American Journal
In Quality, We trust

Energy Harvesting System From Foot Steps Using Piezoelectric Sensors

Habibur Rahman Mukul, Saidur Rahman
Dept. of Electrical & Electronic Engineering (EEE)
American International University-Bangladesh (AIUB)
Dhaka, Bangladesh
mukulkrahman@gmail.com , saidkrahman@gmail.com

Mir Md. Newaz Morshed, Khairul Anam Roman
Dept. of Electrical & Electronic Engineering (EEE)
American International University-Bangladesh (AIUB)
Dhaka, Bangladesh
newazmorshed30@gmail.com , aiub.roman@gmail.com

***Abstract*—The scenario of last few years is that the low power electronic devices have been increased in a rapid way and this type of devices are used in a large number to comfort our daily lives. For sustainable development, it is important to develop more efficient, pollution free and renewable energy resources to meet the unending demands. So the concept of harvesting alternative renewable energy arises a new interest among us. In this project we try to make a piezoelectric generator that will produce energy from vibration and pressure which will available from some other term (like- footsteps of people). Just not only the footsteps this concept is also applicable to some other large vibration sources that can find from nature. This project represents a model of energy harvesting system using piezoelectric sensors which is very much cost effective, pollution free and easy to implement.**

Keywords*— *Piezoelectric sensors, Half-wave rectifier, DC-DC buck converter, Rechargeable Battery, Load.

I. INTRODUCTION

At present among all the issues, energy is one of the most concerning issue around the world. This issue is more acute in a densely-populated country like Bangladesh. In Bangladesh energy crisis is a big problem and this crisis is increasing day by day with the extreme growth of population. Renewable energy sources will be a very good media to reduce this absolute energy crisis problem in Bangladesh. As all of us know that the natural resources will finish one day. That's why researchers are trying to develop or introduce alternative or substitute energy sources that can be easily gained from the nature. And that must be green, pollution free and not harmful for the environment. Energy harvesting process is also known as power harvesting process is defined as capturing minute amounts of energy from external sources like solar energy, thermal energy, wind energy, kinetic energy, one or more of the surrounding energy sources and storing them in small, wireless autonomous devices. Energy harvesters give us a very little amount of power for low energy electronics. People have already applied and started to use this type of energy harvesting method in the form of windmill, solar and geothermal energy. Renewable energy can be defined as the energy that come from natural sources. Renewable energy harvesting plants can generate kilowatt (kW) or megawatt (MW) level power and it is called as macro energy harvesting technology. Moreover, micro energy also can produce from natural sources and it is termed as micro energy harvesting technology. Micro energy harvesting technology is produced from mechanical stress or mechanical vibration, also from friction sources and many other biological sources, which can generate milliwatt (m-W) or microwatt (μ-W) level power. Our discussion topic is based on this to generate micro energy from mechanical vibration or pressure using piezoelectric sensors and to store the energy in the battery.

II. PIEZOELECTRIC SENSOR

In present, the main goal of most of the research in the field of energy is to develop or introduce new sources of energy for the future. This days piezoelectric materials (e.g. piezoelectric sensors) are being studied frequently more and more as they turn out to be very unusual materials along with their very specific and unique properties. Piezoelectric materials have the ability to generate electrical energy from mechanical energy [1]. This type of devices are referred to as energy harvesters and they can be used in applications where outside power is not available. From the recent researches it have shown that these type of materials might be used as power generator, though the amount of energy produced by it is still very much low so proper optimization is necessary [2].

Advantages:

1. Unaffected by extra electromagnetic fields.
2. Self-generating, so there is no need of putting external source.
3. Frequency response is very much high.
4. It is pollution free and utilizes the energy that would be wasted.
5. Highly economical and also the installation and replacement method is quite easy.

Disadvantages:

1. One important disadvantage is that it is not suitable for measuring in static condition.

2. Another important disadvantage is piezoelectric sensor gives a high voltage spike but it draws a very few amount of current. Sometimes it produces current which is extremely low in compare with the voltage. The output may vary according to the temperature variation of the crystal.

