

Generation of electricity thorough PZT materials with the help footfall stress

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Abstract

This paper presents an Electricity Generating Floor that is made to pursue the target of producing electricity through transduction of stress generation by human footfall on the surface where he walks. The EGF aims the smart use of material properties and public gathering situations for efficient generation of electricity. EGF not only provides an efficient source of energy but it is also a clean and pollution free environment. The benefit of application of EGF will be that it is cheap and easy in installation. It will not make any effect on the surrounding and as it is smaller in structure it could be installed anywhere. EGF uses a principle which is completely harmless to the environment. It is a onetime installation and will require a negligible amount of maintenance service thus making it more suitable source of energy generation. This project acts as a transducer for converting stress generated by human weight on the floor to electricity. Power generated from the thousands of visitors to the public gathering places is stored and used for a variety of applications including pedestrian lighting and advertising. The system is not noticeable and does not affect the aesthetics of the area. EGF is noise free power source. Less skilled labor is required for installation and maintenance. Power generated could be used for small requirements and could cut the use of power generated by non-renewable sources of energy. The EGF could also be used in dance floors, gyms, exercise machines etc. The dance floor could give feedback to other systems that use electricity, such as the sound system, motivating the DJ to outperform him/her by responding to the energy generated by the crowd. The floor can have different platforms, providing unique visual experiences on every energy level. All visuals will be a continuous real-time interaction between the clubbers on the floor made visible, allowing every individual's actions to contribute to the collective experience. By utilizing the energy

which generally gets wasted the EGF project will be the best option for making these public places independent from the conventional power sources and saving the non-renewable material.

Introduction:

The movement of electric charge is known as an electric current, the intensity of which is usually measured in amperes. Current can consist of any moving charged particles; most commonly these are electrons, but any charge in motion constitutes a current.

By historical convention, a positive current is defined as having the same direction of flow as any positive charge it contains, or to flow from the most positive part of a circuit to the most negative part. Current defined in this manner is called conventional current. The motion of negatively charged electrons around an electric circuit, one of the most familiar forms of current, is thus deemed positive in the opposite direction to that of the electrons. However, depending on the conditions, an electric current can consist of a flow of charged particles in either direction or even in both directions at once. The positive-to-negative convention is widely used to simplify this situation.

The use of electricity gives a very convenient way to transfer energy, and because of this it has been adapted to a huge, and growing, number of uses. The invention of a practical incandescent light bulb in the 1870s led to lighting becoming one of the first publicly available applications of electrical power. Although electrification brought with it its own dangers, replacing the naked flames of gas lighting greatly reduced fire hazards within homes and factories. Public utilities were set up in many cities targeting the burgeoning market for electrical lighting.

Electrical power is usually generated by electro-mechanical generators driven by steam produced from fossil fuel combustion, or the heat released from nuclear reactions; or from other sources such as kinetic energy extracted from wind or flowing water. The modern steam turbine invented by Sir Charles Parsons in 1884 today generates about 80 percent of the electric power in the world using a variety of heat sources. Such generators bear no resemblance to Faraday's homopolar disc generator of 1831, but they still rely on his electromagnetic principle that a conductor linking a changing magnetic field induces a potential difference across its ends. The

invention in the late nineteenth century of the transformer meant that electrical power could be transmitted more efficiently at a higher voltage but lower current. Efficient electrical transmission meant in turn that electricity could be generated at centralized power stations, where it benefited from economies of scale, and then be dispatched relatively long distances to where it was needed.

Since electrical energy cannot easily be stored in quantities large enough to meet demands on a national scale, at all times exactly as much must be produced as is required. This requires electricity utilities to make careful predictions of their electrical loads, and maintain constant co-ordination with their power stations. A certain amount of generation must always be held in reserve to cushion an electrical grid against inevitable disturbances and losses.

Environmental concerns with electricity generation have led to an increased focus on generation from renewable sources, in particular from wind and hydropower. While debate can be expected to continue over the environmental impact of different means of electricity production, its final form is relatively clean.

