# Arduino Based Footstep Power Generation for Security Cameras of BUETK.

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Submitted in partial fulfillment of the requirement for the degree of Bachelor of Electronics Engineering

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## *Certificate*

This is certified that the work presented in this project thesis on **"Ardiuno Based Footstep Power Generation For Security Cameras Of BUETK."** is entirely written by the following students themselves under the supervision of **Engr Abdul Raziq Magsi** & co-supervision of **Engr. Rayees Khan.**

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# DECLARATION

It is to certify that this is the original copy of our thesis. We have completed all the chapters of this thesis by our own self under the directions of our supervisor. We hereby declare that this thesis has not been submitted for any degree elsewhere

# ACKNOWLEDGMENTS

All salutations are directed at ALMIGHTY ALLAH, who bestowed upon humans the wings of knowledge by which they can ascend to intelligence and unravel some of the most important cosmic mysteries. We appeal to the HOLY PROPHET HAZRAT MOHAMMAD (SAW), who serves as the general human race's eternal torch of guidance.

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## LIST OF ABBREVIATIONS

- DC- Direct Current
- AC- Alternating Current
- LED- Light Emitting Diode
- PEGs- Potential for Electricity Generation
- kWh- Kilowatt-Hour
- GaPO4- Gallium phosphate
- CCTV- Closed-Circuit Television
- GPS- Global Positioning System
- PCB- Printed Circuit Board
- LCD- liquid Crystal Display
- PZT- Piezoelectric Zirconate Titanate
- PMN-PT- lead Magnesium Niobate-lead Titanate
- USB- Universal Serial Bus
- RAM- Random-access memory
- KiB- Kibibyte
- I/O- input/output
- GPIO- General Purpose In/Out
- MHz- Megahertz
- Wi-Fi- Wireless Fidelity
- SDGs- Sustainable Development Goals

- GSM- Global System for Mobile Communication

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# ABSTRACT

Throughout history, individuals have consistently required and used energy in order to sustain themselves and promote their overall well-being. Consequently, a significant amount of energy resources have been depleted and squandered. The proposal to harness waste energy from human mobility, namely foot power, is of significant relevance and importance, particularly in densely populated nations such as India, where locations such as train stations and temples see constant overcrowding throughout the day. When the flooring integrates piezoelectric technology, the electrical energy produced due to applied pressure is sensed by floor sensors and then converted into an electrical charge using piezoelectric transducers. This charge is then stored and used as a source of power. This power source has several uses, including but not limited to agriculture, domestic usage, lighting on the roads, and serving as an energy source for sensors deployed in distant areas.

In the contemporary day, energy and electricity have become fundamental requirements in the context of our more advanced society. Given the growing need for energy, the most effective approach to address such challenges lies in the widespread use of renewable energy sources. The footstep power production system may be effectively implemented by harnessing extra power via the utilization of heat, which can be collected from the load applying the Peltier effect. The application involves the generation of electrical energy via the conversion of pressure exerted by the foot on piezo sensors. Upon successfully executing the aforementioned approach or technique, we have acquired the capability to create a suitable system that enables the operation of our household appliances using AC output.

# CHAPTER 1

## 1.1 Introduction

This waste of energy can be converted to usable form using the help of piezo electric sensor. Piezoelectric sensor is a device, which can convert pressure upon it into voltage. We know that energy can be neither be created and nor be destroyed but can be transformed from one form to another. By using this energy conservation theorem and piezo sensor, we are proposing a new method for power generation.

In this Project, we are generating Power through Piezo sensor. Nowadays energy and power are the one of the necessities regarding this modern world. As the demand of energy is increasing day by day, so the ultimate solution to deal with these sorts of problems is just to implement the renewable sources of energy. The objective of this work is power generation through piezo sensors. As our main purpose was to charge the battery through DC output and then by inverting it into AC for normal common usage. Thus, as a result we have concluded that these types of designs and techniques of power generating systems are very useful and handy in order to match the supply and demand of energy globally as well. Today we see more and more applications using piezoelectric transducers. Their use as a source of electrical energy presents increasing interest for embarked electronic devices, low power consumption (less than 1 Watt) such as lamps-based LED (Light-Emitting Diode), displays or sensors **[1].**

The conversion of this energy waste into a useable form may be achieved by the deployment of a piezoelectric sensor. A piezoelectric sensor is a device capable of converting applied pressure into an electrical voltage. It is well understood that energy is subject to the principle of conservation, wherein it cannot be generated or destroyed, but rather undergoes transformation from one form to another. We propose a novel approach for power production by using the energy conservation principle and employing a piezo sensor.

This project focuses on the generation of power using a piezo sensor, as well as the implementation of a battery monitoring system. In the contemporary era, energy and power have emerged as fundamental requirements within the context of our modern society. Given the growing need for energy, the most effective approach to address such challenges lies in the widespread use of renewable energy sources. The objective of this research is to examine the feasibility of generating electrical power via the use of piezoelectric sensors. First, we wanted to utilize the DC power source to charge the battery, and then we wanted to convert it into AC so that it could be used for traditional purposes... Consequently, it has been determined that these designs and methodologies used in power producing systems are very advantageous and practical in addressing the global energy supply and demand dynamics. In contemporary times, there is a discernible increase in the use of piezoelectric transducers across several applications. The use of algae as a potential source of electrical energy has garnered growing attention, particularly in the context of electronic devices that need low power consumption, often below 1 Watt. These devices include LED lights (Light-Emitting Diode), screens, and sensors **[2].**

## 1.1 Project background

Day by day, the population of the country increases and the requirement of the power is also increases. At the same time, the wastage of energy also increases in many ways. So, reforming this energy back to usable form is a major concern. As technology is developed and the use of gadgets, electronic devices increased. Power generation using conservative methods becoming deficient. There is a need arises for a different power generation method. At the same time, the energy is wasted due to human locomotion. To overcome this problem, the energy wastage is converted to usable form using the piezoelectric sensor. This sensor converts the pressure on it to a voltage. By using this energy saving method, foot step power generation system we are generating power. A piezoelectric sensor is a device that uses the piezoelectric effect, to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge.

## 1.2 Problem statement

Now, electricity production has become one of important causes of global warming. This is due to the immense heat being dissipated during the process. This heat contributes to the gradual increase in Earth temperature. Furthermore, burning of fossil fuels also produces a product of carbon dioxide and sometimes carbon monoxide, which are harmful to human health. Carbon dioxide tends to radiate heat back into earth. In addition, the usage of fossil fuel for generation of electricity is very costly. A large sum could be saved by using a renewable energy. This would enable invest in future projects rather than just spending it on purchasing fossil fuels alone. By reviewing and analyzing this entire critical problem, designing new form of renewable energy such as piezoelectricity would be a perfect option in which it is useful for domestic application. Piezoelectricity, on the contrary, is clean and environmentally friendly. Piezoelectric components require little maintenance, and the initial investment can be recovered within a relatively short time. The transducer material is delicate; it needs to be handled carefully. As the voltage produced is less, additional equipment's are needed for the working.

## 1.3 Objectives

2 The objectives of footstep power generation are to generate electricity by converting the kinetic energy (mechanical energy) produced by human footsteps into electrical energy.

3 The technology can be used in high-traffic areas such as shopping malls, train stations, bus stops, and airports to generate electricity that can be used to power lighting, security system, and electrical devices.

4 To reduce the carbon footprint and contribute to environmental sustainability.

To enable efficient energy storage and transfer solution.

### 4.1 Scope of the study

The scope of this study, a prototype is proposed in which a number of sensors are set up in various locations throughout the field. This model also demonstrates how it works that was suggested makes the conventional power generation system more efficient and environmentally friendly. In addition to that, this research proposes an effective energy and network model. This article proposes a model that is cost effective, automated, sustainable, and energy efficient all at the same time.

### 1.6 Thesis Outline

**Chapter #1**: Introduction: This chapter provides a succinct overview of the footstep power generation. It elucidates the introduction, necessity, objective, and theme of this system.

**Chapter #2** Literature Review: This chapter comprises a comprehensive review of existing literature. This study examines the system, including its historical background, evolutionary trajectory, and diverse projects that have been developed based on this concept. Additionally, the investigation delves into the design development and technological aspects of the system, as well as its operational functionality.

**Chapter #3** System Development: The present chapter encompasses a section on System Development, wherein the rationale behind the primary project diagram is elucidated. In this section, the initial hardware development is expounded upon. The block diagram of the footstep power generation system utilizing was presented in the context of hardware development, accompanied by a detailed elucidation. In addition, the block diagram should comprise of sub-points along with their corresponding explanations.

**Chapter #4** Results: This chapter displays the utilization piezo sensor to generate power. The purpose of this simulation is to enable the early production of cheap power sources.

**Chapter #5** Conclusion: The present chapter encompasses a comprehensive conclusion, along with the discussion of about this project. Additionally, the future prospects of this technology are also discussed.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Background

This paper presents a comprehensive analysis of the methods used for electrical power production via the utilization of human footstep energy. This paper explores the potential of harnessing human foot energy from garbage and its uses in power generation. When humans traverse their environment, a force is exerted on the surface, which has the potential to be harnessed for the purpose of power generation. The concept of transforming pressurized weight energy into electrical energy may be achieved by the use of piezoelectric crystals. The use of piezoelectric crystals as an energy converting material has significant potential for the implementation of power producing floors as a prominent application. Piezoelectric crystals possess a crystalline structure and possess the capability to transfer mechanical energy, namely stress, into electrical energy. When a person's foot vibrates, the crystals underneath it may convert that stress or force evenly into electrical energy. Powering electronic equipment like computers, cell phones, and tablets with this electricity is a viable option.

