DESIGN AND CONSTRUCTION OF

FOOTSTEP POWER GENERATION WITH AUTO LIGHT CONTROL SYSTEM

A thesis report submitted to the department of mechanical engineering for the partial fulfillment of the degree of Bachelor of Science in Mechanical Engineering.

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APPROVAL

This is to certify that this project entitled "**FOOTSTEP POWER GENERATION WITH AUTO LIGHT CONTROL SYSTEM**" is done by the following students under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Mechanical Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Mechanical Engineering.

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Declaration

We, hereby, declare that the work presented in this project is the outcome of the investigation and research work performed by us under the supervision of Md. Minhaz Uddin, Asst. Professor, Department of Mechanical Engineering, Sonargaon University (SU). We also declare that no part of this project and thesis has been or is being submitted elsewhere for the award of any degree.

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ABSTRACT

The Footstep Power Generation, here we proposed an advanced footstep power generation system that uses the piezoelectric sensors to generate power through footsteps as a source of renewable energy that we can obtain while walking on a certain arrangement like stepping foot on a piezo tiles. This project describes the use of piezoelectric materials in order to harvest energy from people walking vibration for generating and accumulating the energy. The basic working principle of "**Footstep power generation with auto light control system**" is based on piezoelectric sensors. When the flooring is engineered with piezoelectric technology, the electrical energy produced by the pressure is captured by floor sensors and converted to an electrical charge by piezo-electric plate. These sensors are placed in such a way that it generates maximum output voltage. This output is provided to our monitoring circuitry which is microcontroller based circuit that allows us to monitor the voltage and charges a battery, and this power source has many applications. Our project model is cost effective and easy to implement.

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Chapter 1

Introduction

1.1 General:

In this paper the generation of electrical energy is described by using the weight energy. Person can amaze simply knowing that how much energy a person has by simply walking on the floor with normal speed. So the people usually have thousands steps in a day. While people walk they lose huge amount of energy that their weight energy of foot may be used and converted into electrical energy. The actual electro-kinetic floor is really an approach to make electrical energy by using kinetic energy of person who walks on the floor. The energy that is usually produced by the floor which can make the environment sound without any pollution such kind of energy will cost effective indeed the power floor does not need any fuel or any type of energy source only by using the kinetic energy which based on the person weight who moves on the floor. In case of our project we have used a technique of generating power through foot step which is the source of renewable energy that is obtained by walking on footpaths, stairs, platforms and such a system is installed mainly in populated areas. The basic principle of 'Footstep power generation' is based on piezoelectric sensor in order to employ this system we will adjust wooden plates above and below the piezoelectric sensor and moving springs when person will walk on that mat the force will be applied in the result magnet will be fixed under the top wooden sheet and moves into the cavity. While this cavity is fixed at the bottom wooden sheet of mat. A tile made up of piezo material generates voltage across a piezo tile which is supplied to a bridge rectifier circuit to obtained DC voltage and given to a rechargeable battery and thus the battery gets charged and this can be used to drive DC loads. The power supply unit is used to supply power to microcontroller and LCD.

1.2 Objectives :

The objectives of this thesis are …

- To study the existing system for advanced piezoelectric footsteps power generation system.
- To produce renewable electricity from footstep using piezoelectric disk placed along a pathway.
- To reduce the cost for power generation besides increasing the efficiency of power generation.

Chapter 02

Literature Review

2.1 Introduction :

There are some methods to generate electrical energy from the footsteps. Such as Gear wheel and fly wheel are methods to generate electrical power. This method works on the principle and in it mechanical parts are used because this is placed where there are so many people and the energy is produced by their movements on the floor. Generation of power is done by footsteps from the crowed on floor and piezo plate scheme is used below the floor, then there will be sheet which cover the piezo plate and also spring will be there for vibrating force on piezo sensor. The piezo plate will be struck in the floor such a plates will generate power in the form of electric current. The power which is produced by footsteps can be used as additional features like street light or light which is used at the place of pedestrian's,so the pedestrians should give credit the energy which is produced by their movement.

2.2 History :

Earlier developments in the piezo electric circuitry involved concentration on small vibration and hence small strains. Also, few of them required external voltage supply and there were number of losses in the system which amounts to low voltage output. In December 1929, scientists in U.S Navy performed various researches on piezoelectric crystals. This research proved that by changing the dimension and orientation of crystal the output considerably changed. So, they act as a voltage controlling device too. In 1985, the concept of using handwriting dynamics for electronic identification was performed in Sandia Laboratories. A piezoelectric sensor pen for obtaining the pen point dynamics during writing was studied. Typical output waveforms obtained from the operation of the pen and showed the dissimilarities between dynamics of a genuine signature and an attempted forgery. So, this also shows high sensitivity of Piezo material towards marginal pressure change. In 2000, various applications of piezoelectric in wireless sensing was studied and experimented. Numerous industrial and military applications require remote sensing of various machine and equipment operating parameters in locations where traditional power sources may not be available and long periods of unattended operation are required.

