# Pressure Difference Based Electric Power Generator

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***Abstract***- *Electric power generation is indispensable in day today life. It is very much necessary to generate electricity from any sought of sources. The sources which produce electricity should be available daily with less return on investment. The sources should also possess the following features such as pollution free, reduced dependence on fossil fuels, easy installation and use battery for extra power, safer than traditional electric power generation and it should be renewable. The piezo electric power generation is one of such a kind. The piezoelectric sensor generates electricity for every mechanical input from the source. The piezo electric sensors generates electricity with less power. In order of obtaining more power, this generated electricity should be converted to dc and the output voltage should be buck or boosted depending on the output voltage needed. Hence in this paper, the analysis while designing the electric power generator is discussed, the simulation results are discussed and the hardware implementation is also discussed in detail.*

***Keywords***- Piezo electric power generator, buck boost operation, renewable electric, power generation.

## I. INTRODUCTION

One of the leading sources of pollution in today's world is carbon dioxide which is from sources such as fossil fuels, in proper handling of waste materials and incineration of chemical waste which leads to effects such as rapid rise in the sea level, air pollution and a numerous other health and environmental hazards. Various sources predict that 30 years down the lane, there will be a 0.7m of rise in sea level compared to the level now. It is also predicted many islands will disappear due to this constant level of rise. Hence the movement to renewable energy sources is going on in full swing and is expected to be the primary source of power generation in the years to come. But the most important point is that the performance is yet to reach a level of satisfaction.

In the coming years, devices and gadgets that run on low power will come into trend. The future will be low powered devices that are not only consuming lesser power but also much smaller in size. The current trends in research has shifted towards low powered devices and scientists are looking for ways to produce power from places where it is being wasted and free roaming. One such method of generation of power is piezoelectricity. Piezoelectricity is producing an electrical energy from a mechanical movement. It mainly works on creating electricity from the pressure generated from various sources such as the human body and the environment around us. This piezoelectric energy can be incorporated with the other conventional sources like wind and solar so as to provide a backup power generation system or can act as a dual power generation source along with the other renewable energy sources. The basic block of a piezoelectric system is an AC source connected to a capacitor in parallel, this kind of set up helps us to have a wide range of amplitude. The system can be used to feed both AC and DC and hence the system must include a rectifier and an inverter. This system will host both a DC which will be converted from AC through a rectifier and also an AC from a DC with the help of an inverter. Hence with the help of a rectifier we can feed the power to electronic equipment's and with the help of an inverter we can serve energy to AC sources like lights and fans. Coupling the system with converters such as a buck-boost, the levels of the DC can be increased and decreased according to the requirements. Further, the system can be coupled to an inverter so as to convert the bucked or boosted DC level into an AC voltage. Many application and analysis using piezo electric sensors have been discussed in the past years, Developing as a hardware model for conventional purpose is indispensable. In [1] Renato Cali ò et al, has reviewed the piezo electric harvesting based on power density and bandwidth.in [2] Sreenidhi Prabha Rajeev et al, has discussed an hardware model of an piezo electric power generator using piezo tribo-ferro electric sensor and the various analysis of the system is also discussed. In [3] Mohammed Riaz et al, discussed a technology of designing piezo electric sensor designing with help of ZnO nanowire in various substrates. The nano material behavior on various application medium is discussed in detail. In [4] Ahmadreza Tabesh et al, designed a piezo electric power generator with the help of voltage double rectifier, a stepping down switch converter and an analog controller is designed and implemented in hardware. In [5] S.Edward Rajan et al, the performance of various rectifiers in the piezo electric power generator is analyzed and the results are compared and discussed in detail. In [6] Shohei YAMAGISHI et al designed an piezo electric sensor using zirconate titanate and their performance are evaluated and analyzed. In [7] S.Edward Rajan et al, the performance of various choppers in design of piezo electric power generator is analyzed and the results are

compared. In [8] RAMCHAND M et al, discussed an security control algorithm in the form of study. This security system protects the battery discharge from getting drained. In [9] Canan Dagdeviren et al, after doing an open heart surgery the heart is helped with help of diaphragm. Hence for complete operation of diaphragm we should harvest energy. This is done by fitting a piezo electric sensor on surroundings of the heart. In the above paper, they have designed and implemented the system in hard ware for human being. In [10] Hassan Elahi et al, has reviewed the various mechanisms using which the piezo electric power can be generated. In [11] A. Erturk et al, has discussed an technique to generate piezo electric power on high energy orbits on duffling oscillator and their result are been analyzed. In [12] Anup Chaple et al, discussed the various procedure for electric power generation and their results are also analyzed. In [13],[14] the designing of piezo sensors using different constraints is being discussed and the results are also analyzed. In [15] Jing jing Zhao et al, installed the piezo sensor is being installed in a shoe and the results are been analyzed with respect to the hard ware.

