ENERGY HARVESTING USING PRESSURE POWER GENERATION

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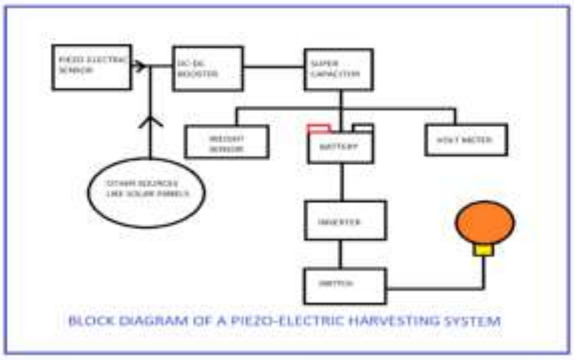
Abstract - *A piezoelectric sensor is a device that uses the piezoelectric effect to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge. The prefix piezo is Greek for `press' or `squeeze'. We are going to create a project on energy harvesting using piezoelectric sensor in which we are going to use a matrix of piezo electric sensors which will generate in response to the pressure applied on the devices or sensors which will be stored in a battery so that it can be used run various appliances.*

***Key Words*: Piezo, press, squeeze**

1. INTRODUCTION

The pyroelectric effect, by which a material generates an electric potential in response to a temperature change, was studied by Carl Linnaeus and Franz Aepinus in the mid-18th century. Drawing on this knowledge, both Rene Just Hauy and Antoine Cesar Becquerel posited a relationship between mechanical stress and electric charge; however, experiments by both proved inconclusive. View of piezo crystal in the top of a Curie compensator in the Museum of Scotland. The first demonstration of the direct piezoelectric effect was in 1880 by the brothers Pierre Curie and Jacques Curie. They combined their knowledge of pyro electricity with their understanding of the underlying crystal structures that gave rise to pyroelectricity to predict crystal behavior, and demonstrated the effect using crystals of tourmaline, quartz, topaz, cane sugar, and Rochelle salt (sodium potassium tartrate tetra hydrate). Quartz and Rochelle salt exhibited the most piezoelectricity. The Curies, however, did not predict the converse piezoelectric effect. The converse effect was mathematically deduced from fundamental thermodynamic principles by Gabriel Lippmann in 1881.The Curies immediately confirmed the existence of the converse effect, and went on to obtain quantitative proof of the complete reversibility of electro-elasto-mechanical deformations in piezoelectric crystals. For the next few decades, piezoelectricity remained something of a laboratory curiosity, though it was a vital tool in the discovery of polonium and radium by Pierre and Marie Curie in 1898. More work was done to explore and define the crystal structures that exhibited piezoelectricity. This culminated in 1910 with the publication of Waldemar Voigt's Lehrbuch der Kristallphysik (Textbook on Crystal Physics), which described the 20 natural crystal classes capable of piezoelectricity, and rigorously defined the piezoelectric constants using tensor analysis. The first practical application for piezoelectric devices was sonar, first developed during World War I. In France in 1917, Paul Langevin and his coworkers developed an ultrasonic submarine detector. The detector consisted of a transducer, made of thin quartz crystals carefully glued between two steel plates, and a hydrophone to detect the returned echo. By emitting a high- frequency pulse from the transducer, and measuring the amount of time it takes to hear an echo from the sound waves bouncing off an object, one can calculate the distance to that object.

2. BLOCK DIAGRAM & WORKING:



BLOCK DIAGRAM OF A PIEZO-ELECTRIC HARVESTING SYSTEM

The faces of piezoelectric material, usual quartz, is coated with a thin layer of conducting material such as silver. When stress has applied the ions in the material move towards one of the conducting surface while moving away from the other. This results in the generation of charge. This charge is used for calibration of stress. The polarity of the produced charge depends upon the direction of the applied stress. Stress can be applied in two forms as Compressive stress and Tensile stress.