In 2005. United States Defense Advance Research Project Agency (DARPA) initiated an innovative project on Energy harvesting which attempts to power battlefield equipment by piezoelectric generators embedded in soldiers' boots. However, these energy harvesting sources put an impact on the body. DARPA's effort to harness 1-2 watts from continuous shoe impact while walking was abandoned due to the discomfort from the additional energy expended by a person wearing the shoes.

Chapter 03

Methodology

3.1 Process of Project:

- Creating an idea for Design and construction of footstep power generation system.
- And designing a block diagram & circuit diagram to know which components need to construct it.
- After arranging the electrical system in proper manner that will transfer mechanical energy into electrical energy.
- The spring is attached to piezo with the help of Sheet in this manner spring arrangement is done, spring is used to vibrate the piezo by force then power will be generated.
- After that voltage which is produced through the steps can be rectified and after battery charger circuit the DC voltage will be stored in the battery.

3.2 Block Diagram:

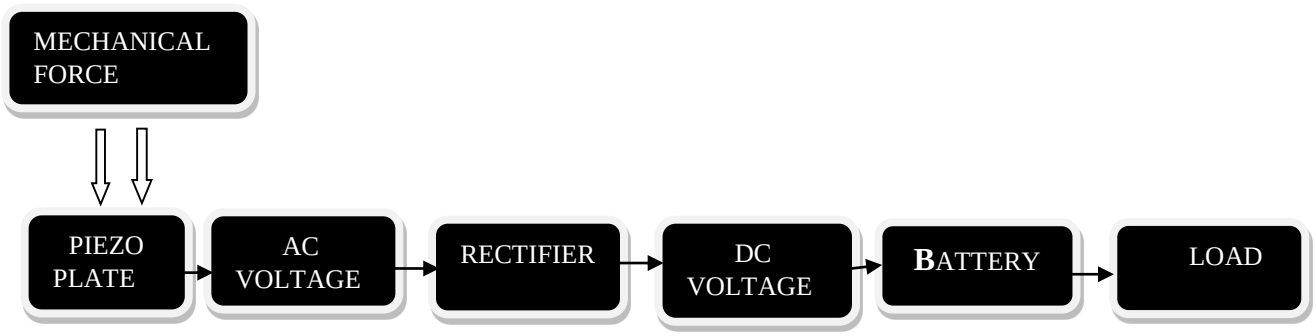

Figure 1 : Block diagram of the project

3.3 Circuit Diagram:

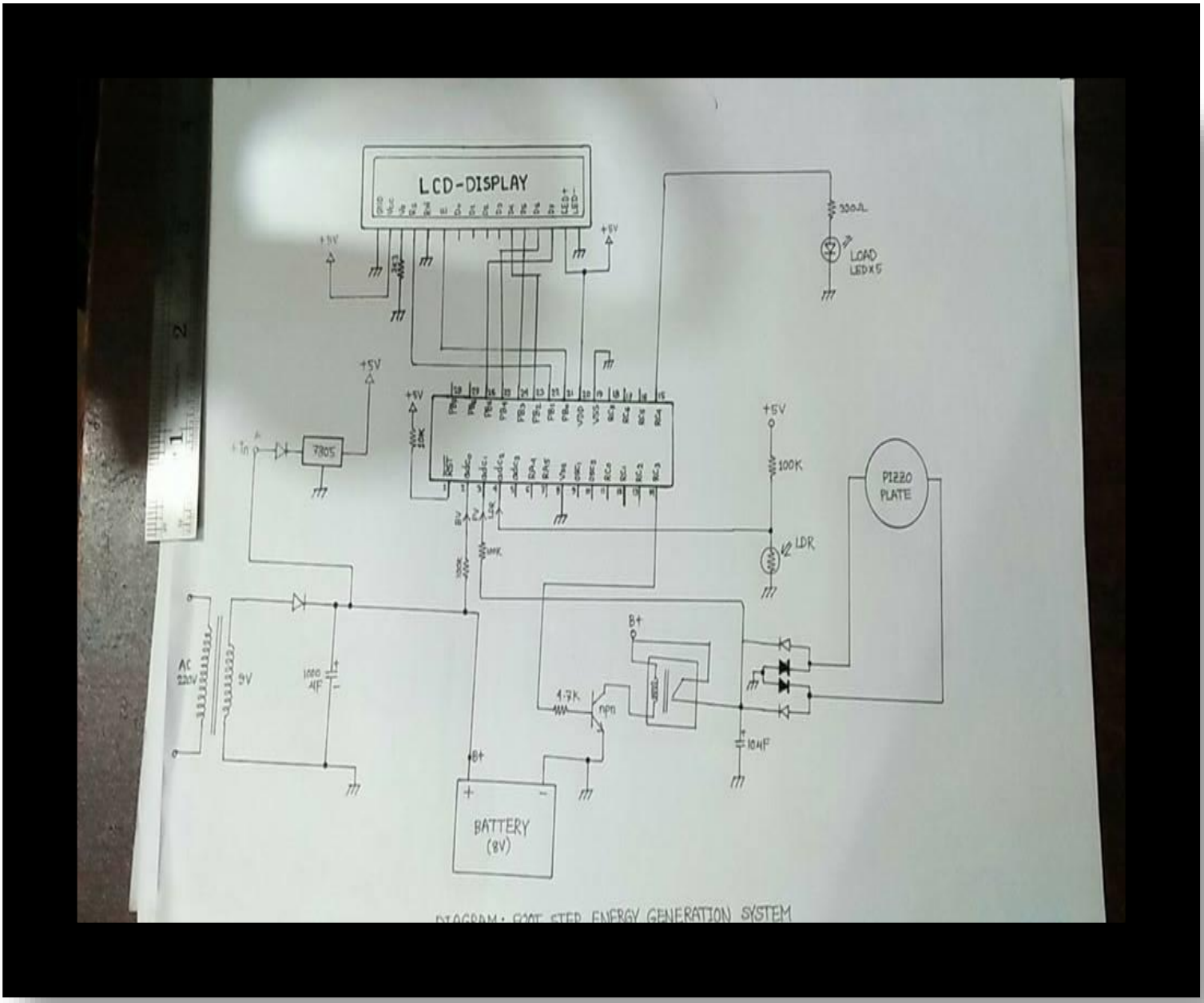

Figure 2 : Circuit diagram of the project

3.4 Working Principle:

Key concept of working of this system is capturing unused energy from surrounding any system and converting it into electrical energy. The piezoelectric placed under insulating material like hard rubber and pressure created by footstep, pressure will produce electrical energy which can be stored and used for domestic purpose. A constant output voltage irrespective of fluctuations will be maintained by a voltage regulator. Rectifier is used to convert AC into Dc. This regulated voltage is stored in the battery through charge controller unit and is fed to the microcontroller. The LCD which is interfaced with the microcontroller in turn displays the amount of charge stored to the battery.

