POWER GENERATION USING PIEZO ELECTRIC TRANSDUCER

ENGINEERING CLINIC PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report **"POWER GENERATION USING PIEZO ELECTRIC TRANSDUSER"** is the Bonafide work of **"NITHIYANANDAM R"** who carried out the project work under my supervision.

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CHAPTER 1

INTRODUCTION

1.1 Objective

Modern technology needs a huge amount of electrical power for its various operations. Here we use a piezo electric transducer which works in the principle of piezo electric effect. The piezoelectric material converts the pressure applied to it into electrical energy. The source of pressure can be either from the weight of the moving vehicles or from the weight of the people walking over it.

Here we use Piezo Electric Transducer for the conversion of mechanical pressure to electrical output. There is a voltage rectifier to convert the variable DC to stable DC. Voltage controller is use in mid way to battery such that battery is not over charged with high volts. An inverter is used to convert the DC voltage to AC. Now to see the output we use a multimeter or a lamp load.

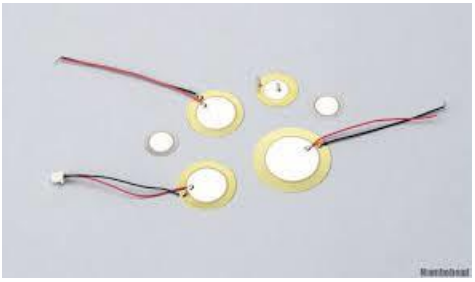


Fig 1.1: Piezo Electric Transducer

1.1 Piezo Electric Effect

Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress.

When piezoelectric material is placed under mechanical stress, a shifting of the positive and negative charge centres in the material takes place, which then results in an external electrical field. When reversed, an outer electrical field either stretches or compresses the piezoelectric material.

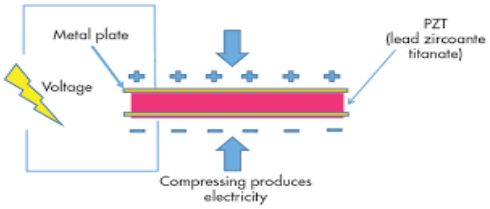


Fig 1.2: Piezo Electric Effect

1.2 Applications Best Suited for the Piezoelectric Effect

1.2.1 High Voltage and Power Sources

An example of applications in this area is the electric cigarette lighter, where pressing a button causes a spring-loaded hammer to hit a piezoelectric crystal, thereby producing a sufficiently high voltage that electric current flows across a small spark gap, heating and igniting the gas. Most types of gas burners and ranges have a built-in piezo based injection system.

Fig 1.3: Electric Cigarette Lighter

1.2.2 Sensors

The principle of operation of a piezoelectric sensor is that a physical dimension, transformed into a force, acts on two opposing faces of the sensing element. The detection of pressure variations in the form of sound is the most common sensor application, which is seen in piezoelectric microphones and piezoelectric pickups for electrically amplified guitars. Piezoelectric sensors in particular are used with high frequency sound in ultrasonic transducers for medical imaging and industrial non-destructive testing.

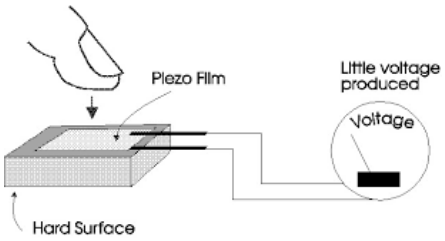


Fig 1.4: Working of Piezo electric sensor

1.3 Literature Review

1.3.1 A Study on the Power Generation Capacity of Piezoelectric Energy Harvesters with Different Fixation Modes and Adjustment Methods on February 2016

In this paper, a commercial piezoelectric ceramic plate (PCP) in simply supported beam fixation mode and cantilever beam fixation mode were analysed through finite element simulations and experiments, and furthermore, two ways of adjusting the natural frequency of PCP are studied and compared. As a result, some guidelines are proposed for the application of PCPs according to the simulation and experimental results.

1.3.2 Footstep Power Generation Using Piezo Electric Transducers on April 2014

In this paper, 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. And this power source has many applications as in agriculture, home application and street lighting and as energy source for sensors in remote locations.

