

Footstep Power Generation Using Piezo-Electric Transducers

Kavita Sharma¹, Sushil Pikhan², Pranita Kohli³, Meenakshi Khajuria⁴

Student of B.E. Electronics, Model Institute of Engineering and Technology, Jammu & Kashmir, India

Abstract: *The most basic need of today's world is energy which is non-renewable source of energy available on earth. This paper attempts how man has needed energy at an increasing rate for the survival and well being time since immemorial. Due to this a lot of energy has been used and wasted. Thus, new power generation techniques are required for next generation of wireless sensors and autonomous system to be feasible. Piezoelectric material is excellent power generation devices because of their ability to couple mechanical and electrical properties. Piezoelectric transducers which is an electromechanical converter undergoes mechanical vibration therefore producing electricity. This power source has many applications as in agriculture, home application and street lighting and as energy source for sensors in remote locations.*

Keywords: Piezoelectricity, PZT, PVDF, Transducer, LPC2148

1. Introduction

At present, electricity has become a lifeline for human population. Its demand is increasing day by day. Modern technology needs a huge amount of electrical power for its various operations. Electricity production is the single largest source of pollution in the whole world. At one hand, rising concern about the gap between demand and supply of electricity for masses has highlighted the exploration of alternate sources of energy and its sustainable use. On the other hand, human population all over the world and hence energy demand is increasing day by day linearly. Accordingly, it is an objective of the present invention to provide a method of electrical power generation from this ever increasing human population that does not negatively impact the environment. This technology is based on a principle called the piezoelectric effect, in which certain materials have the ability to build up an electrical charge from having pressure and strain applied to them. Piezoelectricity refers to the ability of some materials to generate an electric potential in response to applied pressure. Harvesting of energy which means energy is already available, but is going to waste if not utilized. Embedded piezoelectric material can provide the magic of converting pressure exerted by the moving people into electric current.

2. Research Elaborations

A. Study of Piezo Materials

Piezoelectric ceramics belong to the group of ferroelectric materials. Ferroelectric materials are crystals which are polar without an electric field being applied. The piezoelectric effect is common in piezo ceramics like PbTiO₃, PbZrO₃, PVDF and PZT. The main component of the project is the piezoelectric material. The proper choice of the piezo material is of prime importance. For this, an analysis on the 2 most commonly available piezoelectric material - PZT and PVDF, to determine the most suitable material was done. The criterion for selection was better output voltage for various pressures applied. In order to understand the output corresponding to the various forces applied, the V-I characteristics of each

material namely, PZT and PVDF were plotted. For this the Piezo transducer material under test is placed on a Piezo force sensor. Voltmeters are connected across both of them for measuring voltages and an ammeter is connected to measure the current. As varying forces are applied on the Piezo material, different voltage readings corresponding to the force is displayed. For each such voltage reading across the force sensor, various voltage and current readings of the Piezo test material are noted.

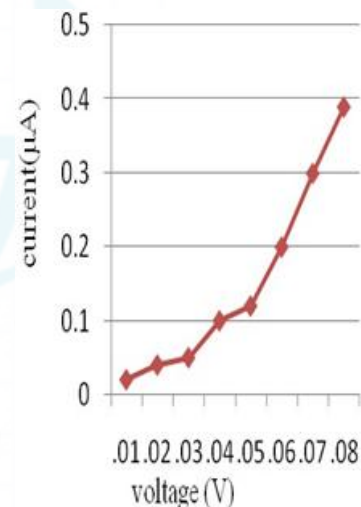


Figure 1: V-I graph of PVDF material

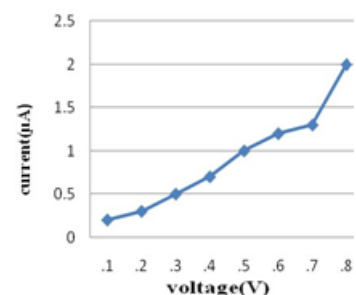


Figure 2: V-I graph of PZT

The voltage from PZT is around 2 V where as that of PVDF is around 0.4V. We can thus conclude that better output is obtained from the PZT than the PVDF.

B. Study of Connections

Next to determine the kind of connection that gives appreciable voltage and current necessary, eight PZT are connected in series.



Figure 3: PZT in series connection

A force sensor and voltmeter is connected to this series combination. As varying forces are applied on this connection, corresponding voltages are noted. Also the voltage generated across the series connection and the current is measured.

3. Hardware Implementation

The hardware set up is as shown in figure 4. A tile made from piezo material is made. The voltage generated across a piezo tile is supplied to a battery for it to recharge and supply the dc loads. A LCD is interfaced to the tile using a LPC 2148 microcontroller to display the voltage generated across the piezo tile.