3.5 Required Instruments :

01. Piezo electric sensor
02. Diode
03. Rectifier
04. Resistor
05. Transistor
06. Relay
07. SPST Switch
08. LDR sensor
09. Motion sensor
10. Vero board
11. LED
12. Battery
13. Voltage regulator

3.5.1 Piezo electric sensor :

Piezoelectric sensors are electronic components that are able to convert a mechanical or thermal input into an electrical signal. It works by the principle of electromechanical coupling.

Figure 3 : Piezo electric sensor

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Piezoelectricity is the phenomenon that some materials will produce an electrical voltage when subjected to mechanical stress and vice versa.

Piezoelectric sensors work on the principle of the piezoelectric effect. Piezoelectric originates from the Greek word piezein, which literally means to squeeze or press. As the latter suggests, we are squeezing quartz crystals to make an electric voltage. Hence, piezoelectric sensors work by applying mechanical energy to a crystal in the following steps:

1. A piezoelectric crystal is placed between two metal plates that are in a perfect balance (even if they're not symmetrically arranged) and does not conduct an electric current.
2. Metal plates apply Mechanical force or stress to the material. Electric charges forced within the crystal are out of balance. Excess negative and positive charges appear on opposite sides of the crystal face.
3. The metal plate collects these charges and produces a voltage that sends an electrical current through a circuit. This transforms to piezoelectricity.

It is important to understand the behavior of the piezoelectric crystals when determining the piezoelectric effect. Piezoelectric Sensors based on the piezoelectric effect can operate from transverse, longitudinal, or shear forces, and are insensitive to electric fields and electromagnetic radiation. The response is also very linear over wide temperature ranges, making it an ideal sensor for rugged environments.

