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A Review on Power Generation Using Piezoelectric Material

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Abstract

In last few years low power electronic devices have been increased rapidly. The devices are used in a large number to comfort our daily lives. With the increase in energy consumption of these portable electronic devices, the concept of harvesting alternative renewable energy in human surroundings arises a new interest among us. In this project we try to develop a piezoelectric generator. That can produce energy from vibration and pressure available on some other term (Like people walking. This project 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 project also represents a footstep of piezoelectric energy harvesting model which is cost effective and easy to implement.

Keywords***: Piezoelectric Sensor, Full-wave bridge rectifier, Lead Acid Battery, Load (LED and USB Charger)***

1. INTRODUCTION

Now a day's energy is one of the most important issue around the world. Especially in Bangladesh energy crisis is a big problem. Renewable energy sources can be a great media to solve this energy crisis problem in Bangladesh. As we know natural resources will finish one day. That's why researchers are trying to introduce substitute energy sources from nature. That must be green and not harmful for the environment. Energy harvesting is defined as capturing minute amounts of energy from one or more of the surrounding energy sources. Human beings have started already to use energy harvesting technology in the form of windmill, geothermal and solar energy. The energy came from natural sources, termed as renewable energy. Renewable energy harvesting plants generate our MW level power, it is called macro energy harvesting

Technology. Moreover, micro energy also can produce from that naturals sources, that's called micro energy harvesting. Micro energy, harvesting technology is based on mechanical vibration, mechanical stress and strain, thermal energy from furnace, heaters and friction sources, sun light or room light, human body, chemical or biological sources, which can generate MW or *we* level power. Micro power supply needs is increasing greatly with time as our technology is moving to the micro and

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Nan no fabrication levels. Our discussion on this is based on generating micro energy from vibration and pressure using piezoelectric material.

2. Energy Harvesting using the Models

The generators modeled are in correspondence with consecutives buried piezoelectric cables. The practical distance of 1, 6 cm between them was obtained by experimental results. This new parameter is included in the models as a time delay between the generators associated to consecutive cables using (3)

$t_d=d_c/n_0.(||/30).R*(3)$In (3) tad is expressed in seconds, dc (m), no (rpm),and R (m) is the rotating platform radio of the test bench. As R=0,75m>>dc=0,016m, we are using the geometric approximation between arc and chord. The value of the capacitor used to hold the charge from the piezoelectric cables, is set constant in order to compare the results. Its value will affect the time needed to achieve the steady state. To collect charge from the positive and negative stress, semiconductor topologies are used. Its type and optimized structure is presented in the next item.

3. OUTPUT STAGE OF PIEZOELECTRIC ENERGY HARVESTING SYSTEM

The output of a piezoelectric crystal is alternating signal. In order to use this voltage for low power consuming electronic devices, it has to be first converted into digital signal [3]. It is done with the help of AC to DC converter shown in Fig. 4.1. Fig.4.1 shows a simple diode rectifier to convert AC to DC. This is followed by a capacitor, which gets charged by the rectifier up to a pre-decided voltage, at which the switch closes and the capacitor discharges through the device. In this way, the energy can be stored in the capacitor, and can be discharged when required. But the energy harvesting capacity of this circuit is not appreciable. Hence, a DC to DC converter is used after bridge rectifier stage, which has been demonstrated in Fig.4.2. The addition of DC-DC converter has shown an improvement in energy harvesting by a factor of 7. A non-linear processing technique "Synchronized Switch Harvesting on Inductor" (SSHI) was also proposed in 2005 for harvesting energy [4]. It consists of a switching device in parallel with the piezoelectric element. The device is composed of a switch and an inductor connected in series.At that instant, the switch is closed and the capacitance of the piezoelectric element and inductor together constitute an oscillator. The switch is kept closed until the voltage on the piezoelectric element has been reversed. This circuit arrangement of the output circuit is said to have a very high energy harvesting capacity.