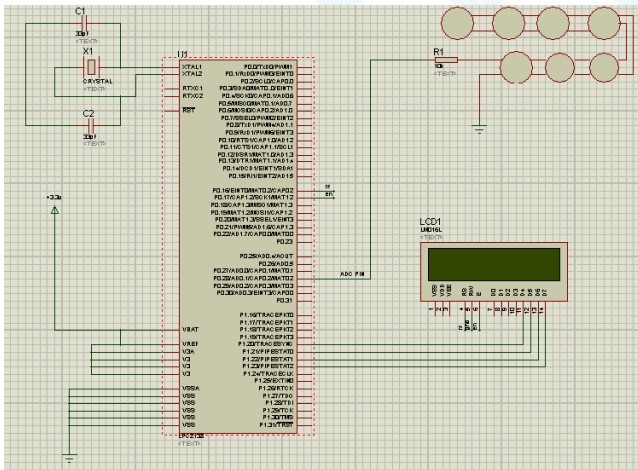


Figure 4: Hardware setup

4. Working

The piezoelectric material converts the pressure applied to it into electrical energy. The source of pressure can be either from the weight of the moving vehicles or from the weight of the people walking over it.. The output dc voltage is then stored in a rechargeable battery. As the power output from a single piezo-film was extremely low, combination of few Piezo films was investigated. With series connection, additional piezo-film results in

increased of voltage output but not in linear proportion. From battery provisions are provided to connect dc load. The voltage produced across the tile can be seen in a LCD. For this purpose microcontroller LPC 2148 is used. The microcontroller uses a crystal oscillator for its operation. The output of the microcontroller is then given to the LCD which then displays the voltage levels

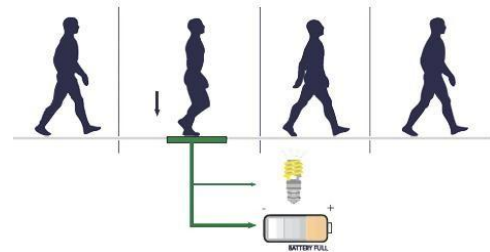


Figure 5: Schematic representation of the working model

5. Maximum Theoretical Voltage Generated

When a force is applied on piezo material, a charge is generated across it. Thus, it can be assumed to be an ideal capacitor. Thus, all equations governing capacitors can be applied to it. In this project, on one tile, we connect 8 piezo in series.

Hence, the net voltage generated in series connection is the sum of individual voltages generated across each piezoelectric disc. Output voltage from 1 piezo disc is 2V

$$\begin{aligned}
 V_{eq} &= V_1 + V_2 + V_3 + \dots + V_8 \\
 &= 2(8) \\
 &= 16V
 \end{aligned}$$

Thus the maximum voltage that can be generated across the piezo tile is around 16V.

6. Analysis Done On the Piezo Tile

People whose weight varied from 40kg to 75 kg were made to walk on the piezo tile to test the voltage generating capacity of the Piezo tile. The relation between the weight of the person and power generated is plotted in figure 6. From the graph it can be seen that, maximum voltage is generated when maximum weight/force is applied. Thus, maximum voltage of 16V is generated across the tile when a weight of 55 Kg is applied on the tile.

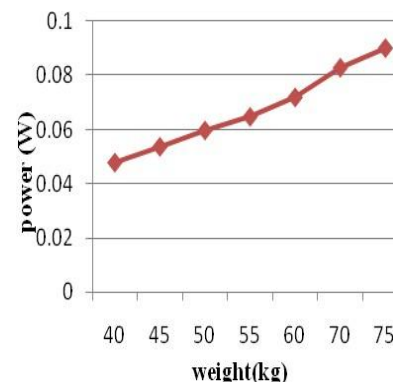


Figure 6: Weight V/s power graph of piezo tile

7. Conclusion

A piezo sensor array of generating 16V has been devised. Comparison between various piezo electric material shows that PZT is superior in characteristics. Also, by comparison it was found that series combination connection is more suitable. The weight applied on the tile and corresponding voltage generated is studied and they are found to have linear relation. The result clearly shows that piezoelectric transducers are the future of electric power generation.

References

- [1] Vibration Based Energy Harvesting Using Piezoelectric Material, M. N. Fakhzan, Asan G. A. Muthalif, Department of Mechatronics Engineering, International Islamic University Malaysia, IIUM, Kuala Lumpur, Malaysia.
- [2] Piezoelectric Crystals: Future Source Of Electricity, International Journal of Scientific Engineering and Technology, Volume 2 Issue 4, April 2013 Third Year Electronics Engineering, Atharva College of Engineering, Mumbai, India
- [3] Electricity from Footsteps, S.S.Taliyan, B.B. Biswas, R.K. Patil and G. P. Srivastava, Reactor Control Division, Electronics & Instrumentation Group And T.K. Basu IPR, Gandhinagar
- [4] Estimation of Electric Charge Output for Piezoelectric Energy Harvesting, LA-UR-04-2449, Strain Journal, 40(2), 49-58, 2004; Henry A. Sodano, Daniel J. Inman, Gyuhae Park
- [5] Center for Intelligent Material Systems and Structures Virginia Polytechnic Institute and State University
- [6] Design Study of Piezoelectric Energy- Harvesting Devices for Generation of Higher Electrical Power Using a Coupled Piezoelectric-Circuit Finite Element Method IEEE Transactions on Ultrasonic's, Ferroelectrics, and Frequency Control, vol. 57, no. 2, February 2010
- [7] Meiling Zhu, Member, IEEE, Emma Worthington, and Ashutosh Tiwari, Member, IEEE