ENERGY GENERATION USING PIEZOELECTRIC CRYSTAL

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In partial fulfillment of the requirements
For the degree of

BACHELOR OF TECHNOLOGY
IN

ELECTRICAL ENGINEERING

By

Abhishek Pandey	**(1130433003)**
Drishti Singh	**(1130433017)**
Jyoti Pandey	**(1130433025)**
Prakhar Vishnoi	**(1130433040)**
Rahul Yadav	**(1130433043)**

Under the supervision of
Ms. Shivangi Upadhyay
(Lecturer)

Department of Electrical Engineering
BABU BANARASI DAS UNIVERSITY
LUCKNOW

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CERTIFICATE

This is to certify that the work contained in this Project entitled **"POWER GENERATION USING PIEZOELECTRIC CRYSTAL"** which is submitted by **Abhishek Pandey(1130433003), Drishti Singh(1130433017), Jyoti Pandey(1130433025), Prakhar Vishnoi(1130433040), Rahul Yadav(1130433043),** in partial fulfillment of the requirement for the award of degree of Bachelor of Technology in Department of Electrical Engineering of Babu Banarasi Das University, is a record of the candidates own work carried out by them under my supervision. The matter embodied in this project work is original and not been submitted for the award of any other degree.

DATE-

Ms. Shivangi Upadhyay

Group Coordinator

Department of Electrical Engineering

School of Engineering

Babu Banarasi Das University

Lucknow (U.P)

Mr. V.K. Maurya

Associate Professor & Incharge

Department of Electrical Engineering

School of Engineering

Babu Banarasi Das University

Lucknow (U.P)

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Abhishek Pandey	**(1130433003)**
Drishti Singh	**(1130433017)**
Jyoti Pandey	**(1130433025)**
Prakhar Vishnoi	**(1130433040)**
Rahul Yadav	**(1130433043)**

ABSTRACT

The project is designed to successfully generate electricity using Piezoelectric crystal and to use the generated energy produced. The system will provide alternative source of energy. This not only reduces the load on the main or major power but also provides a cleaner energy source with little to no input required.

This supply can be applied on small to medium powered appliances. This can also be used to provide electricity to a small system of load in case of Grid failure or as contingency power as in backup power.

This project can be used in commercial as well as industrial purpose.

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INTRODUCTION

1.1 OVERVIEW

The increasing desire for completely self-powered electronics has caused the amount of research into power harvesting devices to become progressively larger over the last decade. With the advances being made in wireless technology and low power electronics, sensor are being developed that can be placed almost anywhere. However, because these sensors are wireless, they require their own power supply which in most cases is the conventional electrochemical battery. Once these finite power supplies are extinguished of their power, the sensor must be obtained and the battery replaced. The task of replacing the battery is tedious and can become very expensive when the sensor is placed in a remote location. These issues can be potentially alleviated through the use of power harvesting devices. The goal of a power harvesting device is to capture the normally lost energy surrounding a system and convert it into usable energy for the electrical device to consume. By utilizing these untapped energy sources electronics that do not depend on finite power supplies, such as the battery, can be developed. One source of typically lost energy is the ambient vibrations present around most machines and biological systems. This source of energy is ideal for the use of piezoelectric materials, which have the ability to convert mechanical strain energy into electrical energy and vice versa. As compact, low power electronics become more prevalent in everyday use and as their increasing portability requires reliable power sources, ambient energy harvesting devices show much potential over batteries. Indeed, by relying on energy scavenged from the environment, such electronics are no longer restricted by the periodic maintenance that batteries demand. In particular, energy harvested parasitically from human movements has garnered much discussion. Perhaps the most energy abundant and readily utilized form of ambient human power is walking. One of the methods of harnessing this energy is from footfalls. This paper is to describe a new, efficient design of a wearable energy supplier. As already discussed foot fall or heel strike is one of the significant methods of harvesting energy. The project aims at developing a shoe embedded with piezoelectric material (PVDF) into a noble wearable energy supplier.

A great way to gather power is via kinetic energy. Energy can be recollected while we are already moving. ‘Piezoelectric crystal’ generates its own power using only the natural movement of the human body. The fabric around the joints is woven with piezoelectric film fibers which convert mechanical strain (created by the fabric’s movement) into electrical voltage while the wearer moves around. Voltage can then be stored in coin batteries disguised as buttons. The electrical potential is then stored as voltage in a centralized small battery and can be disc charged into a device.

With a positive charge on one side and a negative charge on the other, the piezoelectric material creates a voltage when it is deformed like bent or twisted. An integrated extending the growing rectifier circuit connects the strips to capacitors which store electrical charge and feed the electrical power to the coin batteries disguised as buttons. Although the electricity generated in this way might not be able to power an MP3 player or cell phone, it will be sufficient for sensors monitoring heart rate or other biometric parameters interesting for fitness and sport enthusiasts. While the necessary clothing movement to make this concept work might not be sufficient in street wear it will work fine in sports clothing where movement is an essential part. A brilliant idea using piezoelectric material to power future clothing which will be populated with electronic functions to form a second skin extending our senses beyond the passive clothing we wear today. The energy generated is in mill watts. The project aims at increasing electromechanical energy.

1.2 PIEZOELECTRIC GENERATOR

Piezoelectric generators work due to the piezoelectric effect. This is the ability of certain materials to create electrical potential when responding to mechanical changes. To put it more simply, when compressed or expanded or otherwise changing shape a piezoelectric material will output some voltage. This effect is also possible in reverse in the sense that putting a charge through the material will result in it changing shape or undergoing some mechanical stress. These materials are useful in a variety of ways. Certain piezoelectric materials can handle high voltage extremely well and are useful in transformers and other electrical components. It is also used to make motors, reduce vibrations in sensitive environments, and relevant to our interests it can be used as an energy collector. Let's examine some of the ways it can be used for energy.

Some of the most obvious applications of piezoelectric materials for energy collection are personal energy generators that are enough to power phones, MP3 players, etc. The sole of your shoe could be constructed of piezoelectric materials and every step you took would begin to generate electricity. The amount of charges produced is proportional to the pressure applied and these charges were diminished when the pressure is withdrawn. This could then be stored in a battery or used immediately in personal electronics devices.

One new idea that is gaining traction is to use the vibrations created by sound reverberating through piezoelectric materials to generate electricity. When an electric field is applied to the poled piezoelectric ceramic through electrodes on its surfaces, the piezoelectric material gets strained (converse effect). This means that while you're driving your car listening to the radio, sitting outside in a park, or doing anything you could be converting sound to electricity. Piezoelectricity is the charge which accumulates in certain solid materials (notably crystals, certain ceramics, and biological matter such as bone, DNA and various proteins) in response to applied mechanical strain. The word piezoelectricity means electricity resulting from pressure. It is derived from the Greek piezo or piezein, which means to squeeze or press, and electric or electron, which stands for amber – an ancient source of electric charge. Piezoelectricity is the direct result of the piezoelectric effect.

The piezoelectric effect is understood as the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry. The piezoelectric effect is a reversible process in 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 force resulting from an applied electrical field). For example, lead zirconate titanate crystals will generate measurable piezoelectricity when their static structure is deformed to about 0.1% of the original dimension. Conversely, lead zirconate titanate crystals will change about 0.1% of their static dimension when an external electric field is applied to the material.

Piezoelectricity is found in useful applications such as the production and detection of sound, generation of high voltages, electronic frequency generation, microbalances, and ultra fine focusing of optical assemblies. It is also the basis of a number of scientific instrumental techniques with atomic resolution, the scanning probe microscopies such as STM, AFM, MTA, SNOM, etc., and everyday uses such as acting as the ignition source for cigarette lighters and push-start propane barbecues.

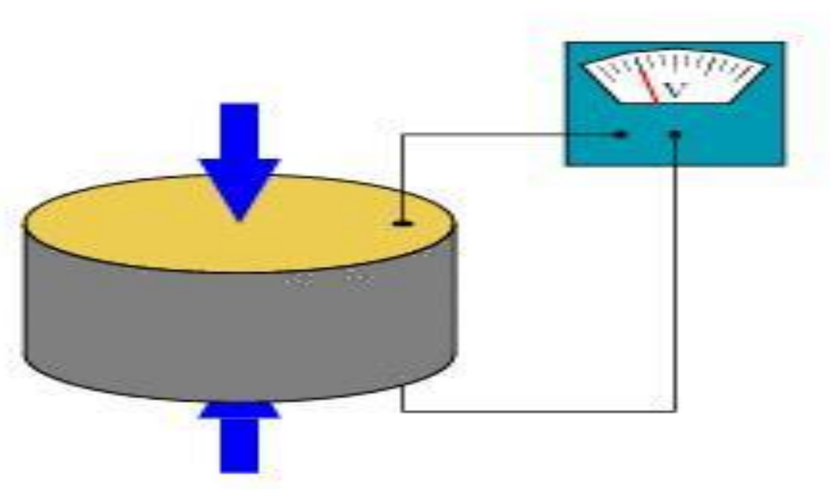

Fig. 1.1 Piezoelectric Generator

1.3 HISTORY

In the year 1880 Pierre Curie and Jacques Curie discovered that some crystals when compressed in particular directions show positive and negative charges on certain positions of their surfaces. The amount of charges produced is proportional to the pressure applied and these charges were diminished when the pressure is withdrawn. They observed this phenomenon in the following crystals: zinc blende, sodium chlorate, boracites, tourmaline, quartz, calamine, topaz, tartaric acid, cane sugar, and Rochelle salt. Hankel proposed the name “piezoelectricity”. The word “piezo” is a Greek word which means “to press”, therefore piezoelectricity means electricity generated form pressure. The direct piezoelectric effect is defined as electric polarization produced by mechanical strain in crystals belonging to certain classes. In the converse piezoelectric effect a piezoelectric crystal gets strained, when electrically polarized, by an amount proportional to polarizing field.

1.3.1 Discovery and early research

The piezoelectric effect, where a material generates an electric potential in response to a temperature change, was studied by Carl Linnaeusand Franz Aepinus in the mid-18th century. Drawing on this knowledge, both René Just Hauy and Antoine César Becquerel posited a relationship between mechanical stress and electric charge; however, experiments by both proved inconclusive.

The first demonstration of the direct piezoelectric effect was in 1880 by the brothers Pierre Curie and Jacques Curie. They combined their knowledge of piezoelectricity with their understanding of the underlying crystal structures that gave rise to piezoelectricity to predict crystal behavior, and demonstrated the effect using crystals of tourmaline, quartz, topaz, cane sugar, and Rochelle salt (sodium potassium tartrate tetrahydrate). Quartz and Rochelle salt exhibited the most piezoelectricity.

A piezoelectric disk generates a voltage when deformed (change in shape is greatly exaggerated). The Curies, however, did not predict the converse piezoelectric effect. The converse effect was mathematically deduced from fundamental thermodynamic principles by Gabriel Lippmann in 1881. The Curies immediately confirmed the existence of the converse effect, and went on to obtain quantitative proof of the complete reversibility of electro-elasto-mechanical deformations in piezoelectric crystals.