In engineering or household applications, current is often described as being either direct current (DC) or alternating current (AC). These terms refer to how the current varies in time. Direct current, as produced by example from a battery and required by most electronic devices, is a unidirectional flow from the positive part of a circuit to the negative. If, as is most common, this flow is carried by electrons, they will be travelling in the opposite direction. Alternating current is any current that reverses direction repeatedly; almost always this takes the form of a sine wave. Alternating current thus pulses back and forth within a conductor without the charge moving any net distance over time. The time-averaged value of an alternating current is zero, but it delivers energy in first one direction, and then the reverse. Alternating current is affected by electrical properties that are not observed under steady state direct current, such as inductance and capacitance. These properties however can become important when circuitry is subjected to transients, such as when first energized.

Need Of An Energy Generating Floor

All started in 2005 with the name Sustainable Dance Club, and the idea was to realize exactly that – a sustainable dance club. Innovators of sustainability worked together with

architects, to create the concept of a sustainable dance club, including an energy generating dance floor. The company started by offering consultancy service to club owners or festival organizers that want to become more sustainable and at the same time developed the prototypes of its first product: The Sustainable Dance Floor. In September 2008 Club WATT was opened in Rotterdam as the first ecological dance club showcasing the earliest model of the Sustainable Dance Floor (SDF). As Energy Floors has grown as a company, so have its potential markets. The concepts prove to have natural appeal to marketing agencies, science museums, and commercial events and according to our new developments also with fitness centers, public transport companies and many other public spaces. Since 2010, SDC narrowed its focus on the further development of the energy generating floor and selling and renting it combined with Energy Experiences worldwide for exhibitions, parties, fairs, festivals or corporate events. The Sustainable Dance Club took it to the next level and developed a more cost effective, efficient floor for large scale applications: The Sustainable Energy Floor.

The energy generating dance floor is a profitable energy generation plant in places where there is always a public gathering and a lot of footfall is experienced in a small area. The requirement of EGF is for utilizing the energy produced during the human footfall. This will make some parts of the system autonomous in its own power production and reduction in dependency on conventional polluting power sources.

Basic Principles Applied

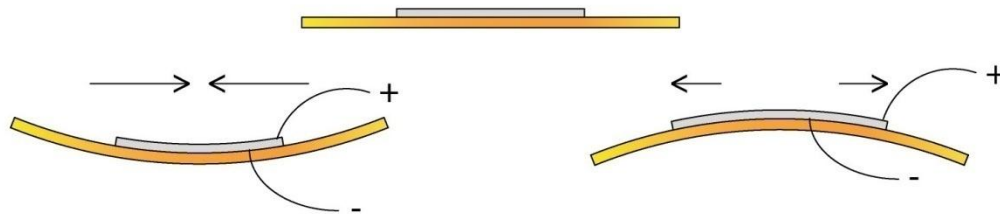
The key principle behind the energy generating floor is the piezoelectric effect shown by metals. When a person walks he puts some pressure on the floor due to his weight and muscle power. The EGF uses this force to generate electricity by utilizing this force for bending the piezoelectric material.

Piezoelectricity is the electric charge that accumulates in certain solid materials (notably crystals, certain ceramics, and biological matter such as bone, DNA and various proteins) in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure. It is derived from the Greek piezo or piezein , which means to squeeze or press, and

electric or electron, which stands for amber, an ancient source of electric charge. This provides a convenient transducer effect between electrical and mechanical oscillations.

The first demonstration of the direct piezoelectric effect was in 1880 by the brothers Pierre Curie and Jacques Curie. They combined their knowledge of piezoelectricity with their understanding of the underlying crystal structures that gave rise to piezoelectricity to predict crystal behavior, and demonstrated the effect using crystals of **tourmaline, quartz, topaz, cane sugar, and Rochelle salt (sodium potassium tartrate tetrahydrate)**. Quartz and Rochelle salt exhibited the most piezoelectricity.

Quartz demonstrates this property and is extremely stable. Quartz crystals are used for watch crystals and for precise frequency reference crystals for radio transmitters. Rochelle salt produces a comparatively large voltage upon compression and was used in early crystal microphones. Barium titanate, lead zirconate, and lead titanate are ceramic materials which exhibit piezoelectricity and are used in ultrasonic transducers as well as microphones. If an electrical oscillation is applied to such ceramic wafers, they will respond with mechanical vibrations which provide the ultrasonic sound source. The standard piezoelectric material for medical imaging processes has been lead zirconate titanate (PZT).. The word piezo is Greek for "push".



