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A Development of Energy Harvesting Floor Using Piezoelectric Sensors

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Abstract

The goal of this research is to create a power generation system that is fueled by human actions. The system generates voltage using footstep force and can be used to create electricity from non-conventional sources. The hardware is set up by employing piezoelectric material to make a tile, which converts mechanical energy into force energy, transformed into electricity by a dc generator. A piezoelectric tile generates voltage supplied into a battery, subsequently recharged and utilized to power dc loads. An inverter receives the generated voltage and distributes it to all ac loads. In its ultimate form, the prototype floor tile can be used for several purposes where power is limited or non-existent. We can utilize this project to both Alternating Current (AC), and Direct Current (DC) loads based on the force we apply to the piezoelectric sensor. As a result, this prototype project aims to boost renewable energy output while reducing dependency on finite fossil energy sources, with generated power precisely proportional to individual mass.

Keywords: - footstep, piezoelectric tile, generate voltage, electricity

1. Introduction

Renewable energy is vital to meet the demand of the whole world nowadays as far as we know that according to Mahmud (2018) states that people are increasingly turning to renewable energy sources such as sun, water, and the wind to generate power after becoming aware of the non-renewable sources' limited availability.

Coal, natural gas, nuclear energy, and petroleum are a few non-renewable energy sources. Many of these sources harm the environment, such as air pollution from fossil fuel power plants, which leads to cumulative effects such as increased rates of global climate change (Saleh and Alonazi, 2020).

The results of a study conducted by Mutiara et al. (2020) have found that many efforts have been studied to obtain renewable energy due to the dwindling availability of gasoline. One of the research projects aims to develop a power generation system based on everyday human actions. Because of that, there are various ways to generate electricity as an alternative, and one of these methods, footstep energy generation, can be an effective way to generate electricity (Tiwari et al., 2019).

Most people spend most of their lives walking. Therefore, many studies have been done as a result of this walking activity and according to Ang et al. (2019) states that walking creates touch between the human foot and the ground surface. When they land on the ground, the pressures experienced by human feet can generate kinetic energy, a renewable energy source. This energy can be utilized in a variety of ways.

According to a study conducted by Abadi et al. (2018) states that foot stepping is one of the quickest motions in everyday life. It is like walking, jogging, running, or dancing steps that require a lot of energy stored in the form of body heat or sweat, as indicated in Figure 1.

Figure 1: Footsteps on energy floor tile (Lombardo, 2013)

This waste energy has the potential to be recycled into another type of usable energy. It can be converted into electrical energy via the piezoelectric effect, allowing it to be retained and used. (Prasad et al., 2019). Piezoelectric sensors provide output energy in the form of Alternating Current (AC) and Direct Current (DC) loads by using piezoelectric action.

According to the findings of a study conducted by Shivendra and Rishikesh (2019), some emerging and newly industrialized countries experience recurrent power outages lasting several hours in practically all cities and villages due to excess demand for electricity. During the power outage, residents in these countries can utilize a power inverter (rechargeable batteries). In industrial, standby generators are frequently used. The power scarcity will worsen as a result of this.

As a result, this prototype project aims to increase renewable energy generation while reducing dependency on fossil fuels, which will run out in the future.

2. Maximum Theoretical Voltage Generated

A charge is created across a piezo material when a force is applied to it. As a result, all capacitor equations can be used to it. This project is based on previous studies that have been done by Jacob et al., (2017). Three piezo are connected in series on one tile. In parallel, ten of these series connections are connected. As a result, when three piezoelectric discs are linked in series, the equivalent capacitance is:

We know, $1/Ceq = 1/C1 + 1/C2 + 1/C3$ (1)

So, $Q = C * V$ (2)

Hence, $C = Q/V$ (3)

Thus, $Veq/Q = V1/Q + V2/Q + V3/Q$ (4)

$\text{Veq} = \text{V1} + \text{V2} + \text{V3}$ (5)

As a result, in a series connection, the net voltage generated equals the total of the individual voltages generated across each piezoelectric disc. One piezo disc produces a voltage of 12 volts.

