IJCSE International Journal of Computer Sciences and Engineering Open Access
Technical Paper Vol. 9, Issue.6, June 2021 E-ISSN: 2347-2693

Energy Generation From Footsteps Using Piezoelectric Sensors

Somashekhar G.C.[1*], Anu Reddy K.H[2], Bini Mariam Biju[3], Prateeka L.[4]

[1,2,3,4]Dept. of Electronics and Communication, Rajiv Gandhi Institute of Technology, Affiliated by Visvesvaraya Technological University, Belagavi, Karnataka, India

[*]*Corresponding Author: gcsomu@gmail.com, Tel.: +91 9964144520*

DOI: https://doi.org/10.26438/ijcse/v9i6.5458 | Available online at: www.ijcseonline.org

Received: 10/Jun/2021, Accepted: 13/Jun/2021, Published: 30/Jun/2021

***Abstract*—** Human race requires energy at very rapid rate for their living and wellbeing from the time of their arrival on this planet, because of this reason power resources have been worn out and enervated. One of the sectors that have gained much interest is devices that are able to convert ambient energy into electrical energy. This paper presents an experimental model for harvesting kinetic energy of footsteps using Piezoelectric. Piezoelectric materials are promising for energy harvesting from the force generated by human footsteps, into a useful form of electrical energy. Installing piezoelectric tile (Piezotile), we can achieve the little amount of power, a single piezotile, which has the capability to produce a maximum of 5-8 volts, eventually installing numerous piezotile, will provide us with much voltage, and application of additional current source we can generate more amount of power . Piezotile is one kind of piezoelectric transducer which transforms foot stress into electric energy. From the stored energy in the battery, the power is supplied to Radio-frequency identification (RFID) as it uses electromagnetic field to automatically identify and track tags attached to objects. And hence only authorized person with tag can login to RFID and use the energy for various applications

***Keywords*—** Footsteps, Piezoelectric tile, Power Generations; Renewable Energy; energy harvesting, Piezoelectric sensors, RFID.

I. INTRODUCTION

At present, electricity is the necessary part of the human life in daily activities and demand of electricity is increasing exponentially day by day. For sustainable development, we need to develop more efficient, pollution free and renewable energy resources to meet the unending demands. Modern technology requires a vast amount of power in the form of electricity for its different operations. Worldwide electricity generation contributes maximum in pollution as the single largest source. Also, exponential increasing demands of electricity creating a large gap between demand and supply.

Energy harvesting is defined as the process by which energy is derived from external sources in the environment and storing it in batteries for powering various systems. The most popular energy harvesting technologies are photovoltaic, wind and piezoelectric energy harvesting. Among these, piezoelectric energy harvesting can be implemented in small and large scale and is relatively easy and cheap to implement. PZT (Piezoelectric Transducer) can be used as a mechanism to transfer ambient energy into electrical energy which can be used for low power devices. The piezoelectric transducer has two properties that are defined as a direct and contrary effect. The direct effect is the property of some materials to promote electric charge on their plane when mechanized strength is put on them, while a contrary effect is the property of some materials to produce mechanized strength when an electric charge is induced.

In this technology, piezoelectric effect is used to generate the electricity. When pressure and strain are applied to a material which shows piezoelectric effect have the capability to build up an electrical charge. Piezoelectric materials act as a transducers and pressure exerted by the moving people transformed into electric current. This paper presents the design of power generation from footstep using piezoelectric sensors and storing the generated power with detailed study of their merits, demerits, the sub equipment and their requirements.
This paper is organized as follows: Section I contains the introduction, the related works are outlined in Section II, Section III describes the experimental setup of the proposed system, Section IV explains the working methodology with flow chart, Section V contains the result, Section VI presents the analysis of the system, and Section VII concludes research work with future directions.

II. RELATED WORK

With reference to the reference paper indicated in [1], piezoelectric materials are promising for energy harvesting from the force generated by human footsteps, into a useful form of electrical energy. The piezoelectric energy harvesting (PEH) module proposed in the present study consists of a novel mechanical structure with

beams and helical compression spring. The structure is optimized to generate maximum deflection in the beams with the applied force resulted from human walking. The maximum deflection in the beams, results in maximum output voltage generation in the PZT disks. The generated voltage is fed to the load through a full-wave rectifier. Further referring to referring to reference paper [2], the purpose here is to develop a device that can convert pressure into electrical energy based on the piezoelectric element. This project will also show that the presence of waste vibration energy might have some values to be used. The system of this energy generating project includes the conversion of continuous compression of floors by human pressure across piezoelectric materials into electrical energy. The reference paper [3], power generation is from the foot over bridge using piezoelectric tile. The suggested scheme of piezotile is based on single piezoelectric transducer and assembled numerous piezotiles. The total system is fabricated on the foot over bridge. To analyze the mechanical system of the piezotile convert to the electrical circuit and PID controller is used to making the system more stable and increase the accuracy in the piezoelectric transducer.