Electric Dipole Moment

The nature of the piezoelectric effect is closely related to the occurrence of electric dipole moments in solids. The latter may either be induced for ions on crystal lattice sites with asymmetric charge surroundings (as in BaTiO_3 and PZTs) or may directly be carried by

molecular groups (as in cane sugar). The dipole density or polarization (dimensionality [Cm/m³]) may easily be calculated for crystals by summing up the dipole moments per volume of the crystallographic unit cell. As every dipole is a vector, the dipole density \mathbf{P} is a vector field. Dipoles near each other tend to be aligned in regions called Weiss domains. The domains are usually randomly oriented, but can be aligned using the process of poling (not the same as magnetic poling), a process by which a strong electric field is applied across the material, usually at elevated temperatures. Not all piezoelectric materials can be poled. One with charge $+q$ and one with charge $-q$, the electric dipole moment \mathbf{p} is:

$$\mathbf{p} = q\mathbf{d}$$

Where \mathbf{d} is the displacement vector pointing from the negative charge to the positive charge. Thus, the electric dipole moment vector \mathbf{p} points from the negative charge to the positive charge. An idealization of this two-charge system is the electrical point dipole consisting of two (infinite) charges only infinitesimally separated, but with a finite \mathbf{p} . The SI units are Coulomb-meter (C m).

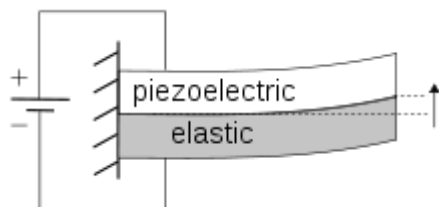
Current Rectification

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-arc valves, solid-state diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches. The simple process of rectification produces a type of DC characterized by pulsating voltages and currents (although still unidirectional). Depending upon the type of end-use, this type of DC current may then be further modified into the type of relatively constant voltage DC characteristically produced by such sources as batteries and solar cells.

Piezoelectric Material

In direct piezoelectric effect stress or strain applied for the piezoelectric material generates a charge on the electrode faces of the component. In vibration based harvesters deformation is produced by vibrating mass of the piezo element itself or external mass or directly transferring deformation of external system into piezoelectric material. The natural stiffness or Young's modulus of the piezoelectric material is relatively high (typically 50-70 GPa) and therefore vibration cannot normally generate required stresses for the material. In order to overcome this problem bending type structures are typically utilized in vibration based harvesters providing extremely compact internal leverage mechanism for the force amplification. One of the commonly used structures is a unimorph type cantilever which was chosen for this research. The component consists of active PZT and passive copper layers where the copper can be substituted with different materials such as post-processed ceramics to enable e.g. embedded and encapsulated structures. In this structure external mass is usually placed at the tip of the cantilever, in order to tune the resonance frequency and to enhance the coupling of the vibration for the piezoelectric material.

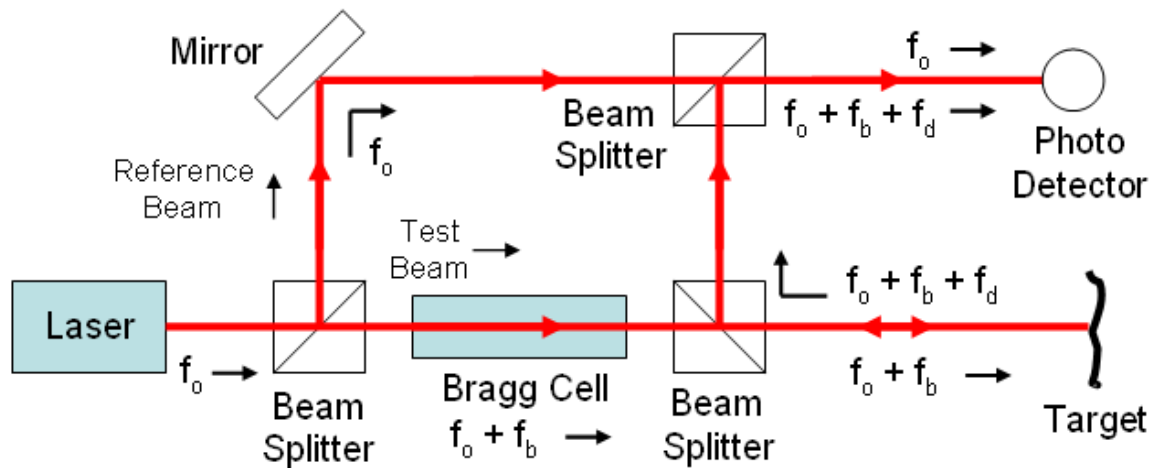
Schematic of the complete energy harvesting system consisting the energy harvester components and requires electronics. The electronics in its simplest form can be a one stage design with a rectifier and the storage capacitor or it can have several stages with switched mode regulators providing controlled output voltage and high voltage energy storage significantly improving efficiency of the harvesting.