## 2.2 Literature review

Electric power is created using a non-conventional very in this case. Therefore, the process of generating electricity involves the act of walking or running by means of footstep. Currently, unconventional energy sources play a crucial role in the energy landscape. This system presents a novel approach to power production using non-conventional energy sources that operate autonomously, requiring no external input to create electrical output. The process of converting force energy into electrical energy occurs in this context **[3].**

Electricity has emerged as an essential resource for the global human population. The demand for power is steadily growing over time. Certain technologies need a significant quantity of electrical power in order to carry out a range of tasks. It is well known that electricity is produced by many means, such as hydropower and wind power. In order to harness energy from these resources, it is necessary to construct large-scale power plants or mills, which incur significant maintenance expenses. As the demand for energy continues to rise, a corresponding increase in the production and subsequent wastage of energy resources is seen. If the rate of energy loss continues to escalate, a future scenario may arise where we encounter a complete depletion of energy resources. This technology operates on the idea of the piezoelectric effect, whereby it may generate an electric charge when subjected to pressure and strain. Piezoelectric ceramics are included under the category of ferroelectric materials.

The fundamental principle behind the operation of this system is the extraction of untapped energy from the environment of any given system, followed by its subsequent conversion into electrical energy. Piezoelectric materials, when situated under insulating substances such as hard rubber, have the ability to generate electrical energy by the application of pressure, such as that exerted by footsteps or the force of waterfalls. This electrical energy may afterwards be stored and used for home purposes. The phenomenon of piezoelectricity the application of pressure to a material result in the generation of electricity. The system has two axes, namely the mechanical axis and the electrical axis. The application of pressure in the mechanical axis results in the generation of power in the corresponding electrical axis. The term "piezoelectricity" refers to the phenomenon whereby a material exhibits electrical polarization in response to mechanical strain. This phenomenon, sometimes referred to as direct effect or generator effect, is a basic principle used in the production of various sensors such as mobile phone vibrators and lighters. Piezoelectric materials, which are also used in actuators, exhibit an inverse or motor effect, whereby the application of an electrical signal induces a mechanical deformation **[4].**

To create an alternating current (AC) voltage when exposed to mechanical stress or vibration, or to cause vibration when subjected to an AC voltage, or both, is the property known as piezoelectricity. Quartz dominates the piezoelectric material market. This phenomenon may be seen in a wide variety of substances, including certain ceramics and Rochelle salts. One or both of the plates will vibrate in response to an incoming sound wave. The crystal is sensitive to these vibrations and converts them into a low AC voltage. As a result, alternating current (AC) voltage between the metal plates emerges with a pattern resembling the sound waves. On the other hand, when an alternating current signal is delivered to the plates, the crystal vibrates in time with the signal voltage. Because of this, the metal plates also shake, creating an audible disturbance. Piezoelectric crystals are the energy sources. The piezoelectric crystals produce the voltage which can be used for power many things. The piezoelectric crystals have a crystalline structure, which converts an applied vibration into an electrical energy in order to get an understanding of the output that corresponds to the different forces that were applied. In order to do this, the piezoelectric transducer being evaluated is mounted atop a piezoelectric force sensor. For purpose of measuring voltages, voltmeters are linked across each of them, and ammeters are connected so that current may be measured. When various forces are applied to the piezo material, the display will show varied voltage readings that are proportional to the force. There are a variety of voltage and current readings of the piezo test material that are recorded for each such measurement of the voltage across the force sensor **[5].**

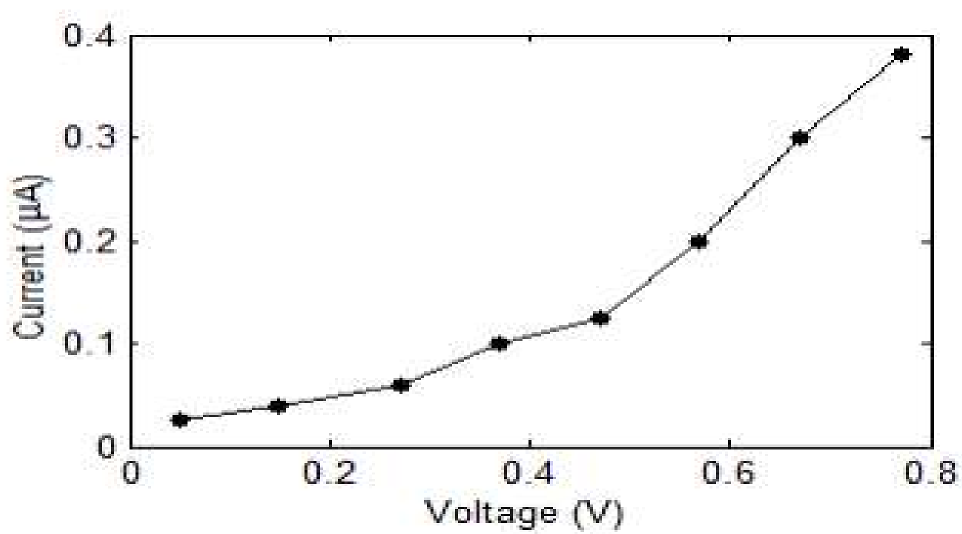


*Figure 2.1 voltage and current characteristic curve*

The flooring tiles consist of rubber, a material known for its ability to absorb vibrations. Positioned underneath these tiles are piezoelectric materials, which have the capability to create energy when subjected to mechanical stress. When tiles of this kind are set in areas with anticipated high volumes of pedestrian traffic, such as railway stations, bus stations, airports, malls, and walkways, a tiny electric charge is generated by the piezoelectric effect when individuals tread on them **[5].**

The energy created by a single individual would be insufficient; but, as the number of steps on these types of tiles increases, the corresponding energy production would also grow. When an individual applies pressure on tiles containing piezoelectric crystals, the crystals undergo mechanical stress, resulting in the accumulation of electric charge on the surface of the crystals. This charge may then be collected via the use of electrodes. This kind of energy has the capability to be stored inside capacitors, enabling the transmission of power to locations experiencing a deficit in energy. Japan has started experimental use of the piezoelectric effect for energy production by implementing specialized flooring tiles at the two most heavily trafficked stations in its capital city. The installation of tiles is seen near ticket turnstiles. Consequently, whenever a passenger meets the mats, a little vibration is generated which may be harnessed and stored as potential energy **[6].**

There is a higher volume of traffic during daylight hours compared to nighttime, and sometimes traffic persists over the whole 24-hour period. Furthermore, the intensity of traffic fluctuates throughout the course of the day. The determination of the aggregate force applied by mobile motor vehicles on the surface of a roadway may be achieved by the analysis of the mean quantity of vehicles through a certain location during a designated temporal interval. According to the conclusions of a study conducted in and Europe country, it has been observed that PEGs are being placed at a depth of 6cm below the road surface, with a spacing of 30cm between each PEG. The testing conducted revealed that a vehicle with a weight of around five tones has the capability to produce 2000V. Furthermore, a cluster of generators of similar capacity across a distance of 1 km was found to create an energy output of 400 kilowatt-hours (kWh). If 600 cars are permitted to use this roadway throughout a one-hour timeframe, it has the potential to provide energy to around 600-800 residential households **[7].**

The railway rails serve as a significant location for the creation of substantial energy due to the considerable pressure applied by trains onto them. The piezoelectric crystals are strategically placed inside the railway tracks to capture the pressure and force exerted by the wheels when they encounter the rails. When a result, these materials accumulate a significant quantity of energy **[8].**

Significant amounts of pressure are put onto runways during the process of airplane takeoff or landing. By positioning the piezoelectric clusters in this location, it becomes possible to effectively transform mechanical energy. The enhancement of system efficiency may be achieved by the use of a stacked structure composed of many layers of piezoelectric clusters. This configuration has the capability to effectively manage substantial levels of pressure. The Airbus A380 aircraft has a maximum takeoff weight of 560 metric tons and is capable of generating 224 kilovolts. Consequently, when taking into account the cumulative number of landings on a runway, a substantial quantity of energy might potentially be generated. Approximately 8138 kilowatt-hours of energy might potentially be generated, which has the capacity to provide electricity to a range of 12207 to 16276 households **[9].**

Currently, there is a significant issue that is being widely debated, namely the energy crisis. Utilizing renewable energy sources that are amenable to modification is the method that has been suggested as the best option for fixing this issue. The human population is a massive energy resource that has not yet been used to its full potential, making it one of the numerous energy sources that exists alongside solar energy and tidal energy. This resource makes it possible to estimate the expected amount of energy that will be produced, which hints to the possibility that it may be feasible to extract electricity from the world's growing population. The act of individuals walking on a floor may result in the generation of electricity, since this technology harnesses the variable of pressure to produce energy. The energy produced is then stored inside the batteries. The installation of this technology in a densely populated region is expected to provide efficient outcomes. The successful execution of this idea has the potential to greatly improve the production of power via the utilization of pressure generated by human footfall. The potential implementation sites for this system include roadways, train stations, and bus terminals, which see continuous movement of millions of people. The user's text does not contain any information to be rewritten academically **[10].**

