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POWER GENERATION USING PIEZOELECTRIC EFFECT

J. Ashwini Kumari[1], K. Sowbhagya[2], P. Shivani[3], G. Reshma[4]
[1]Assistant Professor, Department of EEE, Bhoj Reddy Engineering College for Women, India
[2,3,4]UG Student, Department of EEE, Bhoj Reddy Engineering College for Women, India

ABSTRACT

Now-a-days Several number of power sources are present both renewable and non-renewable but still we cannot overcome our power needs. The demand for the electricity is more than generation. To solve such types of problem, we try to develop electricity generating techniques with the help of wasting human energy for our better future. In this paper, we are generating electrical power through non-conventional method and utilizing energy from the surroundings. Piezoelectricity is a fascinating phenomenon, can generate an electric charge in response to mechanical stress or pressure.

When mechanical stress or pressure is applied to the piezoelectric material, such as when someone steps on piezoelectric tile, it causes the material to deform slightly, leading to the separation of charges within the material, creating an electric potential difference, which is essentially voltage. In this paper, we are utilizing this power to supply the Automatic Street Lights. By placing the piezoelectric titles on walkways or busy areas, the kinetic energy from people footsteps can be transformed into electrical energy. This energy can then store in batteries and utilized to automatically power street lights when it gets dark.

Keywords: Piezoelectric plates, Battery, Arduino UNO, LDR, Streetlight, Mobile USB.

1. INTRODUCTION

The growing global demand for electricity, coupled with concerns over energy shortages, has driven the need for alternative and renewable power sources. One innovative solution involves the use of piezoelectric materials to generate energy, particularly for applications in urban infrastructure. Piezoelectric plates convert mechanical energy, often produced through pressure into electrical energy. This technology can be harnessed in a variety of environments, including roads, where pedestrian movement generates mechanical stress on the plates.

By embedding piezoelectric plates under walkways, energy can be harvested from footsteps and used to power streetlights, contributing to more sustainable urban energy consumption. This power generation method not only addresses the increasing energy demands but also reduces the environmental impact of conventional power generation techniques.

In an automatic street lighting system, the energy generated by piezoelectric plates can be stored and utilized to power streetlights when ambient light falls below a certain threshold. These smart lighting systems, integrated with light sensors, are programmed to turn on the lights automatically during night-time or low-light conditions, ensuring optimal energy usage.

This innovative approach offers a renewable, low-maintenance solution for urban lighting, contributing to energy conservation and helping alleviate the burden of power generation on traditional electricity grids.

Henry Sodano and Daniel J Inman (2002) introduced one of the earliest concepts of an alternating power generation method "Electric power generation using piezo electric devices." This paper explores the use of

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piezoelectric devices for electric power generation. The authors investigate the potential of piezoelectric materials to convert mechanical vibrations into electrical energy and experimentally investigated Lead Zirconate Titanate (PZT) dynamics to estimate power generation capacity and feasibility for real-world applications [1].
Priyanka Baniya, Shivanjali Barge, Rahul Patil and Prof. Poonam Yewale (2019) "Power generation using piezoelectric material." Explores the principles of piezoelectricity, its applications in energy harvesting, and the potential of these material in converting mechanical energy into electrical energy for low-power devices [2].
Hari Anand and Binod Kumar Singh (2021) "piezoelectric energy generation in India." Explores the potential of piezoelectric energy generation in India. It focuses on harvesting energy from human locomotion, particularly footsteps, in high-traffic areas like railway stations and temples. Piezoelectric materials embedded in flooring capture mechanical energy from foot traffic, convert it into electrical energy, and store it for later use. The study compares this method with solar energy, emphasizing its cost-effectiveness, ease of implementation, and adaptability to India's dense population and energy needs [3].
Embedded C theory has been studied, highlighting its prominence as the predominant programming language in the software industry for crafting electronic devices. Embedded software is intricately linked with each processor utilized in electronic systems. [4].
Studied about Atmega328p microcontroller and it is widely utilized in embedded systems for its balance of processing power and energy efficiency. Featuring a rich set of built-in peripherals and Arduino compatibility, it offers versatility for diverse electronic projects. Understanding its pin configuration and operational principles is crucial for effective utilization in embedded applications [5].

