A Mini Project Report On

GENERATION OF ELECRTICAL ENERGY USING AMBIENT VIBRATIONS THROUGH PIEZO-ELECTRIC MATERIAL

Submitted in partial fulfillment of the requirement for the award of the degree of

BACHELOR OF TECHNOLOGY IN ELECTRICAL AND ELECTRONICS ENGINEERING

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CERTIFICATE

This is to certify that the Mini Project report on "Generation of Electrical Energy using Ambient Vibrations through Piezo-Electric Material" that is being submitted by M. Sai Sharanya , 23255A0213, M. Usha Sree, 23255A0221, S. Esther Vashmi, 22251A0287, E. Bhargavi, 22251A0268, B. Jessie Hadassah, 21251A0295. in partial fulfillment for the award of degree BACHELOR OF TECHNOLOGY in ELECTRICAL AND ELECTRONICS ENGINEERING from G. Narayanamma Institute of Technology and Sciences (AUTONOMOUS) is a record of Bona-fied work carried out by the students under our guidance and supervision in the academic year 2024-25.

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ABSTRACT

The electrical energy generation and storage from piezoelectric materials are focused and discussed in this paper. This kind of materials is able to directly convert mechanical energy into electrical one, which can be later stored by utilizing energy harvesting technique/circuit. The energy conversion from ambient vibration is indeed nowadays fascinating research area. Due to the compatibility to integrate with electronics and microsystem with high voltage and supporting standalone circuit, it is the most popular electromechanical transducer materials for low power consumption applications, such as wireless and sensors. This paper focuses how to extract energy from piezoelectric materials to be stored in the energy storage device such as battery, in order to later supply electronic/electrical device/equipment. Consequently, this work may be practical for energy supplying of low power devices.

TYPES OF COMPONENTS

LIST OF FIGURES

1. Introduction

Although wind power generation and solar power generation are the eminent achievements of the above work, their development is restricted for the following reasons. First, for China, except western areas, the resources of wind power and solar power in most of the mainland are not abundant, the exploitation and utilization of which are not economic. Second, the electrical distance from the western wind farms and solar farms to the central and eastern load center is very large; therefore, with the limitations of transient stability or dynamic stability, the power of the AC transmission lines cannot reach the natural transmission capacity, which may produce “abandoned wind” and “abandoned sunlight”; if the energy is transmitted by DC transmission lines instead, considering the high cost of DC transmission lines, the method cannot be used widely. Third, when the penetration rate increases, in order to balance the power fluctuation caused by the intermittency of wind and sunlight, the peak load regulation capacity distributed to thermal power units will increase as well, and this increases the extra cost of coal and thus reduces the low carbon benefit of wind power and solar power [2] .Fourth, large-scale wind farms and solar farms tend to occupy a very large area and even urban-type equipment needs also enough spaces to install; moreover, wind power generator may induce noise pollution [3] and solar power generation equipment may induce light pollution; therefore, it is not very appropriate to install wind power generator and solar power generation equipment in cities with high concentration of population and construction and the suburban areas. As a consequence, other possible energy sources must again be explored. One of the promising options is by using piezoelectric material through ambient vibrations. PZT can be used as a mechanism to transfer ambient vibrations into electrical energy. This energy can be stored and used to power up electrical and electronics devices. With the recent advancement in micro scale devices, PZT power generation can provide a conventional alternative to traditional power sources used to operate certain types of sensors/actuators.

2.COMPONENTS

The Components which are used for the Generation of Electricity through Ambient Vibrations of Piezo-Electric material are Piezo-electric sensors, Resistors, Battery, Capacitor, LED’s, Switch, Battery holder, Connecting wires.

2.1 Piezo-Electric Sensor:

A piezoelectric sensor is a device that converts mechanical stress or pressure into electrical signals. This type of sensor utilizes the piezoelectric effect, where certain materials generate an electric charge in response to applied mechanical stress. When pressure or force is applied to a piezoelectric material, it deforms slightly, causing a shift in the distribution of charges within the material and generating a voltage across the sensor.