1.3.2 World War I and post-war

The first practical application for piezoelectric devices was sonar, first developed during World War I. In France in 1917, Paul Langevin and his coworkers developed an ultrasonic submarine detector. The detector consisted of a transducer, made of thin quartz crystals carefully glued between two steel plates, and a hydrophone to detect the returned echo.
By emitting a high-frequency chipform the transducer, and measuring the amount of time it takes to hear an echo from the sound waves bouncing off an object, one can calculate the distance to that object.

The use of piezoelectricity in sonar, and the success of that project, created intense development interest in piezoelectric devices. Over the next few decades, new piezoelectric materials and new applications for those materials were explored and developed.

Piezoelectric devices found homes in many fields. Ceramic phonograph cartridges simplified player design, were cheap and accurate, and made record players cheaper to maintain and easier to build. The development of the ultrasonic transducer allowed for easy measurement of viscosity and elasticity in fluids and solids, resulting in huge advances in materials research. Ultrasonic time-domain reflectometers (which send an ultrasonic pulse through a material and measure reflections from discontinuities) could find flaws inside cast metal and stone objects, improving structural safety.

1.3.3 World War II and post-war

During World War II, independent research groups in the United States, Russia, and Japan discovered a new class of man-made materials, called ferroelectrics, which exhibited piezoelectric constants many times higher than natural materials. This led to intense research to develop barium titanate and later lead zirconate titanate materials with specific properties for particular applications.

One significant example of the use of piezoelectric crystals was developed by Bell Telephone Laboratories. Following World War I, Frederick R. Lack, working in radio telephony in the engineering department, developed the “AT cut” crystal, a crystal that operated through a wide range of temperatures. Lack's crystal didn't need the heavy accessories previous crystal used, facilitating its use on aircraft. This development allowed Allied air forces to engage in coordinated mass attacks through the use of aviation radio.

Development of piezoelectric devices and materials in the United States was kept within the companies doing the development, mostly due to the wartime beginnings of the field, and in the interests of securing profitable patents. New materials were the first to be developed- quartz crystals were the first commercially exploited piezoelectric material, but scientists searched for higher-performance materials. Despite the advances in materials and the maturation of manufacturing processes, the United States market had not grown as quickly. Without many new applications, the growth of the United States' piezoelectric industry suffered.

In contrast, Japanese manufacturers shared their information, quickly overcoming technical and manufacturing challenges and creating new markets. Japanese efforts in materials research created piezoceramic materials competitive to the U.S. materials, but free of expensive patent restrictions. Major Japanese piezoelectric developments include new designs of piezoceramic filters for radios and televisions, piezo buzzers and audio transducers that can connect directly to electronic circuits, and the piezoelectric igniter, which generates sparks for small engine ignition systems (and gas-grill lighters) by compressing a ceramic disc. Ultrasonic transducers that transmit sound waves through air had existed for quite some time, but first saw major commercial use in early television remote controls. These transducers now are mounted on several car models as an echolocation device, helping the driver determine the distance from the rear of the car to any objects that may be in its path.

Chapter-2

BLOCK DIAGRAM EXPLAINATION

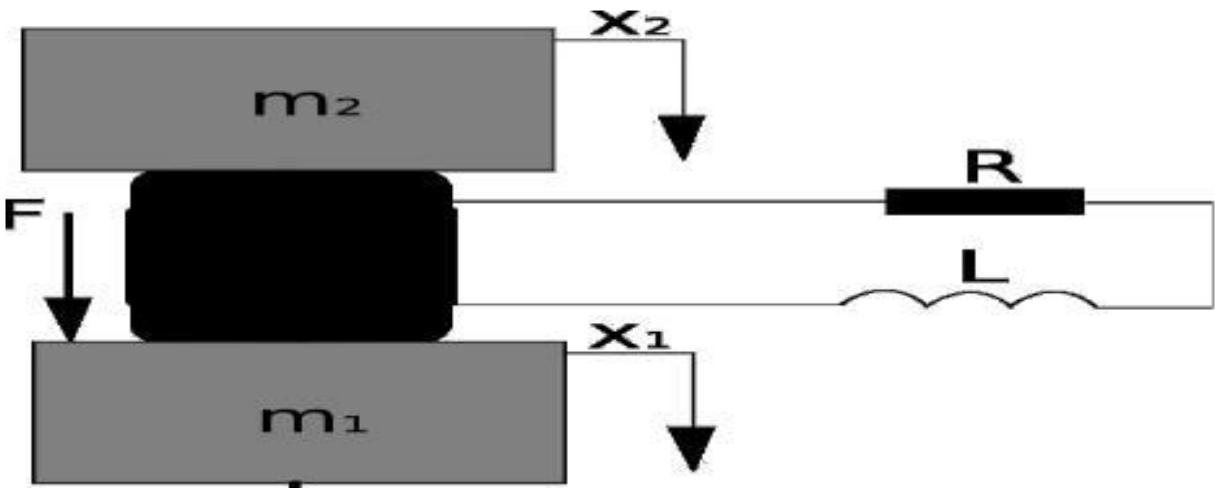

Fig.2.1

The diagram of this model is shown below.

Where $x1$ and $x2$ are the displacement of lumped masses $m1$ and $m2$ respectively, k is the spring, F is the force exciting the mechanical part of the system, R is resistance, and L is inductance of electrical circuit, between mass $m1$ and $m2$ is piezoelectric transducer.

We see here that in this block diagram there is actual representation of how a piezoelectric crystal works.

The idea behind such a model is simply utilizing the fact that it converts mechanical energy into electrical energy. The energy being converted is stored in batteries or cells and can be used later.

In this particular block diagram we can see that there are two masses….

“m1” and “m2”. A piezoelectric crystal is put between them.
It is further connected to inductor and resistor. These act like load in the system and thus the circuit is completed.

The mass m2 is attached to a spring having spring constant “k”.

Now the mass m1 pushes the crystal kept between m1 and m2.

This mechanical input is transferred to the spring and is stored as spring potential energy.
This energy is transferred to the circuit and electrical energy is developed from mechanical input.
And this what piezoelectric crystal exactly does.

A single piezoelectric crystal produces a small current of 0.1 ampere.
But when a large number of crystals are connected together they generate a large amount of current which can be used for various purposes.

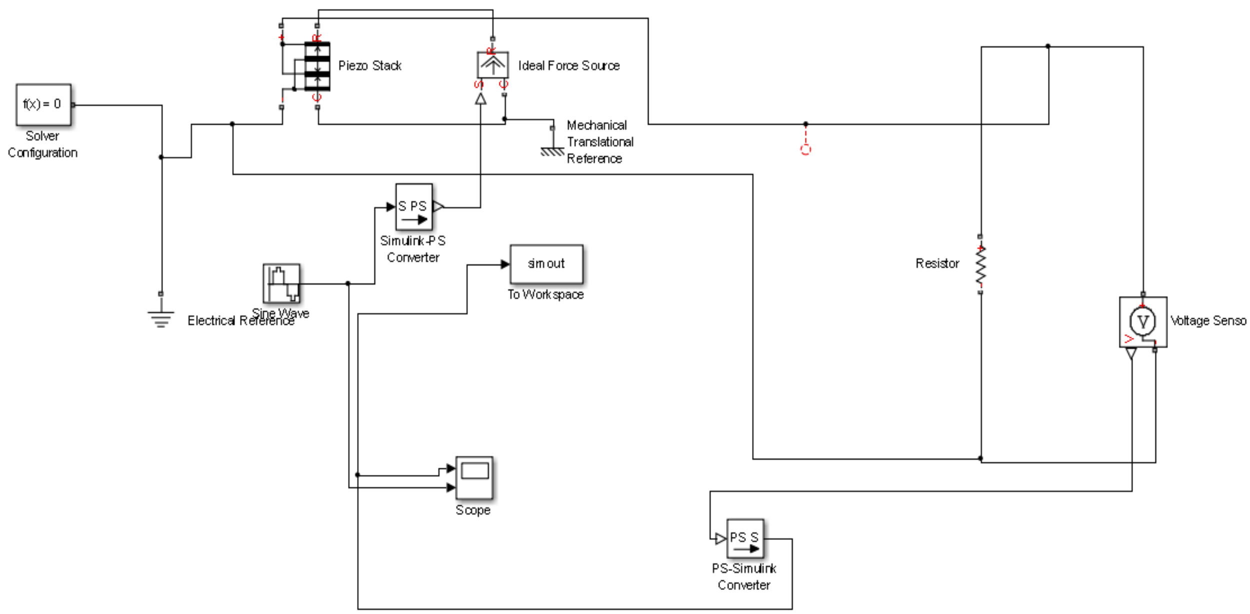
f(x) = 0
Solver Configuration
Piezo Stack
Ideal Force Source
Mechanical Translational Reference
S PS
Simulink-PS Converter
simout
To Workspace
Sine Wave
Electrical Reference
Resistor
Voltage Senso
Scope
PS S
PS-Simulink Converter

Fig 2.2

2.1 MATHEMATICAL EXPRESSION FOR THE CONVERSIONS

Using constitutive equation for a linear piezoelectric material:

for constant electric field,

$$T = c^{E} S - Ee \qquad (1.1)$$

$$D = eS + \varepsilon^{\varepsilon} E \qquad - \qquad (1.2)$$

S – strain

E – electric field [V/m],

D – electric displacement [C m^{-2}],

c^{E} – elastic stiffness

e – piezoelectric constant [C m^{-2}],

Hence, using the displacement along with the strain we are able to determine the amount of voltage generated using this model.

The voltage generated hence gives us an exact idea of how much energy is being generated and the generated energy can be put to what use.

The piezoelectric material converts pressure into electrical energy .

Now the pressure can be either weight of moving vehicles or from the weight of people walking on it.

In case of the model that we are presenting we have taken into consideration the pressure exerted by the trains in the railway tracks.

The produced output is in variable form, so bridge circuit is used tp convert variable voltage into linear voltage.

An AC filter is used to filter out this output voltage into linear voltage and then as mentioned earlier it is stored in rechargeable batteries.

Inverter is also connected to the battery and battery connection provide AC load.

If in any case we want to keep a check on voltage being generated then we can connect a LCD display which would show the voltage being generated with time.

Now there might be a question so as to why piezoelectric crystal for chosen for the purpose when one certainly has so many options.

Well it is certainly because of the two basic piezoelectric properties.

First one is the direct piezoelectric effect which means the material has ability to convert mechanical strain into electrical energy.

Second one is the converse effect, in which the applied electrical potential is converted into mechanical strain energy.

That means material is used as a power harvesting medium.

Hence we have piezoelectric crystal kept under the railway tracks.
And every single time a crystal experiences force or pressure due to the passing train, energy is generated.

The piezoelectric crystal are connected through wires.

After that the generated energy is stored in battery.

