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Foot Step Piezoelectric Sensor Power Generation Project

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Abstract: The demand for power in the modern world is rapidly growing at an accelerating rate. There are an endless number of ways to produce renewable sources of energy, and one of those ways is the generation of electricity using footsteps. As the demand for electricity continues to grow, it becomes imperative to explore and adopt alternative approaches for sourcing and harnessing energy. Objective of this project is to analyze the relationship between the quantity of energy generated by the footstep generator and the frequency of footsteps applied to the piezoelectric transducer sensor. In addition, create a prototype of a footstep generator that can generate electricity and able to run properly. In this power generation method, piezoelectric sensors are utilized to convert the applied force during walking into electrical energy, serving as the primary source of power generation. The piezoelectric sensors are placed below the platform to generate a voltage when a footstep is detected. The batteries are then utilized to store this energy, making it available for consumption at any time that is convenient. Arduino nano is used to generate modular code that performs a specific task and then returns to the calling code. Implementation of this project will take place in a busy pedestrian area around the university campus. Piezoelectric sensors have the capacity to generate a higher quantity of usable energy if the number of steps taken across the surface also high. Each step on a piezoelectric sensor pad can produce approximately 0.020 V to 0.050 V of electricity. The nation's non-conventional energy system is critical at this time. There is a need arises for an alternative power generation method. The technology is cost-effective and affordable energy solution. It also can be utilized for a variety of purposes in crowded places and its pollution-free energy generation from renewable sources.

Keywords: Piezoelectric Sensor, Footstep Power Generation, Full-Wave Bridge Rectifier, Piezoelectric effect

1. Introduction

Our modern lives now depend heavily on electricity. It is the type of energy that is most often utilized worldwide. The globe is currently experiencing a scenario where energy resources are now being decreased [1]. The saving usage of energy has to be practice from now. There are a variety of

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methods through which electricity can be produced and one of these methods is the development of footstep energy, which can be an efficient method for producing electricity [2]. Most people spend most of their lives walking. When a person is walking, there are interactions made between their feet and the ground. Kinetic energy is a form of renewable energy that can be produced by the forces that human feet experience when they touch the ground. A footstep power generator can transform this energy into electricity. The piezoelectric sensor can be used to transform the wasted energy from walking into usable energy. The pressure applied to this sensor is converted to a voltage. The proposed system functions as a tool for producing power by applying force. This project is helpful for public areas like bus stops, mall and university campus. At university campus is the best place to use this project because it is installed in areas where most campus community walk, and they must use them to pass through entrances or exits. Then, these devices can produce voltage with each footstep. Moreover, by applying this project also will ensure the sustainable development by encouraging the campus community to use bicycle and walking facilities as their primary transportation options to limit the use of motor vehicles when moving around the campus.

This project aims to design a renewable circuit and develop a prototype using a piezoelectric sensor to generate energy from human footsteps. The objective is to design a renewable circuit by using piezoelectric sensor. The piezoelectric sensor is a key component in converting pressure into electrical energy [3]. Next, to develop a prototype that can produce energy from human footsteps through the utilization of a piezoelectric sensor. The prototype will be designed to efficiently capture and convert the mechanical energy produced by foot pressure into usable electrical energy. The objective also involves analyzing the data acquired from the piezoelectric sensor when subjected to applied pressure.

2. Literature Review

In 1880, Pierre and Jacques discovered a crystal that generates electricity when subjected to mechanical stress, this phenomenon is known as the piezoelectric effect. These substances are known as piezoelectric materials. The term "piezoelectricity" is derived from the Greek word "piezos." In this context, 'piezein' means to press or squeeze. Until forces are exerted upon them, these substances behave like stable crystals [1]. The piezoelectric technique has been used in a variety of applications, including quality control, manufacturing combustion engines in the industry, and as a secondary power source. The wiring diagram below show piezo element that to convert mechanical energy or vibrations into electrical energy. When pressure or strain is applied to the sensor, it generates an electric charge or voltage output. The rectifier function of converting the alternating current (AC) signal generated by the piezoelectric sensor into direct current (DC) signal and the capacitor will store electrical energy in the form of an electrostatic field. The wiring diagram is shown in Figure 1.