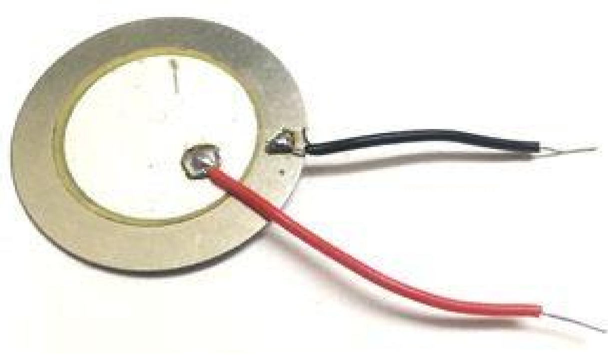

Fig 2.1 Piezo-Electrical Sensor

Piezoelectric sensors are commonly used in various applications such as industrial machinery monitoring, medical devices, automotive systems, and touch-sensitive input devices. They offer advantages like high sensitivity, fast response times, and wide frequency ranges.

Piezoelectric sensors can operate in harsh environments and withstand extreme temperatures. The electrical output from a piezoelectric sensor can be measured, amplified, and processed to provide valuable information about the magnitude and frequency of the applied force or pressure. Calibration and proper signal conditioning are necessary to ensure accurate and reliable measurements from piezoelectric sensors in different applications.

2.2 Resistors:

Resistors are essential components in electrical circuits that limit the flow of electric current. They are designed to have a specific amount of resistance, measured in ohms, to control the amount of current flowing through a circuit. Resistors are commonly used to adjust signal levels, divide voltages, provide biasing in transistors, and protect components from excessive current.

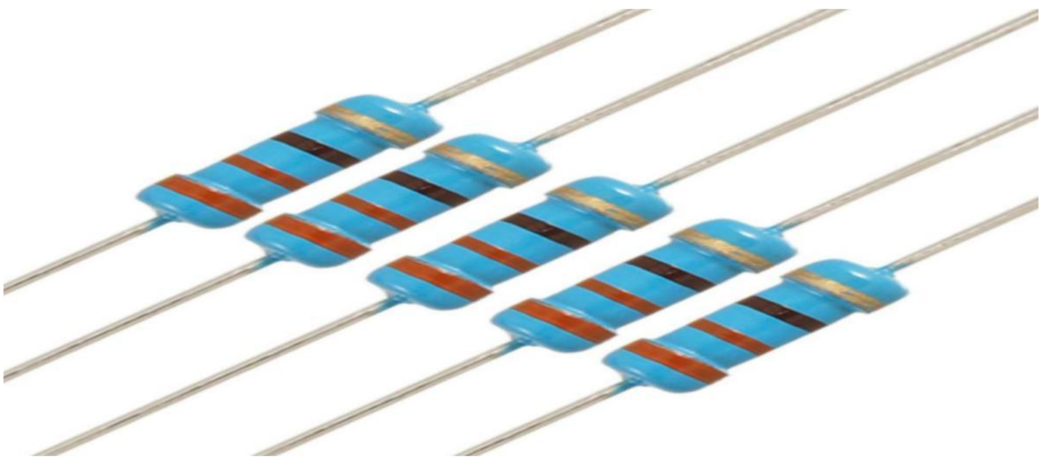

Fig 2.2 Resistors

Resistors come in various types, including fixed resistors with a constant resistance value and variable resistors that allow for adjustment of resistance. They are made from materials like carbon composition, metal film, or wire-wound resistive elements.

Understanding the color code on resistors helps identify their resistance value. Resistors follow the color-coding scheme with different colored bands representing digits and a multiplier to determine the resistance value. Proper selection and placement of resistors in circuits are crucial for controlling current flow, voltage levels, and ensuring the overall stability and functionality of electronic devices and systems.

2.3 Battery:

A battery is an essential component in electrical systems as it stores electrical energy in a chemical form and releases it as electrical power when needed. Batteries consist of one or more electrochemical cells, each containing positive and negative electrodes separated by an electrolyte. When a circuit is connected to the battery, a chemical reaction occurs within the cell, causing electrons to flow from the negative electrode to the positive electrode, generating an electric current.