The generated voltage which is generated by piezoelectric crystal is DC which is changed into AC by inverter.

The load is connected to the inverter, which glows when AC is given by the inverter.

2.2. MAXIMUM THEORETICAL VOLTAGE GENERATED

When a force is applied on a piezo material, a charge is generated across s it.

Thus it can be assumed to be an ideal capacitor.

Thus all equations governing capacitor can be applied to it.

Assuming that on one straight track we connect three piezo crystal in series.

Therefore the equivalent capacitance becomes equal to

$$\frac{1}{Ceq} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} \quad - \qquad (1.3)$$

We know,

$$Q = C/V \qquad (1.4)$$

So,

$$C = Q/V \qquad (1.5)$$

Hence,

$$\frac{Veq}{q} = \frac{V1}{q} + \frac{V2}{q} + \frac{V3}{q} \qquad (1.6)$$

Thus

$$Veq = V1 + V2 + V3 \qquad (1.7)$$

Hence the voltage generated in series connection is the sum of all the individual voltages generated across each piezoelectric crystal.

If output from each crystal is assumed to be 13V then the total voltage would be 39V.

Hence the maximum voltage that can be generated across the piezo from one section is 39 V.

Comparison between various piezoelectric material shows that PZT is superior in characteristics.

Also by comparison, we know that series parallel combination connection is more suitable.

The weight applied and the corresponding voltage being generated were studied and they were found to have a linear relation.

So such a system is most suited to be installed in crowded areas. It can be used in street lightning without use of long power lines.

It can be use as charging ports, lightning of pavement side buildings.

Now piezolelectric crystal were available in two options.

-Rotational piezoelectric crystal

-Piezoelectric stack model

The question arises that which type we chose and why.

Well the answer to this is we chose piezoelectric stack model.

The reason being that the expenditure should not exceed the energy generated. Hence we do not use rotational model since there are a lot of energy losses associated with its usage that being loss by carbon brushes, wear and tear and unreliability due to its constant movement.

A low voltage piezoelectric stack is a monolithic ceramic construction of many thin piezo ceramic layer which are connected in parallel electrically.

The principle characteristics of the stack are:

- High energy conversion
- Efficiency
- Low voltage operation
- Large force
- Low motion
- Fast response

- No EM

Motion may be increased at the expense of force by mechanical amplification.

The stack offers a high energy density in a small package.

Due to its superior compressive strength , it provides a high load bearing capability.

However it is relatively weak in tension.

Generally excitation should be applied in the direction of polarization.

Hysteresis is typically about 15% in application.

2.3. SINE WAVE GENERATOR

In case of mechanical to electrical energy conversion, the piezoelectric crystal is subjected to mechanical stress which generates mechanical force which is then converted to electrical energy.

The sine wave generator is hence used to signify the mechanical force being exerted as a sine wave.

The sine wave is just an exemplar reference to such mechanical force that could be applied at any instant of time over the crystal to generate electricity.

What is important to mention here is that the output for the model will vary if the type of mechanical wave is varied.

This implies that a sine wave will generate output that will be completely different from the output generated by the model subjected to a cosine wave input as mechanical.

Ironically, though the phasor diagrams and graphical data suggest that the outputs are different the magnitude in both the cases will be nearly same if the amount of mechanical stress is the same.

2.4. ADVANTAGES AND DISADVANTAGES OF PIEZOELECTRIC CRYSTAL

Everything has its advantages and disadvantages.

Now a day's energy is one of the most important issues around the world.

Especially in Bangladesh energy crisis is a big problem. Renewable energy sources can be a great media to solve this energy crisis problem in Bangladesh. As we know natural resources will finish one day.

That's why researchers are trying to introduce substitute energy sources from nature. That must be green and not harmful for the environment.

Energy harvesting is defined as capturing minute amounts of energy from one or more of the surrounding energy sources.

Human beings have already started to use energy harvesting technology in the form of windmill, geothermal and solar energy. The energy came from natural sources, termed as renewable energy.

Renewable energy harvesting plants generate kW or MW level powers, it is called macro energy harvesting technology. Moreover, micro energy also can produce from those natural sources, that's called micro energy harvesting.

Micro energy harvesting technology is based on mechanical vibration, mechanical stress and strain, thermal energy from furnace, heaters and friction sources, sun light or room light, human body, chemical or biological sources, which can generate mW or μW level power.

Micro power supply needs is increasing greatly with time as our technology is moving to the micro and nano fabrication levels. Our discussion on this based on generating micro energy from vibration and pressure using piezoelectric material.

This day most of the research in the energy field is to develop sources of energy for future. It is time to find renewable surceases of energy for the future.

Piezoelectric materials are being more and more studied as they turn out to be very unusual materials with very specific and interesting properties.

In fact, there materials have the ability to produce electrical energy from mechanical energy for example they can convert mechanical behavior like vibrations in to electricity.

Such devices are commonly referred to as energy harvesters and can be used in applications where outside power is unavailable and batteries are not a feasible option.

While recent experiments have shown that these materials could be used as power generators, the amount of energy produced is still very low, hence the necessity to optimize them.

Piezoelectric materials have two properties that are define as direct and converse effect.

Direct effect is the property of some materials to develop electric change on their surface when mechanical stress is exerted on them, while converse effect is the property of some materials to develop mechanical stress when an electric charge is induced.

Moving on to the advantages of using piezoelectric crystal we have

Advantages:

1) Very high frequency response.
2) Self generating, so no need of external source.
3) Simple to use as they have small dimensions and large measuring range.
    a. Barium titanate and quartz can be made in any desired shape and form. It also has a large dielectric
4) They are used for the measurement for displacement.
5) Such crystal are also used for the measurement of force, pressure and acceleration.
6) Piezoelectric transducers are very useful in medical treatment and sonochemistry.
7) In automotive companies piezoelectric transducers are used for the detection of detonations in engines.
8) One most important thing about piezoelectric crystal is that they are direction sensitive.
9) A tensile stress produces voltage of one polarity while a compressive stress produces voltages of another polarity.
10) Due to their reversible nature they are also called inverse transducer.
11) Piezoelectric crystals give high frequency response.
12) It means change in any parameter that takes place at high speed can easily be sensed.
13) Output is high that can be measured in electronic circuit.
14) This transducer can detect events of microseconds and give linear output.
15) These are very compact and small in size and tough rugged construction.
16) They generate a voltage proportional to the velocity the crystal is deformed.
17) So they do not require local power source.
18) It is unaffected by external electromagnetic fields.
19) It is pollution free.
20) It is low maintenance.

21) There is always easy replacement of equipments.
22) Electrical signal obtained from electrical transducer can be easily processed.
23) It can be brought to a suitable level for output device which may be an indicator or recorder.
24) The electrical systems can be controlled with a small level of power.
25) The electrical output can be easily used, transmitted and processed for the purpose of measurement.
26) With the advent of IC technology, the electronic systems have become extremely small in size, requiring small space for their operation.
27) No moving mechanical parts are involved in the operation in electrical systems.
28) Therefore no question of wear and tear arises and no possibility of mechanical failure arises.
29) Friction effect is minimized.
30) The output can be indicated and recorded remotely from the sensing element.
31) Power requirement is very low for controlling the electrical or electronic equipment.
32) An amplifier may be used for amplifying the electrical signal according to the requirement.
33) Mass inertia effect is also minimized.
34) In case of electrical or electronics equipment the inertia effect is due to the mass of the electrons which can totally be neglected.

Result and finding

In 1 square ft. we used 12 piezo sensors.

As piezo sensors power generating varies with different steps, we get

Minimum voltage = 1V per step

Maximum voltage = 10.5V per step

We took an average of 50Kg weight pressure from single person. Considering the steps of a 50Kg weighted single person, the average calculations are:

It takes 800 steps to increase 1V charge in battery.

So, to increase 12V in battery total steps needed

= (12*800)

= 9600 steps

As we will implement our project in a populated area where foot step as source will available, we took an average of 2 steps in 1 second.

For 9600 steps time needed

= 9600/ (60*2)

=80 minutes. (Approximately).

DISADVANTAGES

1) It is not suitable for measurement in static condition.
2) Since the device operates with the small electric charge, they need high impedance cable for electrical interface.
3) The output may vary according to the temperature variation of the crystal.
4) The relative humidity rises above 85% or falls below 35%, its output will be affected. If so, it has to be coated with wax or polymer material.

Some Common Mistakes

Though piezoelectric material has the property of converting mechanical energy into electrical energy but developing piezoelectric generators is challenging because of their poor source characteristics (high voltage, low current, high impedance) and relatively low power output.

In the past these challenges have limited the development and application of piezoelectric generators.

The main limitation of our project is we could not amplify the current or power from source to charge our battery faster with less steps.

And another one is we could not find better piezoelectric sensor in our region. That’s why we use buzzer as piezoelectric sensor, which has a little amount of piezo crystal material in its surface.

And the thickness of these sensors is much less. So these sensors could break by people pressure. But, finally we managed with our mechanical structure to give the strength and got maximum output as mW range.

Secondary batteries must be charged before use; they are usually assembled with active materials in the discharged state.

Rechargeable batteries or secondary cells can be recharged by applying electrical current, which reverses the chemical reactions that occur during its use.

Devices to supply the appropriate current are called chargers or rechargers.

The project is successfully tested which is the best economical, affordable energy solution to common people. This can be used for many applications in city areas where want more power.

Bangladesh is a developing country where energy management is a big challenge for huge population. By using this project we can drive D.C loads according to the force we applied on the piezo electric sensor.

Although the theory developed in this report justifies the use of switching techniques in efficiently converting that energy to a usable form, there are obviously some practical limitations to the systems presented.

The final prototype design does fulfill the objective of generating electricity from piezoelectric disk. Due to the low cost design of the piezoelectric system it is a practical product which could increase the operating period of most common products. The data collected is capable of extending the operational lifespan per charge of portable electronic devices.

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Measurements of source current into the primary and load current transferred from the secondary reveal that very little current gain truly occurs between the input and output ports of the switch in the forward converter hybrid.

Further, similar results were encountered when one examines the energy transferred through the series switch and inductor in the buck converter.

In addition, based on the results gathered in this investigation, the final prototype design does fulfill the objective of generating electricity from piezoelectric disk.

Due to the low cost design of the piezoelectric system it is a practical product which could increase the operating period of most common products. The data collected is capable of extending the operational lifespan per charge of portable electronic devices.

CHAPTER-3

HARDWARE USED AND THEIR DESCRIPTION

3.1. PIEZOELECTRIC CRYSTAL

Piezoelectricity is the ability of some materials (notably crystals, certain ceramics, and biological matter such as bone, DNA and various proteins) to generate an electric field or electric potential in response to applied mechanical strain. The effect is closely related to a change of polarization density within the material's volume. If the material is not short-circuited, the applied stress/strain induces a voltage across the material. However, if the circuit is closed the energy will be quickly released. So in order to run an electric load (such as a light bulb) on a piezoelectric device, the applied mechanical stress must oscillate back and forth. For example, if you had such a device in your shoes you could charge your cell phone while walking but not while standing.