A piezoelectric sensor is a device that uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical signal. Piezoelectric sensors have proven to be versatile tools for the measurement of various processes. They are used for quality assurance, process control and for research and development in many different industries it was only in the 1950s that the piezoelectric effect started to be used for industrial sensing applications. Since then, this measuring principle has been increasingly used and can be regarded as a mature technology with an outstanding inherent reliability. It has been successfully used in various applications, such as in medical, aerospace, nuclear instrumentation, and as a pressure sensor in the touch pads of mobile phones. In the automotive industry, piezoelectric elements are used to monitor combustion when developing internal combustion engines. The sensors are either directly mounted into additional holes into the cylinder head or the spark/glow plug is equipped with a built in miniature piezoelectric sensor. The rise of piezoelectric technology is directly related to a set of inherent advantages. The high modulus of elasticity of many piezoelectric materials is comparable to that of many metals and goes up to 10eó N/m Even though piezoelectric sensors are electromechanical systems that react to compression; the sensing elements show almost zero deflection. This is the reason why piezoelectric sensors are so rugged, have an extremely high natural frequency and an excellent linearity over a wide amplitude range. Additionally, piezoelectric technology is insensitive to electromagnetic fields and radiation, enabling measurements under harsh conditions. Some materials used (especially gallium phosphate or tourmaline) have an extreme stability even at high temperature, enabling sensors to have a working range of up to 1000°C. Tourmaline shows piezoelectricity in addition to the piezoelectric effect; this is the ability to generate an electrical signal when the temperature of the crystal changes. This effect is also common to piezo ceramic materials.

One disadvantage of piezoelectric sensors is that they cannot be used for truly static measurements. A static force will result in a fixed amount of charges on the piezoelectric material. While working with conventional readout electronics, imperfect insulating materials, and reduction in internal sensor resistance will result in a constant loss of electrons, and yield a decreasing signal.

3.5.2 Diode :

A diode is a device which only allows unidirectional flow of current if operated within a rated specified voltage level. A diode only blocks current in the reverse direction while the reverse voltage is within a limited range otherwise reverse barrier breaks and the voltage at which this breakdown occurs is called reverse breakdown voltage. The diode acts as a valve in the electronic and electrical circuit. A P-N junction is the simplest form of the diode which behaves as ideally short circuit when it is in forward based and behaves as ideally open circuit when it is in the reverse biased. Beside simple PN junction diodes, there are different types of diodes although the fundamental Page | 21 principles are more or less same. So a particular arrangement of diodes can convert AC to pulsating DC, and hence, it is sometimes also called as a rectifier.

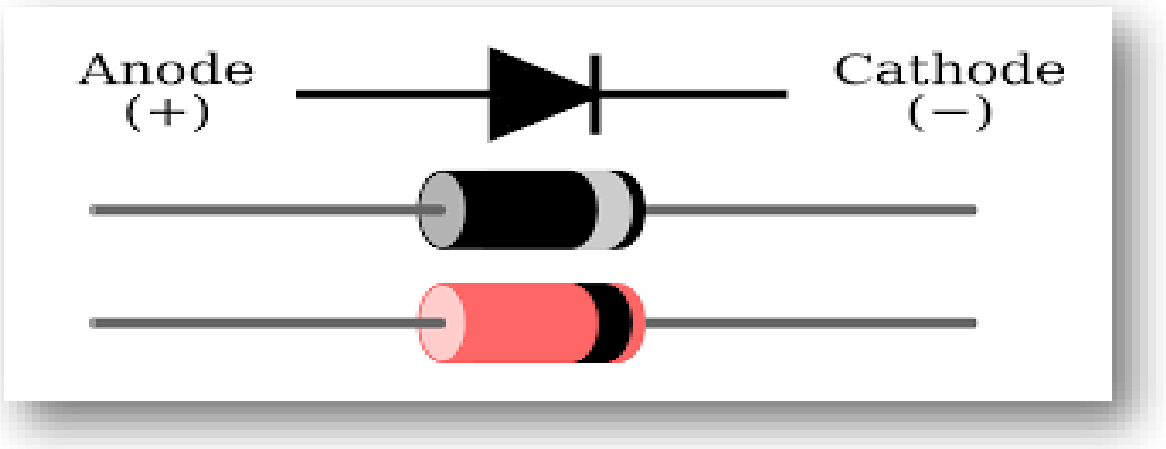

Figure 4: Typical diode

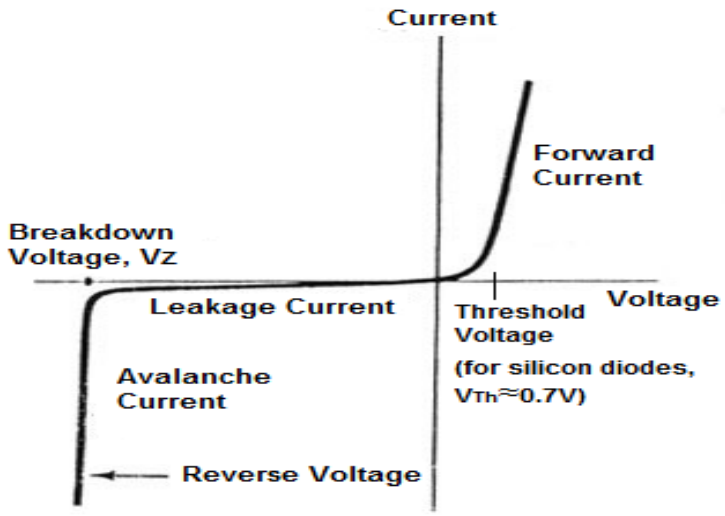

Figure 5 Characteristic curve of diode

3.5.3 Rectifier:

A rectifier is an electronic device that converts an alternating current into a direct current by using one or more P-N junction diodes. A diode behaves as a one-way valve that allows current to flow in a single direction. This process is known as rectification.

