Experimental Study of Energy Scavenging Contrivance with Green Material Through Harmonic Excitation

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Abstract - Electrical energy is one of the major building blocks of modern society. Fossil fuels are finite and environmentally costly. Large-scale ambient energy such as solar, wind and tide is widely available and large-scale technologies are being developed to efficiently capture it. Recovering even a fraction of energy would have a significant economic and environmental impact[1][2]. This is where energy scavenging (ES) comes in. Energy scavenging is a process that captures small amounts of energy that would otherwise be lost as heat, light, sound and vibration. It uses this captured energy to improve efficiency and enable new technology such as wireless sensor networks.ES also has the potential to replace batteries for small and low power electronic devices[3]. This has several benefits such as maintenance free, environmentally friendly and opens up new applications[4]. In this paper authors are demonstrating how to capture electrical energy and developed a voltage of 150 volts by using green material as Lead Zirconate Titanate (PZT 5 A) patches by using harmonic vibrations for the charging of low power devices through investigated novel energy scavenging contrivance.

Keywords: Electrical energy, fossil fuels, energy scavenging, PZT.

I. INTRODUCTION AND THEORY

Piezo electricity is a form of coupling between the mechanical and the electrical behaviors of ceramics and crystals belonging to certain classes. These materials exhibit the piezoelectric effect, which is historically divided into two phenomena as the direct and the converse piezoelectric effects. When a piezoelectric material is mechanically strained, electric polarization that is proportional to the applied strain is produced. This is called the direct piezoelectric effect and it was discovered by the Curie brothers in 1880.When the same material is subjected to an electric polarization, it becomes strained and the amount of strain is proportional to the polarizing field. This is called the converse piezoelectric effect or inverse piezoelectric effect. The constitutive equations for a piezoelectric material are given by [2][3]. It can be seen that the first equation is the Hooke's Law when electric field is zero and the second is Gauss's law of Electricity when stress is zero.

$$\delta = \frac{\sigma}{Y} + dE$$

$$D = \varepsilon E + d\sigma$$

Where,

δ - Mechanical strain
σ – Mechanical Stress
Y – Modulus of Elasticity (Young's Modulus)
d- Piezoelectric strain coefficient
E – Is the electric field
D – Electric Charge Displacement
ε – Dielectric constant of piezoelectric material

By doping the PZT material, its piezoelectric characteristics can be modified: especially the hardness or softness of the material. Piezoelectric sensor are devices using the piezoelectric effect to measure acceleration, pressure, strain or force and converting them to an electrical signal. Piezo elements are suitable for the detection of dynamic processes. In static applications the piezoelectric charges are too small, in order to be detected. An amplifier is used to convert the piezoelectric charges into a measurable electrical tension. Principle of operations three modes of operation exist depending on how a piezoelectric material is cut such as transverse, longitudinal and shear. High Power "Hard" Piezoelectric Materials are ceramics able to withstand high levels of electrical and mechanical stress and are particularly suited to high voltage and power applications. High Sensitivity "Soft" Piezoelectric Materials are particularly useful for sensing applications due to its high sensitivity and permittivity. piezoelectric ceramics are frequently used in low power applications as electronic measuring scales, mobiles chargers etc.

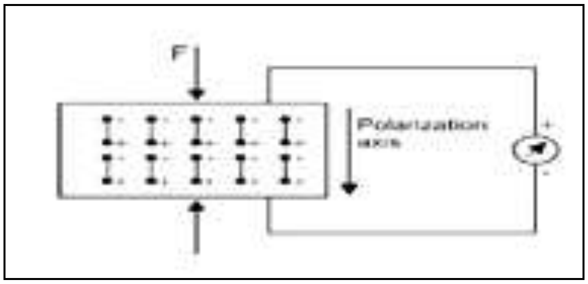

Fig.1: Energy generation using the environmental benign material (Source: PI company Ltd)

II. EFFECT OF E-WASTE ON ENVIRONMENT

According to United nations conference on trade and development report that India is producing 26×10^{8} kg of electronic waste where as America is producing 1.26 times more than India's. In America electronic waste is being used for building roads but another side effect is that the rain water is not being absorbed by those roads. Because of burning of E-waste , the earth is becoming highly polluted and leads to cause severe diseases such as respiratory illness, Asthma, Chronic obstructive pulmonary disorder, Lung cancer etc. The report predicts that India's waste rate from old computers will quadruple from 2007 levels by 2020[7]. Authors are mainly focusing on to minimize the E-waste by providing the recharging facility.

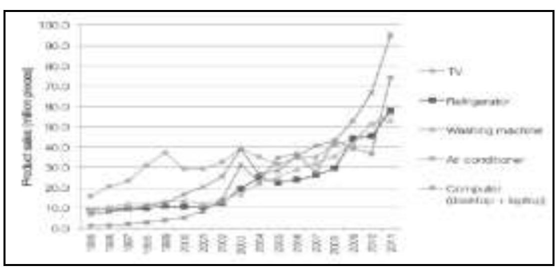

Fig.2: Major electronic equipment sales in the highest population countries [7]

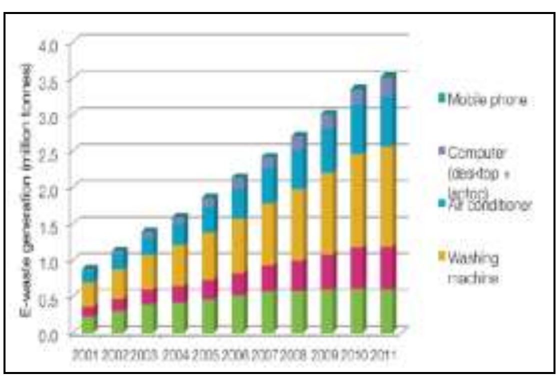

Fig.3: Generation of E-waste in the highest population countries[7]

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

It is observed from figure 4 that the source of external energy is harmonic vibration and energy conversion takes place because of Figure 5 is subjected to impact force which is given by a lead ball having a mass of 10 grams. Here two stage energy scavenging device was designed for getting maximum voltage output of 100 Volts by connecting in series.