***"It is the ability of some materials to generate an electric potential in response to applied mechanical stress"*.**

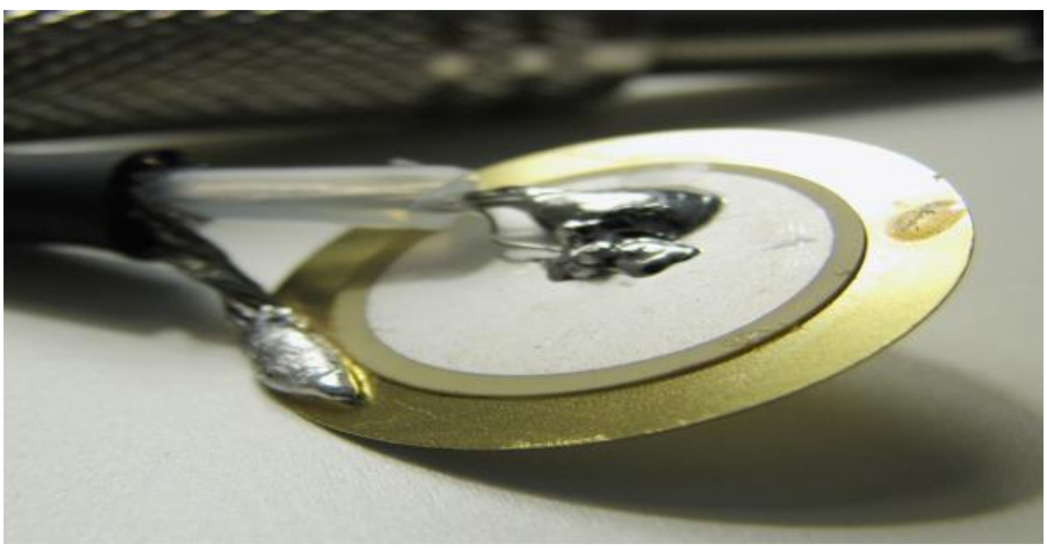

Fig. 3.1 Piezoelectric Crystal

3.2. ATMEGA 8 BASE

ATmega8 microcontroller has 23 programmable input/output (I/O) pins which can be used for interfacing with external world. It is possible to configure them as input or output by setting a particular register value through programming. This IC comes in 3 different packages, but we are using the popular 28-Pin PDIP package (Atmega8-16PU). Note that Atmega8 is available in 2 versions; ATmega8 and Atmega8L. Atmega8L is a low frequency version which works up to 8MHz frequency.

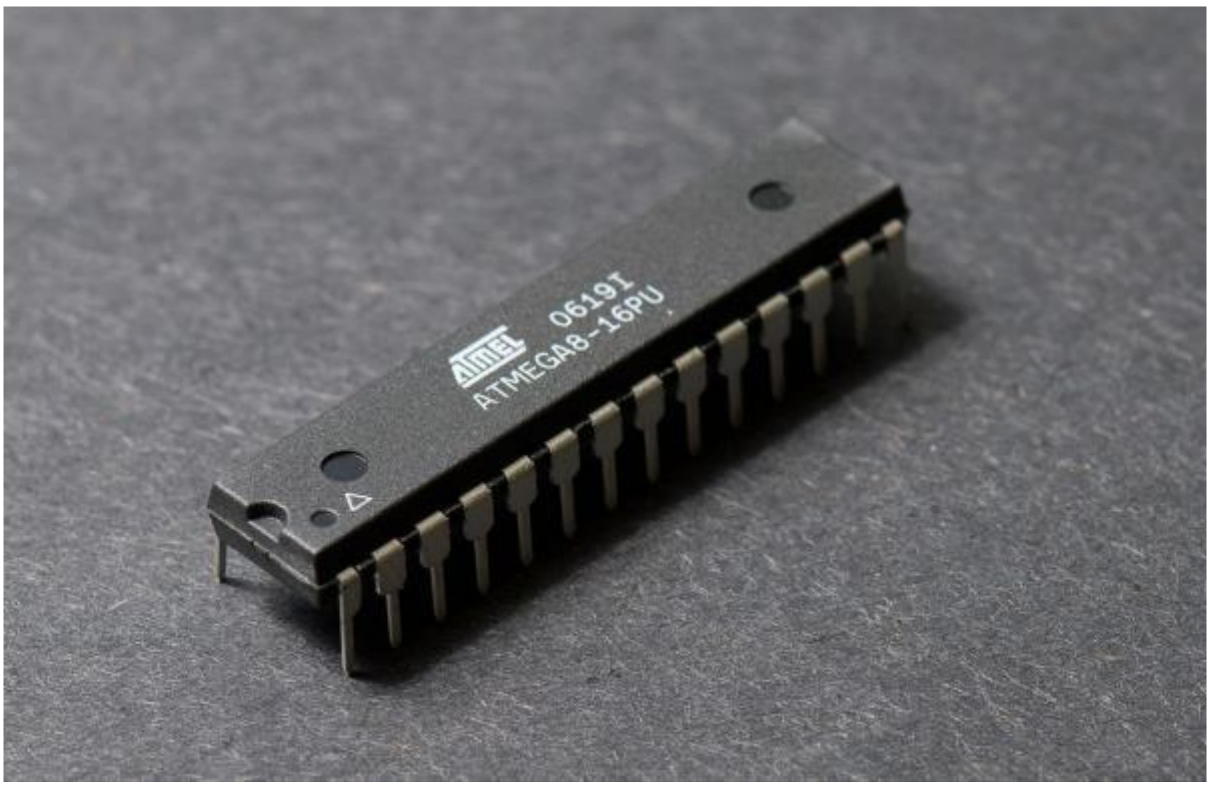

Fig. 3.2.Atmega 8 Base

3.3. IC 7805 VOLTAGE REGULATOR

Voltage regulator IC's are the IC’s that are used to regulate voltage. **IC 7805** is a **5V Voltage Regulator** that restricts the voltage output to **5V** and draws 5V regulated power supply. It comes with provision to add heatsink. The maximum value for input to the voltage regulator is 35V. It can provide a constant steady voltage flow of 5V for higher voltage input till the threshold limit of 35V. If the voltage is near to 7.5V then it does not produce any heat and hence no need for heatsink. If the voltage input is more, then excess electricity is liberated as heat from 7805.

It regulates a steady output of 5V if the input voltage is in rage of 7.2V to 35V. Hence to avoid power loss try to maintain the input to 7.2V. In some circuitry voltage fluctuation is fatal (for e.g. Microcontroller), for such situation to ensure constant voltage **IC 7805 Voltage Regulator** is used. For more information on specifications of **7805** Voltage Regulator please refer the data sheet here (IC 7805 Voltage Regulator Data Sheet).

IC 7805 is a series of 78XX voltage regulators. It’s a standard, from the name the last two digits 05 denotes the amount of voltage that it regulates. Hence a 7805 would regulate 5v and 7806 would regulate 6V and so on. The schematic given below shows how to use a 7805 IC, there are 3 pins in IC 7805, pin 1 takes the input voltage and pin 3 produces the output voltage. The GND of both input and out are given to pin 2.

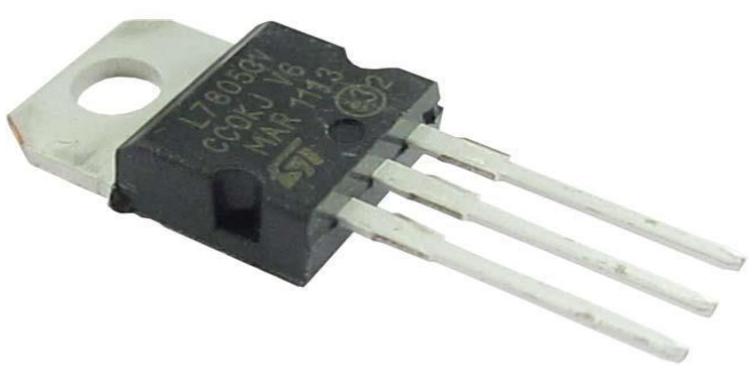

Fig.3.3.IC 7805 Voltage Regulator

3.4. BATTERY 12V

A battery converts chemical energy into electrical energy by a chemical reaction. Usually the chemicals are kept inside the battery. It is used in a circuit to power other components. A battery produces direct current (DC) electricity (electricity that flows in one direction, and does not switch back and forth).

Using the electricity from an outlet in a building is cheaper and more efficient, but a battery can provide electricity in areas that do not have electric power distribution. It is also useful for things that move, such as electric vehicles and mobile phones.

Fig. 3.4 Battery

3.5. CAPACITOR 500uF, 25V; 470uF, 25V

While capacitance exists between any two electrical conductors of a circuit in sufficiently close proximity, a capacitor is specifically designed to provide and enhance this effect for a variety of practical applications by consideration of size, shape, and positioning of closely spaced conductors, and the intervening dielectric material. A capacitor was therefore historically first known as an electric condenser. The physical form and construction of practical capacitors vary widely and many capacitor types are in common use. Most capacitors contain at least two electrical conductors often in the form of metallic plates or surfaces separated by a dielectric medium. A conductor may be a foil, thin film, sintered bead of metal, or an electrolyte. The non conducting dielectric acts to increase the capacitor's charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, paper, mica, and oxide layers. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy.

When two conductors experience a potential difference, for example, when a capacitor is attached across a battery, an electric field develops across the dielectric, causing a net positive charge to collect on one plate and net negative charge to collect on the other plate. No current actually flows through the dielectric; however, there is a flow of charge through the source circuit. If the condition is maintained sufficiently long, the current through the source circuit ceases. However, if a time-varying voltage is applied across the leads of the capacitor, the source experiences an ongoing current due to the charging and discharging cycles of the capacitor.

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Capacitance is defined as the ratio of the electric charge on each conductor to the potential difference between them. The unit of capacitance in the International System of Units (SI) is the farad (F), defined as one coulomb per volt (1 C/V). Capacitance values of typical capacitors for use in general electronics range from about 1 pF (10−12 F) to about 1 mF (10−3 F).

The capacitance of a capacitor is proportional to the surface area of the plates (conductors) and inversely related to the gap between them. In practice, the dielectric between the plates passes a small amount of leakage current. It has an electric field strength limit, known as the breakdown voltage. The conductors and lead introduce an undesired inductance and resistance.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In resonant circuits they tune radios to particular frequencies. In electric power transmission systems, they stabilize voltage and power flow. The property of energy storage in capacitors was exploited as dynamic memory in early digital computers.

