Footstep Power Generation

Rose Mariya Davis, Sara Susan B, Sneha Shaji and Sonah S Tiju
Electronics Dept., Model Engineering College, APJ Abdul Kalam Technological University, Kerala, India

Keywords: Piezoelectric Effect, Energy Harvesting, Sensors, Footsteps.

Abstract: The objective of our project, Footstep Power Generation, is to harvest energy through means of a non-conventional energy source. We suggest a method for power generation using piezoelectric sensors. These sensors produce an alternating voltage across them on application of pressure. The voltage produced is proportional to the rate of change of applied pressure. For densely populated nations like India and China, where the roads, railway stations, bus stops, temples, etc, are overcrowded and millions of people move around all the time, the proposal for the utilization of power generation via human locomotion is very relevant and important. The energy generated from this project can be used to power energy required facilities like street lights and other public facilities.

1 INTRODUCTION

Electricity has now become a lifeline for the human population, with demand increasing by the day. The growing worry about the gap between demand and supply of power for the masses has heightened interest in the research of alternative energy sources and their sustainable use. That is where the concept of energy harvesting comes into play. Energy harvesting is capturing energy that is already available but will go waste if not used.

Electrical power generation via piezoelectricity is one such energy harvesting approach that does not negatively impact the environment based on a principle called the piezoelectric effect. Piezoelectric energy harvesting converts mechanical energy into electrical energy and can power low-power electronics. While piezoelectric materials operate at lower energy levels compared to other methods, they provide a way to harness wasted energy without negatively impacting the environment.

2 OBJECTIVE

Our project aims to harvest energy through means of a non-conventional energy source. We propose a method for generating power utilizing piezoelectric sensors. When pressure is applied to these sensors, an alternating voltage is produced across them. The voltage produced is proportional to the rate of change of applied pressure.

3 LITERATURE REVIEW

We have done extensive research on the areas pertaining to our project, ranging from piezoelectricity to the concept of energy harvesting. Many papers were taken into consideration, of which the relevant papers are given below:

3.1 Design of footstep power generator using piezoelectric sensors (Akshat Kamboj, Altamash Haque, et al. 2017)

This paper investigates various methodologies for footstep power generation using piezoelectric sensors. The authors describe the experimental setup and present results in terms of output voltages, effectively demonstrating power generation through current-voltage plots. The research inspires the potential for widespread adoption and progress in footstep-generated power technology. Motivated by the concept of energy harvesting through the piezoelectric effect, we undertook a project to implement our experimental setup, showcasing the practicality of power generation. As part of our project, we thoroughly studied and plotted the V-I characteristics of piezoelectric materials under different stress and strain conditions.

Mariya Davis, R., Susan B, S., Shaji, S. and S Tiju, S.
Footstep Power Generation.
DOI: 10.5220/0013596000004664

In *Proceedings of the 3rd International Conference on Futuristic Technology (INCOFT 2025) - Volume 2*, pages 523-528
ISBN: 978-989-758-763-4

3.2 Footstep Power Generation using Piezoelectric Plate (K.Soni, N. Jha, et al. 2022)

This research paper recommends making use of human locomotion energy, which, despite being extractable, is largely wasted. This approach presents an energy storage concept that employs human movement, skipping, and running as energy. The paper further talks about the experimental setup which provided us a model to study from. The analysis that people's weight provides power when they walk on the rungs or platform made us implement our project using a platform.

3.3 Power Generation from Steps (Ramesh Raja R and Sherin Mathew 2017)

This research paper demonstrates the potential of harnessing and utilizing energy from commonly used floor steps. Given the growing prevalence of staircases in buildings, even in small structures, substantial energy is currently being wasted through heat and friction dissipation when people climb stairs. The paper proposes the concept of converting each staircase into a power generation unit, capturing and generating electricity from this untapped energy source. The generated power can then be stored in batteries and subsequently used to power the lighting systems within the building.

3.4 Shoe-mounted piezoelectric energy harvester (K. Q. Fan and Z. H. Liu 2018)

This paper presents the design of a piezoelectric energy harvesting system embedded in footwear to convert mechanical energy from human walking into electrical energy. The proposed device integrates a spring-mass system magnetically coupled to four piezoelectric cantilever beams that respond to bidirectional accelerations generated during walking.

3.5 Design of Footstep power generation (P. Venkatesh, M. Satya, et al. 2019)

This paper presents the design and development of a footstep-based power generation system using piezoelectric sensors. It compares the performance of different piezoelectric materials and analyzes the voltage and current output under various pressures. It also discusses the limitations of the current setup, including low energy output. It suggests future improvements, such as the use of DC-DC converters for better efficiency, and proposes wider applications in high-traffic areas such as stairs and treadmills.