Unimorph type cantilever system

Measured piezo components were 25.4 and 33.0 mm long unimorph type cantilevers. The width of the cantilevers varied from .5 mm to .9 mm and the thickness of the active layer was 250 μm . PZT-5H material and copper was used for active and passive layers, respectively. The thickness of the passive layer was 100 μm and external mass was not used in these measurements. The measurement setup, shown in Figure 2 (a), consisted of a differential Doppler shift vibrometer (OFV-5000 , Polytec GmbH, Germany) for the displacement measurements of the energy harvester, a piezo stack actuator for generating the vibration and

energy harvesting electronics based on one stage rectifier with a 1000 μF capacitor. The piezo cantilever was clamped to an aluminum base which was then in turn attached to the piezo stackactuator.



Laser Doppler vibro-meter (LDV)

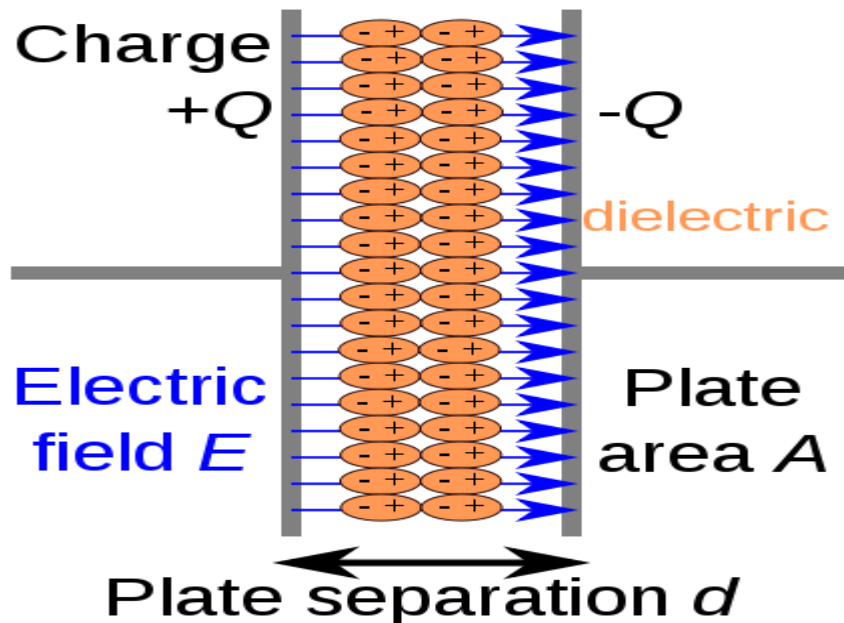
These materials are usually ceramics with a perovskite (a calcium titanium oxide mineral species composed of calcium titanate, with the chemical formula CaTiO_3 .) structure. The perovskite structure exists in two crystallographic forms. Below the Curie temperature they have a tetragonal structure and above the Curie temperature (Curie temperature (T_c), or Curie point, is the temperature where a material's permanent magnetism changes to induced magnetism, or vice versa. The force of magnetism is determined by magnetic moments.) They transform into a cubic structure. In the tetragonal state, each unit cell has an electric dipole, i.e. there is a small charge differential between each end of the unit cell.

A mechanical deformation (such as a compressive force) can decrease the separation between the cations and anions which produces an internal field or voltage.

Crystal classes

Any spatially separated charge will result in an electric field, and therefore an electric potential. Shown here is a standard dielectric in a capacitor. In a piezoelectric device, mechanical stress, instead of an externally applied voltage, causes the charge separation in the individual atoms of the material.

