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Generation of Power using Piezoelectric Transducer

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Abstract:- As technology develops, the need for power also increases. In future, the need for power will be very high. This proposed method uses piezoelectric transducer to produce power using its property [1]. Countries like India have a need to establish this kind of power transmission. We can keep the piezoelectric tiles in pedestrian way, railway platforms and even in speed breakers. This also focuses on using the wasted human pressure. When pressure is applied on the tiles, the pressure is converted to electrical energy. This is done by piezoelectric transducer, by using its piezoelectric effect. This electrical energy is stored. Later it is converted to AC using an inverter circuit and can be used for various AC components. The AC component used in the proposed method is AC load bulb. The proposed method concentrates more on bringing an efficient output from the used piezoelectric material. This power source can be implemented in agriculture, industries, home, etc. The proposed method uses 30 discs PZT type transducer. It is inferred that the total output voltage of transducer is 20-25 V.

Keywords:- *AC to DC Converter, Piezoelectric Transducer, Rectifier and Voltage Controller.*

I. INTRODUCTION

As there is a development in electronics, there is development in microelectronics as well. Need for power increases day by day. Power generation and transmission is the single largest source of pollution in the world. On one hand the non-renewable sources are vanishing. On the other hand, the human population is overwhelmingly increasing day after day. This proposed method deals with reducing the pollution in power generation as well as increasing the power transmission standards. This uses a piezoelectric transducer which has the ability to convert the all types of mechanical pressure to electricity. This effect is called as 'Piezoelectric effect'. This electricity is further rectified and converted to 220V AC 50Hz power supply. Piezoelectric transducers are embedded into disc structure. These discs are connected serially to provide continuous high voltage and current[2-5].

The piezoelectric materials section-II deals with the output of different piezoelectric materials and choosing of the right material based on efficient output. The block diagram of the proposed method is discussed in section-III. Each block is explained in detail. The circuit diagram is presented in section-IV. The output and analysis of the proposed method is summarised in section-V. The results are tabulated.

II. PIEZO ELECTRIC MATERIAL

There are many elements or materials which can be called as piezoelectric materials. These materials will produce electricity when given pressure. The piezoelectric effect is common in disc transducers made of Quartz, PZT, PVDF [6-7]. The proper choice of material is very important. It must be selected based on the efficient output it generates when subjected to pressure applied by an average human. This is the main component in the project. The mostly used piezoelectric materials are PVDF and PZT. To select the perfect material, V-I characteristics of both the materials are noted. First, each type of disc is soldered to two wires and a multi meter is used measure voltage. The values are noted, for different pressure values applied to transducer [11-14].

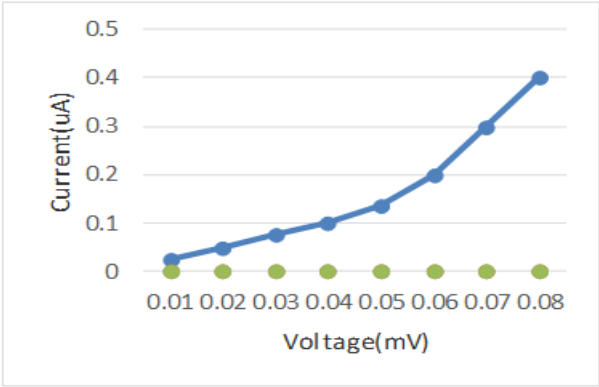

Fig 1:- V-I Characteristics of PVDF

Fig 1 shows the voltage to current characteristics of PVDF (Polyvinylidene DiFlouride). The x-axis shows the voltage in V. It increases mostly in a linear way but the start-up has low voltage. The y-axis shows the current produced in the material. The current produced is in µA (micro ampere). The maximum current produced is less when compared to the PZT material.

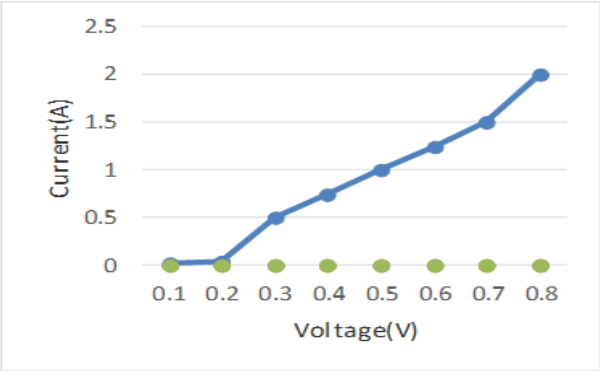

Fig 2:- V-I Characteristics of PZT

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Fig 2 shows the voltage to current characteristics of the PZT (Lead Zirconate Titanate). The graph axis is same as the previous figure 1. It shows that the starting voltage level is high and in the end, it gives an output of 2V. The current produced is also efficient. From this analysis, we concluded by opting for PZT over PVDF.