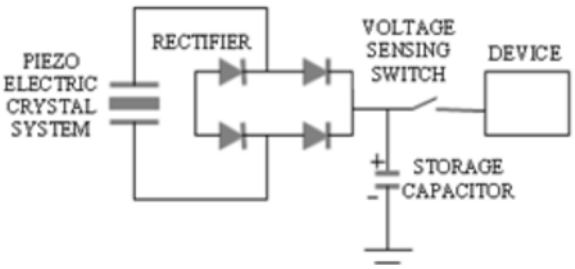

Fig...1: Bridge Rectifier type AC to DC

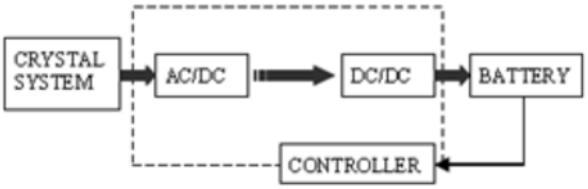

Fig...2: Energy Harvesting Circuit

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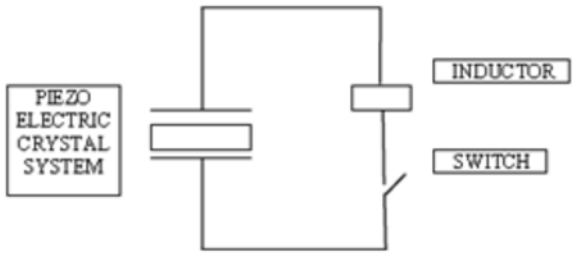

Fig.3: SSHI (Synchronized Switch Harvesting on Inductor) Technique

4. METHODOLOGY

Implementation of piezo sensors in a tile to get optimum power. Configurability is achieved by using different piezo sensors with different compositions of piezo materials. Performance evaluation of piezo tiles wirelessly using ZigBee for smart analysis. Comparison of piezo sensors with other micro energy harvesting devices.

5. MOTIVATION

In developing countries like India the demand for power is increasing day by day. Due to increase in population there is lot of power cut-off. Human being uses power generators which requires fuel to produce electricity which has harmful effect to the environment. So we got motivated to harvest power using an alternative source of energy and also doesn't have any negative effect to the environment and to see India without any power cut-off.

6. PIEZOELECTRIC ENERGY HARVESTING FROM VIBRATIONS

Piezoelectric Materials. Piezoelectricity stems from the Greek word "piezo" for pressure and the word "electric" forelectricity. When a force or stress is applied to a piezoelectric material, it leads to an electric charge being induced across

The material. This is known as the direct piezoelectric effect. Conversely, the application of a charge or electric field to the same material will result in a change in strain or mechanical deformation. This is known as the indirect Piezoelectric effect. It is the direct piezoelectric effect that is employed in energy harvesting. Examples of ceramics which exhibit the piezoelectric effect are lead-zirconated-titan ate (PZT), lead-titan ate (PbTiO2), lead-zirconated (PbZrO3), andbarium-titanate (BaTiO3). To date, the most commonly used piezoelectric ceramic is PZT mainly because it has very high electromechanical coupling ability. However, PZT is an extremely brittle material and hence this presents limitations to the strain that it can safely withstand without being damaged [26, 27]. Polyvinylidenefluoride (PVDF) is another Common piezoelectric polymer which is more flexible and can be employed in energy harvesting applications [27].Research in nanoscience has outputted novel piezoelectric material systems used to fabricate next generation Nano generators employed in energy harvesting technology. The notable work of Wang and Song introduced piezoelectric Nano generation using a single zinc oxide (ZnO) nanowireby atomic microscopy [30]. Since then, piezoelectric semiconductormaterials such as ZnO [31–33], indium nitride(InN) [34, 35] gallium nitride (GaN) [36], and zinc sulphide (ZnS) [37], and piezoelectric insulator materials, such asPVDF [38], BaTiO3 [39] and PZT [40], have been studiedfor potential electrical power generation.