1.3.3 Power Generation Using Piezoelectric Transducer on May 2016

This paper attempts to show how man has been utilizing and optimizing kinetic energy. Current work also illustrates the working principle of piezoelectric crystal and various sources of vibration for the crystal. "The idea of energy harvesting is applicable to sensors as well as transducers that are placed and operated on some entities for a long time to replace the sensor module batteries. Such sensors are commonly called self-powered sensors." Embarked piezoelectric transducer, which is an electromechanical converter, undergoes mechanical vibrations therefore produce electricity.

1.4 Existing method

Since this piezo electric power generation is not yet gives a stable and constant amount of power, there are no existing method and these power generators are not yet used in real life.

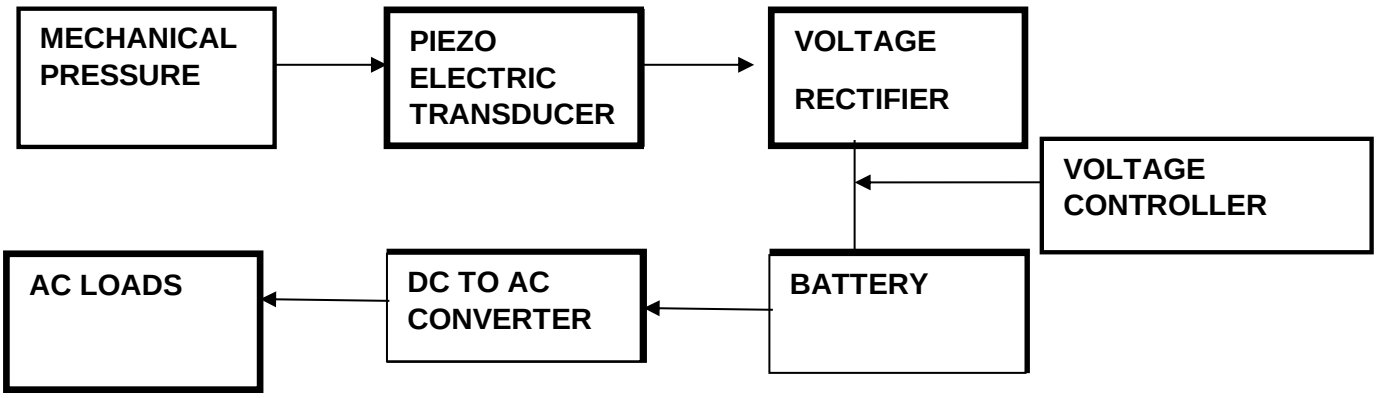
1.5 Proposed method

The proposed system aims to develop a system that tends to produce power via piezo electric transducer using pressure. There is a voltage rectifier to convert the variable DC to stable DC. Voltage controller is used to regulate the voltage entering the battery. This charge the battery in a controlled voltage. Then the DC voltage from battery is converted to AC using an inverter. It is then used for powering up AC devices.

CHAPTER 2

BLOCK DIAGRAM AND WORKING PRINCIPAL

2.1 Block Diagram



This project uses set of piezo electric transducer are connected in such way that all positives and negative sides of transducer are connected to each other giving a one positive and negative end. The battery used here to store is 12v 4.5amps rechargeable battery so that it recharges whenever it runs down of charge by mechanical pressure applied on the piezo electric transducer. For further power generation more, pressure can be applied on the piezo electric transducer and it converts it the mechanical energy to electrical energy. The voltage rectifier is used to convert the variable DC to stale DC. Then it is sent to the voltage controller were, the voltage is regulated to 15v and battery gets charged. Later the battery output is given to the inverter and AC is produced. It can be used for AC loads.

2.2 Working Principle

2.2.1 Piezo Electric Transducer

This system produces power according to the mechanical pressure applied on it. It uses piezo electric effect to do it. Piezo electric effect is such that when a mechanical pressure is applied to a piezo electric transducer it converts the mechanical pressure to electrical output. It also has a reverse process where electrical input is given to convert it into mechanical output such as motor.

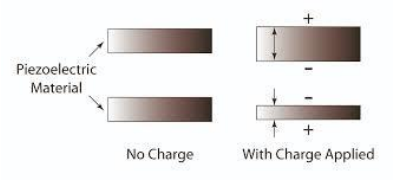


Fig 2.1: Working of Piezo Electric Transducer

2.2.2 Voltage Rectifier

The output voltage of the piezo electric transducer is variable DC. So, the rectifier circuit is used. It converts the variable DC to stable DC. Here we use a bridge rectifier constructed using 1N4007 diode and capacitor. When the variable voltage enters the diodes, according to the biasing it converted to linear DC. Also, a capacitor used for filtration.