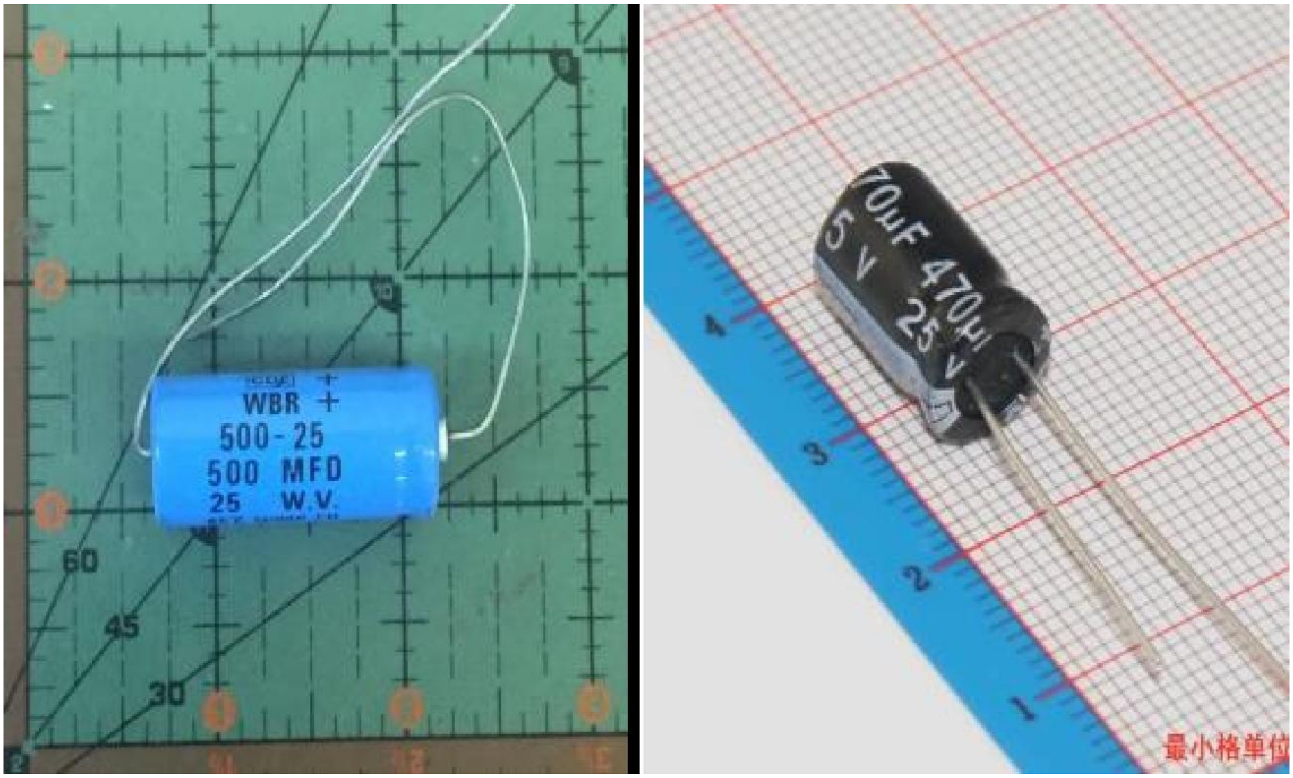

Fig. 3.5 Capacitors

3.6. ZERO PCB

A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non conductive substrate. Components (e.g. capacitors,resistors or active devices) are generally soldered on the PCB. Advanced PCBs may contain components embedded in the substrate.

PCBs can be single sided (one copper layer), double sided (two copper layers) or multi-layer (outer and inner layers). Conductors on different layers are connected with wires. Multi-layer PCBs allow for much higher component density.

FR-4 glass epoxy is the primary insulating substrate. A basic building block of the PCB is an FR-4 panel with a thin layer of copper foil laminated to one or both sides. In multi-layer boards multiple layers of material are laminated together.

Printed circuit boards are used in all but the simplest electronic products. Alternatives to PCBs include wire wrap and point to point construction. PCBs require the additional design effort to lay out the circuit, but manufacturing and assembly can be automated. Manufacturing circuits with PCBs is cheaper and faster than with other wiring methods as components are mounted and wired with one single part.

A minimal PCB with a single component used for easier prototyping is called a breakout board.

When the board has no embedded components it is more correctly called a printed wiring board (PWB) or etched wiring board. However, the term printed wiring board has fallen into disuse. A PCB populated with electronic components is called a printed circuit assembly (PCA), printed circuit board assembly or PCB assembly (PCBA). The IPC preferred term for assembled boards is circuit card assembly (CCA), and for assembled backplanes it is backplane assemblies. The term PCB is used informally both for bare and assembled boards.

The world market for bare PCBs exceeded $60.2 billion in 2014.

Initially PCBs were designed manually by creating a photo mask on a clear sheet, usually at two or four times the true size. Starting from the schematic diagram the component pin pads were laid out on the sheet and then traces were routed to connect the pads. Rub-on dry transfers of common component footprints increased efficiency. Traces were made with self-adhesive tape. Pre-printed non-reproducing grids on the sheet assisted in layout. To fabricate the board, the finished photo mask was photo lithographically reproduced onto a photo resist coating on the blank copper-clad boards.

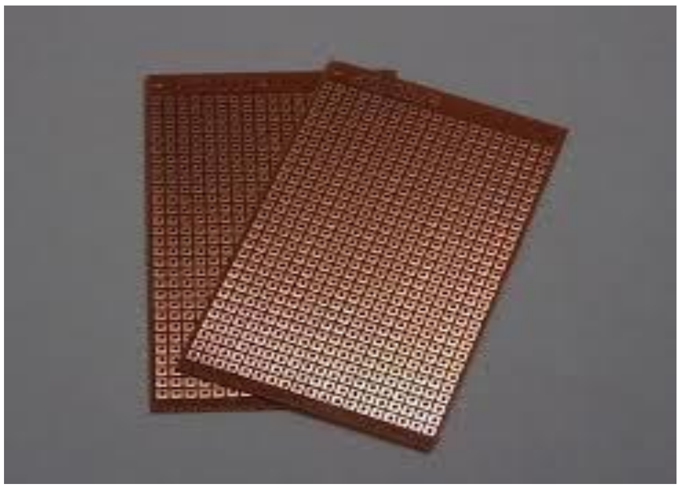

Fig. 3.6 Zero PCB

3.7. FAST SWITCHING DIODE

The Schottky diode (named after German physicist Walter H. Schottky), also known as hot carrier diode or fast switching diode, is a semiconductor diode formed by the junction of a semiconductor with a metal. It has a low forward voltage drop and a very fast switching action. The cat's-whisker detectors used in the early days of wireless and metal rectifiers used in early power applications can be considered primitive Schottky diodes.

The most important difference between the p-n diode and the Schottky diode is the reverse recovery time (trr), when the diode switches from the conducting to the non-conducting state. In a p–n diode, the reverse recovery time can be in the order of several microseconds to less than 100 ns for fast diodes. Schottky diodes do not have a recovery time, as there is nothing to recover from (i.e., there is no charge carrier depletion region at the junction). The switching time is ~100 ps for the small-signal diodes, and up to tens of nanoseconds for special high-capacity power diodes. With p–n-junction switching, there is also a reverse recovery current, which in high-power semiconductors brings increased EMI noise. With Schottky diodes, switching is essentially "instantaneous" with only a slight capacitive loading, which is much less of a concern.

Fig. 3.7 Fast Switching Diode

3.8. DIODE

The most common function of a diode is to allow an electric current to pass in one direction (called the diode's forward direction), while blocking current in the opposite direction (the reverse direction). Thus, the diode can be viewed as an electronic version of a check valve. This unidirectional behavior is called rectification, and is used to convert alternating current to direct current, including extraction of modulation from radio signals in radio receivers—these diodes are forms of rectifiers.

However, diodes can have more complicated behavior than this simple on–off action. Semiconductor diodes begin conducting electricity only if a certain threshold voltage or cut-in voltage is present in the forward direction (a state in which the diode is said to be forward-biased). The voltage drop across a forward-biased diode varies only a little with the current, and is a function of temperature; this effect can be used as a temperature sensor or voltage reference.

Semiconductor diodes nonlinear current–voltage characteristic can be tailored by varying the semiconductor materials and doping, introducing impurities into the materials.

Diodes were the first semiconductor electronic devices. The discovery of crystals' rectifying abilities was made by German physicist Ferdinand Braun in 1874. The first semiconductor diodes, called cat's whisker diodes, developed around 1906, were made of mineral crystals such as galena. Today most diodes are made of silicon, but other semiconductors such as germanium are sometimes used.

Fig. 3.8 Diode

3.9. LDR

A photo resistor (or light-dependent resistor, LDR, or photo conductive cell) is a light-controlled variable resistor. The resistance of a photo resistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photo resistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits.

A photo resistor is made of a high resistance semiconductor. In the dark, a photo resistor can have a resistance as high as several mega ohms (MΩ), while in the light, a photo resistor can have a resistance as low as a few hundred ohms. If incident light on a photo resistor exceeds a certain frequency,photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electrons (and their hole partners) conduct electricity, thereby lowering resistance. The resistance range and sensitivity of a photo resistor can substantially differ among dissimilar devices.

Moreover, unique photo resistors may react substantially differently to photons within certain wavelength bands.

A photoelectric device can be either intrinsic or extrinsic. An intrinsic semiconductor has its own charge carriers and is not an efficient semiconductor, for example, silicon. In intrinsic devices the only available electrons are in the valence band, and hence the photon must have enough energy to excite the electron across the entire band gap. Extrinsic devices have impurities, also called dopants, added whose ground state energy is closer to the conduction band; since the electrons do not have as far to jump, lower energy photons (that is, longer wavelengths and lower frequencies) are sufficient to trigger the device. If a sample of silicon has some of its atoms replaced by phosphorus atoms (impurities), there will be extra electrons available for conduction. This is an example of an extrinsic semiconductor.

Photo resistors are less light-sensitive devices than photodiodes or photo resistors the two latter components are true semiconductor devices while a photo resistor is a passive component and does not have a PN junction. The photo resistivity of any photo resistor may vary widely depending on ambient temperature, making them unsuitable for applications requiring precise measurement of or sensitivity to light photons.

Photo resistors also exhibit a certain degree of latency between exposure to light and the subsequent decrease in resistance, usually around 10 milliseconds. The lag time when going from lit to dark environments is even greater, often as long as one second. This property makes them unsuitable for sensing rapidly flashing lights, but is sometimes used to smooth the response of audio signal compression.