Fig 2.3 Battery of 3.7v

There are various types of batteries, such as lead-acid, lithium-ion, nickel-cadmium, and alkaline batteries, each with different characteristics and applications. Batteries play a crucial role in powering a wide range of devices, from small electronics like smartphones and laptops to larger systems like electric vehicles and grid energy storage.

It's important to consider factors like voltage, capacity, and rechargeability when choosing a battery for a specific application to ensure optimal performance. Regular maintenance and proper handling are also essential to maximize the lifespan and efficiency of batteries.

2.4 Battery holder:

A battery holder is a device used in electrical circuits to secure and connect batteries in place. It provides a convenient and reliable way to hold batteries within a circuit, ensuring proper electrical contact for power transmission. Battery holders come in various shapes and sizes to accommodate different battery types, such as AA, AAA, C, D, and coin cell batteries.

Fig 2.4 Battery holder

These holders typically consist of a plastic casing with metal contacts that make contact with the battery terminals. They often have features like springs or clips to securely hold the battery in position and maintain a stable connection. Battery holders are commonly used in electronic devices, toys, remote controls, and other portable gadgets where batteries need to be easily replaced or removed.

Choosing the right battery holder is important to ensure compatibility with the specific battery size and type required for the application. Proper installation and maintenance of battery holders help in preventing electrical interruptions, ensuring continuous power supply to the circuit.

2.5 Breadboard:

A breadboard is like a playground for building and testing electronic circuits without soldering. It's a rectangular board with lots of holes for inserting and connecting electronic components like resistors, capacitors, and integrated circuits. The holes are connected in rows and columns, making it easy to create circuits by plugging components and wires into the breadboard.

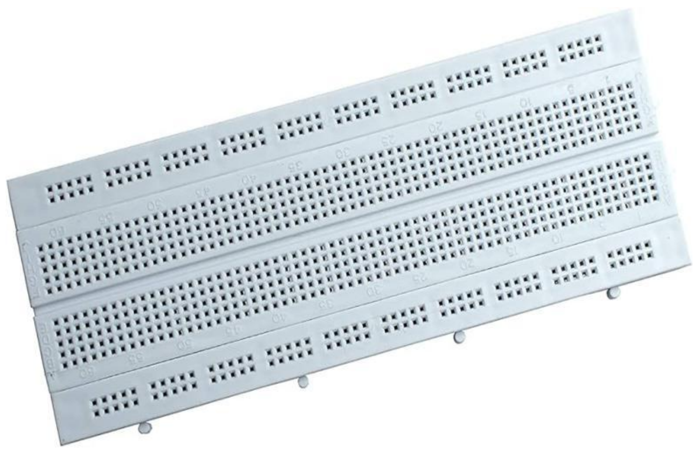

Fig 2.5 Breadboard

Breadboards are great for prototyping and experimenting with circuits because they allow you to quickly make changes and test different configurations without damaging components. They have metal strips underneath the holes that connect components together, simulating a circuit without the need for soldering.

By using jumper wires, you can connect components on the breadboard to create complex circuits. Breadboards are commonly used by students, and professionals to design and test circuit ideas before moving to a more permanent circuit board.

2.6 Jumping wires:

Jumper wires are essential tools in electrical circuits for making connections between components on a breadboard or other prototyping platforms. These wires are typically made of flexible insulated material with metal connectors at each end, allowing for easy and temporary connections between different points on a circuit.

