HARVESTING ACOUSTIC ENERGY : SOUND TO ENERGY

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Abstract

This project attempted to explore the idea of obtaining useful electrical energy from noise pollution. Noise, as a source of energy, is ubiquitous. With a speaker as the transducer (without amplifier), the sound was collected using electromagnetic induction and converted into electric power, which was used to charge up a capacitor, serving as the basis of charging up chemical batteries in the future. The result of this experiment was the harvest of 1mW of electrical power solely from energy contained in sound. The conclusion reached from such a conversion process is that with the help of better infrastructure and methodology, an even greater amount of electrical power can be obtained from the energy contained in sound.

Keywords: *Electromagnetic Induction, Speakers.*

Introduction

Sound is a form of mechanical vibration travelling through any material medium predominantly as a longitudinal wave, composed of a series of compressions and rarefactions. This basically results in changes in the pressure of the fluid if the medium of transfer of sound is fluid and changes in interparticle distances in solids. As sound is a compression, mechanical wave, it transfers energy (whose quanta are 'phonons'). By the First Law of Thermodynamics, any form of Mechanical energy can be converted into Electrical Energy. So Sound Energy can be converted to Electrical Energy. Now what remains is to carry out such a conversion process in practice using a cost- effective way.

The most popular modes of conversion of Sound Energy to Electrical Energy are by using (a)Electromagnetic Induction and (b) Piezoelectric crystals.

- Electromagnetic Induction can harness the mechanical vibrations (which sound can induce on some membrane) to move a coil within a magnetic field, inducing an EMF across the ends of the coil. The current flowing through the coil then depends on the resistance of the coil. It is a reliable and cheap process of conversion of acoustic energy into electrical energy.

- When pressure is exerted upon piezoelectric crystals, they develop charges on their surfaces. Varying the pressure proportionally changes the charge developed on the surface changes, which results in a current. The drawbacks of using Piezoelectric

crystals is that they make the conversion too expensive and unreliable. There are very few commonly available and economical Piezoelectric crystals. If we could use piezoelectric crystals the results are expected to be far better. If more investment can be made, then we can get a considerable amount of useful power by the use of piezoelectric crystals. This can be easily put into use to power street lights and charge batteries.

This project mainly explores the principle of Electromagnetic Induction, to convert sound energy to electrical energy. This is the governing principle in a microphone and a speaker converted to a microphone, which was the principal transducer in this project.

Motivation

These days, energy crisis have become mammoth and scientists all around the globe are in the quest for some clean source of electrical energy. On the other hand tremendous amount of acoustic energy is wasted in the environment everyday, on roads, in factories, in airports and metro stations. If we can utilize this energy present in sound, we can give out a clean and green solution to the energy crisis.

Further, if we extend our scope from sound to mechanical vibrations in general, then we have a huge amount of energy potentially available to harness and convert to electrical energy.

This energy can be used to power the LEDs used in street lights, and to charge chemical batteries as that of a mobile phone. Once a good transducer is established as viable, then cell phones can start getting charged up as soon as they ring and one can shout around at one's electrical devices to make them work.

Related Work

The idea of transducing sound to electrical energy originated at Los Alamos National Laboratory in collaboration with Northrop Grumman Space Technology, USA. They developed a generator which could use the sound energy produced by the motion of Helium gas, to drive a piston, which moved a coil into and out of a magnetic field.

