ISSN : 2231-0711

P.C. Krishna Devi | International Journal of Computer Science Engineering and Technology(IJCSET) | October 2014 | Vol 4, Issue 10,256-259

Survey on Energy Harvesting Techniques

P.C. Krishna Devi

P.G. Scholar
Department of Computer Science and Engineering,
SNS College of Engineering, Sathy main road, Coimbatore-641035, Tamil Nadu, India
krishnachandrangathan@gmail.com

Abstract – **Environmental energy can be used as an alternative to electrochemical battery. Researches are carried out to harvest energy from solar, wind, tidal, thermal and other mechanical sources which have finite lifespan. Here, random sound is proposed as a new source of renewable energy. The transducer used to convert sound energy into electric energy is a piezoelectric crystal.**

Keywords – Environmental energy, energy harvesting, sound energy, piezoelectric material.

I. INTRODUCTION

Energy harvesting from various renewable energy source is an ongoing research topic. Need for energy is increasing day by day and hence new and efficient energy resources need to be exploited. Energy harvesting is the mechanism by which useful energy is derived from various sources and utilized in increasing technological demand. Energy harvesting can also be defined as capturing energy and storing it for meeting the future needs. Various traditional energy harvesting mechanisms are solar farms, wind farms, geothermal farms, tidal energy farms and so on. Advancement in technology has increased the way by which these sources can be utilized to power electronic systems. Various energy harvesting technologies have been developed which leads to the development of self-powered systems. Self-powered systems are systems that require minimum maintenance and can be deployed in inaccessible locations. The main target of energy harvesting is to power this self-powered system.

Solar energy, wind energy, tidal energy, thermal energy are all renewable sources of energy. But all these impose some restrictions on the working environment of electronic devices. Unlike all these sources of energy, mechanical energy can be found in instances when others become insufficient. Mechanical energy can be used to power electronic systems by harvesting energy from it. The source of mechanical energy can be vibrations, motion, heat, noise, flow induced vibrations and so on. Piezoelectric materials, pyro electric materials, electrostatic materials are used to convert the mechanical energy into useful energy form.

Through this paper a new step in the direction of energy harvesting, piezoelectric energy harvesting is discussed. The basic working principle of piezoelectric material and some ideas to harvest electric energy from sound wave is discussed.

II. RELATED WORK

A. *Solar Energy Harvesting*

Solar energy can be defined as energy derived from sun. It is harnessed using various technologies like photovoltaic panels and solar thermal collectors. Solar power is actually the conversion of sunlight into electricity, either directly or indirectly using photovoltaic (PV) or concentrated solar power (CSP) respectively. Photovoltaic uses photoelectric effect to convert light into electric current. In CSP sunlight in large area is focused into small beam using lenses or mirrors.

I) Photovoltaic energy harvesting

In photovoltaic method, semiconductors exhibiting photoelectric effect are used to convert solar radiations into direct current electricity. The device used to convert light into electric current using photoelectric effect is known as a photovoltaic cell or a solar cell. Dye Sensitized Solar Cell is the recent PV technology to harvest energy as dyes absorb light as chlorophyll does in plants.

II) Concentrated Solar Power harvesting

Concentrated Solar Power system focuses sunlight in large area into small beam using lenses or mirrors. This concentrated heat is then used as a heat source for conventional power plant. Various techniques like Fresnel reflector, Stirling dish, and solar power tower are used to track the sun and focus light. In CSP systems power is generated by heating a working fluid with the help of concentrated sunlight.

B. *Wind Energy Harvesting*

Wind power has been recognized as a viable source of "free" energy for hundreds of years. Since it pre-dates the petroleum economy or even the industrial revolution, it seems odd to refer to it as an "alternative" energy source. Wind turbines have been a significant player as a renewable energy source since the early 1980s. Wind power covers a wide range of applications and can be harnessed by large wind turbine farms providing up to 800 MW of power, and small residential wind turbines providing 3 kW to a home.

The wind turbine generator converts mechanical energy to electrical energy. Wind turbine generators are a bit unusual, compared to other generating units ordinarily found attached to the electrical grid, in that the generator has to work with a power source which supplies fluctuating mechanical power.

C. Thermal Energy Harvesting

Through a process known as thermionic conversion, heat energy can be converted into electricity with very high efficiency. Because of its promise, researchers have been trying for more than half a century to develop a practical thermionic generator. Heat can be used to generate **steam**, and use the steam to spin a **turbine**. The turbine can drive a **generator**, which produces electricity. This setup is very common, but it requires a fair amount of equipment and space.

A TE energy-harvesting system takes advantage of any temperature difference between its two surfaces. Temperature gradients are everywhere. Current is generated when there is a temperature difference between two junctions of a conducting material. Thermal energy harvesting uses temperature differences or gradients to generate electricity, e.g. between the human body and the surrounding environment. Devices with direct contact to the human body can harvest the energy radiated from the human body by means of thermo generators (TEGs). To address the needs of telecommunications and other embedded applications, design of micro structured thermoelectric devices has been proposed. Due to the lack of moving parts in thermal energy harvesting devices, they tend to last longer than vibration-based devices.