III. PROPOSED METHOD

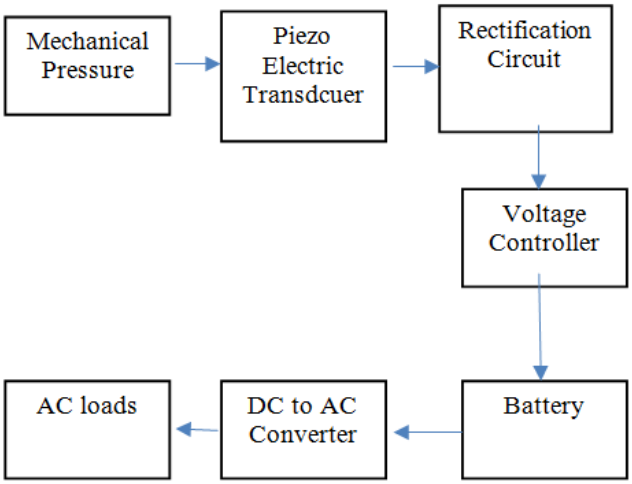

Fig 3:- Block Diagram

Block diagram of the proposed method is depicted in Fig 3. Piezoelectric transducers are a type of electro acoustic transducer which converts the mechanical pressure to electrical signals. This effect is called as "Piezoelectric Effect". These types of transducers are available in various forms in various materials. We use PZT material (i.e.) Lead Zirconate Titanate, in a disc type transducer. It produces around 2.4 volts, which depends on the pressure that is applied [8-10**].**

A rectifier circuit is used to convert the AC voltage to stable linear DC. Filtering the pulsated voltage is performed with one or more capacitors attached across the load, so that filtering of DC is performed. The capacitor rating also depends on the output voltage. We rectify the variable DC to linear DC.

A voltage controller 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. In our study, we use IC-7815 which gives positive 15 volt (+15v).

A lead acid battery is a storage device for storing DC voltage. Sealed lead acid batteries are batteries where the sulfuric acid is in a gel form, which stays in, even when the battery is turned upside down. We used 12v 4.5amp rechargeable battery.

A converter is used to convert DC voltage to AC voltage and it consists of a step-up transformer which steps-up 12V DC to 220VAC. This output can be used for AC loads.