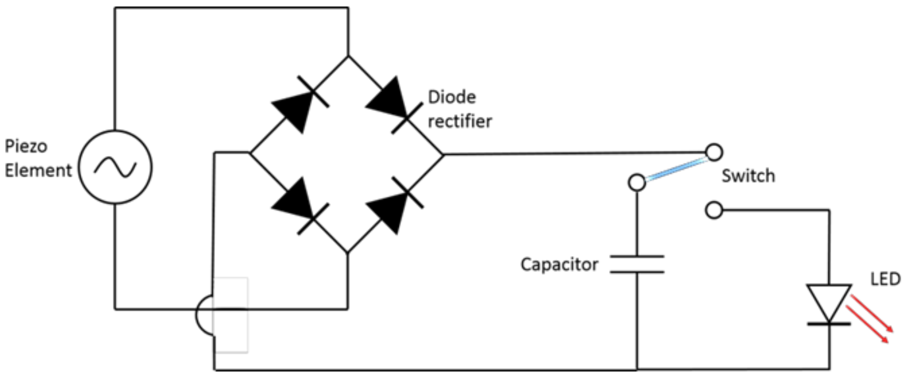


Figure 1: Wiring diagram for a piezoelectric generator.

When pressure is applied to certain materials, a change in electric polarization is generated, this phenomenon is known as the piezoelectric effect. The resulting potential difference across the material is found to be dependent on the applied pressure. Many naturally occurring crystalline materials, such as quartz, Rochelle salt, and even human bone, exhibit a phenomenon known as the direct piezoelectric effect. The piezoelectric effect is greater in engineered materials like lithium niobate and lead zirconate titanate (PZT). Piezoelectricity is the phenomenon where electrical charge is transformed into mechanical strain. Changing the surface charge density of a material in response to an applied force is the direct outcome of the piezoelectric effect [2]. Piezoelectric sensors also have a high natural frequency. Electromagnetic fields and other radiations have no effect on these phenomena [3].

3. Methodology

Figure 2 shows the schematic diagram of footstep piezoelectric sensor power sensor power generation project. The schematic diagram construct using Fritzing Software and it show the whole connection of the component. In this connection we use piezoelectric sensor to change pressure force into an electrical charge using the piezoelectric effect [7]. The connection also involves Arduino Nano, voltage sensor, rectifier, inductor and capacitor. After piezoelectric sensor pad is connected to other components, the generated electricity is directed through a bridge rectifier and subsequently stored in a capacitor. The capacitor, as a passive component in electrical circuits, primarily serves the purpose of storing and discharging electrical charge [8]. The accumulated electrical readings are then displayed on an LCD. When switch 2 is closed and the battery voltage is lower than that of the capacitor, the capacitor discharges and charges the battery. As a result, the motor can be activated.

