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HUMAN FOOTSTEPS POWER: "REVOLUTIONIZING ENERGY HARVESTING WITH PIEZOELECTRIC FLOOR TILES"

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Abstract

The most common type of energy used worldwide is electricity. The energy criterion governs the development of a developing country such as India. In our nation, the need for energy is rising at an exponential rate. Because there are a lot of people walking, jogging, and jumping around, human power can be employed as a power source. The application of leftover energy from foot power combined with human movement is vital and significant in places like train stations, temples, etc. that are always packed. This study discusses the use of piezoelectric materials to provide alternative energy sources. Surface stress is transformed into electrical energy by the piezoelectric tiles. Numerous applications exist for piezoelectric tiles. They can be put in place to create energy in public areas like parks, plazas, and sidewalks allows them to provide electricity for low-power devices like sensors and lighting. Many communities in India are currently experiencing severe power outages, so it is important to make sure that every home has an equal supply of electricity. The primary point of this paper is to give power to the town who is needing power even at this point.

Keywords: Electrical Power Generation, Footsteps, Piezoelectric Sensor, Energy Harvesting Technique.

Introduction

Electronic gadgets used on a daily basis are increasing rapidly. Therefore, power requirements are highly important nowadays. As a result, there is a growing demand for a portable power source that can power these devices, such as batteries, household power supplies, and so on, and that can be accessed from anywhere in the world. Previous efforts have focused on converting various energy sources into electrical energy. The three most frequent processes employed for energy-scavenging applications are electrostatic, electromagnetic, and piezoelectric. Among these three, we primarily employ piezoelectric. Power cannot be created or destroyed; it just changes from one form to another. In fact, piezoelectric materials can generate electricity from electrical power and convert behaviours such as vibration into electricity.

Piezoelectric tiles are floor tiles that use mechanical energy, such as the pressure from footsteps, to generate electricity. They use the idea of piezoelectricity, which refers to the capacity of certain materials to create an electric charge when subjected to mechanical stress. These tiles are made of piezoelectric materials, such as ceramic or crystal, placed between electrodes. When someone steps on the tile, the pressure forces the piezoelectric material to distort, generating a voltage between the electrodes. This voltage can then be collected, saved, or utilized to power electronic gadgets.

Piezoelectric Tiles

Piezoelectric tiles are composed of many layers, each with a distinct function.

Top Surface: People walk on this hard, wear-resistant layer. Usually composed of concrete or a comparable sturdy material, it occasionally has a rough surface for grip.

Piezoelectric Layer: The tile's core component is the piezoelectric layer. It has a piezoelectric substance, which could be crystal or ceramic. This layer is in charge of producing electricity from the pressure of footsteps.

Electrodes: Electrodes are positioned between the piezoelectric layer and the top surface. The electrical charge produced by the piezoelectric material is collected by these tiny, conductive plates.

Backing (optional): For extra stability or waterproofing, some tiles may have a backing layer.

Fig1. Piezoelectric Tile

1.1 Piezoelectric Tiles Manufacturing Process

Step1: Piezoelectric Material Preparation: The piezoelectric material is prepared and processed. It is frequently in the form of powder or tiny crystals.

Step2: Electrode Formation: On a base layer, electrodes are created. Electrodes are usually made of copper or similar conductive material.

Step3: Layering and Bonding: Piezoelectric material is layered and bonded between the electrodes. Several methods, such as pouring, pressing, or screen printing, can be used to accomplish this. After that, heat and pressure are used to fuse the entire assembly together.

Step4: Encapsulation (optional): The entire tile may be covered in a protective coating for added durability or environmental protection.

Step5: Quality Control: Tests are conducted on the completed tiles to make sure they meet durability and electricity generating requirements.

Piezoelectric Effect

The French brothers Jacques and Pierre Curie made the discovery of piezoelectricity in 1880.
A phenomenon known as the piezoelectric effect occurs when some materials, when subjected to mechanical stress or deformation, produce an electric charge.

How it operates:

Crystalline Structure: The crystalline structure of piezoelectric materials is distinct. Examples of these materials include lead zirconate titanate and certain crystals like quartz. When they are under mechanical stress, they can create an electric field because of its structure.

Symmetry: The molecules or atoms in these materials are aligned symmetrically. But this symmetry is broken when the material is stretched or mechanically deformed, which causes the positive and negative charges to move in relation to one another.

