Design a Smart Energy System for Shopping Mall Based On Piezoelectric Sensor.

Submitted By

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Submitted in partial fulfillment of the requirement for the degree of

Bachelor of Electrical Engineering

December 2023

DEDICATION

We dedicate our project research and thesis with the utmost gratitude and affection to our parents, who we know always pray for us; our teachers, who have always been a source of knowledge and inspiration; and our friend, who helped us along the way until the project was successfully completed.

Every difficult task requires both personal effort and the advice of elders, particularly those who are very close to us.

ABSTRACT

One of the most problem in the world is energy crisis. To reduce this energy crisis problem in the world, renewable energy sources will be a very good medium. Everyone knows that natural resources (fossil fuels) will end one of these days. Just because of this, scholars are trying to grow or introduce substitute or alternative sources of energy that can be effortlessly gained from the environment. It must be pollution-free, green, and not dangerous for the environment. In this research project, we concentrated on the analysis, performance, and application of a piezoelectric transducer, which converts mechanical pulsation into electrical power. We create a piezoelectric tile that will harvest energy from pulsation and pressure, which will be presented in a few terms, like the footsteps of humans. This research project presents an ideal of an energy-producing system using piezoelectric sensors. This technology is cost-effective, green, easy to use on many devices, and pollution-free. This project aims to highlight the importance of replacing stone and ceramic tiles with green, sustainable piezoelectric tiles that can be installed in public spaces and produce a valuable amount of energy for an exciting public space utilizing the guest's highly crowded area. The piezoelectric transducer generates an output voltage of 4.12 volts and a frequency of 1.16 Hz. Since a 3.7V battery cannot be charged using a piezoelectric crystal's output, the very little electrical energy that the crystal produces—roughly 2-4 volts—is first stored in a 3.7V rechargeable battery using a buck boost converter. To raise the voltage, the circuit of the boost converter is employed. A 3.7V battery is used to hold the boost converter, which raises voltage levels to roughly 32V. This project can be carried out in densely populated regions where more vibration energy can be obtained, such as bus stops and train stations.

Keyword: piezoelectric sensor, bright rectifier, LED.

ACKNOWLEDGMENT

I am grateful to Almighty Allah for giving us this chance and giving us the skills we need to complete the task at hand. Thanks to the help and advice of multiple people, this thesis is presented in its current form. As a result, we sincerely thank each and every one of them. We are incredibly grateful to our parents for their support, encouragement, attention, and prayers. We gained strength and spirit from their blessing.

We are thankful and would like to sincerely thank **Dr.Muhammad Ilyas.**

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We are thankful and would like to sincerely thank **Dr.Muhammad Ilyas,** our kind supervisor, for his perseverance, inspiration, vast knowledge, and suggestions during this project. It would not have been possible to complete the project thesis without his interest and support.

We extend our sincere gratitude to **Dr. Atta Ullah Khaidrani, the Chairman of the Electrical Engineering Department (BUETK),** for his gracious coordination and unwavering support in providing the necessary internet access and extra lab hours to finish the project.

I would also like to express my gratitude to everyone who has contributed to this project, whether directly or indirectly.

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List of Abbreviations

K.E.	**Kinetic energy**
kw	**Kilowatt**
MW	**Megawatt**
mW	**Milli watt**
µ-W	**Microwatt**
MEMS	**Micro-electromechanical systems**
Vd	**Voltage drop**

Balochistan University of Engineering and Technology

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Certificate

This is to certify that the work presented in this project report / thesis on "**Design a Smart Energy System For Shopping Mall Based On Piezoelectric Sensor.**" is entirely written by the following students themselves under the supervision of Dr.Muhammad Ilyas .

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This Project is submitted in partial fulfillment of the requirement for the award of "Degree of Bachelor of Engineering" in Electrical discipline.

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Chapter 1

Introduction

1.1 Motivations

The piezoelectric effect is a new, environment-friendly, and non-toxic method for harvesting energy. It avoids the presence of all toxic chemicals in our environment. The piezoelectric energy technique has a high power density and high flexibility. Utilization of this technology is on a small scale, i.e., used to give power to street lights. Piezoelectric materials have the properties and the ability to convert pressure energy into electrical energy.

1.2 Problem Statement

To sustain our civilization, one of the basic requirements is energy, so its quantity should be abundant and secure. In the 21st century, electrical energy plays a pivotal role in the development of industrialized nations. To improve the living standards of people, a reliable source of energy is required. Therefore, piezoelectric is one of the most reliable and renewable sources of energy that produces electrical energy from vibration and pressure energy. It plays a vital role in harvesting green energy.

Piezoelectric-based energy harvesting is new and not currently available in the local market. Low-cost solutions and low output current are the main problems of existing piezoelectric-based energy harvesters.

1.3 Significance/Justification of Study

The piezoelectric effect is a new, environment-friendly, and non-toxic method for harvesting energy. It avoids the presence of all toxic chemicals in our environment, such as carbon dioxide, carbon monoxide, nitrogen, etc. The piezoelectric energy technique has a high power density and high flexibility. Piezoelectric materials have the properties and the ability to convert pressure energy into electrical energy.

1.4 Objectives

1.1 Outlines

This project report comprises of five chapters, introduction, literature review, method, result and discussion, and conclusion.

Chapter 1

This chapter includes the motivation, background, problem statement, significance of study and objectives.

Chapter 2

Literature review focused on the new, affordable and sustainable piezoelectric technology based energy harvesting system from the footsteps.

Chapter 3

Discuses methodology of prototype piezoelectric based sustainable and green energy harvesting setup (tile) and its structure.

Chapter 4

Discuses results and discussion.

Chapter 5

This chapter contain the conclusion

Chapter 2

Literature Review

At the present time, the third world's countries are facing a huge challenge to energy creation. The energy crisis is the most serious matter facing these underdeveloped countries. In the last few years, Egypt has suffered a shortage of power, which disturbs the industry sector as well as the domestic sector due to the rape of fossil fuels [10]. Moreover, it disturbs the development of these countries and structures new super projects [11].

One of the top alarming problems around the world is energy. This problem is especially critical in a densely populated nation like Bangladesh. In Bangladesh, the energy crisis is a large issue, and with the supreme growth of population, this crisis is increasing day by day [12]. To reduce this energy crisis problem in Bangladesh, renewable energy sources will be a very good medium. As we know, the natural resources (fossil fuels) will finish one day [13]. Just because of this, scholars are trying to grow or introduce substitute or alternative sources of energy that can be effortlessly gained from the environment. And that must be pollution-free, green, and not dangerous for the environment [14].

The process of energy harvesting, also called the power harvesting process, is well-defined as capturing minute amounts of energy from other sources such as thermal energy, solar energy, wind energy, kinetic energy (K.E.), etc. [15] and storing them in wireless, small devices. Energy harvesters provide us with a very small amount of power for low-energy electronics [16]. People have already applied and started to use this type of method of energy harvesting in the practice of windmills, geothermal, and solar energy [17]. Renewable energy is energy that can originate from natural sources [18]. Renewable energy plants can produce kilowatt (kW) or megawatt (MW) power and are called macro energy harvesting technology [19]. Micro energy can also be created from natural sources, and it is called micro energy harvesting technology [20]. From mechanical stress or mechanical vibration, as well as from friction sources and many other biological sources, micro energy harvesting technology is produced that can produce milliwatt (m-W) or microwatt (μ-W) power. Our project is based on this micro-energy from vibration or pressure via piezoelectric sensors and stores this energy in a battery [21].

In the form of walking, running, etc., human-powered transport has been in existence since ancient times. On the other hand, recent technology has led to the development of equipment to boost the use of human power in a more effective way [22]. This project comprises a simple system and components that are fitted under the walking platform. After a person applies pressure to this walking platform, his or her body weight compresses the system, and current is produced that will be stored in the battery [23]. More motion by people will generate more energy. This setup utilizes human movement power that would derive energy from the footsteps of human beings in crowded places [24]. This system produces electricity without creating pollution. The source of energy is nonstop and renewable [25].

The world's pollution from conventional sources of energy shifts scientists to search for new sources of energy [26]. The sustainable, non-toxic, and green source of energy is the power generation from the pedestrian's footsteps. The aims are to design and measure a simple device that converts the (K.E.) kinetic energy of pedestrians to electrical energy [27]. This type of device may be installed in all crowded areas with a large number of pedestrians, such as football grounds, mosques, underground stations, churches, stadiums, etc. The technique of energy harvesting from this device seems suitable for such applications as street lights, information displays, and advertising billboards [28].

2.1 Piezoelectric materials

There are both nature and man-made materials, that show a rang of piezoelectric effect. They are classified into three categories:

1-Naturally occurring, crystal substrates, 2- Ceramics with perovskite structure, 3- Polymer film

These further classifications are single crystals and polycrystals. Generally,

I. Single crystals such as $LiTaO_3$, SiO_2, $LiNbO_3$, $La_3ga_5SiO_{14}$, etc., have a steady assembly of elements that's the way they have stable characteristics.

II. Polycrystals such as $Pb(Zr.Ti)O_3$, $BaTiO_3$, $PbTiO_3$, etc., have a lot of rates of the elements because they have multiple characteristics[29] .

Materials	Specific permittivities ε	Piezoelectric constants, $d/10^{-12}CN^{-1}$
Quartz crystal (SiO_2)	$\varepsilon_{11}^T/\varepsilon_0 = 4.52$, $\varepsilon_{33}^T/\varepsilon_0 = 4.68$	$d_{11} = 2.31$, $d_{14} = 0.727$
Lithium niobate	$\varepsilon_{11}^T/\varepsilon_0 = 84$	$d_{15} = 68$, $d_{22} = 21$
($LiNbO_3$) crystal	$\varepsilon_{33}^T/\varepsilon_0 = 30$	$d_{31} = -1$, $d_{33} = 6$
Lithium tantalite	$\varepsilon_{11}^T/\varepsilon_0 = 51$	$d_{15} = 26$, $d_{22} = 7$
($LiTaO_3$) crystal	$\varepsilon_{33}^T/\varepsilon_0 = 45$	$d_{15} = 68$, $d_{33} = 8$
Lead zirconate titanate	$\varepsilon_{11}^T/\varepsilon_0$ = from 1500 to 1700	d_{15} = from 500 to 580, d_{31} = from − 170 to – 125
($Pb(Zr,Ti)O_3$) ceramics	$\varepsilon_{33}^T/\varepsilon_0$ = from 1300 to 1700	d_{33} = from 290 to 370

Table 2.1 constants of single crystal and polycrystalline piezoelectric

2.1.1 Commercially available piezoelectric sensors

There are many piezoelectric transducer/piezo sensors are available in the Pakistani online market. These are shown in below table

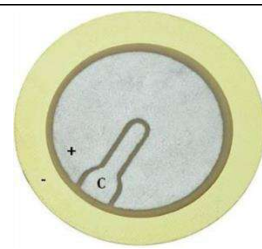
No.	Name of piezo based sensor	Cast in PRs.	Physical appearance
1	27mm piezoelectric transducers piezoelectric sensor, piezo transducer	10-40	
2	Flexible piezoelectric transducers	900-1500	
3	Piezo vibration sensors	1500	
4	Piezo buzzer u shaped audio indicator KDS 22mm X 7.0mm	10-100	

Table 2.3 Commercial available piezoelectric sensors in Pakistani market

The three reported application that applied piezoelectric floor tiles in native project and Advantage from the clean energy created. The case studies will existent the advantage and difficulties that come about after using piezoelectric tiles.

