

GENERATION OF ELECTRICITY USING PIEZO-ELECTRIC EFFECT

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Abstract : Man has needed and used energy at an increasing rate for the sustenance and well-being since time immemorial. Due to this a lot of energy resources have been exhausted. Proposal for the utilization of waste energy of foot power with human locomotion is very much relevant and important for highly populated countries like India where the railway station, temples etc., are overcrowded all round the clock. When the flooring is engineered with piezo-electric technology, the electrical energy produced by the pressure is captured by floor sensors and converted to an electrical charge by piezo transducers, then stored and used as a power source. This power source has many applications agriculture, home application and street lighting and as energy source for sensors in remote locations.

IndexTerms - Piezo-Electric effect, PZT, PVDF, Bridge rectifier, Load.

I. INTRODUCTION

The depletion of the fossil fuels has affected in the generation of electricity and the price of petroleum, which in turn affect the worldwide economics. This has forced an increase in the price of other items including food, import duty etc. In India, there is an increase in demand for petroleum products by 5.5% compared to last year. Indian mainly depend on the petroleum products to generate electricity. Besides, petroleum as a source of electrical energy has contributed in severe environmental pollution. Therefore, the search for alternate sources for the generation of electricity has become an important aspect now-a-days. Other main sources for the generation of electricity are nuclear and hydro-electric power plants. However, these options require more initial cost and maintenance cost. Solar and wind energy power plants are also expensive. Generation of electricity using Piezo-Electric crystals is a new and innovative method of power generation. This works with the principle of "Piezo-Electric effect", in which specific materials have the capacity to generate an electric charge in response to applied mechanical stress. The mechanical energy produced by human locomotion or vehicle movement is utilized to generate electric energy, which can be used in domestic low power lighting, for running low power consumption electronic products and can be stored for further use.

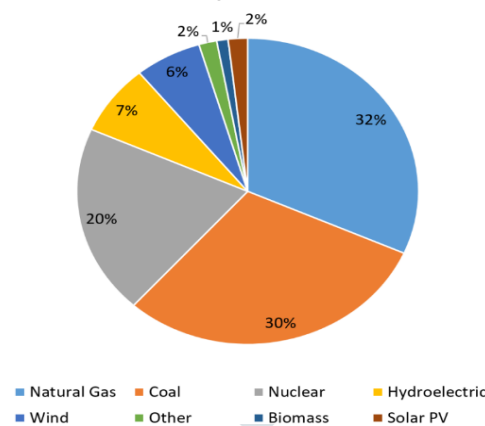


Fig 1. World Power generation pie chart.

II. PROJECT ELABORATIONS

(a) PIEZO-ELECTRIC EFFECT

The Piezo-electric effect is the generation of electrical potential across the sides of a crystal when subjected to mechanical stress. Normally, the charges in a piezo-electric crystal are exactly balanced, even if they are not symmetrically arranged. The effects of the charges exactly cancel out, leaving no net charge on the crystal faces. If the crystal comes under any kind of mechanical stress, the charges go out of balance. Now the effects of the charges no longer cancel one another out and net positive and negative charges appear on opposite crystal faces. By applying the force on the crystal, voltage across the crystal is produced.

(b) STUDY OF PIEZO MATERIALS

Piezo-electric materials are Ferroelectric material crystals which are polar without an electric field being applied. The piezo-electric effect is common in piezo ceramics like Lead Titanate (PbTiO_3), Lead Zirconate Titanate (PZT), and Polyvinylidene Fluoride (PVDF). The main component of the project is the piezo-electric material. The proper choice of piezo material is of prime importance. For this, an analysis on most commonly available piezoelectric material – PZT was done. The criterion for selection was better output voltage for various pressures applied. In order to understand the output corresponding to the various forces applied, the V-I characteristics of PZT was plotted. For this the Piezo transducer material under test is placed on a Piezo force sensor. Voltmeters are connected across both of them for measuring voltages and an ammeter is connected to measure the current. As varying forces are

applied on the Piezo material, different voltage readings corresponding to force is displayed from the literature it is learnt that PZT module gives 5 times more voltage than the PVDF module.

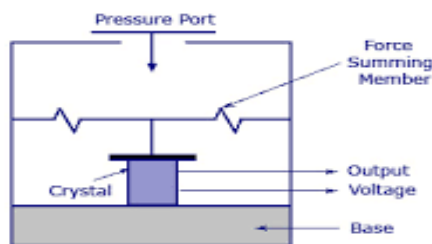


Fig 2: Piezo-Electric Transducer

(c) STUDY OF CONNECTIONS

To determine the kind of connection that gives appreciable voltage and current necessary, 6 PZTs are connected in series. A voltmeter is connected to this series combination. As varying forces are applied on this connection, corresponding voltages are noted. Also, voltage generated across the series connection and the current is measured. Similarly, the connections are done for parallel and series-parallel combinations. The voltage from a series connection is good but the current obtained is poor, whereas the current from a parallel connection is good but the voltage is poor. This problem is rectified in a series-parallel connection where a good voltage as well as current is obtained.

