PROJECT REPORT

ON

PIEZO ELECTRIC ENERGY HARVESTING

SUBMITTED BY

YASH VIJAY PANCHAL

UNDER THE GUIDANCE OF

Mrs. JYOTI BANSODE

INFORMATION TECHNOLOGY DEPARTMENT

SHAH & ANCHOR KUTCHHI POLYTECHNIC

CHEMBUR, MUMBAI-400088

2015-2016

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CERTIFICATE

CERTIFIED that this Report is submitted by **Mr. Yash Vijay Panchal** Roll No. **20153417** a student of **Third Year** of course **Information Technology** as a part of project work as prescribed by **Maharashtra State Board of Technical Education**, Mumbai for the project.

And that I have guided them for the said work from time to time and I found their work progressing satisfactorily.

And that following students were associated with his for this work and their contribution was proportionate.

NAME	ROLL NO
Ms. Shruti Shankar Khatpe	*20153406*
Ms. Jaee Vishwanath Desai	*20153421*

And that the said work has been assessed by me and I am satisfied that the same is up to standard envisaged for the level of the course, and therefore can be presented to the External Examiner.

Project Guide	**Head of Department**	**Principal**
(Mrs. Jyoti Bansode)	**(Mrs. Vaishali Kosamkar)**	**(Dr. Bhavesh Patel)**

External Examiner

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SUBMISSION

I, ***Mr. Yash Vijay Panchal***, Roll No. ***20153417,*** a student of **Third Year** of the course **Information Technology** humbly submit that I have completed from time to time project work as described in this report by own skills and study between period from June, 2015 to March, 2016 as per the guidance of **Mrs. Jyoti Bansode.**

And that all the following students were associated with me for this work and the quantum of my contribution has been approved by my guide.

NAME	ROLL NO
Ms. Shruti Shankar Khatpe	*20153406*
Ms. Jaee Vishwanath Desai	*20153421*

And that we have neither copied the Report nor it's any important parts from any other literature in contravention of the academic ethics.

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PREFACE

Energy harvesting has been a topic of discussion and research since three decades. With the ever increasing and demanding energy needs, unearthing and exploiting more and more energy sources has become a need of the day. Energy harvesting is the process by which energy is derived from external sources and utilized to drive the machines directly, or the energy is captured and stored for future use. Through this report, we will describe the Piezo effect basic working of a piezoelectric cell. Then later in the report, we have proposed the idea of combining energy from a number of piezoelectric cells to obtain higher voltages. Piezoelectric cells can be utilized to obtain voltages of very small values and hence can drive low voltage devices i.e. using this Piezo cells electrical energy can be generate by converting the applied mechanical force into electrical energy and storing that produced energy for its later use. Hence, Piezoelectric Energy Harvesting comes under the category of Micro scale energy harvesting scheme. The piezoelectric effect is a reversible processing that materials exhibiting the direct piezoelectric effect (the internal generation of electrical charge resulting from an applied mechanical force) also exhibit the reverse piezoelectric effect (the internal generation of a mechanical strain resulting from an applied electrical field).

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Energy harvesting has been a topic of discussion since last three decades, considering all those need to be satisfied we have come across a concept called Piezo Electricity. Energy Harvesting systems are used to harvest the normally lost environmental energy and to convert it into electrical energy, the concept Piezo Electricity is also the same technique which would convert the pressure or mechanical force into electrical voltages. We are aware of Railway tunnels and lights used inside them which are always on i.e. continuous electricity are supplied to them. Use of those tunnel lights is to give light inside the dark tunnel when the train is inside the tunnel; even when then train is not inside the tunnel the lights are still always on which is wastage of electricity. There are many railway tunnels which are large in size i.e. area in km, such large tunnels are having number of lights in them which would be consuming electricity, so to overcome such wastage of electricity we thought of a system which would use the pressure of the train and convert it into electricity and such an electricity would be used for those tunnel lights. The generated electricity will be stored in the condenser and electricity will only be supplied to the tunnel lights when the train arrives at the tunnel point and till it doesn't get out of the tunnel. Here the pressure would be given by the train running in the tracks on the PZT material i.e. .piezo cell would be placed underneath the tracks. In such way electrical energy would be harvested and further used for tunnel lights.

1.2 PREVIOUS RELATED WORK

Travelling through trains we have seen various tunnels from which the train route goes through. Such tunnels have no natural light inside hence artificial lights are placed for light inside the tunnel. Such lights need electricity to turn on. Thus Electrical energy is needed which is being supplied to those lights continuously for 24*7hrs.

1.3 PROBLEM STATEMENT

Currently there is no technique to harvest energy i.e. electrical energy which is continuously used by the tunnels for train. Even if the train is not inside the tunnel, lights of the tunnel are always on, thus this makes the unnecessary use or waste of electricity, and thus we have proposed our system to overcome this unnecessary waste of electricity. Apart from our proposed energy harvesting technique there are various energy harvesting techniques are used

but these techniques causes harm to nature or overall environment cycle, thus to overcome all these demerits and constraints of the energy harvesting techniques, concept of energy harvesting techniques for the tunnels is further proposed in the report or the project i.e. Piezo electric energy harvesting.

1.4 CONCLUSION

Thus understanding the earlier work related i.e how electricity is unnecessary wasted for the tunnel lights, the proposed system would help in overcoming the demerits of the previous system or rather current system and also overcome the wastage of the electrical energy.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

- What is Energy harvesting?

Power harvesting, energy harvesting, power scavenging, and energy scavenging are four terms commonly used to describe the process of extracting useful electrical energy from other ambient energy sources using special materials called transducers that have the ability to convert one form of energy into another. While the words power and energy have vastly different definitions, the terms "power harvesting" and "energy harvesting" are used interchangeably throughout much of the literature to describe the same process of extracting electrical energy from ambient sources. Even though most of the energy coupling materials currently available have been around for decades, their use for the specific purpose of power harvesting has not been thoroughly examined until recently, when the power requirements of many electronic devices has reduced drastically[7]. Harvesting Energy harvesting can be obtained from different energy sources, such as mechanical vibrations, electromagnetic sources, light, acoustic, airflow, heat, and temperature variations. Energy harvesting, in general, is the conversion of ambient energy like natural energy, human energy, mechanical energy, light energy etc into usable electrical energy. When compared with energy stored in common storage elements, such as batteries, capacitors, and the like, the environment represents a relatively infinite source of available energy. Ambient energy harvesting is also known as energy scavenging or power harvesting, and it is the process where energy is obtained from the environment. A variety of techniques are available for energy scavenging, including solar and wind powers, ocean waves, piezoelectricity, thermoelectricity, and physical motions. For example, some systems convert random motions, including ocean waves, into useful electrical energy that can be used by oceanographic monitoring wireless sensor nodes for autonomous surveillance. Ambient energy sources are classified as energy reservoirs, power distribution methods, or power-scavenging methods, which may enable portable or wireless systems to be completely battery independent and self sustaining [6].

2.1.1 A general overview of ambient energy sources are presented, and summarized the resources according to their characteristics:

- Human Body:

Energy can also be produced through various human actions such energy can be stored and used for various applications. Mechanical and thermal (heat variations) energy can be generated from a human or animal body by actions such as walking and running.

- Natural Energy:

Energy sources for natural energy are available. They are finite in nature. But they are pollutant. Ex. Wind, water flow from waterfall, sea/ocean waves, and solar energy can provide energy from the Environment.

- Mechanical Energy:

Vibrations from machines, mechanical stress, and strain from high-pressure motors, manufacturing machines, and waste rotations can be captured and used as ambient mechanical energy sources.

- Thermal Energy:

Waste heat energy variations from furnaces, heaters, and friction sources.

- Light Energy:

This source can be divided into two categories of energy: indoor room light and outdoor sunlight energy. Light energy can be captured via photo sensors, photo diodes, and solar photovoltaic (PV) panels. And Electromagnetic Energy: Inductors, coils, and transformers can be considered as ambient energy sources, depending on how much energy is needed for the application.

2.1.2 HARVESTING METHODS

- Piezoelectricity

Brothers Pierre and Jacques Curie discovered the piezoelectric effect in quartz crystals in 1880. In general, can be defined as the conversion of mechanical energy into electrical energy (direct effect) or conversion of electrical energy into mechanical energy (inverse effect) [8]. The direct piezoelectric effect provides that an electrical charge is generated when it subjected to a mechanical energy, whether delivered from compression, tractionor just vibration. In turn, the inverse piezoelectric effect is the ability of the piezoelectric material to produce mechanical energy when subjected to an electrical charge in opposite sides [10].

- Thermal Energy

The body temperature changes when it receives or provides energy. In this situation, the molecules are in constant motion, and this agitation is measured by temperature. Only by temperature difference can energy extraction from a thermal reservoir (e.g. body) be guaranteed. The possibility of conversion between heat and work has been restricted to thermal machines. The Second Principle of Thermodynamics, developed by Sadi Carnot in 1824, is stated as follows [9]: "To be continuous conversion of heat into work, a system must perform cycles between hot and cold sources continuously. In each cycle, is extracted a certain amount of heat from the hot source (useful energy), which is partially converted into work, being the remainder rejected to the cold source (energy dissipated)". Carnot's equation, based on the 1st and 2nd law of thermodynamics, is a reference mathematical expression for the conversion of thermal energy into work. Its theoretical maximum efficiency in a steam engine is related to the thermal reservoirs kept at hot, Th, and cold, Tc, temperatures [22]. The thermoelectric conversion works by absorbing and releasing heat in the connection interface between different electrical conductors (thermocouples or thermos junctions). A thermocouple is defined as a transducer composed by two metals or alloys, electrically joined at its ends, resulting in two junctions. When these joints are subjected to different temperatures, the thermocouple circuit has an electrical current. One of these joints is called the measurement junction and is subjected to temperature to be measured, while the other junction, reference junction, is applied to a known temperature, usually the temperature of an ice bath [10]. The electromotive force, which generates electric current, is generated by the difference between the joints temperatures. To measure this thermal electromotive force, the thermocouple circuit is opened at some point, where a voltmeter is introduced. After the discovery of Thermoelectricity by Alexandre Volta (1800), other studies have been developed on the effects of thermal electricity generation, which stand to Thomas Seebeck (1821), Jean Peltier (1834) and William Thomson – Lord Kelvin (1848-1854). These scientists have led to names of the three basic effects of thermoelectricity thermometry, which although different, are related among them. These effects are known as thermoelectric effects, getting these names because involve either temperature or electricity. The Seebeck effect transforms thermal energy into electricity, while the Peltier effect is related with the absorption or emission of heat in presence of an electric current in the junctions. However, both effects act in different materials. Finally, the Thomson effect presents similarities to the

Peltier effect as electrical current produces a different heating effect, according to the direction of hot/cold source, but in the same material [10].

