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Conversion of Mechanical Energy to Electricity Using Piezoelectric Crystals

Akash Biyani[1], Ashutosh Mithari[2]
Dept. Of Electronics and Telecommunication, Pimpri Chinchwad College Of Engineering, Pune, India.

Abstract: ***To achieve electrical energy from mechanical energy, we have constructed a model where, when someone applies force on the model, it creates pressure on the piezoelectric sensors, which are present between two tiles. These sensors convert mechanical energy (force) into electrical energy. The single piezoelectric sensor will produce a few watts of energy. We have a series and parallel connection to generate more power to get the required output voltage and current. The produced energy is in the form of ac which is rectified by the rectifier circuit, and then the fixed voltage is regulated to get the constant dc. Then this dc voltage can be used to light the streetlights and traffic signals.***

Keywords: Piezoelectric crystals, Piezoelectricity, Mechanical energy to electrical energy conversion, Microcontroller, AC to DC conversion.

I. INTRODUCTION

In the current era, energy and power are necessities of this modern world. As the energy demand is increasing day by day, the ultimate solution to deal with these sorts of problems is to implement renewable energy sources. The objective of this work is power generation through footsteps as a source of renewable energy that we can obtain while walking on specific arrangements like footpaths, stairs, and plate forms. These systems can be installed elsewhere, especially in densely populated areas. We can implement this footstep power generation system by use of a Piezoelectric sensor and efficient diode rectifier circuit along with a filter circuit. As a result of completing the above procedure or technique, we made ourselves able to design such a compatible system through which we could run our home appliances through DC output as our primary purpose was to charge the battery through DC output. The output voltage is significant when piezoelectric sensors are connected in a series combination. Still, the output current is low, and when piezoelectric sensors are connected in a parallel hybrid, the output current is large, but the voltage is low. We need a combination where the output voltage, as well as the output current, is high. We must make the connection in such a way that it should match the required current and voltage. So, piezoelectric sensors are combined with series and parallel connections.

II. METHODOLOGY

A. Working

When anyone walks or runs on any platform or surface, they exert their weight force on the ground. This is a pure waste of energy. To overcome this wastage and to create an energy source which is not harmful to the environment, we introduce this idea. To achieve electrical power from mechanical energy (weight), we have constructed a model where, when someone applies force on the model, it creates pressure on the piezoelectric sensors, which are present between two tiles. The single piezoelectric sensor will produce a few watts of energy. We have a series and parallel connection to generate more power to get the required output voltage and current. These sensors convert mechanical energy (force) into electrical energy. The produced energy is in the form of an Alternating form which is rectified by the rectifier circuit. Then this fixed voltage is filtered by a capacitor filter and regulated to get the constant DC signal. The related block diagram is provided in fig 1. This way, we can convert unused mechanical energy into an Electric signal. This Electrical signal is fed to the battery,

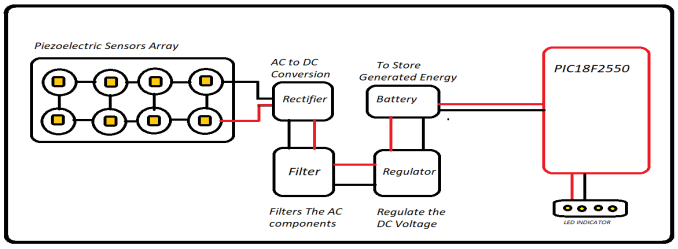

Fig. 1 Block Diagram

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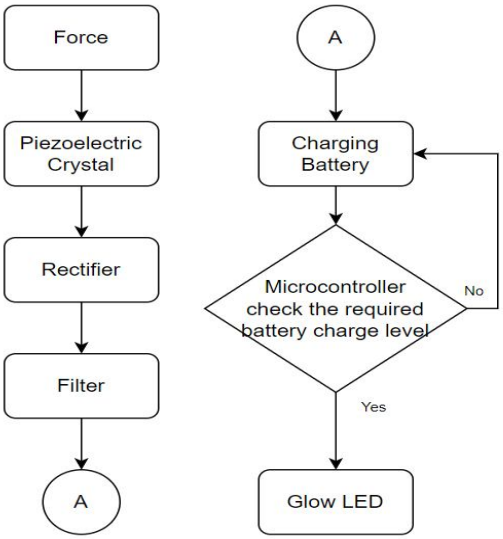

Fig. 2 Flowchart

And with the help of a PIC microcontroller battery level is watched. If the battery is charged above a certain level, then LED will glow, indicating the charging of the storm. The flow of the process is shown in the process flowchart in fig 2.

