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Piezo-Step Power Generator

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ABSTRACT: The current energy landscape is marked by a growing demand for sustainable energy sources. While traditional methods rely on solar, wind, and hydroelectric power, they often face environmental constraints and require significant infrastructure investment. A proposed solution harnesses the potential of high-traffic areas by converting mechanical energy from footsteps into electrical energy using strategically placed piezoelectric sensors beneath walking surfaces. These sensors generate electricity in response to pressure, offering a reliable and sustainable power source unaffected by environmental conditions. Contrasted with previous approaches, this system minimizes the need for infrastructure changes and taps into a readily available energy source - human motion. It presents a novel means of powering low-energy devices in busy public spaces, thus alleviating strain on conventional power grids. Improvements in piezoelectric sensor output voltage and power, achieved through novel materials, optimized designs, or advanced power management techniques, can enhance efficiency and durability. Additionally, measures such as protective coatings, feedback mechanisms, or smart materials can further increase sensor performance. With a piezo tile capable of generating up to 35V, this project has the potential to significantly contribute to addressing energy crises, as only 11% of our primary energy comes from renewables. Implementing such initiatives now could mitigate energy challenges and foster positive environmental changes globally.

KEYWORDS: Footsteps, piezoelectric sensors, conventional power grids, mechanical to electrical energy.

I.INTRODUCTION

Piezoelectric generators are devices that convert mechanical energy into electrical energy by using the piezoelectric effect of certain materials. They have various applications in energy harvesting, sensing, and actuation. One of the potential sources of mechanical energy for piezoelectric generators is human footsteps, which can be utilized to power low-consumption electronic devices or charge batteries. However, there are several challenges in designing and optimizing piezo-step power generators, such as low output voltage, high impedance, nonlinear behaviour, and environmental factors. Utilizing wasted energy from human locomotion, particularly in densely populated countries like India and China, holds significant relevance and importance. In these nations, where roads, railway stations, bus stands, temples, and other public spaces are constantly crowded with millions of people, harnessing the energy generated by their movement could lead to a ground-breaking invention. Crowd energy farms could transform the idle movement of individuals into a valuable energy source, benefiting both the environment and the local community. Walking through a Crowd Farm could become an enjoyable activity for people, promoting health and fitness while simultaneously generating electricity for nearby applications. Therefore, there is a need for further research on improving the performance and efficiency of piezo-step power generators. In this paper, we propose a novel piezo-step power generator that uses a piezoelectric ceramic plate and a spring-mass system to enhance the output power and voltage. We also design a power conditioning circuit that can boost and rectify the AC signal from the piezoelectric element and store it in a supercapacitor. We conduct experiments to evaluate the performance of our proposed piezo-step power generator under different loading conditions and compare it with existing methods. Our results show that our piezo-step power generator can achieve a maximum output power of 1.3 W and a maximum output voltage of 39 V, which are significantly higher than the previous works.

II.LITERATURE REVIEW

L. Shiva Kumar et al. [1] presents a low-cost foot step power generation using piezoelectric sensors. The paper demonstrates a circuit design that uses piezoelectric sensors to convert the mechanical stress of footsteps into electrical energy. The paper compares the output voltage, current, and power of the piezoelectric sensor for different number of steps, weight, and speed of the person walking on the platform. The paper also discusses the advantages and disadvantages of different applications of foot step power generation such as street lighting, agriculture, and home appliances.

S. S. Patil et al. [2] published in 2021. This paper proposes a model that uses human walking, jumping and running as a source of energy and stores it for basic use. The paper illustrates a method of harvesting this human advancement energy with the use of piezoelectric sensor and shows an application with the stored energy such as to charge a mobile phone and to glow an LED based on the motion using the passive infrared sensor. The paper also promotes green energy and environment friendly approach towards energy generation.

Somashekhar G.C et al. [3] (2021) used a piezoelectric sensor of 35 mm diameter and 0.5 mm thickness, which produced a maximum voltage of 8.7 V and a maximum current of 6.8 mA when a force of 50 N was applied on it. The output power was 58.76 mW, which was stored in a 9 V battery.

P.Venkatesh et al. [4], used a piezoelectric sensor of 30 mm diameter and 0.3 mm thickness, which generated a maximum voltage of 5 V and a maximum current of 4 mA when a force of 50 N was applied on it. The output power was 20 mW, which was stored in a 12 V battery.