The technology of various kinds of piezo electric power generator need to be changed with the circuit which is more useful for the people in day today life. This article discusses a novel topology through which an piezo electric power generator is being designed and the hard ware and software results are being analyzed.

## II. DESIGNING OF SYSTEM

The piezo electric generator block diagram is shown in the figure-1. The block diagram consists of following blocks such as piezo electric sensors, rectifier circuit, charge controller circuit, battery and discharge circuit. Piezo electric sensors are made using zinc oxide nanowires, poly vinylidene fluoride polymer around a conducting fibers. Whenever it experiences pressure these

Sensors generate electricity with less power in the output. This output is in the form of AC. In order to make this output consistent. The output from piezo electric sensors are converted to DC and these output is made constant using an charge controller circuit and fed into battery and then while discharging in order control the returning voltage from the load, discharge circuits are being used.

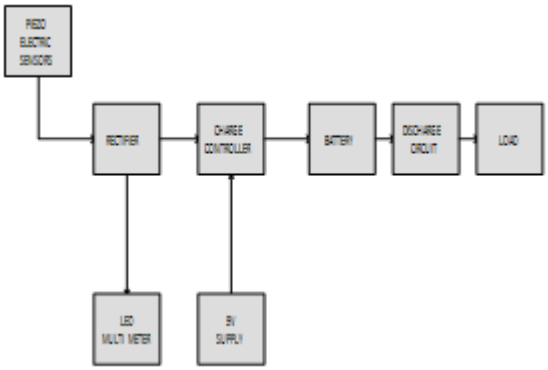


FIGURE-1-BLOCK DIAGRAM

### *A. Analysis of uncontrolled rectifier*

A single phase bridge rectifier consists of following components four diodes and single phase ac source. These uncontrolled rectifiers performance varies with respect to the load connected to the circuit. In our paper we are using battery as load which feds EMF. Hence rectifier is designed in such a way that it doesn't get damaged while battery sends return voltage. The voltage equations are obtained as follows:

$$V = \frac{1}{\pi}\int_{0}^{t_{\pi}} v_m * \sin(\omega t) \ * d(\omega t)$$

Where $v_m$ represents the input voltage.

$\omega$ represents time period.

### B. *Analysis of charge controller-*

Charge controller is always necessary in a battery charging circuits to safe guard the battery charging from low dropout voltage. Usually charge controller uses components such as simple differential amplifier and MOSFET linear regulator. The current is being limited by controlling the linear regulator. Hence designing a charge controller plays an important role in Piezo electric generator. In several paper charge controllers are designed in the form of choppers. Choppers have more efficiency than amplifier charge controllers. The voltage are obtained as :

$$V_{out} = -V_{in} * \frac{D}{1-D}$$

Where $V_{in}$ represents the input voltage.
D represents the duty cycle.

## III. SIMULATION OF PIEZO ELECTRIC GENERATOR

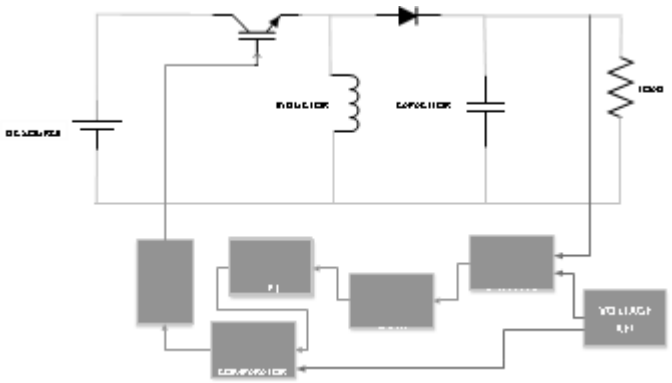

FIGURE-2-SIMULATION CLOSED LOOP BLOCK DIAGRAM

Since closed loop control provides more stability more researches are done in closed loop control of chopper. As in our project chopper is necessary for maintaining constant voltage. Closed loop control plays main role in maintenance of output voltage. Usually in simulation the major components used for closed loop control are PI controller, constant block, comparator, relay, etc. The simulation block diagram is represented in the figure-2.

The simulations are done using MATLAB-2014. The proposed Simulink model is shown in the figure-3. It consist of a closed loop operation of buck-boost converter. Buck-boost converters are often preferred in the places where input and output are inconsistent. As the piezo electric power generator output is in milli-watt. In order to make the output constant of more power. These output from sensors are fed to the charge controllers and then to battery. The values fed in simulations are as follows-(i) Inductor=$1e^{-6}$H, (ii) Capacitance=1mF, (iii) Resistance=100 ohms. The time period value fed in pulse generator is 0.0001 seconds and duty cycle is 50%.

