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A Project Report On

"Knock/ Vibration Activated Alarm"

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Rajarshi Shahu Mahavidyalaya (Autonomous), Latur

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Partial Fulfilment For

The Award of the Degree of

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PHYSICS

UNDER THE FACULTY OF SCIENCE

BY

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Rajarshi Shahu Mahavidyalaya (Autonomous), Latur

LATUR-413512 M.S. INDIA

2021-2022

शिव छत्रपती शिक्षण संस्था लातूर

CERTIFICATE

This is to certify that the project report entitled " Knock/Vibration Activated Alarm" which is being submitted here with is the result of the project work completed by Mr Nathbone Rushikesh Pandurang (RLS2244221), Mr. Birajdar Ravi Siddheshwar (RLS2244206), Mr. Kamble Abhishek Nagnath (RLS2244216), Mr Kshirsagar Abhimanyu Narsing (RLS2244219) Under my supervision and guidance.

Place : Latur

Date : 27-04-2022

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Examiners signature & date:

1) 52/60

2)

DECLARATION

I hereby declare that the project " Knock/ Vibration Activated Alarm " submitted to department of physics, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur during the year 2021-2022 as a part of partial fulfilment of degree of Master of Science In Physics is completed by me and has not previously been formed on the basis for the award of any degree or diploma or similar title of this or any other university, or examining body.

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ABSTRACT

In this modern world everyone wants something new, something different, so instead of using a switch to ring the doorbell just an alarm is produced by knocking the door which people feel more luxurious. The circuit of automatic alarm on knocking uses a thin piezoelectric plate, senses the vibration generated on knocking a surface (such as a door or a table) to activate the alarm and can also be used to safeguard motor vehicles. The piezoelectric plate is used as the sensor. Piezoelectric material is used at the input in order to convert any mechanical vibration into electrical variation, it avoids false triggering. The plate can be fixed on a door, cash box, cupboard, etc. using adhesive. A 1-1.5m long, shielded wire is connected between the sensor plate and the input of the circuit. A led is placed at the output. The circuit operates off a 9V or a 12V battery.

Keywords: piezoelectric plate Sensor, Resistor, Capacitor, Transistor etc.

INDEX

Chapter I : INTRODUCTION

The circuit of Knock alarm uses a thin piezoelectric plate, senses the vibration generated on knocking a surface (such as a door or a table) to activate the alarm and can also be used to safeguard motor vehicles. The piezoelectric plate is used as the sensor.

Piezoelectric material is used at the input in order to convert any mechanical vibration into electrical variation, it avoids false triggering. When someone knocks on the door, the piezoelectric sensor generates an electrical signal, which is amplified by transistors. The amplified signal is rectified and filtered to produce a low-level DC voltage, which is further amplified by the remaining transistors. The plate can be fixed on a door, cash box, cupboard etc. using adhesive. A 1-1.5m long, shielded wire is connected between the sensors plate and the input of the circuit. A led is placed at the output. The circuit operates off a 9V or a 12V battery.

An earthquake consists of vibrations to the Earth's surface that follow a release of energy in the Earth's crust. The vibration is called seismic waves it travel outward from the source of the earthquake along the surface and through the earth at different velocities depending on the materials that they move through (Pakiser & Shedlock, 2016).

There are several, different kinds of seismic waves, and these move in different ways. The two main types of waves are body waves and surface waves. Body waves can travel through the earth's inner layers, but surface waves can only move along the surface of the planet like ripples on water. Earthquakes radiate seismic energy as both body and surface waves.

Earthquakes strike suddenly without a warning. Nevertheless, if your local schools are in a region at risk for earthquakes, there are things that can be done to reduce the chances of injury, damaged of school properties and risk of the students and its employees. (Fema,

2018) Earthquake causes a lot of destruction, killing many casualties and destroying properties especially when intensity is high.

Earthquakes come without a warning. This, learning institutions should be prepared and ready. Creation of an emergency hazard plan and implementation of earthquake drills is one of best precautionary measures and it would create awareness among students, staff and teachers regarding appropriate actions during the actual occurrence of earthquake.

Chapter II : WORKING

This is inexpensive project can be used as Knock/ Vibration activated alarm. Piezo Electric Sensor plate can be fixed on table, door, cupboard, window etc. Using cello tape or adhesive.

