Advanced Research in Electrical and Electronic Engineering
p-ISSN: 2349-5804; e-ISSN: 2349-5812 Volume 4, Issue 2 April-June, 2017, pp. 66-70

http://www.krishisanskriti.org/Publication.html

Wireless Battery Charging Equipment using Piezoelectric Sensors

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Abstract—*The humans have used energy at an increasing rate for their sustainance and well being ever since he came on the earth millions of years ago. Due to this a lot of energy sources have been exhausted and wasted.This paper proposes the utilization of the human locomotory energy which is goes a waste. The energy of foot power due to the walking, jumping or running is very much relevant and important in highly populated countries like India. The paper illustrates the Design and implementation of energy harvesting system by converting energy due to human locomotion to usable form . It describes the method of charging an electronic gadget by generating the electrical voltage from the array of piezoelectric sensors fixed to the sole of the footwear.*

1. INTRODUCTION

The interest in the research and development of advanced smart phone technology has been increasing especially in the recent years. As the technology grew so did the problems associated with it, the fast battery drainage being the one among those. Now, imagine your phone getting charged where ever you go. This is possible by Piezo electric wireless power transfer mobile charging technique. The keys to this technique are the piezoelectricity and Wireless power transfer (WTP).

Harvesting mechanical energy from human motion is an approach for obtaining clean and sustainable electric energy [1]. The electrical energy which is produced from mechanical pressure (such as walking, running, jumping). When pressure is applied to the piezoelectric crystal, a negative charge is produced on the expanded side and a positive charge on the compressed side. The electrical current flows across the material,when the pressure is relieved.In wireless energy transmission, the transmission of electrical energy takes place from a Power source (piezoelectric power generator) or a storage rechargeable battery to a load(such as any electrical device) without any physical connector such as wires or conductors.

Thus, the energy is harvested from the human movements and is transmitted wirelessly thorough wireless power transfer technique and is used to charge the mobile battery.

2. PIEZOELECTRIC GENERATOR

In piezoelectricity there are two effects : direct piezoelectric effect and converse piezoelectric effect. the generation of electric charge takes place when mechanical strain is applied on piezoelectric materials in the direct piezoelectric effect; whereas in the converse effect the deformation in the crystal is caused when an electrical voltage is applied to the piezoelectric materials. Direct piezoelectric effect is employed in manufacturing sensors and converse piezoelectric effect is employed in manufacturing actuators. The piezoelectric materials are both natural and artificially made. Quartz is a natural piezoelectric material while Lead Zirconate Titanate (PZT) is an artificial piezoelectric material.The following equations describes direct piezoelectric effect(3) and its converse effect (4) where, D denotes electric displacement vector, T denotes stress vector

$$D = d.T + T.E \qquad (3)$$

$$S = sE.T + dt.E \qquad (4)$$

ƐT denotes dielectric permittivity at constant mechanical stress, sE denotes the matrix for compliance coefficients at constant electric field, S denotes strain vector, d denotes piezoelectric constant matrix, E denotes electric field vector.

In piezoelectric effect, charge density is developed on

its surface when external pressure is applied.

Where, D is the charge density, Q is the electric charge

$$D = Q/A \qquad (5)$$

that is accumulated on the surface, A is the area of the

conductive electrode.

Table 1 shows the comparison of energy storage density

between the three generators.

Thus we can see from the Table 1 that piezoelectric has more energy storage density when compared with the other techniques. PZT piezoelectric sensor can be used for small scale energy harvesting because of its high energy storage density.

Table 1. Energy storage density comparison

Energyharvester Working	Energy Storage Density
Principle	(mJ/cm3)
Electromagnetic	24.8
Electrostatic	4
Piezoelectric	35.4

Piezoelectric Sensor

It converts the mechanical stress to electrical voltage.
When the mechanical stress is applied onto the sensor, electrical charge is accumulated on the crystal surface that can be extracted using a wire. Piezoelectric sensor can be considered as an electrical equivalent of combination of resistance R, capacitance C and an alternating current source I connected in parallel as shown in Figure 1.

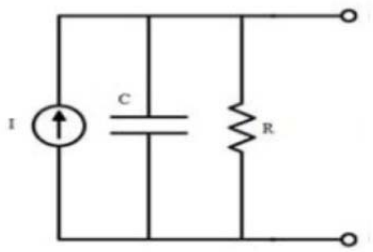

Figure 1. Electrical model of piezoelectric sensor.

The sensor used in this work is made of piezoceramic material Lead Zirconate Titanate (PZT). It is circular in

shape which fits comfortably into the sole of the footwear

and it is commercially available at low cost.

In this work, eight piezoelectric sensors are connected

in parallel that are fitted in to the sole of the footwear.

During jogging and jumping, mechanical stress that is applied on the sole of the footwear is converted to electrical voltage which is given to the electronic gadget

(Figure 3). A human while walking exerts about 30W

of power on the ground and theoretically out of which

100mW of electrical power is possible to obtain without

disturbing the comfort of the person's walk.