Piezoelectric crystals are a very appropriate approach for acquiring the energy encompassing a given system. Piezoelectric crystals are considered a viable source of energy at a small scale. When piezoelectric crystals experience vibrations, they produce a minute electrical potential, generally referred to as piezoelectricity. The material has a crystalline structure that facilitates the conversion of externally induced vibrations into electrical energy. The piezoelectric effect is seen in two distinct properties: The first phenomenon is known as the direct piezoelectric effect, which pertains to the capacity of a material to convert mechanical strain into an electrical charge. The converse effect refers to the capacity to transform an externally provided electrical potential into mechanical strain energy. These qualities enable the material to serve as a medium for power harvesting **[11].**

The underlying mechanism of this system is the conversion of pressure exerted by footsteps into rotational motion. This rotary motion is then used to spin a device such as a Dynamo or Sanyo coil. The degree of rotation is contingent upon the pressure exerted by the vertical force of an individual's body weight when walking on the floor **[12].**

The piezoelectric material has the ability to transform mechanical pressure exerted against it into electrical energy. The origin of pressure may arise from either the gravitational force exerted by the moving vehicles or the gravitational force exerted by individuals traversing the surface. The piezoelectric material has an inconsistent output. A bridge circuit is used for the purpose of transforming a variable voltage into a linear value. Once again, an AC ripple filter is used in order to effectively eliminate any further variations in the output. Subsequently, the direct current (DC) voltage is accumulated inside a rechargeable battery. The investigation focused on the combination of many piezo films due to the significantly low power output of a single piezo film. Two potential connections were examined, namely parallel and series connections. The voltage output did not exhibit a substantial rise in the case of the parallel connection. In the context of series connection, the introduction of supplementary piezo-film leads to an augmentation of the voltage output, but not in a linearly proportional manner. In this particular configuration, a hybrid approach is used, using both parallel and series connections, in order to provide a voltage output of 40V while maintaining a high current density. DC loads may be connected to battery supplies. An inverter is linked to a battery in order to facilitate the connection of an AC load **[13].**

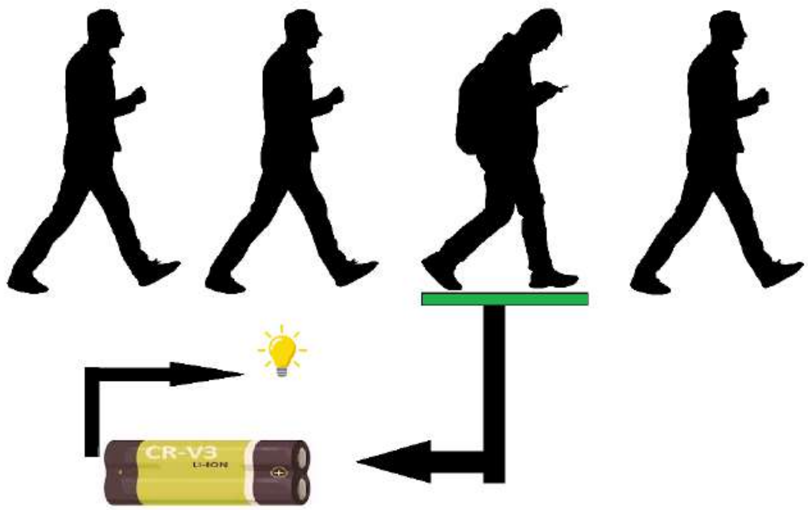


*Figure 2.2 Stepping method*

The application of a force on a piezoelectric material result in the generation of an electric charge across the substance. Therefore, it may be inferred that it has the characteristics of a perfect capacitor. Hence, any equations that regulate capacitors may be applied to the aforementioned device. In this project, a configuration is used whereby three piezoelectric elements are connected in series on a single tile. A parallel connection is established by interconnecting 10 series connections. Therefore, when three piezoelectric discs are linked in series, the resulting capacitance is determined as follows **[14].**

$$1/Ceq = 1/C1 + 1/C2 + 1/C3 \ldots\ldots\ldots\ldots\ldots \text{(I)}$$

We know $Q = C * V$……………………………………… (ii)

So $C = Q/V$…………………………………......(iii)

Hence $Veq/Q = V1/Q + V2/Q + V3/Q$…………... (IV)

Piezoelectricity is the phenomenon whereby the application of mechanical pressure on certain crystals, such as quartz, induces the generation of an electric current. Similarly, it is often seen that the opposite is true: when an electric current is applied to these crystals, they undergo a self-induced compression and expansion because of their vibrational motion. Piezoelectricity may be succinctly described as the phenomenon whereby some materials exhibit the ability to generate an electric charge in response to applied mechanical stress. However, in the interest of scientific rigor, it is essential to provide a rigorous definition: Piezoelectricity, known as the piezoelectric effect, refers to the generation of an electrical potential, or voltage, between the surfaces of a crystal when it is subjected to mechanical stress, such as compression. In practical use, the crystal materializes as a miniature battery, exhibiting a positive charge on one surface and a negative charge on its opposing surface. The establishment of an electrical circuit occurs when the two surfaces are interconnected, therefore facilitating the passage of electric current **[15]**.

The unit cell, which serves as the fundamental repeating unit in many crystals including metals, often exhibits symmetry. However, this is not the case with piezoelectric crystals. Piezoelectric crystals often exhibit electrical neutrality, whereby the internal arrangement of atoms may lack symmetry, but the distribution of electrical charges is precisely balanced. Consequently, the presence of a positive charge in one location is counteracted by a corresponding negative charge in close proximity. Nevertheless, when a piezoelectric crystal is subjected to compression or tension, it undergoes structural deformation, resulting in the displacement of atoms, hence disrupting the equilibrium between positive and negative charges and leading to the emergence of net electrical charges. The aforementioned phenomenon persists throughout the whole of the structure, resulting in the manifestation of net positive and negative charges on diametrically opposed external surfaces of the crystal. The reverse-piezoelectric effect is seen in an inverse manner. By applying a voltage across a piezoelectric crystal, the atoms inside the crystal experience the phenomenon of "electrical pressure." In order to restore equilibrium, piezoelectric crystals undergo displacement, resulting in a tiny alteration of their shape when subjected to an applied voltage **[16].**

Piezoelectric sensors exhibit a high level of durability, an exceptionally high natural frequency, and an impressive level of linearity across a wide range of amplitudes. Moreover, it is worth mentioning that piezoelectric technology demonstrates a remarkable immunity to electromagnetic fields and radiation, thereby enabling the collection of data even in demanding electromagnetic environments. Certain materials, such as phosphate or tourmaline, demonstrate remarkable thermal stability; enabling sensors to function optimally even under high-temperature conditions of up to 1000 °C. Tourmaline, apart from its inherent piezoelectric characteristics, exhibits pyro electric phenomena as well. This implies that it is capable of generating an electric signal in response to alterations in the temperature of its crystal structure. The aforementioned phenomenon is frequently observed in piezo ceramic materials, as they exhibit this behavior quite commonly **[15].**

One inherent constraint of piezoelectric sensors resides in their incapability to precisely evaluate static quantities. The application of a static force engenders a uniform magnitude of electric charge on the piezoelectric substance. Because of issues with insulating materials and a potential drop in internal sensor resistance, using traditional readout electronics may be problematic. The cumulative effect of these causes is a continual electron depletion that weakens the signal over time. As the temperature rises, the resistance within the object decreases, making it more sensitive. Reduced sensitivity due to the formation of twins under increasing pressure loads and temperature is the key factor affecting the piezoelectric action. In order to conduct measurements at temperatures over 300 °C, it is necessary to cool quartz sensors. However, some crystals such as gallium phosphate ($GaPO4$) have the unique characteristic of not forming twin structures even at temperatures up to the point of material melting.

Contrary to the assertion, it is incorrect to claim that piezoelectric sensors are only applicable to rapid processes or limited to ambient circumstances. Indeed, a considerable number of piezoelectric applications generate quasi-static data, whereas some other applications operate at temperatures above 500 °C.

Piezoelectric sensors have the capability to ascertain airborne smells via the concurrent measurement of resonance and capacitance. The range of uses that may be found for piezoelectric sensors can be greatly broadened by the use of electronics that are controlled by a computer **[16].**

The Arduino hardware and software were specifically developed to cater to a diverse range of individuals, including artists, designers, hobbyists, hackers, novices, and anybody with an interest in constructing interactive things or surroundings. The Arduino microcontroller platform has the capability to establish communication and interface with a wide range of devices, including buttons, LEDs, motors, speakers, GPS units, cameras, the internet, as well as smart-phones and televisions. The Arduino software has cost-free nature, coupled with its affordable hardware boards and user-friendly learning curve, and has fostered a substantial user community. This community has actively engaged in code contribution and the dissemination of instructions for an extensive range of projects based on the Arduino platform.

The Arduino microcontroller board is a versatile tool that may serve as the central processing unit for a wide range of electrical projects, including many applications such as robotics, hand warming blankets with heating pads, fortune-telling devices, and even dungeon-related endeavors **[22].**

Future Electronics offers a comprehensive range of bridge rectifier chips sourced from many manufacturers. These chips may be effectively used in the construction of various circuits, including full wave bridge rectifiers, half wave rectifiers, and other circuits that need the incorporation of a bridge rectifier. By selecting the technical qualities of a bridge rectifier from the options provided, you can efficiently filter down your search results to find a bridge rectifier that suits your unique application requirements.

