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Electric Footprint

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***Abstract*: We live in a world marred by pollution. Every day, the hazardous effects of fossil fuels and other bio-hazardous energy sources continue to upset our ecosystems and harm the biosphere. We must find cleaner, more sustainable sources of power. As such, we have tapped into other sources of renewable energy through the use of solar panels, hydroelectric dams and wind turbines, to name a few. However, there is one potential provider of energy that we have yet to fully explore: the human body. The unused kinetic force generated by a human being can be converted into storable electricity. Individually, this may be but a drop in the ocean compared to the vast amount of electricity generated from other devices. But, with enough participants, it can become significant enough to displace the use of harmful fuels in many public locations. This goal forms the basis of the project.**

***Keywords*: Application, Battery, Electric energy, Footstep, piezoelectric crystal, Power storage, Raspberry pi, Sustainable power generation.**

1. Introduction

The convenience of electricity as a mode of energy exchange has resulted in it being adapted to a number of uses. Electricity is generated by turning or rotation of turbines. These turbines are rotated by means like coal, steam, nuclear energy, renewable energy such as solar energy, etc. In most power plants, turbines are rotated by the pressure of steam or by the force of running water downstream through a dam. The accelerated use of conventional sources like coal, fossil fuels, etc. to generate any form of energy is leading to its depletion. There are a number of methods by which electricity can be produced, out of such methods footstep energy generation can be an effective method to generate electricity. Walking is one of the most common activities in our daily life. When a person walks, energy is lost to the road surface in the form of impact, vibration, sound, etc. This energy can be tapped and converted into a usable form, such as electrical energy. This device, when embedded in the footpath, can convert the energy exerted by out feet into electrical form. The non-conventional energy system is very essential at this time to our world. Pedal power creates storable power, which can be applied to a wide range of jobs and is a simple, cheap, and convenient source of energy. The use of inconvenient sources like the cost inefficient wind turbines or environmental hazards like fossil fuels causes problems when considering small scale demands for electricity. There is a need for a replenishable, inexpensive source of clean energy. As such, unconventional sources of power must be tapped, such as the kinetic energy created by human footsteps. In this project, we would generate non-conventional electrical power by simply walking or running on the given platform.

2. Literature Review

It is observed that major systems have failed to provide the end product for their system. Footstep power generation runs on a combination of mechanical and electrical parts, in which any loss of energy is negligible. The voltage generated by Piezoelectric crystals is then given to a Unidirectional Diode. This enhanced voltage is passed to a Super Capacitor which uses it to charge the battery [1]. Any electricity produced is stored in a LA battery, which supplies local appliances like bulbs and fans with energy. An Arduino board uses a Bluetooth Module to wirelessly control the bulb & fan. The pressure applied on piezoelectric crystals are used to create electricity. Then, using Bluetooth and Arduino board loads, the fan and bulb are controlled [2]. Proposal for the employment and application of extravagant energy in the feet of humans is very much to the purpose for extremely populated nations like China and India. The physical foot interface is placed on chain sprocket arrangement and spring which is connected to the piezoelectric sensors. The sensors generate AC voltage which can be converted to DC supply. The AC output power will be used in running of load [3]. Man's need for energy to sustain himself has rapidly increased over the ages. Due to the pressure, the iron plate moves, which in turn drives gears which generates rotational motion which is then converted to linear motion using a crank shaft. Crank Shaft moves in "TO AND FRO" motion with magnet which generates AC current [4]. Small mats, in which the crystals are embedded, are combined to form larger variants. These mats can be installed in schools, markets, temples, etc. and thus the electrical energy is utilized when the pressure is applied on piezoelectric crystals, this pressure is then converted into voltage. This voltage is fed into the amplifier and then to the bridge rectifier using Schottky diode for converting pulsating DC signal into continuous form. A capacitor is used to remove ripples from the DC currents [5].

The conversion of energy that is exhausted and wasted while walking or running. This energy is converted into electrical energy. This is the latest trend in electrical power generation and it is achieved by converting human's kinetic energy. The pressure applied on piezoelectric crystals generates AC voltage which is converted into DC voltage [6]. In the world of modern technology, newer sources of energy and new methods of power generation are two important areas of interest for researchers and engineers. A piezoelectric sensor based costly product is available in some developed countries only. The lost kinetic energy is converted to electrical energy. The design consists of a top plane made up of iron on to which the force of footsteps is exerted. Below the top place helical springs are used. A rack and pinion arrangement is attached along with the top plane which converts the mechanical force into rotational force. [7]. In many systems, the power stored in the capacitor gets directly supplied to the output. However, use of user controls allows the directed utilization of electricity. The hardware set up is done for a limited number of crystals. Therefore, arrangement will be done in such a way that the hardware will also be shared.