Thus, $\text{Veq} = \text{V1} + \text{V2} + \text{V3}$ (6)

$= 12V+12V+12V$

$= 36V$

As a result, the maximum voltage generated across the piezo tile is approximately 36V.

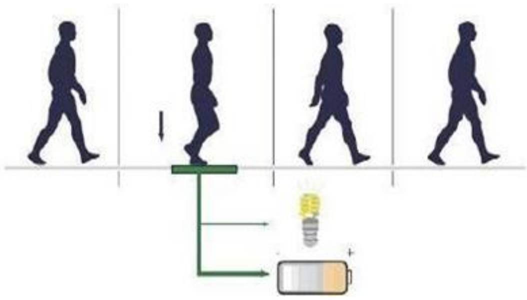

Figure 2: Diagram of the working model

Figure 2 shows the working model relationship between a person's weight and the amount of power generated. To test the Piezo tile's voltage generating capacity, people weighing between 40 and 75 kg were forced to walk on it. When the maximum weight/force is applied, the maximum voltage is generated.

3. Methodology

3.1 Hardware Implementation

The hardware is set up according to the block diagram in Figure 3. The piezoelectric material is used to create a tile. The voltage produced by a piezoelectric tile is fed into a battery, which is then recharged and used to power dc loads. The generated voltage is also provided through an inverter, from whence it is distributed to all ac loads.

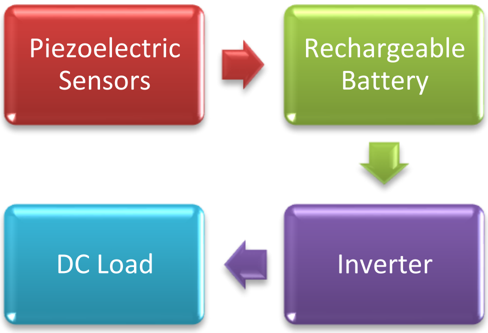

Figure 3: Block diagram

It demonstrates that the transducer utilized is piezoelectric, a type of material that can create an electrical voltage when subjected to pressure or strain, like certain crystals and other materials. When mechanical stress is applied to a piezoelectric, electrical voltage is generated (Iswanto et al., 2018).

Figure 4 shows a piezoelectric sensor, which converts applied stress into electrical energy and stores the output dc voltage in a Lead-Acid Rechargeable battery in Figure 5.

Figure 4: Piezoelectric sensor

Figure 5: Lead Acid Rechargeable battery

The piezoelectric arrangement on the prototype tile that converts the pressure applied to it into electrical energy is shown in Figure 6. The weight of moving vehicles or the importance of individuals walking over it can both be a pressure source.

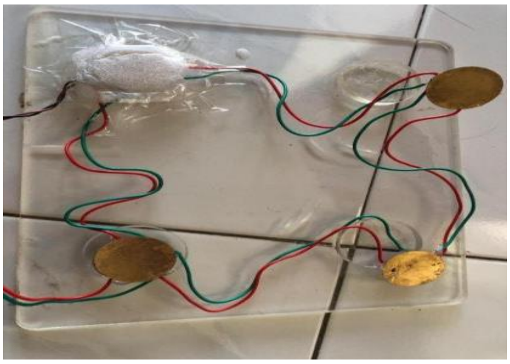

Figure 6: Piezoelectric arrangement

3.2 Hardware Specifications

- Piezoelectric Crystal Material
- Buzzer
- Amplifier
- Battery
- Weight Sensor
- LED's
- Multimeter

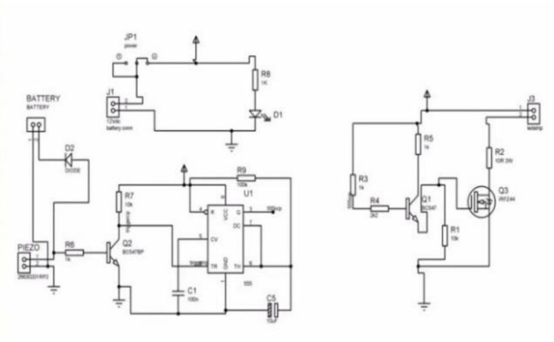

Figure 7: Schematic diagram

According to the circuit diagram in Figure 7, when mechanical stress is applied to the piezoelectric sensor, voltage is produced. The piezoelectric sensor's output is in the form of an alternating current (AC). We'll use a complete bridge rectifier to convert it from AC to DC. A capacitor connects the rectifier's output to the ground and stores the voltage produced by the piezoelectric sensor.