The main use of bridge rectifiers is to convert an alternating current (AC) source into direct current (DC) electrical power. Bridge rectifiers are often used inside the power sources of almost all electronic devices due to the inherent need for direct current in their operation. Bridge rectifiers are often used in the detection of the amplitude of modulated radio signals. The discovered signal has the potential to undergo amplification prior to its detection. In the event that this condition is not met, it becomes necessary to use either a diode with a very low voltage drop or a diode that is biased with a set voltage. Rectifiers are often used in the provision of polarized voltage for welding purposes. The regulation of output current is a crucial aspect in circuits of this kind. One method to do this is by substituting certain diodes inside a bridge rectifier with thyristors. Thyristors are specialized diodes that can be controlled and regulated by using phase-fired controllers to turn them on and off. **[8]**

*Figure 2.3 bridge rectifies*

## 2.3 Summary

The literature review has provided valuable insights into the current and previous methods of power generation. Focusing on sensor integration and power generation from these sensors. The study of these papers serves as a foundation of the design of footstep power generation and using this power to cctv cameras

# CHAPTER 3
# Methodology

## 3.1 INTRODUCTION

The proposed system or implementation is designed to generate electrical power for the security cameras of BUETK, it is the Energy conversion process which changes mechanical energy into electrical energy by some specific process. This system consists of following steps.

## 3.2 Piezo Sensors

It is the key component of the system which is responsible for energy conversion, it is the first electronic component in the system for sensing the weight energy, A piezoelectric sensor is a device that operates the piezoelectric effect to quantify variations in pressure, acceleration, temperature, strain, or force by the conversion of these variables into an electrical charge. The etymology of the prefix "piezo" may be traced back to the Greek language, where it derives from the words meaning "press" or "squeeze".

*Figure 3.1 Piezoelectric Sensor*

## 3.3 Principle

Piezoelectricity is the fundamental principle that underpins the operation of the footstep power generation system. Piezoelectric materials possess a remarkable property: they generate an electric charge when mechanical pressure or stress is applied to them. This phenomenon is based on the crystal structure of piezoelectric materials, which causes the displacement of positive and negative charges, resulting in the creation of an electrical potential. In the context of the project, the piezoelectric plates used in the system respond to the pressure exerted by human footsteps, converting this mechanical energy into electrical voltage.

### 3.4 Application

The application of piezoelectricity in the footstep power generation system offers a sustainable and renewable energy solution. By strategically placing piezoelectric plates in high-traffic areas such as public walkways and commercial spaces, the system efficiently captures the kinetic energy generated by people as they walk. This harvested energy is then rectified, stored, and used to charge external devices like power banks or other electronic gadgets. The system's application extends to various urban environments, including bus stands, theaters, and shopping streets, where it provides a reliable source of electricity while contributing to environmental sustainability by reducing the reliance on traditional fossil fuel-based power generation. This innovative application of piezoelectricity aligns with the growing need for clean energy solutions and addresses the challenges of urban energy shortages.

## 3.5 Block Diagram

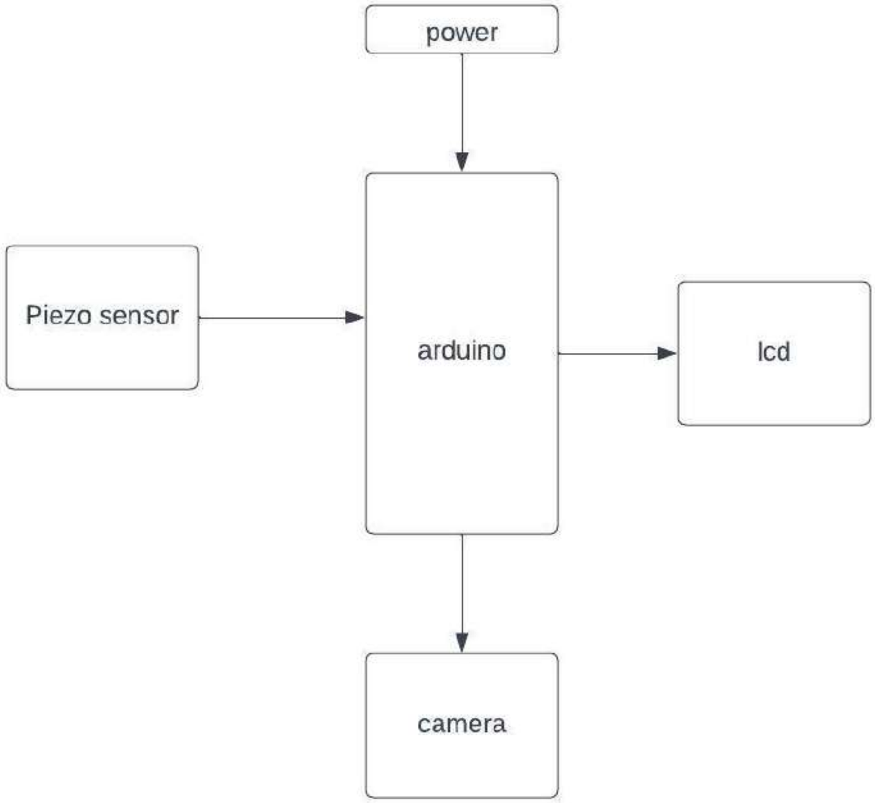


*Figure 3.2* ***Block Diagram***

## 3.6 Detailed Block Diagram Description

The block diagram illustrates the components and connections involved in the footstep power generation system. Following is an explanation of each block and their connections:

- **Piezo Electric Sensors Block:** This block represents the piezoelectric sensors placed in areas with pedestrian traffic. These sensors generate electrical voltage when subjected to pressure from footsteps.
- **Arduino:** It is the brain of system which have both hardware and software part, it is connected with PCB and piezoelectric sensor for calculating values and processing of signals. This types Arduino is known as microcontroller Arduino.

- **Printer Circuit Board (PCB Circuit):** It is the electrical and electronic circuit which consists on different type of electronic components, and these components are individually connected to every single piezoelectric sensor, it is the combination of rectifiers and diodes which protect the sensors by blocking reverse current.
- **Inverter:** It is the part of circuit which receive the signal from PCB and convert the signal from one form to another form.
- **LCD:** The I2C LCD component is used in applications that require a visual or textual display. This component is also used where a character display is needed but seven consecutive GPIOs on a single GPIO port are not possible. In cases where the project already includes an I2C master, no additional GPIO pins are required.
- **Indication LED:** The rectified DC power from the bridge diodes is connected to an indication LED. This LED serves as a visual indicator to show that the system is generating electricity. It lights up when power is being generated, providing a real-time feedback signal.
- **Direct Charging Cell:** The rectified and rectified DC power is then connected to a direct charging cell. This cell can be a rechargeable battery or a similar energy storage unit. It stores the electrical energy for later use.
- **Step-Up Module:** The stored electrical energy in the direct charging cell is connected to a step-up module. The step-up module's primary function is to increase the voltage level of the electricity. This is necessary to match the requirements of the power bank, which usually operates at a higher voltage than what is generated by the piezoelectric sensors.
- **Power Bank:** The output from the step-up module is connected to a power bank. The power bank acts as a portable battery storage device, capable of storing the harvested electrical energy. It can be used to charge phones and other electronic devices, providing a practical and convenient way to utilize the generated power.

- **Camera:** It is the output part of the system which is charged by piezoelectric sensors and gives visual.

In summary, this block diagram depicts the flow of electricity from the piezoelectric sensors to the power bank, with each component serving a specific function in the energy harvesting and storage process. The bridge diodes rectify the generated AC power, the indication LED provides visual feedback, the direct charging cell stores the energy, the step-up module increases the voltage, and the power bank offers a means to use the stored electricity for various applications.

### 3.7 System Functionality

The proposed footstep power generation system is designed to harness mechanical energy from human footsteps and convert it into usable electrical power. Its functionality can be broken down into several key steps:

- **Energy Harvesting:** The system's primary function is to capture mechanical energy generated by people walking over piezoelectric sensors. These sensors, strategically placed in high-traffic areas, generate electrical voltage when compressed by the weight of footsteps. The system thus acts as an energy harvesting mechanism.
- **Rectification:** The electrical energy generated by the piezoelectric sensors is in the form of alternating current (AC). To make this energy usable, the system employs bridge diodes to rectify the AC into direct current (DC). This step ensures that the harvested electricity can be stored and utilized efficiently.
- **Indication LED:** An indication LED serves as a visual feedback mechanism. It lights up to indicate that the system is actively generating electricity. This feature can also serve to inform passersby about the system's environmental and sustainable energy contribution.
- **Energy Storage:** The rectified DC power is directed to a direct charging cell, which acts as an energy storage unit. This storage cell accumulates the harvested electrical energy, making it

available for use when needed. This functionality ensures a continuous supply of power, even when foot traffic is sporadic.

- **Voltage Boosting:** To make the harvested energy suitable for charging a power bank or other electrical devices, the system employs a step-up module. This module increases the voltage level of the electricity to match the requirements of the power bank.
- **Charging Power Bank:** The boosted electricity is then channeled to a power bank. The power bank serves as a portable energy storage solution capable of charging phones, tablets, and other electronic devices. This practical functionality ensures that the harvested energy can be used for various applications.
- **Continuous Power Generation:** The system remains active and generates electricity as long as there is foot traffic on the piezoelectric sensors. This continuous power generation allows the system to provide a steady supply of energy, making it a reliable and sustainable source of electrical power.
- **Environmental Sustainability:** The system significantly contributes to environmental sustainability by reducing the reliance on traditional fossil fuels for power generation. It harnesses clean, renewable energy from human activity, mitigating the environmental impact associated with conventional energy sources.