2.2.1 Reported application 1:

Figure 2.1 Tokyo Station

This circumstance study was an investigation made by JR East Company. This company fixed the piezoelectric floor tiles "energy-generating floor" at Tokyo station's Yaesu Inter or Exit permit door (Japan), operating power made to cover a section of the electrical yield for such offices, such as automated ticket entrances and electroluminescence screens. On January 19, 2008, it starts installing and starts operating in March 2008 (Madonna et al., 2020).

2.2.2 Reported application 2

Figure 2.2 Ponte 25 De April

The researchers placed piezoelectric energy-generating tiles on a bridge situated in Lisboa, Portugal. This kind of tile was called "Waynergy Tiles," with a size of 0.25 x 3 m. The road traffic thickness on this bridge is 155,000 automobiles per day. The energy price for lighting the bridge is nearly 10.000 €/year. While investing in fixing piezoelectric tiles (Waynergy), the power price will be 30.000 €. Piezoelectric tile installed power is 6 kilowatts, which will power refunds in a few years. The ratio of life savings is nearly 65%. The typical investment in ten years is almost 35.000 € (Madonna et al., 2020).

2.2.3 Reported application 3:

Figure 2.3 Dance floor

The Club Watt, The date of opining was September 12, 2008; it is found in Rotterdam. The club contains four areas: a hall with a capacity of 1,500, a basement for 300, two rooftops with a relaxation area for smoking, and 20 covers at road level. This club utilizes piezoelectric energy-harvesting tiles to produce green and effective energy. I noticed that these tiles made noteworthy savings on energy consumption of about 30%. This project used sustainable techniques so that it saves water H2O with an average of 50%, decreases carbon dioxide CO2 emissions with an average of 50%, and uses the waste K.E. of humans as they dance on the floor. This sustainable club's dance floor moved on. Each tile consists of an electromechanical framework that changes the vertical motion produced by the movement of individuals in the form of rotating motion that operates the generator. The dance floor tiles are divided into two portions: the first is energy collection, and the second is lighting, as shown in Madonna et al. (2020).

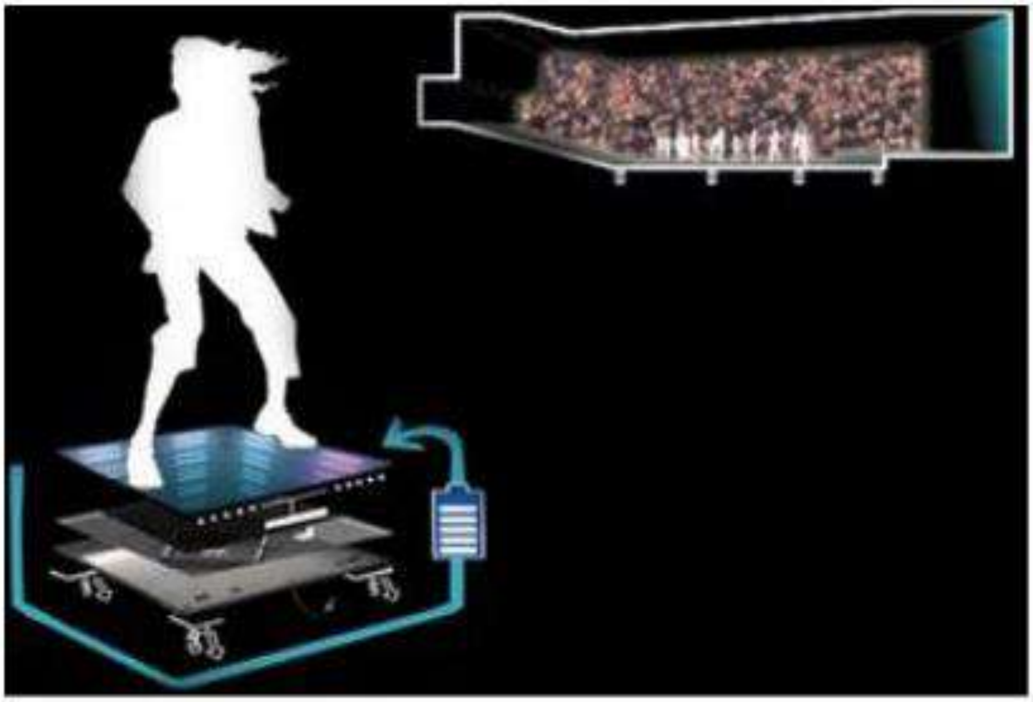


Figure 2.4 Dance floor

The sustainable project was based on the fact that each watt produced from the dancing floor includes a variety of sustainable processes that incorporate the use of LED lighting rather than a power spotlight. The club's LED dance floor transforms every person's kinetic energy into 20W, enabling it to power itself. Every person’s kinetic energy, K.E., with the help of the club’s LED dance floor, transforms into 20W that is enabled to power itself. This technology reduces CO2 emissions (Madonna et al., 2020).

With the current invention, the individual can harvest 5–20 watts of power, depending upon their weight and motion (the greater they move, the greater the power). That suggests one single person could electrify a connected LED light, and a CFL light could be electrified by two individuals (Madonna et al., 2020).

For lighting the club, the energy cost is almost $274,834.56 per year. While the cost of installing piezoelectric tiles will be $115,124,.The savings will be about $82,450.37 per year, and that may be repaid within 4 years. The energy-saving is almost 30% percentage. In 10 years, the saving average is nearly $824,503.68 (Madonna et al., 2020).

2.2.4 Analysis

Allowing for the preceding, the investigation will specify the case studies in this segment to investigate the efficacy of utilizing piezoelectric floor tiles in inner places, as displayed in the following table.

Location name	Ponte 25 De Abril	Tokyo Station	Club Watt
Figures			
Project Type	Bridge	Metro Station	Dance Club
Site (area)	Lisboa, Portugal	Tokyo, Japan	Rotterdam
Price	67,200$	27,090$	115,124$
Area	---	25.00 m^2	38.00 m^2
Sum of energy	240 W / Motor vehicle	500 kW-seconds power per day	25w single module
Tile Shape	Rectangle	Square	Square
Pattern	tiles Replacing	Over tiles	Replacing tiles
type of Piezoelectric tiles	Waynergy	Sound Power Tile	(SEF) Sustainable Energy Floor
Tile Size	00.25 x 3.0 m	90 cm^2, 2.5 centimeter thick	75.0 x 75.0 x 20.0 cm
Color	Black	Black	Transparent
Total users used per day	155.000 motor vehicle	400,000	1400
Saved energy	65% of the bridge power	An adequate amount of energy	Decreases the club utilization tilesby 31%

Table 2.4 Scrutinize the case studies

2.3 Properties and type of Piezoelectric Tile

Company Name	**Tile size**	**Energy produced**	**Price in US $**	**Life span by year**
Waynergy Floor Sustainable Energy floor (SEF)	40 x 40 cm20 75 x 75cm OR 50 x 50 cm	10 W per step tile Up to 30 watt of continuous output. Typical power output for continuous stepping by a person lies between 1 and 10W (average 7W)	451.5 1,693	20
Pavegen tiles	50 x 50 cm	5 W	395	20
(EAPs) Electro-Active Polymers	Sheets	1W	-----	20
Sound Power PZT ceramic (Lead Zirconate Titanate) Parquet PVDF layers	50 x 50 cm Manufacturing in a small size Layers	0.1W0.0084 W per 2 steps 0.0021 W per pulse with loads of about 70 kg	270.9 36.1 -------	20 20 20
Drum Harvesters - Piezo buzzer Piezoelectric Ceramics	Vary	Around 0.002463 W	56.4	
POWER leap PZT hybrid energy floor combines human power with solar energy	60 x 60 cm 75 x 75 cm tile OR 100 x 200 cm	0.5 - up to 250 kWh per year per tile	------- 1,693	20 20

Table 2.5 properties & type of piezo sensor

Chapter 3

3.1 prototype design based on Simulink

In an era marked by escalating energy demands and growing concerns about sustainability, the development of innovative energy harvesting systems has emerged as a critical area of research. These systems are designed to harness ambient mechanical energy from various sources and convert it into usable electrical power. Among the plethora of energy harvesting methodologies, the system under consideration employs a multi-stage process involving mechanical input, piezoelectric sensors, a bridge rectifier, a filter, a cuk converter, a battery, and a load. This comprehensive approach not only maximizes energy extraction but also ensures a reliable and continuous power supply to a variety of applications.

