Footstep Energy Harvester Using Piezoelectric Transducer

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Abstract- **Innovation, design and implementation of new technologies leading environment and societal benefits, is the basis of this project, which aims to provide an alternative to an existing product, giving it added value, generating energy cleanly and storing it for reuse.**

The development of the idea behind the project deals with the need of using piezoelectric transducers to produce energy by harvesting it from the footsteps. Walking is the most common activity in day to day life. When a person walks, he loses energy to the road surface in the form of impact, vibration, sound etc, due to the transfer of his weight on to the road surface, through foot falls on the ground during every step. This energy can be tapped and converted in the usable form such as in electrical form and can be temporarily stored for later use.

Keywords: Power harvesting, piezoelectric transducer, Footsteps, Energy

I. INTRODUCTION

1.1 Need of project

Human-powered transport has been in existence since time immemorial in the form of walking, running etc. However modern technology has led to the development of machines to enhance the use of human-power in more efficient manner [1]. The pedal power is an excellent source of energy and has been in use since the nineteenth century making use of the most powerful muscles in the body. Ninety-five percent of the exertion put into pedal power is converted into energy. Pedal power can be applied to a wide range of jobs and is a simple, cheap, and convenient source of energy[2-4]. However, human kinetic energy can be useful in a number of ways but it can also be used to generate electricity based on different approaches and many organizations are already implementing human powered technologies to generate electricity to power small electronic appliances[5].

Free play Energy Company (USA) had suggested that piezoelectric material can be used to generate electricity by pushing piezoelectric material sheet with foot[6]. A similar, newly released portable energy source is a foot-powered device that allows individuals to generate some amount of energy to charge its own internal rechargeable battery In another approach, if everyone had small magnets in their shoes and the paving slabs had inter-connected coils cast inside, all linked to batteries, electricity can be generated and the amount will depend on how many people are on the move[7-9].

Working on the project has provided us with sufficient results that has justified our case of generation of electricity by human foot using piezoelectric material, it can also be noted that the setup harnesses human locomotion power by making use of the mechanism that would derive energy from pounding feet in crowded places. This technology is a proposal to harness human power as a source of sustainable energy.

1.2 Features

- There is sufficient use of free human energy for generation.
- Only installation cost is high, otherwise it is maintenance free.
- No requirement of fuel for generation.
- Eco-friendly.
- Cost effective.
- 24 hours of generation in crowded areas.

1.3 Work done

The first purpose of our project is to design such a type of generation plant which can effectively produce power without any use of fuel, like coal in thermal power plant, nuclear fuel in nuclear power plant, So that the preservation of environment can happen. Since we know that, due to this harmful fuels like coal, radioactive materials etc, there is damage to environment, Hence to overcome the above disadvantages of other power plant, we have designed this type of circuit which can produce electricity by using waste energy.

In our present work, we make use of piezoelectric material for power generation. The property of this type of material is that, it converts the applied pressure into electrical energy; by using this property, we are generating the power. First of all, we have developed a piezoelectric plate on which pressure can be applied; these plates are embedded with piezoelectric crystals. We have designed an indigenous circuit that stores the generated energy in batteries, which can be reused for variety of purposes. We have also incorporated a LED display that effectively displays the amount of voltage generated. The operation of LED Display is controlled by using a microcontroller.

II. MATERIAL AND METHODS

2.1 Piezoelectric Crystal

One of the most suitable methods for obtaining the energy from footsteps is by using piezoelectric crystals. Piezoelectric crystals are one of small scale energy sources. Whenever the piezoelectric crystals are subjected to vibration; they generate a very small voltage, commonly known as piezoelectricity. The piezoelectric crystals has a crystalline structure that converts an applied vibration into an electrical energy, the piezoelectric effect exists in two properties: The first is the direct piezoelectric effect that describes the material's ability to transform mechanical strain into electrical charge. The second form is the converse effect, which is the ability to convert an applied electrical potential into mechanical strain energy. These properties allow the material to function as a power harvesting medium.

Figure1: Piezoelectric crystal

This crystal uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them into an electrical signal. Piezoelectric sensors have proven to be versatile tools for the measurement of various processes. They are used for quality assurance, process control and for research and development in many different industries; it was only from the 1950's that the use of piezoelectric effect for industrial sensing applications gained its importance. Since then, this measuring principle has been increasingly used and can be regarded as a mature technology with an outstanding inherent reliability. It has been successfully used in various applications, such as in medical, aerospace, nuclear instrumentation, and as a pressure sensor in the touch pads of mobile phones. In the automotive industry, piezoelectric elements are used to monitor combustion when developing internal combustion engines.