III. EXPERIMENTAL SETUP

The direct piezoelectric effect is discovered in many artificial ceramic materials such as lead-zirconate (PbZrO3), lead-titanate (PbTiO3), barium-titanate (BaTiO3), aluminium nitride (AIN), potassium-sodium niobate (KNLN) and lead zirconate-titanate (PZT). Because of their high electrochemical coupling coefficient and piezoelectric constant compared to piezoelectric polymers. Piezoelectric ceramic materials are mostly preferred for energy harvesting and sensing applications from resulting stresses vibrations. Heart of the present footstep power generator is the piezoelectric sensor which works as shown in Figure 1.

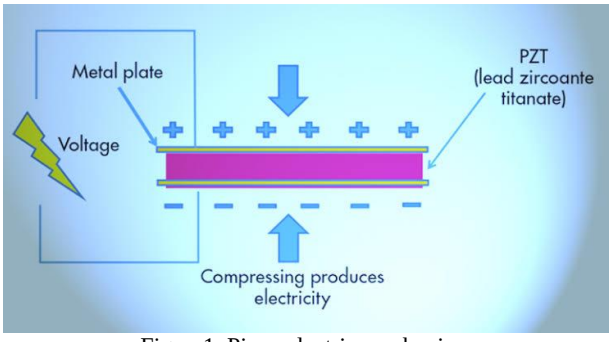

Figure1. Piezo electric mechanism

In this present footstep power generator, the piezoelectric material plays a great role so its choice is of great importance. PZT and PVDF are the two most commonly available piezoelectric materials, so an analysis on these two materials was carried out, to chose the most suitable material. The basis for selection was better output voltage for various pressures applied. In this project, piezoelectric elements effectively implemented as a source of green energy. Electromechanical coupling between the electrical and mechanical domains is shown here. When people walk across by the piezoelectric tiles it will generate small electrical energy, this energy is also known as piezoelectricity.

A. Block Diagram of the designed system

The basic design system of the block diagram is shown in figure 2, some pressure will be given on the piezo surface and voltage is generated. The output voltage is connected with rectifier and by this ac to dc voltage conversion takes place and stored in the battery. The Arduino that is interfaced control the process of displaying the voltage generated, power utilization only for authorized people using RFID module in the system.

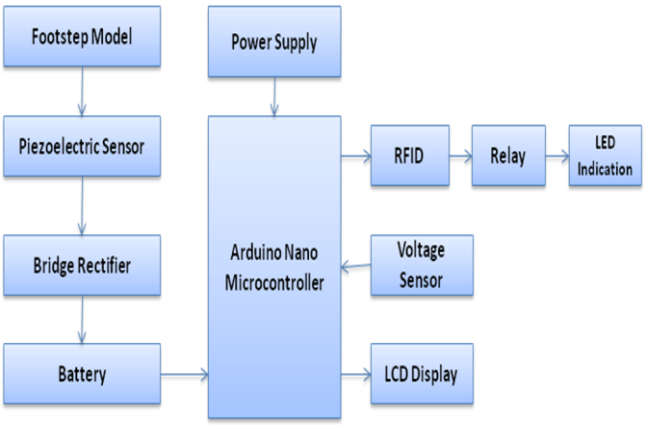

Figure2. Block Diagram of footstep power generation

B. Conceptual design

The main concept was to build a piezoelectric tile which can generate electricity in the most efficient way. A conceptual design is shown in Figure 3 and Figure 4. Figure 3 represents the conceptual design of piezoelectric disc array and Figure 4 shows the connections of the discs.