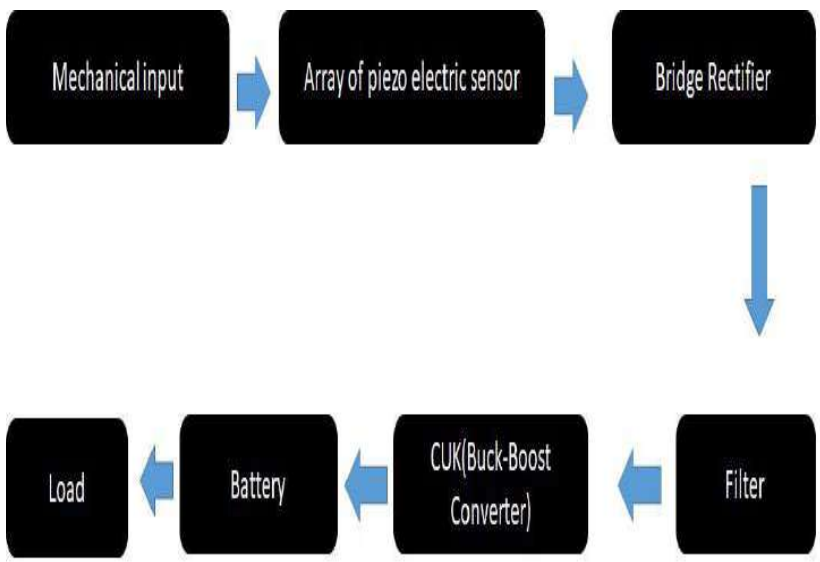


Figure 3.1: Block diagram of the circuit

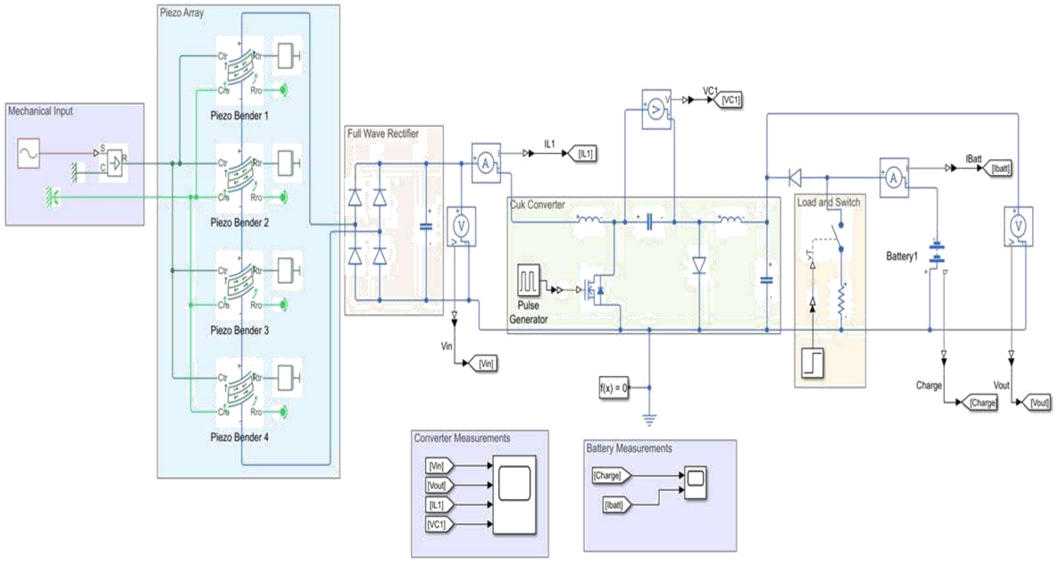


Figure 3.2: Simulink model Circuit

3.1.2 Mechanical Pressure

The foundational stage of this energy harvesting system involves the application of mechanical energy. This input can be sourced from a diverse array of origins, including vibrations, pressure differentials, or any form of mechanical movement. By tapping into these read-ily available sources of energy, this system exhibits versatility and adaptability, making it suitable for a wide range of real-world applications.

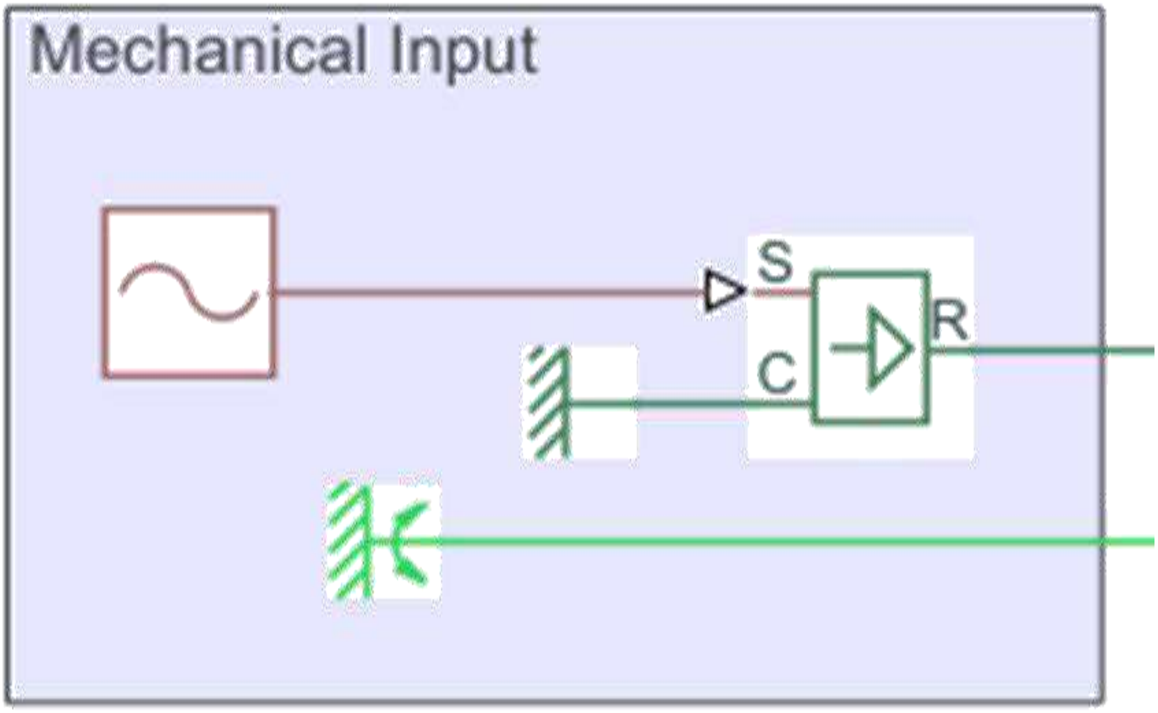


Figure 3.3: Array of Piezo electric Transducers

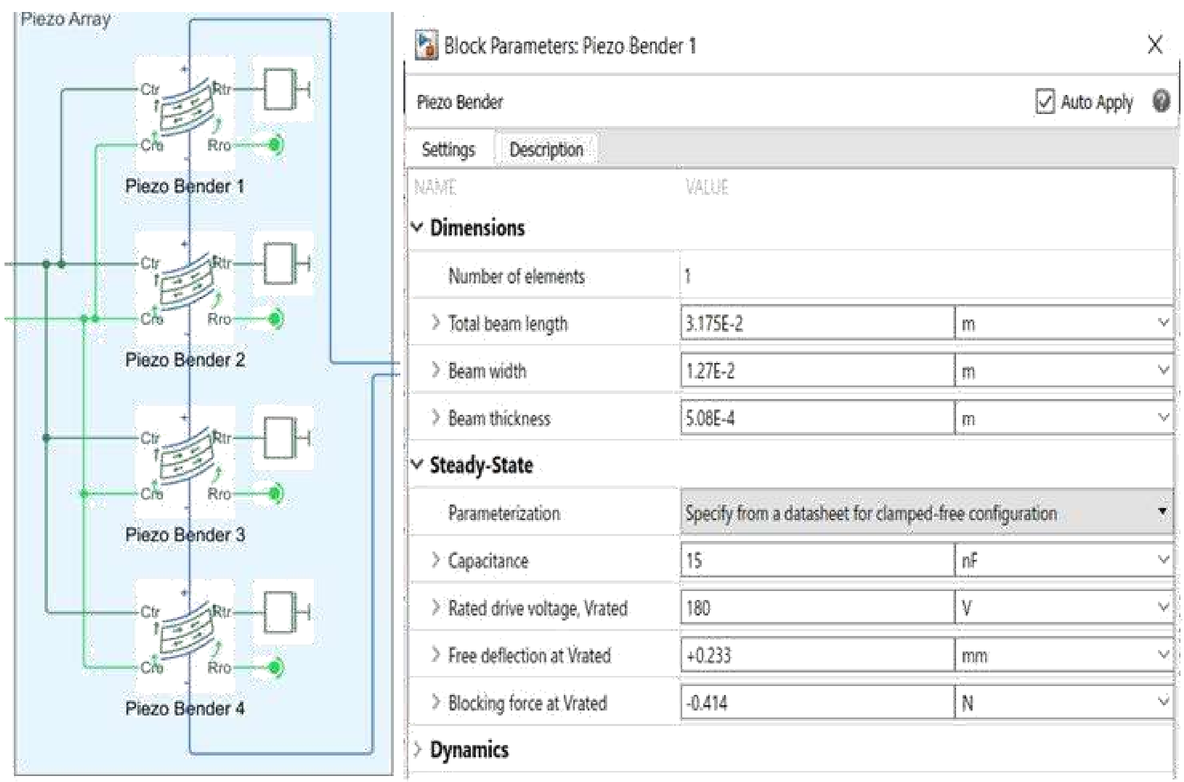


Figure 3.4: Array of Piezo electric Transducers

3.1.3 Array of Piezoelectric Sensors

Following the introduction of mechanical energy, the next crucial step involves the implementation of an array of piezoelectric sensors. These sensors are instrumental in the conversion of mechanical energy into electrical energy. Piezoelectric materials possess a unique property: they generate a voltage when subjected to mechanical stress. By employing an array, the system ensures efficient energy conversion and capture, thereby enhancing overall performance and output.

3.1.4 Bridge Rectifier

The output from piezoelectric sensors typically manifests as an alternating current (AC). To prepare this energy for further processing, a bridge rectifier is introduced. This essential component is tasked with the conversion of AC to direct current (DC). This rectification process is imperative for establishing a unidirectional flow of electricity, a foundational requirement for subsequent stages.

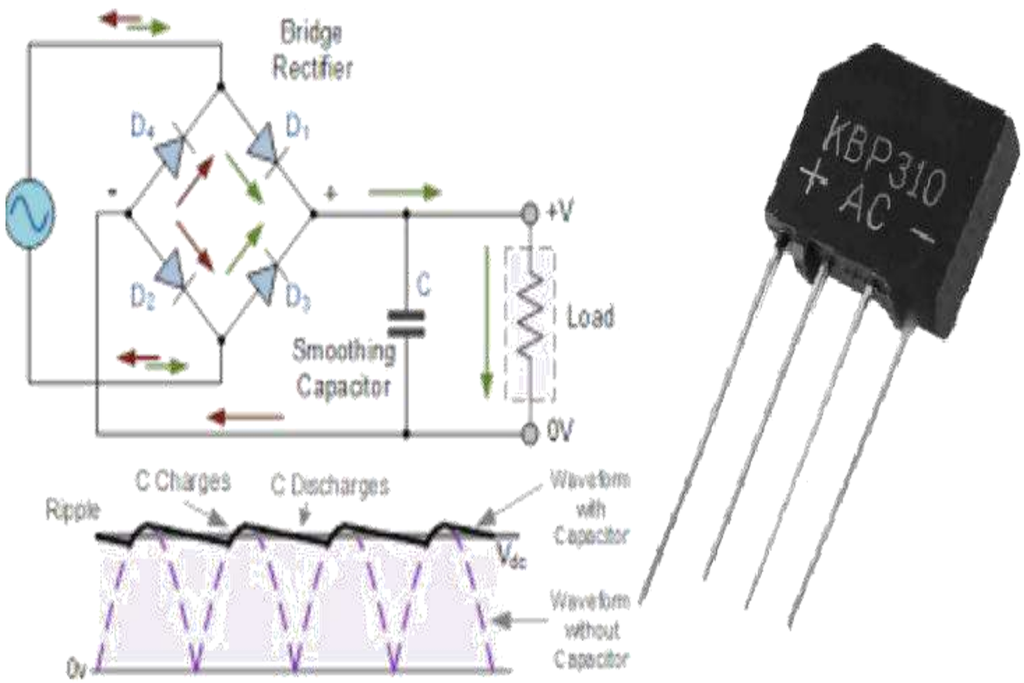


Figure 3.5: Bridge Rectifier

3.1.5 Filter

Even after the rectification process, the DC signal may still contain minor ripples or undesirable fluctuations. To mitigate this, a filter is incorporated into the system. This component works to smooth out the DC signal, resulting in a more stable and consistent output. The filter is integral to preparing the energy for subsequent stages, ensuring optimal performance.