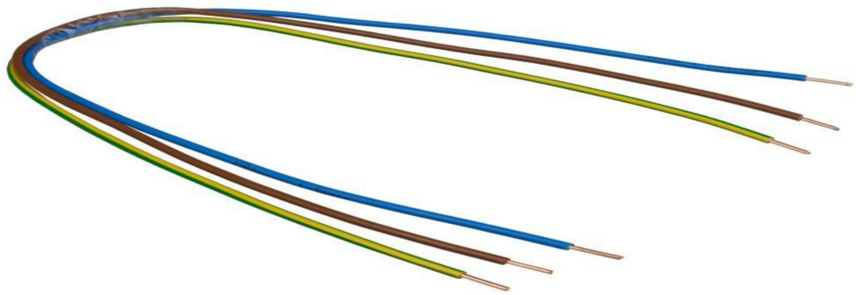

Fig 2.6 Jumper wires

Jumper wires come in various lengths, colors, and types, such as male-to-male, male-to-female, and female-to-female, to accommodate different circuit layouts and configurations. They enable users to create complex and customized circuit designs by bridging specific points on a breadboard or connecting components that are not directly adjacent.When working on electronic projects, jumper wires provide a convenient way to establish electrical connections without the need for soldering, making it easy to modify and troubleshoot circuits quickly.

2.7 LED’s:

LED lights or Light Emitting Diodes, are semiconductor devices that emit light when an electric current passes through them. They are highly efficient and durable compared to traditional incandescent or fluorescent lights. LEDs are used in a wide range of applications, from indicator lights on electronic devices to lighting up entire rooms and buildings.

Fig 2.7 Light Emitting Diodes

LED lights produce light by the movement of electrons in a semiconductor material within the LED chip. The color of the light emitted depends on the material used in the semiconductor. LEDs are available in various colors, including red, green, blue, and white. LED lights are known for their energy efficiency, long lifespan, and low heat output, making them environmentally friendly and cost-effective lighting solutions. LED lights are commonly used in residential, commercial, and industrial settings due to their versatility and energy-saving properties. They are also used in automotive lighting, street lighting, and electronic displays. Understanding the benefits and technical aspects of LED lights is important when selecting the right lighting solutions for different applications.

2.8 Switch:

A switch in electrical terms is a device that controls the flow of electricity in a circuit. It can either allow or interrupt the current passing through it. Switches come in various types, such as toggle switches, push-button switches, and rotary switches, each serving different purposes based on their design and functionality.

Fig 2.8 Switch

When a switch is in the "on" position, it completes the circuit, allowing electricity to flow through and power the connected devices or components. Conversely, when the switch is in the "off" position, it breaks the circuit, stopping the flow of electricity and turning off the connected devices.

Switches are fundamental components in electrical systems, enabling users to control the operation of lights, appliances, machinery, and other electrical devices. They play a crucial role in circuit design by providing a means to manually control the flow of electricity. Understanding the different types of switches and their applications is essential for effectively managing and operating electrical systems.

2.9 Capacitor:

A capacitor in electrical terms is a component that stores and releases electrical energy in a circuit. It consists of two conductive plates separated by an insulating material known as a dielectric. When a voltage is applied across the plates, an electric field is created, causing one plate to accumulate positive charge and the other to accumulate negative charge.

Fig 2.9 Capacitor

Capacitors are used in various electrical applications to perform functions such as filtering, energy storage, and timing. They can store energy temporarily and release it when needed, smoothing out voltage fluctuations in circuits. Capacitors also block direct current (DC) while allowing alternating current (AC) to pass through, making them useful in coupling and decoupling circuits.

Different types of capacitors exist, each with unique characteristics suited for specific applications. Understanding the capacitance value, voltage rating, and other specifications of capacitors is essential when selecting the right component for a particular circuit design. Capacitors play a vital role in electronics by stabilizing power supplies, filtering noise, and storing energy efficiently.