Table 2.1. Comparison of Vibration Energy Harvesting Techniques [6]

	Electrostatic	Electromagnetic	Piezoelectric
Complexity of process flow	Low	Very High	High
Energy density	4 mJ cm-3	24.8 mJ cm-3	35.4 mJ cm-3
Current size	Integrated	Macro	Macro
Problems	Very high voltage and need of adding charge source	Very low output voltages	Low output voltages

- Electromagnetic

An electric field always produces a magnetic field and, conversely, a time variable magnetic field always produces an electric field. The induction law of Faraday describes the modification that a magnetic field will induce in an electric current. In turn, the equation of Ampere-Maxwell states the modification generated by an electric field into a magnetic field. There are already several types of electrical generators that use mechanical vibrations, including those who are present in watch and radio frequency circuits [8]. These are able to use the energy recovered and generated from the natural environment. There are two types of mechanical generators: those who use the relative motion of objects in which the generation system is connected and those that use rigid body motion. Its basic settings or construction are shown in Figure. 2.1.2.1.

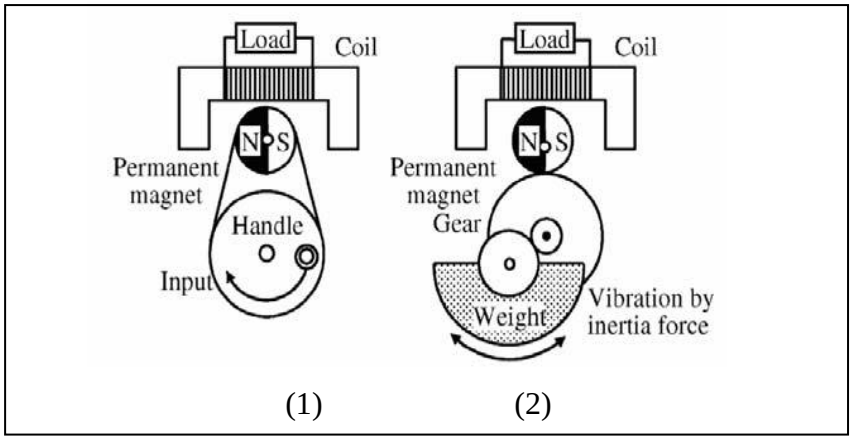

Figure 2.1.2.1. Types of Mechanical Generators: 1) Relative Movement 2) Rigid Body [8]

Both systems use the electromagnetic induction principle to convert movement into electric power. The relative motion of the armature corresponding to the permanent magnet is given by the object relative motion in which the generating system is fixed. In the case of rigid body motion, the inertia force of the weight is installed on the generator. These relative movement systems are employed on bicycles' generators, radios and mobile phones. When the handle is moved 10 cm (diameter) by a force of 10 N at a rate of 3 rev/sec is produced 9.3 W (neglecting losses), 10 times higher than the power produced by the rigid body [8]. The rigid body motion type is more susceptible to vibratory movements than to constant movements, since it uses inertia, i.e. the resistance to movement. The power available for each vibration cycle is just the kinetic energy that remains in the system. Assuming that the equipment is attached to the body of a person and considering that the weight movement is equivalent to the human body motion, the kinetic energy is about 10 μJ and the electric power generated is about 10 μW, which are lower values than those produced by relative motion. Thus, this generator can operate unconsciously and can be installed anywhere, obtaining a considerable amount of energy. There are some effective methods for this mechanism, as resonance generators, self-excitation generators and rotational generators as gyroscopes [8].In order to improve these results, [15] applied an elastomer generator in the heel of a boot, as shown in Figure 2.1.2.2.

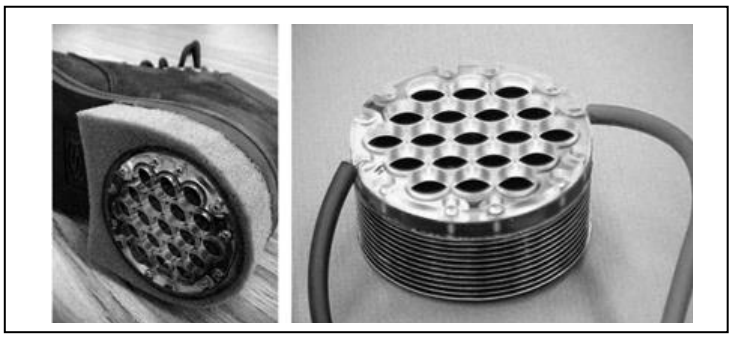

Figure 2.1.2.2. Electrostatic Generator based in the Compression of a Dielectric Elastomer[15]

When the heel is pressed against the ground, the pad compresses the implemented elastomeric membrane producing a voltage. When a voltage is applied across the electrodes, it produces energy. Another application that uses the walk movement to generate energy considers the insertion of the piezoelectric materials in the floor. In this case, the floor beneath our feet acquires, accumulates and converts into electricity the energy generated by the passage of people, rather than applying it to the shoe [16]. According to studies conducted by [17], each step produces 8 W. This power is absorbed by the floor, being possible to capture at least 30% of that energy. In this context, it is possible to imagine a dance floor where the floor is designed to reduce vibration and disperse energy, capturing it and generating electricity, as it is equipped with energy scavengers under the surface. Considering the natural walk movement, [18] tried to implement magnetic generators in shoes, as shown in Figure 2.1.2.3. This prototype is implemented in a shoe only with the following components i.e. a spring, a pendulum and a generator system that produces a peak power near 1 W, i.e. the produced enough energy to power a radio while walking. However, these generators are difficult to integrate in shoe, without causing discomfort to the user after wearing the shoes, since the mechanical system has proved quite intrusive.

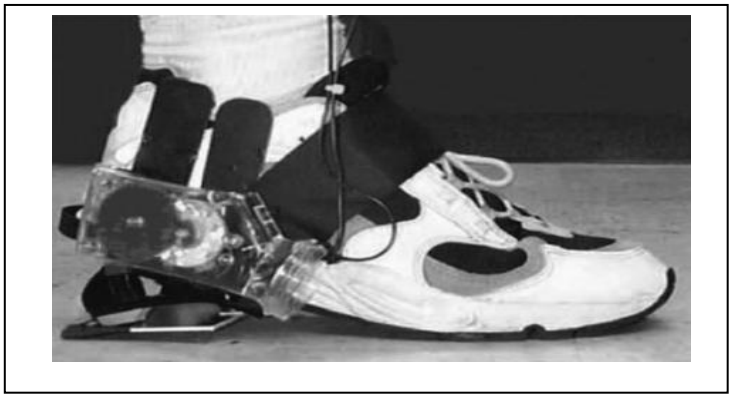

Figure 2.1.2.3. Rotating Generator Adapted in a Shoe [18]

Thus, [19] developed a model to improve the integration of the generator in the shoe's sole, as shown in Figure 2.1.2.4. As the rotating generators need to turn quickly to achieve the desired efficiency, all other systems that involve significant gear relationships, make a considerable mechanical complexity and a reasonably high torque, leading to a high probability of collapse [8].

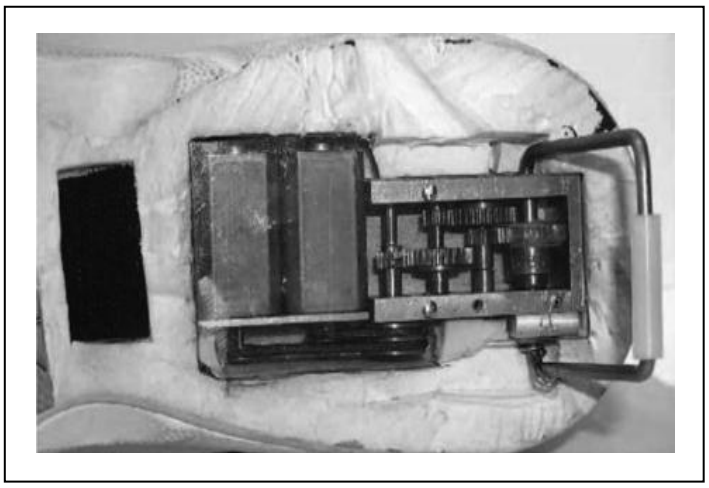

Figure 2.1.2.4. Improvement of the Rotational Generator, with two Magnetic Generators built in the Shoe's Sole [19]

Since the electromagnetic systems can be made of a coil and a permanent magnet attached to a spring, this mechanical movement caused by structural vibration, induces a voltage at the coil's terminal that converts it into an electric charge. The magnetic field in the coil will be easily induced if the magnet is large. However, the size and layout of the magnet is limited by the spring and the structure of the device itself [8].

- Asphalt solar collector combined with piping system

Energy harvesting from surfaces that serve as solar collectors is no longer conceived as a new technology and is often discussed in combination with embedding pipes and pumps in particular arrangements to harvest the extracted solar energy and convert it to thermal or electric energy. These so called 'asphalt collectors' are also known as asphalt solar collector (ASC) and they circulate water through a series of pipes below the pavement surface for use. The principle for the technique is that the radiation from the sun and atmosphere is absorbed in the pavement through an increase in warmth which is captured by water piping system and stored in the ground or other storage reservoirs over summertime. The stored energy could

then be used for supporting nearby facilities for district heating and cooling, electricity, recharging or de-icing the roads (e.g. via a hydronic system).

- Photovoltaic (PV) applications in the road infra

Researchers at one of the Korea Institute also investigated several approaches to harvest solar energy from asphalt pavements. In addition to the heat generated inside the pavement itself, they also intended to identify if it is feasible to utilize current solar cell or photovoltaic technologies by embedding those into the pavement infrastructure. It should be noted, however, that current thin film solar cells are difficult to use in surfaces that receive vast mechanical load cycles and environmental conditioning could cause premature corrosion and wear. For this reason the researchers are developing new thin film solar cells that can meet the requirements for using it on road surfaces.

2.2 LITERATURE OF DOMAIN USED

2.2.1 PIEZOELECTRIC EFFECT

The piezoelectric effect describes the relation between a mechanical stress or pressure and an electrical voltage in solids materials. It is reversible: an applied mechanical stress will generate a voltage and an applied voltage will change the shape of the solid by a small amount (up to a 4% change in volume) [1].

