

## Development of Footstep Power Generation System Using Piezoelectric Sensor

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**Abstract:** This technology uses non-renewable resources like the sun's heat and the wind's vibration to create and store electrical power for later use. With the depletion of fossil fuels and non-renewable energy, we need another source of energy to meet the growing demand. This study investigated piezoelectric energy harvesting. This project used Arduino to measure piezoelectric energy. This project uses a 20x4 LCD to display piezoelectric voltage. The piezoelectric sensor detects vibration and converts mechanical stress to electricity. In series, piezoelectric sensors are connected. Then, it's placed on an acrylic board tile to serve as a model for a pressure-point footstep tile. Pressure on a piezoelectric sensor generates a little voltage that is stored in a 12 V acid lead battery. Bridge rectifiers convert piezoelectric AC to DC for consistent output voltage. This project will be utilized on sidewalks, stairs, and other high-traffic areas. Piezoelectric tiles can power DC loads like a cellphone.

**Keywords:** Piezoelectric Sensor, Arduino Microcontroller, Footstep Power Generation, Full-Wave Bridge Rectifier, Power Generation, Vibration Energy

### 1. Introduction

Energy harvesting captures and stores energy from outside sources such wind, sun, thermal, vibration, and biomechanical energy. This energy harvester is employed in wireless sensors and electronics. Piezoelectric material powers devices with human motion or vibration [1]. Researchers have studied biomechanical and mechanical energy transformation. Environmental energy collection has gained popularity recently. Attaching a PVDF piezo film sensor to a support beam produced an electrical signal [2].

Low-power electronics like remote sensors and embedded devices run on batteries. Even long-lasting batteries must be replaced every few years. Replacements are pricey for hundreds of remote

sensors. Energy harvesting technologies allow low-power gadgets to run indefinitely and avoid the need to replace batteries in expensive, difficult, or toxic situations [3].

Most energy harvesting solutions are self-sustaining, cost-effective, and require minimal maintenance. Power is consumed near the source, eliminating transmission losses and long connections. If the energy is sufficient, the device can run without a battery [3]. Piezoelectric devices are better at collecting energy from vibration and human motion [4]. So it's used to capture energy. First, a piezoelectric device is stressed. The piezoelectric device powers the harvesting circuit and charges the battery. Energy is a part of everything we do, from gas and electricity to making the bed and playing tennis. We need an energy source to execute these duties or use gas or electricity in our homes. Both energy creation and emission waste a lot of energy. Two-thirds of a power plant's potential energy reserves are lost as heat. This level of efficiency won't be enough as the world's population and energy demand grow rapidly. Many scholars and renewable energy enthusiasts focus on 'energy harvesting' This means that any heat, light, vibration, or movement wasted in production or output will be captured and used to produce self-sustaining technology.

With the depletion of fossil fuels and non-renewable energy, we need another source of energy to meet growing demand. Energy is work ability [1]. Electricity is a commonly used and developing energy source. Wasted energy must be utilized to make power. Walking wastes energy that could be used for electricity. Humans do 3000 to 5000 steps each day [5-6]. This can generate extra power. Footstep vibration can be converted to electromagnetic, electrostatic, or piezoelectric energy [8]. There are various ways to generate electricity from road traffic. Variation in ground pressure produced by passing people or vehicles is handled using an unknown method [7]. A piezoelectric transducer is explored for generating power. Arvin et al. proposed human-powered electricity [5]. It embeds a piezoelectric transducer in pedestrians to power lamps. Ghosh et al. proposed footstep-powered electricity for metropolitan areas [6]. This paper proposes piezoelectric tile-based power generating. Piezoelectric transducers turn pressure into electricity. A full wave bridge rectifier will convert the piezoelectric transducer's alternating current voltage to direct current voltage. The smoothing capacitor removes voltage anomalies. This energy will charge a smartphone from a battery.

### 1.1 Objective

The main objectives for this project are;

- a) To investigate the energy harvesting process of a piezoelectric device
- b) To develop a footstep power generation system using piezoelectric sensor
- c) To verify the performance of the developed footstep power generation system via experimental setup.