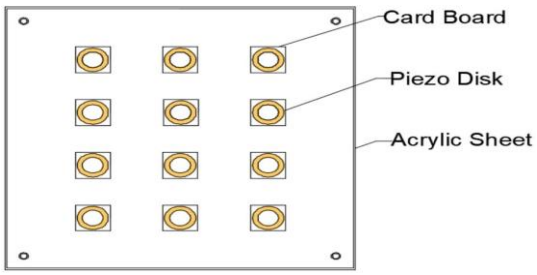

Figure3. Design for piezoelectric disk array

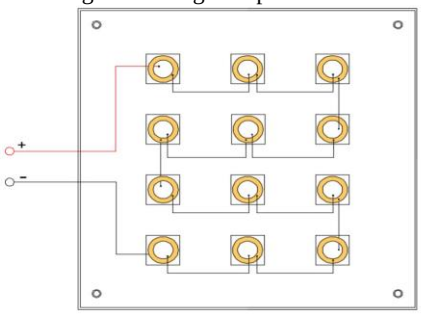

Figure4. Piezo Electric Disc Connections

Acrylic sheet is used for uniform pressure distribution. Cardboard is used on both sides of the piezo disc in the design because the deformation of cardboard is high so the electricity generation will also be high.

IV. METHODOLOGY

The prototype contains a piezoelectric tile containing six piezo sensors connected in series. Here piezoelectric sensors form the heart of the system. They generate electrical charges when pressure is applied on them. When physical foot is layed on the footstep model the pressure is applied on the model. Due to the pressure and strain applied the piezo sensors convert the mechanical energy into electrical charges. The sensors generate the AC voltage and cannot be feed to the battery directly. By using the bridge rectifier it is converted to DC signal. In order to get the constant supply will use diode followed by the capacitor. The capacitor is charged by the rectifier. Charging threshold voltage of this capacitor is predetermined and at this voltage the switch closes and discharging of capacitor takes place through device.

The voltage sensor calculates and monitors the amount of voltage generated. Voltage sensors can determine the AC voltage or DC voltage level. The input of this sensor is voltage whereas the output is analog output signal. The out of the voltage sensor is given to the Arduino. The Arduino microcontroller controls the entire process. Through the LCD display connected to the Arduino we can see the generated voltage. The power generated is stored in the battery. We are using Arduino IDE, the open source Arduino software to write the code for working of the system and has been uploaded to the Arduino board.
The RFID is interfaced with the Arduino and it uses electromagnetic fields to transmit and receive data. It consists of transponder or tag (card) that has to be identified and transceiver known as reader. The reader consists of Radio Frequency module and antenna. It emits radio waves and receives signals back from RFID tag. Tags consist of microchip that stores and process information use radio waves to communicate their identity and other information to nearby reader. When placed in close proximity to the reader enables the reader to read the information. The people who have access to it can connect to the supply by tapping the card on it. And the people who do not have the access cannot connect to the supply. When the person is authorized the led turns on for a specified time period. Switching the LED is realized through relay module. For application purpose the mobile charger can be connected and the mobile can be charged for specified time. The power that is stored in the battery connected to an inverter can be used in running of load. Figure 5 shows the flowchart of working of the proposed system.

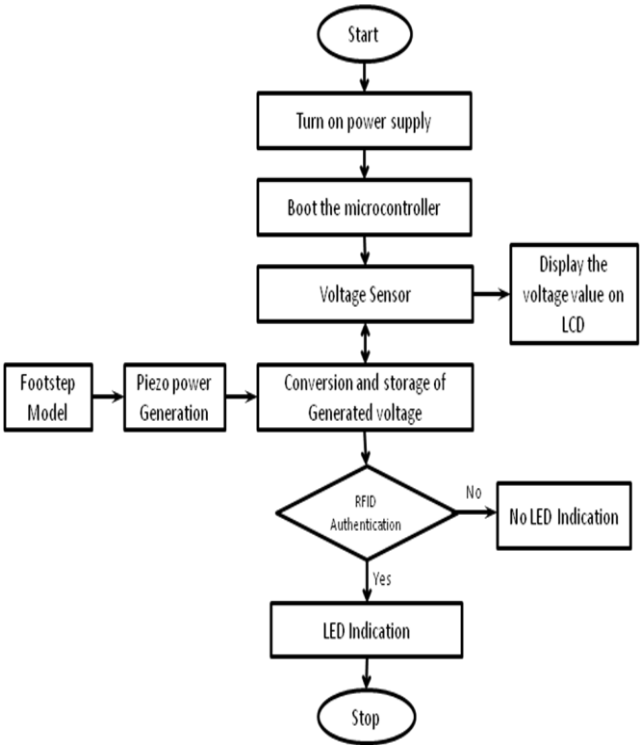

Figure5. Flowchart of the proposed system

V. RESULT

This project provides the methodology for footstep power generation using piezoelectric sensors. The experimental setup is discussed with all sub equipments. The hardware and software components are successfully implemented. As different observed pressure and strain are tested on the piezoelectric material, different voltage readings were noted corresponding to the different pressure and strain.