When an intruder knocks on them Piezo electric censor converts mechanical vibrations into electrical variations. Electrical pulses are undergone amplification by transistor amplifier stages.

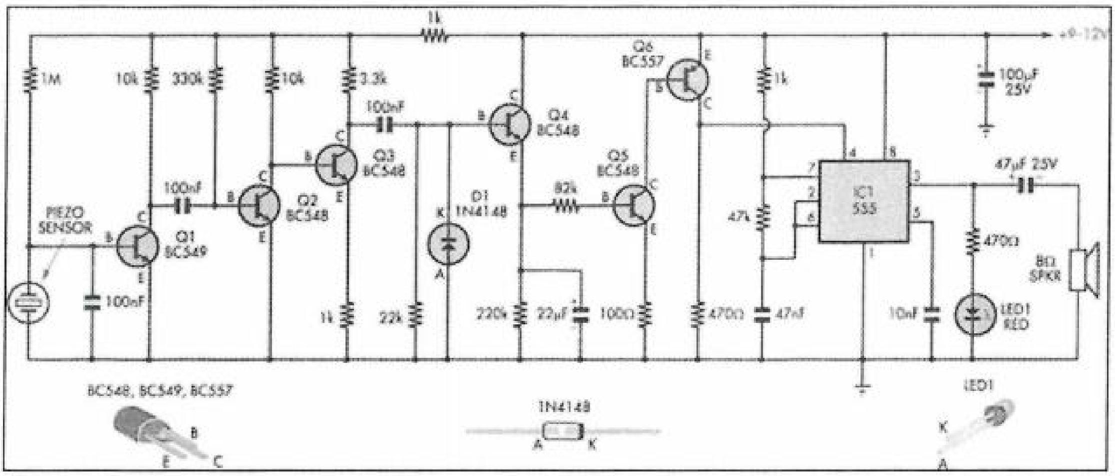
Final transistor drives a piezo buzzer.

Time delay can be changed by adjusting value of capacitor connected across 220k resistors.

To activate Ac loads buzzer may be replaced with a relay. Load to be controlled can be connected via normally opened contacts of the relay.

For demonstration a 9V battery can be used. For continuous use, alarm may be powered using 9v or 12v AC adaptor. Simple unregulated supply is enough.

This alarm can be used to protect car and other vehicles. Other application of this project is an earthquake warning alarm. Circuit of Power supply with battery backup shown below.



Simple Knock Alarm Circuit Diagram

Chapter III : Components Details

RESISTORS AND CAPACITORS

Resistors:

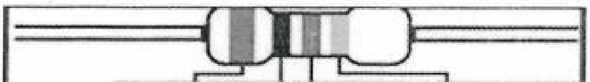
Introduction

A resistor is a two-terminal electronic component that produces a voltage across its

Terminals that is proportional to the electric current through it in accordance with Ohm's law:

$V = IR$

Resistors are elements of electrical networks and electronic circuits and are ubiquitous in most electronic equipment. Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel-chrome).



Gold	-	-	÷10	5% tolerance
Black	0			
Brown	1	1	0	1% tolerance
Red	2	2	00	
Orange	3	3	000	
Yellow	4	4	0000	
Green	5	5	00000	
Blue	6	6	000000	
Violet	7	7	0000000	
Grey	8	8		
White	9	9		

Fig: resistor code

The primary characteristics of a resistor are the resistance, the tolerance, the maximum working voltage and the power rating. Other characteristics include temperature coefficient, noise, and inductance. Less well-known is critical resistance, the value below which power dissipation limits the maximum permitted current, and above which the limit is applied voltage.

Critical resistance is determined by the design, materials and dimensions of the resistor. Resistors can be integrated into hybrid and printed circuits, as well as integrated circuits. Size, and position of leads (or terminals), are relevant to equipment designers; resistors must be physically large enough not to overheat when dissipating their power.