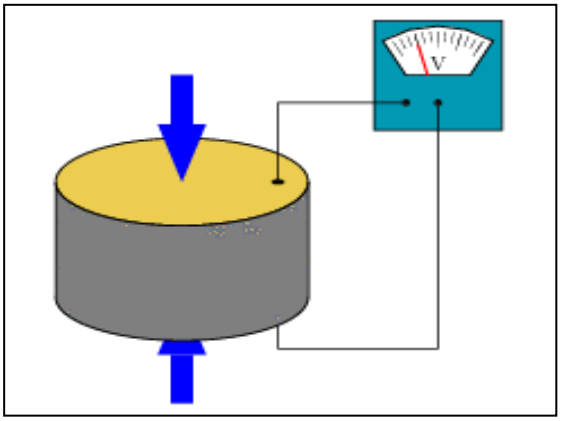

Figure 2.2.1.1. Piezoelectric Effect [1]

Piezoelectric ceramics have been used for many years to convert mechanical energy or pressure into electrical energy. The following sections describe the range of piezoelectric generators described in the literature to date. For the purpose of this review, piezoelectric generators have been classified by methods of operation and applications and include bothmacro scale (>cm) and micro scale (μm to mm) devices. It begins with a brief description

of piezoelectric theory in order to appreciate the different types of generator and the relevant piezoelectric material properties [1].

2.2.2 DIRECT AND INVERSE PIEZOELECTRIC EFFECT

The Pressure applied generates charges on the surface of piezoelectric materials. This direct piezoelectric effect, also called generator or sensor effect, converts mechanical energy into electrical energy. Vice versa, the inverse piezoelectric effect causes a change in length in this type of materials when an electrical voltage is applied. This actuator effect generated converts electrical energy into mechanical energy. The piezoelectric effect occurs both in monocrystalline materials and in polycrystalline ferroelectric ceramics. In single crystals, an asymmetry in the structure of the unit cells of the crystal lattice, i.e. a polar axis that forms below the Curie temperature T_C, is a sufficient prerequisite for the effect to occur. Piezoelectric ceramics additionally have a spontaneous polarization, i.e. the positive and negative charge concentration of the unit cells is separate from each other. At the same time, the axis of the unit cell extends in the direction of the spontaneous polarization and a spontaneous strain occurs [3].

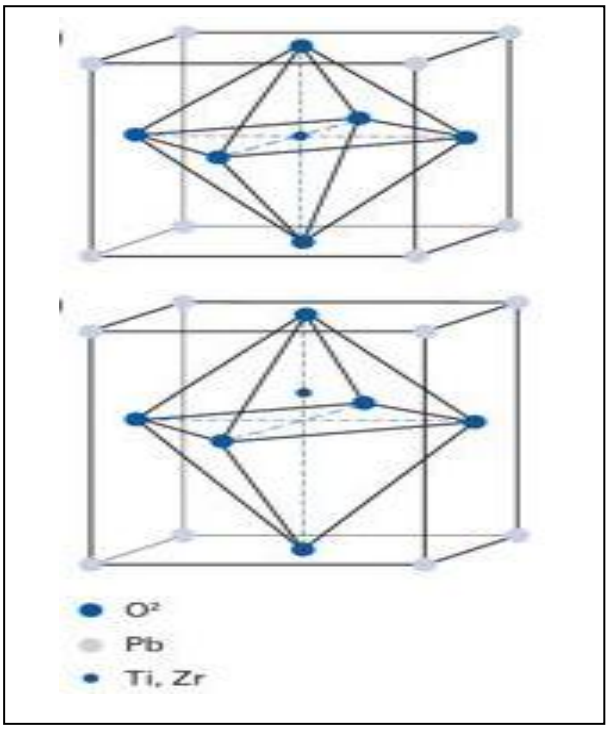

Figure 2.2.2.1. Direct and Indirect Piezoelectric Effect [3]

2.2.3 TYPES OF PIEZO MATERIALS

- Soft Piezoelectric Materials

Ideal for piezo actuators and sensors. Ferroelectrically soft piezo ceramic materials can be polarized fairly easily even at relatively low field strengths. This is due to the comparably high domain mobility typical for them. The advantages of soft PZT materials are their large piezoelectric charge coefficient, moderate permittivities and high coupling factors [4].

Figure 2.2.3.1. Soft Piezoelectric Materials

Hard Piezoelectric Materials

The materials are High Performance Material mostly used for Ultrasonic Transducers. Ferro electrically hard PZT materials can be subjected to high electrical and mechanical stresses. Their properties hardly change under these conditions. The advantages of these materials are their moderate permittivity, large piezoelectric coupling factors, high mechanical qualities and very good stability under high mechanical loads and operating field strengths. Low dielectric losses facilitate their continuous use in resonance mode with only low intrinsic heating of the component [4].

Figure 2.2.3.2. Hard Piezoelectric Materials

Table 2.2. Summary of Several Piezoelectric Materials [2]

Summary Of Several Piezoelectric Materials Investigated.			
Author	**Type Of Material**	**Advantages/Disadvantages**	**Power Harvesting Capabilities**
Lee *et al* (2005)	Monolithic PZT	Most common type of device. Not flexible. Susceptible to fatigue crack growth during cyclic loading	N/A
Lee *et al* (2004, 2005	PVDF film coated with PEDOT/PSS electrodes	Resistance to fatigue crack damage to electrodes	N/A
Mohammadi *et al* (2003)	Piezofiber composite	Increased flexibility	120 mW from 34 × 11mm plate of 5.85 mm thickness
Churchill *et al* (2003)	Piezofiber composite	Increased flexibility	7.5 mW from 130 × 13 mm patch of 0.38 mm thickness
Sodano *et al* (2004a)	MFC composite quick pack IDE quick pack	MFC–flexibility, MFC and quick pack IDE—low-capacitance devices quick pack—energy harvesting capability	Quick pack proved to harvest the most energy

2.2.4 INDUSTRIAL APPLICATIONS

In the 80’s, Seiko developed a kinetic watch powered by human movement. It dispensed the conventional batteries, being the human arm movement used instead. Since then, several kinetic watches were developed, but the potential of this system to power larger devices is limited by the slowness how people move and consequently reduced arm movement. According to [11], the American and British armies have tried to power up sensors placed in soldiers' boots. These devices allow radiotelephone operation, which is often equipped with heavy batteries. However, the energy harvesting devices were not sufficiently robust to withstand extreme conditions [12]. In the early 90's, Freeplay marketed devices such as radios, lamps and lanterns with handles to provide increased capacity of energy availability through the

incorporation of this type of energy harvesting systems. Since then it has developed generators with cranks to charge mobile phones, foot pumps capable of powering larger appliances and a series of prototypes of medical equipment with handles. The introduction of piezoelectric materials, as Polyvinylidene fluoride (PVDF), in shoes in order to recover some power from walking offers several advantages. Note that a piezoelectric plate is only 1.1 mm thick (without electrodes), having a reduced weight and high duration, thus promoting the flections needed for power generation by the natural deformation of the shoe during walking [13]. In order to regain power by the force exerted on the heel and toes, [14] integrated Piezo elements in the shoe's removable sole. Figure 2.2.4.1 shows this type of material and how it is designed to be placed in a shoe. Due to the limited efficiency of the electromechanical conversion, the average power produced is respectively 8.3 mW on heel and 1.3 mW on toes during a walk.

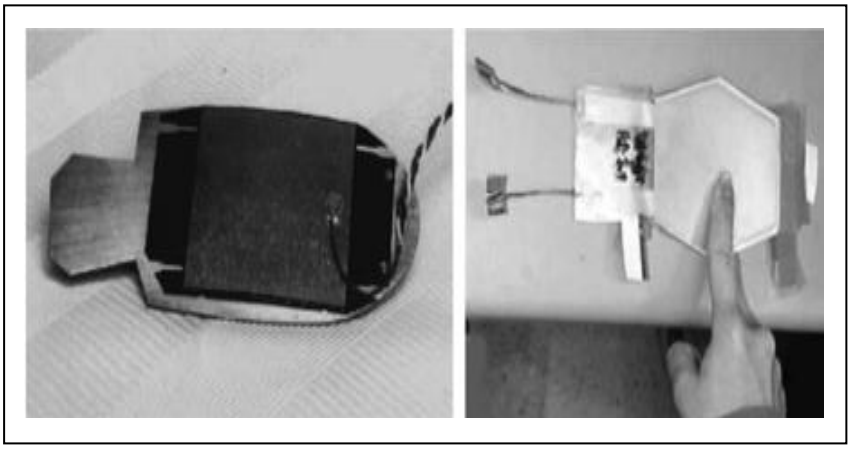

Figure 2.2.4.1. Piezoelectric Application [14]

2.3 COMPARISON WITH EXISTING SYSTEM

The existing system as discussed in background is that tunnels which has tunnel lights inside them are always on and electricity is continuously passed to them even when the train is not at inside the tunnel this leads to wastage of electricity and thus to overcome the system piezo electric energy harvesting would help. Also there is no system relevant to the prototype of the Piezo Electric Energy Harvesting to overcome the wastage of electricity of the tunnel lights. This system represents a prototype which would help for harvesting electrical energy by conversion of pressure to electricity and then passing that electricity to the tunnel lights.

2.4 CONCLUSION

Thus after reviewing the system we have understood the conceptual view of the domain also it is to be concluded that this energy harvesting technique is pollution free i.e. using this technique no radiations are emitted mean not harming the environmental beauty. Also this energy harvesting technique is less expensive than other alternative energy harvesting technique. Thus this domain can be used to implement the proposed prototype Also after research the domain can be further used for various other applications for energy harvesting.

CHAPTER 3

SYSTEM ANALYSIS AND DESIGN

3.1 INTRODUCTION

Your consultant's goal for the design phase is to develop a specification for a system that will meet your business needs and take into account time, resources, and cost. During this phase, your consultants assemble the information they gathered from you during the requirements capture phase. They identify what you need in a system, how you will use it, who will use it, what system you currently have in place, and how much of the current system you want to keep or change. The consultants will then design the system.

The output of the design phase is the system specification. The system specification is like a set of blueprints that the consultants follow when developing your system. And just as it is very difficult, inefficient, and costly to build a house without blueprints, it is very difficult, inefficient, and costly to build a software system without a system specification.