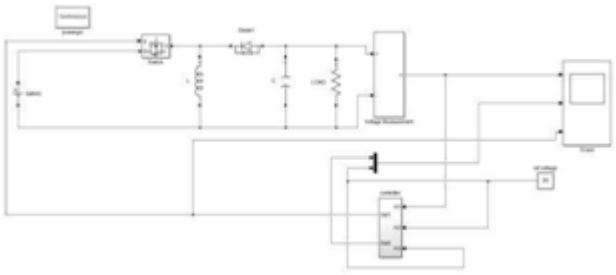

FIGURE-3-SIMULINK MODEL OF PROPOSED SYSTEM

Since the buck boost converter can perform both buck and boost operations are discussed in figure-4 and figure 5. Then the results of PWM signal output and closed loop voltage wave forms are also discussed in figure-4 and figure-5. The simulation results are also discussed in table-1.

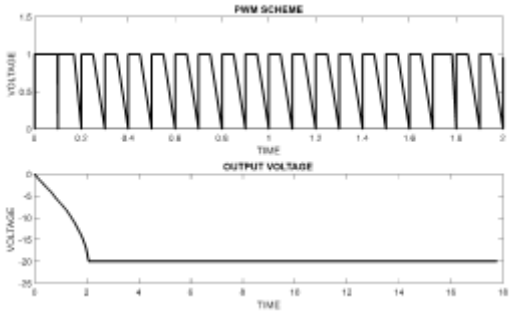


FIGURE-4-BOOST OPERATION RESULT

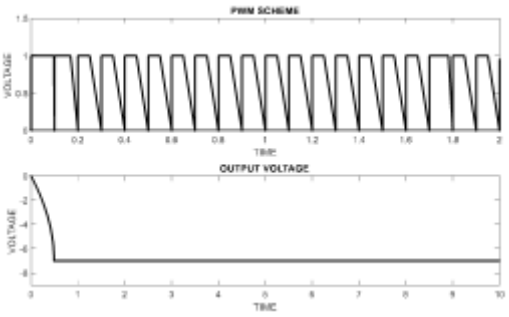


FIGURE-5-BUCK OPERATION RESULT

TABLE I RESULTS OF SIMULATION

| PARAMETER | BOOST OPERATION | BUCK OPERATION |
|---|---|---|
| INPUT VOLTAGE | 12 Volt | 12 Volt |
| OUTPUT VOLTAGE | 20 Volt | 7 Volt |
| PWM SIGNAL OUTPUT | 1 Volt | 1 Volt |
| INPUT POWER | 41.98 W | 41.98 W |
| OUTPUT POWER | 41.32 W | 41.32 W |

From table-1 we can infer that the converter uses the voltage from the piezo electric transducer. For any fluctuation in the output voltage from the piezo electric transducer is fed to the proposed converter and the output power from the converter is calculated and the results are analyzed.

## IV. HARDWARE IMPLEMENTATION

A. *RECTIFIER-*

The piezo electric crystal generates electric power. The voltage generated is in the form of ac and of less power. The generated ac waveform is converted to dc by an rectifier. Usually an rectifier circuit consists of diodes and capacitor. Capacitor acts as an filter.

*B. CHARGE CONTROLLER-*

The 555 timer being an integrated circuit is used as a comparator in this circuit. The 555 is used to compare the high and low voltages of the battery. The high and low state of battery is detected by the second and sixth pin of the 555. When the second pin goes to 33% below the nominal supply the third pin of the 555 will give a high output. The output on the third pin is not affected much even if the voltage tends to go a bit higher in the second pin. The 555 set internally to resist such disturbances to shift in the value. In case the voltage tends to become higher and passes over 66 percent of the nominal voltage, the third pin gets triggered and sets its output to the low state. The battery when fully charged will automatically get disconnected from receiving power and in case the power falls below the nominal value, it will once again start gathering power until it is fully charged. The power MOSFET used in the output is to drive a constant high current.

*C. DISCHARGE CONTROLLER-*

The CD4047 IC is used as an a stable multivibrator. A stable multivibrator are an oscillatory circuit that constantly keep running between two output states and these two states produce the square waveform which is denoted as the output of an astable multivibrator. The circuit mainly works by charging a capacitor with the help of a rheostat, the rheostat is a variable resistor, and the value of resistance can be adjusted so as to maintain a constant frequency of around 50Hz. The output produced by the CD4047 switches between a high and a low state which are complementary to each other. The pins 10 and 11 of CD4047 produce the complementary output of the circuit. The output needs to be amplified to a constant value and this is done using a bipolar junction transistor (BJT) BC547. To drive the inverter, two power MOSFETs are connected in parallel, this parallel connection increases the current going to the inverter. For the IC to perform, a constant supply of 9V must be maintained, in order to accomplish this another capacitor and a diode IN4007 is used so as to provide 9V of supply constantly, the diode assures unidirectional supply and prevents flow of back supply. The ICs two outputs drives the two windings of the inverter transformer. When pin 10 produces the low state, pin 11 produces high current state which in turn triggers the upper windings of the inverter transformer to produce a high output cycle. When pin 10 produces a high output, the complementary of it is produced in pin 11 and a low cycle of output is obtained.