B. Piezoelectric crystal vibration and excitation

The piezoelectric crystal is perfectly balanced between two metal plates and does not conduct an electric current. When Mechanical pressure is applied to the material by metal plates, it forces electric charges within the crystal out of balance. Excess negative and positive charges appear on the side of the crystal face.

Fig 3) At the start, Net charge = 0

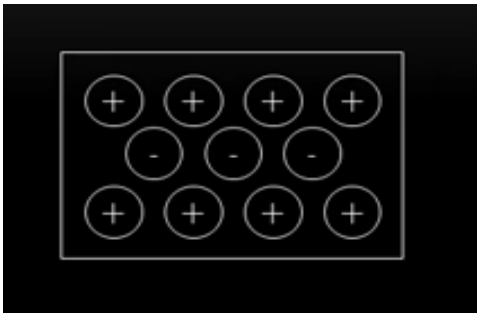

Fig – 3 (Initial Dipole moment)

Fig 4) Shift of equilibrium state leads to accumulation of charges on opposite ends.

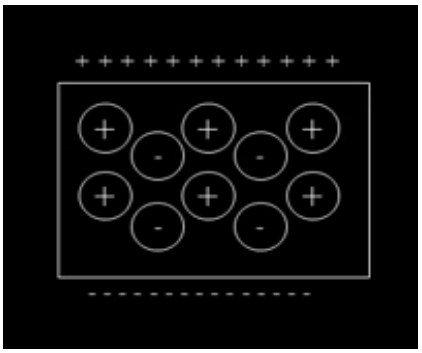

Fig – 4 (Excited state)

III. COMPONENTS USED

Components for this model were selected based on requirements. The list of different features and quantities is written in table 1.

Table 1 – List of Components

Sr. no	Equipment	Quantity
1)	PIC16F877A	1
2)	PIEZOELECTRIC TRANSDUCER	10-12
3)	CONNECTING WIRES	1 Bundle
4)	TILE PLATES	2
5)	CAPACITORS (10uf,1000uf)	5
7)	DIODE	4
8)	PIC18F2550	1
9)	BATTERY	1
10)	VOLTAGE REGULATOR	1
11)	LED	5
12)	HARD SPRING (between 2 metal plates)	2

IV. PSIM CIRCUIT

PSIM is an Electric circuit simulation software package designed specifically for Power Electronics and can be used to simulate any electronic circuit. We have used PSIM version 12.0. Fig 6 shows the simulation results of the course. Thus, the alternating signal from the piezoelectric transducer is converted to a DC signal with the help of a combination of the bridge rectifier and capacitor filter. As shown in fig 5 above, we have considered the alternating current coming from piezoelectric crystals as an AC source for simulation. We have used the rectifier and capacitor filter circuit. This circuitry is used to convert the output of the piezoelectric sensor, which is in alternating format and to charge different electric components we need to change this alternating signal form into a Direct form.