Concept design development essentially enables you to make sure your products are innovative, marketable, and importantly, how much they cost to manufacture. It also means you can asses whether you can actually manufacture them. In other words, it helps you and the business to decide whether or not you should invest the time, money and effort to fully develop the product in question.

With traditional parametric tools, exploring all the different design options can be a tedious task. As a result, these constraints mean that designers aren't able to explore all of the different concepts in full

The majority of the communication you may receive from your consultants during the design phase may be questions to verify aspects of your requirements capture. It is important to make sure the design is carefully created, as a flaw in design can lead to a flaw in coding, which in turn can lead to a flaw in the system.

3.2 ALGORITHM

- Step1: Start the train.
- Step 2: Running train on tracks puts pressure on the Piezo crystals which are under the track.
- Step 3: Piezo crystals will convert mechanical force or pressure into electrical energy.
- Step 4: Electrical energy which is produced by converting mechanical force will be stored in the capacitor.
- Step 5: If the train arrives at the tunnel point, sensors will sense the sensory information i.e. the arrival of train and will supply electricity to the LED's i.e. tunnel lights.
- Step 6: Once the train is passed out from the tunnel electrical supply for the LED's will be cut.

3.3 BLOCK DIAGRAM

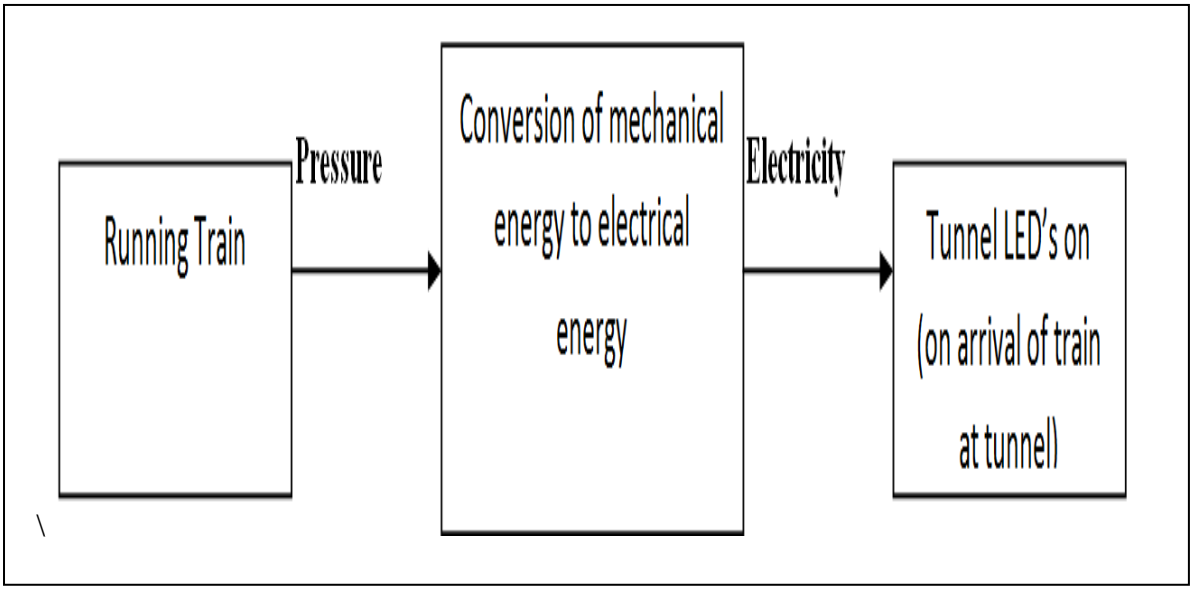

Figure 3.3.1. Block Diagram of System.

The above diagram represents the Block diagram of Piezo Electric Energy Harvesting technique. The diagram explains the working of running model of train on track which are embedded on piezo cells:

- The First block represents the running train which is running continuously on a track. Then this train produces the pressure on the piezo cells below the track.

- The second block represents the conversion of mechanical energy to electrical energy. The pressure on the piezo cells is stored in the capacitors and then this mechanical energy is then converted into electrical energy.

- This energy which is converted into electrical form is stored in capacitors produces electricity with help of which the LEDs glow.

- The third block represents the Tunnel LEDs (on the arrival of the train at tunnel).The electricity produced helps the LEDs inside the tunnel to glow and create light.

- As soon as the train arrives at the tunnel the LEDs glow due to which the train can smoothly run inside the tunnel.

- Thus the overall block diagram represents the conversion of mechanical energy into electrical energy with the help of piezo cells to create electricity.

3.4 FLOWCHART

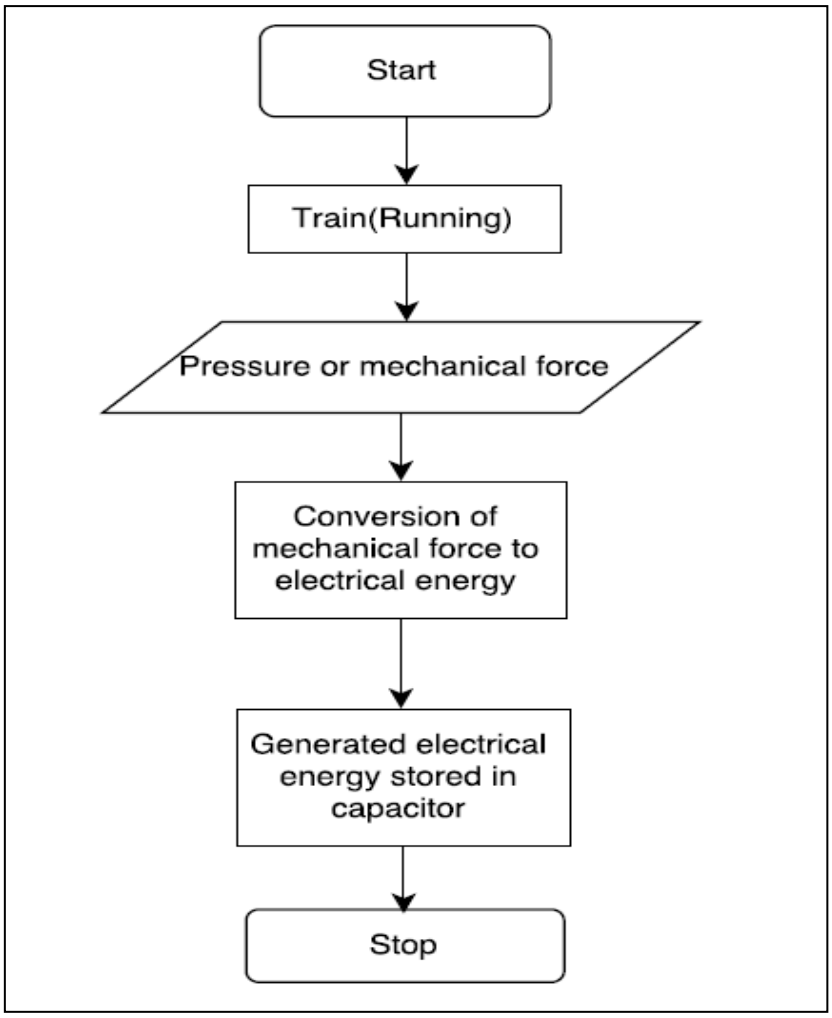

Figure 3.4.1. Conversion of Mechanical Force to Electrical Force

The above flowchart depicts the conversion of mechanical force into electrical energy:

- When the train passes through the Piezo cells present under the track of the tunnel it would release pressure on the piezo cells.
- As the pressure is released on the Piezo cells then it would convert that pressure or mechanical force into electrical energy using Piezo cells.
- Then this generated electrical energy is stored into the capacitor.

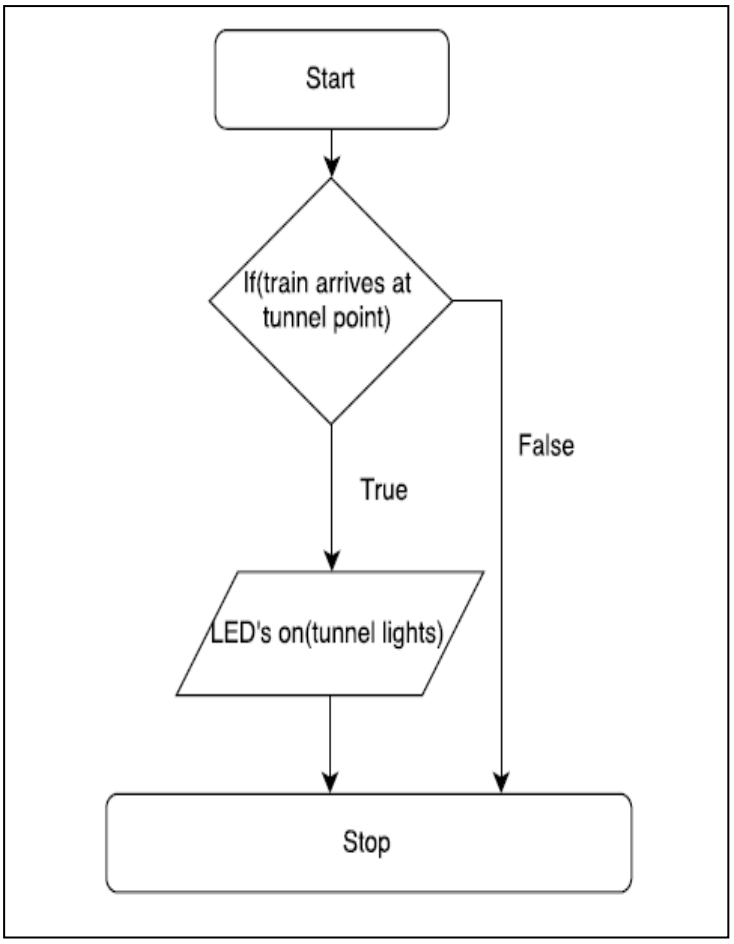

Figure 3.4.2. Sensing the Arrival of Train at Tunnel Point

The above flowchart depicts the sensing of arrival of train at the tunnel:

- While the train is running on the track which are embedded with Piezo cells, if the train arrives at the tunnel the LED's inside the tunnel would be ON.
- If the train does not arrives at the tunnel the LED's inside the tunnel would be OFF.