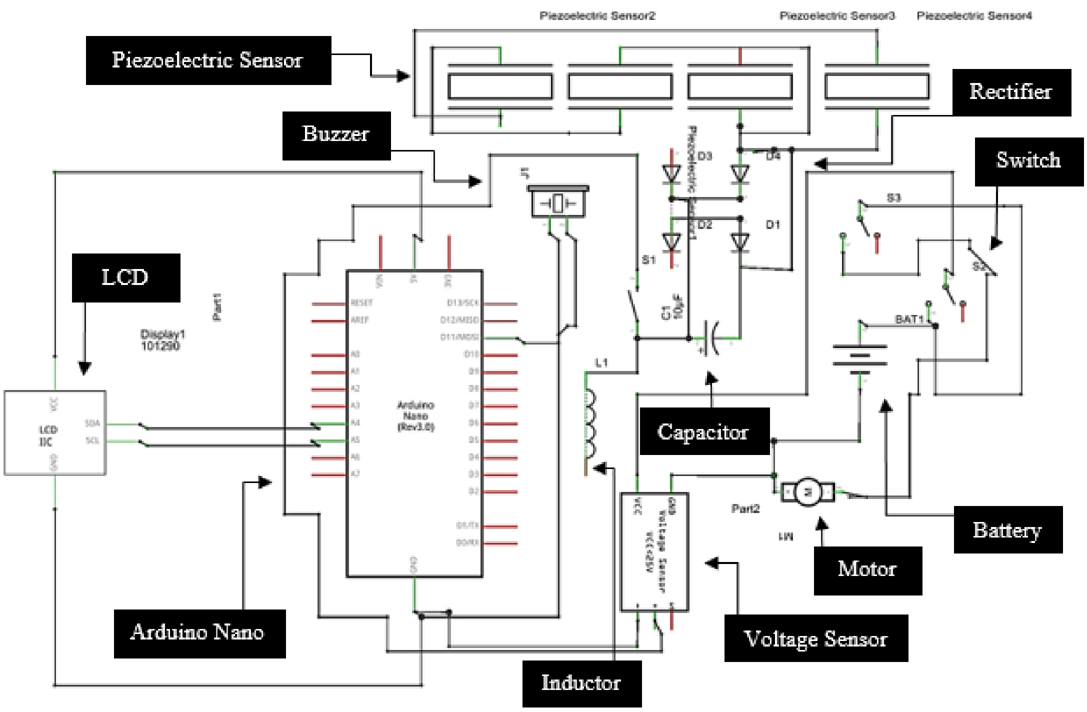


Figure 2: Schematic Diagram.

To ensure the successful implementation of the project, the selection of the project's site required a comprehensive analysis of numerous important variables. The significance of the selected site depends on its environmental suitability, as certain factors could potentially interfere with the collection of data during the project's execution. As excessive heat and noise may trigger and slightly disturb the piezoelectric sensor, it is important that the location has a moderate temperature and a relatively peaceful environment [9]. Additionally, the number of students passing through the area was taken into consideration to guarantee that pressure remains on the piezoelectric sensor pad, which is necessary for generating voltage. Figure 3 shows the chosen site for the project, which is located on Edu Hub Pagoh library stair.

Figure 3: Edu Hub Pagoh Library Stair.

The dimension of a single step of the stair is 160 cm in length and 20 cm in width is ideally suited for accommodating this project. This surface area enables two sets of piezoelectric sensor pads to be placed on each step. Consequently, the probability of individuals stepping on the pads increases, resulting in a larger voltage accumulation. Table 1 demonstrates usage frequency of stair by student who choose to reach to the upper level of the library, observed and recorded for a day.

Table 1: Frequency of Stair Used.

Time	Frequency
8.00 am – 10.00 am	34
10.00 am – 12.00 pm	63
12.00 pm – 2.00 pm	89
2.00 pm – 4.00 pm	55
4.00 pm – 6.00 pm	41

4. Results and Discussion

This experiment is being conducted to explore the study of piezoelectric effects to gain a deeper understanding of the relationship between the generated output and the applied pressure and stress. By subjecting the piezoelectric sensor pad to various pressures and stresses, diverse voltage readings are obtained and analysed. In the experiment, a total of 60 times pressure were applied consistently throughout. However, the variation in pressure was achieved by placing different weights on the piezoelectric sensor pad as shown in Table 2. The recorded value is the average voltage obtained from conducting this experiment three times in separate trials. This allowed for the examination of how the voltage readings corresponded to the different levels of pressure exerted on the sensor.