In summary, the proposed footstep power generation system is designed to efficiently capture, store, and utilize energy from human footsteps, providing a continuous and sustainable source of electricity. Its functionality contributes to environmental sustainability, addresses energy needs in high-traffic public areas, and offers practical applications for powering electronic devices.

### 3.8 Flow chart

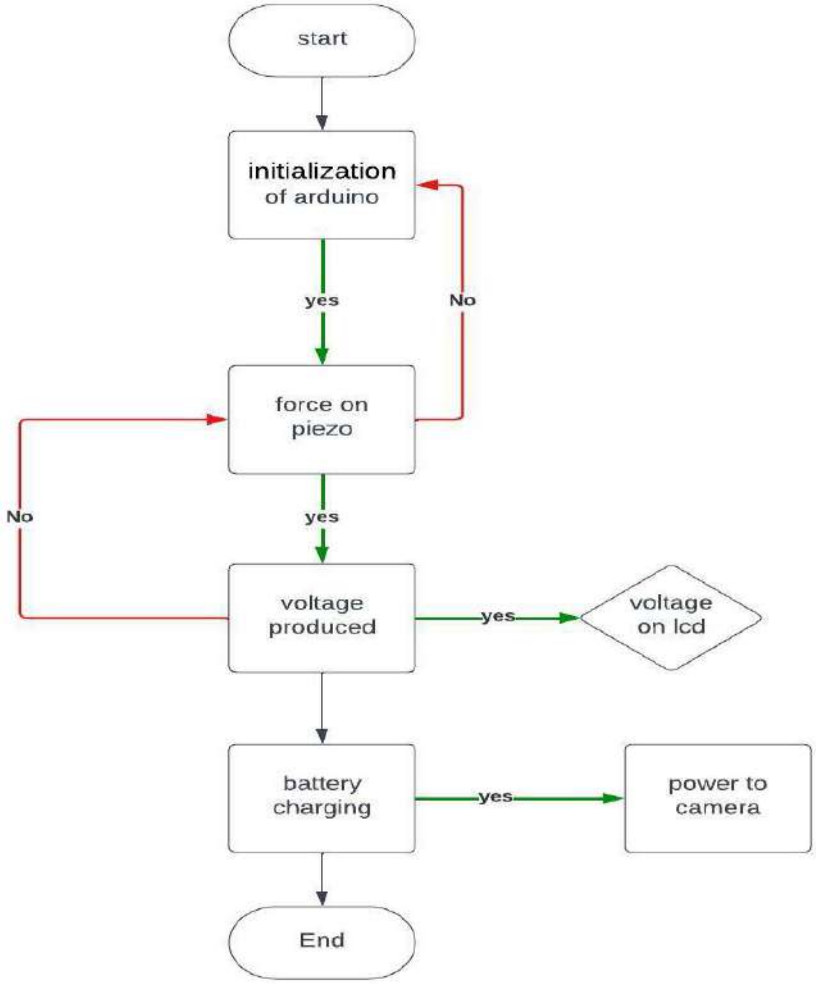


*Figure 3.3 flow chart*

### 3.9 Explanation

When we turn on the system. We have to place foot or apply force on piezo sensors, from output of the piezo sensor we used voltage divider to send signal to Arduino which will tell us about the voltage produce by the sensors and also led will be turn on which tell us about the voltage production.

### 3.10 Principle of operation

The operating modes of a piezoelectric material are mostly determined by the manner in which it is cut.

- The first kind of wave is transverse in nature.
- The second type of wave is longitudinal in nature.
- The topic of discussion is shear.

### 3.11 Sensor design

Metal discs embedded with piezoelectric material are used in the construction of buzzers and contact microphones, which rely on piezoelectric technology. These devices enable the measurement of several physical characteristics, with pressure and acceleration being the most often assessed variables. Pressure sensors use a configuration consisting of a slender membrane and a substantial base, which effectively directs the applied pressure to load the components in a unidirectional manner. In the case of accelerometers, the crystal components are affixed with a seismic mass. When the accelerometer undergoes movement, the unchanging seismic mass imparts stresses onto the components in line with the second rule of motion established by Newton.

$F = ma$………. (i)

The primary distinction in operational principles between these two instances is in the manner in which they exert pressures onto the sensing components. The transmission of force in a pressure sensor occurs via a thin membrane, while in accelerometers, forces are applied by a connected seismic mass.

Sensors often exhibit sensitivity to many physical quantities. Pressure sensors may exhibit erroneous readings when subjected to vibrations. In order to enhance accuracy, advanced pressure sensors include acceleration correction components alongside the pressure detecting elements. The correct pressure information is derived by subtracting the acceleration signal that comes from the adjustment part and is made up of the pressure and motion signals that are perfectly matched.

In addition, vibration sensors have the capability to capture and use energy that would otherwise be lost as a result of mechanical vibrations. The conversion of mechanical strain into useful electrical energy is achieved via the utilization of piezoelectric materials.

### 3.12 Sensing materials

There are two main types of materials that are used in piezoelectric sensors: piezoelectric ceramics and single crystal materials. It is about two orders of magnitude bigger for ceramics, like PZT ceramic, than for natural single crystal materials when it comes to piezoelectric constant or sensitivity. Moreover, these ceramic materials may be manufactured using cost-effective sintering techniques. The piezoelectric effect shown by piezoelectric ceramics undergoes a process of "training" which leads to a gradual degradation of their initial high sensitivity over time. The observed deterioration has a strong positive correlation with increased temperature.

The materials gallium phosphate, quartz, and tourmaline, which possess lower sensitivity and occur naturally as single crystals, have a greater degree of long-term stability, which may be considered almost infinite with careful handling. Additionally, Single-crystal materials like PMN-PT are commercially available. These materials are more sensitive than PZT, however they have a lower maximum temperature threshold and greater production costs.

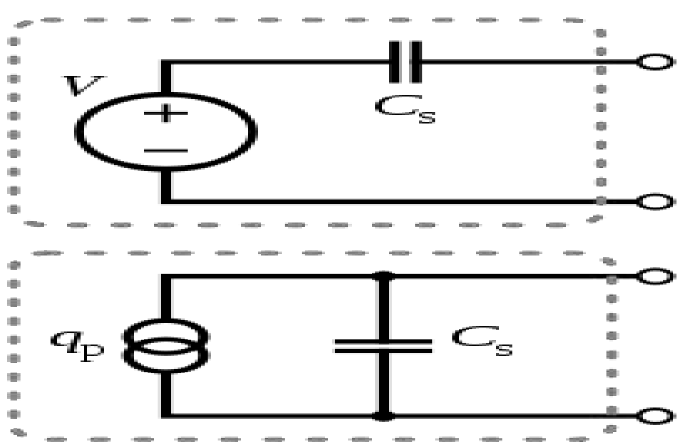


*Figure 3.4 Sensing material process*

### 3.13 Inverter

An inverter is an electrical device used for the conversion of direct current (DC) into alternating current (AC). The design of a system determines the interdependence of the input voltage, output voltage, and frequency. Static inverters use a conversion procedure that does not involve the utilization of any moving components. Inverters find several uses, both the induction of direct current from sources such as batteries and the transform of high-voltage direct electricity from utility lines into alternating current.

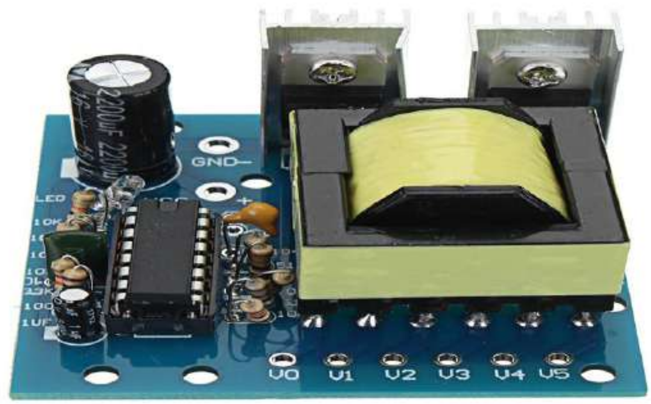


*Figure 3.5 inverter*

A power inverter, often known as an inverter, is an electrical apparatus or system that converts direct current (DC) into alternating current (AC). The design of the individual device or circuitry determines the input voltage, output voltage and frequency, and overall power management. The inverter does not generate electricity; rather, it relies on the DC source to provide the power.

A power inverter might consist solely of electrical components or may have a blend of mechanical mechanisms, such as a rotating device, together with electronic circuitry. The conversion process in static inverters does not involve the use of any moving components. The user's text is already academic and does not need to be rewritten.

## 3.14 Bridge Rectifier

A bridge rectifier refers to a configuration of four or more diodes arranged in a bridge circuit, enabling the production of a consistent output polarity regardless of the input polarity. The device serves the purpose of transforming an alternating current (AC) input into a direct current (DC) output. The use of a bridge rectifier enables the achievement of full-wave rectification by using a two-wire AC input. Consequently, this approach offers advantages in terms of reduced weight and cost compared to rectifiers that rely on a three-wire input from a transformer including a center-tapped secondary winding Diodes D3 and D4 are forward biased during the input AC waveform's negative half cycle, whereas D1 and D2 are reverse biased. The flow of load current starts when the D3 and D4 diodes enter a state of conduction, as seen in the provided diagram.