III. HALF WAVE RECTIFIER

Rectifier is an electronic device that is capable to convert the alternating current (AC current) to unidirectional current (DC current). The half wave rectifier is a type of rectifier that has the ability to rectify only the half cycle portion of the waveform [3]. Half wave rectifier is commonly used to convert the AC output of a piezoelectric into a DC output and the rectifying circuit builds with only one diode [4]. In this project we have used rectifier for converting the AC output into DC output because from the piezoelectric sensors we have got AC output. So it is necessary to convert this AC output into DC output and also to minimize the power dissipation in that process. We have successfully converted the AC to DC with our goal.

IV. DC-DC BUCK CONVERTER

A buck converter is a switch mode DC to DC electronic converter that is capable to do the transformation of output voltage to level less than the input voltage. It is also referred as step down converter and the name step down converter comes from the fact that analogous to step down transformer the input voltage is stepped down to a level less than the input voltage [5]. So we have used buck converter in our project for bucking the rectified output as required.

V. RECHARGEABLE BATTERY

A rechargeable battery or a storage battery is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use. Lead acid batteries are finding considerable use as both primary and backup power sources. In this project for storing electrical energy we have used a rechargeable battery of 12V.

VI. LOADS

The USB charging converter converts 12V dc to 5V dc. It consists of IC-LM2576Adj, capacitor, diode and LED. This entire component converts voltage to charge device like as Mobile, IPod, Tab, MP3 devices, and charger light etc.

VII. PRINCIPPLES OF WORKING

In this project we had generated electrical power as nonconventional method using piezoelectric sensors by applying footsteps on it. The technology is based on a principal called the piezoelectric effect. We had used 36 piezoelectric sensors and all of them are kept on a transducer pad by connecting each of them in parallel along with the half wave rectifier. We were not connected the piezoelectric sensors with each other in series because after connecting them in series we got less amount of current. To get the maximum amount of current value we had connected all the 36 piezoelectric sensors in parallel combination. The AC output that came from transducer pad was converted into DC output and stored into the battery. A buck converter is used for bucking the rectifier to run the desire loads.