3. Materials and Method

We have designed a prototype tile structure which can be installed in various high for traffic areas to harness the kinetic energy of footsteps and convert into electrical energy. We have used following materials or equipment to build our prototype:

Soldered piezoelectric crystal Rectifier Capacitor LED Raspberry Pi (we used 3b version of Pi) Cardboard Jumper wires.

A. Modular Diagram

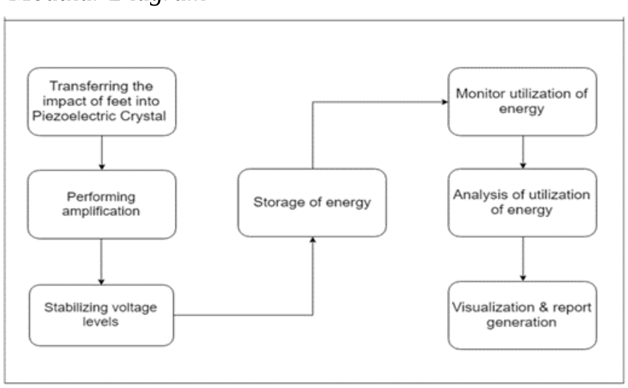

Fig. 1. Modules of our system

Kinetic energy is captured from footsteps where piezoelectric tiles are installed. This energy can then be used to offset some of the power used to operate lighting systems. The electric energy generated by the crystal will be converted into a usable form i.e. by performing amplification, by stabilizing the voltage levels, etc. Once the electric energy is transformed to a convenient form, it is stored in capacitors/batteries to use when and wherever required. Raspberry pi is then connected to the battery which will be used to draw a controlled amount of current and voltage to the user's low powered devices and appliances. After building the required hardware we can implement is electric energy monitoring software which can be an application to monitor the amount of electrical power generated with each unit of hardware equipment. Along with monitoring, users can apply the stored electrical energy in running small household appliances from the application as shown in fig. 1.

B. Tile Design and Crystal Arrangement

Tile in our system is the unit of measurement for various parameters based on which the overall output is predicted. Tile includes the design and crystal arrangement in single tile and various components connected with each other. To occupy the entire room grid of tiles can be connected to produce to desirable voltage output. So each tile should be designed to easily cover the room with less possibilities of gaps and errors. So, we decided to build a triangular tile which contains two layers of three crystals in parallel and these layers are connected in series with the circuit. Figure 2 shows the diagrammatic implementation of our tile. The readings of output voltage generated by this model of lower tile is taken and shown in table 1 and table 2. Hence the overall output would be double because the upper tile will also generate the same output and since both tiles are connected in series the voltage adds up and outputs to the circuit. We modelled this using cardboard but in real life it will be manufactured using polycarbonate material which gives strength to withstand heavy weight on it.

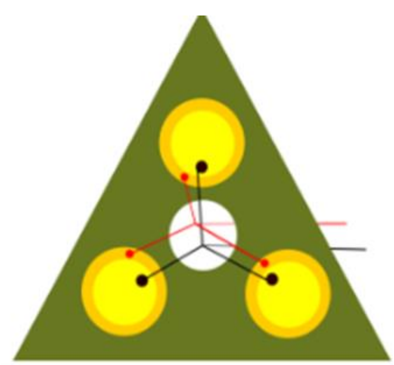

Fig. 2. Crystal arrangement and tile design

C. Circuit Design

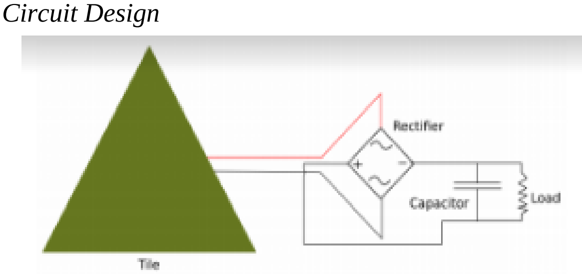

Fig. 3. Tile circuit diagram

D. Raspberry Pi Connection

The energy stored is connected to raspberry pi pins which can control the power drawn from the battery. So, here raspberry pi acts as a switch between load and battery. The value of the switch can be controlled by the application on smartphones which we developed and tested on android.