3. DESIGN

The Design consists of three units :

Generation unit, storage unit and transmission-receiver unit. The Generation- storage unit side consists of the Piezo electric generator, capacitance bank/rechargeable battery (storage unit). This unit is integrated inside the shoe. Fig. 3 shows the design of the system.

Transmitter-Receiver unit consists of capacitance

bank, rectification circuit and charging circuit.The receiver receives the power and this power is converted to DC supply using a rectification process and the output is fed to a battery of a device (mobile) through the charging circuit. Also there is comparator circuit which indicates the percentage level of charging of the rechargeable battery storage.

3.1 Piezoelectric Generator Design

The Piezo electric generator is an array of eight piezoelectric sensors (PZT) placed in parallel connection over the sole of the shoe.

In a shoe the pressure exerted is maximum at the the heel and the toe, the exact place where the piezo electric unit is placed. Fig.3 shows the arrangement of the piezoelectric generator inside a shoe.

The receiving and charging side collects intermittent or continuous energy input from the piezo generator and efficiently stores their energy in the three rechargeable batteries, each of 4V or the capacitance bank.

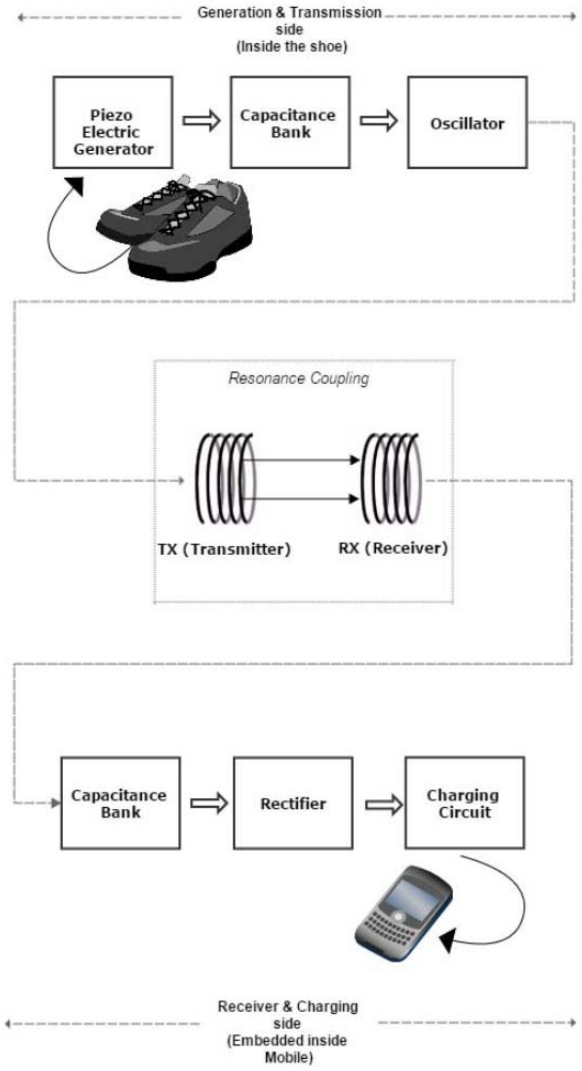

Fig.2. Block diagram of Piezo electric wireless power transfer mobile charging technique.

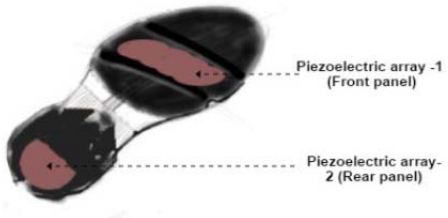

Fig.3. Arrangement of piezoelectric sensors in the piezoelectric generator in the shoe sole.

Wireless Power Transfer

The Wireless power supply allows portable and even non-portable applications. They reduce installation costs by eliminating wiring and this feature is particularly important where sources of wired power are not locally available.In recent years, there has been increasing interest in research and development of wireless power technology to eliminate the "last cable" afterWi-Fi becoming widely accepted [4]. Wireless electricity technique used here is based on strong coupling between electromagnetic coils to transfer energy wirelessly between them. Basically, it involves two coils: a transmitter and a receiver coil. The transmitter coil is powered by an Ac current to produce a magnetic field, which in turn induces a voltage in the receiver coil.

The basics of WPT involve the inductive energy transmission from a transmitter to a receiver through an oscillating magnetic field. To get this DC current, that is supplied by a power source, it is converted into high –frequency AC current by the specially designed electronics built into the transmitter.

In the transmitter section, the AC current boosts a copper wire, which generates a magnetic field. Once a receiver coil is placed within the close vicinity of the magnetic field, the field can induce an AC current in the receiving coil. The electrons in the receiving device, then converts the AC current back into DC current, which becomes utilizable power.