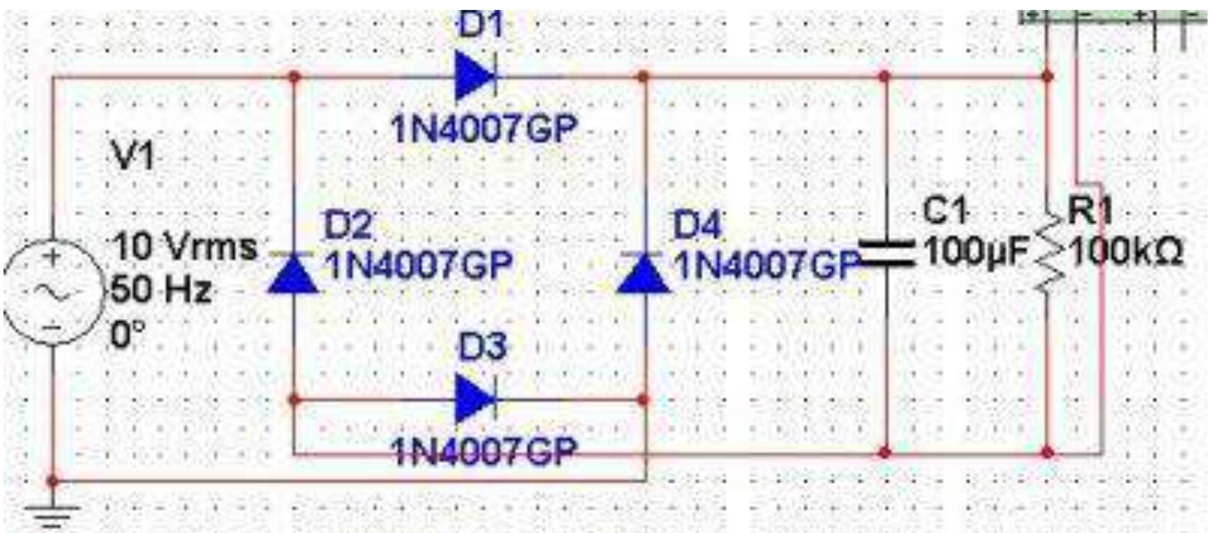


*Figure 3.6 voltage and current characteristic curve*

## 3.15 Diode

Within the field of electronics, a diode is an electrical component consisting of two terminals that exhibits a predominant conduction in a singular direction, characterized by asymmetric conductance. Specifically, it has a minimal resistance, ideally zero, to the passage of electric current in one direction, while concurrently presenting a substantial resistance, preferably infinite, in the opposite direction. The semiconductor diode, which is widely used in contemporary applications, consists of a crystalline semiconductor material with a p–n junction that is linked to two electrical terminals. A vacuum tube diode consists of two electrodes, namely a plate (also known as the anode) and a heated cathode. Semiconductor diodes emerged as the first kind of semiconductor technology. Ferdinand Braun, a German scientist, first discovered the rectifying capabilities of crystals in the year 1874. The first iterations of semiconductor diodes, known as cat's whisker diodes, were fabricated about 1906 and comprised mineral crystals like galena. Currently, the majority of diodes are fabricated using silicon as the primary semiconductor material, while other semiconductors like selenium or germanium are sometimes used.

*Figure 3.7 Diode*

The primary purpose of a diode is to facilitate the unidirectional flow of electric current, allowing conduction in the forward direction while impeding transmission in the reverse direction. Therefore, the diode may be conceptualized as an electrical counterpart of a check valve. The phenomenon of unidirectional behavior, known as rectification, is used in the conversion of alternating current to direct current. This process also involves the extraction of modulation from radio signals in radio receivers, wherein diodes are utilized as rectifiers.

### 3.16 Arduino uno

The Arduino microcontroller is a single board computer that combines user-friendly operation with robust capabilities. Notably, the Arduino is an open-source platform, resulting in affordable hardware and freely accessible programming software. Originating in Italy, the Arduino project was started with the aim of creating cost-effective hardware for the field of interface design [Wikipedia].


*Figure 3.8 Arduino uno*

The ATmega328 microcontroller is designed to function at a voltage of 5 V. It has a random-access memory (RAM) capacity of 2 kilobytes (KiB) and a flash memory capacity of 32 kilobytes (KiB). The clock frequency is 16 MHz, leading to an estimated execution rate of 300,000 lines of C source code per second. The board is furnished with a combined quantity of 14 digital input/output (I/O) pins and 6 analogue input pins. The device is equipped with a USB interface that enables communication with the host computer. Additionally, it has a DC power connector specifically intended for connecting an external power source within a voltage range of 6-20 V, such as a 9 V battery. This feature enables the gadget to autonomously run programs without relying on the host computer. The inclusion of headers enables the connection between the input/output (I/O) pins and external components via the use of either 22-gauge solid wire or header connectors.

The programming language used by Arduino is a modified version of the C/C++ programming language that has been optimized for efficiency. Possessing a comprehensive understanding of the C programming language may greatly enhance the efficiency and effectiveness of programming the Arduino microcontroller. If an individual had minimal understanding in the programming language C, there is no need for apprehension since just a finite set of instructions is necessary to perform actual activities.

### 3.17 Working of Arduino

The Arduino hardware and software were specifically developed to cater to a diverse range of individuals, including artists, designers, hobbyists, hackers, novices, and anybody with an interest in constructing interactive things or surroundings. The Arduino microcontroller platform has the capability to establish communication and interface with a wide range of devices, including buttons, LEDs, motors, speakers, GPS units, cameras, the internet, as well as smart-phones and televisions. The Arduino software's cost-free nature, coupled with its affordable hardware boards and user-friendly learning curve, has fostered a substantial user community.

### 3.18 Programming Concepts

A computer program may be defined as a series of sequential instructions that are designed to be executed by a computer system. The computer will execute precisely the instructions provided to it, without exceeding or falling short of the specified actions. The computer's understanding is limited to the information included inside the program, without insight into the user's intended meaning. Hence, the etymology of the expression, "Garbage in, garbage out"

### 3.19 Camera

This Mini Full HD Camera Has Many Strong Functions Strong Magnetic Adsorption, Smart Wear, Personal, Home, Business Super Security Monitoring, Law Enforcement, Driving, Cycling Records With 150-Degree Recording Angle for Surveillance. It Has Night Vision and Makes a Mini Hidden Camera Able to Capture Clear Video Even in Total Darkness. Allow Wi-Fi Connection, And It Has Own Wi-Fi Hotspot. The Continuous Recording Time Can Last One Hour.


*Figure 3.9 Camera*

### 3.20 Lcd

The I2C LCD component is used in applications that require a visual or textual display. This component is also used where a character display is needed but seven consecutive GPIOs on a single GPIO port are not possible. In cases where the project already includes an I2C master, no additional GPIO pins are required.


*Figure 4.10 lcd*

### 3.21 Resistor

In the realm of electronic circuits, the primary objective of a resistor is to effectively modulate the magnitude of electric current, thereby guaranteeing the secure functionality of intricately interconnected components. This facilitates the aforementioned intricate components to execute their intended operations with maximum efficiency and efficacy. Resistors, being passive electronic components, find extensive application within electronic circuits. The importance of these components lies in the fact that the design of an electrical circuit can become highly complex in the absence of resistors. The fundamental objective of a resistor is to consistently hinder the flow of electrical current, wherein the magnitude of hindrance is denoted as its resistance. The definitive link between voltage, current, and resistance was discovered by Sir G.S. Ohms, a renowned scientist from Germany. As per his statement, the potential difference or voltage (V) across a resistor (R) is directly proportional to the instantaneous current (I) passing through it, and may be expressed as: $V = IR$

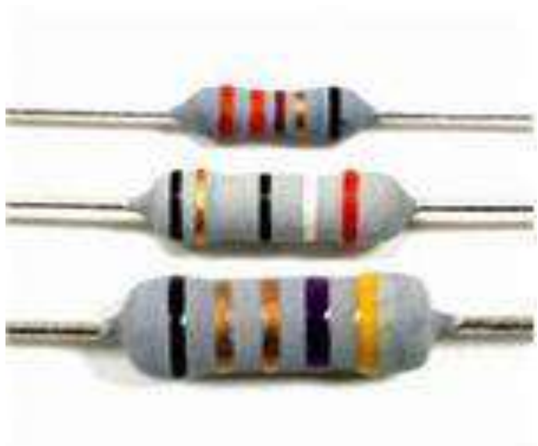

*Figure 3.11 Resistor*

### 3.22 LED Current Limit

Similar to transistors, light-emitting diodes (LEDs) also exhibit a high degree of sensitivity to elevated levels of electrical current. The use of a resistor in series with the LEDs serves to manage the appropriate current flow through the LEDs. In order to determine the value of a resistor for a series LED circuit, one may use the following mathematical expression:

R = V – (N. VLED)/ I

# CHAPTER 4
# HARDWARE RESULTS

## 4.1 Introduction

In this project, the piezo sensors are designed and linked in parallel with each other. There are 18 piezoelectric sensors in our possession. The piezoelectric sensors provide an output signal that serves as the input for the bridge rectifier. The bridge rectifier incorporates a diode, which functions as a reverse diode. The rectified output of the bridge rectifier is sent to the battery in order to facilitate the charging process of the battery.

