or it can be stored in a battery.

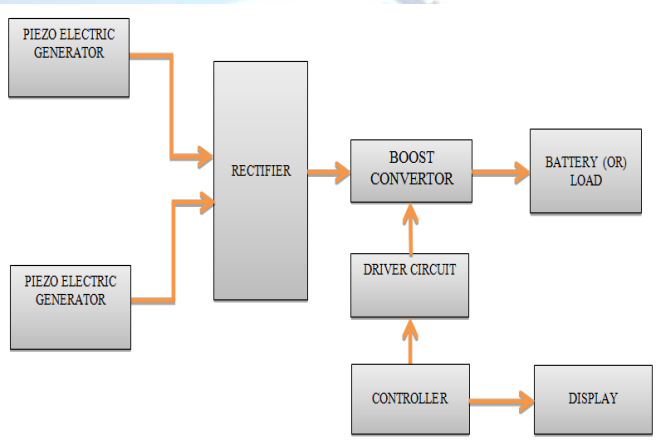


Fig 5.Block Diagram

IV. CIRCUIT DIAGRAM

The input supply is given from 9V AC. This is rectified using bridge rectifier DB106. This rectified voltage is stabilized using a voltage regulator LM7805. The regulated output is 5V. Here the microcontroller act as a feedback control system. Each and every signals generated at the various levels of circuit is passed through the micro controller for generating the trigger pulses.The generated power signals from sound and pressure sensors are given to the PIC controller. This controller then activated the rectifier for AC to DC conversion.

After rectification, the voltage is boosted in the boost converter. A comparator cum voltage regulator is used in the circuit for providing proper regulated output of 5V.

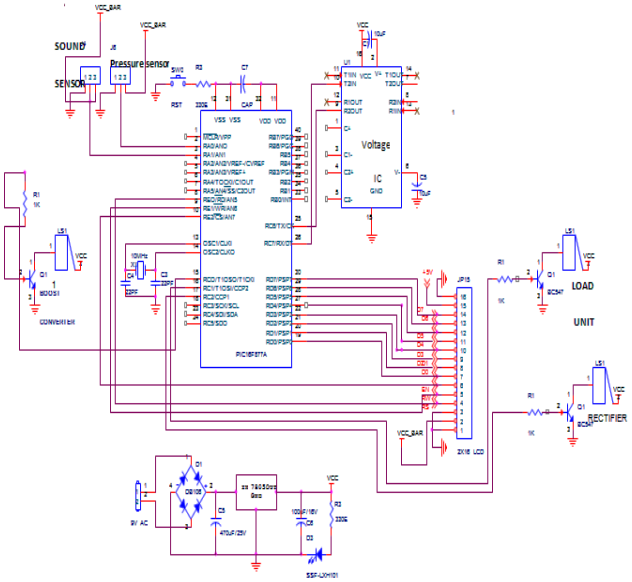


Fig 6.Circuit Diagram

V. EXPERIMENTAL WORK

1 micro pascal pressure input is given to pressure sensor or 120dBA input is given to sound sensor at 1m distance. The sensor produce the output voltage is AC. This AC voltage is converted into DC by using rectifier. The output of rectifier is 5V DC. Fi The output level of the rectifier is 1-2V from sound and 4-6V from pressure. The combined output level is 6 to 9V.

After rectification the voltage is boosted using a boost converter. The output voltage of boost converter is 8 to 10V from sound and 14-18V from pressure. The combined output is 24-28V.Finally we get 3W power from one sensor. This power is given to the load(bulb).

Fig 7.Result

VI. APPLICATIONS

1. Dance Clubs

Series of crystals can be laid below the floor mats,tiles and carpets and also fixed in the sound systems. When mob uses the dance floor an enormous voltage is generated.

2. Mobile Phones

Crystals are laid down under keys of mobile unit. If key pressed vibrations are created. Some other crystals are fixed near to the speaker in mobile. If songs played vibrations are created. These vibrations can used for charging purpose.

3. Railway Tracks

We all must have seen the vibrating rails when train goes on it and also it produces sound. Hence we can use the sound and pressure source the piezoelectric energy harvesting concept at stations.

4. Auditorium

Series of crystals can be laid below the floor mats,tiles and carpets and also fixed in the sound systems. When functions are conducted the voltage is generated.

VII. CONCLUSION

In this project we have designed a system which generates electrical energy using piezoelectric transducers. We have used the freely available pressure energy and sound energy as sources for power generation.

When pressure is exerted on a piezoelectric material, then that pressure will be converted into electrical energy using pressure sensor and a sound sensor will convert the sound energy into electrical energy. Thus the pressure energy and sound energy that will be wasted in many crowded areas can now be effectively used as a source of energy to produce electrical energy using this project.

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