The rise of piezoelectric technology is directly related to a set of inherent advantages. The high modulus of elasticity of many piezoelectric materials is comparable to that of many metals and goes up to 10E6 N/m² .Even though piezoelectric sensors are electromechanical systems that react to compression; the sensing elements show almost zero deflection. This is the reason why piezoelectric sensors are so rugged, have an extremely high natural frequency and an excellent linearity over a wide amplitude range. Additionally, piezoelectric technology is insensitive to electromagnetic fields and radiation, enabling measurements under harsh conditions. Some materials used (especially gallium phosphate or tourmaline) have an extreme stability even at high temperature, enabling sensors to have a working range of up to 1000°C. Tourmaline shows pyro electricity in addition to the piezoelectric effect; this is nothing but the ability to generate an electrical signal when the temperature of the crystal changes. This effect is also common to piezo ceramic materials.

One disadvantage of piezoelectric sensors is that they cannot be used for truly static measurements. A static force will result in a fixed amount of charges on the piezoelectric material. While working with conventional readout electronics, imperfect insulating materials, any reduction in internal sensor resistance will result in a constant loss of electrons, and yield a decreasing signal.

2.2 Methods

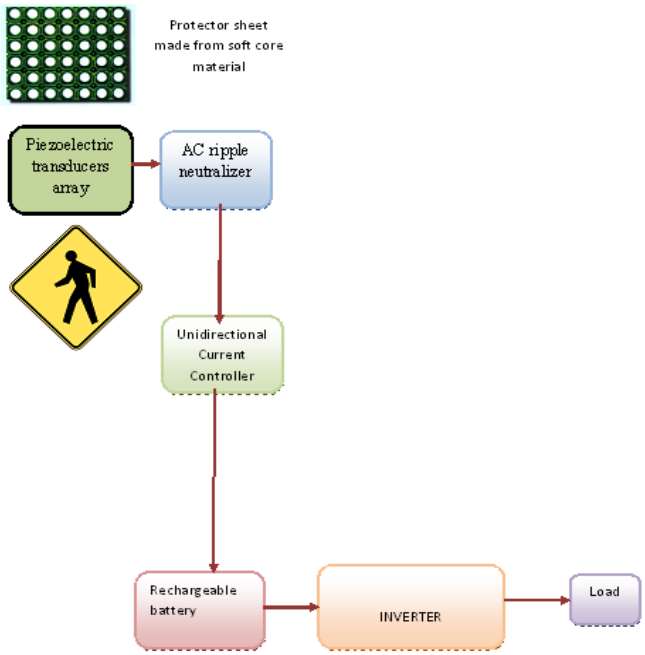

Figure2: Block diagram

In this project we generate electricity using a piezoelectric material. When we press the piezoelectric material sheet, then the positive charge is produced and when we release it then the negative charge is produced. This is the basic concept in this project; it is predominantly attributed to the ion structure. here when we press the sheets, positive ions are produced, actually the structure of piezoelectric crystal is such that, during pressing the distance between two respective atom get altered due to which the deformation occurs in between atom and positive ions are produced. And same process can occur during relaxation, but this time negative ions are produced and due to this alternate complete cycle, the voltage gets produced. The positive charge is produced at positive side and the negative charge will be produced at negative side.

Here we are using 16 crystals connected in parallel manner that is four crystals are arranged in series and the

resultant series circuits are then connected in parallel. We connect a capacitor in parallel with crystals for filtering purpose. Here we are providing the rubber sheet over crystal panel, to prevent the physical damage occurring due to the application of extra pressure.

The other block is AC ripple neutralizer. This block is for filtering purpose. The circuits consists of capacitors provided in parallel with crystals arrangement .since we know that the amount of voltage generated is directly proportional to the pressure applied and due to varying pressure there is variations in output voltage. But we require constant DC voltage; hence for this purpose rectifiers are used.

The next block is unidirectional current follower. The function of this block is indicated by its name itself, which means it prevents the backward flow of current. This block consists of diodes, because the property of diode is it is provided to facilitate the path of current flow in one direction only i.e. during forward bias only.

In this project diodes are connected to each crystal individually. After this block, the generated power is stored in 12 volt rechargeable battery.