Electric Potential: This charge separation causes a differential in the electric potential across the substance. If the material is a component of a closed circuit, this potential difference results in the flow of electric current.

Reversible Piezoelectric phenomenon: Remarkably, this phenomenon may also be reversed. That is, a material may experience mechanical deformation or strain if an electric field is given to it. In systems like piezoelectric actuators and sensors, this phenomenon—known as the inverse piezoelectric effect—is used.

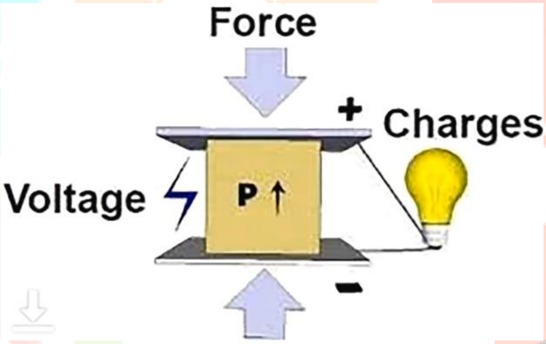

Fig2. Piezo power with force direction.

System Requirements

Piezoelectric Sensor

Sensors that use the piezoelectric effect to transform mechanical stress into an electrical signal are known as piezoelectric sensors. Some materials have a property known as the piezoelectric effect, which causes a voltage shift in response to mechanical pressure. The force or pressure applied to the sensor can be determined by measuring this voltage change. Piezoelectric sensors are a flexible and dependable kind of sensor that have numerous applications. Their broad frequency range, great sensitivity, and durability are well known.

How it works:

Piezoelectric Material: The sensor's heart is a piezoelectric crystal, which is typically constructed of quartz. These crystals have a unique crystal structure that produces a voltage differential when compressed or stretched.

Force Application: When a force is applied to the sensor, the piezoelectric crystal therein is distorted. This deformation applies pressure to the crystal's interior structure.

Voltage Generation: The piezoelectric effect generates an electric charge proportionate to the applied force. In simple words, the harder you push on the sensor, the stronger the electrical signal it produces.

Signal Processing: The generated charge is sometimes quite tiny and requires amplification. The sensor may include built-in electronics or require an external amplifier to transform this little charge into a quantifiable voltage signal.
Piezoelectric force sensors are noted for their high sensitivity, wide force range, and rapid response.

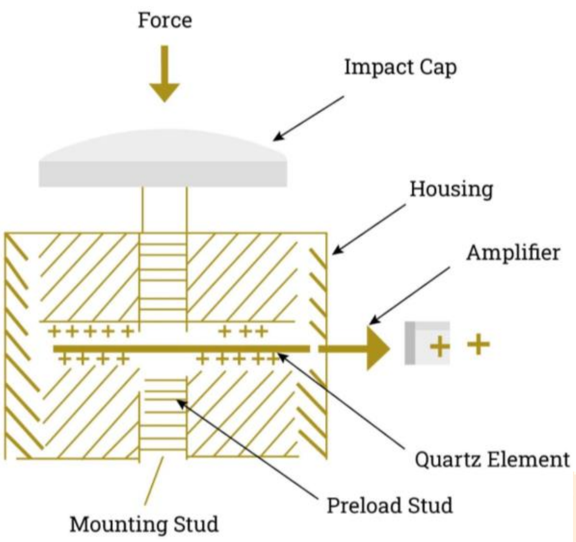

Fig3. Piezoelectric force sensor

Rectifier circuits
Rectifier circuits are power-harvesting circuits (PHCs) that efficiently utilize the power generated by piezoelectric tiles by converting alternating current (AC) to direct current (DC).
The purpose of piezoelectric tiles is to generate electrical energy by transforming pressure into electrical impulses. The signals are then transformed into the desired signals by power optimization circuits or rectifiers.

There are three types of rectifier circuits: half-wave, full-wave, and bridge. A bridge rectifier is usually the best option for producing energy from an alternating current (AC) power source. The main reason for choosing a bridge rectifier is as follows:

1. Efficiency: By using both halves of the AC waveform, bridge rectifiers are more efficient than half-wave rectifiers. This indicates that a larger proportion of the incoming AC power may be converted into useful direct current (DC) power by them. Bridge rectifiers use fewer components than full-wave rectifiers, but they nonetheless attain the same efficiency.