2. BLOCK DIAGRAM

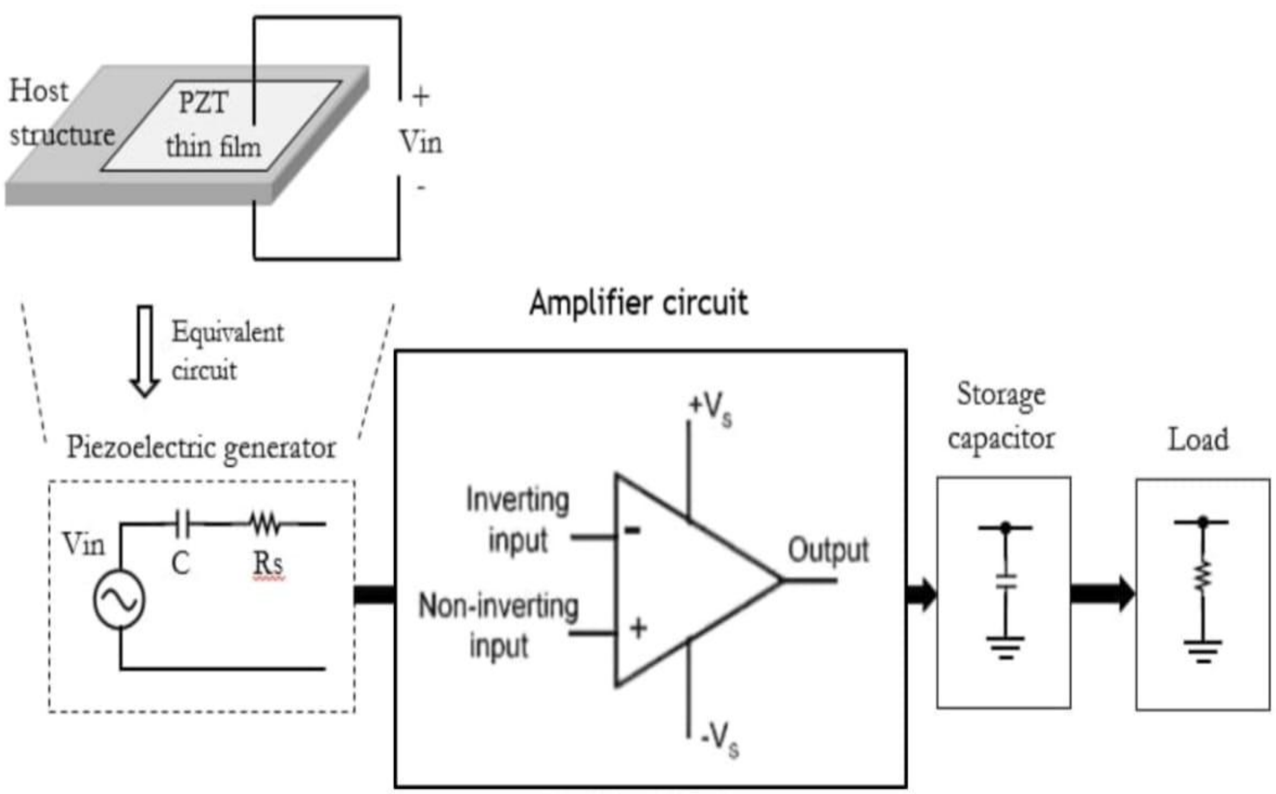

Fig 7.1 Block Diagram

4. WORKING PRINCIPLE

The piezoelectric effect results from the linear electromechanical interaction between the mechanical and electrical states in crystalline materials with no inversion symmetry. The piezoelectric effect is a reversible process: materials exhibiting the piezoelectric effect also exhibit the reverse piezoelectric effect, the internal generation of a mechanical strain resulting from an applied electric field.

For example, lead zirconate titanate crystals will generate measurable piezoelectricity when their static structure is deformed by about 0.1% of the original dimension. Conversely, those same crystals will change about 0.1% of their static dimension when an external electric field is applied.

The inverse piezoelectric effect is used in the production of ultrasound waves.

French physicists Jacques and Pierre Curie discovered piezoelectricity in 1880. The piezoelectric effect has been exploited in many useful applications, including the production and detection of sound, piezoelectric inkjet printing, generation of high voltage electricity, as a clock generator in electronic devices, in microbalances, to drive an ultrasonic nozzle, and in ultrafine focusing of optical assemblies.

It forms the basis for scanning probe microscopes that resolve images at the scale of atoms. It is used in the pickups of some electronically amplified guitars and as triggers in most modern electronic drums. The piezoelectric effect also finds everyday uses, such as generating sparks to ignite gas cooking and heating devices, torches.

