A Review: Piezoelectric Power Generation for Low Power Electronic Devices

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Abstract - In the few years the low power electronic devices have been increased rapidly. Hence Small electronic devices of a very low power requirement can be powered by piezoelectric materials that are offered as natural candidates for making devices that scavenge ambient power by converting mechanical energy into electric energy. There are two types of piezoelectric material such as crystal and ceramics. Piezoelectric material has two properties, first one is when a mechanical force is applied on any piezoelectric material it produces an electric charge on it and another one is when a electrical force is applied on piezoelectric material it produces a mechanical distortion. i.e. it converts a mechanical vibration into electrical energy. The motive is to obtain a pollution-free energy source and to utilize otherwise the energy being wasted.

Keywords: Piezoelectric material (PZT, PVDF), Nickel metal hydride battery, piezoelectric power generators (PEG).

I. INTRODUCTION

In this review paper, we will emphasis on the use of the piezoelectric material in the various low power devices and sensors etc. for this purpose the material used are piezoelectric material which has the tendency to make the charge when the force is applied. After reading so much research paper and the Wikipedia we will now able to describe the whole process of the generation of the power. First of all in this power generation process material like PZT etc are used to make the charge, when some desirable amount of force is applied. These force somewhat like force by car load or wheel under the deformation condition etc. Secondly; power output from the single piezoelectric film was extremely low, Therefore combination of the few piezoelectric film was used.

In this report we will focus on the renewable energy which is generating by converting mechanical energy to electrical energy. When the force is apply to piezoelectric material by tyre pressure the energy is created. In this piezoelectric material is used as the input. When any pressure is exerted on piezoelectric material it produces a mechanical stress on it. And piezoelectric materials have an ability to transform mechanical stress into electric charges. Hence power is generated from piezoelectric material. The output thus obtained is in the A.C form. So using the full wave rectifier to convert to DC form which is our need.

II. MATERIALS

The ability of certain materials to generate an AC (alternating current) voltage when subjected to mechanical stress or vibration, or to vibrate when subjected to an AC voltage, or both. The most common piezoelectric material is quartz. Certain ceramics, Rochelle salts, and various other solids also exhibit this effect. A piezoelectric transducer comprises a "crystal" sandwiched between two metal plates. When a sound wave strikes one or both of the plates, the plates vibrate. The crystal picks up this vibration, which it translates into a weak AC voltage. Therefore, an AC voltage arises between the two metal plates, with a waveform similar to that of the sound waves. Conversely, if an AC signal is applied to the plates, it causes the crystal to vibrate in sync with the signal voltage. As a result, the metal plates vibrate also, producing an acoustic disturbance. **Examples** of such material are: Barium titanate ($BaTiO_3$), Potassium niobate, Sodium tungstate and the Barium titanate was the first piezoelectric ceramic discovered. The most common piezoelectric ceramic in use today is **Lead zirconate titanate (PZT)**.

Fig.1 Pzt Material

III. FULL WAVE BRIDGE RECTIFIER

Full wave bridge rectifier circuit to converts the AC output of the piezoelectric material into a DC voltage. The rectifying circuit consists of 4 diodes. The voltages needs to rectify due to the need for the constant supply of the voltages light up the series of the LED placed in parallel.

The four diodes labelled D_1 to D_4 are arranged in "series pairs" with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below:

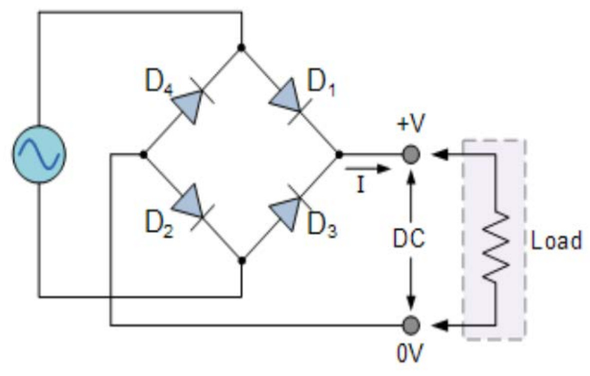

Fig.2 Full Wave Rectifer

IV. BATTERY

After making of the DC voltage. The device which is used to store the DC voltage is small nickel metal hydride battery. A nickel–metal hydride battery, abbreviated **NiMH** or Ni–MH, is a type of rechargeable battery. The chemical reaction at the positive electrode is similar to that of the nickel–cadmium cell (NiCd), with both using nickel oxide hydroxide (NiOOH). However, the negative electrodes use a hydrogen-absorbing alloy instead of cadmium. A NiMH battery can have two to three times the capacity of an equivalent size NiCd, and its energy density can approach that of a lithium-ion battery.

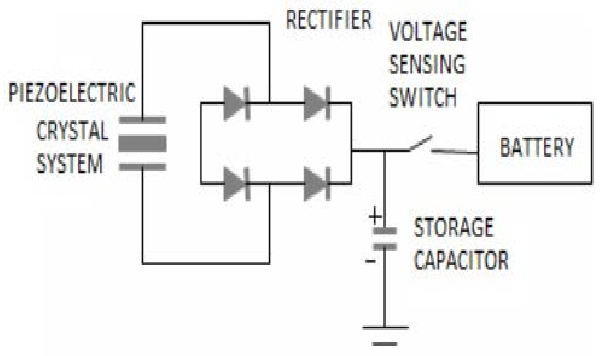

Fig 3 Full Circuit Diagram.

V. LITERATURE REVIEW

[1] This Research paper focuses on to use of PZT materials that can convert the ambient vibration energy surrounding them into electrical energy. This electrical energy can then be used to power other devices or stored for later use. This technology has gained an increasing attention due to the recent advances in wireless and MEMS technology, allowing sensors to be placed in remote locations and operate at very low power. The need for power harvesting devices is caused by the use of batteries as power supplies for these wireless electronics. As the battery has a lifespan, recharging needs to be done once discharged. Charging of batteries in order to provide energy to the electronic devices in the applications such as borders or hilly regions is a tedious job to do. Through this paper, they proposed two new ways of harnessing the piezoelectric energy. Implementation aspects focus on the practical work carried out in this field of piezoelectric energy harvesting. The idea of piezoelectric windmill will solve the problem of continuous microcell discharging in the devices being used at remote places or in rough terrains. The concept of combining two energy sources piezoelectric energy and electromagnetic energy has been proposed in the paper. So these two ideas can greatly help in harnessing the piezoelectric energy thereby improve the results of the system

[2] In this paper they have mainly two approaches of power generation were discussed for the purpose of powering the TPMS module replacing the battery used in conventional systems. PZT harvesters provide virtually infinite product life, which is impossible to achieve with finite capacity batteries. Since the energy required to power TPMS modules is only generated during vehicle operation, extra sensors and circuitry is not required to power down the sensor when the vehicle is not being driven. Tire mounted PZT harvesters allow pressure reading to be transmitted every 2.3 seconds at 60 km/h and every 1.3 second at 100 km/h, much more frequently than a battery powered device. Use of very low cost PZT bender elements enable the development of cheap TPMS modules that outperform battery powered alternatives in every aspect.