3.1.6 Cuk Converter

The Cuk converter is a specialized DC-DC converter that plays a pivotal role in regulating the voltage level. Depending on the specific requirements of the load, the cuk converter can either step up (boost), step down (buck), or even invert the voltage. This stage is particularly significant in ensuring compatibility with both the battery and the load. By precisely adjusting the voltage, the cuk converter optimizes the energy for seamless integration with the subsequent components.

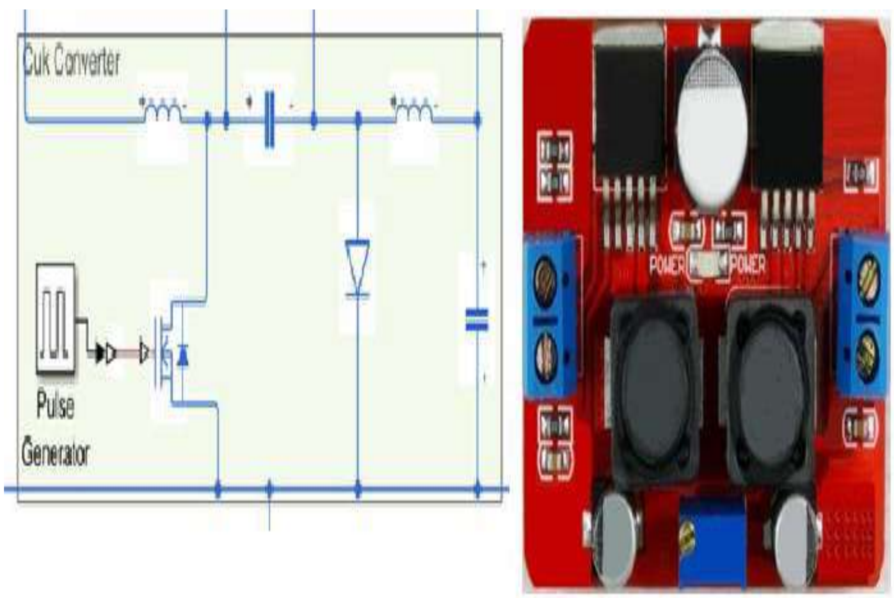


Figure 3.6: Cuk Converter

3.1.7 Battery

The cuk converter channels the stabilized energy into the battery, a critical component of the system. The battery functions as an energy reservoir, facilitating storage for future use. This aspect is of paramount importance, particularly in scenarios where the mechanical input is intermittent. The battery ensures a continuous and reliable power supply, enhancing the system's overall efficiency and performance.

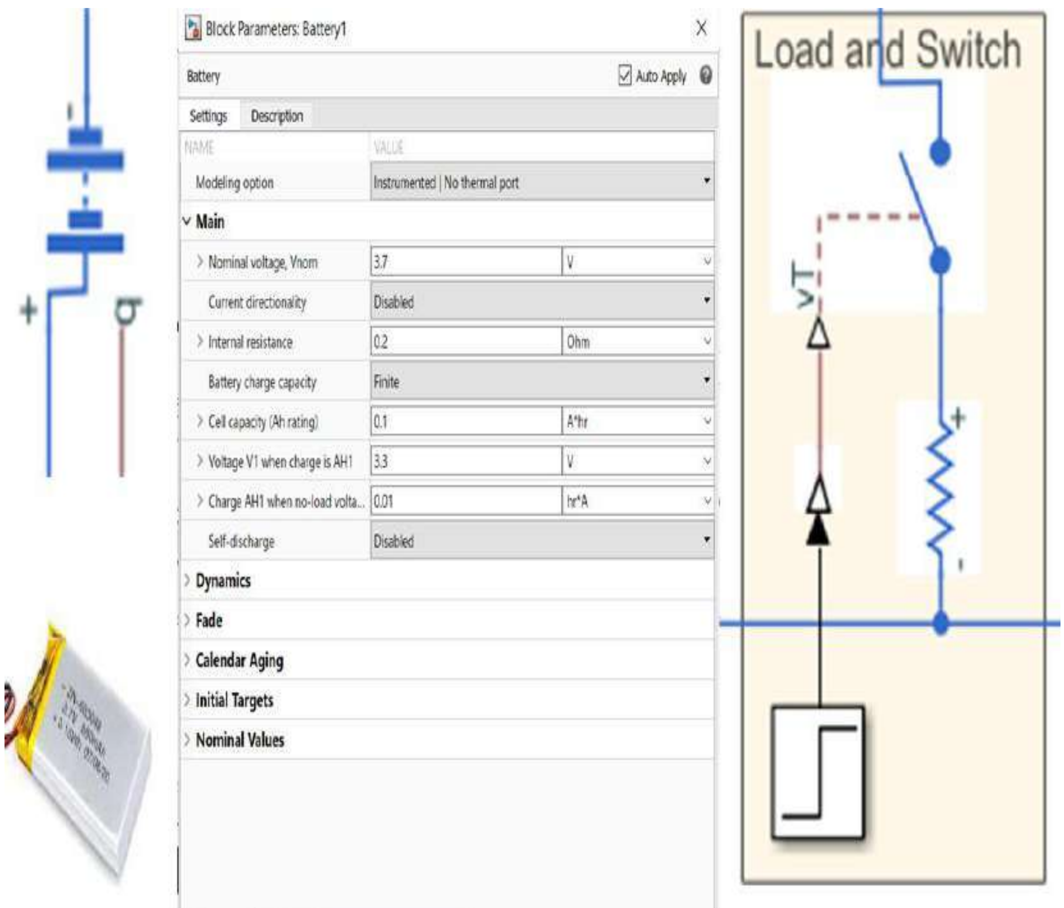


Figure 3.7: Battery

3.1.8 Load

The final stage of the energy harvesting process involves the utilization of the stored energy to power the desired device or system. The load represents any electrical or electronic component that requires the generated energy for operation. By tailoring the system to meet the specific needs of the load, this stage ensures that the harvested energy is put to practical use, underscoring the system's real-world applicability.

Simulated results

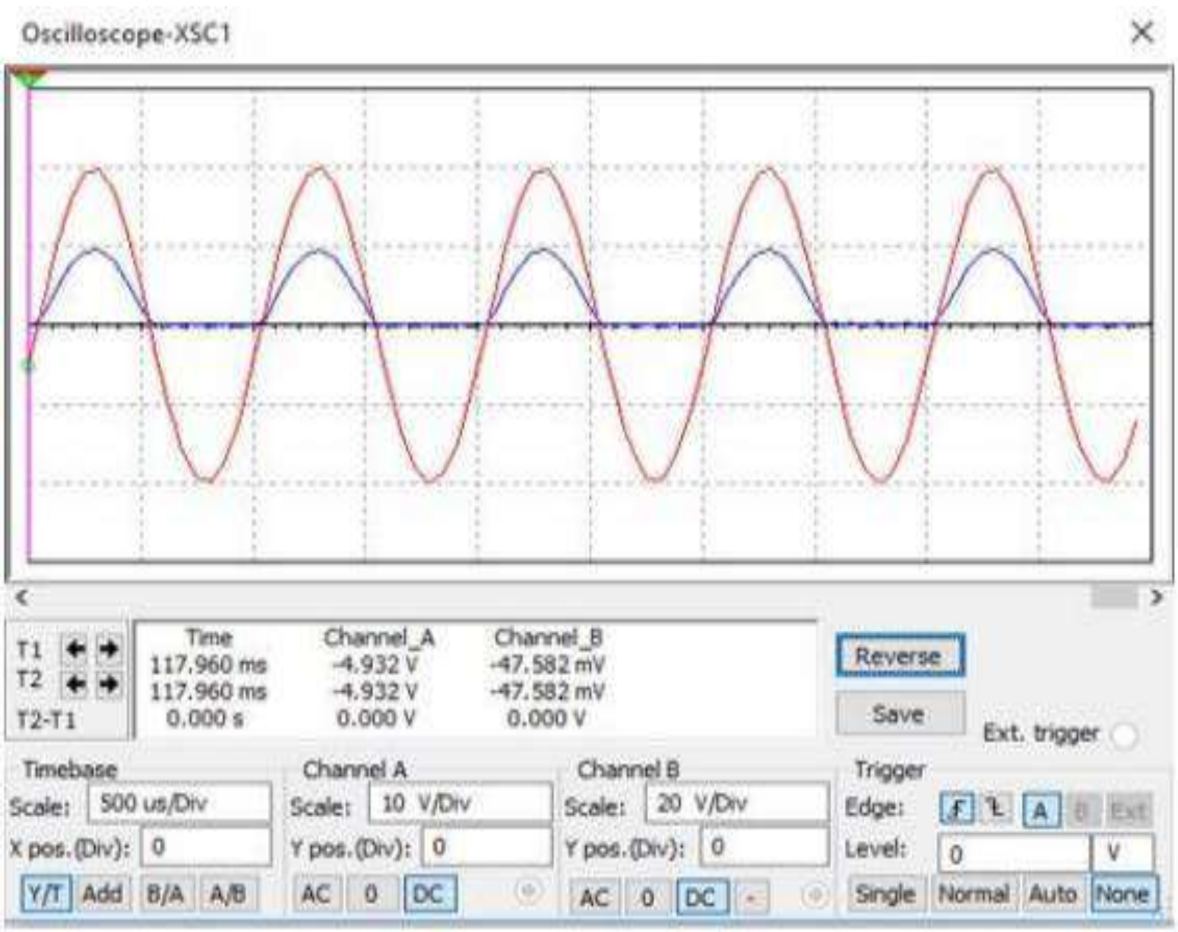


Figure 3.8 The half- wave rectifier output.