5.ADVANTAGES

1.) Renewable and Sustainable Energy Source:- Piezoelectric sensors convert mechanical energy from vibrations into electrical energy, providing a renewable and sustainable energy source that doesn't rely on fossil fuels.

2.)Energy Harvesting from Ambient Sources:- This method can capture energy from various ambient sources like traffic, machinery, human movement, and environmental vibrations, making it versatile and widely applicable.

3.)Scalable Technology:- Piezoelectric energy harvesting systems can be scaled to different sizes, from small sensors in wearable devices to larger systems embedded in infrastructure like Roads and buildings.

4.)Minimal Environmental Impact:- The installation of piezoelectric sensors typically has a Low environmental impact, especially compared to large-scale renewable energy projects like Wind farms or solar parks.

5.)Reduced Energy Waste:- By capturing and utilizing ambient energy that would otherwise go to waste, piezoelectric sensors contribute to overall energy efficiency.

6.)Maintenance-Free Operation:- Piezoelectric sensors are generally robust and require minimal maintenance, leading to lower operational costs over time.

7.)Power Supply for Remote and Low-Power Applications:- Piezoelectric energy harvesting is deal for powering remote sensors, IOT devices, and low-power electronics, reducing the need for batteries and frequent maintenance.

8.)Enhanced Safety and Monitoring:- Piezoelectric sensors can be used in structural health monitoring systems, detecting vibrations and stresses in buildings, bridges, and other infrastructure, thus enhancing safety.

6.DISADVANTAGES

1. High Initial Cost: The installation of piezoelectric materials in roads is expensive. The cost of the materials themselves, along with the specialized installation process, can be prohibitively high.

2. Maintenance Challenges: Maintaining piezoelectric roads can be difficult and costly. Repairs and replacements require specialized knowledge and materials, and the process can disrupt traffic.

3. Durability Concerns: The longevity of piezoelectric materials in the harsh conditions of roadways is a concern. They must withstand heavy loads, temperature fluctuations, and wear and tear from constant traffic.

4. Efficiency Issues: The energy conversion efficiency of piezoelectric systems is relatively low. The amount of electricity generated may not justify the investment and maintenance costs.

5. Limited Power Output: The power generated by piezoelectric roads is often limited and may not be sufficient for large-scale applications. This makes them more suitable for small-scale, localized power needs rather than significant energy production.

6. Environmental Impact: The production and disposal of piezoelectric materials can have environmental impacts. Some materials used in these systems may be hazardous or difficult to recycle.

7. Technical Complexity: Integrating piezoelectric systems with existing road infrastructure and power grids can be technically complex, requiring significant planning and engineering efforts.

8. Weather Dependence: Extreme weather conditions, such as heavy snow or intense heat, can affect the performance and durability of piezoelectric materials, potentially reducing their effectiveness and lifespan.

7. APPLICATIONS

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. Depending on the design of a sensor, different "modes" to load the piezoelectric element can be used: longitudinal, transversal and shear.

Detection of pressure variations in the form of sound is the most common sensor application, e.g. piezoelectric microphones (sound waves bend the piezoelectric material, creating a changing voltage) and piezoelectric pickups for acoustic-electric guitars. A piezo sensor attached to the body of an instrument is known as a contact microphone.

Piezoelectric sensors especially are used with high frequency sound in ultrasonic transducers for medical imaging and also industrial nondestructive testing (NDT).

For many sensing techniques, the sensor can act as both a sensor and an actuator—often the term transducer is preferred when the device acts in this dual capacity, but most piezo devices have this property of reversibility whether it is used or not. Ultrasonic transducers, for example, can inject ultrasound waves into the body, receive the returned wave, and convert it to an electrical signal (a voltage). Most medical ultrasound transducers are piezoelectric.

In addition to those mentioned above, various sensor and transducer applications include:

Piezoelectric elements are also used in the detection and generation of sonar waves.
Piezoelectric materials are used in single-axis and dual-axis tilt sensing.
Power monitoring in high power applications (e.g. medical treatment, sonochemistry and industrial processing).