3. HARDWARE DESCRIPTION:

1. Piezo-sensor
2. Adder Circuit
3.18650 battery
4. Capacitor (100V, 100microF/100V, 50microF)
5. Bridge rectifier W04/w05
6. 1N4007 diode
7. Switch
8. Single core wire
9. Regulator IC
10. Protection Board
11. LED
12. Zener Diode(15V)

3.1 Bridge Rectifier:

A Bridge rectifier is an Alternating Current (AC) to Direct Current (DC) converter that rectifies mains AC input to DC output. Bridge Rectifiers are widely used in power supplies that provide necessary DC voltage for the electronic components or devices. They can be constructed with four or more diodes or any other controlled solid-state switches. The W04 is a 4-pin 400V 1-phase through-hole Silicon Bridge Rectifier Diode for use with the printed circuit board.

3.2 Use of an 18650 Cell:

The 18650 Cell is a Li-ion type battery which has found its application in many fields such as Portable electronics like torch lights, Electric Vehicles/Cars like Tesla and much more. The main reason for this battery being successful is its properties compared to its competitors. These properties include current carrying capability, voltage, cycle life, storage life, safety, and operating temperature and much more. Below table shows the comparison between popular batteries for key parameters.

3.3 Capacitor:

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals.

In our project we are using two types of capacitors, 50V100uF and 100V100uF.

Diode:
1N4007 is a PN junction rectifier diode. These types of diodes allow only the flow of electrical current in one direction only. So, it can be used for the conversion of AC power to DC. 1N 4007 is electrically compatible with other rectifier diodes and can be used instead of any of the diode belonging to 1N400X series.

3.4 Zener Diode:

A Zener diode is a type of diode that allows current to flow in the conventional manner - from its anode to its cathode i.e. when the anode is positive with respect to the cathode. When the voltage across the terminals is reversed and the potential reaches the *Zener voltage* (or "knee"), the junction will break down and current will flow in the reverse direction - a desired characteristic. In our project we are using zener to minimize extra voltage coming from the capacitor. In sense, we are using a 15 volt zener to allow only 15 volts to the protection board. Since most of the DC appliances require 5 to 12 volts to operate.

3.5 Protection Board:

Built-in high precision voltage detection circuit. Connect to the charger terminals which uses high pressure device. Built-in three over current detection circuit (1 over current, 2 over current, load short circuit). Through the MOS tube, it can control the battery charging and discharging. Low standby current consumption.

Properties of the lithium battery protection board Model: HH - P3-10.8 Charging voltage range: 4.25-4.35 v + / - 0.05 v Size: 48 * 15 * 1.0 mm Discharge voltage range: 2.5 + / - 0.05 v to 3.0 v Maximum working current: 3A Working temperature: - 40 - + 50 deg C Maximum instantaneous current: 4-6A Storage conditions: - 40 - + 80 °CStatic electricity: less than 6uA Useful life time: more than 50000 hours Resistance: less than 45 m Ω Short circuit protection: can protect, need charging.

4. PROCEDURE:

We made a matrix of piezo sensors in a manner of 7x5 matrix, connected it to the rectifier IC W04. Then, we connected it to the 50V100uF capacitor. The voltage generated by the sensors was stored in the capacitor. The charge held by the capacitor was forwarded to the adder circuit, which contains three 1k resistors connected in parallel to the one 10k resistor. The purpose of two more 1k resistors were so that we can add two more matrix of piezo sensors. Then one 100v100uF capacitor was connected in parallel with the zener and resistor. The other side of zener was connected to the one side of switch. On the other side of the switch is the protection board. The output of the protection board was connected to the battery circuit which also had two switches one is to connect to the 15V rail of LEDs and the other to the USB port to charge mobile devices.

5. OBSERVATION:

The piezo sensors were generating the voltage more effectively when constant pressure was being applied on its surface. We observed that no matter how many piezo sensors we used, it does not produce more voltage rather than adding more piezo sensors, a rapid tapping on piezo sensors would produce voltage rapidly. The drawback was we couldn’t get more or desired current by simply adding piezo sensors. Then we came to know that to produce more current there are different piezo sensors which are made of different materials are used. But our purpose was to store the energy, not to use it in instantaneous manner which these piezo sensors are doing efficiently.

6. CONCLUSIONS

Flexible piezoelectric materials are attractive for power harvesting applications because of their ability to withstand large amounts of strain.

PZT materials that can convert the ambient vibrations energy surrounding them into electrical energy. This electrical energy can 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 batteries as power supplies for these wireless electronics.

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