E. Application Design

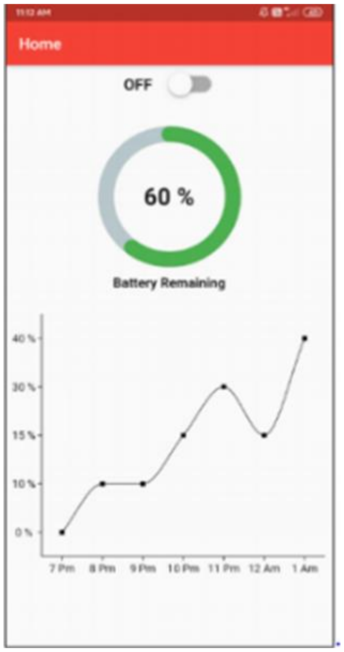

Fig. 4. Application UI - switched off

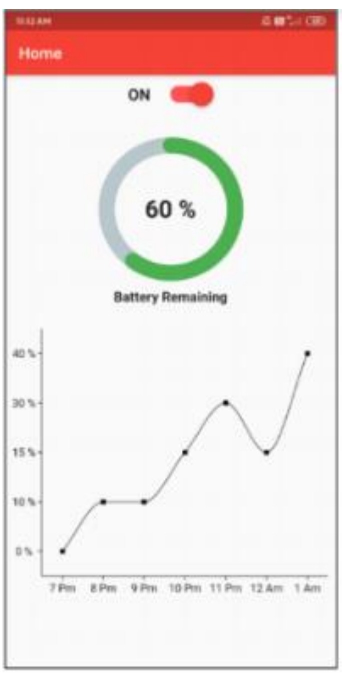

Fig. 5. Application UI - switched on

We developed an android application which as far as now just has a toggle button to function as a switch but later it can be used to monitor or analyse the power drawn from the battery and can control the usage of electricity. Fig. 4 & 5 shows the UI of our application which consists of a toggle button, battery indicator and battery usage graph for present day with battery percentage on y-axis and time on x-axis. In Fig. 4, the toggle button is switched off which indicates no current is drawn from battery, hence load connected to the battery is switched off. While in Fig. 5, the toggle button is switched on, which allows the battery to draw current towards the load connected to it, hence load utilizes the energy stored in the battery.

The circuit consists of a rectifier which converts the AC current of crystals to DC and capacitor which acts as a storage device for a tile as shown in fig. 3. Here we tested on a single tile hence we kept a capacitor but in real cases where many tiles are connected with each other output would be sufficient to charge a 12V battery.

F. Communication between Application and Pi

Raspberry Pi stores the power values from battery to cloud database, these values are read by our application using the internet and displays the user's remaining power on battery. When the application toggles the button on the signal reaches to raspberry by using cloud messaging and it closes the circuit for load with battery.

4. Results and Discussion

We have taken results based on two types of loads - medium load and heavy load.

A. Medium Load

In medium load test results, we applied a variety of weight less than 6 kg which in turn generated a max Voltage of 30 volt. We observed two factors, *weight applied and voltage generated* with time. The other columns we have derived from the two we observed. Here are the results we found out:

Table 1
Medium Load Results

Time (second)	Weight (kg)	Voltage (volt)	Change of Weight (kg)	Change of Voltage (volt)
0	0	0	-	-
0.5	0.08	16.5	0.08	16.5
1	0.94	1.8	0.86	14.7
1.5	2.24	24.7	1.3	22.9
2	4.32	19.4	2.08	5.3
2.5	5.24	12.3	0.92	7.1
3	0.8	30	4.44	17.7
3.5	0	8.9	0.8	21.1
4	0	3.3	0	5.6
4.5	0	1.2	0	2.1
5	0	0.7	0	0.5
5.5	0	0.5	0	0.2
6	0.06	0.4	0.06	0.1
6.5	0	0.3	0.06	0.1
7	0	0.1	0	0.2
7.5	0.1	0.1	0.1	0
8	0	0	0.1	0.1
8.5	0	0	0	0

From the above results we got, we inferred conclusion from the following graphs drawn:

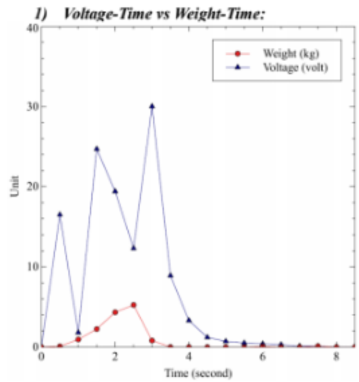

Fig. 6. Medium load line graph indication the change in voltage with weight

In above Fig. 6, x-axis represents time and y-axis represents two factors we observed i.e. weight applied in (Kg) and voltage generated in (V) for medium load.