4 SCOPE AND RELEVANCE

Due to advancement and applications in the present life of humans, there is an increasing demand for electricity day by day. There are numerous ways to generate electricity, and one of them, footstep power generation, could be an efficient method. This is an efficient method to harness the tremendous amount of energy lost while walking. While walking, weight is transferred to the road surface via foot falls on the ground with each step, and energy is lost to the road surface via sound, throbbing and impact.

Footstep power generation technology is based on the idea of piezoelectric concept. When piezoelectric materials are subjected to pressure and strain, they can accumulate an electrical charge. Piezoelectricity, in other words, is the capacity of a few materials to generate an electric potential in the presence of a load.

5 APPLICATION

The proposal to use the lost energy from human movement to generate power is especially relevant and crucial for highly populated nations like India and China, where people's mobility will be a boon in producing electricity from their footsteps. In India, roads, train stations, and bus stops are all packed, with hundreds of people travelling in an hour. As a result, this innovative and promising technology has the potential to create massive amounts of power. The application of such technologies would help to pull civilization away from non-renewable energy sources such as coal, petroleum and natural gas.

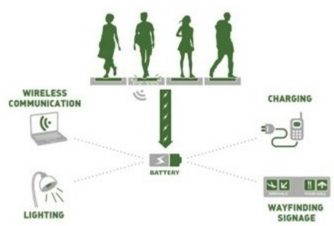

Figure 1: Different applications

6 NOVELTY

The project on footstep power generation using piezoelectric crystals brings a novel and innovative approach to sustainable energy production. It presents an exciting and groundbreaking approach to address the world's energy needs.

By tapping into the kinetic energy produced by human footsteps, this project harnesses an underutilized and often overlooked energy source. The utilization of piezoelectric crystals, which convert mechanical pressure into electrical energy, offers a unique and efficient method of energy conversion. Unlike traditional renewable energy sources such as solar or wind, which rely on external factors, this project leverages the inherent movement of individuals to valuable sources of power. This novel concept opens up a realm of possibilities for energy harvesting in various settings, including crowded urban environments, public spaces, and even high-traffic areas like airports or train stations. This concept not only promotes renewable energy generation but also encourages the integration of energy harvesting into our urban environments.

With the potential to power various low-energy devices and contribute to the overall reduction of carbon emissions, this project represents a pioneering effort in the field of energy harvesting and sustainable living. By transforming footsteps into a sustainable energy source, this project not only promotes renewable energy adoption but also encourages a more conscious and energy-aware society. The novelty lies in the exploration of the unconventional sources and their integration into mainstream energy systems, providing a pathway towards a cleaner, more sustainable future.

7 METHODOLOGY

The footstep arrangement is used to generate the electric power. Nowadays power demand has increased, so the footstep arrangement is used to generate the electrical power in order to compensate for the electrical power demand. In this arrangement, the mechanical energy is converted into electrical energy.

This project makes use of piezoelectric sensors, capacitors, bridge rectifiers and diodes. The piezoelectric sensors are soldered together in series parallel combinations and connected to various components on the circuit board.

The footstep arrangement is used to generate the electric power. In this arrangement, the mechanical energy is converted into electrical energy. The working mechanics of piezoelectric sensors are shown below:

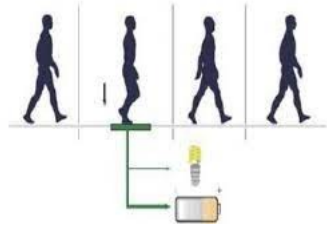

Figure 2: Schematic representation of footstep

8 SYSTEM OVERVIEW

The system consists of several key components working together to achieve efficient energy harvesting. The components used in this project are piezoelectric sensors, 2200 μF 16V capacitors, bridge rectifier ICs (MB10) and IN4007 diodes. The output of each piezoelectric sensor is given to a bridge rectifier and then connected in series parallel combinations soldered together. Inorder to prevent reverse flow current, a PN junction diode is placed at the end of each combination to obtain the final output. In order to enhance the output power efficiency, non-electrical components like sponge and silicone bumpers are used in the circuit.

9 BLOCK DIAGRAM

The block diagram represents the flow of energy conversion and storage in the footstep power generation system.

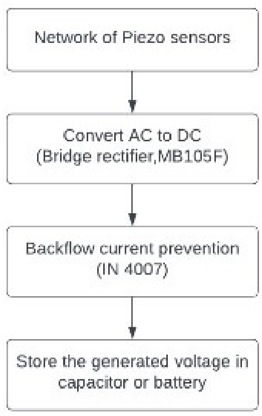

Figure 3: Block diagram

9.1 Network of Piezoelectric sensors

The core component of the system, piezoelectric sensors, are strategically placed in areas where foot traffic is significant. These sensors are typically made of special materials, such as crystals or ceramics, that exhibit the piezoelectric effect. When subjected to pressure or stress, the piezoelectric materials generate an electric charge across their surfaces, proportional to the applied force. The piezoelectric sensors are deployed in the designated areas to detect and measure the footstep impact. These sensors are responsible for producing voltage when footsteps are detected.