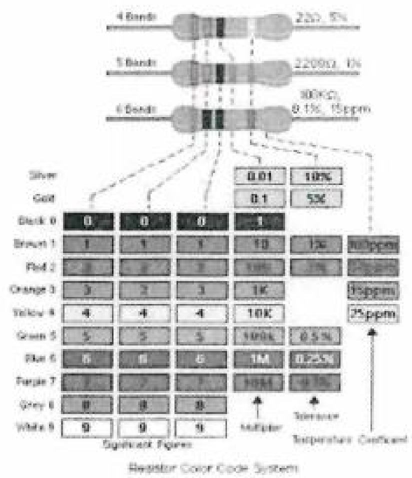


Fig. Resistor colour code

Theory of operation

Ohm's law

The behaviour of an ideal resistor is dictated by the relationship specified in Ohm's law:

Ohm's law states that the voltage (V) across a resistor is proportional to the current (I) through it where the constant of proportionality is the resistance (R).

Equivalently, Ohm's law can be stated:

This formulation of Ohm's law states that, when a voltage (V) is maintained across a resistance (R), a current (I) will flow through the resistance.

This formulation is often used in practice. For example, if V is 12 volts and R is 400 ohms, a current of 12 / 400 = 0.03 amperes will flow through the resistance R.

Resistors used in Knock Alarm using piezoelectric material Circuitry:

i. 100 Ω

ii. 470 Ω

iii. 1 K Ω

Iv. 3.3 K Ω

v. 10 K Ω

Vi. 22 K Ω

Vii. 47 K Ω

Viii.82 K Ω

Ix. 220 K Ω

x. 330 K Ω

Xi. 1 M Ω

Capacitors:

A capacitor is an electrical device that can store energy in the electric field between a pair of closely spaced conductors (called 'plates'). When current is applied to the capacitor, electric charges of equal magnitude, but opposite polarity, build up on each plate.

Capacitors are used in electrical circuits as energy-storage devices. They can also be used to differentiate between high-frequency and low-frequency signals and this makes them useful in electronic filters.

Capacitors are occasionally referred to as condensers. This is now considered an antiquated term. The capacitor's capacitance (C) is a measure of the amount of charge (Q) stored on each plate for a given potential difference or voltage (V) which appears between the plates:

$C=Q/V$

In SI units, a capacitor has a capacitance of one farad when one coulomb of charge is stored due to one volt applied potential difference across the plates. Since the farad is a very large unit, values of capacitors are usually expressed in microfarads (μF), Nano farads (mph), or Pico farad (pF).

The capacitance is proportional to the surface area of the conducting plate and inversely proportional to the distance between the plates. It is also proportional to the permittivity of the dielectric (that is, non-conducting) substance that separates the plates.

Capacitor types:

Vacuum:

Two metal, usually copper, electrodes are separated by a vacuum. The insulating envelope is usually glass or ceramic. Typically of low capacitance - 10 - 1000 pF and high voltage, up to tens of kilovolts, they are most often used in radio transmitters and other high voltage power devices. Both fixed and variable types are available. Variable vacuum capacitors can have a minimum to maximum capacitance ratio of up to 100, allowing any tuned circuit to cover a full decade of frequency. Vacuum is the most perfect of dielectrics with a zero loss tangent. This allows very high powers to be transmitted without significant loss and consequent heating.

Air:

Air dielectric capacitors consist of metal plates separated by an air gap. The metal plates, of which there may be many interleaved, are most often made of aluminium or silver-plated brass. Nearly all air dielectric capacitors are variable and are used in radio tuning circuits.

Metalized plastic film:

Made from high quality polymer film (usually polycarbonate, polystyrene, polypropylene, polyester (Mylar), and for high quality capacitors polysulfide), and metal foil or a layer of metal deposited on surface. They have good quality and stability, and are suitable of timer circuits suitable for high frequencies.

Mica:

Similar to metal film, often high voltage, suitable for high frequencies, expensive, excellent tolerance.

Paper:

Used for relatively high voltages. Now obsolete.

Glass:

Used for high voltages, expensive, stable temperature coefficient in a wide range of temperatures.

Ceramic:

Chips of alternating layers of metal and ceramics. Depending on their dielectric, whether Class 1 or Class 2, their degree of temperature/capacity dependence varies. They often have (especially the class 2) high dissipation factor, high frequency coefficient of dissipation, their capacity depends on applied voltage, and their capacity changes with aging. However they find massive use in common low-precision coupling and filtering applications, suitable for high frequencies.