7. PIEZOELECTRIC MEMS GENERATOR SYSTEM. IN PIEZOELECTRIC

Energy harvesting from vibration, a mass is suspended by abeam, with a piezoelectric layer on top of the beam. When the mass vibrates, the piezoelectric lever is mechanically deformed and a voltage is generated. The most common energy harvesting systems are cantilever structures that are mainly designed to operate at their resonance frequencies. Such structures (anamorph or

bimorph cantilevers) are popular because they enable relatively high stress levels on the piezoelectric material while minimizing the dimensions of the devices [1, 2, 26, 28]. Figure 3 shows such a system composed of a piezoelectric patch which is bonded to the host cantilever beam surface, which is under alternating deformation.

8. PIEZOELECTRIC NANOGENERATOR SYSTEM.

The ground breaking work by Zheng L. Wang and his Nano Research Group at the Georgia Institute of Technology, USA, has greatly influenced the current research efforts in the conversion of nanoscale mechanical energy into usable electrical energy using Nano generators. In their original paper Wang and Song first introduced piezoelectric Nano generation by examining the piezoelectric properties of a single No nanowire (NW) by atomic

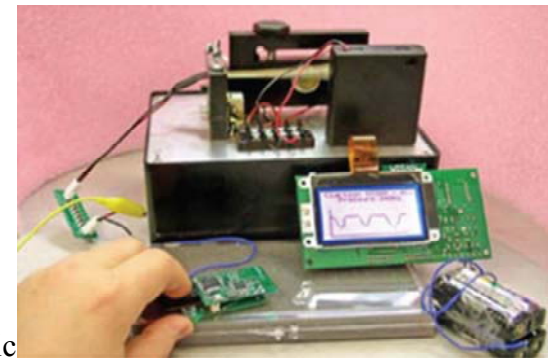

Figure 4: piezoelectric Nano generator system.

9. COMPARISON OF CONVENTIONAL MICRO GENERATORS AND NANO GENERATORS.

A simple Nano generator is principally a nanowire which is a one-dimensional nanomaterial that has a typical diameter less than 100nm and a length of 1 μm The majority of ceramic nanowires are in fact single crystal materials. Compared to the conventional ceramic/thin film-based piezoelectric cantilever energy harvesting devices, Nano generators offer three distinct advantages as reported by Wang as follows.

(1) Enhanced Piezoelectric Effect. When a strain gradients experienced by a ferroelectric nanowire, 400–500% enhancement of the piezoelectric effect can be achieved.

(2) Superior Mechanical Properties. The lattice perfection of nanowires enables much larger critical strain, higher flexibility, and longer operational lifetime [42, 47]-compared to conventional ceramic micro generators [44, 48].

(3) High Sensitivity to Small Forces. Large aspect ratio and small thickness allow the creation of significant straining the nanowires under a force at the Nano newton or Piconewton level.Oil and Environmental Concerns.

10. FUNDAMENTAL MATERIAL ISSUES.

The performance of piezoelectric energy harvesting systems primarily depends on the piezoelectric properties used to fabricate the generators. Generally, thin film piezoelectric materials show better piezoelectric properties compared to bulk piezoelectric materials. The use of single crystals and nanomaterials (nanowires) has, in principle, improved the power density and energy conversion efficiency hence the advance the miniaturization of device size while maintaining a reasonable power output. Despite great research efforts on these nanomaterials, there is lack of fundamental scientific understanding of and experimental research on piezoelectric and flex electric effects in single crystalline nanowires. This lag in research at this fundamental level compromises fidelity of the mathematical algorithms used in modeling and predicting the piezoelectric potential, mechanical to electrical energy conversion efficiency and device material optimization. The other challenge relates to the

coupling of piezoelectric and semiconducting effect—resulting in the socalledpiezotronic effect. The scientific understanding of the interaction of electron distribution and semiconductor band structures requires additional research efforts. The research will potentially present an opportunity to facilitate in sit rectification of the potential output by making use of theSchok key barrier formed between ZnO and metal electrodes. While single crystal materials offer better piezoelectric performance and give better power density compared to their bulk material counterparts, costs of these materials are still very high and at times very inhibitive. The current fabrication methods and the associated device integration

techniques at nanoscale are not yet suited for large scale processing, and research efforts along this line will substantially reduce fabrication costs and help translate piezoelectric energy harvesting from mere experimental curiosity into real engineered device realizations to power wirengineerineless sensors.