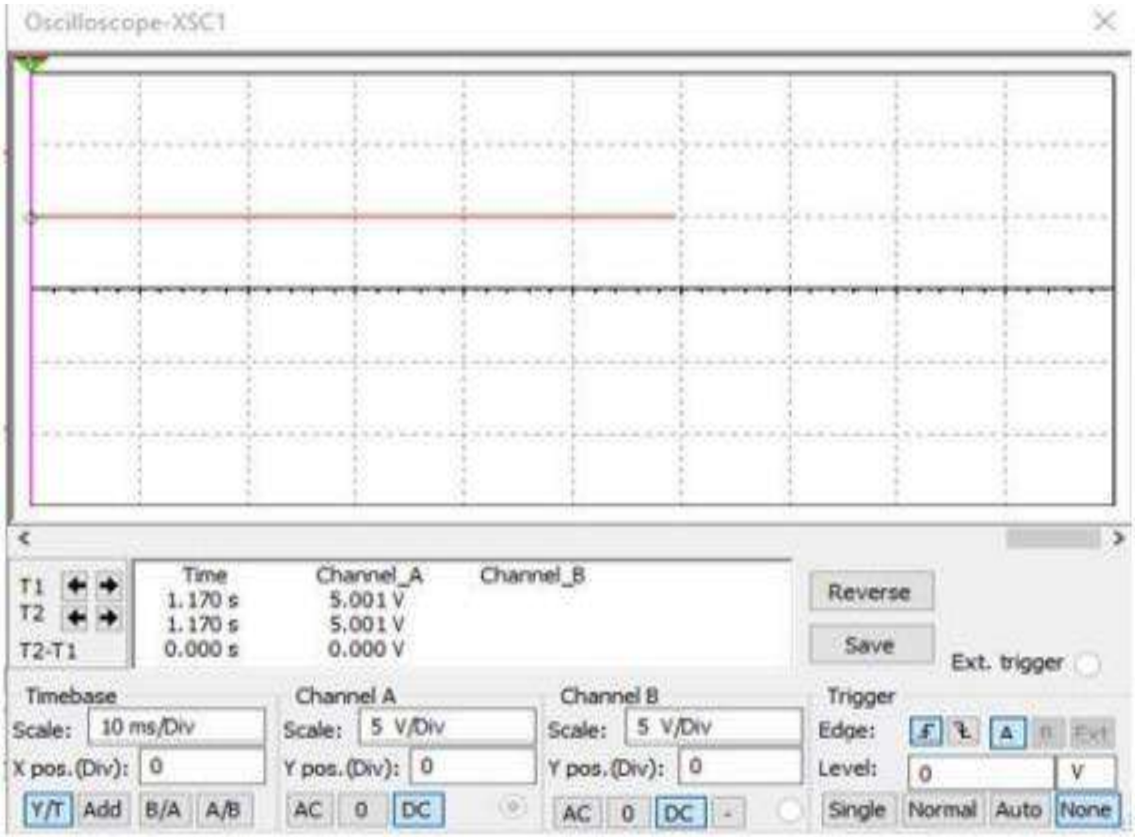


Figure 3.9 Simulated buck boost converter output of the DC-DC

3.2 Hardware prototype design

To understand the piezo energy harvester system, a prototype system was designed with block diagram as shown.

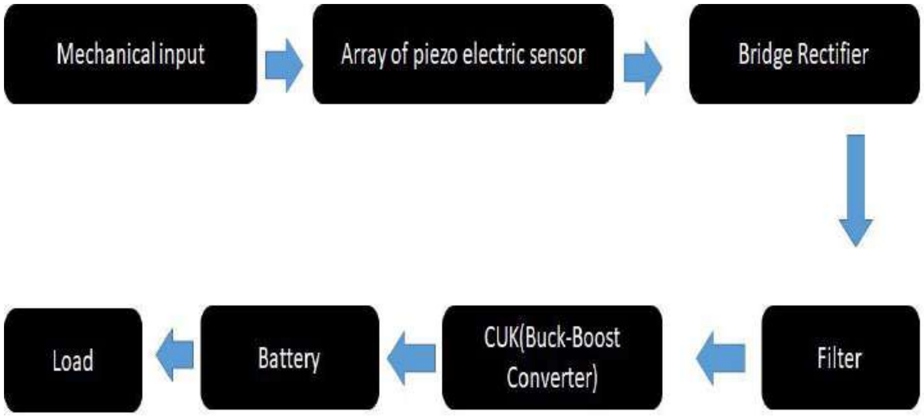


Figure 3.10 Piezoelectric energy harvesting tile block diagram.

Piezo tile contains a plastic sheet, and piezoelectric transducers were sketched as displayed. In Fig. 3.4, Piezo tile was arranged in a regular 12 x 9-inch size. Plastic sheet plates were located to make sure uniform pressure spread across the tile. The piezoelectric transducer was attached in parallel to the plastic sheet. At the end of the assembly, a couple of wires join the rectifier circuit, thus replacing a storage capacitor. Now, small power loads such as LEDs are used to evidence that the arrangement turned on the LED.

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Figure 3.11 Piezoelectric Tile prototype.

To test this prototype piezoelectric tile by providing pressure in the form of human weights with variable mass and different foot steppes as shown Fig.5.

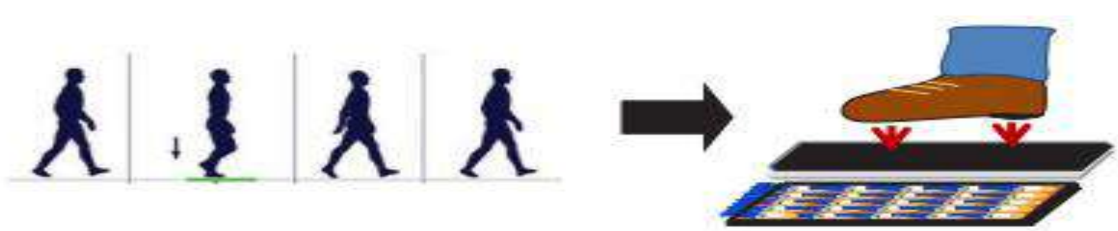

Figure 3.12 foot stepping activities on prototype plastic sheet

Differences in pressure from human walking on a plastic sheet are made by the speed of piezo sensors pressing about ± 0.45 seconds; in the meantime, for running on the mat, the speed of the foot switch pressing piezo sensors is about ± 0.23 seconds. The output (V) voltages and (P) pressures are achieved for 50–108 kg of human weight after they press 2–16 pcs of coupled piezoelectric transducers below the plastic sheet.

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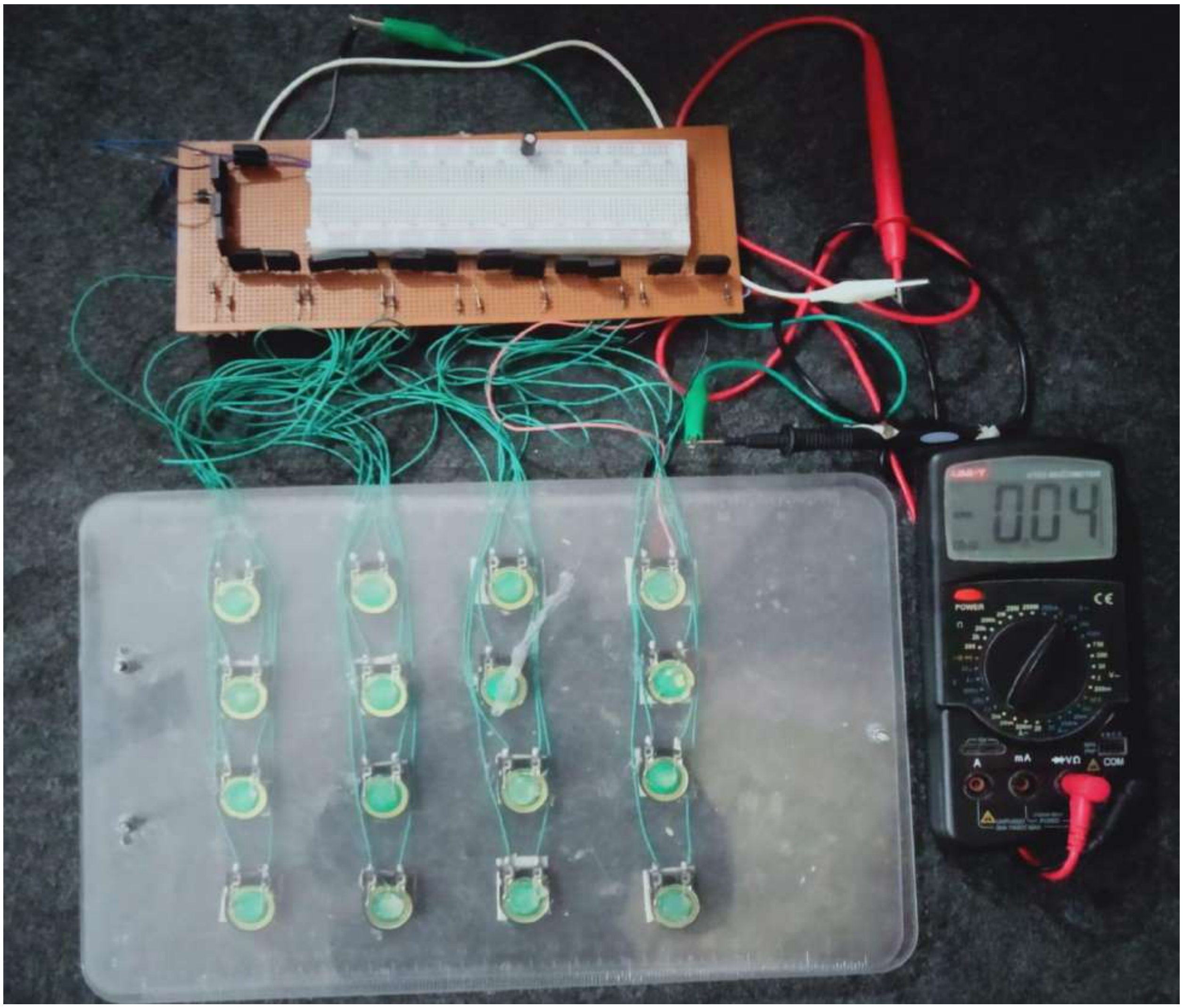

Figure 3.13 Piezo floor tile with 16 piezoelectric transducers.

Chapter 4

4.1 Materials and Methodology

The methodology for a sustainable piezoelectric energy harvesting system is the measurement and performance of hardware piezoelectric sensors. Harvesting tiles is used for low-power applications. The block diagram of the system model illustration is shown in Figure 4.1.

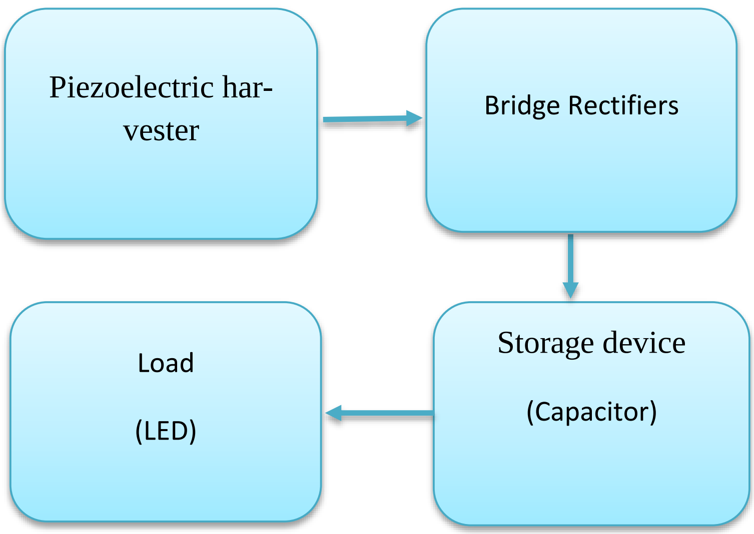

Figure 4.1 block diagram of system model.