A. *Figures*

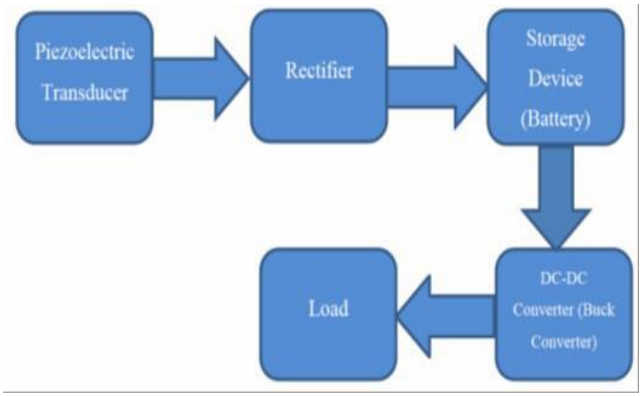

Fig. 1. Block diagram of working principles

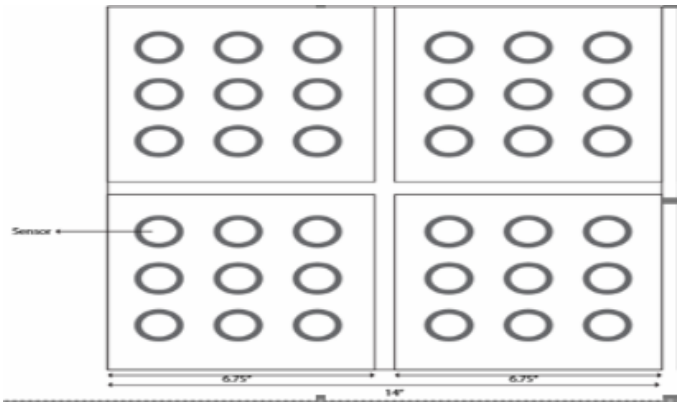

Fig. 2. 2D view of piezoelectric sensors implemented

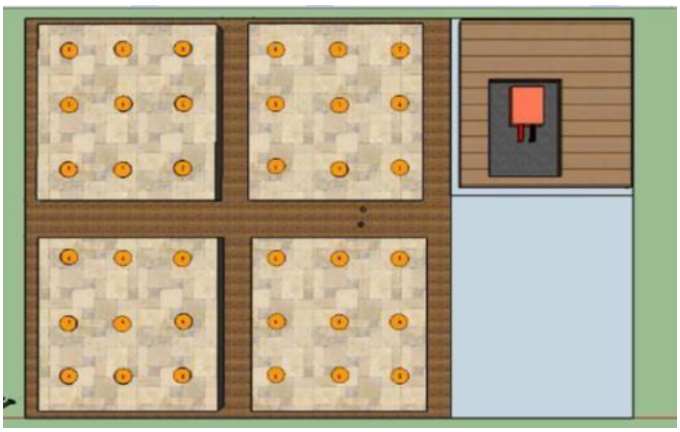

Fig. 3. 3D view of piezoelectric sensors implemented

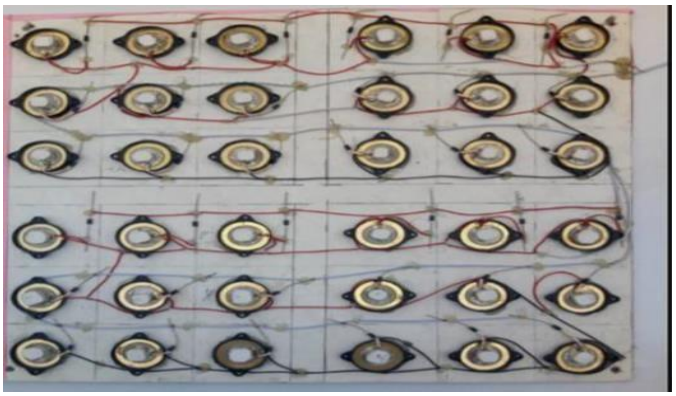

Fig. 4. Physical implementation of 36 piezoelectric sensors

Fig. 5. Mechanical stress was provided on transducer pad

Fig. 6. LED was turned on as load

Fig. 7. Mobile was charging

B. Simulated results

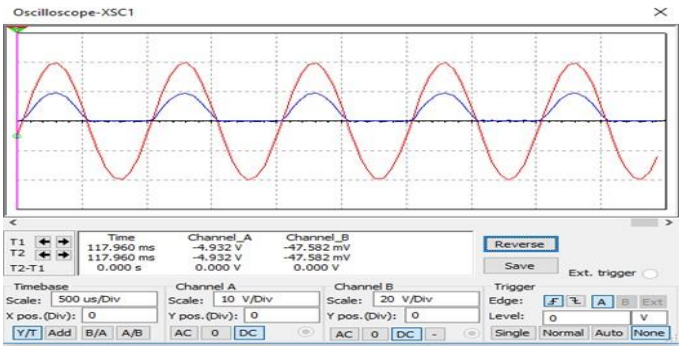

Fig. 8. Simulated output of the half-wave rectifier

Fig. 9. Simulated output of the DC-DC buck converter

C. Results and findings

For Rechargeable Lead-Acid Battery (12Volts)

As we know, piezoelectric sensors act as an energy generator and the generate energy will store in the battery.

During the testing performed, we used 36 piezoelectric sensors. As power generation from piezoelectric sensors varies with different steps so we got,

Maximum voltage level = 1V per step

Minimum voltage level = 19.5V per step

We observed that it needed approximate 1200 steps to increase 1V charge in the battery. In this project we took 12V rechargeable lead-acid battery. To fully recharge this 12V battery it needed,

To increase 1V it took 1200 steps so for 12V,

$= (1200 \times 12)$ steps
= 14400 steps (Approximately)

During our experiment we applied one step per second and for 14400 steps it took,

$= 14400 \times 1$ seconds
= 14400 seconds
= (14400/60) minutes

If we implement our project in a populated area we will get 2 steps per second. So for (14400/2) = 7200 steps then the time will be needed,

= (7200/60) minutes
= 120 minutes (Approximately)

D. Some important considerations about piezoelectric sensors

As we know that piezoelectric material has the property of converting mechanical energy into electrical energy but important fact is that developing piezoelectric generator is challenging because of their poor source characteristics (high voltage, low current, high impedance) and relatively low power output and the main limitation of our project is that we could not amplify the current or power from source to charge our battery quicker with applying less steps. Another problem that we have faced that we could not find better quality piezoelectric sensors in our region.