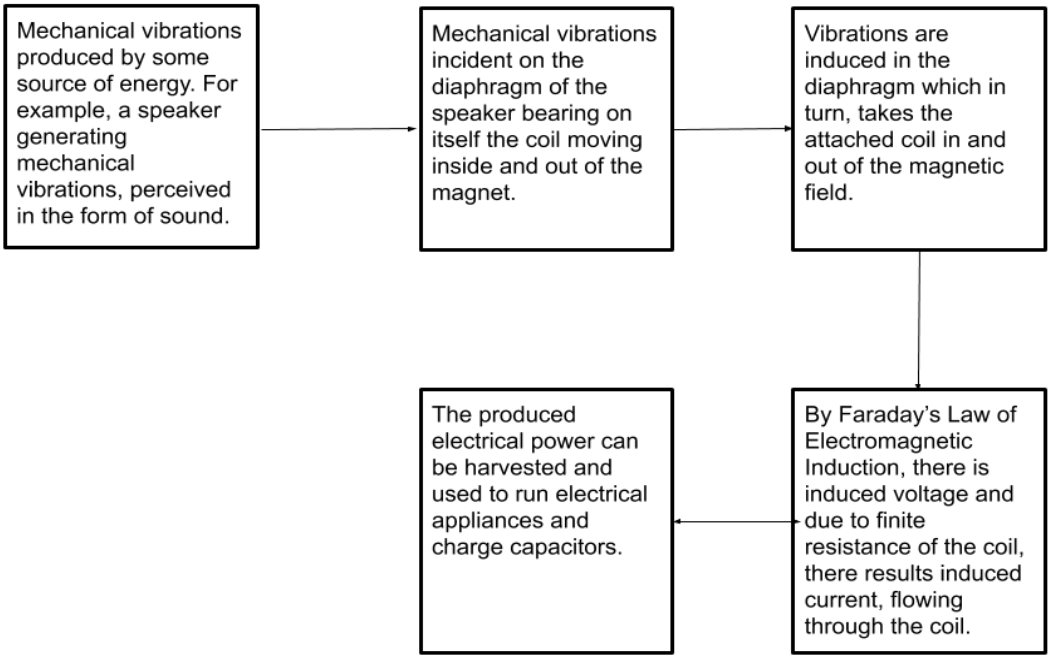
Similar ideas have been implemented by various researchers, who have experimented with sound to electrical energy conversion in various places with high decibel level.

Method

This project was initiated with an aim to try to convert mechanical vibrations in general to electrical energy. Correspondingly, a number of basic mechanical systems were developed to cause mechanical motion of either the coil in magnet or magnet in coil.

The result was a very low power, mainly due to the primitive and less realistic nature of the mechanical models.

Due to the lack of resources and knowledge to build suitable mechanical systems, the focus of the project was shifted to working with sound as a source of mechanical vibrations and see the results obtained from that. The principal transducer used here was an 8 ohm laboratory speaker without any amplifier, which was subjected to sound from a home speaker (maximum decibel level: 83 dB). The sound was composed of computer simulations of vehicular traffic, different frequencies of sound (sine waveform) at various amplitude levels and loud beats of Bollywood songs. The block diagram for the entire process is shown in the figure below. The results are tabulated in the table below.



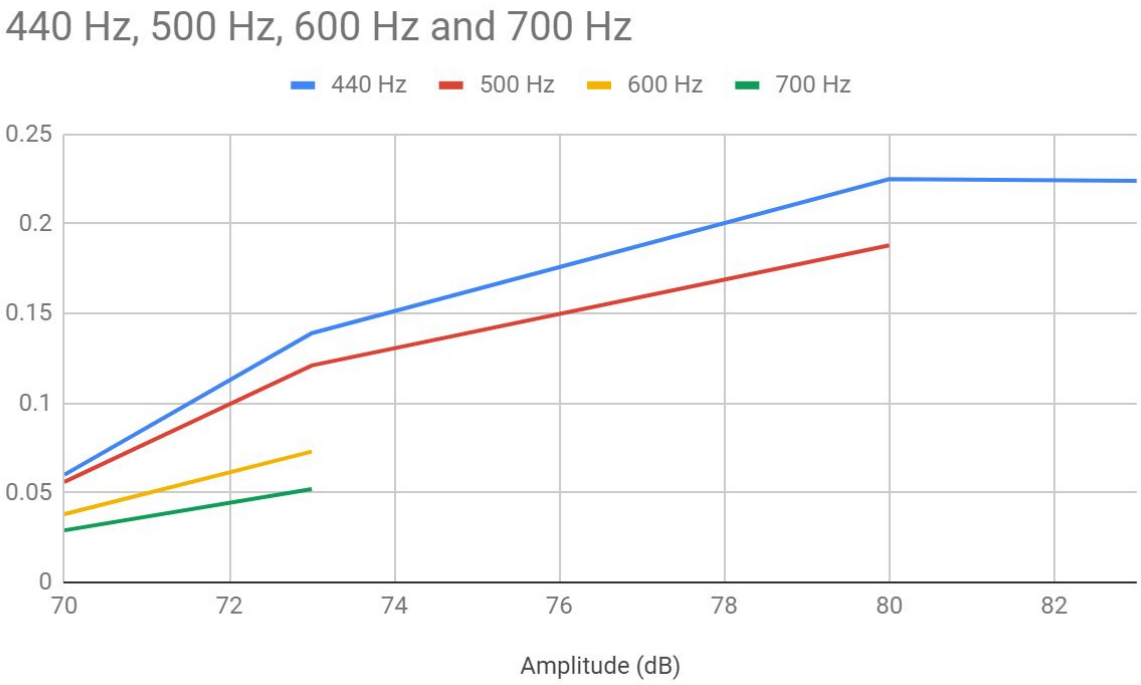
A similar AC voltage was found to develop on a capacitor when introduced in the circuit, which eventually leads the way to store the electrical energy which has got produced in chemical batteries.