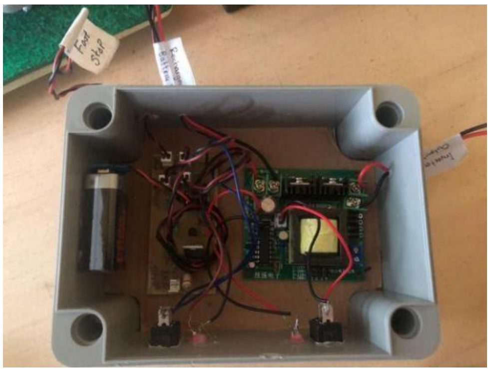

Figure 8: Inverter circuit

An inverter is a device that converts DC power into AC power at a desired output voltage and frequency. Line commutated inverters are phase-regulated converters that are used in the inverter mode. However, line commutated inverters require an existing AC supply for commutation at the output terminals. The inverter circuit utilized in this project is shown in Figure 8.

4. Result and Discussion

In this study, nine healthy volunteers were used as test subjects, with each group consisting of five people who had no foot problems. The participants in each group might be children or adults, with body weights ranging from 15 to 55 kg. To reduce variation, the average reading from each group was taken.

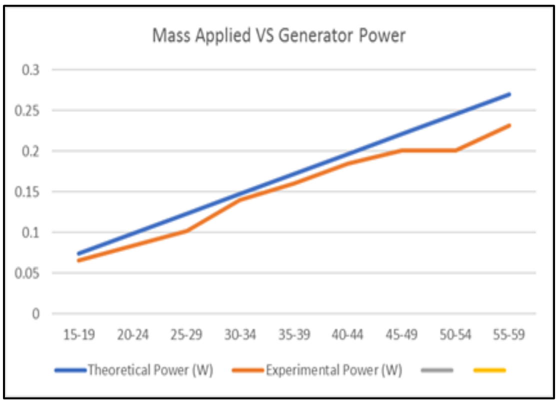

Figure 8: Theoretical and experimental results differ from one another

The test subjects were advised to step on the suggested automatic footstep generator with their hind foot because prior research by Klimiec et al., (2017) found that the back foot applies the most pressure when walking on a flat plane, accounting for almost one-third of total foot pressure.

The differences between the theoretical and actual results for different ranges of mass of individuals are shown on the graph of Mass Applied vs. Generator Power in Figure 8. The generated power increased directly proportional to the individual's mass. Therefore, to generate additional electrical energy, connecting more piezoelectric sensors is required in series.

The conversion of kinetic energy from human footsteps into electricity energy is regarded as a renewable energy approach. It can be used for several applications where power is scarce or non-existent. Figure 9 displays the prototype of floor tile in its final state.

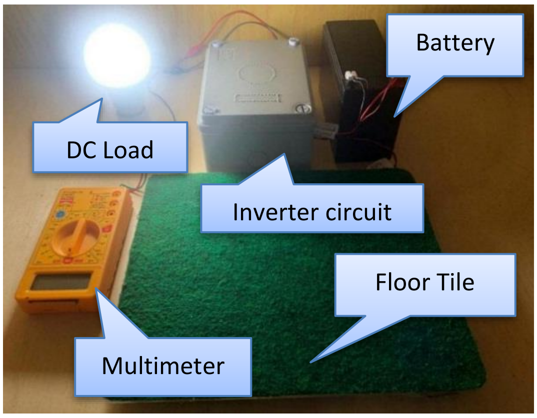

Figure 9: The prototype floor tile

5. Conclusion

This prototype floor tile has been successfully tested and installed, and it is the most cost-effective and accessible energy solution for the general public. We can use this project to drive both Alternating Current (AC), and Direct Current (DC) loads based on the force we provide to the piezoelectric sensor.

Acknowledgment

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