2. PIEZOELECTRICITY

Piezoelectricity is a form of energy harvesting where electrical energy is generated by applying mechanical stress to specific materials, such as quartz, Rochelle salt, and ceramics. This phenomenon, known as the piezoelectric effect, was discovered in 1880 by Jacques and Pierre Curie. When a crystal structure is deformed, it creates a separation of charge centers, leading to an electrical voltage across the material.
Although the energy output is lower compared to solar or wind power, piezoelectric systems are valuable in capturing small amounts of energy from sources like vibrations, footsteps, or passing vehicles. This makes them ideal for use in areas where traditional renewable energy sources are less feasible. Applications include smart cities and energy-efficient buildings, contributing to sustainable energy practices. Modern technological advancements use synthetic materials like lead zirconate titanate (PZT) due to their high efficiency, making piezoelectric materials integral to various industrial and technological devices.

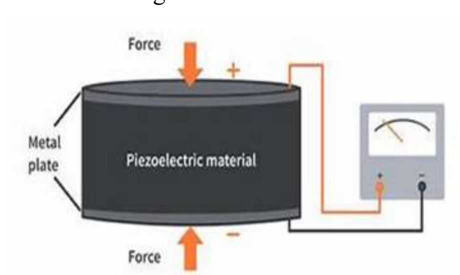

Fig. 1 Piezo electricity

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3. BLOCK DIAGRAM

The block diagram for Power Generation Using Piezoelectric Effect is shown in the Fig. 2.