Results

Frequency (Hz)	Amplitude (dB)	Voltage induced (V)	Current Induced (mA)
440	70	0.060	7.48
440	73	0.139	15.00
440	80	0.225	27.00
440	83	0.224	28.00
500	70	0.056	6.75
500	73	0.121	13.10
500	80	0.188	24.00
600	70	0.038	4.75
600	73	0.073	8.76
700	70	0.029	3.64
700	73	0.052	5.15

Notes:

- The voltage was not stepped up or stepped down. Original values are projected in this tabulation.
- Frequency of 440 Hz is also known as ‘Stuttgart Pitch’. It denotes the musical note of A above middle C and serves as a reference for tuning musical instruments. (Source: Wikipedia)



Conclusion

- The power obtained at different frequencies and at different amplitude levels is approximately 1 mW. This power can be used to run small sensors and other low power requiring devices. This can be useful in the upcoming Nanoelectronics technologies.
- The voltage obtained can be rectified only with Precision Rectification circuits, as the normal diodes (with high knee voltage for forward biasing) fail here.
- After appropriate rectification,substantial amount of energy can be stored in a capacitor or a chemical battery, over a long period of exposure to the acoustic energy.
- This way, we get a source of clean energy from our surroundings itself.

Applicability of the ideas

- The energy contained in noise, which is otherwise considered to corrupt signal transmissions, can be used to power several low power devices. The battery requirements of low power devices which are put for critical operations, such as pacemakers; MEMs used for laboratory on chip realizations, which can be injected into the human body; small sensors, which can be used in the fields of defence,

emitting waves with such low amplitude and frequency, that they can't be sensed by enemies; etc. can be satiated by a reliable energy source, contained in sound signals.

- This project was not just about sound, but was about vibrations in general. The energy contained in vibrations, which are otherwise considered to be a waste, can be exploited using the ideas of electromechanical energy conversion. Seismic energy, tidal energy, etc. can be put to use in getting energy for operations, where the conventional powering mechanisms cannot survive.

Further scope

The output of this experiment can be enhanced in the industrial setup, where better receiver cum transducers for this conversion can be used. The diaphragm of the transducing speaker can be made lighter and bigger, more number of turns can be introduced in the coil and the magnetic field can be made stronger.

A louder and more realistic input source of acoustic energy can be used for testing.

After determining the natural frequency of the diaphragm plus coil system of the speaker and ensuring that it is the most commonly encountered frequency in the environment of the establishment of the device, a resonance tube of suitable length and material can be connected to the diaphragm, to conduct the sound from the source (Eg.: the floor of an industry, or that of an airport or metro station) to the transducer. This will help to establish a better mode to transfer of sound and utilize the maximum amplitude of the sound when the incident frequency matches up with the natural frequency of the diaphragm plus coil system.

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