[3] This paper focuses on the self-powered system for measuring the power directly from the tire. This power supplies the wireless sensor system installed inside the tire. The energy harvesting system utilizes the generated energy from the tire behaviour while driving. The analysis of a usable energy source from the modelling of the energy harvester and the estimation of the quantity of the generated energy has been executed. Since the final goal of this study is the development of an energy harvester with a wireless sensor system installed in a real car, it was applied to a Santa Fe made by Hyundai Motor Co. for an applicability test. The results from modelling, tire test rig, and real car test have been compared and verified. In order to utilize the strain energy of the tire generated while driving, the characteristics of the piezoelectric patch have been estimated. In addition, a scheme for increasing strain to enhance generation efficiency has been suggested. Finally, the structural simplicity and stability have been established through attaching the energy harvester to the inner liner of the tire. The energy generated in the piezoelectric energy harvester ($60 \times 10 \times 0.3$ mm) for 1 cycle with 500 kgf and 60 km/h was 380.2 µJ and the energy stored in the system was 34.5 µJ, which shows a storage efficiency of approximately 9.07%. The results from modelling, tire test rig, and real car test are 7.3 s, 6.9 s, and 8.3 s for charging time and 33.7 µJ, 34.5 µJ, and 32.2 µJ for the stored energy for 1 cycle, respectively. The external load of a wireless sensor system can consume the energy of 1.9 mJ at every 8.3 s with the velocity of 60 km/h by applying the 2nd capacitor of 2000 µF. Previous researches have published the quantity of energy generated from energy harvester itself. However, the consumable quantity of energy should be presented for driving the system including the actual circuit. The energy harvester developed in this study can actually supply the usable energy of 32.2 µJ even if the efficiency of the circuit is 9.7%. In addition, the usable energy can be increased if the leakage of capacitors is reduced and the efficiency of the circuit is increased through impedance matching. The power obtained from the energy harvester proposed in this study was 1.37 µW/mm3 while the power published from another research group was 0.49 µW/mm3. Our result is preferable because our system, which is an energy harvester based on strain, has overcome the limit of the other study due to utilizing the resonant mode.

[4] In this paper the authors aim is to approach the harvesting electrical energy from deflected pneumatic tires. The loads on an elastic pneumatic tire cause a contact patch to the road surface. An estimate of the energy loss in tire deflection is given in this paper. It has been shown that more than 1 KW energy wastes because of deflections of tires in passenger car. To recycle some of this energy for application that does not require huge energy for operations, an energy harvesting technique is introduced. PZT stacks are used to convert mechanical strain to electricity. Finally an analytical model of the tire energy harvesting system is derived. The model predicts that 2.95 mW of useable power will be gained from a PZT mounted in a tire. With the concept of arrays of piezos, 14 stacks of piezoelectric devices of the same size can be placed inside the tire. Therefore about 42 mW of electrical power is estimated to be harvested using PZT. This amount of energy will be enough to provide power for the wireless sensors inside the tire. The findings of this research have an immediate benefit to the applications such as remote wireless sensors and transducers in automotive industry where the power demand is small. These wireless devices are generally hard to reach and their life span are mainly limited to the capacity of their powering systems

[5] This paper describes the use of piezoelectric materials in order to harvest energy from people walking vibration for generating and accumulating the energy. This concept is also applicable to some large vibration sources which can find from nature. This paper also represents a footstep of piezoelectric energy harvesting model which is cost effective and easy to implement The paper is successfully tested which is the best economical, affordable energy solution to common people. This can be used for many applications in city areas where want more power.. By using this project. We can drive D.C loads according to the force I applied on the piezo electric sensor. Although the theory developed in this report justifies the use of switching techniques in efficiently converting that energy to a usable form, there are obviously some practical limitations to the systems presented. The final prototype design does fulfill the objective of generating electricity from piezoelectric disk. Due to the low cost design of the piezoelectric system it is a practical product which could increase the operating period of most common products. The data collected is capable of extending the operational life span per charge of portable electronic devices. Although the theory developed in this report justifies the use of switching techniques in efficiently converting that energy to a usable form, there are obviously some practical limitations to the systems presented. Measurements of source current into the primary and load current transferred from the secondary reveal that very little current gain truly occurs between the input and output ports of the switch in the forward converter hybrid. Further, similar results were encountered when one examines the energy transferred through the series switch and inductor in the buck converter. In addition, based on the results gathered in this investigation, the final prototype design does fulfill the objective of generating electricity from piezoelectric disk. Due to the low cost design of the piezoelectric system it is a practical product which could increase the operating period of most common products. The data collected is capable of extending the operational lifes pan per charge of portable electronic devices.