3.5 SEQUENCE DIAGRAM

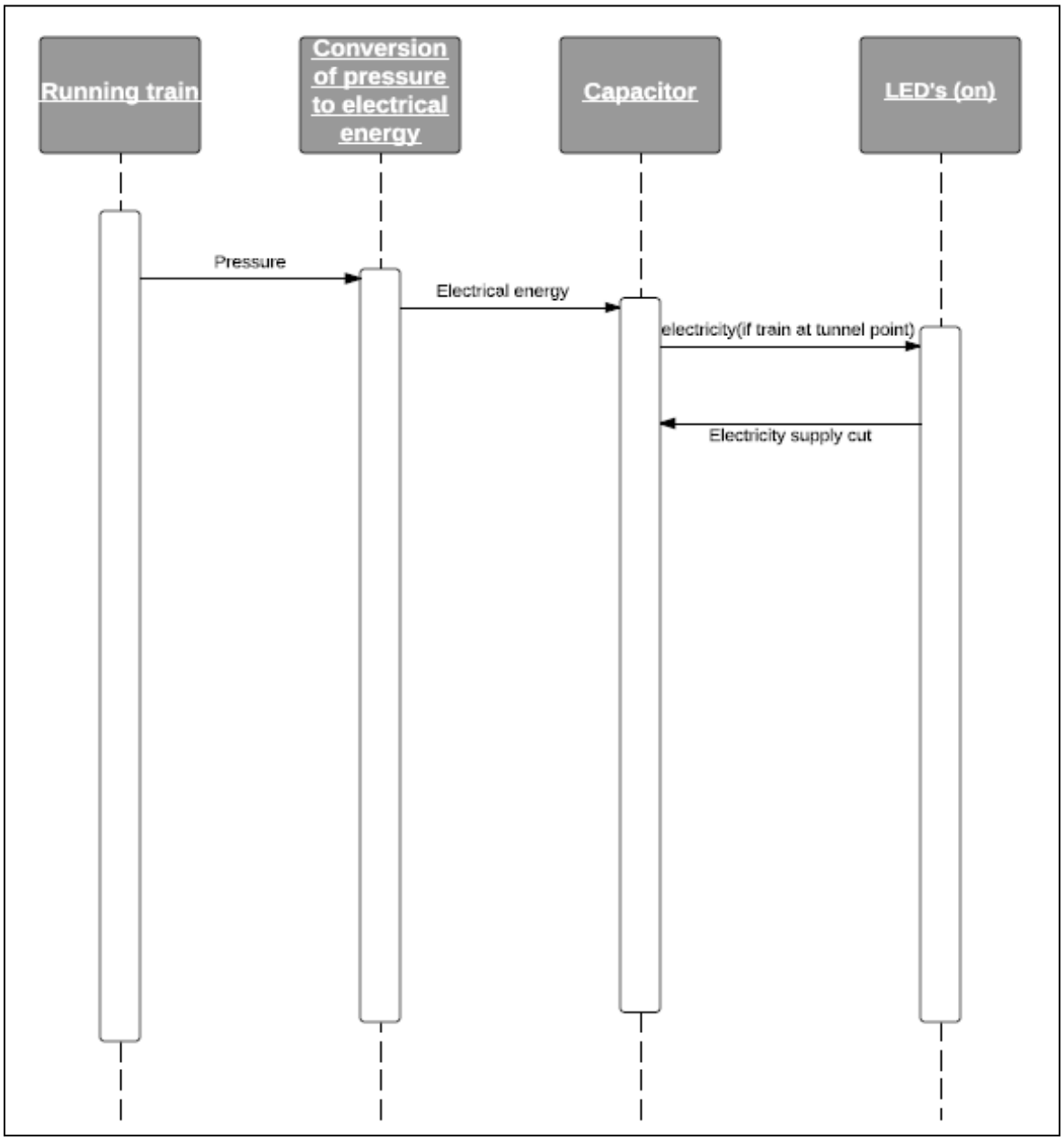

Figure 3.5.1. Sequence Diagram of the System

The above diagram depicts the Sequence Diagram of the system:

- The first block indicates the running train.
- The second block indicates the conversion of pressure to electrical energy.
- The third block indicates the Capacitor.
- And the fourth block indicates the LED's.

In the first block, it indicates that the train is running on the track which is under the tunnel. The pressure is created on the piezo cells due to train passes through it.

In the second block, due to the pressure on the piezo cells it converts that pressure into Electrical energy.

In the third block, the electrical energy which is generated is stored in the Capacitor. The capacitor is used to store energy in it and then it supplies that generated electrical energy to the LED's in the tunnel if the train arrives at the tunnel point. The sensing part would be done by the infrared proximity sensor.

In the fourth block, the electrical energy is supplied by the Capacitor to the LED's in the Tunnel. If the train passes through the tunnel, as it enters the tunnel LED's would be ON. And if the train does not enters the tunnel, the electricity supply would be not given by the capacitor to the LED's which are their in the tunnel.

3.6 USE CASE DIAGRAM

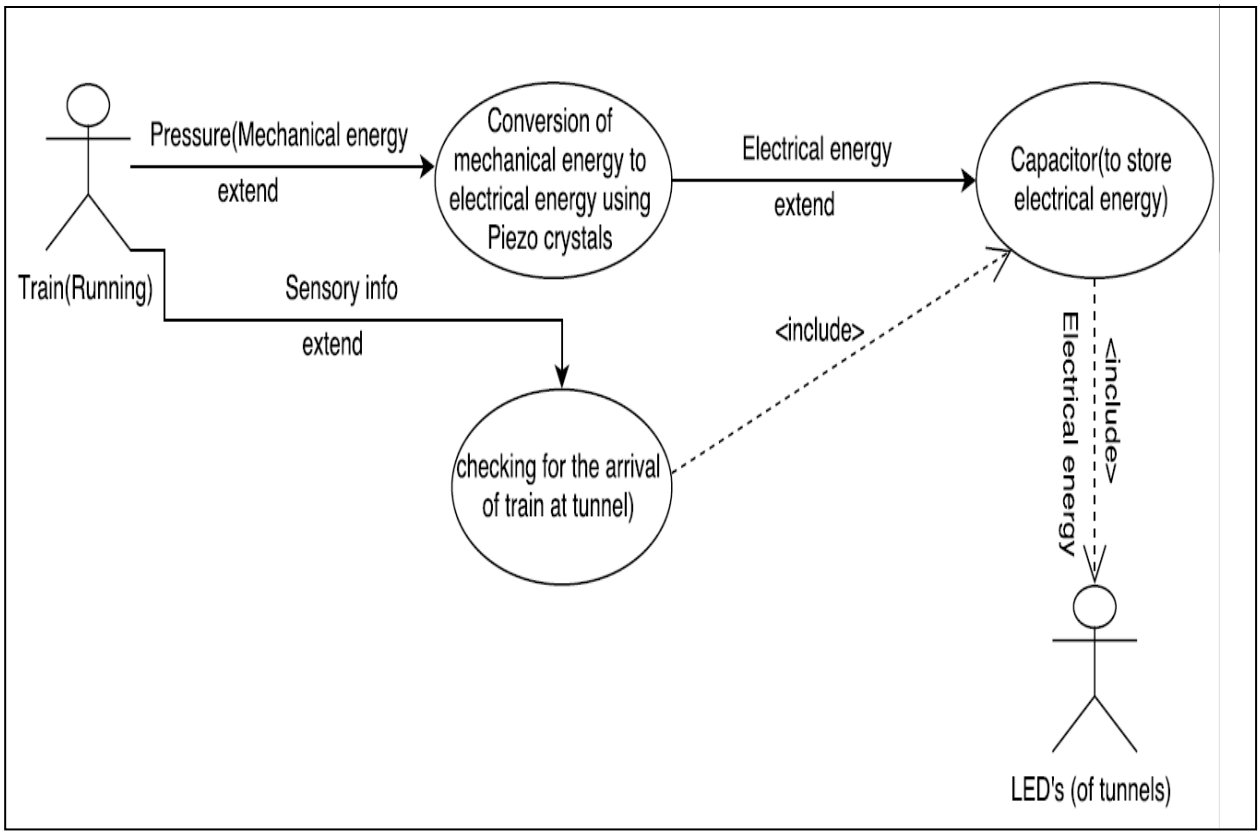

Figure 3.6.1. Use Case Diagram of the System

The Use Case Diagram of our project is shown in the above figure:

There are two actors in the system first is the train and second are the led's or the tunnel lights. The first actor i.e. the train which is running on the tracks put its heavy weight on the track. Such tracks have piezo cells underneath them for conversion of the weight or pressure of the train into electrical energy. Each time the train runs electricity will be produced. Such a generated electrical energy is stored in the capacitor for further usage of it. This is the first activity performed by the actor train its second activity is sensing the arrival of the train at the tunnel point so that if train is arrived at the tunnel point electrical energy which is stored in the capacitor would be passed on to the led's which is the second actor of the system.

3.7 DATA FLOW DIAGRAM

Data flow diagram (DFD) represents the flows of data between different processes in a business. It is a graphical technique that depicts information flow and the transforms that are applied as data move form input to output. It provides a simple, intuitive method for describing business processes without focusing on the details of computer systems. DFDs are attractive technique because they provide what users do rather than what computers do.

I. Level 0

Level 0 is basically the overall flow of data presented diagrammatically in short. The diagram below shows the level 0 of the system (i.e. Piezo electric energy harvesting). The data flow starts from the Running train which produces pressure where the pressure is converted to electrical energy which is further stored in capacitor. The stored electrical energy stored in capacitor is then supplied to the tunnel lights when the train arrives at the tunnel.