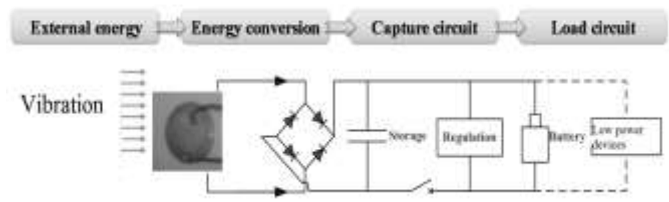

Fig.4: Schematic diagram of electrical energy scavenging by using green material patch

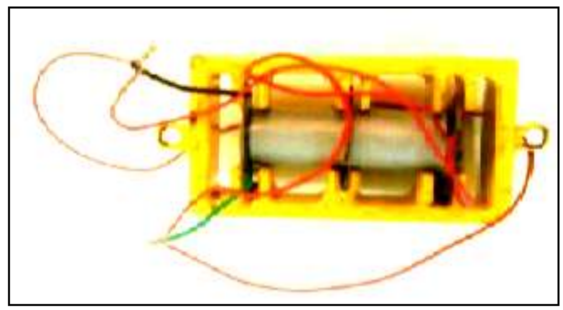

Fig.5: Energy scavenging cram with three green material patches connected in series

Fig.6: Experimental station

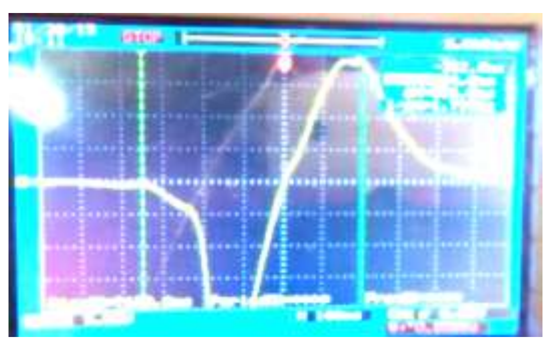

Fig.7: Oscilloscope reading for single patch

But figure 7 shows the oscilloscope reading of 20 volts for a single benign patch. When the Scavenging device is located on Syscon vibration generator having a load capacity of 200 N and is subjected to a different harmonic vibration under the frequencies of 8.3614 Hz, 252.94 Hz and 886.7 Hz.(Fig.8). The voltage is developed by Scavenging device is AC and it is converted into DC with the help of rectifier circuit as shown in figure 4. 25 micro fared capacitor is used for capturing the DC voltage and AAA battery is used for storing purpose. For all these equipment is experimented on experimental set up as shown in figure 6. By using three stage scavenging device, the output power of 155 V has been developed by connecting the patches in series connection as shown in figure 9.

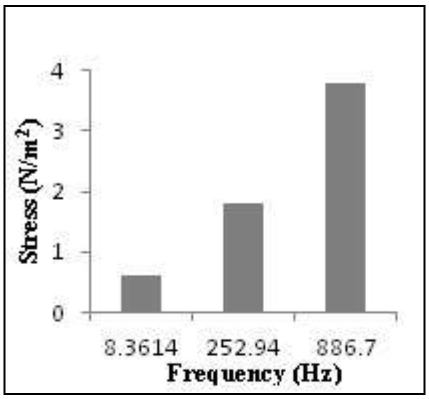

Fig.8: Graph of frequency Vs stress

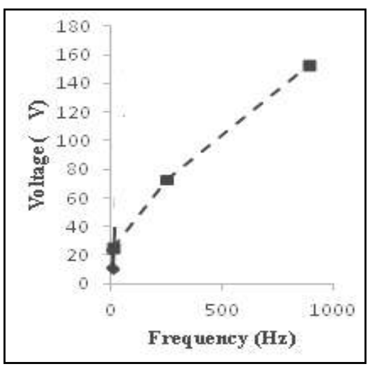

Fig.9: Graph of Frequency Vs Voltage

IV. CONCLUSIONS

In this paper, the effect of E- waste and it's generation has been in the more population density countries like India and India. Because of inadequate power supply to low power devices and improper usage of low power devices the density of E - waste has been grown up day by day. As shown in figure 3, the waste of Mobile phones is 3.5 million tonnes in the year of 2011 , just consider the population of India in 2015 is 127 crores, just for our estimation at least 60 crores watt power supply per day is required if we consider the number of mobiles are 60 crore provided each mobile is charging with one watt power per day. Therefore to minimise the environmental pollution and at the same to develop electricity in the future is Piezo electric materials to be used. By using three stage scavenging device the output voltage is 150 V and it is useful for charging low powered micro electro mechanical systems.

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