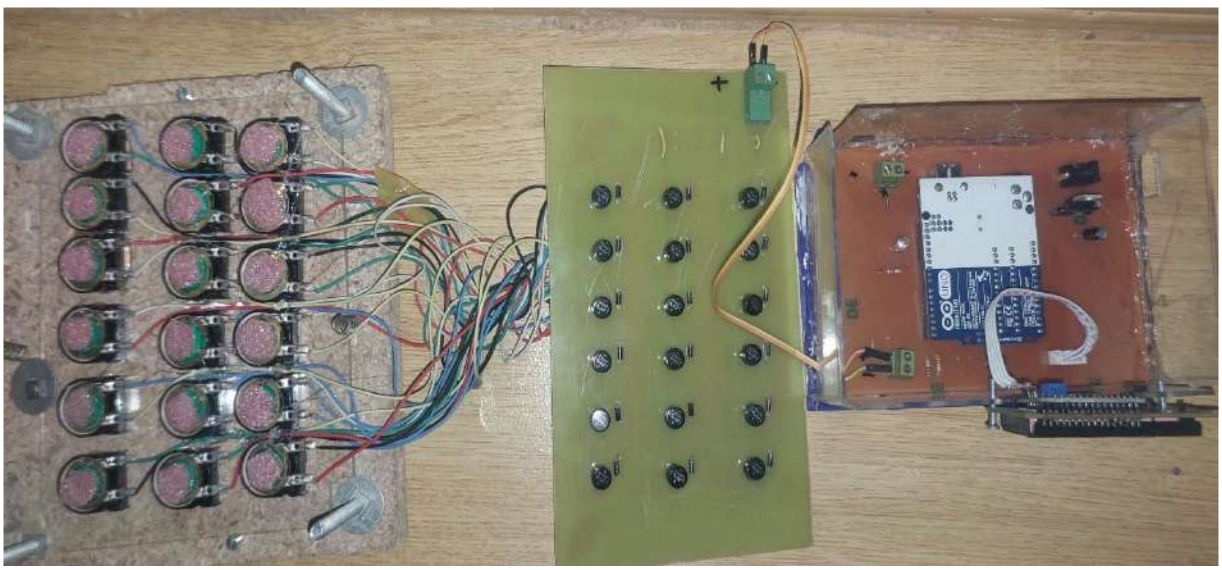

*Figure 4.1 final project hardware*

Converting the potential energy of the force into electrical energy is the goal of this endeavor. A piezo electric sensor, an AC ripples neutralizer, a unidirectional current controller, a 12V, 1.3Amp lead acid dc rechargeable battery, and a voltage regulator are all components that are carried by the control mechanism. This mechanism also drives AC/DC loads. The battery is linked to the voltage regulator in this configuration. This regulator is what you need to change the direct current voltage from 12 volts to 5 volts. This voltage, which is a direct current of 5 volts, is what activates the security cameras. For both the charging of the batteries and the provision of power to the circuitry, we are making use of a standard battery-charging device

## 4.2 Study of connections

After that, three PZT are linked in series in order to find out what form of connection would provide the required amount of noticeable voltage and current. This series combination has connections made for a force sensor as well as a voltmeter. The connection is monitored for matching voltage changes when different pressures are applied to the connection. Additionally, both the current and the voltage that is produced across the series connection are monitored. In a similar fashion, the connections for parallel and series-parallel are both completed at the same time.

## 4.3 Hardware design

It is possible to make tiles out of piezo material. The voltage that is created across a piezo tile is transferred to a battery so that the battery may be recharged and then used to power the dc loads. Additionally, the voltage that is created is sent to an inverter, and from there it is distributed to all of the ac loads. Using a mega 328 microcontroller as the interface to the tile, I was able to show the voltage that was being created across the piezo tile.

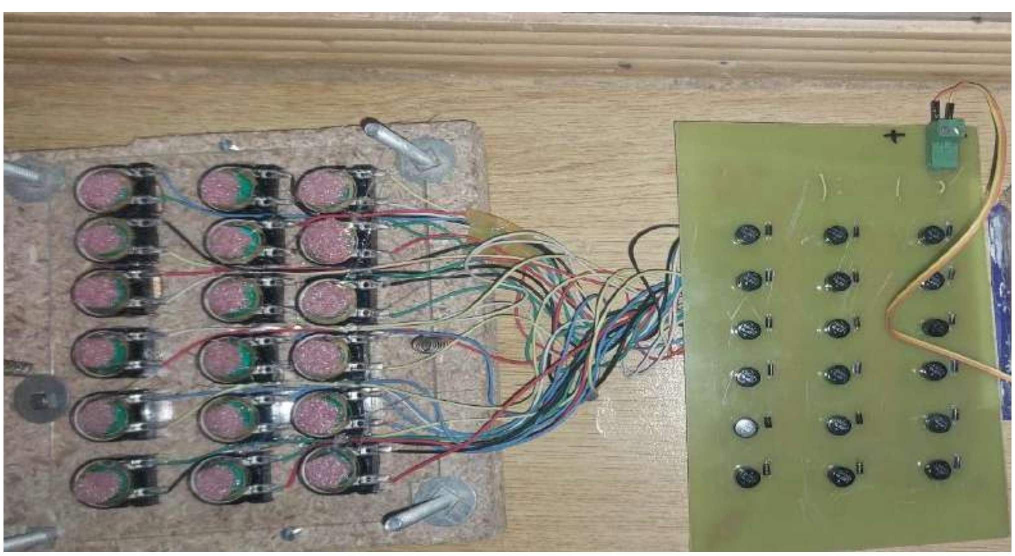

*Figure 4.2 Piezo sensors hardware*

### 4.4 Analysis and Result done on the Piezo Tiles

For determining the voltage producing capability of the Piezo tile, its effectiveness was evaluated by having people whose weight ranged from 40 kg to 75 kg walk on it. Figure 8 is a graph that illustrates the relationship between the amount of a person's weight and the amount of power that they create. It is clear from looking at the graph that the largest amount of voltage is produced when the utmost amount of weight or force is applied. When a weight of 75 kilograms is imposed on the tile, the maximum voltage that may be created across the tile is thus 25 volts.

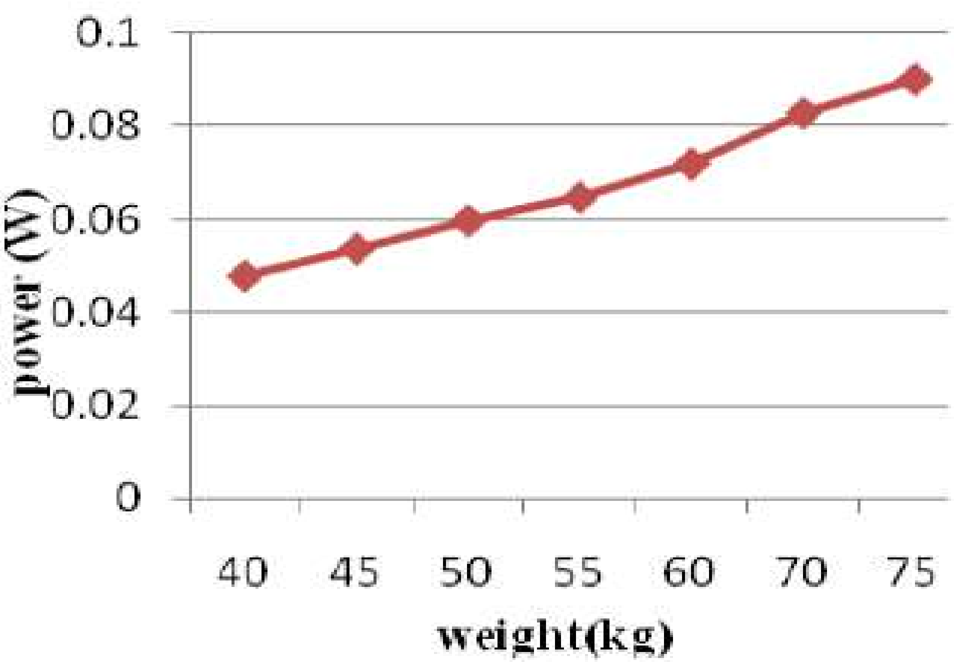


*Figure 4.3 Power (W) and Weight (Kg) Cur*

Piezoelectricity is the phenomenon whereby the application of mechanical pressure on certain crystals, such as quartz, induces the generation of an electric current. Similarly, it is often seen that the converse holds: when an electric current is applied to the aforementioned crystals, they undergo oscillatory vibrations, resulting in a self-compression phenomenon. Piezoelectricity may be succinctly described as the phenomenon in which some materials generate an electric charge in response to applied mechanical stress. However, in the interest of scientific rigorous, it is necessary to provide a rigorous description.

The phenomenon known as piezoelectricity, or the piezoelectric effect, refers to the generation of an electrical potential, specifically a voltage, between the surfaces of a crystal when it is subjected to mechanical stress, such as compression.

In practical use, the crystal assumes the role of a miniature battery, exhibiting a positive charge on one surface and a negative charge on the opposing surface. The establishment of a circuit by connecting the two surfaces facilitates the passage of electric current. The phenomenon known as the reverse piezoelectric effect occurs when an electric field is given to a crystal, resulting in mechanical stress and deformation of its shape.

The unit cell, which serves as the fundamental repeating unit in many crystals including metals, often exhibits symmetry. However, this is not the case with piezoelectric crystals. Piezoelectric crystals often exhibit electrical neutrality, whereby the internal arrangement of atoms may lack symmetry, but the distribution of electrical charges is precisely balanced. Consequently, the presence of a positive charge in one location is effectively counteracted by a neighboring negative charge. Nevertheless, by applying pressure to a piezoelectric crystal, the crystal undergoes deformation, resulting in the displacement of atoms, so altering the equilibrium between positive and negative charges and consequently generating an overall electrical charge. The aforementioned phenomenon persists throughout the whole of the crystal's structure, resulting in the emergence of net positive and negative charges on diametrically opposed external surfaces.