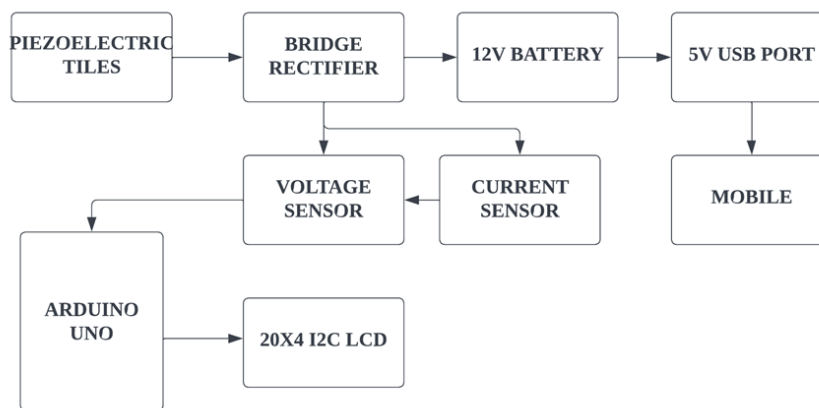
### 1.2 Scope of Project

- a) This project is to create an energy harvesting device out of piezoelectric material.
- b) This project will create energy using piezoelectric material and the energy will be stored in a 12 v acid lead battery.
- c) The energy created will be stored in this battery than can be supply to the DC load such as mobile phone.

## 2. Methodology

This chapter focuses on the approach that will be used to fulfil the goals for the design of a footstep power generation system that utilizes piezoelectric material. The strategy is the primary topic of discussion in this chapter. This chapter details the creation of the project's software and hardware, as well as its implementation, as well as the methods that were used to define and accomplish the project's objectives.

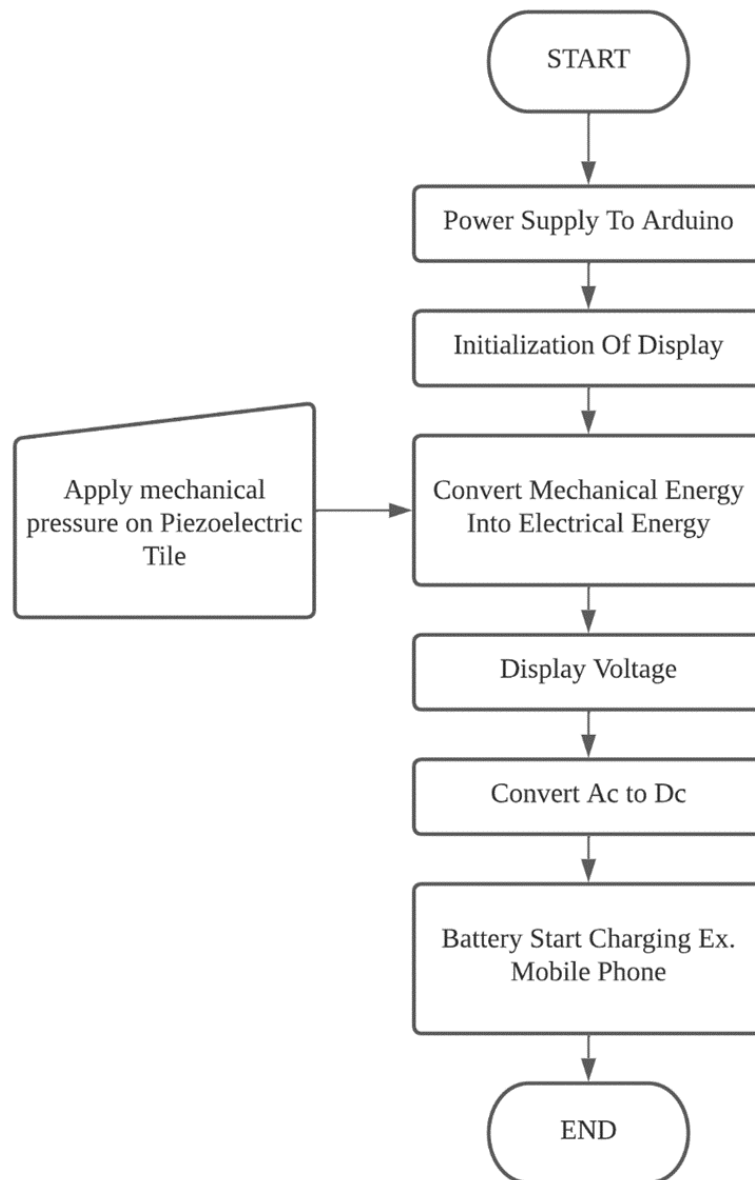
The primary block diagram for the project is shown here in Figure 1. It depicts all of the project's most important hardware and software components. The system is composed of blocks, each of which is designed to compress in response to the weight of a person's stride, therefore exerting pressure on the mechanical apparatus that is located directly behind it within the system. This consists of a platform at the bottom that is fixed in place and a platform at the top that may compress. The piezoelectric material converts the mechanical force that is supplied into usable electrical energy. It's possible that the pressure is being caused by the weight of the people walking over it. The output of the piezoelectric material does not remain constant. A bridge circuit is utilized in order to accomplish the transformation of this variable voltage into a linear value. Once more, an AC ripple filter is utilized in order to filter out any additional irregularities that could occur in the output. The boost converter is responsible for bringing the voltage to a higher level. After the dc voltage has been created, it is then stored in a battery that may be recharged. The LCD is connected to the ATMEGA328P microcontroller so that programming may be performed on it. The DC voltage produced by the piezoelectric tile may be measured with the help of the voltage sensor. Both the CPU and the LCD are powered by a lead acid battery that has 12 V of voltage. In order to reduce the voltage from 12 V to 5 V, buck converters are utilized. Using the mobile charger, we are able to charge our mobile phones.