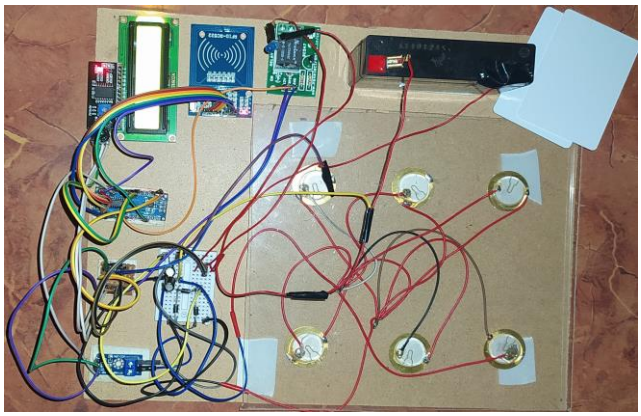
Figure6. Footstep model

In this way, the energy can be stored in the capacitor by charging the capacitor, and will be discharged on the basis of requirement. However the energy harvesting capacity of this circuit is not very much appreciable. To overcome this problem, after bridge rectifier stage, one may use a DC to DC converter. The DC voltage will be stored in battery. Voltage sensor will measure the generated voltage and that value is displayed in the LCD display module. The power stored in the battery is used for running low powered loads.

The RFID connected through the arduino and the people who have access to it can connect to the supply by tapping the card on it. When the person is authorized the led turns ON for particular time period through relay module.

From one piezo disk a peak voltage of 1.9volt and 0.064mA peak current reading showed in the multi-meter. Then we increased the number of the piezo disk from 1 to 6. When we used 6 piezo disks the peak voltage of 10.9volt and 0.09mA of current is generated.

Figure7. Display of the results obtained

VI. ANALYSIS

V-I characteristics of both the piezoelectric material under consideration were studied to understand the output corresponds to the various pressure and strain applied on them. Voltmeters and ammeter are used for measuring the voltages developed across the piezoelectric materials and amount of current flowing them respectively. Figure 8 shows the V-I characteristics graph.

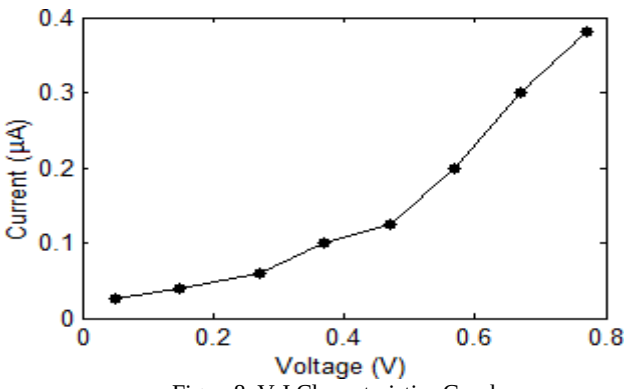

Figure8. V-I Characteristics Graph

We tapped on the single disk 3 to 4 times and found that 1.9 volt peak voltage and 0.064mA peak current reading showed in the multi-meter. Then we increased the number of the piezo disk from 1 to 6. When we used 6 piezo disks the peak voltage was 10.9volts. For different number of piezo disks the voltage generated is shown in table 1.

Table1. Voltage output from different numbers of piezo disks

Number of Piezo disk	Voltage (V)
1	1.86
2	3.56
4	6.96
6	10.9

Table 2 shows the current reading from the multi-meter. As like voltage reading when we increased the number of the piezo disks the amount of current also increased. The amount of current is very low but it increased with the increasing of disks.

Table2. Current output from different numbers of piezo disks

Number of Piezo disk	Current (mA)
1	0.064
2	0.072
4	0.082
6	0.094

VII. CONCLUSION AND FUTURE SCOPE

In this project, the main object was to find an approach to generate electrical energy from mechanical stress using piezoelectric elements. It was seen that mechanically excited piezoelectric materials were giving high voltage spike but low current. Using the design system energy was generated and the output was observed carefully. But the amount of time to charge was too long as only 6 piezoelectric elements were used in the experiment setup. Thoroughly calculations were done and it was seen that for the results a large array of the piezoelectric element needed to be connected in series. Some calculations were made with 10-15% error but it can be modified and still beneficial for a green source of energy.