Aluminium electrolytic:

Polarized, construction ally similar to metal film, but the electrodes are made of etched aluminium to acquire much larger surfaces. The dielectric is soaked with liquid electrolyte. They can achieve high capacities but suffer from poor tolerances, high instability, gradual loss of capacity especially when subjected to heat, and high leakage. Tend to lose capacity in low temperatures. Bad frequency characteristics make them unsuited for high-frequency applications. Special types with low equivalent series resistance are available.

Tantalum electrolytic:

Similar to the aluminium electrolytic capacitor but with better frequency and temperature characteristics, high dielectric absorption, high leakage. Has much better performance in low temperatures.

Super capacitors:

Made from carbon aerogel, carbon nanotubes, or highly porous electrode materials. Extremely high capacity and can be used in some applications instead of rechargeable batteries.

Gimmick capacitors:

These are capacitors made from two insulated wires that have been twisted together. Each wire forms a capacitor plate. Gimmick capacitors are also a form of variable capacitor. Small changes in capacitance (20 present or less) are obtained by twisting and untwisting the two wires.

Varian capacitors:

These are specialized, reverse-biased diodes whose capacitance varies with voltage. Used in phase-locked loops, amongst other applications.

Capacitors used in this project are:

- 0.01 μF
- 0.1 μF
- 22 μF
- 47 μF
- 100 μF

TRANSISTOR

A transistor is a semiconductor device used to amplify and switch electronic signals. It is made of a solid piece of semiconductor material, with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current flowing through another pair of terminals. Because the controlled (output) power can be much more than the controlling (input) power, the transistor provides amplification of a signal. Today, some transistors are packaged individually, but many more are found embedded in integrated circuits.

The transistor is the fundamental building block of modern electronic devices, and is ubiquitous in modern electronic systems. Following its release in the early 1950s the transistor revolutionised the field of electronics, and paved the way for smaller and cheaper radios, calculators, and computers, amongst other things.

A bipolar junction transistor (BJT) is a three-terminal electronic device constructed of doped semiconductor material and may be used in amplifying or switching applications. Bipolar transistors are so named because their operation involves both electrons and holes.

Charge flow in a BJT is due to bidirectional diffusion of charge carriers across a junction between two regions of different charge concentrations. This mode of operation is contrasted with unipolar transistors, such as field-effect transistors, in which only one carrier type is involved in charge flow due to drift. By design, most of the BJT collector current is due to the flow of charges injected from a high-concentration emitter into the base where they are minority carriers that diffuse toward the collector, and so BJTs are classified as minority-carrier devices.

Introduction

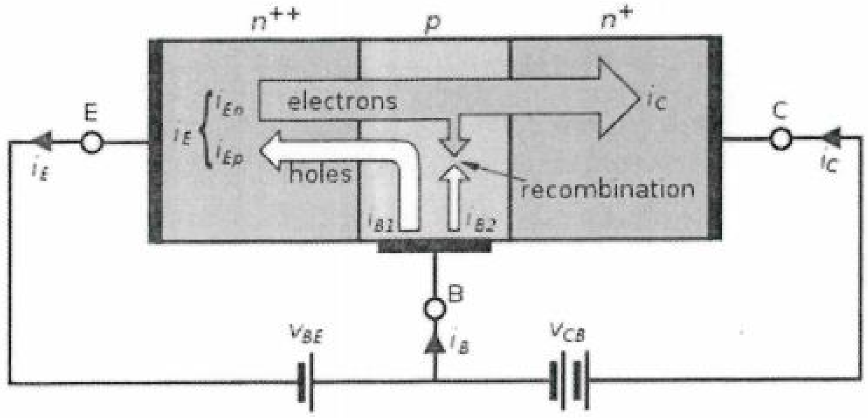


Fig:-1 NPN BJT with forward-biased E–B junction and reverse-biased B–C junction

An NPN transistor can be considered as two diodes with a shared anode. In typical operation, the base-emitter junction is forward biased and the base–collector junction is reverse biased. In an NPN transistor, for example, when a positive voltage is applied to the base–emitter junction, the equilibrium between thermally generated carriers and the repelling electric field of the depletion region becomes unbalanced, allowing thermally excited electrons to inject into the base region. These electrons wander (or "diffuse") through the base from the region of high concentration near the emitter towards the region of low concentration near the collector. The electrons in the base are called minority carriers because the base is doped p-type which would make holes the majority carrier in the base.