Of the thirty-two crystal classes, twenty-one are non-centrosymmetric (not having a centre of symmetry), and of these, twenty exhibit direct piezoelectricity (the 21st is the cubic class 432). Ten of these represent the polar crystal classes, which show a spontaneous polarization without mechanical stress due to a non-vanishing electric dipole moment associated with their unit cell, and which exhibit pyroelectricity. If the dipole moment can be reversed by the application of an electric field, the material is said to be ferroelectric.



For polar crystals, for which $P \neq 0$ holds without applying a mechanical load, the piezoelectric effect manifests itself by changing the magnitude or the direction of P or both. For the non-polar, but piezoelectric crystals, on the other hand, a polarization P different from zero is

only elicited by applying a mechanical load. For them the stress can be imagined to transform the material from a non-polar crystal class ($P = 0$) to a polar one, having $P \neq 0$.

Key Properties

- The ability to produce a voltage output in response to an applied stress
- The ability to produce a strain output (or deformation) in response to an applied voltage.

Electromechanical equations

The following relationships apply only to small electrical and mechanical amplitudes, i.e. small-signal values.

Only in this region is it possible for polarized piezoelectric ceramics to be described by linear relationships between the mechanical strain (S) or mechanical stress (T) components and the components of the electric field E or the dielectric displacement D. These linear relationships are derived using dielectric, piezoelectric and elasticity “constants”. Because they depend on the anisotropy of the piezoelectric material, these physical quantities can only be defined in terms of tensors which reflect the directionality of the electric field, the mechanical stresses, etc.

In simplified form, the basic relationships between the electrical and elastic properties (for a static or quasistatic application) can be represented as follows

$$\begin{aligned} \mathbf{D} &= \mathbf{d} * \mathbf{T} + \boldsymbol{\varepsilon}^T * \mathbf{E} \\ \mathbf{S} &= \mathbf{s}^E * \mathbf{T} + \mathbf{d} * \mathbf{E} \end{aligned}$$

where:

- **D** dielectric displacement
- **T** mechanical stress
- **E** electric field
- **S** mechanical strain

- d piezoelectric charge constant
- ϵ^T permittivity (for $T = \text{constant}$)
- s^E elasticity constant ($E = \text{constant}$)

The piezoelectric constants relating the electric field E , the dielectric displacement D , the mechanical stress T and the strain S require directionality indexing. Analogous to crystallographic descriptions for piezo-ferroelectric ceramics, the polarization vector is usually set parallel to the z or 3rd axis of a right handed Cartesian coordinate system.

The directional parameters are given the subscripts 1,2 and 3 corresponding to the directions of x , y and z , respectively. Mechanical shear stresses (couples) about x , y and z , and the corresponding shear strains, are designated with the subscripts 4, 5 and 6, respectively.

The strain-charge for a material of the 4mm (C_{4v}) crystal class (such as a poled piezoelectric ceramic such as tetragonal PZT or BaTiO_3) as well as the 6mm crystal class may also be written as (ANSI IEEE 176):

$$\begin{bmatrix} S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \end{bmatrix} = \begin{bmatrix} s_{11}^E & s_{12}^E & s_{13}^E & 0 & 0 & 0 \\ s_{21}^E & s_{22}^E & s_{23}^E & 0 & 0 & 0 \\ s_{31}^E & s_{32}^E & s_{33}^E & 0 & 0 & 0 \\ 0 & 0 & 0 & s_{44}^E & 0 & 0 \\ 0 & 0 & 0 & 0 & s_{55}^E & 0 \\ 0 & 0 & 0 & 0 & 0 & s_{66}^E = 2(s_{11}^E - s_{12}^E) \end{bmatrix} \begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \\ T_5 \\ T_6 \end{bmatrix} + \begin{bmatrix} 0 & 0 & d_{31} \\ 0 & 0 & d_{32} \\ 0 & 0 & d_{33} \\ 0 & d_{24} & 0 \\ d_{15} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \end{bmatrix}$$

$$\begin{bmatrix} D_1 \\ D_2 \\ D_3 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & d_{15} & 0 \\ 0 & 0 & 0 & d_{24} & 0 & 0 \\ d_{31} & d_{32} & d_{33} & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \\ T_5 \\ T_6 \end{bmatrix} + \begin{bmatrix} \epsilon_{11} & 0 & 0 \\ 0 & \epsilon_{22} & 0 \\ 0 & 0 & \epsilon_{33} \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \end{bmatrix}$$

Where the first equation represents the relationship for the converse piezoelectric effect and the latter for the direct piezoelectric effect.