11. Design and Power Management Issues.

The design of piezoelectric micro power generators and Nano generators is in itself a multidisciplinary area with challenges based in

Fundamental physics, material science, mechanical engineering, and electrical g. Different researchers from different discipline and background have reported several researches in the area of piezoelectric energy harvesting. The multidisciplinary approach and a holistic paradigm is perhaps the most promising way of designing piezoelectric energy harvesting device. As can be observed from the review, there is still a need to improve the power output of piezoelectric generators to match the requirements of wireless sensor devices. This challenge can be addressed by using piezoelectric material with the best piezoelectric properties, the best device geometries, and the best power electronics to condition and manage the power output. This is arguably calls for a holistic design and optimization regime, together with an established Smart Materials Research 11 international metrology standard of piezoelectric energy harvesting (which currently does not exist). Latest advances in synchronized switching techniques have been reported

As the latest achievements in power conditioning interface circuits to date [29, 48]. Further research and integration of efficient interface circuits, advances in power conditioning power management techniques and development in ultralow power wireless microcontroller units will greatly drive energy harvesting technology to heights never envisaged before.

12. PIEZOELECTRICITY AND POWER GENERATION USING TRANSVERSE MODE THIN FILM PZT AND MEMS, PMPG

As piezoelectric effect converts mechanical strain into electric current or voltage and generates electric energy from weight, motion, vibration and temperature changes. Considering piezoelectric effect in thin film lead zirconated titan ate, Pb(Zr,Ti)O3 (PZT), MEMS power generating device is developed [5]. It is designed to resonate at specific frequencies from an external vibration energy source, thereby creating electrical energy via the piezoelectric effect using electromechanical damped mass as shown in following

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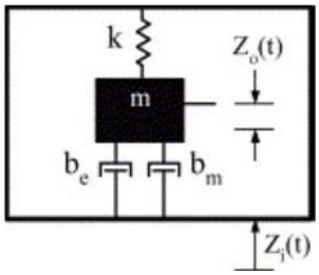

Figure 5. Schematic of generating vibration convertor

13 PIEZOELECTRIC SENSORS NETWORK FOR SMART ROAD

The present invention relates generally to methods of electrical power generation, and more particularly is a method and device to generate electricity by using traffic on existing roadways to drive an electrical generator [6]. This paper provides technical review for the production of electric power using PZT,MEMS, PMPG in piezoelectric roads-Harvest traffic energy to generate electricity as shown in following

Figure 6. Network for smart roads and generation of electric voltage

Since Energy demand and heavy traffic correlation motivate to dream about a device in the road that would harvest the energy from the vehicles driving over it. For this, embed piezoelectric material beneath aroad can provide the magic of converting pressure exerted by the moving vehicles into electric current. The method uses an electrical generation device installed beneath the roadbed. The electrical generation device Includes pressure plate covered with one or more protection layers which lie beneath the surface of threadfin this process, piezoelectric material is embedded beneath the road with the electrical generating device. For a road with embedded piezoelectric generators, part of the energy the vehicle expands on roads deformation is transformed into electric energy (via direct piezoelectric effect) instead of being wasted as Thermal energy (heat).