2.2.3 Voltage Controller

From the rectifier circuit it is moved to voltage controller. This circuit regulates the voltage entering battery. Here we use IC-7815 to regulate the voltage. To completely charge a battery of 12v we have to produce or pass 15v through it. So, the IC-7815 regulates the voltage entering the battery to 15v.

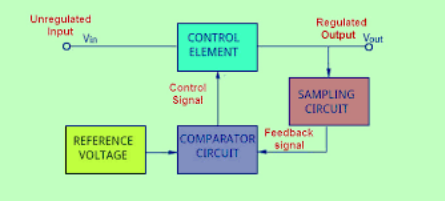


Fig 2.2: Block Diagram of Working of Voltage controller

2.2.4 Battery

At last a battery is used in the circuit. Battery is charged and it is ready to be used for dc devices. Here it a 12volt 4.5amps battery. It is a rechargeable battery so that we can reuse for times. This is the working principle of this project

CHAPTER 3

HARDWARE REQUIREMENTS

3.1. Hardware Equipment's

S.NO	HARDWARE	QUANTITY
1	Piezo Electric transducer	10
2	Voltage Rectifier	1
3	Voltage Controller	1
4	Battery(12v4.5amp)	1
5	DC to AC Converter	1

3.2 Piezo Electric Transducer

The piezoelectric transducers work on the principle of piezoelectric effect. When mechanical stress or forces are applied to some materials along certain planes, they produce electric voltage. This electric voltage can be measured easily by the voltage measuring instruments, which can be used to measure the stress or force.

The output voltage can be calibrated against the applied stress or the force so that the measured value of the output voltage directly gives the value of the applied stress or force. In fact, the scale can be marked directly in terms of stress or force to give the values directly.

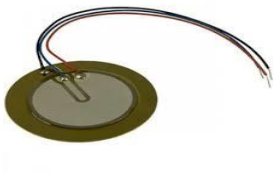


Fig 3.1: Piezo Electric Transducer

The voltage output obtained from the materials due to piezoelectric effect is very small and it has high impedance. To measure the output some amplifiers, auxiliary circuit and the connecting cables are required.

3.3 Materials used in Piezo Electric Transducer

There are various materials that exhibit piezoelectric effect as mentioned above. The materials used for the measurement purpose should possess desirable properties like stability, high output, insensitive to the extreme temperature and humidity and ability to be formed or machined into any shape. Quartz, which is a natural crystal, is highly stable but the output obtained from it is very small. It also offers the advantage of measuring very slowly varying parameter as they have very low leakage when they are used with high input impedance amplifiers.

Due to its stability, quartz is used commonly in the piezoelectric transducers. It is usually cut into rectangular or square plate shape and held between two electrodes. The crystal is connected to the appropriate electronic circuit to obtain sufficient output.

Fig 3.2: Quartz Crystal

Rochelle salt, a synthetic crystal, gives the highest output amongst all the materials exhibiting piezoelectric effect. However, it has to be protected from the moisture and cannot be used at temperature above 115-degree F. Overall the synthetic crystals are more sensitive and give greater output than the natural crystals.

3.4 Advantages of Piezo Electric Transducer

Every devise has certain advantages and limitations. The piezoelectric transducers offer several advantages as mentioned below:

1) High frequency response: They offer very high frequency response that means the parameter changing at very high speeds can be sensed easily.

2) High transient response: The piezoelectric transducers can detect the events of microseconds and also give the linear output.

3) High output: They offer high output that be measured in the electronic circuit.
4) The piezoelectric transducers are small in size and have rugged construction.

3.5 Limitations of Piezo Electric Transducer

1) Output is low: The output obtained from the piezoelectric transducers is low, so external electronic circuit has to be connected.

2) High impedance: The piezoelectric crystals have high impedance so they have to be connected to the amplifier and the auxiliary circuit, which have the potential to cause errors in measurement. To reduce these errors amplifiers high input impedance and long cables should be used.

3) Forming into shape: It is very difficult to give the desired shape to the crystals with sufficient strength.

3.6 Voltage Rectifier

A **rectifier** is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. Here it is used to convert the variable DC from piezo electric transducer to linear stable DC. The process is known as rectification.