**Figure 1: Block Diagram**

## 2.1 Flowchart

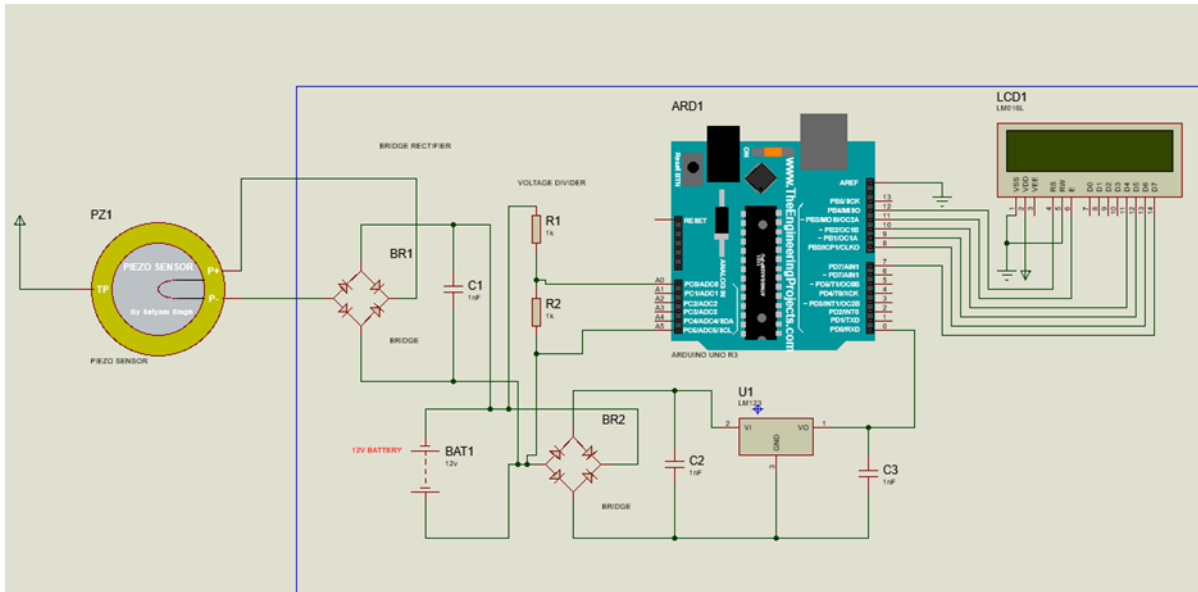
Based on flowchart in Figure 2, this process shows the procedure from the start to the end. The programming which being write in Arduino IDE software must be included with the sensor library, and the pins for each component used in the circuit must be accurately labelled in the coding. To generate a voltage, the pressure must be applied to piezoelectric tiles. It will convert the mechanical energy to electrical energy. The voltage sensor will measure the voltage through the piezoelectric tile. The sensed data will be displayed on 20x4 LCD display. After that, 12 v acid lead battery will charging based on the voltage that generate from piezoelectric tiles. The 5 v USB is connected directly to the 12 V acid lead battery to charge a mobile phone.