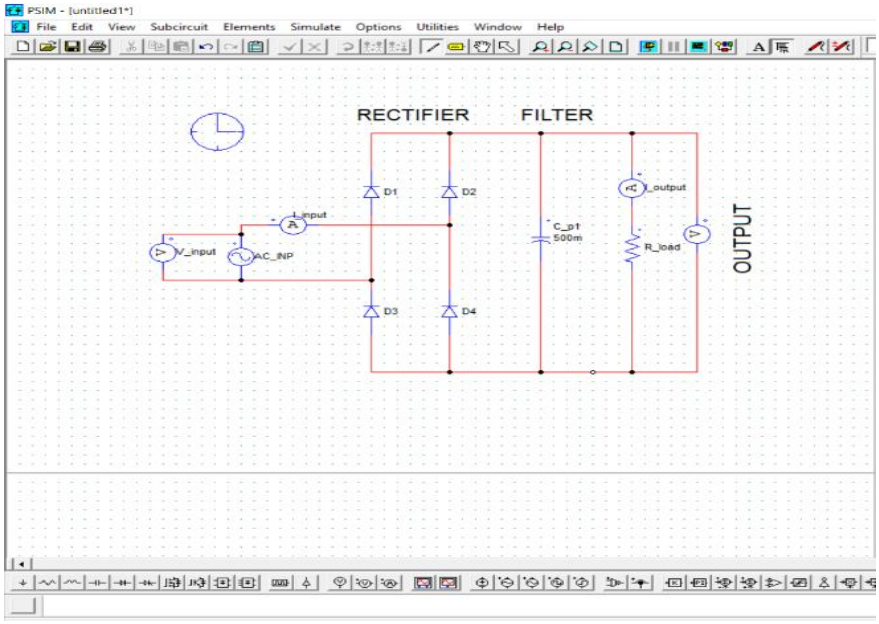

Fig. 5 PSIM Circuit Simulation

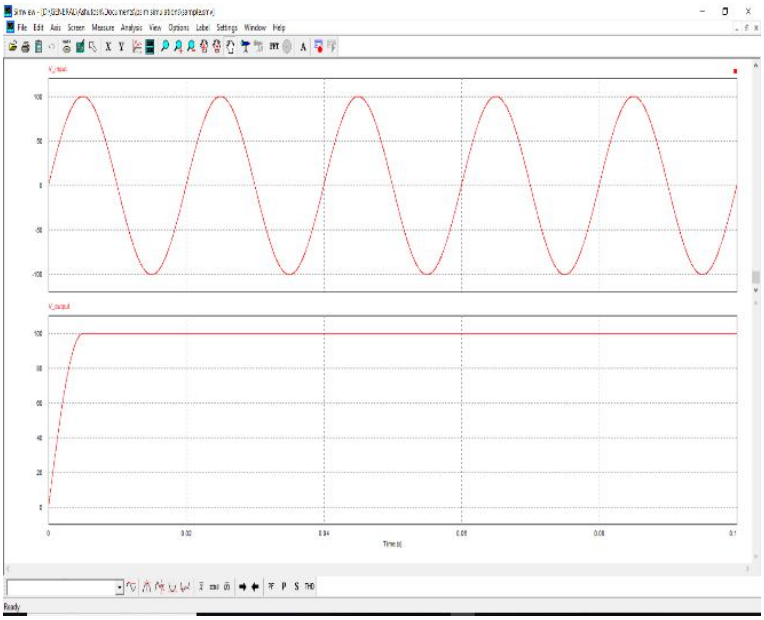

Fig. 6 PSIM Circuit Simulation Result

V. MPLAB CODE

MPLAB is an environment for developing embedded applications on PIC and dsPIC microcontrollers. Microchip Technology develops this software. The latest edition of MPLAB is MPLAB X, developed on the NetBeans platform. We have performed all coding practices related to this project on this platform.

VI. PROTEUS SIMULATION

The Proteus Design Suite is a proprietary software tool used primarily for electronic design automation. We have used PIC18F2550 for the management of the Battery level. The potentiometer here is significant to the battery. As the resistance of the potentiometer rises to a certain level, the LED will glow, indicating that the battery is charged. Fig 6 shows the initial condition of the battery level when no DC supply comes from the rectifier and filter circuit. Later, when we step on piezoelectric sensors, it produces electric energy, which is passed through the rectifier and capacitor filter circuit and fed to the battery. The battery started to charge, and glowing LEDs controlled by PIC18F2550 indicated this charge level. The LED will glow when the battery is assigned to the required level. In our case, we kept that level to 50%. Fig. 7 shows this condition specifically. The functionality of this project is shown in Fig. 2 with the help of a flowchart. The flow of battery charge condition is also shown.