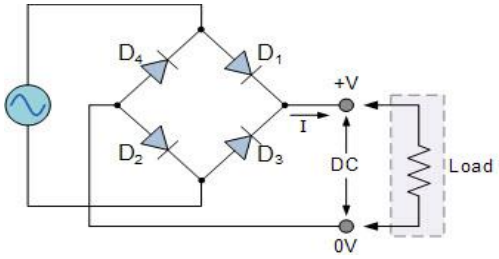


Fig 3.3: Bridge Rectifier

3.7 Voltage Controller

A voltage regulator is a system designed to automatically maintain a constant voltage level. A voltage regulator may use a simple feed-forward design or may include negative feedback. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

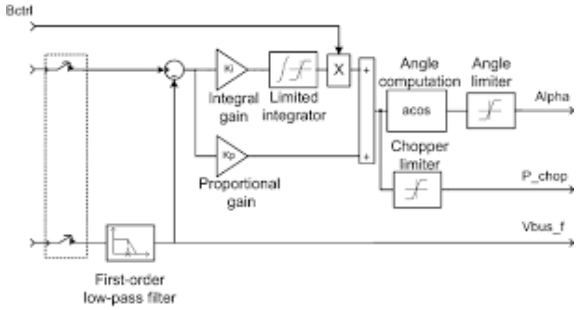


Fig 3.4: Block Diagram of Voltage Controller

3.8 IC 7815

In this method IC 7815 is used for regulate the voltage passing through the Battery. IC 7815 is used for positive 15v voltage regulation. The 15v is regulated to charge the battery since it is 12v.

Specifications

- Output Type: Fixed
- Output Voltage: +15V DC
- Current Output: up to 1.5A
- Input Voltage: 17.7 - 35VDC
- Quiescent (standby) current: 8mA
- Dropout Voltage (Max): 2 V @ 1A
- Category: Linear Voltage Regulators - Standard
- Polarity: Positive
- Operating Temperature: 0 to +125°C
- Mounting Style: Through Hole
- Pin Spacing Pitch: 2.54mm
- Hole Diameter: 3.8mm
- Dimensions: 10.4 x 4.6 x 9.15mm

3.9 Battery

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smartphones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device.

Fig 3.5: 12V Rechargeable Battery

3.10 Working of Battery

Batteries convert chemical energy directly to electrical energy. A battery consists of some number of voltaic cells. Each cell consists of two half-cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the negative electrode, the electrode to which anions (negatively charged ions) migrate; the other half-cell includes electrolyte and the positive electrode to which cations (positively charged ions) migrate.

3.11 DC to AC Converter

A power inverter, or 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. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process. Circuitry that performs the opposite function, converting AC to DC, is called a rectifier.

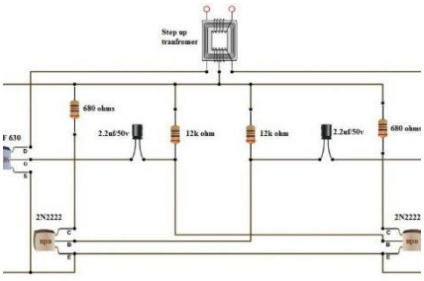


Fig 3.6 DC to AC Inverter

In this circuit, 50Hz oscillator means 50Hz frequency ac supply. In this circuit, we will get oscillation by R1, R2, R3, R4, C1, C2, T2, and T3. Every transistor will provide inverting square wave. The value of frequency depends on Resistor 1, R2, and capacitor C1. We will amplify MOSFET T1 and T2 by oscillator power.

CHAPTER-4

CIRCUIT DIAGRAM

4.1 Circuit Diagram

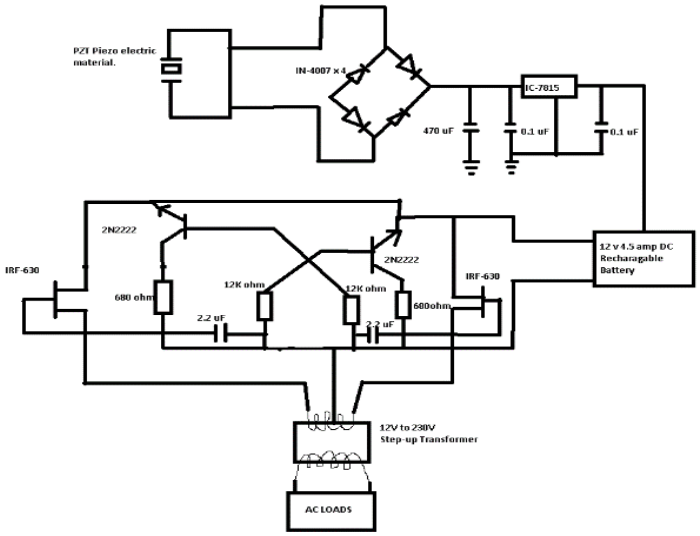


Fig 4.1: Circuit Diagram

The piezo electric transducer converts the mechanical pressure given to electrical signal. The pressure maybe from a normal person pressure, footstep pressure, pedestrians' pressure on pedestrians' path, vehicle pressure in speed breakers and even in roads. This pressure is given to the piezo electric transducer where the PZT material converts it into electrical non-linear DC voltage as output. Each disc produces 2.5V. This variable DC is given to the rectifier circuit.