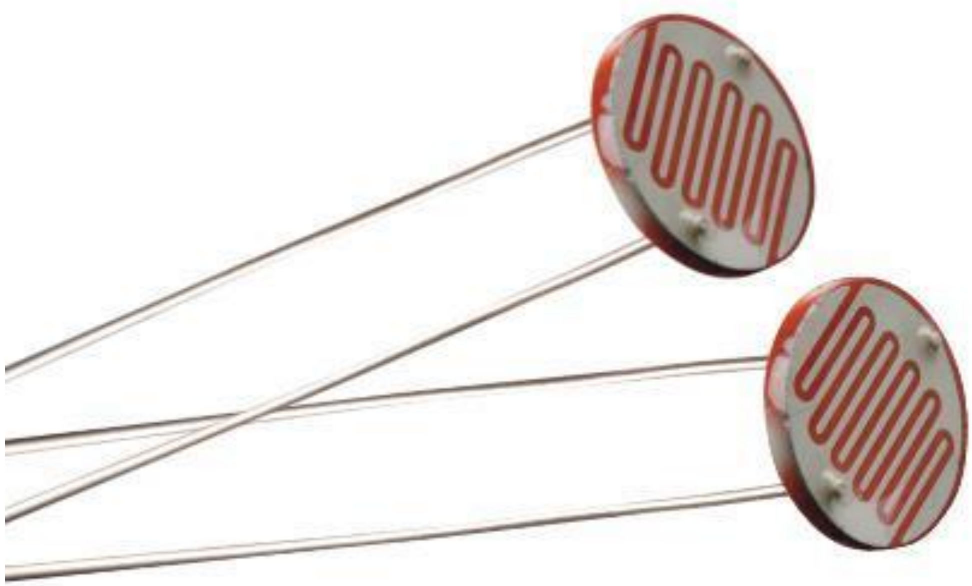

Fig.3.9. LDR

3.10. LM 358 Base

The LM358 IC is a great, low power and easy to use dual channel op-amp IC. It is designed and introduced by national semiconductor. It consists of two internally frequency compensated, high gain, independent op-amps. This IC is designed for specially to operate from a single power supply over a wide range of voltages. The LM358 IC is available in a chip sized package and applications of this op amp includes conventional op-amp circuits, DC gain blocks and transducer amplifiers. LM358 IC is a good, standard operational amplifier and it is suitable for your needs. It can handle 3-32V DC supply & source up to 20mA per channel. This op-amp is apt, if you want to operate two separate op-amps for a single power supply. It's available in an 8-pin DIP package.

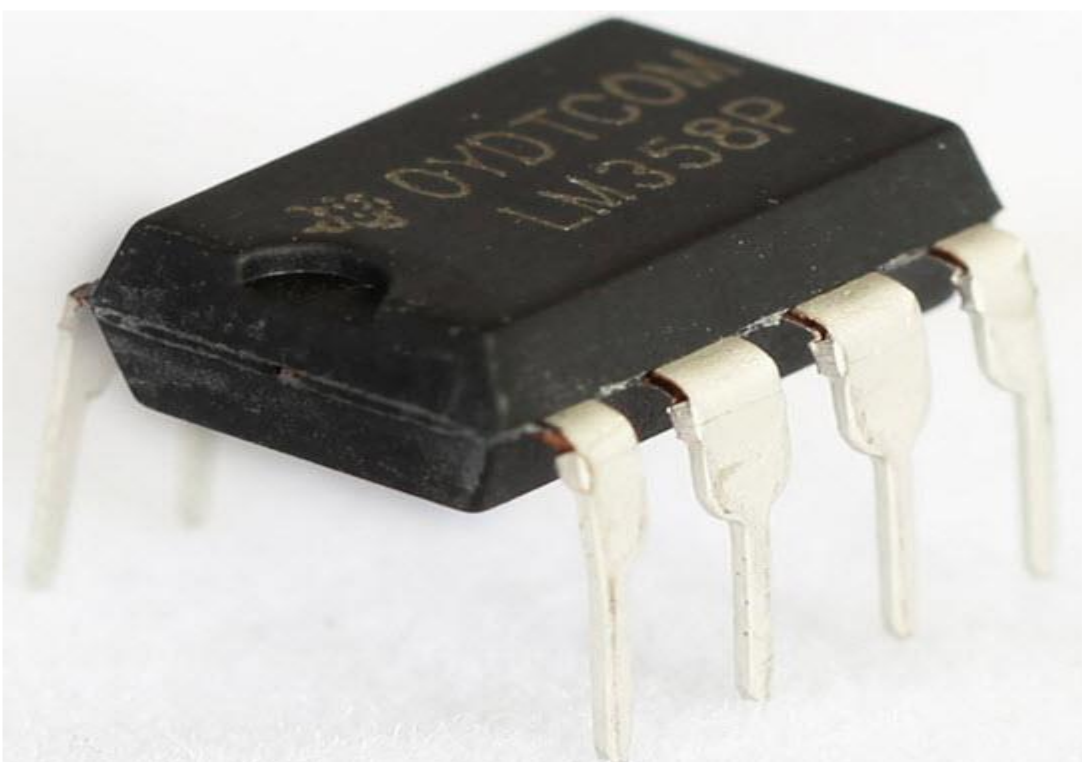

Fig. 3.10 LM 358Base

3.11. POTENTIOMETER

A potentiometer, informally a pot, is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat.

The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.

Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducer for example, in a joystick. Potentiometers are rarely used to directly control significant power (more than a watt), since the power dissipated in the potentiometer would be comparable to the power in the controlled load.

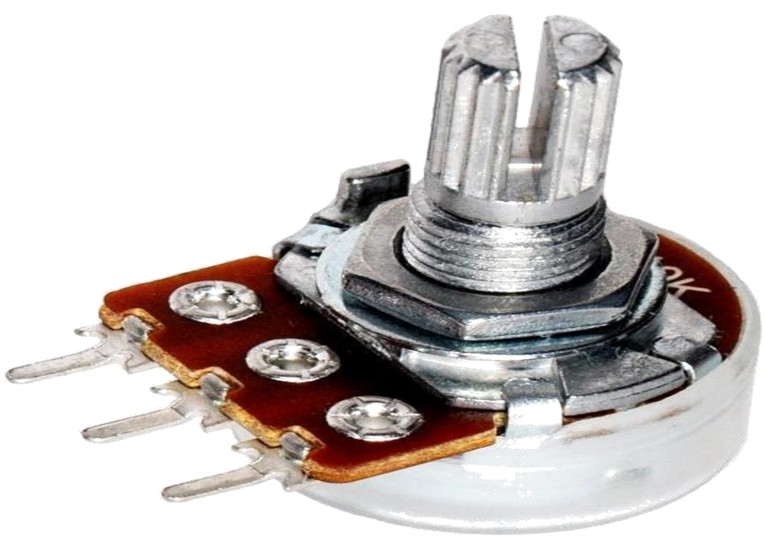

Fig3.11. Potentiometer

3.12. USB-ASP PROGRAMMER

USB-asp is a USB in-circuit programmer for Atmel AVR controllers. It simply consists of an ATMega88 or an ATMega8 and a couple of passive components. The programmer uses a firmware-only USB drive, no special USB controller is needed.

Features

- Works under multiple platforms. Linux, Mac OS X and Windows are tested.
- No special controllers components are needed.
- Programming speed is up to 5kBytes/sec.
- SCK option to support targets with low clock speed (< 1,5MHz).
- Planned: serial interface to target (e.g. for debugging).

Fig. 3.12 USB-ASP Programmer

Chapter-4

METHOD OF WORKING

4.1 PIEZOELECTRIC CRYSTAL

Piezoelectricity is the ability of some materials (notably crystal, certain ceramics, and biological matter such as bone ,DNA and various proteins) to generate and electric field or electric potential in response to applied mechanical strain. The effect is closely related to a change of polarization density within the material's volume. If the material is not short-circuited, the applied stress/strain induces a voltage across the material. However, if the circuit is closed the energy will be quickly released. So in order to run an electric load (such as a light bulb) on a piezoelectric device, the applied mechanical stress must oscillate back and forth. For example, if you had such a device in your shoes you could charge your cell phone while walking but not while standing.

"It is the ability of some materials to generate an electric potential in response to applied mechanical stress"

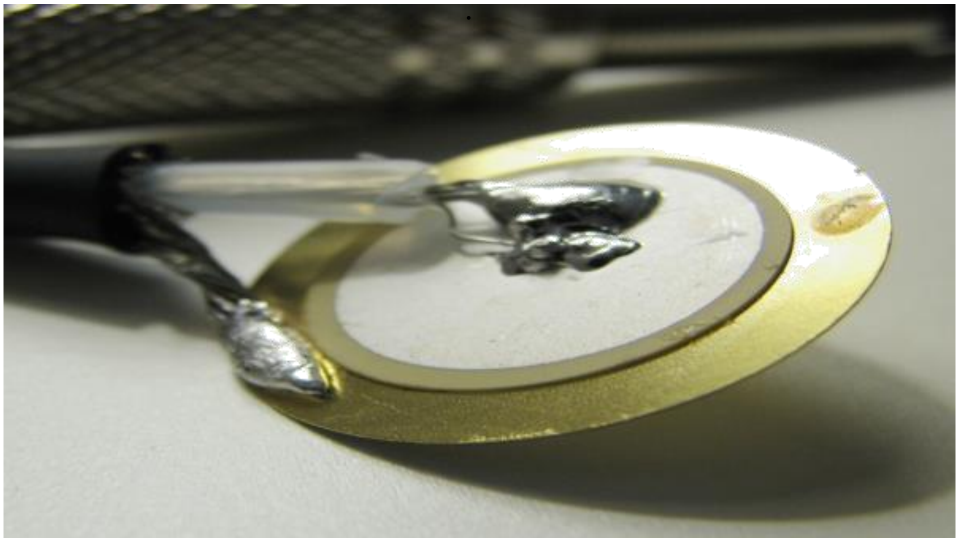

Fig. 4.1Piezoelectric Material

4.2 HOW THE PIEZOELECTRIC EFFECT WORKS

Any spatially separated charge will result in an electric field, and therefore an electric potential. Shown here is a standard dielectric in a capacitor. In a piezoelectric device, mechanical stress, instead of an externally applied voltage, causes the charge separation in the individual atoms of the material.

Of the thirty-two crystal classes, twenty-one are non-centre symmetric (not having a centre of symmetry), and of these, twenty exhibit direct piezoelectricity. Ten of these represent the polar crystal classes, which show a spontaneous polarization without mechanical stress due to a non-vanishing electric dipole moment associated with their unit cell, and which exhibit piezoelectricity. If the dipole moment can be reversed by the application of an electric field, the material is said to be ferroelectric.