[6] This Project is used to produce enough power to operate GPS receivers, location tags and eventually, even a cell phone, the piezoelectric generator prototype was small enough to be embedded in the sole of a shoe. The prototype shoe generator used a low-cost polymer transducer with metalized surfaces for electrical contact. While, ceramic transducers are hard and therefore unsuitable to use in shoes, Kaajakari's generator is soft as well as strong so it could replace a normal heel shock absorber without loss to the user experience. According to Kaajakari, the new voltage regulation circuits can convert the piezoelectric charge into a usable voltage and combined with the polymer transducer give a time-averaged power of two milli watts per shoe on an average walk - that’s comparable to lithium coin/button cells and enough to power running sensors, RF transponders and GPS receivers.

[7] Attiki Odos (Attiki Road) is a highway road that is newly constructed and crosses Athens from North- East to South-West side. The reason of its construction was to absorb the Athens daily high traffic load of the more heavy traffic profile. It appears that the traffic profile of specific areas like toll stations and closed Routes have a traffic potential, where embedded piezoelectric generators could be used for energy harvesting and centricity generation. Embedded piezoelectric generators can harvest the wasted mechanical that vehicles impart, when they move on roadways, transform it into electrical energy, than can be used either for the electrification of nearby buildings, household's needs, stoplights, speed sensors, road side billboards or connected directly into the grid. Alternatively, the electricity can be stored in an electrical storage system for later use. For the purposes of this research, the traffic data of Attiki Odos grid in order to estimate harvesting potential in kWh per hour are used. The idea was to calculate the output potential by the installation of the energy harvesting system a number of meters before and after the toll stations that present the highest traffic volume, since friction caused by regular breaking, increases the deformation as a result embedded piezoelectric generators transform additional mechanical energy, deformation, to electrical energy.

a)

b)

Fig 4 Top view of the material placed on the Attiki road (a,b)

In this research they took the four toll station for the estimate KWh per hour.

1. Roupaki
2. Katechaki
3. Metamorfosi (East Section)
4. Koropi

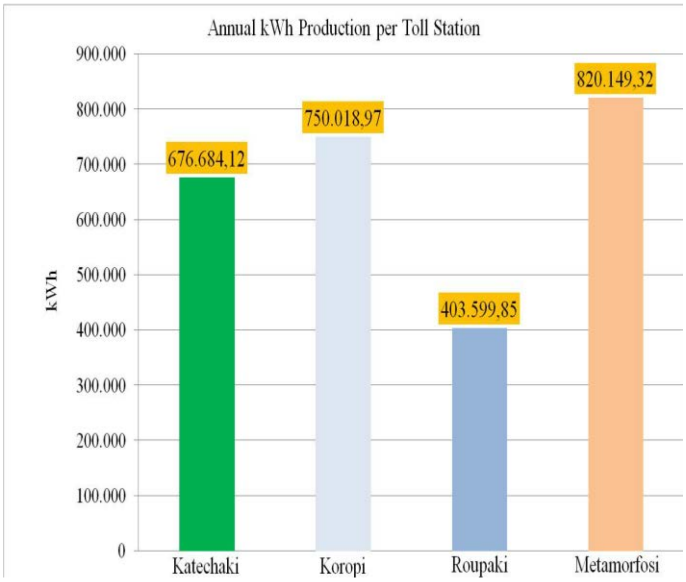

Fig 5 Power develop at different toll station

VI. CONCLUSION

we will focus on the renewable energy which is generating by converting mechanical energy to electrical energy Active materials employed by piezoelectric generators generate a charge when mechanically activated. Based on these, Innovations, It provides environmental benefits, where parasitic mechanical energy on roads, highways, railways and airport runaways is harvested and transferred back, in a process by which the energy is captured, stored and reused. More specifically, the traffic grid of Attiki Odos was thoroughly examined. From this study it is clear that a possible implementation of such a Piezoelectric system is really advantageous as it provides enough electric energy to cover local needs of Highways and most important the produced energy is consumed at the same place avoiding energy transfer. Finally, the huge positive environmental impact of such an investment must be also taken into account as it combines many environmental advantages of other energy production technologies. Among the most notable advantages is the fact that where installed, they preserve environment in its original state.

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