To minimize the percentage of carriers that recombine before reaching the collector–base junction, the transistor's base region must be thin enough that carriers can diffuse across it in much less time than the semiconductor's minority carrier lifetime. In particular, the thickness of the base must be much less than the diffusion length of the electrons. The collector–base junction is reverse-biased, and so little electron injection occurs from the collector to the base, but electrons that diffuse through the base towards the collector are swept into the collector by the electric field in the depletion region of the collector–base junction. The thin shared base and asymmetric collector–emitter doping is what differentiates a bipolar transistor from two separate and oppositely biased diodes connected in series.

Voltage, current, and charge control

The collector–emitter current can be viewed as being controlled by the base–emitter current (current control), or by the base–emitter voltage (voltage control). These views are related by the current–voltage relation of the base–emitter junction, which is just the usual exponential current–voltage curve of a p-n junction (diode)

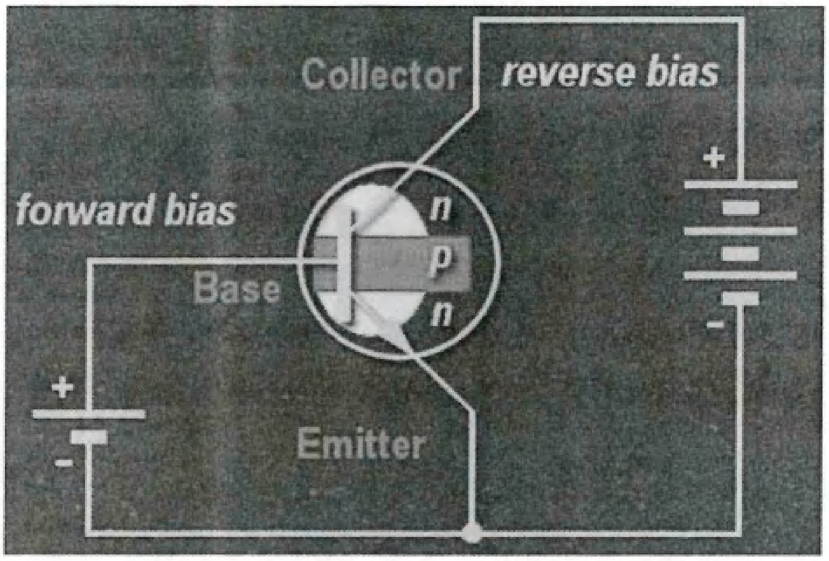


Fig. 2 Voltage, current, and charge control

The physical explanation for collector current is the amount of minority-carrier charge in the base region. Detailed models of transistor action, such as the Gummel–Poon model, account for the distribution of this charge explicitly to explain transistor behaviour more exactly.

The charge-control view easily handles phototransistors, where minority carriers in the base region are created by the absorption of photons, and handles the dynamics of turn-off, or recovery time, which depends on charge in the base region recombining. However, because base charge is not a signal that is visible at the terminals, the current- and voltage-control views are generally used in circuit design and analysis.

In a log circuit design, the current-control view is sometimes used because it is approximately linear. That is, the collector current is approximately βF times the base current. Some basic circuits can be designed by assuming that the emitter–base voltage is approximately constant, and that collector current is beta times the base current. However, to accurately and reliably design production BJT circuits, the voltage-control (for example, Ebers–Moll) model is required. The voltage-control model requires an exponential function to be taken into account, but when it is linearized such that the transistor can be modelled as a Tran's conductance, as in the Ebers–Moll model, design for circuits such as differential amplifiers again becomes a mostly linear problem, so the voltage-control view is often preferred. For Tran's linear circuits, in which the exponential I–V curve is key to the operation, the transistors are usually modelled as voltage controlled with Trans conductance proportional to collector current. In general, transistor level circuit design is performed using SPICE or a comparable analogue circuit simulator, so model complexity is usually not of much concern to the designer.