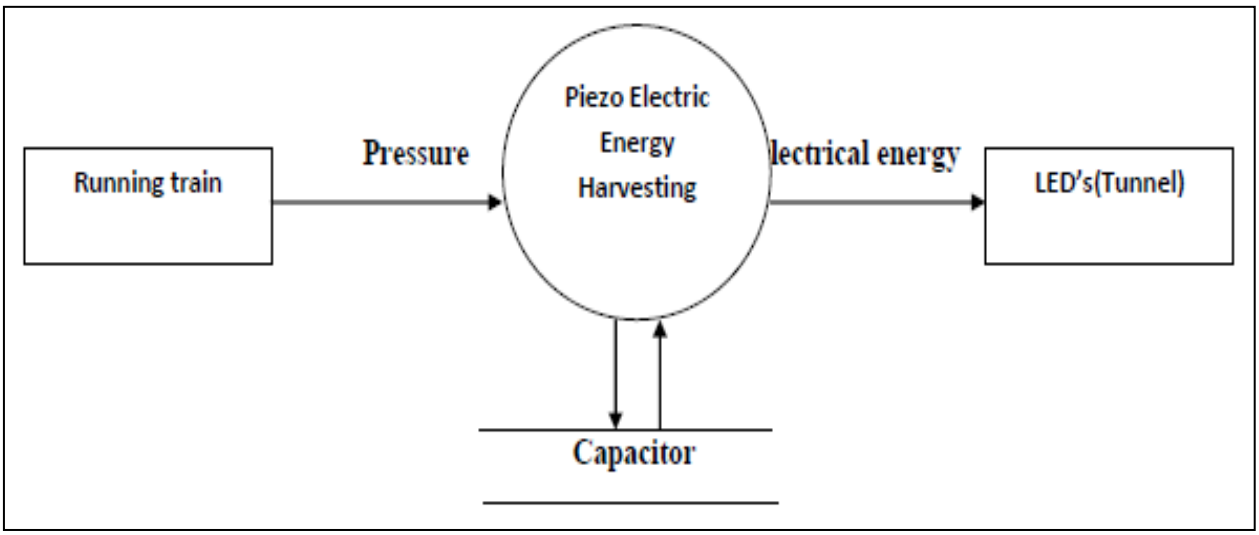

Figure 3.7.1. DFD Level 0

II. Level 1

In this level the data flow for the system module is presented or diagrammatically explained. In level 1 module, the pressure produced by the train running train on tracks in taken into the Piezo crystals which converts the mechanical force or energy into electrical energy. The generated electrical energy is the further passed on to capacitor which stores the energy for further use when needed.

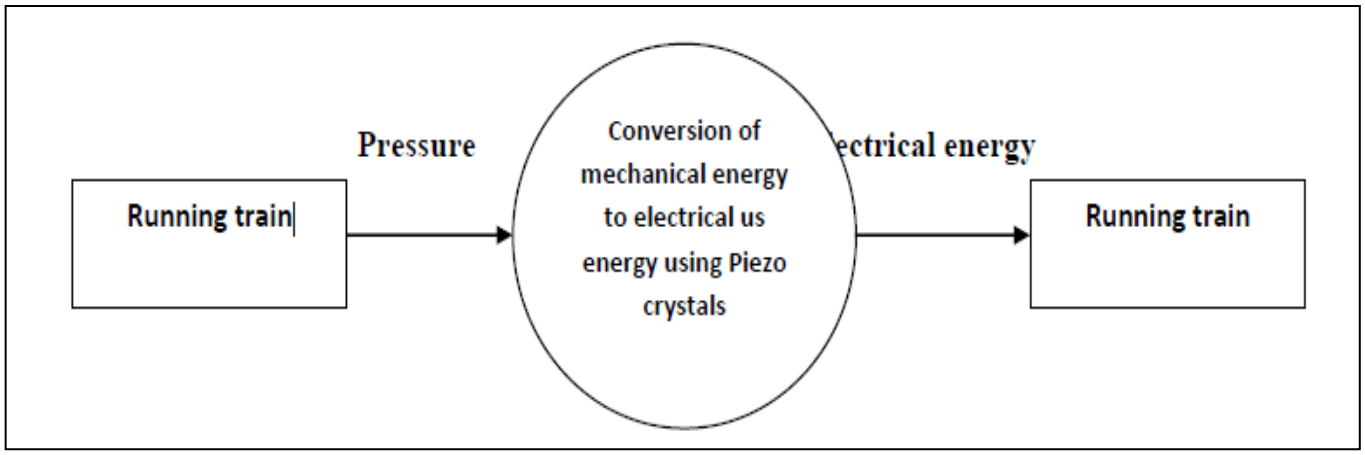

Figure 3.7.2. DFD Level 1

III. Level 2

The module in this level is the last module of the system which to sense the arrival of train at the tunnel point and if the train is arriving then the sensory information is send further to supply the electricity to the LED's i.e. Tunnel lights.

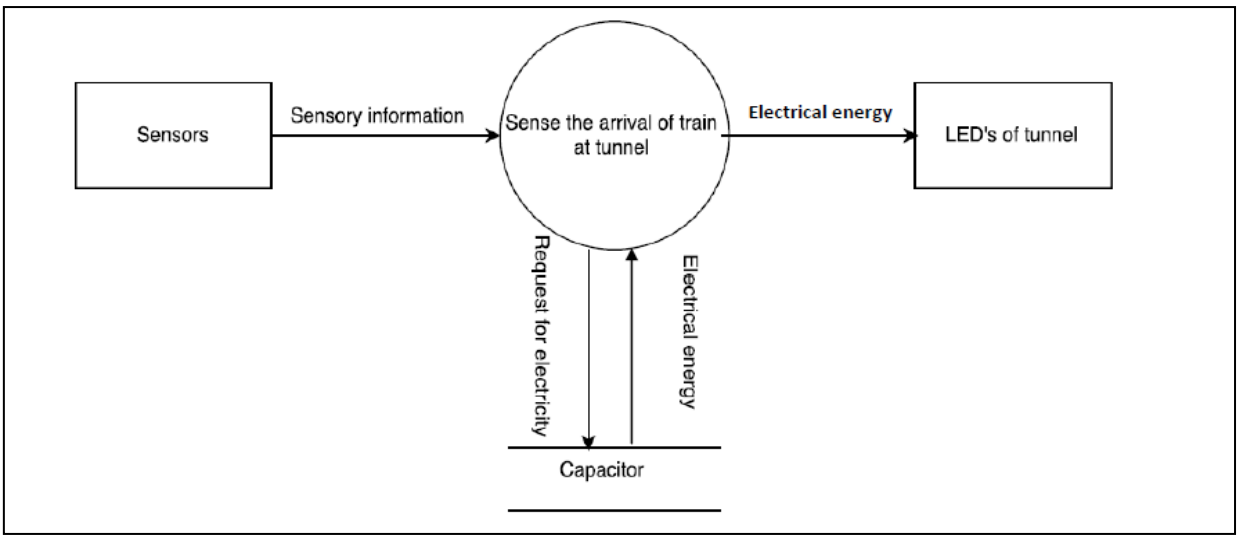

Figure 3.7.3. DFD Level 2

3.8 SYSTEM REQUIREMENT

3.8.1 HARDWARE REQUIREMENTS

- Wooden board
- Wires for connection
- Piezo cells
- Capacitor
- Toy train(including tracks for the train)
- LEDs
- Rechargeable batteries

3.9 CONCLUSION

The above components listed are the important components to be used for the implementation of the system.

CHAPTER 4

IMPLEMENTATION

4.1 INTRODUCTION

The aim of the system discussed in this system is to generate electrical energy from applied mechanical force or any physical force and then converting that force into electrical energy, which further can be stored and can be used for various electrical purposes. The Piezo cells will first be implemented under the track of toy train where the track of the toy train or entire system will be demonstrated on a wooden ply. The piezo cells will be connected to the capacitor via connecting wires; also a rechargeable battery will be connected to the piezo cells. LEDs will be placed beside the tracks which will be connected to the capacitor through a wire. As soon as the train starts working i.e. starts running on the track, pressure will be produced on the tracks; where the piezo cells under the track will be pressed due to the pressure of the train on it, the piezo cells will convert this pressure or force into electrical energy form which will be then supplied to the capacitor to store the electrical energy produced from the pressure of the running train. The electrical energy stored in the capacitor will be the supplied at appropriate voltages to the led's which will act as lights inside the tunnels. The stored electrical energy will only be supplied to the led's or tunnels only when the train arrives at the tunnel point. The arrival of the train at the tunnel point can be detected using sensors which will sense the sensory information or the arrival of the train and will allow the capacitor to supply the appropriate amount of electrical energy to the tunnels or the led's. Once the train is out of the tunnel the power supply will be cut and the led's will shut down or lights will be off. Thus using this technique energy harvesting can be successfully done without harming or polluting environment as compared to other energy harvesting methods.

- SYSTEM COMPONENT DESCRIPTION

Toy Train set:-

Figure 4.1.1. Toy Train Set

Piezo cells:-

The piezoelectric effect describes the relation between a mechanical stress or pressure and an electrical voltage in solids materials. These cells would be placed under the tracks in parallel combination.

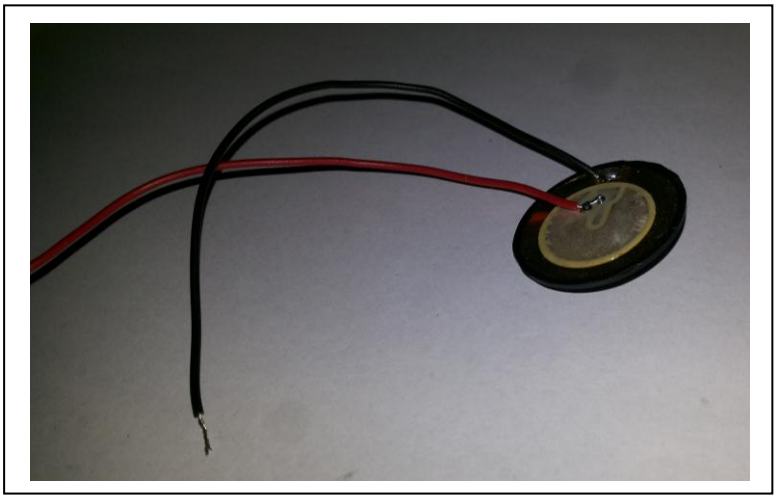

Figure 4.1.2. Piezo Cells

Zener diode:-

A Zener diode is a diode which allows current to flow in the forward direction in the same manner as an ideal diode, but also permits it to flow in the reverse direction when the voltage is above a certain value known as the breakdown voltage. Here the use of the zener diode is use to control the excessive current passed from the battery and cop it into 5V to supply it to the sensor of 5V.

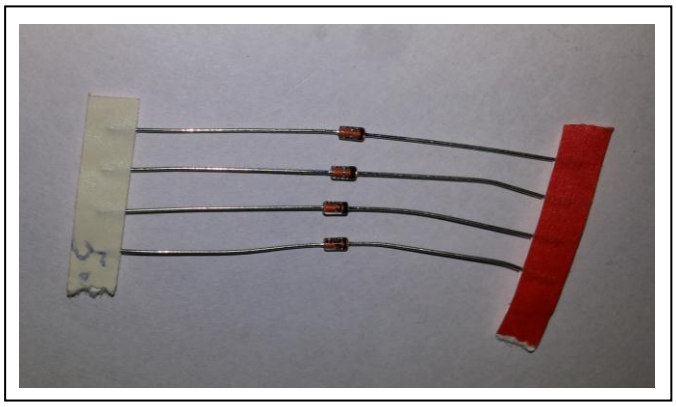

Figure 4.1.3. Zener Diode

Relay:-

Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The use of relay in this system is to take the sensory information from the sensor and control the current flow when needed.

