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Piezocantilever Based Structure Health Monitoring

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Abstract - At present, a great deal of research effort has been directed to finding eco-friendly and renewable sources of energy. With the rising costs of crude oil and petroleum, along with the derogatory effects that they pose to the environment, this sort of approach is of utmost importance. This has also led to the search for alternate methods of transforming the various forms of energy into electrical form. Popular renewable energy sources such as hydropower, solar power and wind power require massive financial investments, give comparatively much lower power output, and have a low scale of efficiency. Walking is the most common activity in day to day life. When a person walks, he loses energy to the road surface in the form of impact, vibration, sound etc, due to the transfer of his weight on to the road surface, through foot falls on the ground during every step. This energy can be tapped and converted in the usable form such as in electrical form. Piezoelectric materials are by far, one of the most efficient transducer elements to accomplish this task. Over the last decade many piezoelectric elements, both natural and artificial, have been found. They have, however, been mostly used for applications with a low power generation, in the range of μW to mW. This paper presents a suggestion to expand the field of piezoelectricity generation to other areas for large scale electrical power generation. Many other methods are possible, and some of the promising ones are mentioned in this paper.

Keywords – **Piezoelectric materials, piezoelectricity, Power generation, sensors, PZT.**

I. INTRODUCTION

Mechanical stresses applied to piezoelectric materials distort internal dipole moments and generate electrical potentials (voltages) in direct proportion to the applied forces. These same crystalline materials also lengthen or shorten in direct Proportion to the magnitude and polarity of applied electric fields. Because of these properties, these materials have long been used as sensors and actuators. Piezoelectricity refers to the ability of a material to produce a charge separation along its surface upon application of mechanical strain. A type of dipole is created in the material and this result in a potential difference across its ends. The piezoelectric effect is the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry. In this paper we are generating electrical power as non-conventional method by simply walking or running on the foot step. Non-conventional energy system is very essential at this time to our nation. This system converts waste mechanical energy into useful electric energy. The word piezoelectricity means electricity resulting from pressure. A property certain materials have to generate an electric current when they are squeezed or pressed. For example, lead zircon ate titanate crystals will generate measurable piezoelectricity when their static structure is deformed by about 0.1% of the original dimension. Conversely, those same crystals will change about 0.1% of their static dimension when an external electric field is applied to the material.

II. RESEARCH ELABORATIONS

The word piezoelectricity means electricity resulting from pressure. It is derived from the Greek piezo or (piezein), which means to squeeze or press (electric or electron), which stands for amber, an ancient source of electric charge. Piezoelectricity was discovered in 1880 by French physicists Jacques and Pierre Curie. This effect describes the association between mechanical stress and electrical voltage in solids. In fact, it is often defined as the bridge between electrostatics and mechanics.The piezoelectric effect can only happen in certain materials that are nonconductive. These materials are manufactured very small to the size of nano-particles, and they make up two main groups which are crystals and ceramics. When pressure is applied to these nano-particles, the symmetry of the crystal structure is inverted creating a nonzero dipole moment within the lattice structure. This process is demonstrated by the picture below:

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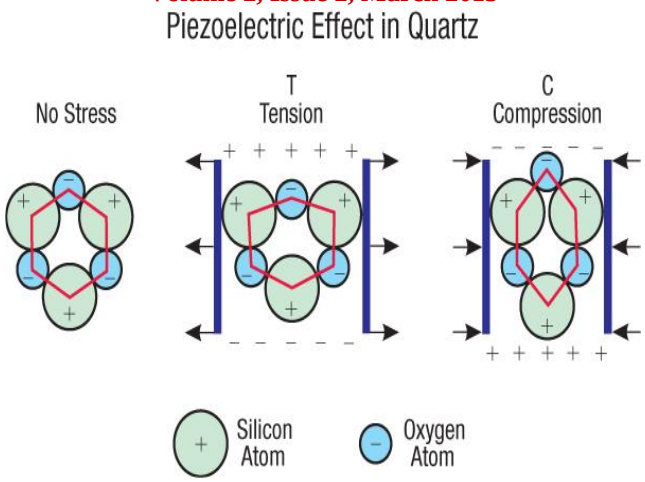

Fig 1: Effect in piezo-electric Crystal due to stress

Piezoelectric crystals are one of many small scale energy sources. Whenever piezoelectric crystals are mechanically deformed or subject to vibration they generate a small voltage, commonly known as piezoelectricity. The ability of certain crystals to generate Piezoelectricity in response to applied mechanical stress is reversible in that piezoelectric crystal, when subjected to an externally applied voltage, can change shape by a small amount.