The rectifier circuit converts the unstable variable DC voltage to linear stable DC voltage. This is given to the voltage controller circuit. This circuit uses an IC-7815 where, it controls the voltage entering the rechargeable battery. This IC allows only 15v to the battery. The battery used is an 12v 4.5amp lead-acid rechargeable battery. This battery is used as a cyclic.

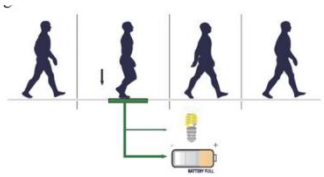


Fig: 4.2 Schematic diagram of Piezo electric Transducer

The 12v DC is now stored up in the battery. Now the battery is connected to the DC to AC converter. This converter has MOSFET and transistors to amplify the circuit. Also, the RC network in the converter used acts as a multivibrator. This is then given to the transformer present in the converter circuit. Transformer is a 12v to 230v 50Hz step up transformer. This output AC is given to the AC to loads to power it up.

CHAPTER-5

OUTPUT

5.1 Piezo Electric Transducer

Fig 5.1: Piezo Electric Transducer

This is a piezo electric transducer. Here we have taken an outer coating of inside wide material and placed a wire for positive charge from inside. Then we have taken an outer coating of copper plate outside and soldered a wire for negative output. Now we can get both negative and positive output. Inside the positive coating there will be a quartz material which works with piezo electric effect. When we give pressure on the white coating, the quartz crystal present gets the mechanical pressure and converts it into an electrical output. These two ends are given to positive and negative pins of LED respectively. When a pressure applied the LED glows. One transducer gives 0.4mV.

5.2 Piezo Electric Array

Fig 5.2: Piezo electric array

This is the combination of 10 piezo electric transducer are connected one by one by wires by positive to positive and negative to negative respectively. When pressure is applied on them, they combine to give more output.

5.4 Battery

Fig 5.4: 12V 4.5 Amp Battery

We used a 12v 4.5amp rechargeable battery. The battery is reusable as it is rechargeable. It can hold up to 12v and 4.5amp and give output in such a way.

5.5 DC to AC Converter

Fig 5.5: DC to AC Converter connected with AC LAMPSS

DC to AC converter used here converts 12v DC from the battery to 220v AC 50 Hz. Here a step-up transformer is used to step up the voltage. The output of inverter is given to a AC lamp to verify the output.

