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Footstep Power Generation Using Piezoelectric Sensors

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ABSTRACT: The innovative method for capturing energy from human footsteps using piezoelectric sensors is introduced in this paper. A Piezoelectric Sensor Foot Base (PSFB) is designed for utilizing the pressure of feet to generate electrical energy. The research for meeting UNs 17 Sustainable Development Goals (SDGs) intensifies the need to fulfill the sustainability trilemma with energy security, social equity and reduction in environmental degradation. The implementation of PSFB ensures zero pollution and maintains energy security while harnessing the otherwise wasted feet energy of the dense mass gathering of people. The focus of our study is on the development, installation, and optimization of the proposed PSFB that generates power from footsteps by the integration of a piezoelectric sensors beneath the floor surface. For the present research the electricity generation proportional to the applied footstep weight is compiled for a particular series-parallel configuration of piezoelectric sensors. The theoretical foundation, modeling techniques, and test results are explored to demonstrate the feasibility and efficiency of this technology. The designed PSFB is applied on specific populated areas and found to be a practicable alternative for waste energy utilization

KEYWORDS: Electricity, PSFB, Environment, SDGS, Piezoelectricity

I. INTRODUCTION

The increasing population of the country has led to a rise in the demand for power, resulting in an escalation of energy wastage. The solution to this issue lies in the conversion of this wasted energy into a usable form. With the evolution of technology and the widespread utilization of electronic devices, traditional methods of power generation are proving to be inadequate. There is an urgent requirement for alternating power generation techniques to cater to the growing demand.

Furthermore, energy is being squandered through human movement in various manners. To tackle this problem, piezoelectric sensors can be employed to transform this wasted energy into usable power. These sensors have the capability to convert pressure into voltage, enabling the generation of power through systems like footstep power generation system.

This project is focused on producing voltage through the force of footsteps. As a mass of people walks up and down on the stairs, calories are burnt thereby releasing energy of the footsteps on stairs. The generated power will be stored in a battery and used for many purposes. This method can be used in densely populated areas such as schools, colleges, temples, movie theaters, and other places where people walk around all day. By integrating piezoelectric sensors for force and pressure measurement, we can efficiently harness this energy.

This system uses voltmeter for measuring output, LED lights and a battery for better demonstration of the system and for storing the power generated by the footsteps. By implementing this approach, we not only generate power but also contribute to the conservation of natural energy resources.

II. RELATED WORK

In recent years, there has been a growing interest in the development of energy harvesting devices for various applications. One such innovative device is the energy harvesting eel, as proposed by George W. Taylor et al. (2001) in their paper [1]. This device aims to harness power from the natural movements of eels in ocean and river environments, providing a sustainable source of energy.

The concept of utilizing piezoelectric materials for energy harvesting has also been explored in other studies, such as the work by Henry A. Sodano et al. in their comparison of piezoelectric energy harvesting devices for recharging batteries [2]. Additionally, the use of piezoelectric ceramics for electric power generation within orthopedic implants has been investigated by S.R. Platt et al. in their paper published in IEEE/ASME Transactions on Mechatronics in 2005 [3].

The advancements in piezoelectric energy harvesting technology have paved the way for applications in various fields, including vibration energy harvesting as demonstrated by E. Minazara et al. in their work on piezoelectric diaphragms for vibrating energy harvesting in 2006 [4]. Furthermore, the potential for piezoelectric power generation in civil infrastructure systems has been highlighted by Alper Erturk and Daniel J. Inman in 2011 [5].

Noaman Makki and Remon Pop-Iliev (2011) focused on designing a battery-less wireless tyre pressure sensor using piezoelectric power generation for sensor applications. The main finding of this study was the successful design and implementation of a sensor that can generate power using piezoelectric materials without the need for a battery. The limitation of this study was that it only focused on a specific application (tire pressure sensor) and it may not be applicable to other sensor applications [6].

Indrani Dakua and Nitin Afzulpurkar (2013) explored piezoelectric energy generation and harvesting at the nano-scale, focusing on. The main finding of this study was the potential for utilizing nano-scale for efficient piezoelectric energy generation and harvesting [7].

Naresh et al. (2018) presented a study on practical footstep electric power generation on campus utilising piezoelectric material and a microcontroller in the International Research Journal of Engineering and Technology. The study focuses on the design and construction of a system that harvests energy from human footsteps via piezoelectric materials and microcontroller technology. The authors are likely to cover the system's design, building, and testing, specifically the integration of piezoelectric devices with a microprocessor for efficient energy conversion and management. This study contributes to the subject of energy harvesting from human motion, particularly in campus settings, by providing insights into the feasibility and usefulness of using piezoelectric technology for sustainable power generation [8].

Kim et al. (2018) study wave power generation with piezoelectric sensors linked to a coastal structure, as reported in the Journal of Sensors. The study investigates the feasibility and efficacy of capturing wave energy using piezoelectric technology. By attaching piezoelectric sensors to a coastal structure, the scientists hope to absorb mechanical energy created by wave motion and transform it into electricity. The report will most likely describe the system's design, implementation, and performance evaluation, as well as issues like sensor placement, energy conversion efficiency, and environmental conditions. This study advances the field of renewable energy generation by investigating fresh methods of harvesting wave energy with piezoelectric technology [9].