4.1.1 Piezoelectric transducer

The required materials for the piezoelectric energy harvesting system are piezo sensors, a vero board, connecting wire, an oscilloscope, a breadboard, a battery, a Buck boost converter, and a load.

We have selected this KDS type of sensor, named 22mm by 7mm piezoelectric transducers, to use in our project.

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4.1.2 22mm by 7mm piezoelectric transducers

A piezo sensor is a device that works on the principle of the piezoelectric effect, which converts voltage to vibration and vibration to voltage. It normally comes in handy to measure knock (knock sensor) or vibration (vibration sensor).

Figure 4.2 piezoelectric transducer

The write part is show positive polarity and the golden part show the negative polarity .

4.1.3 Specification and features of piezo transducer

1. Model No.: KDS-22p-2.0AS
2. Outside plate diameter: 22mm (1.02 inches)
3. Element diameter: 16mm (0.74 inches)
4. Plate thickness: approximation 0.5mm (0.02 inches)
5. Lead length: approximation 5mm (approximation 0.12 inches)
6. Plate material: brass
7. Resonant frequency: 2.0 KHz +/- 0.5 KHz
8. Resonant impedance: 300 ohm max.
9. Rated voltage: 30 vp-p max
10. Operating temperature: -20 degrees to 70 degrees
11. Weight 2.8g

4.2 sustainable piezoelectric Tile

4.2.1 Sustainable piezoelectric tile

In this research project, we generated electrical energy from a nonconventional source based on piezoelectric sensors by applying pressure with the help of a footstep. This device works on the principle of the piezoelectric effect: "When pressure is applied to the piezoelectric materials, the pressure energy is converted into voltage, and vice versa.”.

The tile consists of a plastic class sheet, a piezoelectric sensor (22mm piezoelectric transducers), a nut and bolt for the support, bridge rectifiers, and connecting wires.

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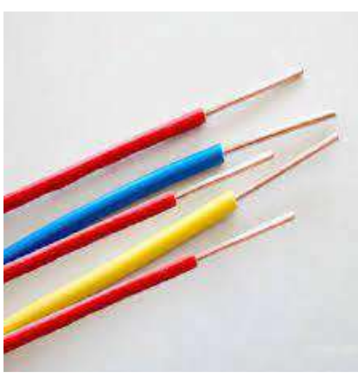

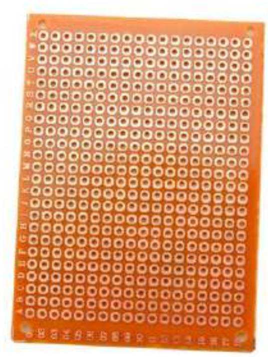

4.2.2 Experimental setup

We had used sixteen 22-mm piezoelectric transducers, piezoelectric sensors, and piezo sensor. We had cut the plastic sheet to 12 x 9 inches and made a hole in each corner. Plastic sheets were employed to ensure constant pressure spreading along with the tile. Each sensor was connected to the bridge rectifier separately and attached to the PCB (printed circuit board) sheet. We had used a bridge rectifier to convert the variable voltage into a linear voltage. We did not join the 22-mm piezoelectric transducers and piezoelectric sensors with each other in series combination because, after attaching them in series, we collected a very low amount of current. To obtain the maximum amount of current, we coupled all the 16 piezoelectric transducers in a parallel combination, and its output was connected to an AC bridge rectifier to convert its ac voltage into dc voltage. This ac bridge rectifier was then concocted with a diode in the forward base, and all sixteen bridge rectifiers were connected in parallel. Approximately from this piezoelectric energy harvesting tile is produced.

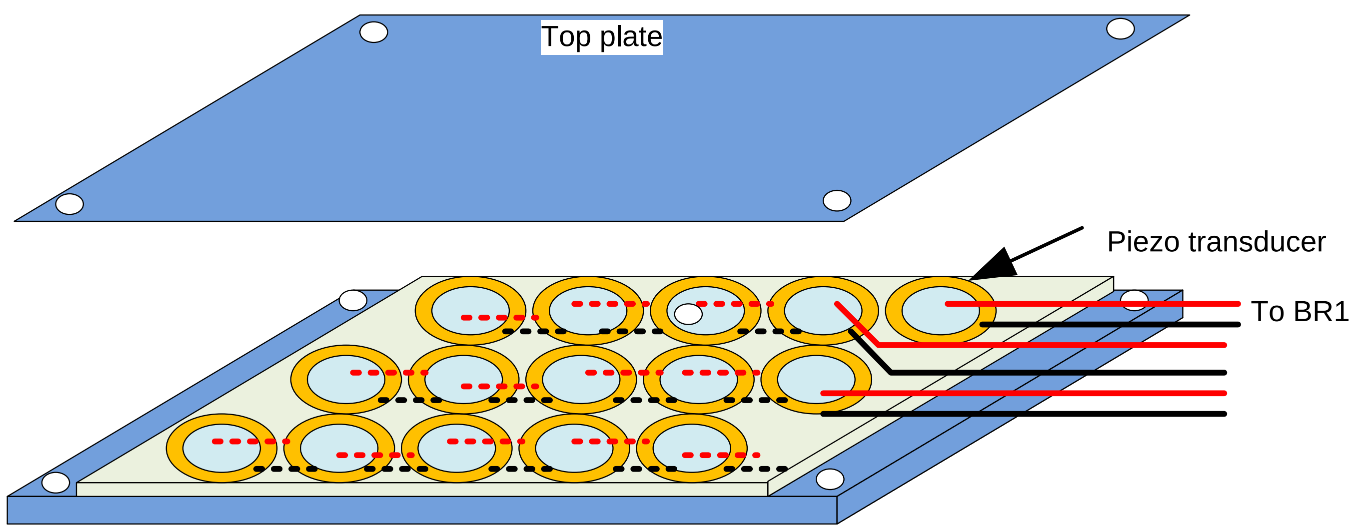

Figure 4.3 prototype of piezoelectric tile

Figure 4.4 Arrangement of piezoelectric in the proto type tile

To obtain the DC current, a simple diode can also be utilized as a half-wave rectifier. The main disadvantage of such a type of rectification is that it only converts half cycles of AC, and the energy of the next half cycle is not utilized and gives no result at the output. But a bridge rectifier can convert the complete AC cycle into DC and give good energy efficiency. The AC-to-DC converter circuit is shown in the figure.

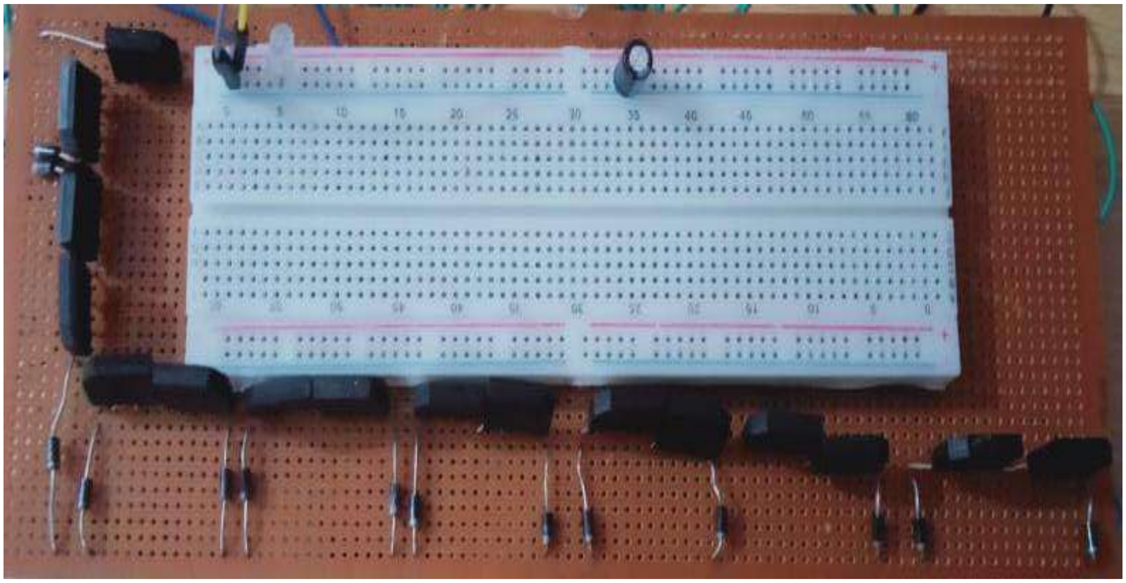

Figure 4.5 AC to DC converting, bridge rectifier’s assembly.

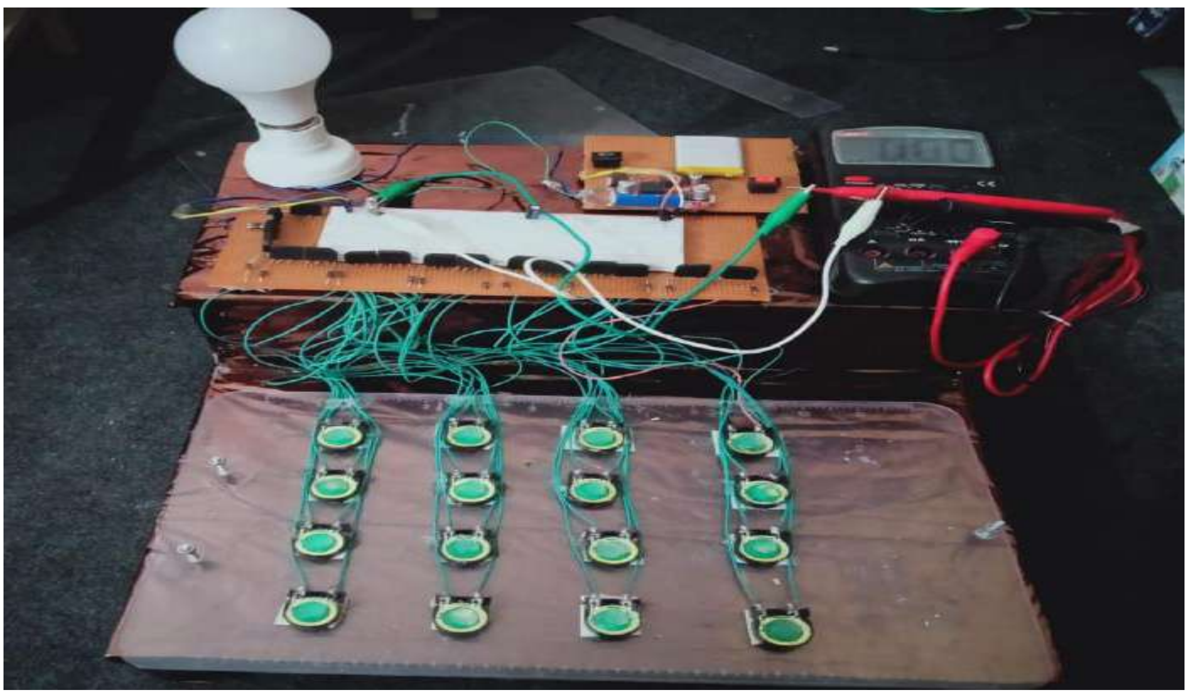

Figure 4.6 complete structure of proto type of piezoelectric tile

4.2.3 Storage demonstration Circuit

To store the electrical energy from the piezoelectric sensible energy tile, we need a drive circuit. A circuit diagram of the entire system to store the electrical power from the piezoelectric harvesting tile is shown in Fig.This circuit consists of a buck boost converter, a 3.7-volt, 16-micro farad capacitor for storage of electrical energy from the source, a switch to turn on and off the LED, and an LED to discharge the capacitor. This circuit was designed on a PCB sheet. When you press the tile, it generates the electrical power that is stored in the capacitor, then turns the battery switch to charge the 3.7-volt battery. After the capacitor was fully charged, the LED was on as long as the capacitor was completely discharged. The complete circuit is shown in Fig 4.7.