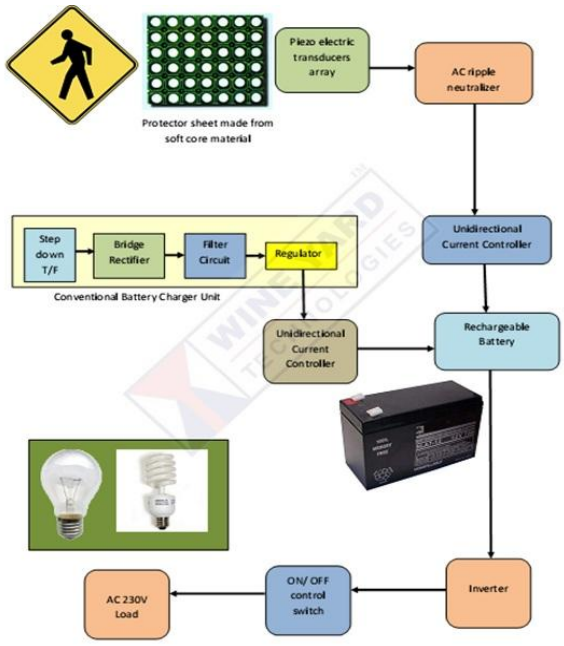

Fig 2: Diagram of Power Generation

A crystal having approx 5cm^2 can generate up to 5 to 6 volts, more voltage can be generated when an array of crystals is made. This voltage can be increased by using amplifier. There are following research areas in this project-

1. We can research on generating more energy by using minimum size of piezo-electric crystal. Because we know that one piezo-electric produces more voltage but very less current, so overall power is very less. So, for generating more power we use more than one piezo-electric crystals about three crystals, such that overall power increased.
2. Another one is the implementation of foot step power generation like in structural health monitoring. It is used to find out cracks in bridges and buildings.

For SHM implementation, we can use PIC-16F73 Microcontroller which is basically used for interfacing between Sensors and Relays through which we can perform many operations like as Alarm ring, DC Motor etc.

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3. Main research area is the interfacing of sensor which is used in SHM with monitor for showing graphs. For interfacing Sensors with microcontroller, we use port A of PIC-16F73 microcontroller because Port A has Analog to Digital Converter which convert analogous data from graph of sensors to Digital form which is accepted by microcontroller.

III. HARDWARE

Hardware Implementation of this system contains many components. The main component is piezoelectric crystal which is pressure sensitive. An array of these crystals is used to generate more voltage. This generated voltage is A.C. so bridge rectifier is used for D.C. and filters are used to remove the noise. A microcontroller is used to control whole the operation so to operate microcontroller voltage is regulated to 5 volt by voltage regulator IC. This microcontroller drives all other components like relays, LCD, sensors. For storing purpose a D.C. battery can be used.