III. PIEZOELECTRIC SENSOR CONNECTION CIRCUIT

The below piezoelectric sheet consists of 16 piezoelectric crystals. These 16 crystals are arranged in 4*4 pattern, means first 4 crystals are connected in series and these set of 4 crystals are now connected in parallel to pattern them in 4*4 array. Diodes are connected along with each crystal to avoid reverse battery current which can damage the crystals. The diode is IN4007 having forward conducting characteristics. It's a silicon diode having Pick up value of 0.7 volt and hence it can consume some generated energy that causes reduction in efficiency.

The capacitor is connected in parallel with piezoelectric sheet for filtering purpose. One LED is provided to indicate the generation of power. The arrangement is done on a hard sheet over which a rubber sheet is provided to protect the sheet from physical damage.

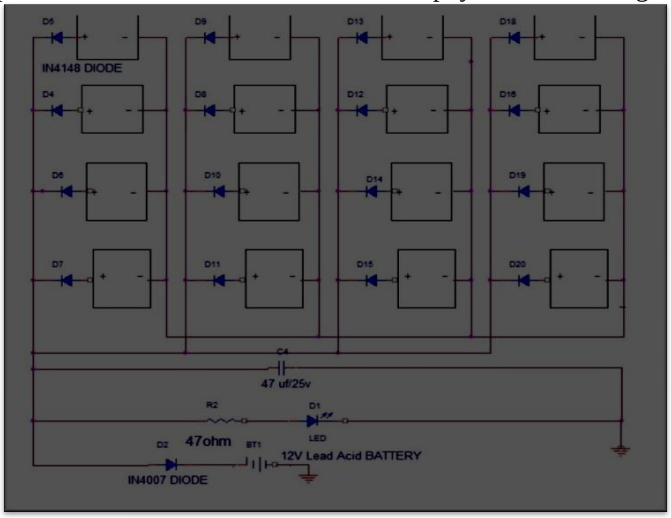

Figure 3: Connection of Piezoelectric sensors

IV. CALCULATIONS

When we applied pressure on the piezoelectric sensor the voltage deflection is sensed as shown in the figure 4, i.e. when we apply pressure and release it then the voltmeter shows some deflection and this deflection depends upon the applied pressure and type of Piezoelectric material.

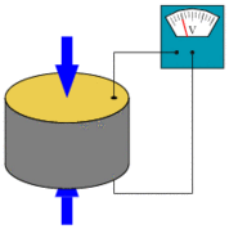

Figure 4: Schematic of Piezoelectric sensor testing setup

For a weight of 50 kg, wt=50kg,
We get the value of voltage V=3 V and
Current I =0.0015 A
Then P=V*I=3*0.0015=0.0045 W,
It infers that, for 50kg we get power (P) =0.0046 W.
From repeated experimentation we come across the fact that, Weight is directly proportional to the amount of power generated,
Now we find a correlation between them as follows:

$$P \alpha Wt$$

Here we take the constant of proportionality as Ķ, then the equation becomes

$$P = Ķ\ Wt$$

Where,
Ķ- Constant of proportionality
Wt-weight
P-power

We know that for wt=50kg,
We get power (P) =0.0045 W
From this we can find the value of Ķ

$$Ķ=P/wt=0.0045/50=0.00009$$

The table given below gives the relation between Power & weight for different values of weight applied on the piezoelectric crystal:

S.N.	P (Watt)	Wt (kg)
1	0.0009	10
2	0.0018	20
3	0.0036	40
4	0.0045	50
5	0.00675	75
6	0.00765	85
7	0.009	100

Table 1: showing Power generation at different weight

V. CONCLUSION

After critical observation and analysis, we obtain certain conclusions:

- Here we are introducing a new source or way of generation of electricity.
- The power produced in this experiment is proportional to the weight applied on the piezoelectric sheet.
- To produce 0.325Ahr power, nearly 1000 steps are required.
- To charge a 12 V battery completely, 4 to 5 days are required.
- Running cost is negligible of the project because here no special fuel is required like other power generating stations.
- There is no pollution with this technology as compared to other power generating technologies, hence it is eco- friendly in nature.
- Untapped Mechanical energy associated with footsteps is used for generation of electricity.
- For more generation of electricity, more pressure is required hence the project can be successfully implemented in crowded areas.

VI. FUTURE SCOPE

This project can be successfully implemented in airports, railway stations and the technology can be incorporated to generate power in the following applications.

- In Car Tires
- Below Railway tracks
- In speed breaker
- In Boxing panel
- Staircases
- School/college
- Treadmill
- Discos

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