Although the above equations are the most used form in literature, some comments about the notation are necessary. Generally D and E are vectors, that is, Cartesian tensor of rank-1; and permittivity ϵ is Cartesian tensor of rank 2. Strain and stress are, in principle, also rank-2 tensors. But conventionally, because strain and stress are all symmetric tensors, the subscript of strain and stress can be re-labeled in the following fashion: 11 \rightarrow 1; 22 \rightarrow 2; 33 \rightarrow 3; 23 \rightarrow 4; 13 \rightarrow 5; 12 \rightarrow 6. (Different convention may be used by different authors in literature. Say, some use 12 \rightarrow 4; 23 \rightarrow 5; 31 \rightarrow 6 instead.) That is why S and T appear to have the "vector form" of 6 components. Consequently, s appears to be a 6 by 6 matrix instead of rank-4 tensor.

In total, there are 4 piezoelectric coefficients, d_{ij} , e_{ij} , g_{ij} , and h_{ij} defined as follows:

$$d_{ij} = \left(\frac{\partial D_i}{\partial T_j} \right)^E = \left(\frac{\partial S_j}{\partial E_i} \right)^T$$

$$e_{ij} = \left(\frac{\partial D_i}{\partial S_j} \right)^E = - \left(\frac{\partial T_j}{\partial E_i} \right)^S$$

$$g_{ij} = - \left(\frac{\partial E_i}{\partial T_j} \right)^D = \left(\frac{\partial S_j}{\partial D_i} \right)^T$$

$$h_{ij} = - \left(\frac{\partial E_i}{\partial S_j} \right)^D = - \left(\frac{\partial T_j}{\partial D_i} \right)^S$$

where the first set of 4 terms correspond to the direct piezoelectric effect and the second set of 4 terms correspond to the converse piezoelectric effect. A formalism has been worked out for those piezoelectric crystals, for which the polarization is of the crystal-field induced type, that allows for the calculation of piezo electrical coefficients d_{ij} from electrostatic lattice constants or

higher-order Madelung constants. The various properties of lead zirconate titanate can be easily available on the internet.

Materials	Piezoelectric Constant $\times 10^{-12} \text{ m/V}$
Quartz	2.3
Barium titanate	100-149
Lead niobate	80-85
Lead zirconate titanate	250-365

Working Methodology

For energy generation through piezoelectricity piezoelectric crystals made of PZT are arranged in a grid on the floor. The unique piezoelectric and converse piezoelectric properties of crystalline PZT allow us to design an electro-mechanical device. By operating the device at its mechanical resonance frequency, we can get a useful electrical output out of it. The active element is the heart of the transducer as it converts the stress due to weight to electricity. The active element is basically a piece of polarized material (i.e. some parts of the molecule are positively charged, while other parts of the molecule are negatively charged) with electrodes attached to two of opposite faces. As the major aim of making the Electricity generating floor is to utilize the stress from human foot fall and generate electricity the mechanical stress due to human weight is considered as the input power and the electricity generated through it is the output.

Apparatus Used:

- **Power plant**
 1. Piezoelectric crystal (Dia 28mm)

2. Enamel coated copper wire (35 & 34 gauge)
3. Wood ply board (350*350*12mm and 2*(170*170*12mm))
4. Solder iron and solder wire (grade-60-40)
5. Paper sheet (80gsm)
6. Scotch box sealing tape
7. Cardboard (3mm thickness)
- **Control and display panel**
 1. 6 white LEDs (3v 10mA)
 2. Plywood Panel (160*60*5mm)
 3. 1000 μ F 10v electrolytic capacitor
 4. 1N4148 signal diode
 5. SPDT switch
 6. SPST switch
 7. Voltmeter
 8. Connecting wires
 9. Terminal Connection male and female plugs



Piezoelectric Crystal Using Lead Zirconate Titanate (Pzt)

Making Of Power Plant

For making an electricity generating floor the piezoelectric crystals are arranged in pack of 60 crystals in a square plane in grid formation.