Turn-on, turn-off, and storage delay

The Bipolar transistor exhibits a few delay characteristics when turning on and off. Most transistors, and especially power transistors, exhibit long base storage time that limits maximum frequency of operation in switching applications. One method for reducing this storage time is by using a Baker clamp.

Transistor 'alpha' and 'beta'

The proportion of electrons able to cross the base and reach the collector is a measure of the BJT efficiency. The heavy doping of the emitter region and light doping of the base region cause many more electrons to be injected from the emitter into the base than holes to be injected from the base into the emitter. The common-emitter current gain is represented by βF or hfe; it is approximately the ratio of the DC collector current to the DC base current in forward-active region. It is typically greater than 100 for small-signal transistors but can be smaller in transistors designed for high-power applications. Another important parameter is the common-base current gain, αF. The common-base current gain is approximately the gain of current from emitter to collector in the forward-active region. This ratio usually has a value close to unity; between 0.98 and 0.998. Alpha and beta are more precisely related by the following identities (NPN transistor): Structure

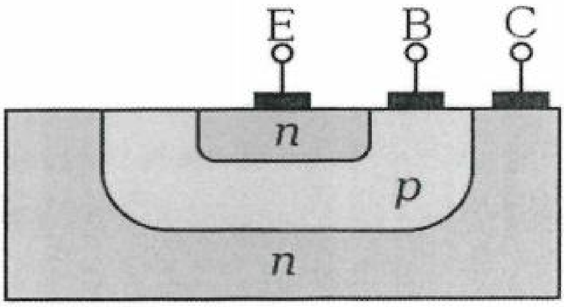


Fig: Simplified cross section of a planar NPN bipolar junction transistor

A BJT consists of three differently doped semiconductor regions, the emitter region, the base region and the collector region. These regions are, respectively, p type, n type and p type in a PNP, and n type, p type and n type in a NPN transistor. Each semiconductor region is connected to a terminal, appropriately labelled: emitter (E), base (B) and collector (C).

The base is physically located between the emitter and the collector and is made from lightly doped, high resistivity material. The collector surrounds the emitter region, making it almost impossible for the electrons injected into the base region to escape being collected, thus making the resulting value of α very close to unity, and so, giving the transistor a large β. A cross section view of a BJT indicates that the collector–base junction has a much larger area than the emitter–base junction.

NPN

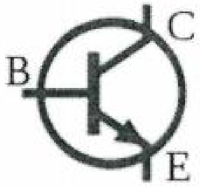


Fig The symbol of an NPN Bipolar Junction Transistor.

NPN is one of the two types of bipolar transistors, in which the letters "N" (negative) and "P" (positive) refer to the majority charge carriers inside the different regions of the transistor.

Most bipolar transistors used today are NPN, because electron mobility is higher than whole mobility in semiconductors, allowing greater currents and faster operation.

NPN transistors consist of a layer of P-doped semiconductor (the "base") between two N-doped layers. A small current entering the base in common-emitter mode is amplified in the collector output. In other terms, an NPN transistor is "on" when its base is pulled high relative to the emitter.

The arrow in the NPN transistor symbol is on the emitter leg and points in the direction of the conventional current flow when the device is in forward active mode.

Transistors used in this project are:

- BC 548 (NPN)
- BC 549 (NPN)
- BC 557 (PNP)

DIODE

Introduction:

In electronics, a diode is a two-terminal electronic component that conducts electric current in only one direction. The term usually refers to a semiconductor diode, the most common type today. This is a crystalline piece of semiconductor material connected to two electrical terminals.

A vacuum tube diode (now little used except in some high-power technologies) is a vacuum tube with two electrodes: a plate and a cathode.

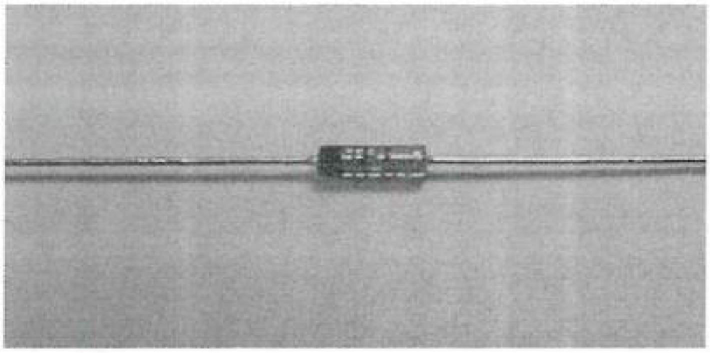


Fig: Diode

The most common function of a diode is to allow an electric current to pass in one direction (called the diode's forward bias direction) while blocking current in the opposite direction (the reverse direction). Thus, the diode can be thought of as an electronic version of a check valve. This unidirectional behaviour is called rectification, and is used to convert alternating current to direct current, and to extract modulation from radio signals in radio receivers.