Methods of wireless transmission

i.Transformer Coupling or Induction Energy

The energy transfer takes place between two coils through magnetic fields. However in this technique, distance between two coils should be very small (few centimeters). The principle of mutual induction between two coils can be used to transfer electrical energy without using wires. The best demonstration of how mutual induction works would be the transformer, where there isn't a physical contact between primary plus the secondary coils. The transfer of energy develops due to electromagnetic coupling therby relating the two coils.

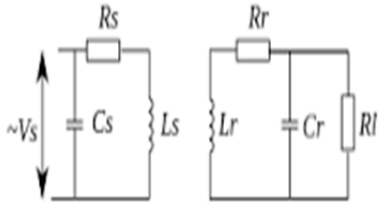

Fig 4. Inductive coupling

ii. Resonant Induction Coupling / Evanescent

Wave Coupling Researchers at MIT have discovered an alternative way of wirelessly transferring power using non-radiative electromagnetic energy resonant tunneling. Since electromagnetic waves would tunnel, they won't propagate

through the air for being absorbed or wasted, and wouldn't normally disrupt electronics or cause injuries like microwave or radio transmission. Researchers anticipate around 5 meters of range. According to them, an electro-magnetic wave in a very high angular waveguide is called as evanescent waves which carry no energy, when if a proper resonant waveguide is brought at the transmitter then the tunnel is formed towards power drawing waveguide and this can be converted in DC using rectifier circuits. A prototype model is achieved with 5 meters of ranges using this method.

iii.Radio/Microwave Energy Transfer

It is possible to achieve a long range using this method. In this method, microwave is sent to the long distances which are received through rectenna. Rectenna extracts microwave energy back to electrical energy. The main problem with this particular strategy is how the diameter of antenna needs to be in order of kilometer. Power transmission via radio waves can be produced more directional, allowing longer distance power beaming, with shorter wavelengths of electromagnetic radiation, conversion efficiencies exceeding 95% are actually realized.

4. CIRCUIT DESIGN

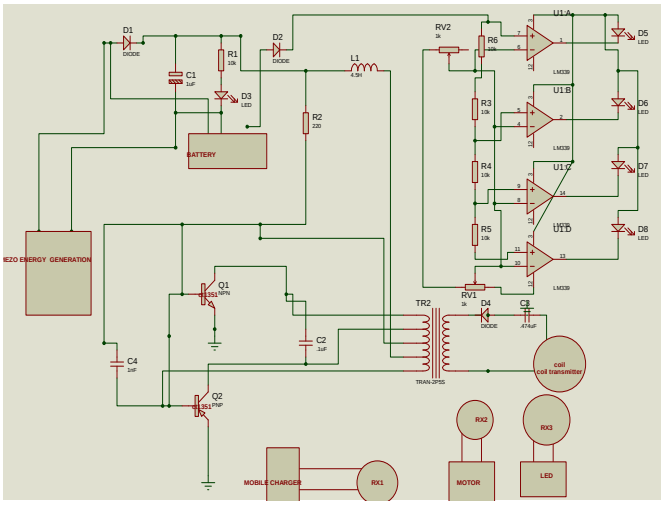

Fig 5 : prototype circuit diagram

5. WORKING

The AC power which is generated from the piezo electric generator is then converted into DC using Rectification circuitwhich in our prototype is a bridge rectifier. This power is further filtered using filtering elements. This power is regulated using regulator, then this power is converted into high frequency AC using high frequency inverter

The power transmitted using wireless power transfer, here Inductive Coupling technique is used to transmit the power efficiently. This power is the received in the Rx (ReceiverCoil) and the obtained power is further rectified using bridge rectification circuit. Since the output voltage received from the rectification circuit is insufficient low for charging electronic device.

This project demonstrates the idea of battery charging level by using lm-339 comparator ic that checks the status of battery and demonstrates it through the led indication in form of percentages (25%,50%,70%,100%).

We use two circuit tx and rx .In tx module we use peizo material that generates the electrical energy that is stored in battery. The high oscillator circuit generates the high frequency that will be provided to power amplifier and convert into high voltage and send it wirelessly using transmitter circuit.

At the receiving end receiving coil is used and the noise is rectified. The signals will recharge the mobile battery.

6. CONCLUSION

In this project we have illustrated the design ofsystem which can harnesses the power generated by the human movements and transfer the power to a device wirelessly. We believe that this research holds the key to an uninterrupted way of using smart phones and other devices. This system can also be built shoe independent and as a compact version that can strap on to any shoe.

This humanitarian project holds the solution to the

problem almost every smartphone user faces. Around 1.8 billion people use smartphone, and almost every smart phone user wishes he had more battery and a way to charge it anytime.

Harvesting energy from human motions is an

attractive approach for obtaining clean and sustainable energy and has its root in all the areas of consumer

electronics. This project also extends future work includes designing authentication and monitoring systems for this project.

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