The plywood measuring 350*350*12mm is used as a base for the floor from the center 240*240mm square part is used for placing the crystal grid. Paper Ribs measuring 240*12*1mm

are placed in the square 15mm apart parallel to each other. The end of the paper ribs are fixed to the ply board using scotch tape. This placement will create 15mm slots between the paper ribs and as the ribs are attached end to end via tape there is an air gap between the ply board and the paper rib. The air gap is variable from center of the square to the sides. On these slots the piezoelectric crystals are placed with the PZT surface above and copper plate resting on the paper ribs. Crystals are fixed by their one side only by scotch tape and the other side is just let to rest on the paper rib. Each crystal when stressed at the center and deflected up to 1 mm from its resting plane generates 15- 18v and .8- 1 mAmp. So to light up 6 LEDs 60 crystal should be connected parallel to each other so that the amount of current generated is multiplied 60 times and voltage is uniform. Using solder iron and solder wire all 60 crystals are connected in parallel connection. The power output line made of 34 gauge wire is connected to the female connector and the connector is fixed to the base on the corner. Card board ribs measuring 240*10*3mm with a paper rib measuring 240*10*1mm fixed at the bottom is fixed with the paper rib touching the PZT layer. This rib is fixed to transfer stress due human foot fall to the crystal for straining it 1mm. when a 60kg person steps on the EGF then he puts a stress of 588N force on the floor. Stress applied on each crystal is 9.8N and the crystal is deflected up to 1mm. Two ply board pads measuring 17.5*17*12mm are placed on the cardboard ribs these as the force distributors. Triangular pocket are made on the force distribution pads and pads of same size are extruded on the base plate for fixing the pads to their respective position.

Control And Display Panel



Control and display panel

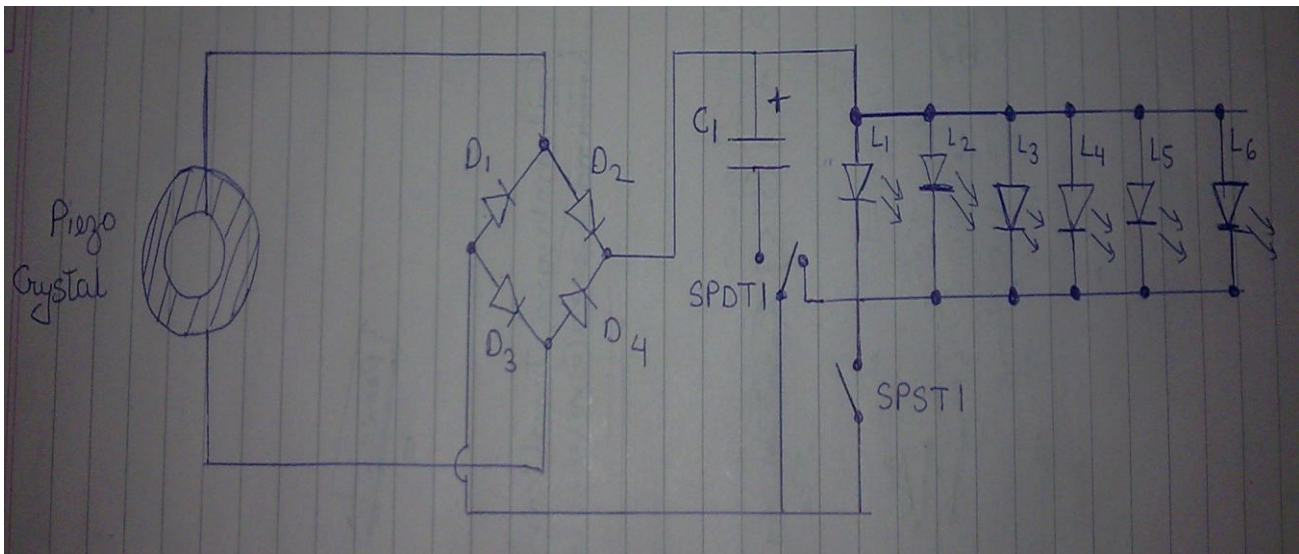
The control and display panel takes the electric output from the EGF power plant and displays it in form of electricity and voltage variation on a voltmeter

The panel consists of 6 white LEDs connected in parallel connection which will consume 2.4-3v and 60mA electricity to glow. Electricity from the EGF comes in form of alternating current and since LED work on DC current a full wave bridge rectifier circuit is applied to convert AC to DC current. The bridge circuit consists of 4 1N4148 signal diodes. These diodes are used for rectification of electricity up to 150mA, 500mW. The control and display panel consists of 2 modes which could be activated by a SPDT slide Switch. The 2 modes are as follows:

- a) Direct Display on LED mode

- b) Storage of power in a capacitor and releasing it when required.