IV. CIRCUIT DIAGRAM AND RESULTS

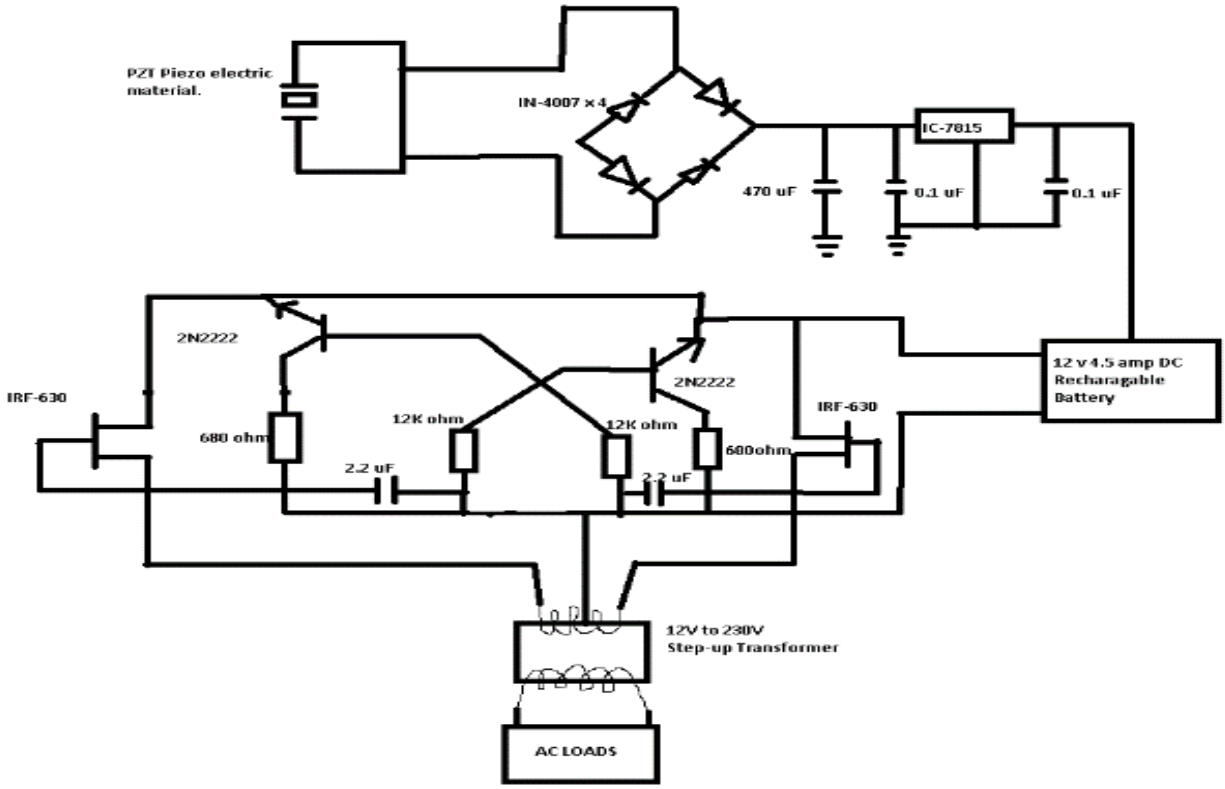

Fig 4:- Circuit Diagram

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Fig 4 shows the circuit diagram of proposed method. The piezoelectric transducer converts the mechanical pressure applied to electrical signal. The pressure may be from an average person's footstep, pedestrian's footstep on pedestrians' path or vehicle pressure in speed breakers or roads. This pressure is applied to the piezoelectric 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 a 12V 4.5amp lead-acid rechargeable battery. This battery is used as a cyclic battery.

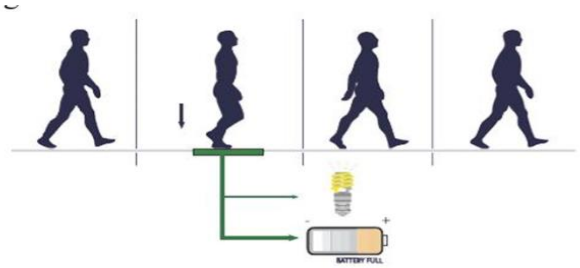

Fig 5:- Schematic diagram of Piezoelectric Transducer

The 12V DC is now stored 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 multi vibrator. 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 loads to power it up.

The piezoelectric transducer is connected in series and their output voltage is shown in equation (1).

$$\frac{1}{Ct} = \frac{1}{C1} + \frac{1}{C2} + \cdots \frac{1}{Cn} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots equation(1)$$

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

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 1:- Voltage output for various persons' weight/pressure.

From the table 1, analysis was done on the various output voltages produced for a series connection of 10 disc transducers. Series connection is more efficient when compared to parallel. In parallel connection, the voltage is shared and charges the battery slowly, while in series connection the output voltage is summed and the battery charging time is low. For different types of pressure, the voltage changes are very little. So, an average human's pressure was found enough to produce efficient electricity with 30 transducers in series.

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 2:- Voltage produced per second based on the pressure and number of steps

From the table 2, analysis was done on the various output voltages produced for a single step with different pressure values applied. The output voltage for 3 different pressure values are almost the same(2V). So, the voltage produced per second is 2V. The theoretical derivation is done

No. of steps for producing 12V = 65 steps

$$Time = \frac{Total\ No\ of\ steps}{Voltage\ produced\ X\ 60} \quad \ldots\ldots\ldots\ldots\ldots\ldots equation(2)$$

Total time taken for the obtaining the voltage is calculated using the equation (2). It takes 12 minutes to produce 12V. This voltage must be constant to charge the battery.

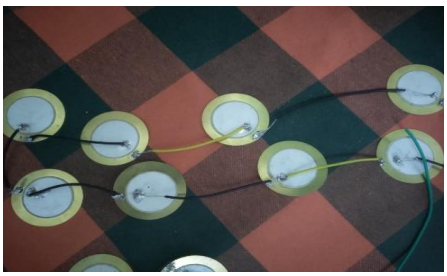

Fig 6:- Series connection of Transducers

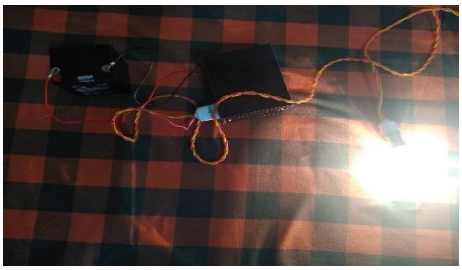

Fig 7:- AC load output

The Fig. 6 shows the PZT discs, about 30 discs connected in series, it produces around 2.1V for a single step. The battery is charged using this method.

The Fig. 7 shows the output produced using PZT material. The DC voltage is converted into AC voltage using a converter. The 12V from the battery will be converted into 220V using step-up transformer.

Parameter	Zhixiang Li [14]	Kiran Boby [12]	Chandan Kumar Dubey [11]	Proposed
Piezoelectric material	PZT	PZT	PZT	PZT
Type of transducer	Ceramic plate	Disc transducer	Disc transducer	Disc transducer
Type of connections	-	Series	Parallel	Series
Voltage produced	150VAC	39VDC	15VDC	220V AC
Application	Agriculture	Research	DC Devices	AC Devices

Table 3:- Comparison with the existing methods

Table 3 shows the comparison of proposed method with existing methods. The output voltage produced in the proposed method is high when compared with the existing methods.

V. 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 is analysed and the time taken for charging the battery is calculated. This can be implemented in staircase, elevator, pedestrian's pathway, and speed breakers. In future, the output produced by this method can be used in homes and industries to power up appliances. Efficient output can be produced by further research and development.

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