III. EXISTING MODEL

In the existing method piezo electric sensors are arranged in parallel connection. Here the mechanical energy is converted into electrical energy by applying pressure on the piezo electric sensors uniformly. But as the sensors are connected in parallel the output voltage is not high, which reduces the efficiency and accuracy of the system. According to previous research they got a maximum output voltage as 8volts and total power produced is far less than 100mW. Due to these anomalies, the system failed to produce high yield

IV. PROPOSED MODEL

A piezo step power generator is a device that utilizes the piezoelectric effect to generate small, precise mechanical movements or steps. The piezoelectric effect refers to the ability of certain materials to generate an electric charge in response to applied mechanical stress and vice versa. In the context of a piezo step generator, this effect is harnessed to produce controlled mechanical displacements. The principle of a piezo step generator involves the use of a piezoelectric material, often a crystal or ceramic, which undergoes deformation when an electric field is applied. Thus, the proposed system, however, leverages the untapped potential of high-traffic areas, converting mechanical energy from human footfalls into electrical energy. The block diagram of the working is shown below in the block diagram figure 1.

4.1 BLOCK DIAGRAM

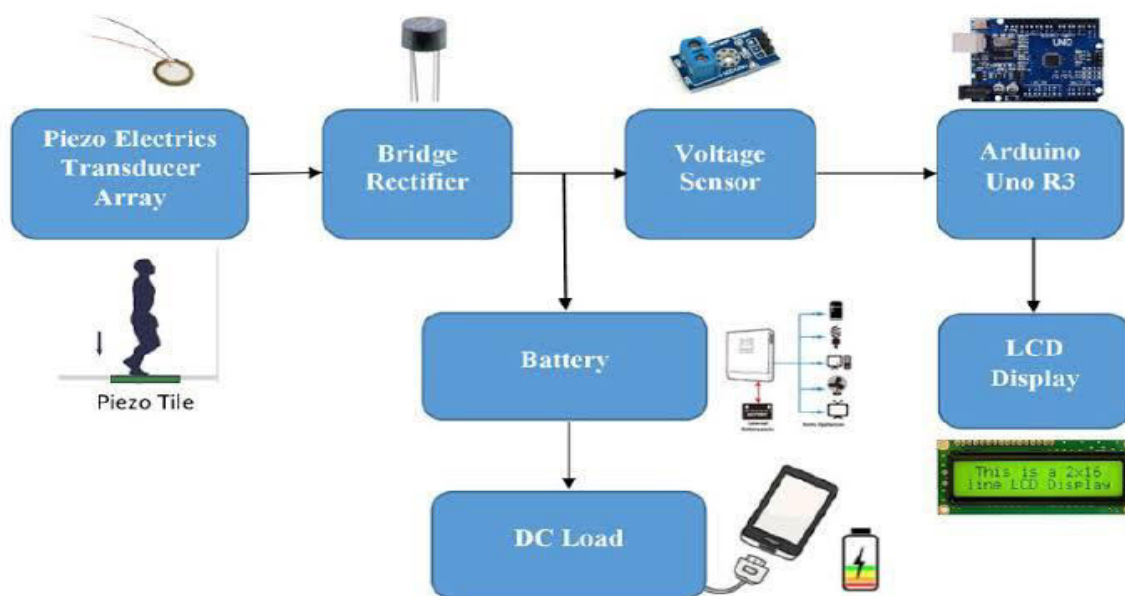


Fig 1: Block Diagram of Piezo-Step Power Generator

4.2 WORKING

To implement this system, we adjust the wooden plates positioned above and below the sensors as illustrated in Figure 2. The process of harnessing non-conventional energy through footstep utilization involves the conversion of mechanical energy into electrical energy. The footstep board incorporates 12 piezoelectric sensors connected in series and later connected with parallel connection. Upon applying pressure to these sensors, they transform mechanical energy into electrical energy. The generated electrical energy is then stored in a 12V rechargeable battery connected to an inverter. The battery charging system utilized is a conventional unit, serving both the purpose of charging the battery and supplying power to the circuitry. The inverter functions to convert the 12 Volt DC to 230 Volt AC. This AC voltage is subsequently employed to activate various loads, enabling the operation of AC-powered devices.

The piezoelectric sensors convert the pressure applied to it into electrical energy. Pressure can originate from either the weight of moving vehicles or the weight of pedestrians traversing the surface. Due to the fluctuating nature of the output from piezoelectric materials, a bridge circuit is employed to convert this variable voltage into a consistent linear output. The resulting DC voltage is then stored in a rechargeable battery for future use. As the power output from a single piezo electric sensor was extremely low, combination of few Piezo electric sensors was investigated. So here a combination of both parallel and series connection is employed for producing up to 40V voltage output with high current density. Provisions are made from the battery to connect DC loads, while an inverter linked to the battery facilitates connection to AC loads. The voltage generated across the tile can be observed on an LCD display.