**Figure 2: Flowchart**

## 2.2 Software Development

Proteus Software was used to implement the schematic simulation of this purpose project. In Proteus Software, using Arduino UNO. Figure 3 shows this project schematic design. The main components of this simulation are an Arduino UNO, a LCD, and voltage sensor.

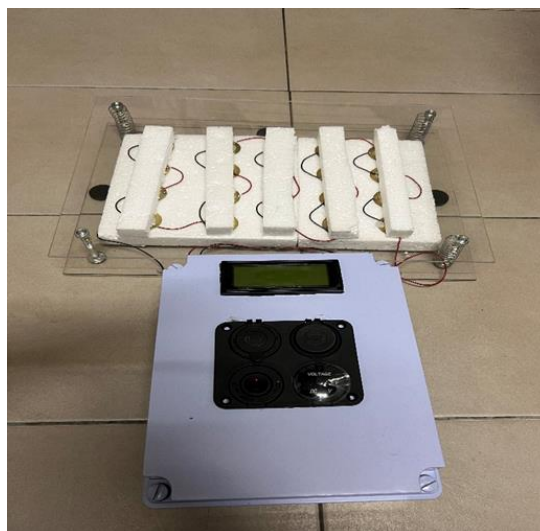


**Figure 3: The schematic design for this project**

The schematic of footstep power generation diagram is shown in Figure 3, a piezoelectric material tiles creates voltage across a piezoelectric tile, which is connected to a bridge rectifier circuit to produce DC voltage and given to a rechargeable battery and will charging the battery. The voltage regulator is linked to the battery to provide consistent voltage, which may be utilized to power DC loads. The battery utilized in this case is a lead acid battery 12 v. A microcontroller is linked to an LCD. The microcontroller used in this project is an ATMEGA 328P, which has an 8-bit, 32kb flash memory, 1k RAM, and a 16MHz speed. The voltage that created by the piezoelectric tiles is displayed on the 20 x 4 LCD.

### 2.3 Product Hardware

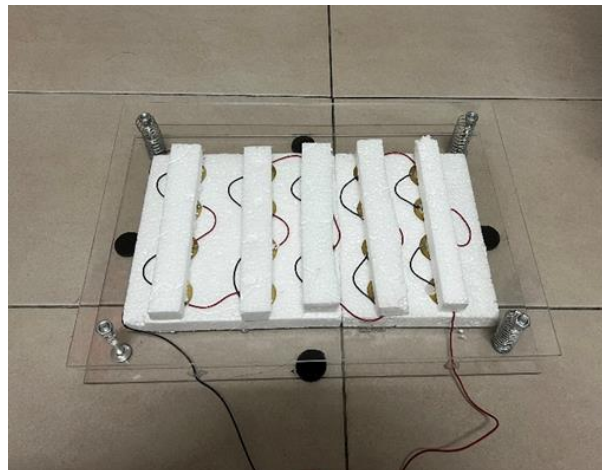
The configuration of the hardware may be seen in Figure 4. A tile built from piezoelectric material is developed. The piezoelectric sensor has been connected in series to produce a larger voltage output. The junction box is used to place electronic items such as battery, LCD, microcontroller which acts as a panel box. It will make easier to see the voltage value resulting from the piezoelectric tiles. The voltage that is created across a piezoelectric tile is sent into a battery, which allows the battery to recharge while also providing power to the dc loads such as mobile phones charger.



**Figure 4: Load used in this project**

## 2.4 Development Piezoelectric Tiles

The piezoelectric sensor are used to perform a tiles. The 20 piezoelectric sensor are used and the connection are in series to get a greater voltage output. Figure 5 shows the pressing mechanism, we use Polystyrene sheet between two acrylic plates. This tile has screws embedded in each of its four edges, which, when combined with the spring, causes the top tile to spring back into place after a human has stepped on it. It is requested of the subjects that they do the foot press activities on the piezoelectric tile in order to collect the voltage that is generated by the 20-cell piezoelectric transducers while they are performing those activities.



**Figure 5: Piezoelectric Tiles**

## 2.5 Development of Electronic Board

For the Figure 6, we use electrical junction box as a panel box. The liquid crystal display (LCD) has been placed to the front of the box so that retrieving data will be easier. The voltage value that is produced by the piezoelectric tiles will be shown on the liquid crystal display (LCD). Following this step, a 5v USB port is installed under the liquid crystal display (LCD) in order to charge the mobile phone.