9.2 Bridge rectifier

When the sensors detect a footstep, mechanical pressure is applied to the piezoelectric crystals. The piezoelectric effect causes the crystals to distort as a result of the pressure, resulting in an electric charge. The electric charge generated by the crystals is initially in the form of a low-voltage, high-frequency alternating current. The bridge rectifier transforms and stabilizes the output from a pulsating AC to DC form. It ensures that current flows in a single direction, eliminating negative half-cycles and providing a DC waveform.

9.3 Backflow current prevention

The 1N4007 is a standard rectifier diode that allows current to flow in one direction while blocking the flow in the opposite direction. The high backward resistance of the 1N4007 diode makes it suitable for backflow current protection in the circuit. When connected in series with a load, it ensures that current can only flow in the appropriate direction, protecting the circuit from potential harm caused by polarity or current backflow.

9.4 Generated voltage stored in Capacitor/Battery

Energy storage devices, such as batteries or capacitors, are used to store excess energy for later use or to maintain a constant power supply. The rectified DC voltage output of the bridge rectifier is connected to the capacitor. The capacitor is an energy storage device. It charges and retains the electrical energy generated by the piezoelectric sensors. It smoothes the DC waveform, eliminating voltage fluctuations and delivering a more steady output.

10 PROTOTYPE DESIGN

A small scale representation of our project is implemented through a prototype design. The design involves arranging piezoelectric sensors in a series-parallel configuration, with six sensors connected in series, and 44 of these connected in parallel. The piezos are mounted between two wooden boards and it bolted with four screws, one at each corner with a spring placed on each screw. Each piezoelectric sensor is positioned on a sponge and equipped with a silicone bumper mounted on top.

Figure 4: Top view of project

Figure 5: Inside view of project

Figure 6: Side view of the project

11 IMPLEMENTATION

In the footstep power generation system using piezoelectric crystals, an array of piezoelectric sensors is employed to convert the applied pressure into electrical energy. As people walk over the sensors, their weight exerts pressure on them, causing the piezoelectric crystals to deform and generate an alternating voltage.

To convert the alternating voltage into a direct current (DC) voltage, a bridge circuit is utilized. The bridge circuit consists of diodes and resistors arranged in a specific configuration. It rectifies the alternating voltage, converting it into a unidirectional flow of current, thereby generating a DC voltage.

To prevent the backflow of current and ensure a one-way flow, a diode is placed after the series parallel combination of sensors. This diode acts as a check valve, allowing the current to flow in one direction while blocking any reverse flow.

The output DC voltage, obtained after the bridge circuit and diode, is then stored in a capacitor. The capacitor serves as an energy storage device, allowing the system to store and accumulate the generated electrical energy over time.

This stored energy can be used to power various low-energy devices or can be further conditioned and distributed for other applications.

12 TESTING AND OBSERVATIONS

After the final assembly, we moved into the testing process of the project. Our project has a combination of 50 piezoelectric sensors, in which 6 are connected in series and the rest of the sensors are connected parallel to them in such a way that we have the highest output efficiency. This design of the project was chosen after going through the observations given below:

Table 1: Power Generation at different weights

Sl. No.	Weight(Kg)	Voltage(V)	Power(mW)
1	20	0.1	0
2	40	3	0.012
3	60	9	0.06
4	80	12	0.138

The voltages formed across the piezoelectric effect, as well as the quantity of current that passes through them are measured. When different pressures and stresses were evaluated on the piezoelectric element, different voltage readings were observed that corresponded to those same different pressures and strains. Different values of weight ranging from 20Kg to 120Kg with intervals of 20 Kg have been tested as shown in Table 1.

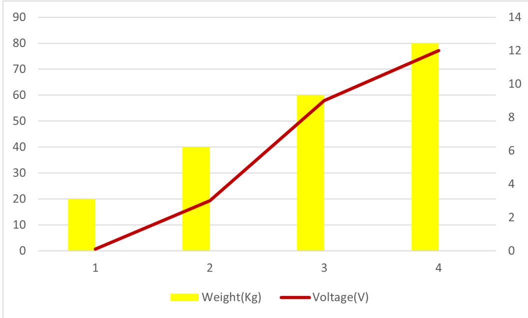

Figure 7: Weight(Kg) versus Voltage(V) graph

13 RESULTS

After conducting thorough research on various types of piezoelectric sensors available in the market, we determined that a 27mm diameter sensor was the more suitable for our project as compared to the 21mm diameter sensor. To optimize power generation, we conducted experiments with different series and parallel connections of the sensors.