# CHAPTER 5
# CONCLUSION AND FUTURE RECOMMENDATION

## 5.1 Conclusion

The ability to create electricity is possessed by a piezo tile. When compared to other piezoelectric materials, PZT demonstrates greater performance in all of the tested parameters. In addition, the results of the comparison showed that the series-parallel combination connection is the one that works best. It has been shown via research that there is a linear relationship between the amount of force exerted on the tile and the voltage that is produced as a result. It is particularly appropriate for use in settings where there are many people. Without the need for lengthy power cables, this may be applied to power security cameras instead. Additionally, it may be used as charging outlets and lights for buildings that are next to pavement.

The concept has been successfully tested and put into action, and it now provides regular people with the most practical, cost-effective answer to their energy needs. This may be put to use for a wide variety of purposes in rural locations, where access to electricity may be limited or nonexistent altogether. As a developing nation, Pakistan has a significant problem in terms of energy management due to the country's large population. Because of this project, we are able to drive either alternating current or direct current loads depending on the amount of force that we apply to the piezoelectric sensor.

## 5.2 Discussion about this Project

Pakistan is a nation with a very high population density. There are several locations in Pakistan in which the majority of people commute only by foot at all times. Because these areas are always bustling with people walking, it should not be difficult for us to locate sources such as vibration or pressure that may be used to generate power from piezoelectric material.

As a result, we developed a framework for the production of electricity. Piezoelectric Sensors were combined with one another and stowed away inside of it. Piezoelectric Sensors may be made to vibrate simply by applying pressure on the structure or Sensors, at which point the Sensors will provide electricity as an output. The charge will be stored in the battery after it has completed its journey around the circuit. Within this project, we make use of two different apps. Because the model will be placed in a densely inhabited region, we will be able to make use of this stored energy to illuminate the pedestrian route and the passes without having to get power from any other sources. A further use is that we may install a charging station for portable electronic gadgets with low power requirements, such as mobile phones, iPods, and other such items.

### 5.3 Future Recommendation

Piezoelectric crystals have been increasingly used with favorable outcomes. At Pakistan, significant levels of public activity are often seen at railway stations, temples, universities, and retail malls. Consequently, these locations provide potential opportunities for the use of piezoelectric crystals in the production of electric power. In addition to the aforementioned locations, endeavors have been undertaken to harness energy from our everyday activities by incorporating piezoelectric crystals into footwear. By doing so, the compression of piezoelectric sensors with each step can generate sufficient power to recharge portable electronic devices such as cell phones and iPads. This approach enables the generation of electric power for the operation of small-scale electronic gadgets.

# CHAPTER 6

## 6.1 Introduction

Developing a footstep power generation system for security cameras using Arduino technology is in line with several Sustainable Development Goals (SDGs), specifically Goal 7 (Affordable and Clean Energy) and Goal 9 (Industry, Innovation, and Infrastructure). Here is a general outline to assist you in getting started:


*Figure 6.1 Sustainable Development Goals Courtesy Caritas*

## 6.2 Required Components:

**1. Piezoelectric Sensors:**

These sensors have the ability to convert mechanical stress, such as footsteps, into electrical energy.

**2. Arduino Board:**

The Arduino board will serve as the central control unit, managing the sensors and the generated power.

**3. Battery**:

A rechargeable battery will be used to store the generated energy, ensuring a continuous power supply.

**4. Power Management Circuit:**

This circuitry will regulate and manage the power generated by the piezoelectric sensors.

**5. Security Camera:**

The camera that requires power to operate.

**6. Voltage Regulator:**

A voltage regulator will be employed to maintain a stable voltage output for the security camera.

## 6.3 System Workflow:

**1. Placement of Piezoelectric Sensors:**

Install the piezoelectric sensors in areas with high foot traffic or frequent footsteps.

**2. Power Generation:**

When someone steps on the sensors, a small amount of electrical energy is generated.

**3. Energy Harvesting Circuit:**

Utilize an energy harvesting circuit to collect and store the generated energy in the battery.

**4. Arduino Control:**

The Arduino board will monitor the battery level and activate the security camera when the battery is fully charged.

**5. Power Management:**

Implement power management algorithms to optimize energy usage and ensure uninterrupted camera operation.

**6. Voltage Regulation:**

Incorporate a voltage regulator to maintain a consistent voltage supply for the security camera.

**7. Communication:**

If feasible, integrate communication modules such as GSM or Wi-Fi to send alerts or provide status updates.

## 6.3 Alignment with SDGs:

**Goal 7: Affordable and Clean Energy:**

This project contributes to the utilization of clean energy by harnessing power from footsteps, thereby reducing reliance on traditional energy sources.

**Goal 9: Industry, Innovation, and Infrastructure:**

The project involves innovative energy harvesting technology and the development of infrastructure for sustainable power generation.

# REFERNCES


[1]. Winey, T., *Method and apparatus for the exploitation of piezoelectric and other effects in carbon-based life forms*. 2006, Google Patents.

[2]. Gautschi, D.-I.E.G., *Piezoelectric sensors*, in *Piezoelectric Sensorics*. 2002, Springer. p. 73-91.

[3]. Uchino, K., *Piezoelectric actuators and ultrasonic motors*. Vol. 1. 1996: Springer Science & Business Media.

[4]. Sodano, H.A., D.J. Inman, and G. Park, *A review of power harvesting from vibration using piezoelectric materials.* Shock and Vibration Digest, 2004. **36**(3): p. 197-206.

[5]. Leonhard, W., *Control of electrical drives*. 2012: Springer Science & Business Media.

[6]. Rabén, H., J. Borg, and J. Johansson. *Improved efficiency in the CMOS cross-connected bridge rectifier for RFID applications*. in *Mixed Design of Integrated Circuits and Systems (MIXDES), 2011 Proceedings of the 18th International Conference*. 2011. IEEE.

[7]. Choi, S., P.N. Enjeti, and I.J. Pitel, *Polyphase transformer arrangements with reduced kVA capacities for harmonic current reduction in rectifier-type utility interface.* IEEE Transactions on Power Electronics, 1996. **11**(5): p. 680-690.

[8]. Manjrekar, M.D., P.K. Steimer, and T.A. Lipo, *Hybrid multilevel power conversion system: A competitive solution for high-power applications.* IEEE transactions on industry applications, 2000. **36**(3): p. 834-841.

[9]. Shenck, N.S. and J.A. Paradiso, *Energy scavenging with shoe-mounted piezoelectrics.* IEEE micro, 2001. **21**(3): p. 30-42.

[10]. Starner, T., *Human-powered wearable computing.* IBM systems Journal, 1996. **35**(3.4): p. 618-629.

[11]. Liu, Y., et al., *Theoretical Study of Piezo-phototronic Nano-LEDs.* Advanced Materials, 2014. **26**(42): p. 7209-7216.

[12]. Kymissis, J., et al. *Parasitic power harvesting in shoes*. in *Wearable Computers, 1998. Digest of Papers. Second International Symposium on*. 1998. IEEE.

[13]. Ruys, D.P., J.F. Andrade, and O.M. Guimarães, *Mercury detection in air using a coated piezoelectric sensor.* Analytica Chimica Acta, 2000. **404**(1): p. 95-100.

[14]. Shu, Y. and I. Lien, *Analysis of power output for piezoelectric energy harvesting systems.* Smart materials and structures, 2006. **15**(6): p. 1499.

[15]. Anton, G., et al., *Study of piezo based sensors for acoustic particle detection.* Astroparticle Physics, 2006. **26**(4): p. 301-309.

[16]. Reissner, E., *The effect of transverse shear deformation on the bending of elastic plates.* 1945.

[17]. Takahashi, Y., et al., *Longitudinal-effect type laminar piezoelectric/electrostrictive driver, and printing actuator using the driver*. 1992, Google Patents.

[18]. Okubo, A., *Some remarks on the importance of the "shear effect" on horizontal diffusion.* J. Oceanogr. Soc. Japan, 1968. **24**(2): p. 60-69.

[19]. Coldren, L.A., S.W. Corzine, and M.L. Mashanovitch, *Diode lasers and photonic integrated circuits*. Vol. 218. 2012: John Wiley & Sons.

[20]. Ng, K.K., *p-n Junction Diode.* Complete Guide to Semiconductor Devices, Second Edition: p. 11-23.

[21]. D'Ausilio, A., *Arduino: A low-cost multipurpose lab equipment.* Behavior research methods, 2012. **44**(2): p. 305-313.

[22]. Badamasi, Y.A. *The working principle of an Arduino*. in *Electronics, Computer and Computation (ICECCO), 2014 11th International Conference on*. 2014. IEEE.

[23]. McMillan, L.A. and R.D. Streeter, *Method and apparatus for an improved single pole double throw micro-electrical mechanical switch*. 2000, Google Patents.

[24]. Oberhammer, J., et al., *Mechanically tri-stable, true single-pole-double-throw (SPDT) switches.* Journal of Micromechanics and Microengineering, 2006. **16**(11): p. 2251.

[25]. De Arcangelis, L., S. Redner, and A. Coniglio, *Anomalous voltage distribution of random resistor networks and a new model for the backbone at the percolation threshold.* Physical Review B, 1985. **31**(7): p. 4725.

[26]. Sudevalayam, S. and P. Kulkarni, *Energy harvesting sensor nodes: Survey and implications.* IEEE Communications Surveys & Tutorials, 2011. **13**(3): p. 443-461.