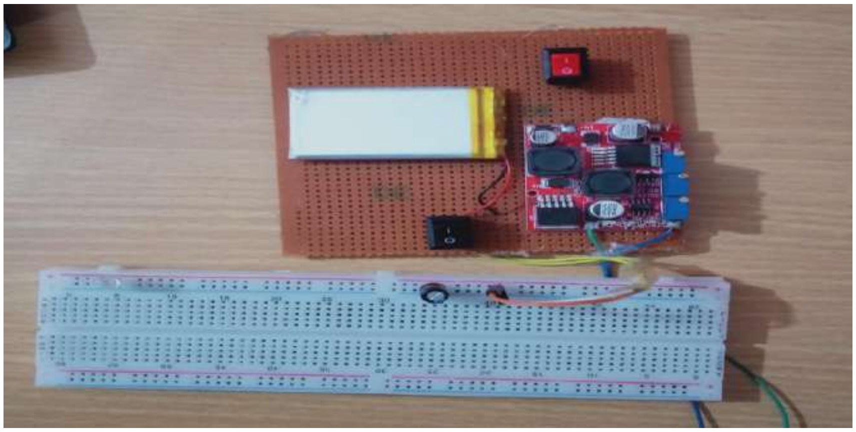

Figure 4.7 the circuit for the storage the electrical

4.3.1 Input observation

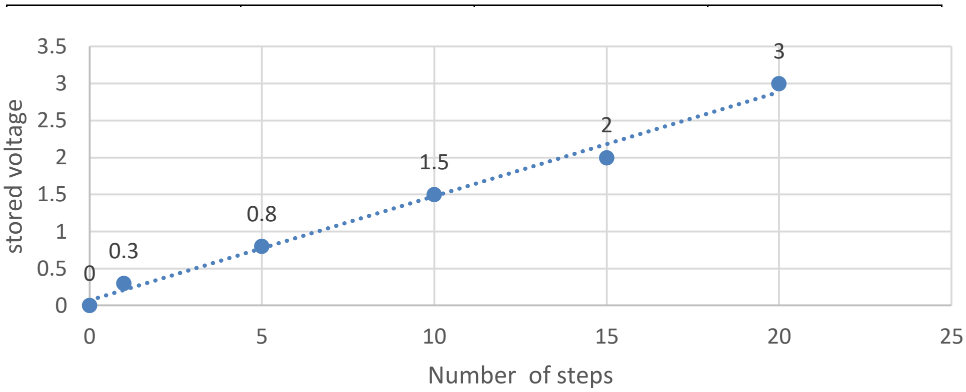

Figure 4.8 graph between step and voltage charging capacitor

4.3.2 Output observation

Device	initial voltage	Drop voltage	Time duration	Voltage used in time duration
LED	3	3	3micro second	3

Table 4.4 discharging of capacitor

4.3.3 Input observation when charging battery

Device	Initial voltage	Step counts	Stored voltage
Li-ion battery	2.5	0	2.5
same	2.5	5	2.5
same	2.5	10	2.88
same	2.5	15	2.95
same	2.5	20	3
same	2.5	25	3.2

Table 4.5 charging a battery

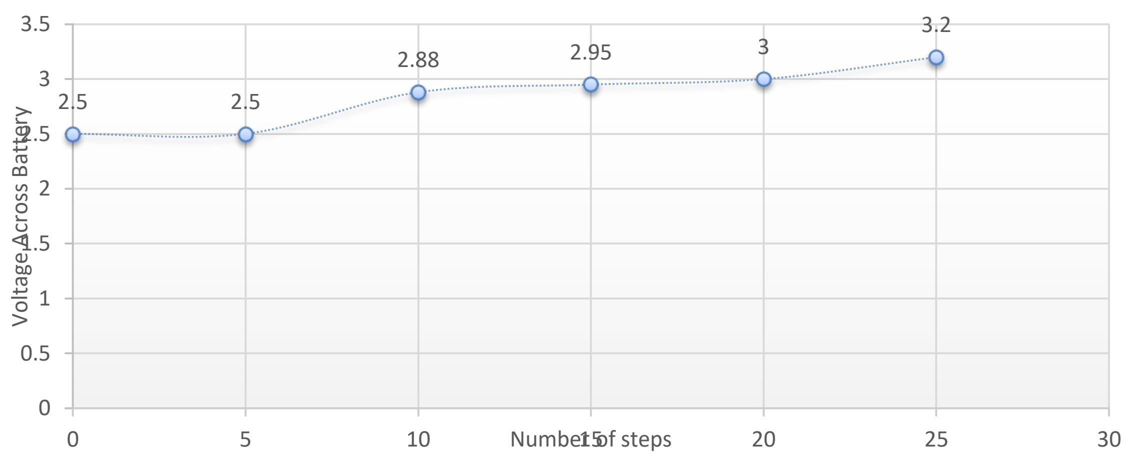

Figure 4.9 graph between step and voltage charging battery

4.3.4 Observation when battery discharging

Device	initial voltage	Drop voltage	Time duration	Voltage used in time duration
12 volt DC lamp	3.2	2.5	45 second	2.5

Table 4.6 discharging of battery

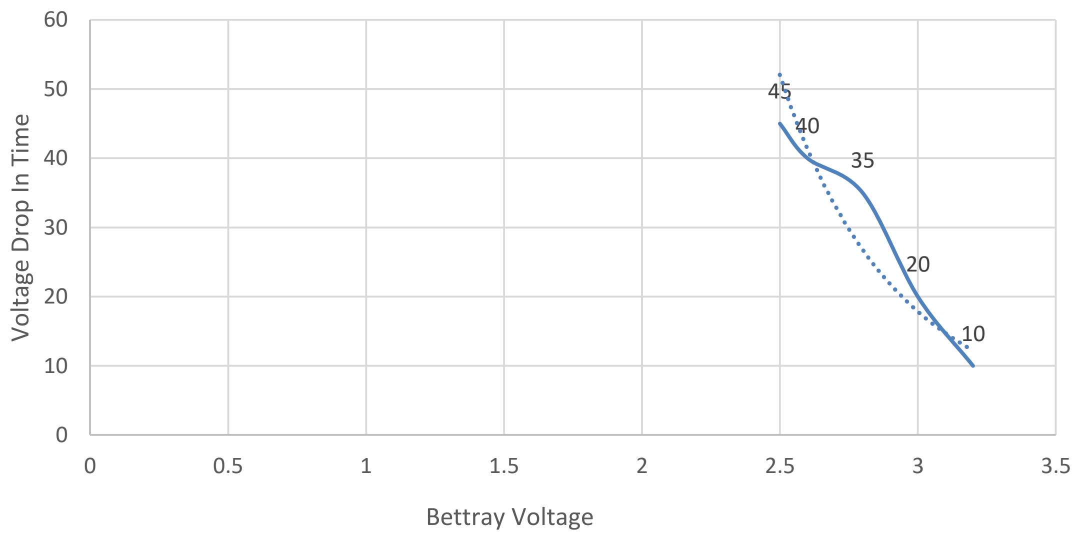

Figure 4.10 graph of voltage drop across load

4.3.5 Observation between Current and Voltage

Weight (kg)	Step number	Voltage (volt)	Current (micro amp)	Time (second)	Power consumed (watt)
25	10	3	2	10	6×10^-5
32	13	5	6	18	5.4×10^-4
55	18	11	13	23	3.289×10^-3
65	20	27	25	45	3.0375×10^-2

Table 4.7 voltage and current

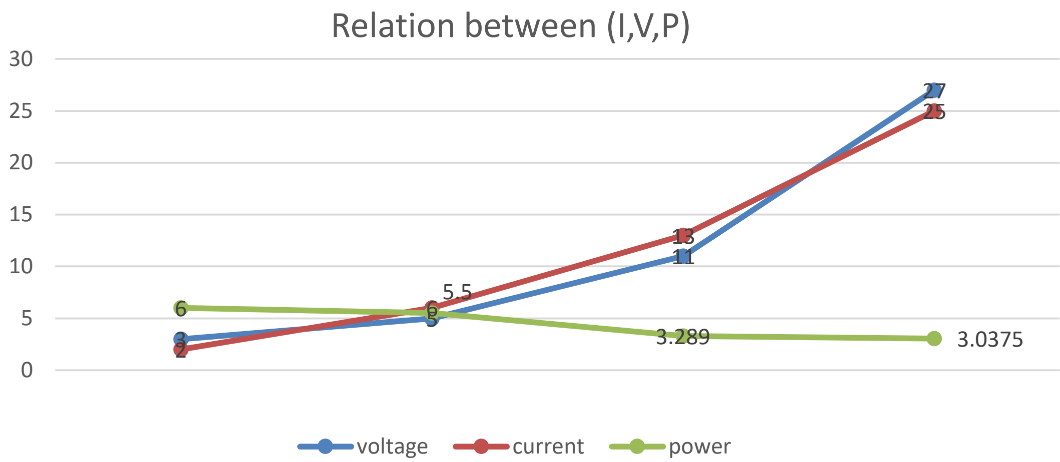

Figure 4.11 graph between of voltage, current and power

4.3.6 Observation between weight, Current and Voltage

Weight (kg)	Voltage (volt)	Current (uA)
34	7	5
50	12	15
61	23	20
69	25	26
71	32	41

Table 4.8 voltage and weight

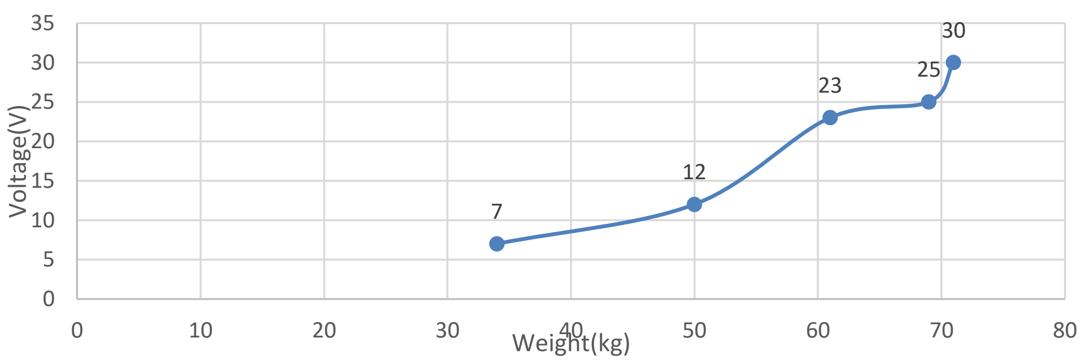

Figure 4.12 graph between Weight & voltage.