A rectifier can take the shape of several physical forms such as solid-state diodes, vacuum tube diodes, mercury-arc valves, silicon-controlled rectifiers, and various other silicon-based semiconductors switches.

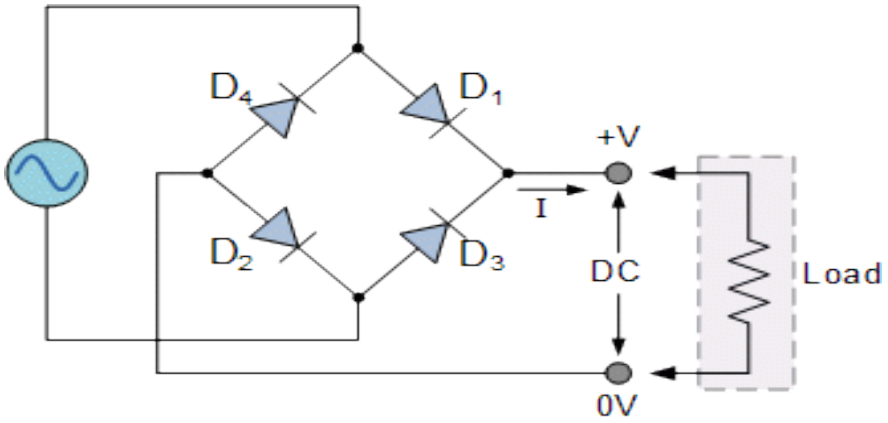

Figure 6 : Rectifier

3.5.4 Resistor:

A resistor's main job is to reduce current flow and lower voltage in a specific section of the circuit and it is dissipated as heat. In today's world of electronic circuits, the heat dissipation is typically a fraction of a watt. It's made up of copper wires that are wrapped around a ceramic rod and coated with insulating paint. Ohm's law states that if I is the current flowing through the resistor in amperes, and R is the resistance in ohms, then V is the voltage drop that is imposed by the resistor it is the electrical potential difference between the two contacts that are attached.

Figure 7: Resistor

3.5.5 Transistor:

A transistor is an electronic component that is used in circuits to either amplify or switch electrical signals or power, allowing it to be used in a wide array of electronic devices.

The basic idea behind a transistor is that it lets you control the flow of current through one channel by varying the intensity of a much smaller current that's flowing through a second channel. Semi-conducting materials make the working of transistor possible. Most of you must be familiar with electrically conductive and non-conductive materials. Metals are typically considered to be conductive. Things like plastics, wood, ceramics, and glass are insulators, or non-conductive. A team of scientists discovered how to test certain types of crystals and utilize them as electronic control devices by exploiting their semi-conductive properties.

Figure 8: Transistor

3.5.6 Relay :

A relay is an electronic control device, which has a control system (also called an input loop) and a controlled system (also called an output loop), and is usually used in automatic control circuits. It is actually an "automatic switch" that uses a smaller current to control a larger current. Relay plays the role of automatic adjustment, safety protection, and conversion circuit in the circuit.

Figure 9: Relay

3.5.7 SPST Switch :

An SPST switch embraces a basic "ON/OFF" control of a single circuit and consists of two terminals that serve as electrical connection points. Power the switch "ON" to establish a connection between the two terminals. Turn the switch to "OFF" to eliminate the terminals' connection terminal.

3.5.8 LDR sensor :

LDR is also referred to as a photo resistor, photocell, or photoconductor. It is a specific kind of resistor, and the amount of light that strikes its surface affects how much resistance it exhibits. A light-dependent resistor or LDR is an example of an electrical component that responds to light. When light beams strike it, the resistance changes right away. An LDR's resistance levels can vary by several orders of magnitude. As the light level rises, the resistance value will decrease. LDR resistance values range from many mega ohms in complete darkness to only a few hundred ohms in strong light. As a result, these resistors are widely used in a variety of applications due to this variation in resistance. The wavelength of the incident light affects the LDR sensitivity as well.