Table 2: Voltage Generate using Different Weight

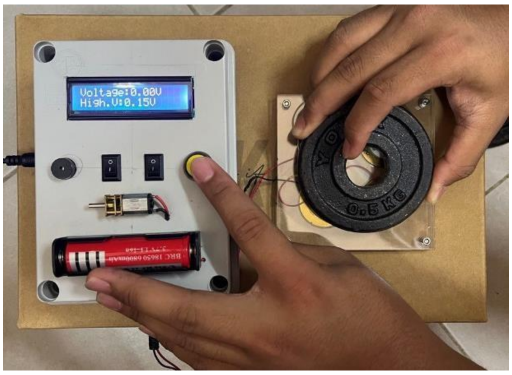
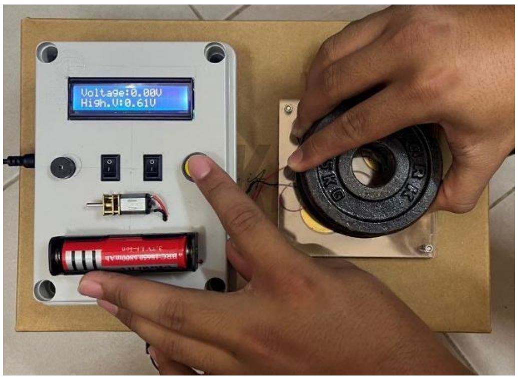
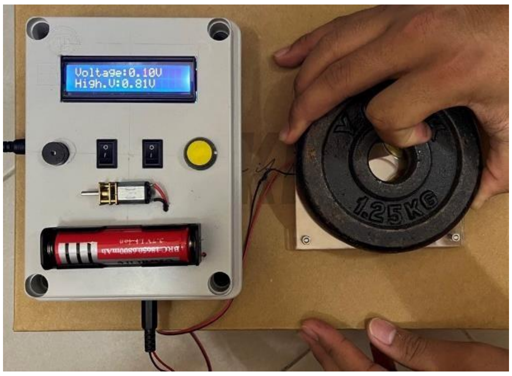
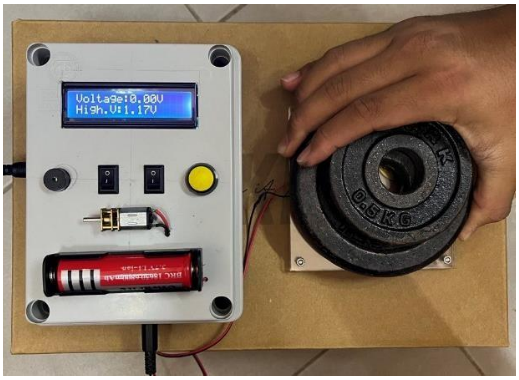
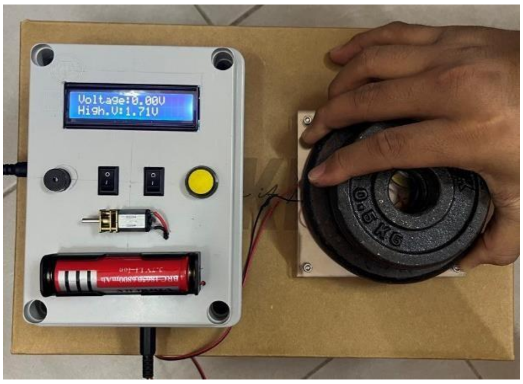
Weight Apply	Voltage Generated
0.5 kg	0.15 V 
1.00 kg	0.61 V 
1.25 kg	0.81 V 

Table 2 (continue)

1.75 kg	1.17 V 
2.25 kg	1.71 V 
2.50 kg	2.22 V 

The experiment conducted to investigate the correlation between the weight applied to a piezoelectric sensor pad and the generated voltage has provided compelling evidence supporting the hypothesis. The results clearly demonstrate that as the applied weight increases, the voltage generated by the piezoelectric device also increases. This finding confirms a direct and proportional relationship between the two variables.

The hardware developed for the piezoelectric footstep sensor power generation project will undergo different stepping frequency to measure the generated voltage readings as show in Figure 4. Theoretically, as more frequent pressure is applied to the piezoelectric sensors, the higher voltage values can be produced. The cumulative voltage readings of the piezoelectric sensor pad, which was stepped on between 10 and 120 times, were recorded and are presented in Table 3.

Figure 4: Voltage Generated with 20 Step.