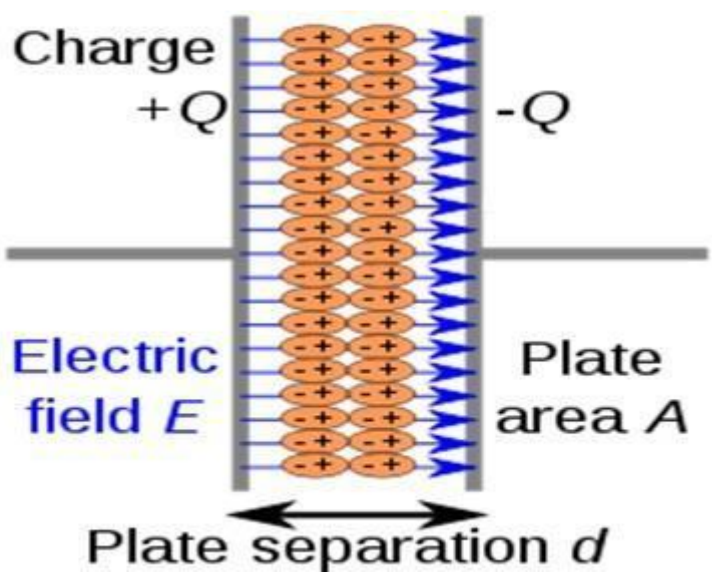

Fig. 4.2 Charge Accumulation in Piezoelectric Material

For polar crystals, for which $P \neq 0$ holds without applying a mechanical load, the piezoelectric effect manifests itself by changing the magnitude or the direction of P or both. For the non-polar, but piezoelectric crystals, on the other hand, a polarization P different from zero is only elicited by applying a mechanical load. For them the stress can be imagined to transform the material from a non-polar crystal class ($P = 0$) to a polar one, having $P \neq 0$.

The piezoelectric effect occurs when the charge balance within the crystal lattice of a material is disturbed. When there is no applied stress on the material, the positive and negative charges are evenly distributed so there is no potential difference. When the lattice is changed slightly, the charge imbalance creates a potential difference, often as high as several thousand volts. However, the current is extremely small and only causes a small electric shock. The converse piezoelectric effect occurs when the electrostatic field created by an electrical current cause the atoms in the material to move slightly.

4.3 MECHANISM

The nature of the piezoelectric effect is closely related to the occurrence of electric dipole moments in solids. The latter may either be induced for ions on crystal lattice sites with asymmetric charge surroundings (as in BaTiO3 and PZTs) or may directly be carried by molecular groups (as in cane sugar). The dipole density or polarization (dimensionality [Cm/m^3]) may easily be calculated for crystals by summing up the dipole moments per volume of the crystallographic unit cell. As every dipole is a vector, the dipole density *P* is also a vector or a directed quantity. Dipoles near each other tend to be aligned in regions called Weiss domains. The domains are usually randomly oriented, but can be aligned during poling (not the same as magnetic poling), a process by which a strong electric field is applied across the material, usually at elevated temperatures.

Of decisive importance for the piezoelectric effect is the change of polarization *P* when applying a mechanical stress. This might either be caused by a re-configuration of the dipole-inducing surrounding or by re-orientation of molecular dipole moments under the influence of the external stress. Piezoelectricity may then manifest in a variation of the polarization strength, its direction or both, with the details depending on

1) The orientation of P within the crystal
2) Crystal symmetry
3) The applied mechanical stress.

The change in P appears as a variation of surface charge density upon the crystal faces, i.e. as a variation of the electrical field extending between the faces, since the units of surface charge density and polarization are the same, C/m^2] = [Cm/m^3]. However, piezoelectricity is not caused by a change in charge density on the surface, but by dipole density in the bulk. For example, a 1 cm^3 cube of quartz with 2 KN (500 lbf) of correctly applied force can produce a voltage of 12500 V.

4.4 BATTERY

Nominal Voltage	6V
Nominal capacity	4.5Ah, 4500mAh
Max. Charging Current	1.35A
Max. Discharging Current	67.5A Max.
Weight	910g
Application	Electronic Toy- Cars, Emergency Lights, Fans. Power 6V Halogen light

4.5 INVERTER

Inverters are used to convert energy stored in DC power supplies, such as batteries, into AC power. Inverters can be small and portable devices that plug into the accessory outlet of a car or boat. They can also be large, permanent components of a battery-powered electrical system used for converting electricity between AC and DC power sources.

An inverter can be used to convert any DC power source to AC power. Small converters can power computers, small appliances, pumps, power tools or other personal electronics.

When the power supply is working, the inverter passes power through while charging the connected batteries as well. During power interruptions, the inverter automatically switches from utility power to battery backup power.

4.5.1 Diode

The most common function of a diode is to allow an electric current to pass in one direction (called the diode's forward direction), while blocking current in the opposite direction (the reverse direction). Thus, the diode can be viewed as an electronic version of a check valve. This unidirectional behavior is called rectification, and is used to convert alternating current to direct current, including extraction of modulation from radio signals in radio receivers—these diodes are forms of rectifiers. However, diodes can have more complicated behavior than this simple on–off action. Semiconductor diodes begin conducting electricity only if a certain threshold voltage or cut-in voltage is present in the forward direction (a state in which the diode is said to be forward-biased). The voltage drop across a forward-biased diode varies only a little with the current, and is a function of temperature; this effect can be used as a temperature sensor or voltage reference.

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4.6 NATURALLY-OCCURRING CRYSTALS

1. Berlinite ($AlPO_4$), a rare phosphate mineral that is structurally identical to quartz

2. Cane sugar

3. Quartz

4. Rochelle salt

5. Topaz

6. Tourmaline-group minerals

4.7 MAN-MADE CRYSTALS

1. Gallium orthophosphate (GaPO4), a quartz analogic crystal

2. Langasite (La3Ga5SiO14), a quartz analogic crystal

The family of ceramics with perovskite or tungsten- bronze structures
Exhibits piezoelectricity:

1. Barium titanate (BaTiO3)- Barium titanate was the first piezoelectric ceramic discovered.

2. Lead titanate (PbTiO3)

3. Lead zirconate titanate (Pb [Zr*x* Ti1−*x*] O3 0<*x*<1) more commonly known as PZT lead zirconate titanate is the most common piezoelectric ceramic in use today.

4. Potassium niobate (KNbO3)

5. Lithium niobate (LiNbO3)

6. Lithium tantalate (LiTaO3)

7. Sodium tungstate (Na2WO3)

8. Ba2NaNb5O5

9. Pb2KNb5O15

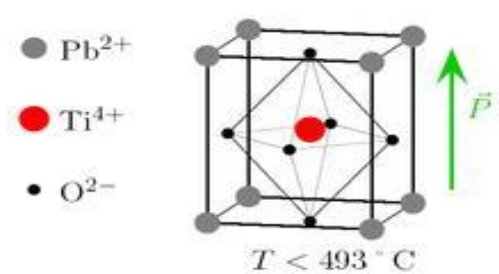


Fig. 4.3 Tetragonal Unit Cell of Lead Titanate

4.8. LEAD-FREE PIEZOCERAMICS

More recently, there is growing concern regarding the toxicity in lead-containing devices driven by the result of restriction of hazardous substances directive regulations. To address this concern, there has been a resurgence in the compositional development of lead-free piezoelectric materials.

1) Sodium potassium niobate (NaKNb). In 2004, a group of Japanese researchers led by Yasuyoshi Saito discovered a sodium potassium niobate composition with properties close to those of PZT, including a high *TC*.

2) Bismuth ferrite (BiFeO3) is also a promising candidate for the replacement of lead-based ceramics. Sodium niobate NaNbO3

3) So far, neither the environmental impact nor the stability of supplying these substances has been confirmed.

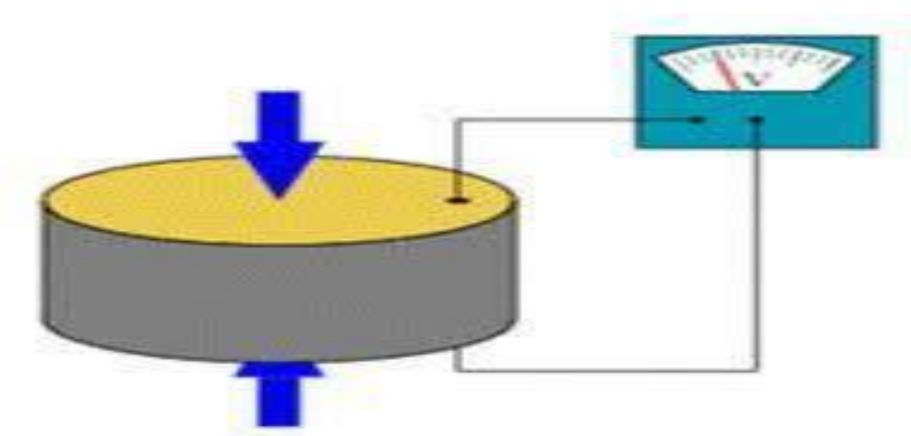


Fig.4.4 Piezoelectric Material

4.9. MODES OF OPERATION OF PIEZOELECTRIC CRYSTALS

The piezoelectric crystals are used in many modes. Modes relate to the direction of the force applied and the direction of corresponding charge produced. Knowledge of modes is important for optimization of the shoe model for voltage production. These modes are

1. Thickness shear
2. Face shear
3. Thickness expansion
4. Transverse expansion

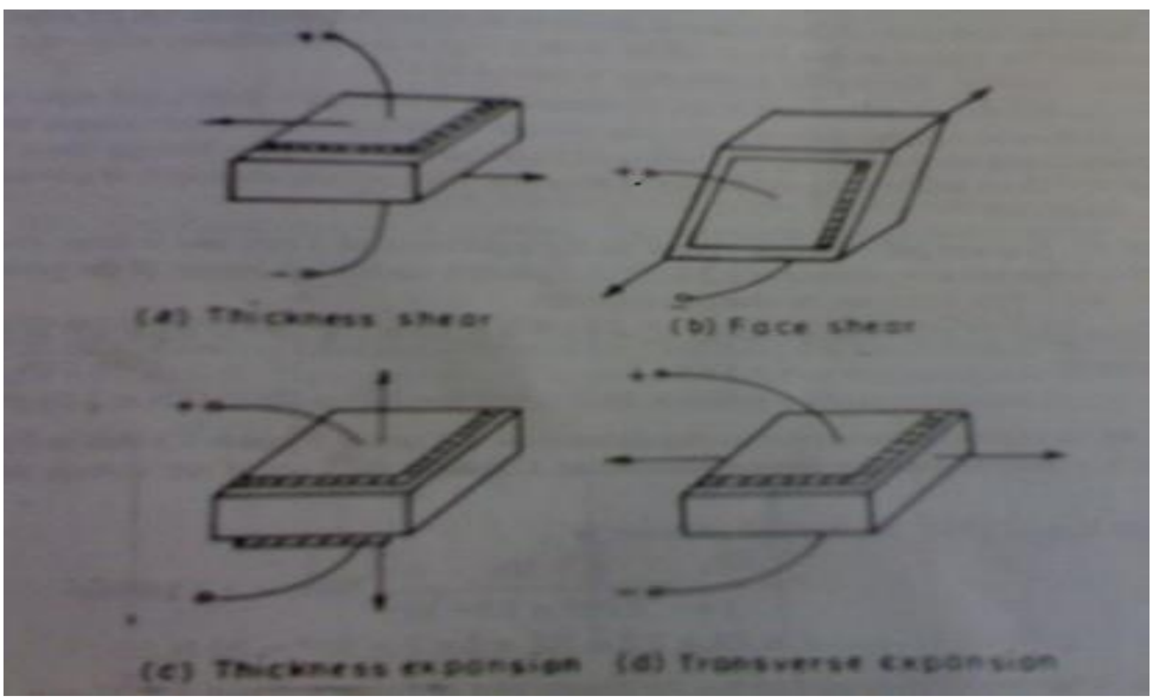


Fig.4.5 Different Modes of Operations

1. Thickness shear

   Force - along thickness.