At first, we used a bridge of IN4007 diodes for full wave rectification in our circuit and on further research we found that the power consumption was considerably less for a MB10 bridge rectifier IC.

During our extensive research, we made a significant breakthrough by discovering that bending the sensors slightly, rather than applying direct pressure, resulted in increased power output. This phenomenon occurs because bending the piezoelectric sensors not only applies stress but also takes into account the strain on the sensor, resulting in higher voltage production compared to a single sensor.

This breakthrough was the missing piece of the puzzle for our project. In order to achieve the desired bending effect without damaging the sensors, we introduced the use of a sponge beneath each sensor and a silicone bumper on top. These additional components allowed us to achieve the desired bending effect without compromising the integrity of the sensors.

14 FUTURE SCOPE

As the consumption of energy grows, the population depends more and more on fossil fuels such as coal, oil and gas day by day. There is a need to secure the energy supply for the future due to the price hike as well as the growing depletion rate of these fuels. This is where the importance of non - conventional energy sources comes into play.

For densely populated nations such as India and China, where roads, railway stations, bus stops, temples, and other public places are overcrowded with millions of people constantly moving around, this project may help to harness the energy lost through our footsteps, which can then be put to good use. The proposal for the utilization of power generation via human locomotion is very relevant and important.

15 ADVANTAGES

Footstep power generation captures the energy from human footsteps to create renewable electricity, readily available in public places and high-traffic areas. This innovative approach efficiently taps into underutilized energy that would otherwise go waste, contributing to a cleaner and more sustainable energy mix. This project reduces carbon emissions and our reliance on fossil fuels making it a smart and eco-friendly way to power our world.

16 DRAWBACKS

Footstep power generation heavily relies on a steady flow of foot traffic to produce enough energy. In areas with low foot traffic, the power output may not be significant, which limits its effectiveness in such locations. Additionally, the amount of energy generated from each footstep is relatively low, making it better suited for low-power applications rather than high-energy-demand situations.

Footstep power generation systems can face mechanical wear and tear due to the continuous impact and pressure of footsteps. This can impact the durability and lifespan of system components, necessitating regular maintenance and replacement. Moreover, the power output can fluctuate due to individual factors like weight and walking patterns, posing challenges in predicting and stabilizing power generation levels.

17 CONCLUSION

The project described is a well-balanced energy generation concept that is simple to set up and apply. If implemented on a wide scale, this concept can be used as an alternative for power supply. This can also be used in locations where there is a high demand for energy conservation. The main component of this approach is mechanical stress or pressure, which occurs naturally in most settings. This strategy can be effectively used in overcrowded areas such as roadways, railway stations, bus stops, temples and other public avenues where millions of people walk around all the time.

ACKNOWLEDGEMENT

We would like to express our gratitude to the Principal, Dr. Jacob Thomas V and our Head of the Department, Dr. Mini M G for providing us all the necessary facilities. We would also like to thank the Mini Project Co-ordinator, Mr. Pradeep M, Associate Professor for his valuable help and support. We acknowledge the use of ChatGPT, which contributed to the content curation and refinement of our ideas through insightful conversations and suggestions.

REFERENCES

Akshat Kamboj; Altamash Haque; Ayush Kumar; V. K. Sharma; Arun Kumar, "Design of footstep power generator using piezoelectric sensors," 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), Coimbatore, India, 2017, pp. 1-3, doi: 10.1109/ICIIECS.2017.8275890.

K. Soni, N. Jha, J. Padamwar, D. Bhonsle, and T. Rizvi, "Footstep Power Generation Using Piezoelectric Plate," International Research Journal of Modernization in Engineering, Technology and Science, vol. 4, no. 3, pp. 1736–1740, Mar. 2022.

Ramesh Raja R; Sherin Mathew, "Power Generation from Staircase (steps)" International Journal of Innovative Research in Science Engineering and Technology, vol.3, Issue 1, February 2014.

K. Q. Fan and Z. H. Liu, "Capturing energy through a shoe-mounted piezoelectric energy harvester," 2018 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), Auckland, New Zealand, 2018, pp. 768-773, doi: 10.1109/AIM.2018.8452404.

P. Venkatesh, M. Satya, M. Sahil, and P. Sai, "Design of footstep power generation using piezoelectric sensors," Pramana Res. J., vol. 9, no. 6, pp. 1358–1363, 2019.

P. Hole and P. Gophane, "Footstep power generation using Piezo electric sensor," Int. Res. J. Eng. Technol., vol. 07, no. 3, pp. 270–272, 2020.

B. Ali and A. Mashaleh, "Power Generation Using Piezoelectric Materials", no. December, pp. 0–4, 2018.

S. S. Patil, M. K. Sushmitha, V. Baliga, and S. L. Vishwanath, "Footstep Power Generation," Int. Res. J. Eng. Technol., vol. 08, no. July, pp. 2835–2837, 2021.