The various merits are power generation is simply walking on the footstep model and no need of fuel, power may also be generated by running or exercising on the footstep model and battery may be used to store the conventional power. There is added advantage that by using RFID only people who are having an access can only use the supply.
In future work, some may attempt to overcome following limiting factors as it is applicable for the particular place and limited power is generated using the conventional ICs present in market. In future we may implement the same methodology in a large scale for satisfying larger loads or household purposes by implementing in treadmills,

staircases and places with frequent human moment with their commercial usage model. By improving durability, the piezo materials can be used in highway road, rail line etc. to produce more energy

REFERENCES

[1]. P. Sirigireddy and P. B. Eladi, "Numerical Design of Novel piezoelectric generating structure that effectively utilizes the force generated from human motion," 2020 IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy (PESGRE2020), Cochin, India, pp.1-6, 2020, doi:10.1109/PESGRE45664.2020.9070599.

[2]. K. Somalaraju, J. G. Singh, "Enhancement of Power Generation From Electromagnetic Scavenging Tile", 2020 International Conference on Power Electronics & IoT Applications in Renewable Energy and its Control (PARC), Uttar Pradesh, India, pp.405-410, 2020, doi:10.1109/PARC49193.2020.236638.

[3]. M. R. Ruman, M. Das and S. M. Istiaque Mahmud, "Human Footsteps for Energy Generation by using Piezoelectric Tiles", Innovations in Power and Advanced Computing Technologies (i-PACT), Vellore, India, pp.1-6, 2019, doi:10.1109/i-PACT44901.2019.8960068.

[4]. T. B. A. Akib, H. Mehedi and M. Nazmuschayadat, "Electrical Energy Harvesting from the Foot Stress On Foot Overbridge Using Piezoelectric Tile," 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT), Dhaka, Bangladesh, pp. 1-5, 2019, doi:10.1109/ICASERT. 2019. 8934544.

[5]. D. Dalabeih, B. Haws and S. Muhtaseb, "Harvesting kinetic energy of footsteps on specially designed floor tiles," 2018 9th International Renewable Energy Congress (IREC), Hammamet, pp.1-4, 2018, doi:10.1109/IREC.2018.8362566.

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

[8]. Divyakumar. N, Ganesh. V. S, Vishnuraju. G, Yogesh. P and Sangappa. S. B, "Production of Electricity through Pressure Based Sensors", 2016 International Journal of Computer Sciences and Engineering (IJCSE), India, Vol.04, Special Issue 03, pp. 188-191, 2016.

[7]. R. M. Veena, B. H. Reddy and S. M. Shyni, "Maximum energy harvesting from electromagnetic micro generators by footsteps using photo sensor", 2016 International Conference on Computation of Power, Energy Information and Communication (ICCPEIC), Chennai, India, pp.757-761, 2016, doi:10.1109/ICCPEIC.2016.7557321.

[8]. T. R. Deshmukh, "Design and analysis of a Mechanical Device to harvest energy from human footstep motion", International Journal of Innovative and Emerging Research in Engineering, Vol.3, Special Issue 1, 2016.

[9]. Miss. Mathane Nitashree V, "Foot Step Power Generation Using Piezoelectric Material", International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), Vol.4, Issue 10, 2015.

[10]. Jose Ananth Vino, "Power Generation Using Foot Step", International Journal of Engineering Trends and Technology (IJETT), Vol.1, Issue.2, 2011.

AUTHORS PROFILE

Mr. Somashekar G C graduated from Karnataka University in Electronics and Communication Engineering and MTech from S.K.University in Communication and Signal Processing. He is pursuing Ph.D from Visvesvaraya Technological University, Belagavi and currently working as assistant professor in Rajiv Gandhi Institute of Technology, Bangalore in the Department of Electronics and Communication Engineering. His area of interest is Image Processing.

Miss. Anu Reddy K H pursuing Bachelor of Engineering in Electronics and Communication Engineering in Rajiv Gandhi Institute of Technology, Bangalore under Visvesvaraya Technological University, Belagavi, Karnataka. Her area of interest is Satellite Communication and IOT.

Miss. Bini Mariam Biju pursuing Bachelor of Engineering in Electronics and Communication Engineering in Rajiv Gandhi Institute of Technology, Bangalore under Visvesvaraya Technological University, Belagavi, Karnataka. Her area of interest is Robotics and IOT.

Miss. Prateeka L pursuing Bachelor of Engineering in Electronics and Communication Engineering in Rajiv Gandhi Institute of Technology, Bangalore under Visvesvaraya Technological University, Belagavi, Karnataka. Her area of interest is Embedded Systems and Machine Learning.

