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Design and Analysis of Energy Generation from Piezo Harvesting Device

[1] Diksha Khuje, [2] Pranali F. Kokate, [3] Ketan N. Kinhekar, [4] Sagar Bhaisare
K.D.K.C.E, Nagpur, Dept. of Electrical, Engineering

***Abstract*: -- Power energy requirement requires a huge amount of alternate sources of energy to fill up the large gap between demand and supply of electricity, also they should be clean, environment-friendly and sustainable. With the increase in demand, the use of nonrenewable energy sources is also increased due to this lots of energy sources are exhausted. This paper focuses on power generation through power harvesting device as there are different power harvesting devices which are used to generate energy from surroundings such as piezoelectric, electromagnetic, solar, flowing water etc. Out of such devices, piezoelectric power generation is one such device which is used to extract energy by means of mechanical force and vibrations. Piezoelectric materials have the ability to build up an electric charge from pressure and strain applies to them.**

***Keywords:* - Power harvesting device, piezoelectric sensor, Vibration, Energy Conversion, Energy Storage.**

I. INTRODUCTION

Over the past decades, the demand of electrical energy is increasing continuously. As the demand was increased the use of non-conventional energy was also increased. Due to this lot of energy was exhausted, and wasted. At present, there are many sources which are used to generate electricity but the energy generation should be clean and safe. Exploring the possibilities of renewable, sustainable, green energy sources to replace fossil fuels is one of the most significant and challenging issues in past because of air/water pollution and oil depletion due to the use of fossil fuels. Now, renewable forms of energy such as sunlight, wind, tides/waves, geothermal heat have been extensively used as a alternative form of energy sources. These sources are continuously use to generate electricity. But over the past decades, the piezoelectric and turboelectric effects for harvesting mechanical energy, the piezoelectric and thermoelectric effects for harvesting thermal energy, and the photovoltaic (PV) effect for harvesting solar energy, have been extensively studied for practical applications. These energy technologies are simply classified by their different energy conversion mechanisms, but the aim of all the energy harvesters is the conversion of wasted environmental energy to electricity. Nevertheless, all of the energy harvesters utilize only one type of energy, with the other types wasted. A PV cell, for example, is only designed to generate electricity under light illumination, and efficiency will be dramatically decreased under room light in indoor situations where sunlight is not available. Furthermore, thermal energy also appears in conjunction with mechanical and light energy. Since micro/nano scale smart systems can work under complicated environments and conditions, the use of only one type of energy harvester is insufficient to drive their operation. Thus, it is highly desirable to integrate energy harvesters so as to accumulate multiple types of energy for conversion into electricity, so that waste energy can be fully utilized and smart systems can be powered at any time and in any place. So, we are using piezoelectric sensor as an energy harvesting device which can convert mechanical energy into an electrical energy.

II. PIEZOELECTRIC EFFECT

Piezoelectric effect is one of the suitable methods to generate electricity from surrounding using piezoelectric crystal. So, converting mechanical force and vibration into an electrical output is known as piezoelectric effect. Piezoelectricity is one of the small scale energy sources which are subjected to generate voltage from vibration and force. Piezoelectric effect exists in two properties: The first is the direct piezoelectric effect that describes the materials ability to transform mechanical strain into electrical charge. The second form is the converse effect, which is the ability to convert an applied electrical potential into mechanical strain energy. These properties allow the material to function as a power harvesting medium.

III. SYSTEM DESIGN

When human pressure is applied on the piezoelectric discs, a reasonable voltage is produced as proportional to displacement of piezoelectric material. The ac signal with high frequency is converted into dc for application purpose. The increase in number of discs causes higher generated voltage. The output of piezoelectric discs is stored in 12 volt battery after that inverter circuit convert dc voltage into ac voltage and output is given to the load. The load we are considering is only lightning load. Fig.1 shows the block diagram of whole system.

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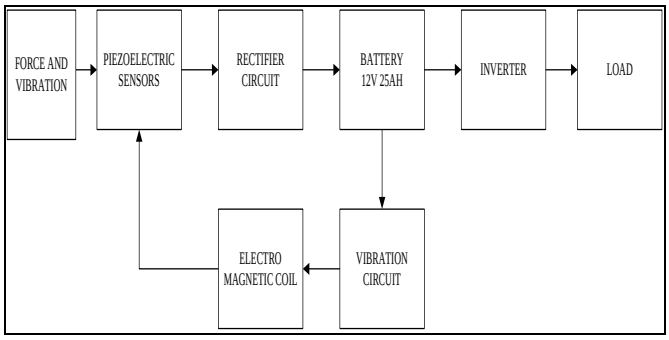

Fig.1 Block Diagram

IV. SYSTEM COMPONENTS LOAD

A. LOAD

The load we are considered is lightning load of our Electrical Departmental Library of our college. So, we are using Dialux software which is used to calculate, visualize the light intensity of single room, floor, office etc. Therefore, by using this software we are calculating the light intensity and luminous lux required for the load which is shown in fig.3.We are using 20 watt led tube light and average lumens produce by single Led is 125 lumens per watt. According to that we are calculating the total lux required for our load. Here fig.2 shows the luminous intensity of room by using Dialux software in which Green region shows the lux between 250-300 and Blue region shows the light intensity in between 190-230lux. And energy consumption is between 470-590 kwh/A obtain from the LED lightning. So, by using this software we get a overall calculation of our load i.e electrical departmental library.