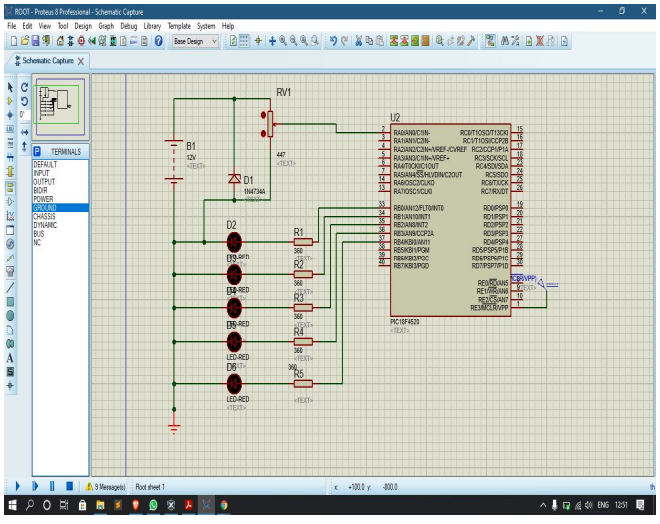

Fig. 6 Battery at 0 charge

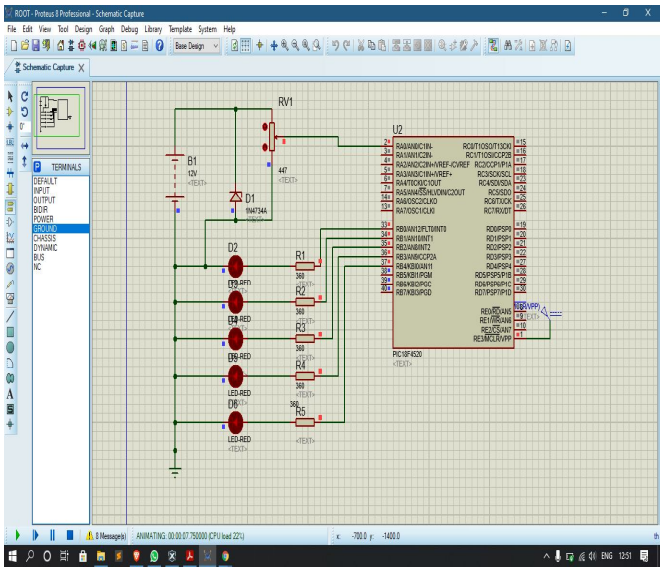

Fig. 7 Battery charged (indicated by LED)

VII. APPLICATION

1) It can be used in crowdy areas, for example, by pedestrians where the energy produced will be used to light up the streetlights.
2) It can be installed in the lift, and the energy produced can be used to open and close the door of the charge.
3) It can be implemented in shoes, and the energy produced can charge any emergency electronics device.
4) Installation of this in malls can be revolutionary as it is populated most of the time and the best source for energy production and its application in the same place.

VIII.ADVANTAGES AND USEFULNESS

1) The demand for electricity keeps increasing to follow population growth, prosperity improvement, and economic development.
2) Despite the importance of electricity and the greater demand for it, many countries still need access to electricity.
3) Most of the reason is about the amount of electricity payment. Then, the piezoelectric tile is the promising option to overcome the greater demand for electricity and the lack of access to electricity. Besides, the tile also can overcome the electricity problem as the survival electricity generation when such disaster or extreme weather causes power loss.
4) The piezoelectric ceramic tile is a renewable electricity source and is unique, safe, reliable, geographically, and economically.
5) This project is simple and easy to access.
6) There is low power consumption. It can be operated from a long range.

IX. RESULTS

We are successfully able to convert mechanical energy into pure electric power. Also, we can successfully generate a system that converts a form of energy to electricity and is not harmful to the environment. The output received is higher than the output received in previous approaches due to the choice of series and parallel combination of circuits.