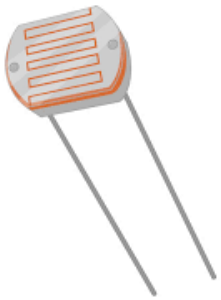

Figure 10: LDR sensor

3.5.9 Motion sensor :

A motion sensor is a device that recognizes and detects the movement of objects in its surroundings, such as humans, animals, or solid objects. They are commonly used in security, lighting control, and automation systems to trigger a response when motion is detected. Motion sensors are available in different technologies and are designed to work differently. All motion sensors have a two-phase mechanism: motion detection and reaction. They detect movements within a defined area and trigger predetermined reactions, such as switching on lights or blasting an alarm.

Figure 11: Motion sensor

3.5.10 Vero board :

Vero board is a brand of strip board, a pre-formed circuit board material of copper strips on an insulating bonded paper board which was originated and developed in the early 1960s by the Electronics Department of Vero Precision Engineering Ltd (VPE). It was introduced as a general-purpose material for use in constructing electronic circuits - differing from purpose-designed printed circuit boards (PCB) in that a variety of electronic circuits may be constructed using a standard wiring board. The original and best strip board available invented by Vero and resulting in a range of prototyping boards with copper tracks and punched component holes in Eurocard and Non Eurocard sizes. Products are available with single or double sided copper and as bare boards without copper.

3.5.11 Battery :

A battery is a device that stores energy and then discharges it by converting chemical energy into electricity. Typical batteries most often produce electricity by chemical means through the use of one or more electrochemical cells. Many different materials can and have been used in batteries, but the common battery types are alkaline, lithium-ion, lithium-polymer, and nickel-metal hydride. Batteries can be connected to each other in a series circuit or a parallel circuit.

3.5.12 Voltage regulator :

A voltage regulator is a system designed to automatically maintain a constant voltage. A voltage regulator may use a simple feed-forward design or may include negative feedback.

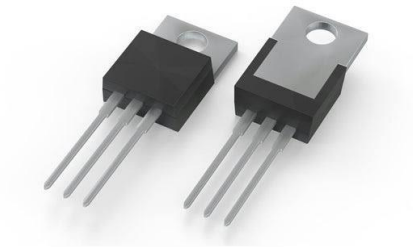

Figure 12: Voltage regulator

It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.

3.5.13 Light-Emitting Diode (LED) :

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for other lighting. Appearing as practical electronic components in 1962 early LEDs emitted low- intensity red light, but modern versions are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness. When a light-emitting diode is forward- biased (switched on), electrons are able to recombine with electron holes within the device, releasing energy in the form of photons.

Chapter 4

Calculation

As we know the pressure is directly proportional to amount of power generated

P α Wt ..... (i)

Wt -weight,

P - power .

We know that for wt=10kg, we get the value of voltage V=3v and I = 0.5(µA)

Then P=V*I=3*0.5= 1.5 µwatt, means we can say that for 10kg we get

power (P) = 1.5 µwatt

we also know that V= gtP

Here, V=output voltage, g= voltage sensitivity, t= thickness of plate, P= pressure

The table given below shows relation between P & wt

Sl NO	Weight (kg)	Voltage (volt)	Current (µA)	Power (µwatt)
01	20	6	1	6
02	40	11	5	55
03	60	15	8	120
04	80	17	11	187
05	100	19	12	228
06	120	20	14	280

Chapter 5

Result and Discussion

4.1 Result :

Finally, we were able to create our project successfully. After connecting all components and setting properly we are able to run our project. We have successfully developed a working model to produce power by applying pressure imitating walking situations, this can also be done by physically walking on the setup of piezoelectric sensors. This model effectively demonstrates the use of power which was previously neglected, the developed model is extremely simple and highly useful. Here is the photo of our dream project