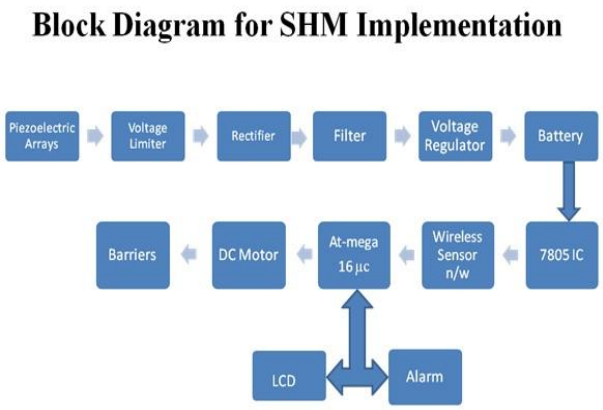

Fig 3: Block Diagram of SHM

IV. WORKING

- We get 12V AC voltage from crystal and convert this into DC with the help of Rectifier (By using four Diodes from D1 to D4).
- After this, we get 12V and 5V regulated voltage supply by using 7812 and 7805 regulators respectively.
- We use three sensors (Vibration Sensor, Weight Sensor and Strain gauge Sensor) at port A of microcontroller PIC 16F73. These Sensors gives information about the condition of bridge in the form of graphs in the form of their related parameters.
- Now, we can perform many operations from microcontroller like connect LCD, USART connection, and relays.
- We perform USART by using IC MAX232, thus IC is the Serial Connector, and this IC is used for the interfacing of microcontroller with computer.

For interfacing of sensors, LCD and relay software is also required so we used CV-AVR for this purpose. The code wizard AVR simplifies the task of writing start-up code for different microcontrollers. The Code Vision AVR C Compiler produces files in a format which is compatible with the Atmel simulator/debugger program which they call Studio and whose running program is AvrDebug.exe. This software uses C language for writing the code. Now for SHM we are using load sensor (strain gauge), is a transducer that is used to convert a force into electrical signal. This conversion is indirect and happens in two stages. Through a mechanical arrangement, the force being sensed deforms a strain gauge. The strain gauge measures the deformation (strain) as an electrical signal, because the strain changes the effective electrical resistance of the wire.

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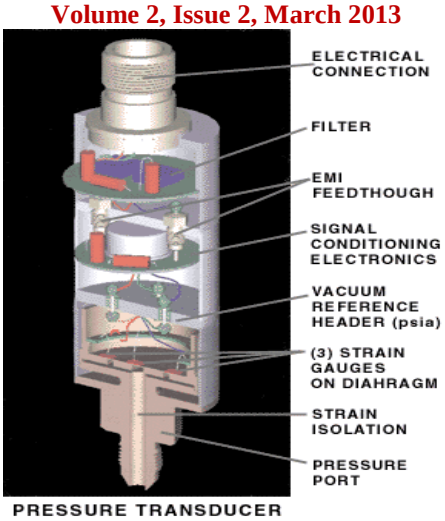

Fig 4: pressure (load) sensor

Critical applications require fast responses of pressure sensing devices. Response to pressure is typically 1000 Hz or better for all strain gauge types. This type of stain gauge has a usable range of -452°F to 550°F in some designs and up to 750°F for short durations. Maximum weight limit is defined at the time of manufacturing for each sensor generally.

V. APPLICATIONS

- Real time monitoring of structures is an excellent field of application for wireless sensor networks.
- Generation of electricity from non-conventional method.
- Structural Health Magnitudes: Loads, fatigue, vibration, crack evolution.
- Structural Health Monitoring for Bridges.
- Railway stations, metro platforms to generate energy.

VI. MERITS & DEMERITS

- This is a cost effective concept of energy generation comparing with traditional method because there is no need of extra energy like fuel, water, sun light etc.
- Piezoelectric crystals are the sources of renewable energy but a single crystal produce very less energy.
- There are many heavy bridges in world and damages occurs due to heavy load or by earthquakes so SHM can monitor the cracks and can define the maximum limit of the load.

VII. CONCLUSION

As India is a developing country so we are to do something innovative which leads our country to top of the list of developed nations. This paper"PIEZOCANTILEVER BASED STRUCTURAL HEALTH MONOTERING" is very helpful economical, and affordable damage preventing solution with a special feature of man made power supply. In non living areas power management is big challenge for SHM purpose, but now we have successfully tested and implemented this concept. This concept can be used for many applications which are discussed a later. With the help of this concept we can implement the SHM also in rural and non-living areas. Using this concept we can also drive both A.C. as well as D.C loads according to the force we applied on the piezo electric sensor.

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