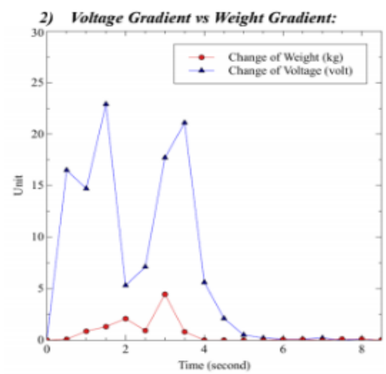

Fig. 7. Medium load line graph indication the change in voltage with change in weight

In above Fig. 7, x-axis represents time and y-axis represents two factors we derived from observed i.e. change of weight applied in (Kg) and change of voltage generated in (V) for medium load.

B. Heavy load

In Heavy load test results, we applied a variety of weight less than 30 kg which in turn generated a max Voltage of 15 volt. Here are the readings we found out:

From table 2, results we got, we inferred conclusion from the following graphs drawn:

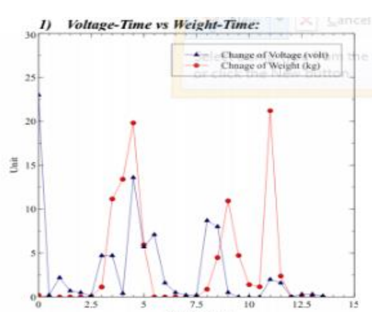

Fig. 8. Heavy load line graph indication the change in voltage with weight

In above Fig. 8, x-axis represents time and y-axis represents two factors we observed i.e. weight applied in (Kg) and Voltage generated in (V) for high load.

Table 2
Heavy load results

Time (second)	Weight (kg)	Voltage (volt)	Change of Weight (kg)	Change of Voltage (volt)
0	0	0	-	-
0.5	0.06	0.5	0.06	0.5
1	1.2	5.2	1.14	4.7
1.5	12.36	0.5	11.16	4.7
2	25.76	0.9	13.4	0.4
2.5	5.94	14.5	19.82	13.6
3	0	8.8	5.94	5.7
3.5	0	1.7	0	7.1
4	0	0.1	0	1.6
4.5	0	0.6	0	0.5
5	0	0.4	0	0.2
5.5	0	0.2	0	0.2
6	0.88	8.9	0.88	8.7
6.5	5.36	0.9	4.48	8
7	16.3	0.4	10.94	0.5
7.5	21.02	0.4	4.72	0
8	22.42	0.4	1.4	0
8.5	23.58	0.4	1.16	0
9	2.38	2.4	21.2	2
9.5	0	0.8	2.38	1.6
10	0	0.8	0	0
10.5	0	0.5	0	0.3
11	0	0.2	0	0.3
11.5	0	0.1	0	0.1
12	0	0.1	0	0

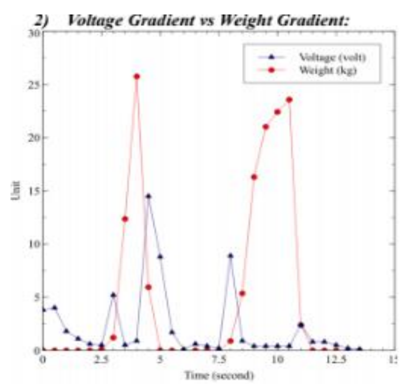

Fig. 9. Heavy load line graph indication the change in voltage with change in weight

In above fig. 9, x-axis represents time and y-axis represents two factors we derived from observed i.e. change of weight applied in (Kg) and change of voltage generated in (V) for high load. While comparing both test results from Fig. 6, 7, 8 & 9, we infer that high weight does not generate high voltage but the high rate of change of weight does as seen in the graphical plot of results.

5. Formulation

Output voltage of a piezoelectric crystal can be calculated by using the below formula [14],

$$V_o = P.g.h \quad (1)$$

Where V_o is the output voltage, P is the pressure applied, g is the acceleration due to gravity, h is the height of the crystal.

We have verified this formula with our results shown in our table 1 and 2.

6. Conclusion

The increase in the population of the country and the requirement of the power for daily activities is increasing with the course of time. Cleaner and more sustainable forms of electrical power are needed in order to keep costs lower and to ensure a healthier environment for future generations. Due to the widespread use of portable electronic devices, and the consequent increase in energy consumption, harvesting alternative renewable energy found in our environments has become the need of the hour. The global motive is to develop a product which can be easily integrated into common man's life in a cost-effective manner. The use of inconvenient sources like the cost-inefficient wind turbines or environmental hazards like fossil fuels causes problems when considering small scale demands for electricity. There is a need for a replenishable, inexpensive source of clean energy. As such, unconventional sources of power must be tapped, such as the kinetic energy created by human footsteps. While one unit would be sufficient to power a minor appliance, multiple instalments in the floor of a building or room would be able to power a wider array of devices.

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