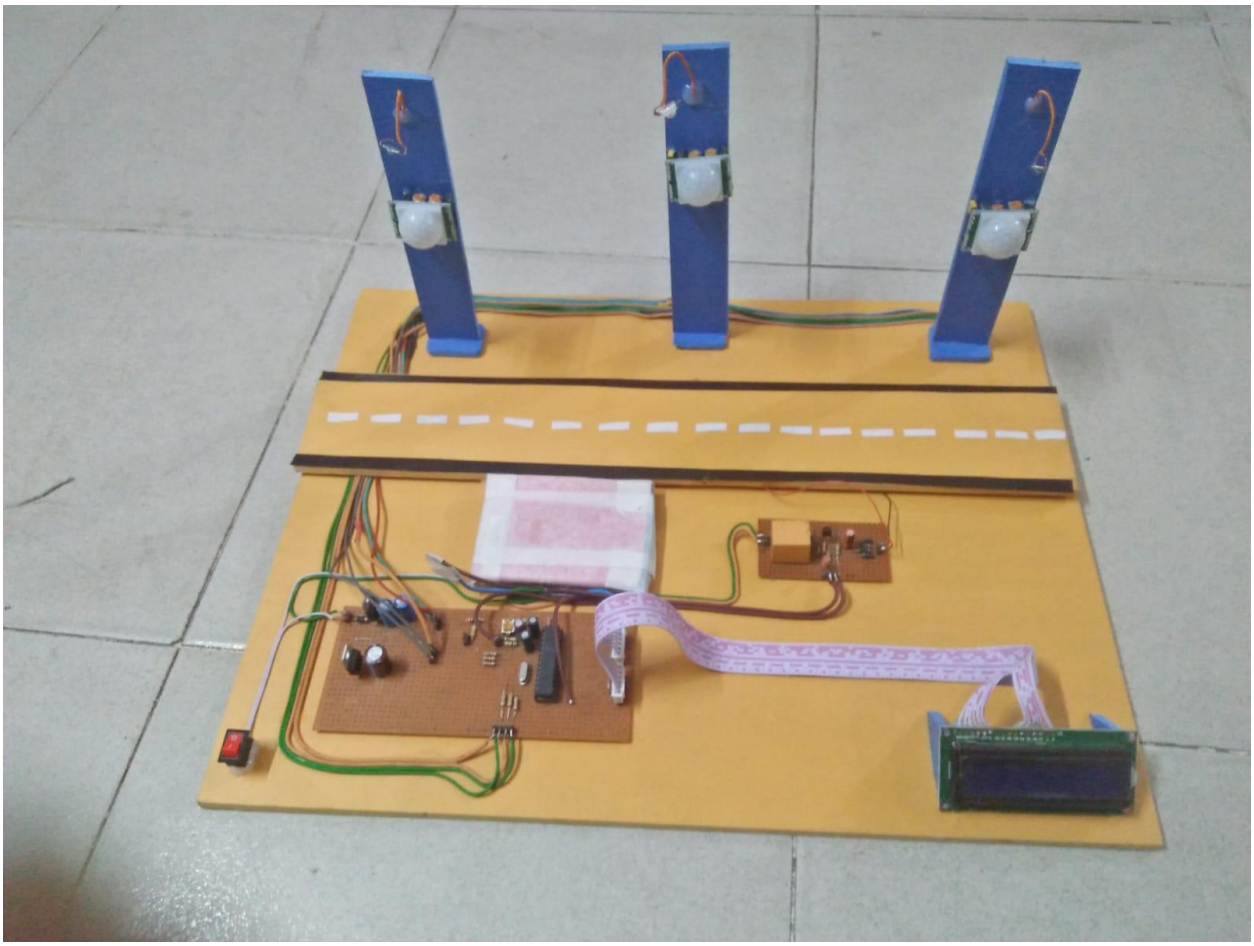

Figure 13: Project photo

4.2 Discussion :

The piezoelectric sensor came into existence because humans tend to exhaust and waste energy especially from locomotion which can be effectively utilized. Electricity can be generated from resources like water, wind etc. To generate the electricity from these resources development of which requires big plants having high maintenance cost. Moreover, considering the overemphasized need for power due to the increase in population, unstable power supply and sometimes scarcity in fuel supply. With innovation like this, power could be generated easily allowing continuity in human services, which requires minimal maintenance cost and also help develop the country. It can be used for charging an electronic device battery for emergency purpose where there is no direct source of electricity. This was the problems that lead to the development of the idea of a piezoelectric sensor. To make the generation of power more clean and usable for production.

Future scope

Man has needed and used energy at an increasing rate for his sustenance and well being ever since he came on the earth a few million years ago. Due to this a lot of energy resources have been exhausted and wasted. Proposal for the utilization of waste energy of foot power with human locomotion is very much relevant and important for highly populated countries.

For Bangladesh :

The future scope of footstep power generation systems using piezoelectric sensors in Bangladesh is promising. Here are a few reasons why:

Energy Demand: Bangladesh is a developing country with a growing population and increasing energy demand. Implementing innovative and sustainable energy solutions such as footstep power generation can help meet the rising energy needs in a cost-effective manner.

Urbanization and Population Density: Major cities in Bangladesh, such as Dhaka, experience high population density and heavy foot traffic. This creates an ideal environment for footstep power generation systems as there is a constant flow of people, which can be harnessed to generate electricity.

Renewable Energy Potential: Footstep power generation systems using piezoelectric sensors are a form of renewable energy. Bangladesh has been focusing on increasing the share of renewable energy in its power generation mix to reduce dependency on fossil fuels. Implementing this technology aligns with the country's goals for sustainable development.

Technological Advancements: Over time, the efficiency and cost-effectiveness of piezoelectric sensors and associated technologies are likely to improve. As the technology evolves, it becomes more feasible to implement footstep power generation systems on a larger scale in public places like train stations, shopping malls, and airports.