2. Output Power: Compared to half-wave rectifiers, bridge rectifiers are able to manage larger power levels. Because of this, they are better suited for uses requiring higher power generation, including large-scale energy-producing systems or power plants.

3. Simplicity: Half-wave rectifiers have a lower efficiency than bridge rectifiers while being less complicated and requiring fewer components. When efficiency is of the essence, a bridge rectifier's added complexity is frequently justified by its enhanced functionality.

4. Versatility: Because bridge rectifiers can correct both the positive and negative portions of the AC waveform, they are more adaptable than half-wave rectifiers. Therefore, they can be used in a greater variety of applications and input voltage scenarios.

Bridge rectifiers are often chosen over half-wave rectifiers when producing energy from AC power sources because of their higher efficiency, greater power handling capacity, and versatility.

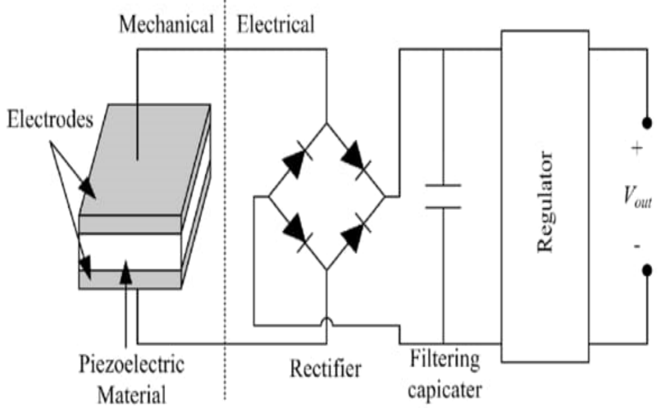

Fig4. Rectifier circuits

Battery

A battery is a collection of electrochemical cells that can be housed in a single unit or connected individually for the purpose of storing electricity. Combining one or more electrochemical cells to transform chemical energy that has been stored into electrical energy is known as an electrical battery. Batteries are utilized as a storage device to store electricity since they are used to create and consume power simultaneously. There are two types of batteries:

1.Primary Batteries

Primary batteries are also referred to as non-rechargeable batteries or disposable batteries. Disposable batteries are meant to be used just once before being thrown away. These are typically utilized in portable electronics where other electric power is only sporadically available, like in alarm and communication circuits. When opposed to rechargeable batteries, primary batteries have the following drawbacks:

1.1. **One-time Use:** Primary batteries are made to be used just once. They have to be disposed of after their chemical energy runs out because they cannot be replenished. This can lead to serious trash production and environmental issues, particularly if recycling isn't done correctly.

2.2. **Limited Capacity:** Compared to rechargeable batteries, primary batteries sometimes have a lower energy density, which means they can hold less energy relative to their weight and size. Devices using primary batteries may see reduced runtimes as a result, particularly high-drain gadgets like digital cameras and portable electronics.

2.Secondary batteries

Secondary batteries are often manufactured with discharged active components and need to be charged before use. Electrical current can be used to recharge secondary cells or rechargeable batteries by reversing the chemical reactions that take place while the device is in operation. Chargers or rechargers are devices that deliver the proper current. Rechargeable or secondary batteries are a great fit for piezoelectric tiles because they are made for long-term energy gathering. The following is the primary justification for our use of secondary batteries:

Reusability: Secondary batteries may be recharged and used once more, in contrast to primary batteries, which must be disposed of after usage. This is consistent with the clean, energy-generating piezoelectric tiles' sustainable nature.

Capacity for tiny charges: When pressure is applied, such as when someone steps on a tile, piezoelectric tiles normally produce little amounts of energy. These little charges can be effectively stored and accumulated for use at a later time in secondary batteries, especially lithium-ion batteries.

Numerous options: Various secondary battery types can be employed, depending on the application. In small-scale applications where power requirements are minimal, a tiny lithium-ion battery could be adequate. A bank of secondary batteries, such as lithium-ion or sealed lead acid (SLA) batteries, may be required for bigger installations that are intended to power entire buildings in order to accommodate the greater storage capacity.

Finally, because secondary batteries can be reused, effectively store small charges, and offer a range of options for various situations, they are the preferred choice for piezoelectric tiles.