   Charge production - along y axis.

2. Face shear

   Force - along the surface.

   Charge production - along the surface.

3. Thickness expansion Force

   - along y axis

   Charge production - along y axis.

4. Transverse expansion Force

   - along y axis

   Charge production - along y axis

By cementing two crystals together so that their electrical axes are perpendicular, ‘benders’ or twisters can be produced. This means that a bending produces an output voltage. Similarly a twisting motion applied to a twister produces an output.

Piezoelectric crystals can be used in another mode for force measurement. A crystal controlled electronic oscillator uses a thin plate of quartz. The natural frequency of mechanical oscillation of the plate determines the frequency of electrical oscillation

4.10 PROPOSED WORK

We connect the piezoelectric crystal in series through wires. After then the generated voltage is stored in the battery. The generated voltage which is generated by piezoelectric crystal is D.C. which is change into A.C by inverter. The load is connected to the inverter, which is glow when A.C is given by the inverter

.

4.11 APPLICATIONS

Piezoelectric measuring devices are widely used today in the laboratory, on the production floor and as original equipment. They are used in almost every conceivable application requiring accurate measurement and recording of dynamic changes in mechanical variable such as pressure, force and acceleration. The list of applications continues to grow and now includes

1) Aerospace: Modal testing, wind tunnel and shock tube instrumentation, landing gear hydraulics, rocketry, structures, ejection systems and cutting force research.
2) Ballistics: Combustion, explosion, detonation and sound pressure distribution.
3) Biomechanics: Multi-component force measurement for orthopedic gait, sports, ergonomics, neurology, cardiology and rehabilitation.
4) Engine Testing: Combustion, gas exchange and injection, indicator diagrams and dynamic stressing.
5) Engineering: Materials evaluation, control systems, reactors, building structures, ship structures, auto chassis structural testing, shock and vibration isolation and dynamic response testing.
6) Industrial/Factory: Machining systems, metal cutting, press and crimp force, automation of force based assembly operations and machine health monitoring.
7) The best-known application is the electric cigarette lighter: pressing the button causes a spring-loaded hammer to hit a piezoelectric crystal, producing a sufficiently high voltage electric current that flows across a small spark gap, thus heating and igniting the gas. The

portable sparkers used to light gas grills or stoves work the same way, and many types of gas burners now have built-in piezo-based ignition systems.

8) Charging microelectronic devices.
9) Military purpose
10) Space bio-suit
11) Medical field
12) Small piezoelectric crystals can produce enough voltage to create a spark large enough to ignite gas. These igniters are used in many gas-powered appliances like ovens, grillers, room heaters, and hot water heaters. They are even small enough to fit inside lighters, although most lighters still use flint because it costs less, and only the more expensive lighters use piezo igniters. While there have been many attempts at generating electricity from the effect, it has proven impractical on a large scale.

13) Piezoelectric crystals are used in electronic clocks and watch to maintain the time and provide the alarm noise. They are also called quartz clocks because the crystal they use is often made from quartz. It has a natural frequency that is ideal for creating the oscillations needed to maintain exact time. Quartz clocks are also used to organize the flow of data in computers. Discs of piezoelectric material are also used to create thin speakers that fit inside wristwatches.

Sonar transducers apply an electrical pulse to a piezoelectric crystal to create a pressure wave, and then produce a current when the reflected wave deforms the crystal. The time gap between the two currents is used to work out how far away an object it. Industrial inkjet printers use the converse piezoelectric effect to move ink through the hundreds of nozzles in their print heads. An electric current makes a tiny crystal in each nozzle bend, creating a pressure pulse that forces the ink out. Ink is drawn into the nozzle when the current stops and the crystal relax.

Chapter-5

RESULTS AND DISCUSSION

As our final year project is to generate electricity from piezoelectric crystals. After making the connection we stored the voltage in a 6V battery which is connected to the load.

5.1 TESTING

We tested the generated voltage by each piezoelectric crystal with multi-meter. The maximum generated voltage by each piezoelectric crystal is 1.1V. However, generated voltage depends on the force applied at each piezoelectric crystal. The resulted power developed is of 6 Watt.

5.2 ISSUES AND PROBLEMS

1**.** It is very difficult to apply the pressure on the crystal in proper manner.

2.Battery takes the long time to charge.

5.3 CONCLUSION

In this project we are generating electricity through piezoelectric crystal by connecting wire with piezoelectric generator and then the results of these experiments confirm that the voltage signals generated from these materials are proportional to the amplitudes of mechanical movement, with good response to high frequencies.

This is an excellent alternative to reach the increasing elements for electricity. We conclude that it should be implemented in INDIA also to accelerate the development. As we all know that

INDIA is facing the problem in the loss of electricity. So to remove this problem piezoelectric material embedded which can generate free electricity. This element is cheap and easy to generate electricity. The piezoelectric materials have been extensively used in the aerospace devices, structural health monitoring, vibration control, and energy harvesting applications. Therefore we are generating free electricity and storing this in the battery.

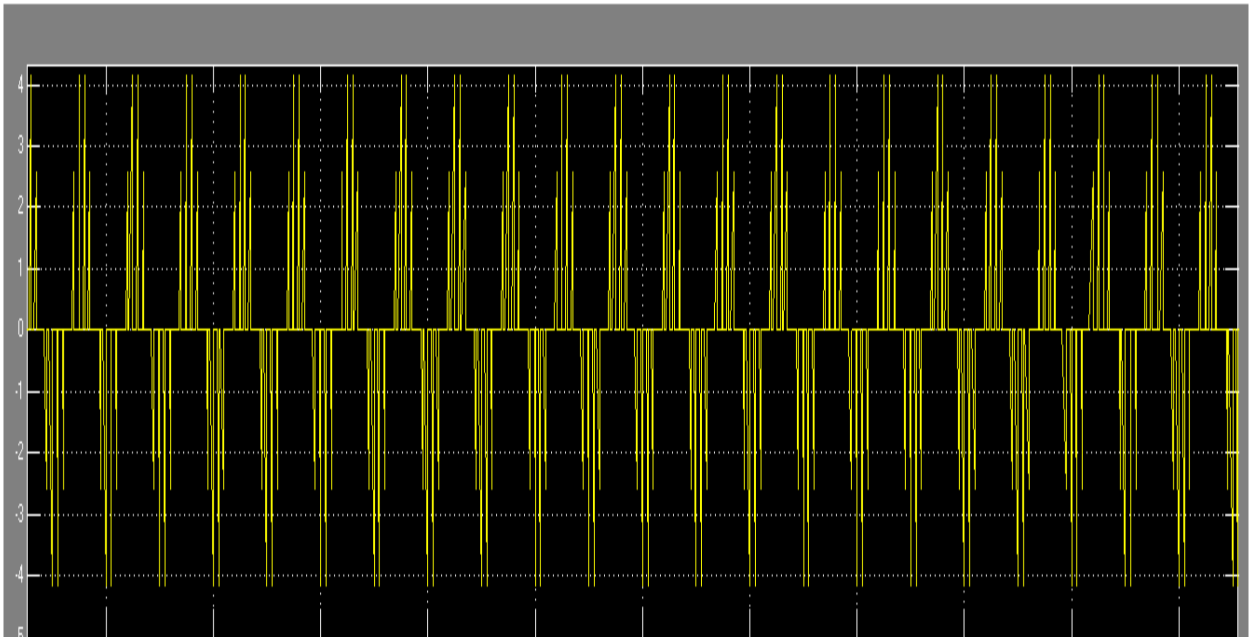
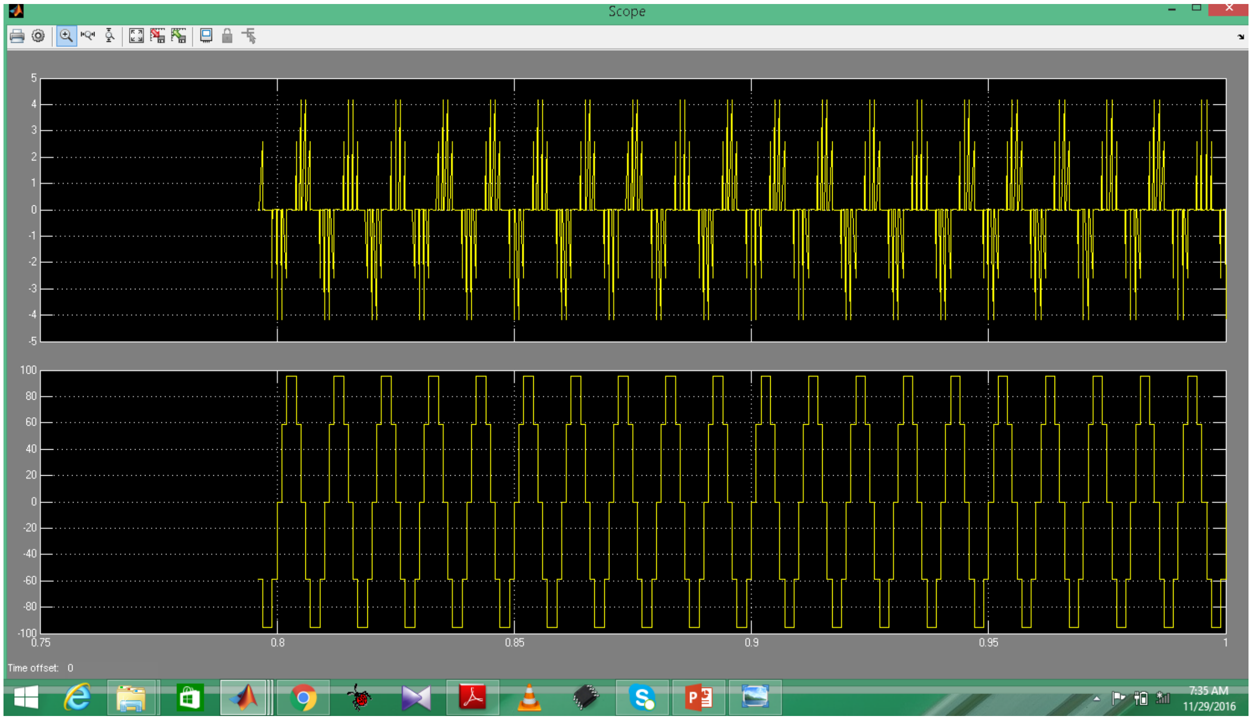


Fig 5.1



Scope
5
4
3
2
1
0
-1
-2
-3
-4
-5
100
80
60
40
20
0
-20
-40
-60
-80
-100
0.75
0.8
0.85
0.9
0.95
1
Time offset: 0
7:35 AM
11/29/2016

Fig 5.2

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