III. METHODOLOGY

The implementation of footstep power generation using piezoelectric sensors involves the following steps:

Setting up of PSFB (Piezoelectric Sensor Foot Base): Firstly, we made a platform in which piezo sensors are mounted below the platform to generate voltage from footsteps. The sensors are placed in such an arrangement so as it generate maximum output voltage. This is then provided to our operating circuitry.

We have used 18 piezo sensors in this project, 6 piezo sensors are connected in series of three line each line consist of 6 piezo sensors making total of 18 piezo sensors, then they are connected in parallel to each other. The rating of one piezo sensor is 6V. The maximum voltage that can be generated by the PSFB is around 12V.

Setting up the operating circuit: The required components such as ACR transistor, multi core transformer, diode(1N4007), current coil, resistance, capacitor, inverter, battery, LEDs and switch and all the components are connected as per the circuit diagram.

The basic working principle of our project is based on the piezoelectric effect. Non-conventional energy using foot step is converting mechanical energy into the electrical energy. Foot step board consist of 18 piezo sensors which is connected in parallel. When the pressure is applied on the sensors, the sensors will convert mechanical energy into electrical energy. The electrical energy which is generated is now stored in the battery connected to the system. An inverter is used to convert the 12 Volt D.C to 230 Volt A.C. This 230 Volt A.C voltage is used to activate the loads. By using this AC voltage we can operate AC loads.

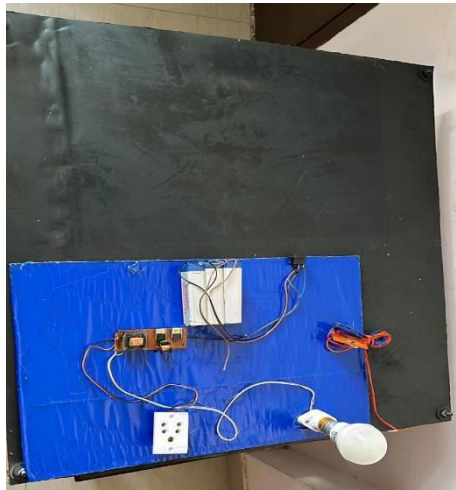


Figure 6: Snapshot of our project

The above figure shows the working model of our project where the 18 piezoelectric sensors are connected in parallel on a tile which is covered with black sheet and other components are arranged as shown in the figure.

When pressure is applied on the sensors the converted electrical energy is stored in battery then it is used to light the bulb (ac load).

IV. APPLICATIONS

The electricity generation is performed by many sensor circuit applications. However, electricity generation from waste energy is an under-utilized field and can be explored as well as implemented on a large scale. PSFB is one such effort in this direction and finds applications in the following areas:

- colleges, schools, and universities.
 - PSFB can be applied on the stairs, entry/exit passages of Institute as well as examination halls.
 - annual fests, cultural events, conferences, workshops etc.

- This can be actualized in air terminals, transport stations, railway stations.

Street lights can be provided electricity utilizing this strategy.



Figure 7: Working of model

V. RESULT

Table: Comparison of weight and voltage

Weight (kg)	Voltage (V)
50	1.8
60	2.1
70	2.5
80	2.9
90	3.3

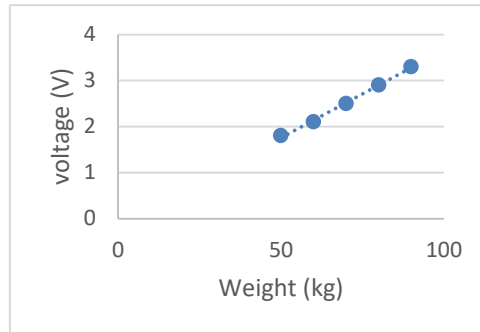


Figure 7: Weight (Kg) versus Voltage (V)

When different pressures and stress are evaluated on the piezoelectric sensors, different voltage readings were observed that corresponded to that same different pressure and strains.

In this project, we connected three piezo in parallel on one tile, such that the series connections are placed in parallel. As a result, connecting six piezoelectric sensors in series raises the equivalent capacitance. Power generated varies with different steps in piezoelectric array that is used. The voltage obtained are based on practical results:

- Min. emf= 1V/step
- Max. emf= 6V/step

Assuming the average weight of the person using the system is 50 kg, the average computation is:

- Steps must be taken to enhance the battery's 1V charge = 800
- To boost the battery's 12 volts = Total footfall required = $(12 \times 800) = 9600$ steps

Considering the implementation of this system in places like college where footsteps as a source is easily available, if time required for 2 steps is 1 second then the time required for 9600 steps will be 80 minutes.

VI. CONCLUSION

A piezo tile capable of generating 12V has been devised. Comparison between various piezo electric material shows that PZT is superior in characteristics. Also, by comparison it was found that series- parallel 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. It is especially suited for implementation in crowded areas. This can be used in street lighting without use of long power lines. It can also be used as charging ports, lighting of pavement side buildings.

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