14. ECOSECURED PIEZOELECTRIC ROAD (PZR)

A. Anamika Bhatia Jain et al proposed Ecosecured Piezoelectric Road. The unused energy in surrounding system is used and converted it into electrical energy. The piezoelectric plates will be placed under the non-conducting material (hard rubber) and the pressure created by the pressure such as footsteps (in PZR) and waterfall pressure (in PZW) will produce energy which can be stored and utilized as mentioned. The figure (Fig 3) illustrates the piezoelectric arrangement. The piezoelectric elements are in their various forms and configurations are designed to operate near resonance. Resonance may vary as a function of number of properties of Piezo materials being employed, which includes the shape, size, density and other physical parameters. Electrical contacts or coupling elements used in the figure are coupled to suitable electrical leads and are electrically coupled to the piezoelectric element. The polarity of charge depends upon whether element is under compression or tension as a result of applied force. If the element is subjected to an applied compressive force its polarity will be positive and due to applied tensile force it will be negative. This element generates the electrical charge to the voltage limiter. The voltage limiter is formed by connecting sneer diode back to back. It provides

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the return channel through which electric charge may flow to the piezo unit to prevent the depolarization of the piezo element. To work in either polarity mode the return channel is used. Voltage limited electrical charge is coupled electrically to bridge rectifier. The pulsating DC output of rectifier is coupled to the capacitive filter which serves as ripple filter. This pure DC output obtained from filter is applied to shunt voltage regulator, to regulate voltage which advantageously coupled to storage element which can be a battery or a capacitor. For large scale production, multiunit piezo electric Array is utilized by plurality of elements. More preferable stack Array arrangement passes the applied force through all layers forming piezoelectric elements in the Array thus causing the voltage to rise. The Array consists of the given type of subsystem embodiments which are eclectically coupled at nodes so as to form a voltage additive series circuit arrangement. The summed electrical charge is input to the regulator by the way of nodes. This output is stored in one or more electrical charge element. Finally the generated, regulated, conditioned and stored electrical charge of the system is available for use by external circuitry. The conditioning circuitry is preferably of relatively low impedance to more efficiently capture the generated charge.

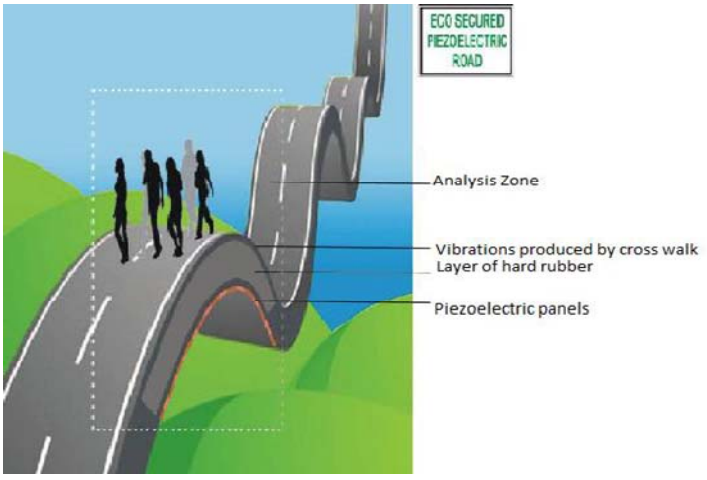

figure 7ecosecured piezoelectric road (par)

CONCLUSION

The project 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. Bangladesh is a developing country where energy management is a big challenge for huge population. By using this project we can drive D.C loads according to the force we 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 Isa practical product which could increase the operating period of most common products. The data collected is capable of extending the operational lifespan 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 oad current transferred from the secondary ıl that very little current gain truly occurs een the input and output ports of the switch e forward converter hybrid. Further, similar ts were encountered when one examines the ɣy transferred through the series switch and ːtor in the buck converter. In addition, based ıe results gathered in this investigation, the prototype design does fulfill the objective nerating electricity from piezoelectric disk.

Due to the low cost design of the piezoelectric system it Isa practical product which could increase the operating period of most common products. The data collected is capable of extending the operational lifespan per charge of portable electronic devices.

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