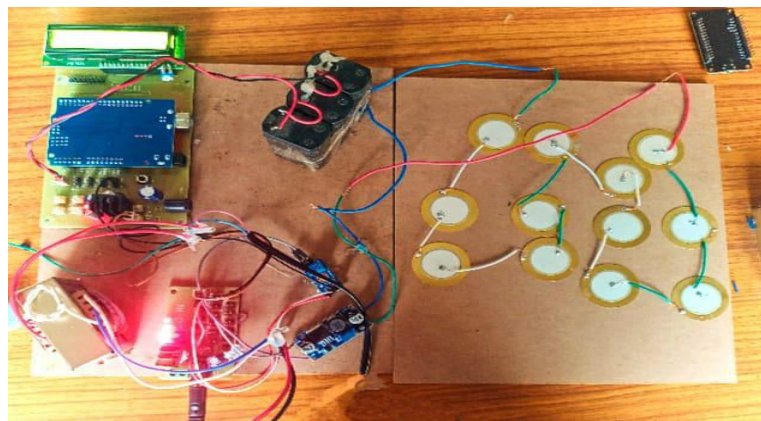


Figure 2: Operational setup for piezo-step power generator

5. CALCULATION OF MAXIMUM THEORETICAL VOLTAGE GENERATED

When pressure is exerted on piezoelectric material, it generates a charge across its surface, behaving akin to an ideal capacitor. Consequently, all equations governing capacitors can be applied to it.

In this project, we connected 12 piezo electric sensors in series of each 3 piezo in series and those series connections are connected in parallel. Now the equivalent capacitance is

$$1/C_{eq} = 1/C1 + 1/C2 + 1/C3$$

We know that, $Q = C \times V$ So, $C = Q/V$

$$\therefore V_{eq}/Q = V1/Q + V2/Q + V3/Q$$

Thus, $V_{eq} = V1 + V2 + V3$

Therefore the net voltage generated in series connection is the sum of individual voltages generated across each piezoelectric sensor. When output voltage from 1 piezo disc is 12V;
then, $V_{eq} = 12+12+12$ $V_{eq} = 36$ Volts Thus the maximum voltage that can be generated across the piezo tile is around 36V.

For Example, a person whose weight is 70Kg were made to walk on the piezo-step generator to test the voltage generating capacity of the Piezo tile. The relation between the weight of the person and power generated is noted and it

can be seen that, maximum voltage is generated when maximum weight/force is applied. Thus, maximum voltage of 35V is generated across the tile when a weight of 70 Kg is applied on the model.

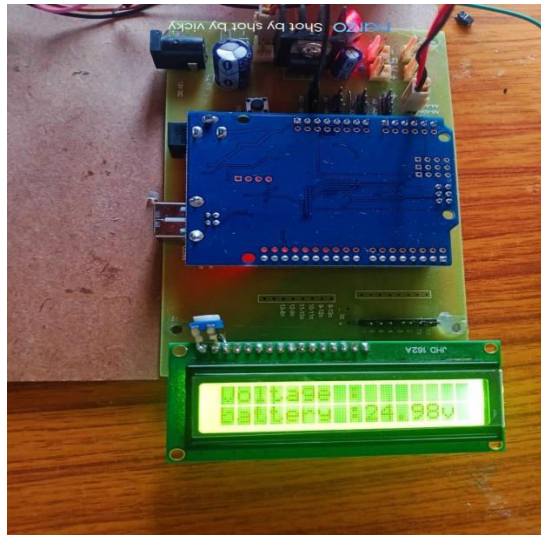


Figure 3:LCD Display showing an output voltage of 24.98V

VI. RESULT

In the culmination of the piezo step power generator project, a noteworthy output voltage of 35V has been achieved through a meticulous combination of series and parallel connections. The system incorporates 12 piezoelectric sensors, strategically connected in a series-parallel configuration. This design has proven effective in maximizing the overall output voltage, showcasing the versatility of the interconnected sensors. Furthermore, it's worth noting that with the applied series-parallel arrangement and accounting for an average human weight of 70kg, the generator has demonstrated the capability to produce an impressive output voltage of up to 40V. This result underscores the success of the project in efficiently harnessing mechanical energy from footsteps and converting it into a substantial electrical output. The innovative series-parallel connection scheme has proven to be instrumental in optimizing the generator's performance, contributing to its effectiveness in generating a noteworthy 35V output voltage, with the potential for even higher voltage production under specific conditions.

VII. CONCLUSION

In conclusion, the Piezo Step Power Generator presents a groundbreaking solution to the evolving energy landscape, addressing the increasing demand for sustainable and renewable sources. By harnessing the untapped mechanical energy from human footfalls using strategically placed piezoelectric sensors, the system offers a consistent and eco-friendly power source. Notably, it stands out for its independence from environmental conditions, minimal infrastructural impact, and reliance on the continuous availability of human movement. The achieved output voltage of 40V through innovative materials and design optimizations underscores its potential impact. Deploying such systems could contribute significantly to overcoming energy crises, fostering a sustainable future and promoting positive global environmental changes, making it a pivotal advancement in renewable energy technology.

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