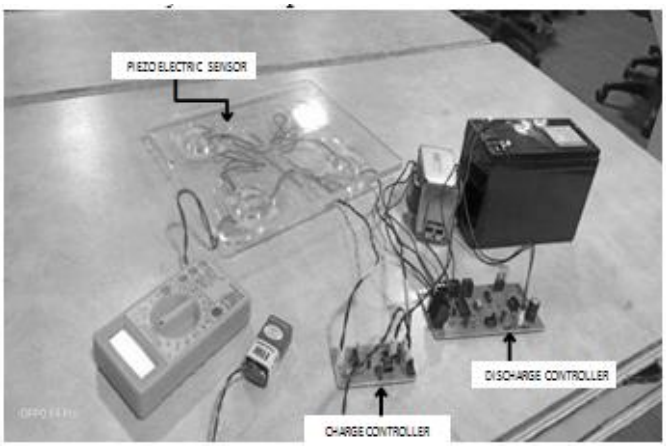


FIGURE-6-HARDWARE MODEL

FIGURE- 7 - HARDWARE WORKING MODEL

## V. APPLICATIONS

**High power generators**

An AC transformer with the help of piezoelectricity is called as a piezoelectric transformer. This transformer is used to increase the voltage value to the necessary value. This happens by the process of acoustic coupling which is not used in regular transformer coupling. It is to be known that piezoelectric transformers are small sized.

**Sensors**

Piezoelectric sensors are used in non-destructive testing.It is also used in medical ultrasound scanning that pass high frequency waves into the body and detect for any issues in the targeted organ. It is also used in under water devices.

**X-Ray imaging**

It is used in the actuators that are used for the opening and closing of the shutters of X-Ray imaging.

**Pregnancy**

It is done in place of In vitro fertilization. In case of failure, the patients seek to using piezoelectric artificial pregnancy.

**Surgery**

Piezo surgery has the ability to cut a tissue without cutting other soft tissues. It helps to keep lesser blood loss around the area being operated and hence provides a better view for the surgeon.

**Quartz**

Quartz is used in the dial of watches. The pressure created from the pulse in the bottom of the wrist helps to power the movement of the dial. The concept of battery less watched was created with the help of quartz. The quartz is used as a piezoelectric standard of frequency.

**Reduction of vibrations and noise**

Different researchers have been looking into ways to reduce vibrations by attaching materials using Piezo property. It is done by balancing the bend of the object when it is put to vibrations and this technology is being planned to be installed in cars and houses of the future.

**PV cells**

PV cells can be made more efficient by combining them with zinc oxide. The test results of this combination proved to be more efficient and produced higher output in systems that used these cells.

**In the future**.

Piezoelectric transducers are in process of being implemented in wearable, shoes, pacemakers, rooftop harvesting, road monitoring, satellites, Nano robots etc. Though there has been a lot of research happening in this field.

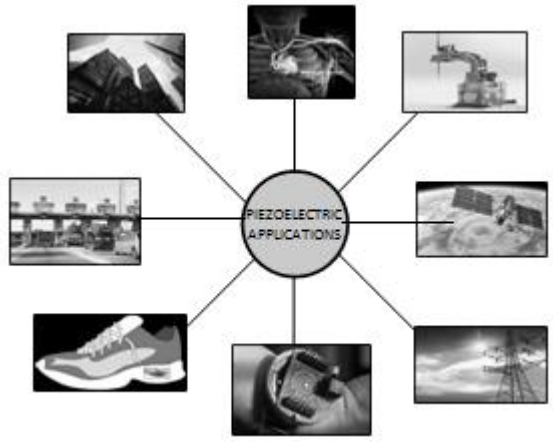


FIGURE-6-APPLICATIONS

## VI. CONCLUSION

A Piezo electric power generator is developed in this paper which can be implemented for various application. One prototype is fabricated and tested. The simulation results of the developed system is also discussed. This work presents that the proposed system produces high stability for varying frequencies occurring from the piezo source and the overall system is used for harvesting energy in various application. The developed technology will be a supplement for several non renewable energy formsand represents a source of motivation for continued work in these and related directions.

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