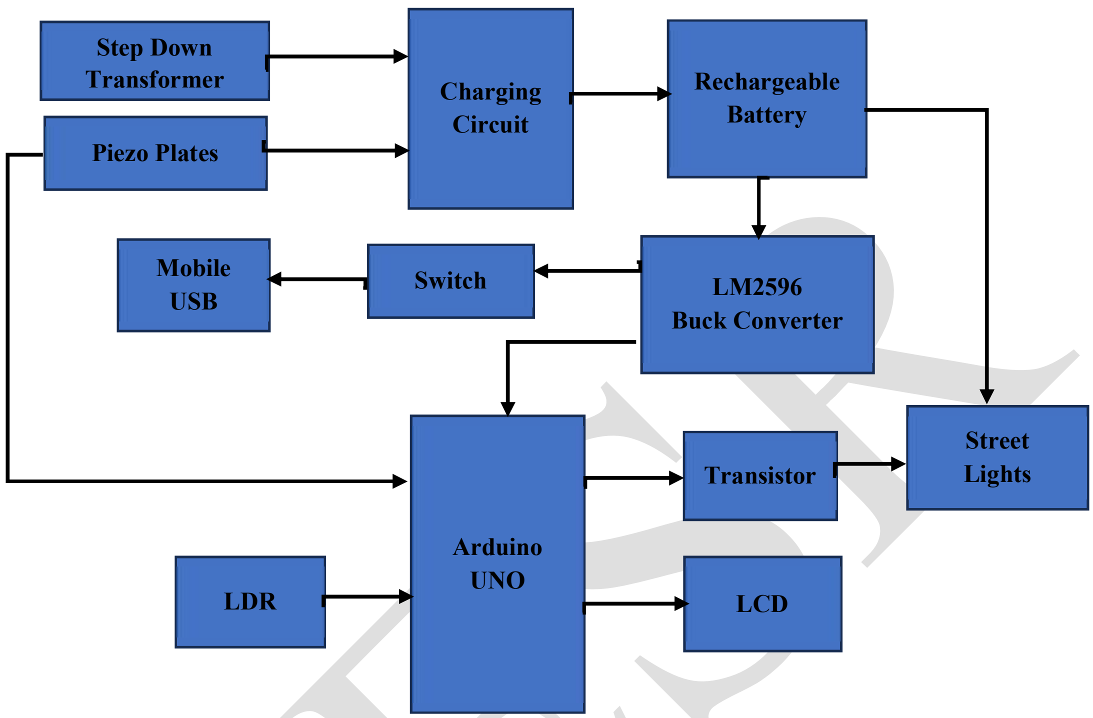

Fig. 2 Block diagram

The footstep power generation system converts mechanical energy from footsteps into electrical energy using piezoelectric plates. This energy is stored in a rechargeable battery via a charging circuit. A buck converter regulates the voltage for powering the system, An Arduino microcontroller [5], powered by the converted voltage, manages the operation of the system. It takes input from a light-dependent resistor (LDR) to detect the ambient light levels, deciding when to turn on street lights. The transistor acts as a switch, allowing the Arduino to control the street lights' activation when it's dark.

Additionally, the system includes an LCD to display information like energy status and a USB output for charging mobile devices. A switch can provide power to the USB for charging when it is on. This setup enables the system to harness and utilize energy from footsteps for both lighting and charging purposes.

4. HARDWARE MODULE

The hardware module is shown in Fig. 3.

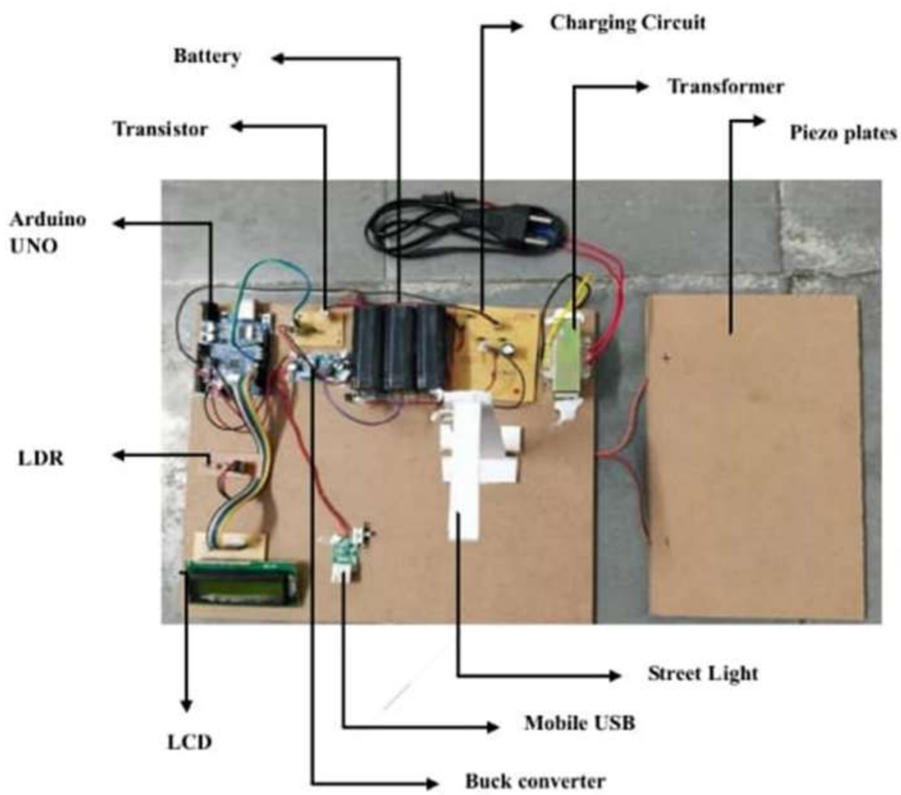

Fig. 3 Hardware Module

The hardware module represents a system designed to generate power using the piezoelectric effect and supply it to an automatic street light and charging pin.

1. Piezo Plate

These plates convert mechanical stress (such as pressure from footsteps) into electrical energy through the piezoelectric effect. The tile contains 9 piezo plates with a size of 25mm.