Environmental Benefits: Footstep power generation systems produce clean energy without harmful emissions, contributing to the reduction of greenhouse gas emissions and environmental pollution. This aligns with global efforts to combat climate change and promote sustainable development.

Research and Development: Bangladesh has been investing in research and development initiatives to explore innovative energy solutions. Further research and development in the field of footstep power generation systems can lead to advancements, optimization of the technology, and potential cost reductions.

It is important to note that the successful implementation of footstep power generation systems in Bangladesh would require collaboration between government agencies, private sector entities, and research institutions. Additionally, financial support, public awareness campaigns, and favorable policies are crucial for the widespread adoption of this technology.

Chapter 6

Conclusion

6.1 Advantage:

- Power generation is simply walking on step.
- No need fuel input.
- This is a Non-conventional system.
- No moving parts.
- Long life service.
- Self-generating.
- No external power required.
- Compact yet highly sensitive.
- Reliable, Economical, Eco-Friendly.
- Less consumption of Non-renewable energies.
- Power also generated by running or exercising on the step.
- Battery is used to store the generated power.
- Extremely wide dynamic range, almost free of noise.
- Easy to analyze.
- Easy to understand.
- Simple circuit.

6.2 Disadvantage :

- Only application for the particular place.
- Initial cost of this arrangement is high.
- Output affected by temperature variation.
- Initial cost of this arrangement is high.
- Care should be taken for batteries

6.3 Application :

- Foot step generated power can be used for home applications, street lighting.
- It can use in emergency power failure situations like hospitals.
- It can be used as a source for both A.C. and D.C applications.
- It is also used in College, Universities, Cinema Theatres, Shopping Complex, Railway Stations, Bus stations, Airports

6.4 Conclusion :

Use of piezoelectric crystals has being started and positive results are obtained. With further advancement in field of electronics, better synthesized piezoelectric crystals and better selection of place of installations, more electricity can be generated and it can be viewed as a next promising source of generating electricity. Nowadays, Bangladesh shares a percentage of renewable energy only 3% of total energy ratio. In concluding the words of our project, since the power generation using foot step get its energy requirements from the Non-renewable source of energy. There is no need of power from the mains and there is less pollution in this source of energy. It is very useful to the places all roads and as well as all kind of foot step which is used to generate the non conventional energy like electricity.

It is able to extend this project by using same arrangement and construct in the footsteps/speed breaker so that increase the power production rate by fixing school and colleges, highways etc.

References

[1] A. G. M.N. Fakhzan, "Vibration Based Energy Harvesting. Using Piezoelectric Material," nternational Islamic University , 2018.

[2] S. E. S. N. V. C. Marshiana D, "Footstep power production using piezoelectric sensors," Asian J 9, p. 831, 2016.

[3] P. M. S. D. M. K. Suresh M, "Generation of electricity using piezoelectric material: Study on asphalt pavement structure on rural road," J Mater Civil Eng 34, p. 4021418, 2022.

[4] G. L. C. S. S. S. Mishra P, "Generation of Electricity Using," Nuclear Energy Science & Power Generation Technology, pp. 1-5, 2022.

[5] R. P. Wali, "An electronic nose to differentiate aromatic flowers using a real-time information-rich piezoelectric resonance measurement," Procedia Chemistry, p. 194–202, 2012.

[6] S. E. S. N. V. C. M. D, "Footstep power production using piezoelectric sensors," Asian J Res Chem, vol. 9, p. 831, 2016.

[7] Z. N. S. B. Nia EM, "A review of walking energy harvesting using," Mater Sci Eng, p. 291, 2017.

[8] C. Y. H. C. T. L. Su WS, "Generation of electricity in GaN nanorods," Appl Phys Lett, p. 90, 2007.

[9] M. I, "Electrical power generation using footsteps," Eur Sci J, p. 318, 2018.

[10] M. F. S. S. I. M. M. A. Asry AMM, "Study on footstep power generation," Indonesian J Electr Eng Compu Sci, pp. 593-599, 2019.

[11] A.-T. A. T. S. L. W. Ang CK, "Development of a footstep power," E3S Web Confer, p. 02001, 2019.

[12] A. H. A. M. K. A. S. M. Aman MA, "Power generation from piezoelectric footstep technique," J Mech Cont Math Sci 13, pp. 67-72, 2018.

[13] S. D. M. S. K. T. Ganesh RJ, "Experimental study on Footstep power generation system using piezoelectric sensor," Mater Today Proceed 45, pp. 1633-1637, 2021.

[14] S. Poddar, "Footstep Voltage Generator using Piezo-Electric," International Journal of Scientific & Engineering Research, pp. 117-120, 2017.