5.6 Design

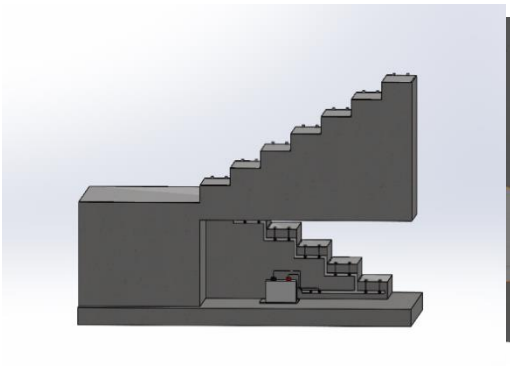


Fig 5.6: Right side view

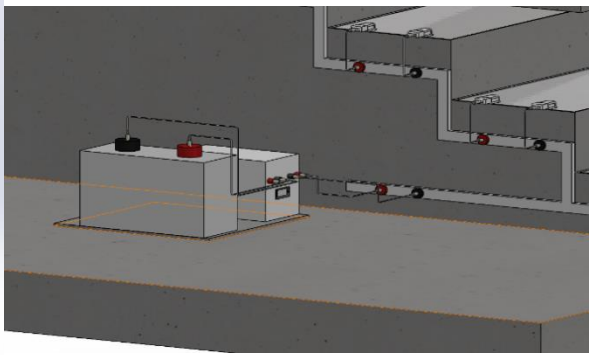


Fig 5.7: Battery and inverter

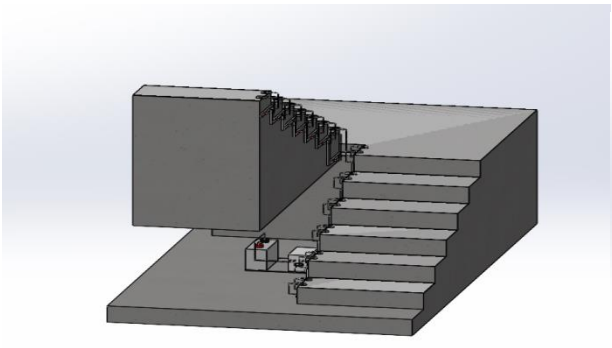


Fig 5.8: Isometric view

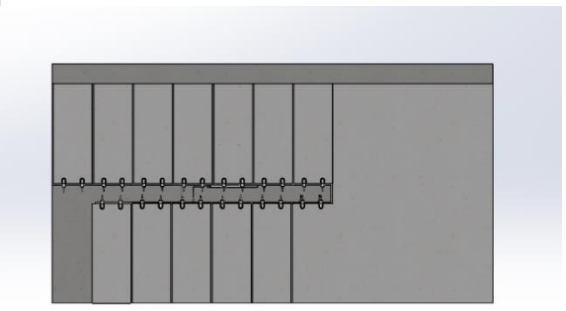


Fig 5.9: Top view

CHAPTER-6

RESULT ANALYSIS

6.1 Calculation

The piezo electric transducer is connected in series and their output voltage is equated.

$$\frac{1}{Ct} = \frac{1}{C1} + \frac{1}{C2} + \cdots \frac{1}{Cn}$$

$$=> Q = \frac{C}{V}$$

$$=> c = \frac{Q}{v}$$

$$=> \frac{1}{C} = \frac{V}{Q}$$

As a result, voltage is charge to capacitance of transducer.

$$=> V = \frac{Q}{C}$$

6.2 Result Analysis

S. No	Weight Applied	Minimum Voltage Produced	Maximum Voltage Produced
1	65 Kg	2.1 V	13 V
2	70 Kg	2.2 V	13.1 V
3	67 Kg	2.1 V	13 V

Table 6.1 Result Analysis of different weights

The different weight persons exhibit a different pressure. Each pressure will produce a different electric output. From the table 5.1, the first person is 65kgs and produce 2.1v in a single transducer. In the third person case it is same and there is no change. But in the second case the person is 70kgs and produces 2.2V voltage. So we can conclude if there is a 5kg increases 0.1v voltage increases.

S.No	Pressure applied	No of Steps	Voltage/sec
1	50Kpa	1	2.1V
2	65Kpa	1	2.2V
3	52Kpa	1	2.1V

Table: 6.2 Voltage produced per second based on the pressure and number of steps.

The table 6.2 shows the different pressure applied for a step-in pascal. It is same pressure of the persons of the table 6.1.

No. of steps for producing 12V = 65 steps

$$Time = \frac{Total\ No\ of\ steps}{Voltage\ produced\ \ X\ 60}$$

The calculation above is a derived calculation for a constant voltage to charge the 12v battery. It has been calculated by using the analysis tabulations.

6.3. Comparison with other proposals

Parameter	**Zhixiang Li [14]**	**Kiran Boby [15]**	**Chandan Kumar Dubey [11]**	**Proposed Method**
Piezo electric material	PZT	PZT	PZT	PZT
Type of transducer	Ceramic plate	Disc transducer	Disc transducer	Disc transducer
Type of connections	-	Series	Parallel	Series
Voltage produced	150V	39V	15V	220V
Application	Agriculture	Research	DC Devices	AC Devices

CONCLUSION

As a result, the voltage 220v AC is produced and AC loads are powered up. The PZT material is very superior, produces required voltage and current. The PZT produces better output in series connection when compared to parallel connection. The pressure applied to the transducer are analysed and the time taken for charging the battery is calculated. This can be implemented in staircase, elevator, pedestrian's pathway, speed breakers.

In future, the output produced by this method can be used in homes and industries to power up the applications. Efficient output can produce by further Research, by developing it.

REFERENCE

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2. Xiaoming Sun, "An Overview on Piezoelectric Power Generation System for Electricity Generation", JPEE (Journal of Power and Energy Engineering), 2017,5,11-18 ISSN: 2327-5901.