Piezoelectric microbalances are used as very sensitive chemical and biological sensors. Piezoelectrics are sometimes used in strain gauges. More commonly however, a Piezoresistive effect element is used.

A piezoelectric transducer was used in the penetrometer instrument on the Huygens Probe. Piezoelectric transducers are used in electronic drum pads to detect the impact of the drummer's sticks, and to detect muscle movements in medical acceleromyography.

Automotive engine management systems use piezoelectric transducers to detect Engine knock (Knock Sensor, KS), also known as detonation, at certain hertz frequencies. A piezoelectric transducer is also used in fuel injection systems to measure manifold absolute pressure (MAP sensor) to determine engine load, and ultimately the fuel injectors milliseconds of on time.

Ultrasonic piezo sensors are used in the detection of acoustic emissions in acoustic emission testing.

Piezoelectric transducers can be used in transit-time ultrasonic flow meters.

8.RESULT

From this project we succeeded in using the positive piezo-electric effect, so we are able to collect vibration energy in the form of mechanical vehicle vibration and apply it to the required application.

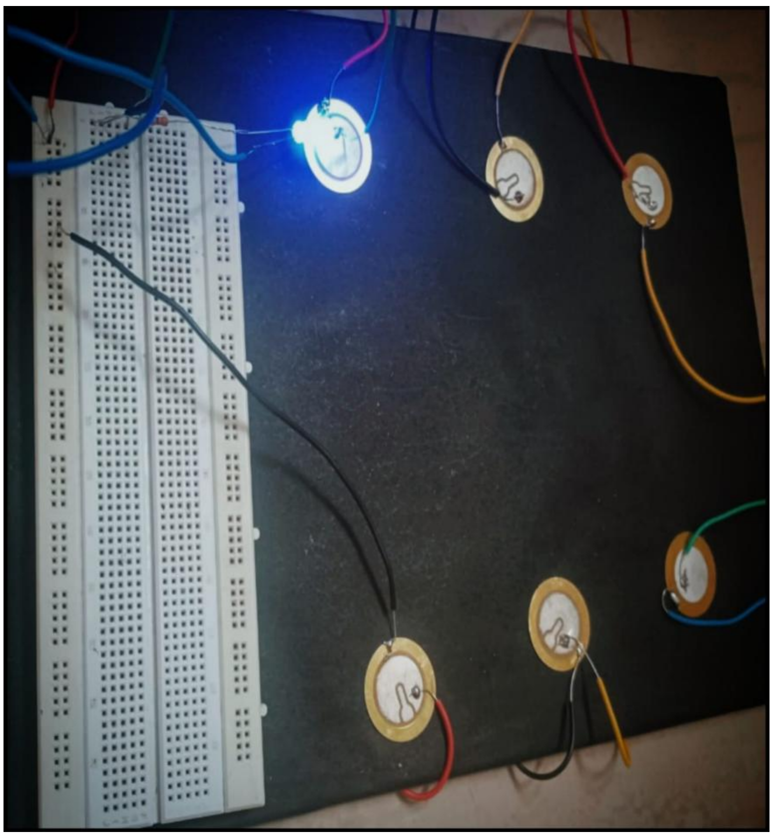

Fig 8.1 Working Model

9.CONCLUSION

The document concludes that piezoelectric materials have potential as a green energy source by converting ambient vibrations into usable electrical energy. Piezo-electricity is a revolutionary source for "GREEN ENERGY". Flexible piezoelectric materials are attractive for power harvesting applications because of their ability to withstand large amounts of strain. Convert the ambient vibration energy surrounding them into electrical energy. Electrical energy can then be used to power other devices or stored for later use. Thus, piezoelectric transduction is the most promising ambient energy harvesting technology that has found applications in many diverse fields including structures, transportation, wireless electronics, microelectromechanical systems, Internet of Things (IoT), wearable and implantable biomedical devices.

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11.IMAGE COURTESY

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