Figure 4.1.4. Relay

Infrared Proximity Sensor:-

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The

object being sensed is often referred to as the proximity sensor's target. This infrared sensor will be used in this system for detection of arrival of the train at tunnel point.

This sensor will be placed at the tunnel end and not at the tunnel starting point considering the direction of running train. Distance for the arrival of train will be managed in the sensor as per the requirement.

Figure 4.1.5. Infrared Proximity Sensor

Capacitor:-

An electric circuit element used to store charge temporarily, consisting ingeneral of two metal lic plates separated and insulated from each other by a dielectric also called condenser. This is used to store the generated electrical energy for further usage of the electrical energy.

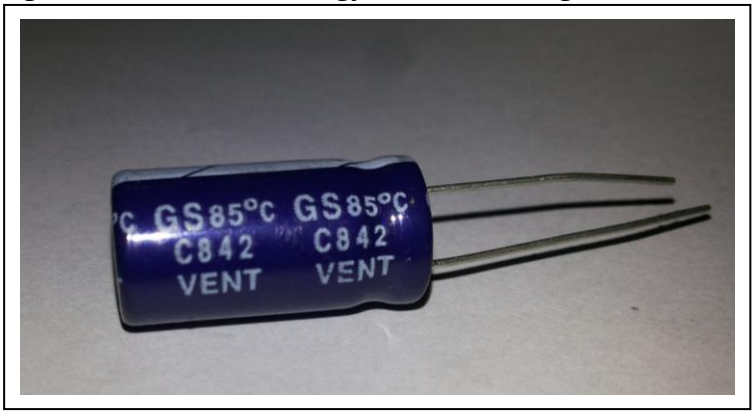

Figure 4.1.6.Capacitor

Resistor:-

A resistor is an electrical component that limits or regulates the flow of electrical current in an electronic circuit.

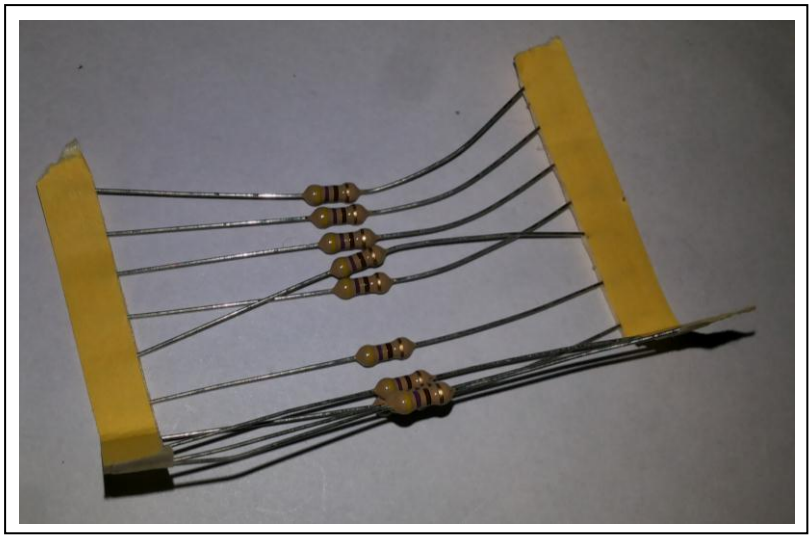

Figure 4.1.7. Resistor

- CIRCUIT DIAGRAM

The above diagram descibes the circuit diagram of the system. As shown in the above diagram Piezo cells are connected in series, where the postive and negative terminal of the Piezo cells are connected to the positive and negative terminal of the capacitor respectively. The positive and the negative terminal of the capacitor is further connected to the positive and negative end of the rechargeable battery. Zener diode is connected to the positive terminal of the recharageable battery. Positive terminal of the sensor is connected to the zener diode so as to control the current. Negative terminal of the sensor is connected to the ground and output of the senor is connected to the positive end of the relay coil and negative end of the relay s connected to the ground. The other three pins of the relay coil i.e NO, NC & COMM are connected as follows: NO and NC are connected to the positive end i.e. connected to the resistors which are connected in series; COMM terminal of the relay is connected to the zener diode for power supply purpose.Each led is connected to individual resistor and there led's are connected in parallel to each other. The negative end of the led's is connected to the negative terminal of the rechargeable battery.

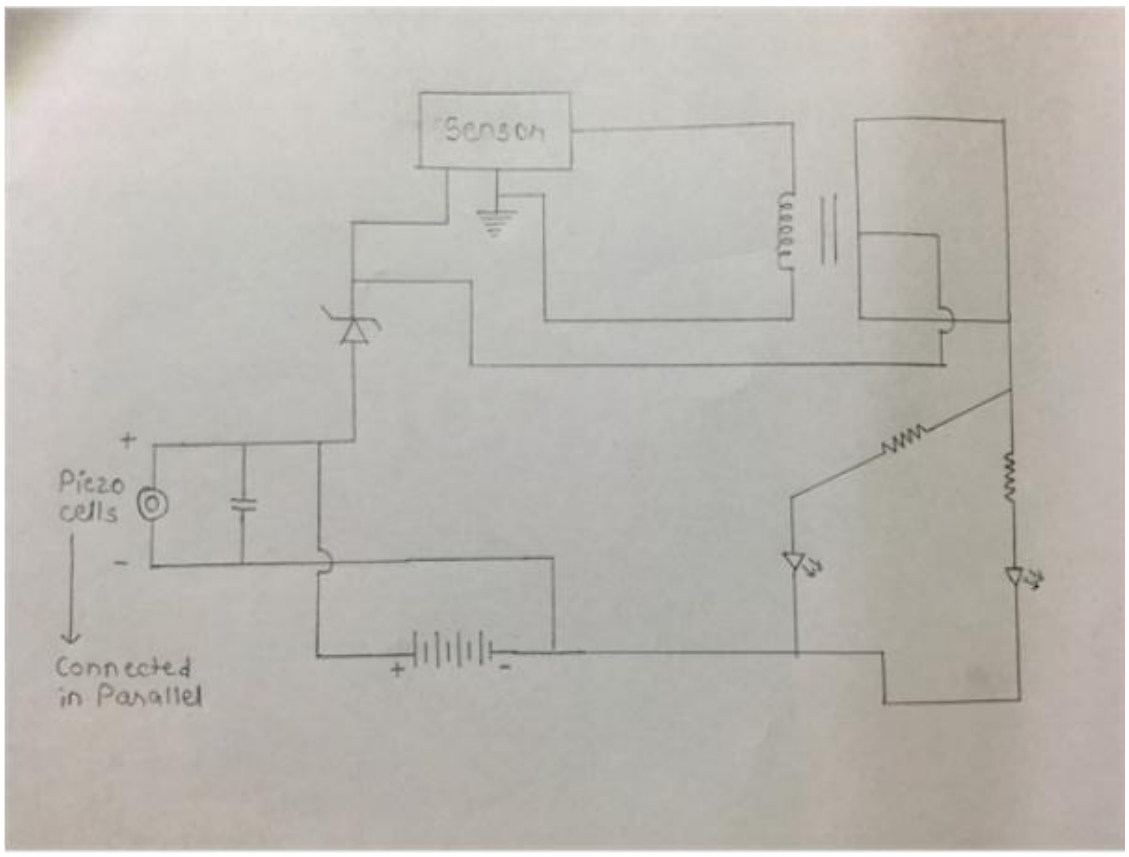

Figure 4.1.8. Circuit Diagram of the System

4.2 MODULE DESCRIPTION

4.2.1 NO.OF MODELS WITH EXPLANATION

The overall modules of the system are two modules. Following are the listed and described below**:**

- Conversion of mechanical energy to electrical energy using Piezo crystals

This module is design for the conversion of mechanical force/energy or pressure to electrical energy. The pressure generated by train on tracks is taken onto Piezo crystals which are placed under the tracks. These Piezo crystals then convert the mechanical energy to electrical energy. This electrical energy is then stored in the capacitor for its further use when needed.

- Sensing the arrival of train at tunnel point

This module is design for sensing the arrival of train at the tunnel point so that if the train is going to arrive at the tunnel then the capacitor which is storing the electrical energy will supply the electricity for the tunnel lights i.e. LED’s.

4.3 MODULE DESIGN

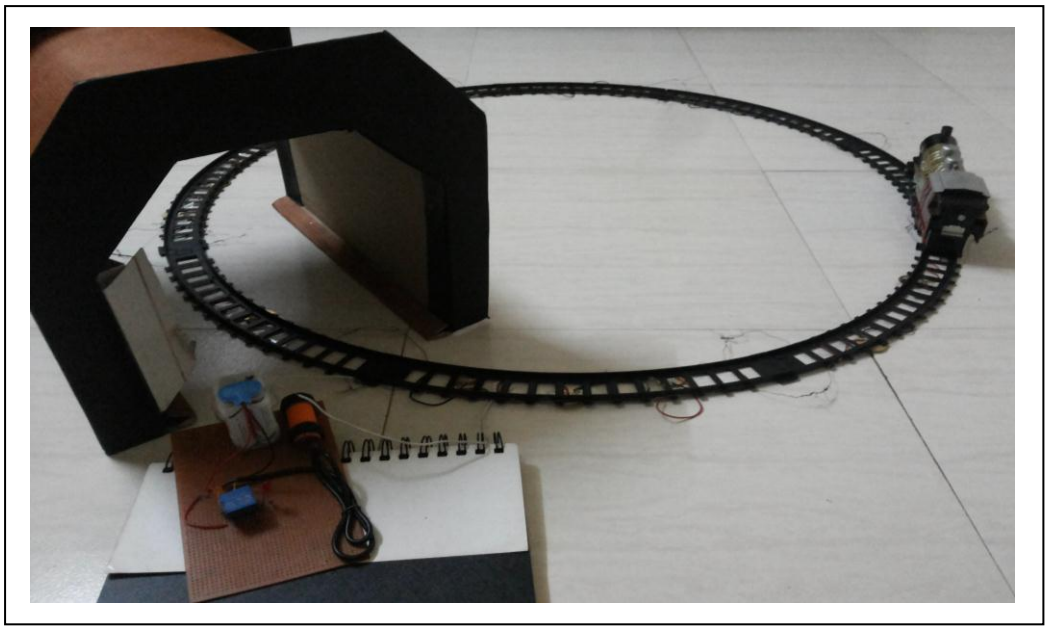

Figure 4.3.1 Train Running on the Track

The above diagram depics the train running on te tracks. Also we can see Piezo cells placed undernenath the tracks parallel combination.