Chapter 5

5.1 Result and Conclusions

The piezoelectric transducer output is in the AC waveform. The output of the transducer needs to be rectified and filtered before being used for storage or for the DC loads. Figure 4.8 shows the output of the piezoelectric transducer before being inserted into the full bridge rectifier.

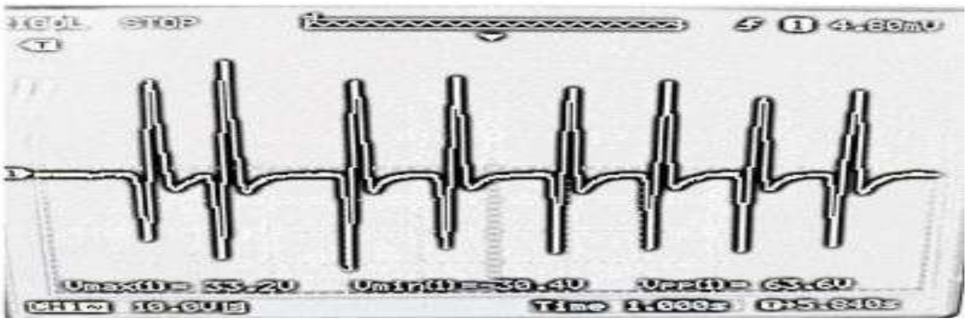

Figure 5.1 The output of the piezoelectric transducer before being rectify

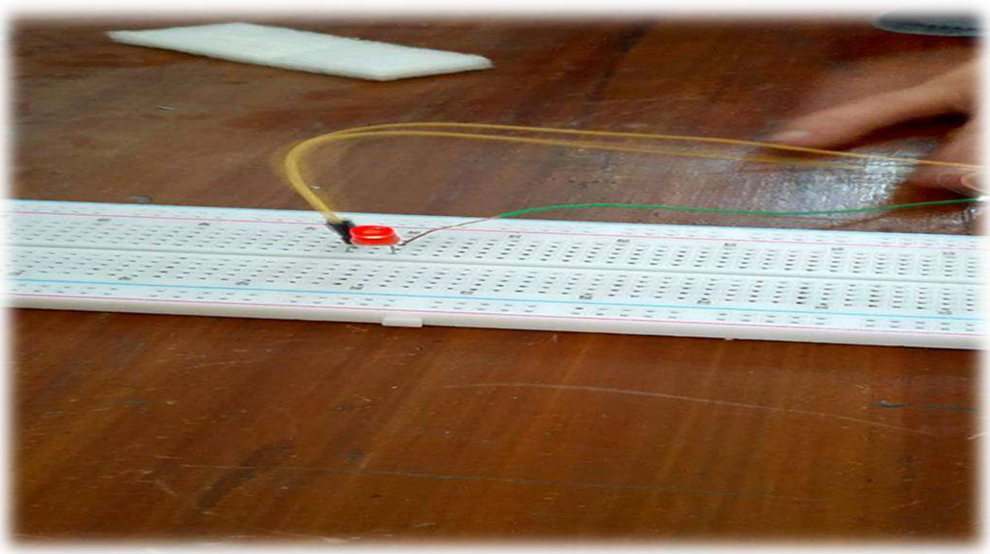

Figure 5.2 demonstration of single transducer performance

In this picture, the LED had been on by us while tapping the piezoelectric sensors. The wires green and yellow are soldered with piezoelectric positive and negative sides.

In this picture, we set one single LED on the breadboard just to find out if the piezoelectric sensor is working or not. We soldered the two wires in the piezoelectric sensor, positive and negative, and put the other end of the soldered wires on the breadboard and attached the LED to it. Although, when we tapped the piezoelectric sensor, it worked perfectly and gave an output in the form of an LED.

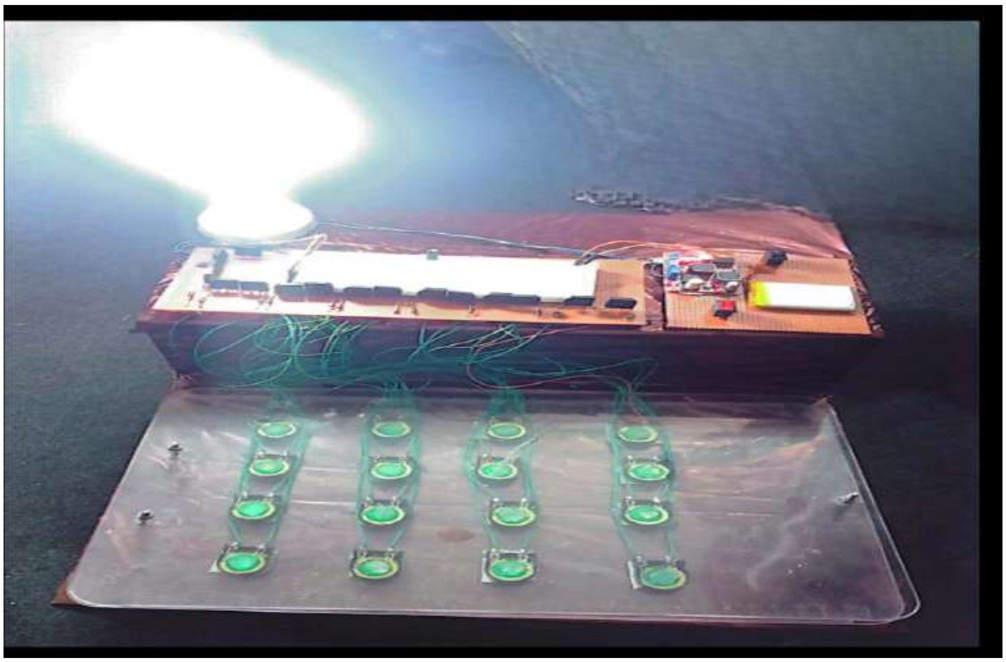

Figure 5.3 Demonstration of complete tile

In this picture, we set up 1 LED on the breadboard, connect the two yellow and gray wires on the breadboard, and connect another end of the wires to the circuit for the storage of electrical energy. We set the piezoelectric sensors between the module (a plastic sheet), and when we put pressure on the piezoelectric sensors, the LEDs turn on.

First, we combine all the piezoelectric sensors, set them between the two plastic sheets, and put the wires of the piezoelectric sensors on a breadboard with bridge rectifiers in order to find out the final result. Our purpose in doing this is to find out whether it is efficient or not. Is he giving us the same output that we want or not? When we try it out, he gives us the maximum output, which is good for our project, which shows that our project expectations are fulfilled.

Figure 5.4 Maximum output voltage

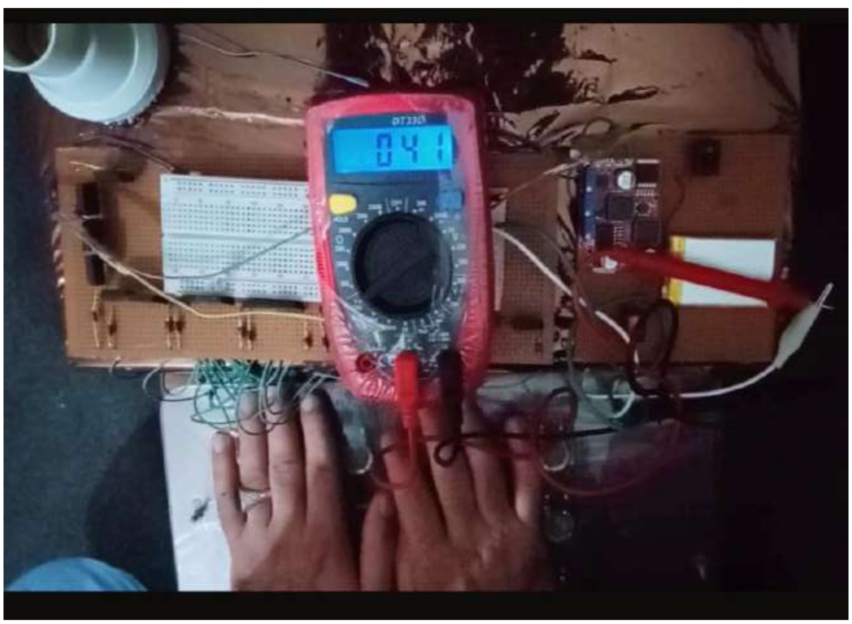

Figure 5.5 Maximum output current

These are the measurements of the project that has been completed, and they're a final measurement of the overall project.

(32.0V)
(41 uA)

These are the overall measurements of the project that we have noted. The purpose of these measurements is to find the output. Meanwhile, we actually need to find out at which frequency, voltage, and milli ampere it gives us a peak result to us. Moreover, we set the multi meter on 200V (DCV), so it gave the overall value of 32V, and then we set the multi meter on 2000 microamperes, and in response, he gave 41 microamperes. So, piezoelectric sensors at the local level work at those values for a great peak, which can operate the low-power components at the local level easily.

CONCLUSION

The main objective of this project is to generate electric current using piezoelectric material. Another goal of this work is to convert the misused mechanical energy into useful energy. Energy is harvested by using the piezoelectric material that is available on the market. For such a purpose, we made a piezoelectric tile. In this project, 16 piezoelectric transducers are arranged in parallel. Different variables are measured. In which the open circuit voltage is 32 volts and the current is 41 uA .We are fortunate to have made a low-cost energy harvesting device, which is the best solution to the energy crisis. In our system, not only is energy harvested, but it can also be stored by adding a battery.

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