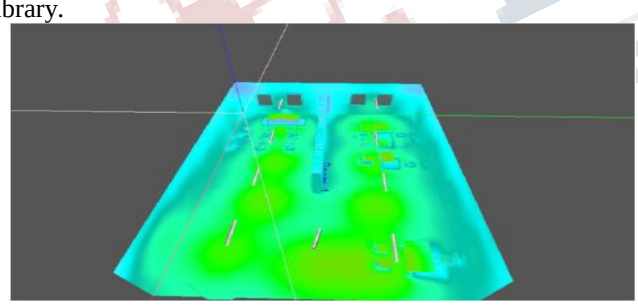

FIG.2 DIALUX SOFTWARE SHOWING LUMINOUS INTENSITY OF ROOM [11]

B. PIEZO CALCULATION

As, we are using piezoelectric sensors as harvesting device.
Then, we can calculate output of required load.
Piezo sensor power generating varies with different steps, get
Minimum voltage = 1V per step
Maximum voltage = 3V per step
So, we are connecting no. of piezo discs in series parallel combination to generate the voltage.
Our load requirement is 230 V.
Considering the steps of a 50 kg weighted single person, the average calculation is:
If it takes 800 steps to increase 1V charge in battery.
So, to increase 12 V in battery total steps needed
= (12*800)
=9600steps
As we will implement our project in a populated area where foot steps as a source will available.

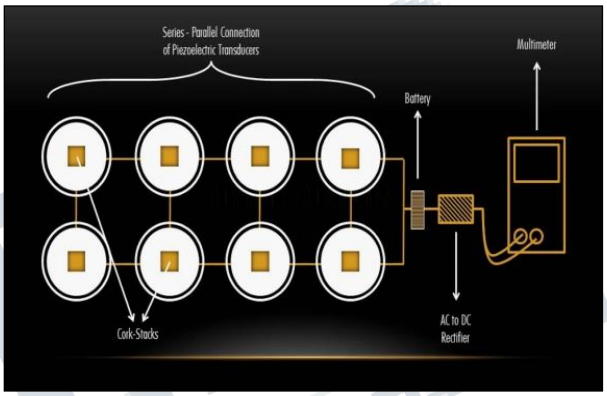

FIG.3 SERIES PARALLEL CONNECTIONS OF PIEZOELECTRIC DISCS[7]

C. SYSTEM REPRESENTATION

Fig.3 shows the whole circuit representation of design. It consists of control circuit and vibration circuit. Control circuits consist of rectifier which converts extracted energy from vibration and force by using piezoelectric disc into dc output voltage. And the output voltage is stored in battery but for continuous vibration some output is given to vibration circuit. Here we are using vibration circuit to get a continuous output from piezoelectric discs. For vibration circuit we are using voltage regulator, IC555 timer and decoder counter. The output of vibration circuit is given to plunger which is used for vibration and output comes from that is stored in battery.

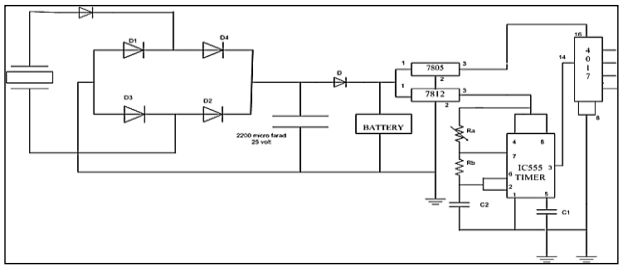

FIG.3 CONTROL AND VIBRATION CIRCUIT OF SYSTEM[5]

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1.Rectifier

Full-bridge rectifier is commonly used as rectifier circuits to convert the AC output of a piezoelectric into a DC voltage. The rectifying circuits consist of 4 diodes. The voltage needs to rectify due to the need for constant supply of voltage light up the LED placed at load.

2. Filter

Capacitors are used as a filter to remove AC components from sensor's output voltage. Capacitors act as a short circuit for AC voltages and an open circuit for DC voltages. The output of the filter is given to unidirectional current controller.

3.Voltage Regulator

As the name implies that, it is a device which regulates the voltage level or voltage regulator is a device which gives a stable output voltage. So, we are using two voltage regulator i.e. IC7802 and 7812 which comes in 78xx family. Voltage regulator can gives 12 volt dc output voltage and 7812 gives a 5volt dc output voltage.

4. IC555 Timer

555 timer is an integrated circuit or chip which is used in variety of timer, pulse generator and oscillator applications. The 555 timer can be used to provide time delay as an oscillator and flip-flop movement. 555timer need 5v dc supply voltage for operation. And output produce by IC555 timer rectangular sine wave.

5. Decoder Counter 4017

IC 4017 is a decoder counter which is used for counting low range applications. It can count from zero to ten and its output voltage is decoded. IC 4017 is a 16 pin integrated chip in which 10 pins are used for output. The 555 IC will operate in astable mode with a frequency of 14Hz. The 555 IC in the circuit is used as a clock pulse generator to provide input clock pulses to the counter IC4017. The IC555 in the circuit operates at a frequency of 14Hz, which means that it produces about 14 clock pulses every second to the IC4017.

D. COMPLETE SET UP

The setup consists of the above elements with inclusion of battery and inverter.

1. Battery

Battery is an electro chemical cell that can be charged electrically to provide a static potential for power or released electrical charged when needed. As per our load requirement we select the battery of 12volt 25Ah. And the output comes from piezoelectric sensor is stored in battery. Max. load the battery can sustain is 300 watt as per load demand.

2. Inverter

Inverter is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. The inverter we are using is 200VA which can convert output from battery which is dc into an ac supply.

After completion of above said representation the expected output we are considered is 200watt for lightning load.

IV.CONCLUSION

Power harvesting is the reliable option to generate the electricity. As there are different power harvesting devices which are used to generate electricity out of such device piezoelectric technology is one such device which are use to generate electricity from mechanical force and vibration. And the energy generation from such a source is very useful. From this paper we focus on piezoelectric energy technology to generate energy and load we are considering is lighting load of electrical library.

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