III. HARDWARE IMPLEMENTATION

The hardware set up is as shown in the Fig 3. A mat is made up of piezo material. The voltage generated across a piezo mat is supplied to a rectifier circuit followed with a filter circuit. Thus obtained output is given to battery for it to charge and supply the dc loads. Voltage generated is also given to an inverter, from where it is supplied to all the ac loads. A LCD is interfaced to mat using PIC microcontroller to display voltage generated across piezo mat.

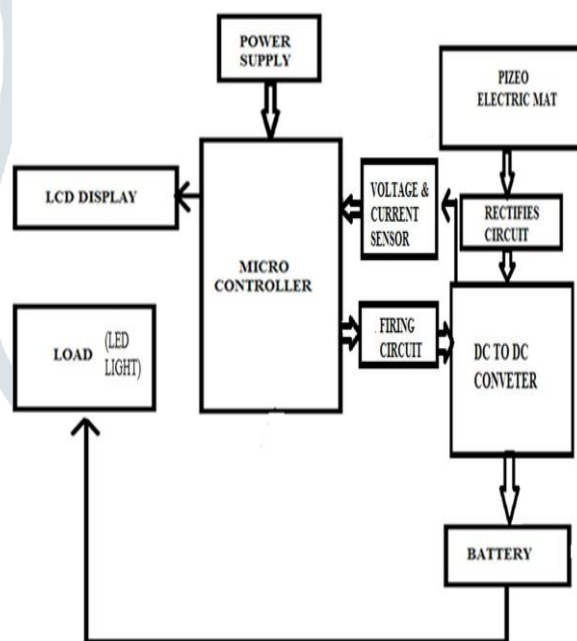


Fig 3: Hardware Setup

IV. WORKING

The piezoelectric material converts pressure applied to it into electrical energy. The source of pressure can be either from weight of the moving vehicles or from the weight of people walking over it. The output of the piezoelectric material is not a steady one. A bridge circuit is used to convert this variable voltage into linear one. Again an AC ripple filter is used to filter out any further fluctuations in output. The output dc voltage is then stored in a rechargeable battery. As the power output from a single piezo-film was extremely low, combination of few piezo films was investigated.

Two possible connections were tested - parallel and series connections. The parallel connection did not show significant increase in the voltage output. Series connection with additional piezo-film resulted in increased voltage output but not in linear proportion. So here a combination of both parallel and series connection is employed for producing 30V voltage output with high current density. Battery provisions are provided to connect dc load. An inverter is connected to battery to provide provision to connect AC load. The voltage produced across the tile can be seen in a LCD. For this purpose, microcontroller PIC16F877A is used. The microcontroller uses a crystal oscillator for its operation. The output of the microcontroller is then given to the LCD which then displays the voltage levels.

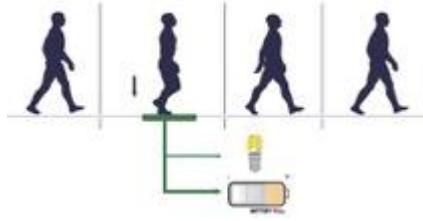


Fig 4: Schematic representation of the working model

The inverter used in this circuit uses the TLP 250IC as a MOSFET driver. It is used to convert the DC voltage stored in the battery to AC voltage. TLP 250IC produces two pulse trains phase shifted by 180° . These pulse trains are used to switch transistors configured in common emitter mode producing pulse trains of 12V, which is capable of switching a MOSFET. The sources of the two MOSFETs used in the inverter circuit are supplied with a 12V supply. When the MOSFETs are switched on by the outputs of transistors, two output pulses of 12V are obtained. These pulses are connected to a step up transformer from whose high voltage side 220V AC supply is obtained.



Fig 5: Working model

V. RESULTS AND DISCUSSION

People whose weight varied from 40kg to 75 kg were made to walk on the piezo mat to test the voltage generating capacity of the Piezo mat. The relation between the weight of the person and power generated is plotted in the below figure. From the graph it can be seen that, maximum voltage is generated when maximum weight/force is applied. Thus, maximum voltage of 40V is generated across the tile when a weight of 75 Kg is applied on the mat.

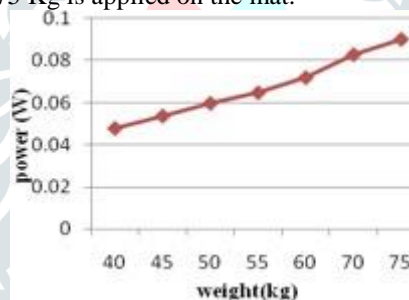


Fig 6: Weight v/s Power graph of piezo tile

VI. FUTURE SCOPE

The installation of piezoelectric crystals at floorings would generate enough power to light up lights of houses as well as air circulation systems. Use of piezoelectric crystals has been started and positive results are obtained. With further advancement in field of electronics, better synthesized piezoelectric crystals and better selection of place of installations, more electricity can be generated and it can be viewed as a next promising source of generating electricity.

VII. CONCLUSION

Piezo-Electric devices have an advantage over the conventional resources, as their versatility in application of power generation makes them considerable over electrically powered devices. Since the voltage obtained from a Piezo-Electric transducer is AC, rectification is needed to be done for loading purpose. As the current obtained by a single Piezo-Electric transducer is low, sensors are connected in series-parallel combination. A total of 40V with high current density is obtained. It is especially suited for implementation in crowded areas.

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