**Figure 6: Electronic Box**

## 3. Results and Discussion

### 3.1 Analysis on the piezoelectric tile

Foot press activities, which are shown in Figure 7, make use of the piezoelectric tile in order to gain voltage. This tile of piezoelectric material has a 20-cell piezoelectric sensor placed in between its top

and bottom pieces. This piezoelectric tile has an acrylic sheet backing and is designed in the form of a square. This tile has screws embedded in each of its four edges, which, when combined with the spring, causes the top tile to spring back into place after a human has stepped on it. It is requested of the subjects that they do the foot press activities on the piezoelectric tile in order to collect the voltage that is generated by the 16-cell piezoelectric transducers while they are performing those activities.



**Figure 7: Analysis on the piezoelectric tiles**



**Figure 8: Charging Mobile Phone**

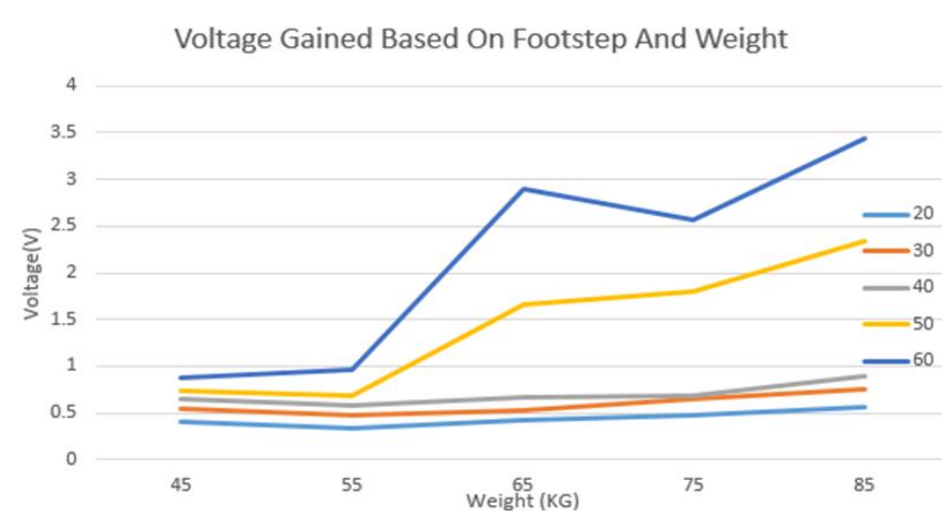
### 3.2 Overall results

**Table 1: The step and the voltage taken**

	Footstep				
Weight (kg)	20	30	40	50	60



45	0.41V	0.55V	0.66V	0.74V	0.87V
55	0.33V	0.48V	0.58V	0.69V	0.96V
65	0.43V	0.53V	0.67V	1.67V	2.89V
75	0.47V	0.65V	0.68V	1.80V	2.56V
85	0.56V	0.75V	0.89V	2.34V	3.44V



**Figure 9: Voltage Gained Based on Footstep and Weight**

The data above represents the voltage output of a 20-cell piezoelectric transducer linked in series. As shown in Table 1, bodyweights of 45 kg, 55 kg, 65 kg, 75 kg, and 85 kg were used to gain a voltage by the piezoelectric tile. The gained voltage depends on the number of steps recorded (20, 30, 40, 50, or 60). A graph showing the relationship between footstep and voltage output has been created for each weight. As shown in Figure 11, maximum voltage is produced when the user takes around 60 steps on the piezoelectric tile. In addition, it is clear that the amounts of force used by each subject change. The voltage produced by a piezoelectric tile is proportional to the force applied to it. In principle, the voltage created by a larger person's step on this piezoelectric tile would be greater than that generated by a smaller person's

#### 4. Conclusion

The project has been implemented, tested, and shown to be successful; in addition, it has extremely low startup costs, low ongoing costs, and is a highly cost-effective technique of producing power. This project overall voltage is roughly 3.44 V. Because it can be produced at a low cost, electricity is readily accessible to almost all of the world's population. This project is particularly applicable in more remote regions, which often have limited access to modern conveniences such as electricity. The output of the piezoelectric tile seems to be rather low. It might be less than 5 volts. Therefore, in order to solve this difficulty, an appropriate connection of piezoelectric sensor must be improve by using series-parallel combination. Therefore, a higher output voltage and current will appear in this project.

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