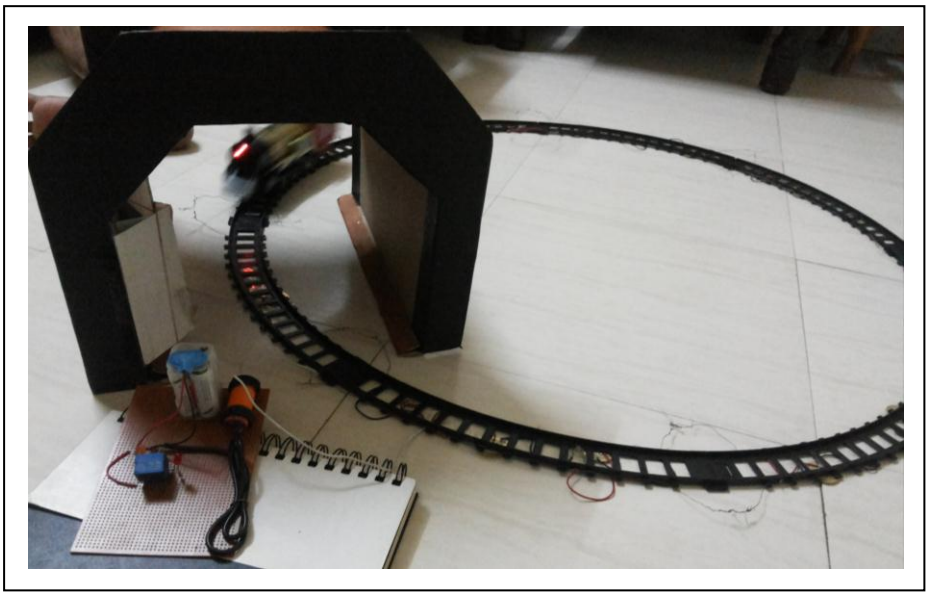

Figure 4.3.2. Train Arrival at Tunnel Point

The above figure descibes that the train in about to arrive at tunnel point. Also it shows that as the train is not yet at tunnel point led/s or the tunnel lights are off.

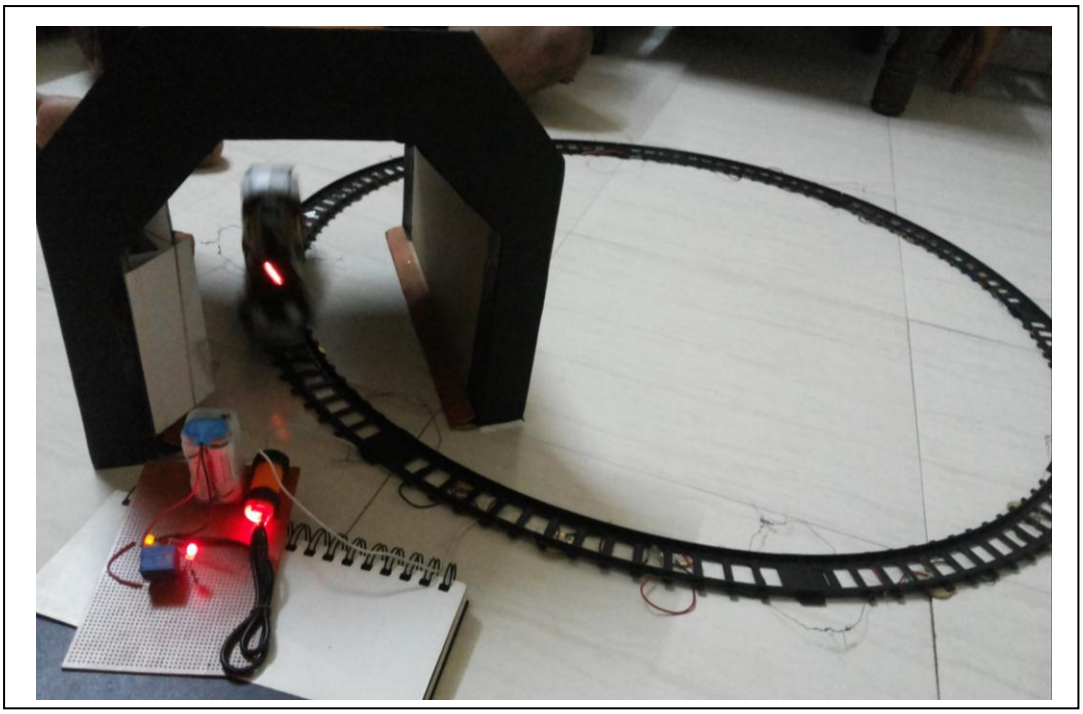

Figure 4.3.3. Train Entering Inside the Tunnel

The above figure depicts that the train is entering inside the tunnel and led's or the tunnel lights are on.

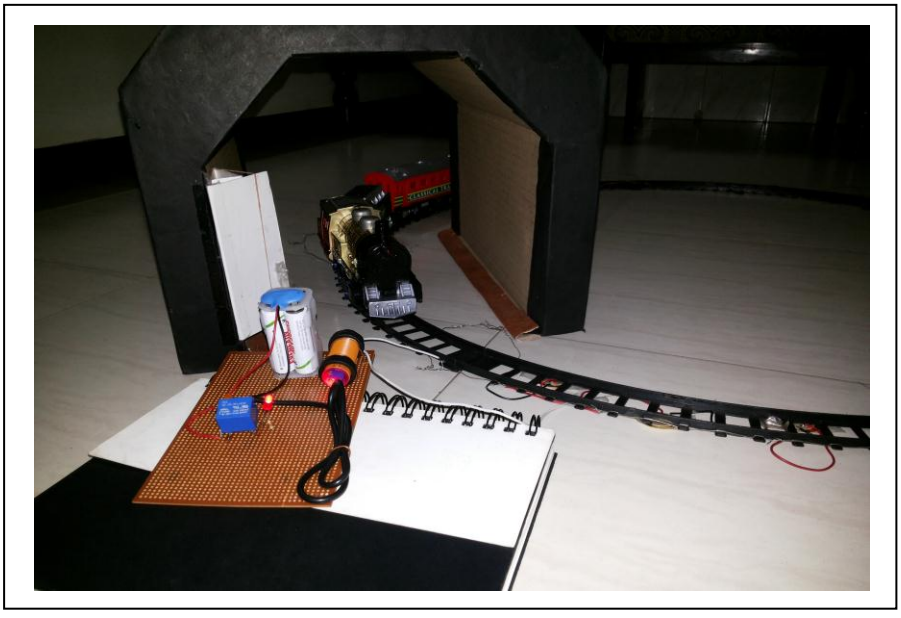

Figure 4.3.4. Train Inside the Tunnel

The above figure depicts that the train is inside the tunnel and the lights of the tunnel i.e led's are on.

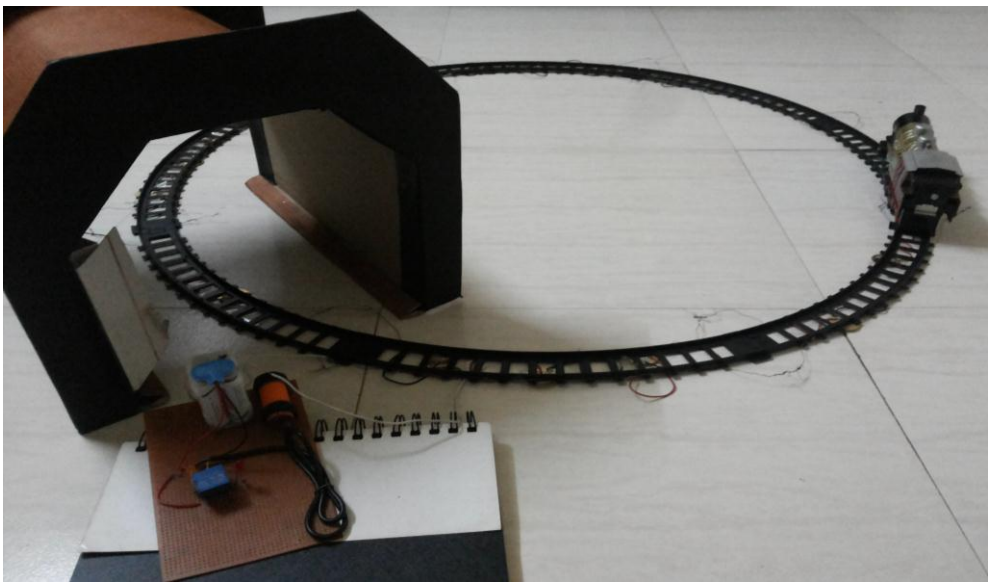

Figure 4.3.5. Train Outside the Tunnel

The above figure depicts that after entering the train the leds's were on but once its outside the tunnel the led's are turned off again.

4.4 CONCLUSION

Considering all the points discussed in the previous chapter we finnally acomplished the implementation of the system. This chapter described all the imlemenatation process of the system thus accomplishing it in working model as shown above in the module design.

CHAPTER 5

FUTURE SCOPE

5.1 FUTURE SCOPE

The proposed work portrays the concept of Piezoelectric Energy Harvesting and the results obtained after the implementation are very encouraging. Future work of the proposed idea encompasses further amplification of the piezo cells output to a greater extent. Future lies in the inclusion of advanced material used to design the piezoelectric cell which further amplifies the cells output in terms of voltage as well as current. A study could be carried out from the variety of piezoelectric cells and after comparing the results, the choice of the optimum material for the best performing cells could be devised.

5.2 CONCLUSION

The method used to perform power harvesting is to use materials that can convert the mechanical energy into electrical energy. This electrical energy can then be used to store in the capacitors. This technology has gained an increasing attention due to the recent advances in wireless technology, allowing sensors to be placed in remote locations and operate at very low power. Through this paper, we have proposed two new ways of harnessing the piezoelectric energy. Implementation aspects focuses on the practical work carried out in this field of Piezoelectric Energy Harvesting. The idea of piezoelectric technique will solve the problem of continuous and unwanted flow of electricity inside the tunnels. So due to this technique the lights inside the tunnel will glow only when the train arrives at the tunnel and electricity will be saved. So this idea can greatly help in harnessing the piezoelectric energy.

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LIST OF FIGURES

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