Thermal energy can be converted to electrical energy by the Seebeck effect while working environment for thermo-powered system is also limited.

D. Tidal Energy Harvesting

The oceans have long been recognized as a potential source of energy. The ocean's motion carries energy in the form of tides, currents, and waves. In principle, some of this energy could be used to perform work. Tidal Energy or tidal power achieved by capturing the energy contained in moving water mass due to tides. Two types of tidal energy can be extracted: kinetic energy of current between ebbing and surging tides and potential energy of currents between high and low tides. The formal method – generating energy from tidal current – is considered much more feasible today than building ocean-based dams or barrages, and many coastal sites worldwide are being examined for their suitability to produce tidal energy. Tidal power is reliable and predictable.

E. Bio-Energy Harvesting

Bio-energy is renewable energy made available from materials derived from biological sources. Biomass is any organic material which has stored sunlight in the form of chemical energy.

Voltree Power's patented bio-energy harvester converts living plant metabolic energy to usable electricity, providing a unique battery replacement alternative for ultra-low power sensors and eventually a power source in nanotechnology. These naturally-occurring phenomena can serve as a power source in environmental sensing networks for climatic and wild life monitoring in areas with limited accessibility and where battery replacement is not an option. Self-sustaining power sources such as tree power will play a critical role in future applications. Trees can be used to power circuits, but their voltage is too small to charge conventional batteries.

F. Mechanical Energy Harvesting

In some instances where solar, thermal, wind or other form of renewable energy is not suitable mechanical energy is found. Mechanical energy is produced with the help of vibrating structure, motion of living beings, flow induced vibration and noise. Here, a piezoelectric material is used to convert this mechanical energy into electric energy. The direct piezoelectric effect converts mechanical strain into electric current or voltage.

I) Energy Harvesting from Machinery Vibrations

In order to harvest energy from machinery vibrations a linear generator is designed to convert kinetic energy into electrical energy. Various transduction mechanisms such as electromagnetic, electrostatic and piezoelectric transducers are used. Among the three transducers electromagnetic energy harvesters have highest power density. But these are not suitable for MEMS applications. The power density of piezoelectric energy harvester is same as that of electromagnetic energy harvester and has simple structure. Electrostatic energy harvesters having low power density is suitable for MEMS applications.

II) Energy Harvesting from Human Movement

In order to harvest energy from human movement broadband, non-linear or non-resonant devices are preferred as human movement is random. The force produced in human body due to movement is concentrated mainly on the feet. Some amount of useful energy is produced for portable electronic devices by the energy harvesters using this mechanism. More care should be taken in order to avoid discomfort in human body due to energy harvesting.

III) Energy Harvesting from Flow Induced Vibrations

Energy harvesters from flow-induced vibration, as an alternative to turbine generators, have drawn more and more attention. Useful amount of energy has been generated by existing devices and the start flow speed has been reduced to as low as 2.5m·s-1. However, most reported devices that produce useful energy are too large in volume compared to other vibration energy harvesters. Thus, it is difficult to integrate these devices into wireless sensor nodes or other wireless electronic systems. Future work should focus on miniaturize these energy harvesters while maintain current power level. In addition, researches should be done to further reduce the start flow speed to allow these technology wider applications.

III. PIEZOELECTIC CRYSTAL

Piezoelectricity means "Electricity from pressure". The so called "direct effect" means that piezoelectric materials develop charge if deformed by mechanical stress. The inverse effect in piezoelectricity is production of deformation due to the application of an electrical field.

When a crystal is mechanically strained, or when the crystal is deformed by the application of an external stress, electric charges appear on certain of the crystal surfaces;

and when the direction of the strain reverses, the polarity of electric charge is reversed. This is called the Direct Piezoelectric Effect, and the crystals that exhibit it are classified as piezoelectric crystal.

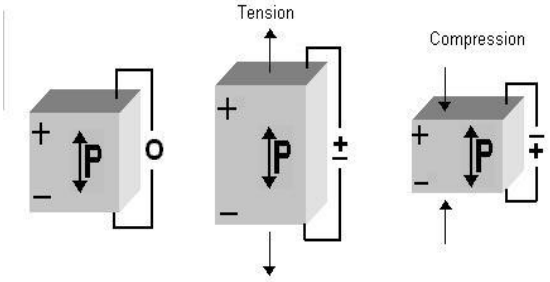

Figure 1- Direct Piezoelectric Effect

When a piezoelectric crystal is placed in an electric field, or when charges are applied by external means to its faces, the crystal exhibits strain, i.e. the dimension of the crystal change. When the direction of the applied electric field is reversed, the direction of the resulting strain is reversed. This is called as converse piezoelectric effect.