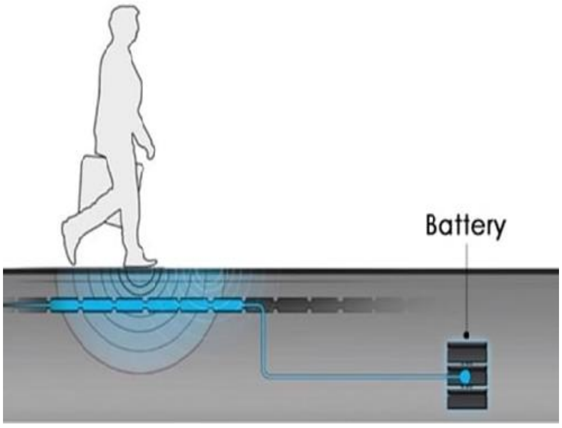

Fig5. Battery

Working Principle

All matter is composed of atoms, each of which has a specific number of electrons spinning about it at a very high speed, as we were taught as youngsters. Additionally, we discovered that electrons can hop between orbits in accordance with their energy levels. These electrons frequently cause the bonding of many atoms that together make up matter. These electrons cause the atom's electric field to be disrupted, which turns them into charged particles.

When a person steps on the piezoelectric tile, it moves downward due to the force applied to the tile. The piezoelectric sensor gets activated, and it uses the piezoelectric effect to convert mechanical stress into an electrical signal. These signals are transformed into the desired signals by rectifier circuits. The rectifier circuit helps to convert the AC voltage generated by the piezoelectric transducers into direct-current DC voltage. Here, we use the Bridge rectifier because of its great efficiency, great power handling capacity, and versatility. The energy created from this can be stored in a storage device such as a primary or secondary battery. Here, particularly, we use secondary batteries, which are rechargeable. This stores electricity and helps to use it efficiently. Secondary batteries are a great choice for piezoelectric tiles because of their properties like reusability, capacity, etc. This stored energy can be used to provide electricity to the country. The number of piezo electrics, the electromechanical coupling coefficient of piezoelectric sensors, transducers, the applied load, and the arrangement system are some of the factors that affect the generation of electrical energy when applied to the sensors as direct strain or ambient vibration.

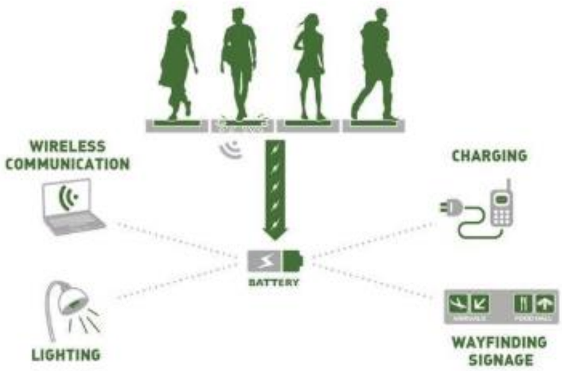

Fig6. Working of Piezoelectric tile

Conclusion

Electricity is really important. Almost every modern utility, including phones, computers, the internet, televisions, heating systems, and light bulbs, is powered by electricity. It's no surprise that demand for power continues to rise. Despite the importance of energy and its increased demand, many countries still lack access to electricity. This paper discusses the benefits of using piezoelectric ceramic tiles to address rising electricity needs and limited access. Piezoelectric ceramic tiles are not only a renewable energy source, but they are also safe, unique, dependable, geographically diverse, and economically viable. This technology makes use of the wasted energy that humans generate when walking. Footstep is a continuous and renewable source of energy. Footsteps are the primary source of electricity generation. This method of power generation requires no energy from conventional sources and emits no pollution. There is no need for any type of power from the mains, and it is critical in places where footsteps are utilized to generate non-conventional energy such as electricity. When deployed in a densely populated location, this technology can be used to its full potential. Because there is no need for fuel in this power-producing facility to generate electricity. As a result, it is possible to conclude that this method of power generation is environmentally friendly in the sense that no pollution is produced during power generation utilizing this model. As a result of these benefits, this system can be implemented in a variety of public settings, including train stations, congested footpaths, malls, and so on. Implementing this approach allows us to easily minimize our reliance on traditional energy sources, which is helpful from that perspective.

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