E. Some possible improvements

As the system is able to harvest only a small amount of energy, a hybrid system can introduce. For storing the energy super capacitors can be used instead of batteries. Fast charging feature might be added for rapid harvesting.

VIII. Applications & Future Scopes

This system can be used in city areas where want more power. As Bangladesh is a very much densely populated country and there are many regions where people are continuously travelling by walking. And these regions are always busy with people walking, which mean we can easily find the sources like vibration or pressure to produce electricity from piezoelectric material. We can also apply this system in some other places like- gyms, footpaths, staircases, shopping malls etc. can be laid with crystals below the floor or tiles and the produced energy can be used to power the equipment in the place. Another possible way to generate power using piezoelectric sensors from vibrations on the sleepers beneath railway tracks [6].

IX. DISCUSSIONS & Conclusions

In this project our main objective was to find an approach for generating electrical energy from mechanical pressure using piezoelectric elements (piezoelectric sensors) and we divided our objectives into two portions. Our primary objective was to convert the wasted mechanical energy into electrical energy and the secondary objective was to store the electrical energy into a battery in an efficient way for load purpose. We were quite successful to achieve our goal and successfully tested it which was the best economical, affordable energy solution to common people. Using the designed system energy was harvested from the piezoelectric sensors. For storing of the harvested energy rechargeable battery was used. But the amount of time to charge the battery was too long as only 36 piezoelectric sensors were used in the experiment set up. The harvested energy got from the system was able to drive an external load showed that the system can be used in real life applications.

Acknowledgment

First and foremost we would like to thank the Almighty Allah for the blessings and strength he had bestowed upon us. We would like to express our sincerest sense of gratitude to our project supervisor Kazi Firoz Ahmed and our external supervisor Shuvra Saha for their interest in the development of the project work and for their invaluable suggestions and guidance.

We are also grateful to Prof. Dr. ABM Siddique Hossain, Dean Faculty of Engineering, American International University-Bangladesh (AIUB) for his vital encouragement and support. We would like to appreciate Dr. Carmen Z. Lamagna, honorable Vice Chancellor, American International University-Bangladesh (AIUB), who exceptionally inspire our growth as a student.

Last but not the least we would like to thank our family and friends for their valuable support to complete this project.

References

[1] M. R. Sarkar, M.R., S.H.M. Ali, M. Othman and S. Islam, 2011, "Designing a low voltage energy harvesting circuits for rectified storage voltage using vibrating piezoelectric", Aust. J. Basic Applied Sci., 5: 341-345.

[2] Instructables.com. 2017. Electricity Generating Footwear - Generate Electricity by Walking (Concept). [ONLINE] Available at: http://www.instructables.com/id/Electricity-Generating-Footwear/. [Accessed 24 March 2017]

[3] http://www.electronicshub.org/. 2016. The half wave rectifier. [ONLINE] Available at: http://www.electronicshub.org/characteristics- and-working-of-half-wave-rectifier/. [Accessed 10 March 2017].

[4] Electronic Circuits and Diagram-Electronics Projects and Design. 2017. Half Wave Rectifier Circuit with Diagram - Learn Operation & Working. [ONLINE] Available at: http://www.circuitstoday.com/half- wave-rectifiers. [Accessed 02 March 2017].

[5] How to Apply DC-to-DC Step-Down (Buck) Regulators Successfully | Analog Devices. 2017. How to Apply DC-to-DC Step-Down (Buck) Regulators Successfully | Analog Devices. [ONLINE] Available at: http://www.analog.com/en/analog-dialogue/articles/applying-dc-to-dc-step-down-buck-regulators.html. [Accessed 07 April 2017].

[6] Harvesting energy from the vibration of a passing train using a single-degree-of-freedom oscillator - Science Direct. 2017. Harvesting energy from the vibration of a passing train using a single-degree-of-freedom oscillator - Science Direct. [ONLINE] Available at:http://www.sciencedirect.com/science/article/pii/S0888327015003143. [Accessed 12 March 2017].