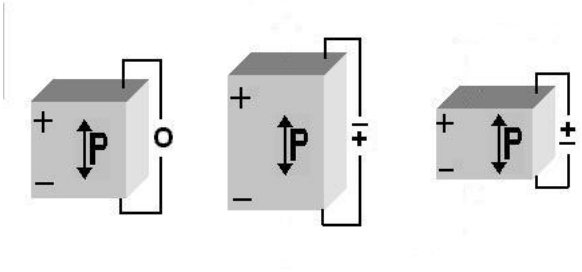

Figure 2- Converse Piezoelectric Effect

The piezoelectric effect describes the relation between a mechanical stress and an electrical voltage in solids. The piezoelectric effect occurs only in nonconductive materials. Piezoelectric materials can be divided in 2 main groups: crystals and ceramics. The most well-known piezoelectric material is quartz (SiO2).

IV. PREVIOUS WORK USING PIEZOELECTRIC CRYSTAL

A. Power Generating Sidewalk:

The piezoelectric crystal arrays are laid underneath pavements, sidewalks and other high traffic areas like highways, speed breakers for maximum voltage generation. The voltage thus generated from the array can be used to charge the chargeable Lithium batteries, capacitors etc. These batteries can be used as per the requirement.

B. Power Generating Boots or Shoes

An idea is being researched by DARPA in the United States in a project called Energy Harvesting, which includes an attempt to power battlefield equipment by piezoelectric generators embedded in soldiers' boots. However, these energy harvesting sources by association have an impact on the body. DARPA's effort to harness 1-2 watts from continuous shoe impact while walking were abandoned due to the discomfort from the additional energy expended by a person wearing the shoes.

C. Gyms and Workplaces

Researchers are also working on the idea of utilizing the vibrations caused from the machines in the gym. At workplaces, while sitting on the chair, energy can be stored in the batteries by laying piezoelectric crystals in the chair. Also, the studies are being carried out to utilize the vibrations in a vehicle, like at clutches, gears, seats, shock-ups, foot rests.

D. Mobile Keypad and Keyboards

The piezoelectric crystals can be laid down under the keys of a mobile unit and keyboards. For the press of every key, the vibrations being created can be used by piezoelectric crystal and hence can be used for charging purpose.

E. People Powered Dance Clubs

In Europe, certain nightclubs have already begun to power their night clubs, strobes and stereos by use of piezoelectric crystals. The crystals are laid underneath the dance floor. When a bulk of people use this dance floor, enormous amount of voltage is generated which can be used to power the equipment of the night club.

V. COMPARATIVE ANALYSIS

Energy	Conversion Mechanism	Drawbacks
Light	Photo voltaic cell	Harnessed when it is daytime and sunny.
Wind	Wind turbine generator	Noise, wind cannot be predicted.
Wave	Ocean thermal energy conversion	Intensity of sea wave is unpredictable and there can be damage to power generation units.
Heat	Thermo electric devices	Pollute atmosphere due to release of smoke and fumes.
Mechanical	Electromagnetic, electrostatic, piezoelectric transducers	Possible only in high power machines
Energy	Conversion Mechanism	Drawbacks

VI. CONCLUSION

Energy harvesting or scavenging, which harvests or scavenges energy from a variety of ambient energy sources and converts into electrical energy to recharge the batteries and power electronic devices, has emerged as a promising technology. Since the sun is the most abundant renewable energy source in the world and the solar energy the earth receives in an hour is greater than the energy consumed in a year. This makes the photovoltaic materials one of the most significant alternative energy harvesters. But here we propose sound as the source of renewable energy to power mobile devices.

REFERENCES

[1] SujeshaSudevalayam, PurushottamKulkarni, "Energy Harvesting Sensor Nodes: Survey and Implications", Dec. 19, 2008.

[2] Y. C. Shu and I. C. Lien, "Analysis of power output for piezoelectric energy harvesting systems", Smart Materials and Structures 15 (2006), pp. 1499-1512

[3] Allen, J. J. & Smits, A. J. (2001). Energy harvesting eel, In: *Journal of Fluids and Structures*, Vol.15, pp. 629-640, ISSN 0889-9746

[4] Guilar, N.; Chen, A.; Kleeburg, T. and Amirtharajah, R. "Integrated solar energy harvesting and storage." *In: International symposium on low power electronics and design – 2006 (ISLPED '06),* Tegernsee, Germany, pp. 20-24, 2006.

[5] John JohnTherampilly, *Energy harvesting from multiple sources for Battery charging*. March 2012.

[6] T. Dikshit, D. Shrivastava, A. Gorey, A. Gupta, P. Parandka, S. Katiyal, "Energy Harvesting via Piezoelectricity" , *proceedings of the 4thNational Conference; INDIACom-2010*, 25 – 26 February, 2010.