2. Charging Circuit

This circuit manages the charging of the battery from the power generated by the piezoelectric plates, regulating the voltage and current to prevent overcharging or damaging the battery.

3. Battery

It is a lead-acid 12V, 1A battery that stores the electricity generated by the piezoelectric plates. The stored energy can be used later to power the street light and other components, even when no energy is being generated by the piezo plates.

4. Transistor

A transistor is included as a switching component, it controls the street light on or off based on input from Arduino.

5. Arduino UNO

Acts as the control unit for the system, processing inputs from sensors such as the LDR and controlling the street light's operation. The Arduino receives signals from the sensors and makes decisions, such as turning the light on when it gets dark.

6. LDR

A sensor used to detect light levels in the environment. When it gets dark, the resistance of the LDR decreases, signalling the Arduino to turn on the street light. It automates the system, ensuring the light only operates at night.

7. Buck Converter

Converts the voltage from the battery to a lower, more stable level suitable for powering devices like the street light and other connected loads (e.g., mobile charging).

8. LCD Display

The LCD provides real-time information about the system, such as power generation status, street light operation status. This visual feedback is important for monitoring the system's performance.

9. Street Light

The final output of the system. The power generated by the piezo plates and stored in the battery is used to light the street at night. The streetlight is automatically turned on and off based on input from the LDR and the control logic implemented in the Arduino.

10. Mobile USB

An additional feature of the system is the capability to charge mobile devices using the USB port. The USB output is powered by the energy stored in the battery, allowing for multiple uses of the harvested energy.

5. TESTING AND RESULTS

5.1 PIEZO PLATE UNDER NO PRESSURE AND PIEZO PLATE UNDER PRESSURE APPLIED

In this case the behaviour of the piezo plate under no pressure and under pressure is tested.

5.1.1 Piezo Plate under No Pressure

When no pressure is exerted on the piezo plates, they do not undergo any mechanical deformation, and thus, no power is generated. Since no power is generated, the Arduino UNO senses zero voltage from the piezo plates. The Arduino UNO is programmed to display the voltage reading on the LCD display. In this scenario, it will show 0v on the LCD as shown in the Fig. 4(b).

Fig. 4(a) Piezo plate under no mechanical deformation.

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Fig. 4(b) Voltage under no mechanical deformation

5.1.2 Piezo Plate under Pressure Applied

When the footsteps on the piezo plate as shown in the Fig. 5(a), it undergoes mechanical deformation due to the applied force. As a result of this deformation, causing the piezo plate to generate electricity. The generated power is then stored in the battery. Once stored, the battery supplies energy to the connected devices, such as the street light and the mobile phone charging system. The Arduino UNO continuously monitors the voltage generated by the piezo plates. It senses and display the real-time voltage reading on the LCD screen as shown in the Fig. 5(b).

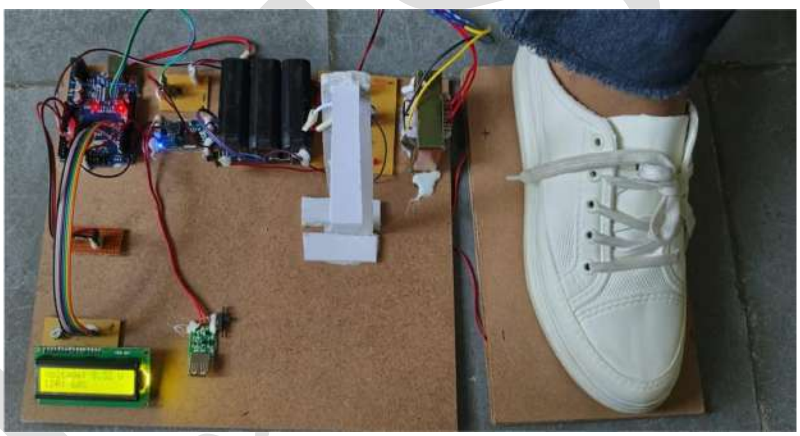

Fig. 5(a) Footsteps on the Piezo Plate

Fig. 5(b) Voltage Generated Under Mechanical Pressure on Piezo Plate

5.2 TESTING THE INTENSITY BELOW AND ABOVE 70%

In this case the behaviour of the LDR below and above 70% is tested.