X. CONCLUSION

A resource of electricity is produced with mechanical energy, i.e., force as input and electricity as output. This source, no matter harms the environment, and its implementation can be done all over the world provided the human force will act upon it in any method (walking or any vehicle passing above it)

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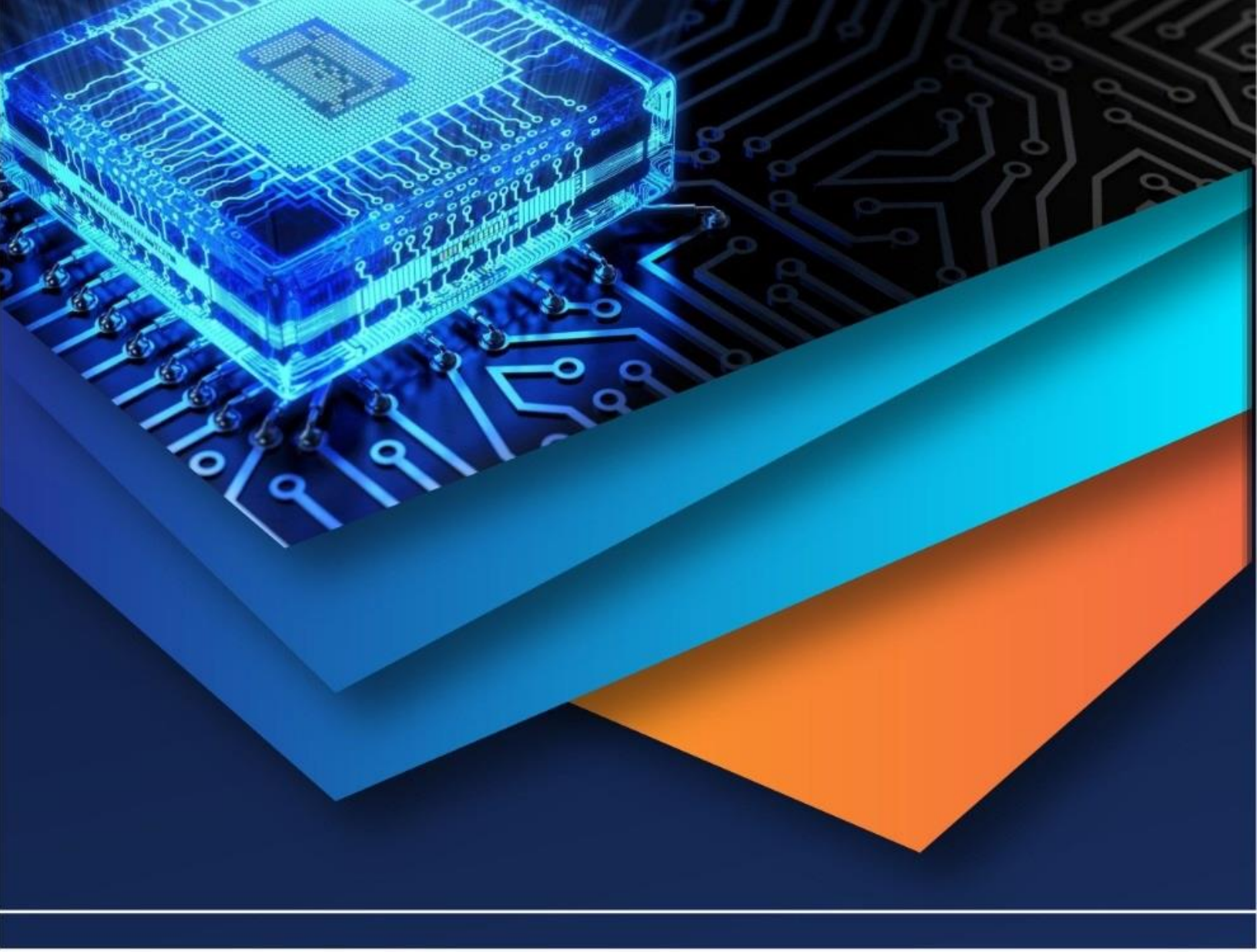

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