Table 3: Data Voltage Generated

Number of Step	Voltage Generated (V)	Charging Storage (V)
10 Steps	0.22	0.22
20 Steps	0.88	0.88
30 Steps	1.00	1.00
40 Steps	1.46	1.46
50 Steps	2.25	2.25
60 Steps	2.59	2.59
70 Steps	2.94	2.95
80 Steps	3.35	3.35
90 Steps	3.71	3.7
100 Steps	4.1	3.7
120 Steps	4.6	3.7

Based on the collected data, it is evident that the voltage generated by the piezoelectric sensor pad is influenced by the frequency of steps taken on it. Increasing the stepping frequency leads to a corresponding increase in the generated voltage. This can be attributed to the higher frequency of steps causing more frequent mechanical stress on the sensor pad, resulting in a greater amount of electrical charge being produced.

The data shows a cumulative rise in voltage as pressure is applied to the piezoelectric sensor pad, with the voltage value increasing proportionally to the number of steps taken. However, the charging storage eventually reaches a certain level and remains constant. This occurs because the charging reaches the maximum voltage capacity of the battery. Once the generated voltage reaches the battery's maximum value of 3.7V, any further increase in generated voltage cannot be stored as the battery cannot hold additional charge beyond its capacity as show in Figure 5.

In summary, while the voltage generated by the piezoelectric sensor pad can continue to increase with more steps, the charging storage will eventually reach a saturation point and remain constant once it reaches the maximum voltage capacity of the battery.

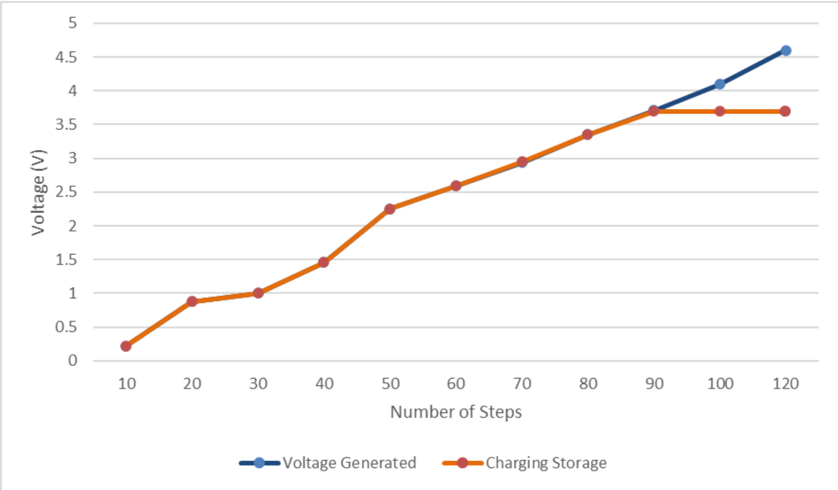


Figure 5: Graph relation between voltage generated and charging storage.

5. Conclusion

In conclusion, the footstep piezoelectric sensor power generation project successfully demonstrates the conversion of footstep pressure into electrical energy using piezoelectric sensors. By harnessing the piezoelectric effect, the project highlights a sustainable and renewable energy generation method. Throughout the project, various components such as the Arduino Nano, voltage sensor, rectifier, capacitor, and display are effectively integrated. Piezoelectric sensors are connected in series, their individual output signals add up, resulting in a stronger combined signal. This series connection enhances the overall sensitivity and improves the ability to detect and measure small variations in pressure or force therefore a voltage reading that generated can be recorded. The full bridge rectifier is a circuit configuration that utilizes diodes to rectify the AC voltage. It allows the passage of current in one direction while blocking it in the opposite direction. By employing four diodes in a bridge configuration, the full bridge rectifier ensures that both halves of the AC cycle are rectified [10]. The inclusion of an LCD display provides real-time monitoring of voltage readings, enhancing the user's understanding and interaction with the system. This project showcases the potential of piezoelectric technology in capturing energy from human activities and demonstrates a step towards sustainable power generation. The footstep piezoelectric sensor power generation project presents an innovative approach to generate electricity from footstep pressure, paving the way for renewable energy solutions and encouraging the exploration of alternative energy sources.

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