5.2.1 Light Intensity below 70 %

The LDR detects light levels in the environment. When it gets dark, say less than 70%, the resistance of LDR decreases, signalling the Arduino to turn on the street light. The Arduino also displays the light intensity on the LCD as shown in Fig. 6(a), automating the system to ensure the light only operates at night, as shown in Fig. 6(b).

Fig. 6(a) Intensity of the light below 70% (During Night)

Fig. 6(b) Street Light turned ON

5.2.2 Light Intensity above 70 %

The LDR detects light levels in the environment. When the light intensity exceeds 70%, the resistance of LDR increases, sending the signal to the Arduino to turn off the street light during the daylight hours. The Arduino also displays the light intensity on the LCD as shown in Fig. 7(a). It automates the system, ensuring the light only operates at night as shown in Fig. 7(b).

Fig. 7(a) Intensity of the light above 70% (During Day)

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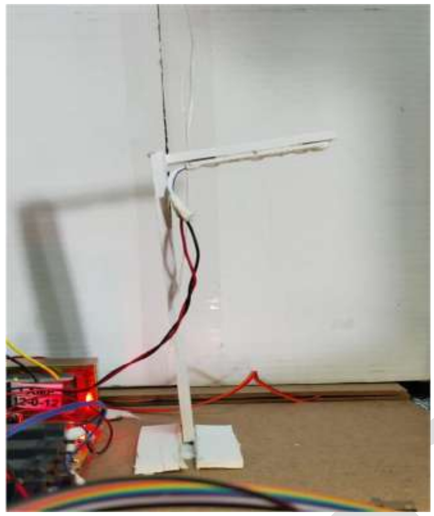

Fig. 7(b) Street Light turned OFF

5.3 TESTING THE CHARGING PIN

The mobile phone is charged by the USB port as shown in the Fig. 8. The USB output is powered by the energy stored in the battery.

Fig. 8 Charging via Piezoelectricity

5.5 RESULTS AND OBSERVATIONS

After testing the Power Generation Using Piezoelectric Effect with various scenarios and the results are tabulated in Table 1.

Table 1 Result Table

Piezo plate condition	Pressure Applied	LCD Display (Voltage)	Intensity Level	Street Light
Piezo plate under no pressure	No	0.09v	59%	ON
Piezo plate under pressure	Yes	6.29v	75%	OFF
Piezo plate under pressure	Yes	8.38v	60%	ON

The table describes the behaviour of a piezoelectric plate under different conditions and impact on a street light system.

In the csae1, the piezoelectric plate is under no pressure, producing a voltage of 0.09V. The intensity level of the light is 59%, and the street light turns ON.

In the case2, pressure is applied to the piezoelectric plate, generating a voltage of 6.29V. Despite the increased voltage, the street light is OFF, with an intensity level of 75%.

In the case3, additional pressure is applied, resulting in a higher voltage of 8.38V. However, the intensity level of light is 60%, and the street light turns ON again.

6.CONCLUSION

The piezoelectric power generation project effectively integrates modern technology to harness mechanical energy from everyday movements and convert it into usable electrical power. By utilizing the piezoelectric effect, this system can generate small amounts of energy to power automatic street lights and charge mobile devices, contributing to energy efficiency and sustainability. This renewable energy solution responds to the growing need for environmentally friendly power sources, reducing reliance on traditional power grids.

Additionally, the system provides reliable and consistent power for outdoor lighting, enhancing safety and visibility in urban and rural areas.

By offering real-time energy generation without the need for external power sources, this piezoelectric system demonstrates a practical and innovative approach to energy production, providing both convenience and environmental benefits. Overall, this project highlights a forward-thinking application of technology that can contribute to a cleaner and more sustainable future.

7.ACKNOWLEDGMENT

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