In the direct display mode the power plant is connected directly to the display LEDs and thus the LEDs light up immediately when they get power. This mode is applicable when ample amount of footfall is available to light the LEDs continuously.



When electricity is to be stored for some specific occasions the electricity generated by the footfall power display standby time could be stored in a 1000 μ F 10v capacitor for some time so that when the foot fall available to light the LEDs is less the capacitor could fill the requirement of electricity. The push button when applied releases the power and the LEDs glow on. A voltmeter socket is provided to know the amount of voltage stored in the capacitor. The formula for calculating the charge stored in the capacitor is as follows:

$$C = \frac{q}{v}$$

$$C = \frac{dq}{dv}$$

$$I(t) = \frac{dQ(t)}{dt} = C \frac{dV(t)}{dt}$$

Where, C= capacitance

q = charge

v = voltage

I(t) = current value at a specific time

When 2.4v is stored in the capacitor it will be able to light up the display LEDs.

Generating Potential

To create electricity, the **EGF** will compress up to 1mm when being stepped on. Because of the air gap and one free end of the piezo crystal it will be able to vibrate freely when stress is released. As a result efficient power generation occurs. This small compression is enough to activate the internal generator of that module producing up to 5 -7 Watts of sustained output per module. The floor is a scalable product made up of modules measuring 350*350*12mm. This system allows for the floor to be set up in a huge range of possible sizes, shapes and designs. The dance floor experience can be custom designed for clients.

The **EGF** is the world's most efficient converter of human footfall into electrical energy with an efficiency of 50%. It is a big enhancement to the dance floor, which had provided us with unique experiences and knowledge of harnessing energy from footsteps. The Sustainable Energy Floor is a more cost effective, efficient floor for large scale applications. .5 Watts per step can be produced by only a very small vertical movement. That means less effort is needed (walking is enough) to create energy. This is the main difference. The tiles are smaller (50cmx50cm) and easier to install. The surface can be customized with light effect, logos, colors, materials.

In India where 2 largest human population of the Earth lives the EGF will be a huge power source. EGFs will produce a lot of current and will recover their installation cost very

soon. In comparison to other countries EF would be successful in India as the input footfall available for power generation is more than anywhere else. A 240*240mm PZT based square grid could generate 1.08w power than by using quartz for power generation and provided ample amount of vibration a power plant ranging 1MW-10MW could be established which could power adjoining areas. The mechanism promises a stable any reliable power source and could be started as a micro power plant any eventually progressed to mega power plant.

APPLICATIONS

The EGF just seeks power to vibrate the piezoelectric materials thus could hold a wide range of areas for its installation. The EGF could be installed in the following places:

1. Railway stations
2. Shopping mall
3. Dance clubs
4. Canteens
5. Footpaths
6. Foot wears sols equipped with piezoelectric pads
7. Gymnasiums
8. Dockyards
9. Gym machinery
10. Places facing vibrations e.g. vehicles

Future Advancements Possible

The whole future of the EGF depends on the material being used for power generation. With the beginning of the era of nano-technology more compact and efficient material could be introduced to produce large amount of electricity. Cheap and highly piezoelectric material would increase the power output. A floor made directly from the piezoelectric material would be more

inexpensive and efficient as force could be directly absorbed by it. Experiment have been run to make EGF a primary source of electricity in public places t o reduce dependency on conventional sources of energy. The floor with minimum deflection and maximum output is being researched for improvement of EGF The mechanism of energy generating floor is further modified for efficiency then it could make places with high public existence autonomous in terms of electricity requirements. Hard piezoelectric material could be used for power generation on roads on which heavy vehicles move. In few decades with the improvement of the EGF no public place will get a power cut when people walking and working around.

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