However, diodes can have more complicated behaviour than this simple on-off action. This is due to their complex non-linear electrical characteristics, which can be tailored by varying the construction of their P-N junction. These are exploited in special purpose diodes that perform many different functions. For example, specialized diodes are used to regulate voltage (Zener diodes), to electronically tune radio and TV receivers (reactor diodes), to generate radio frequency oscillations (tunnel diodes), and to produce light (light emitting diodes). Tunnel diodes exhibit negative resistance, which makes them useful in some types of circuits.

Diode used in the present project is 1N4148

Features:

- Hermetically sealed leaded glass SOD27 (DO-35) package
- High switching speed: max. 4 ns

• General application

• Continuous reverse voltage: max. 100 V

• Repetitive peak reverse voltage: max. 100 V

• Repetitive peak forward current: max. 450 mA.

Applications:

• High-speed switching.

Description:

The 1N4148 is high-speed switching diodes fabricated in planar technology, and encapsulated in hermetically sealed leaded glass SOD27 (DO-35) packages.

PIEZO ELECTRIC SENSOR

Piezoelectric sensor is a device that uses the piezoelectric effect tomeasurechangesin pressure, acceleration, temperature, strain, or force by converting them to an electrical charge. The prefix *piezo-* is Greek for 'press' or 'squeeze'

Piezoelectric sensors are versatile tools for the measurement of various processes. They are used for quality assurance, process control, and for research and development in many industries. Pierre Curie discovered the piezoelectric effect in 1880, but only in the 1950s did manufacturers begin to use the piezoelectric effect in industrial sensing applications. Since then, this measuring principle has been increasingly used, and has become a mature technology with excellent inherent reliability.

They have been successfully used in various applications, such as in medical, aerospace, nuclear instrumentation, and as a tilt sensor in consumer electronics or 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 10^6 N/m^2. Even though piezoelectric sensors are electromechanical systems that react to compression, the sensing elements show almost zero deflection. This gives piezoelectric sensors ruggedness, 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) are extremely stable at high temperatures, enabling sensors to have a working range of up to 1000 °C. Tourmaline shows pyro electricity 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 piezoceramic materials. Gautschi in *Piezoelectric Sensorics* (2002) offers this comparison table of characteristics of piezo sensor materials vs other types:

Principle Strain	Sensitivity (V/µ*)	Threshold (µ*)	Span to threshold ratio
Piezoelectric	5.0	0.00001	100.00
Piezoresistive	0.0001	0.0001	2.500
Inductive	0.001	0.0005	2.000
Capacitive	0.005	0.0001	750.00

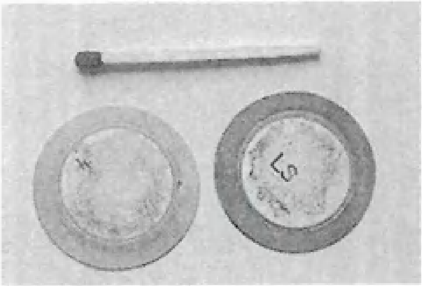
One disadvantage of piezoelectric sensors is that they cannot be used for truly static measurements. A static force results in a fixed amount of charge on the piezoelectric material. In conventional readout electronics, imperfect insulating materials and reduction in internal sensor resistance causes a constant loss of electrons and yields a decreasing signal. Elevated temperatures cause an additional drop in internal resistance and sensitivity. The main effect on the piezoelectric effect is that with increasing pressure loads and temperature, the sensitivity reduces due to twin formation. While quartz sensors must be cooled during measurements at temperatures above 300 °C, special types of crystals like GaPO4 gallium phosphate show no twin formation up to the melting point of the material itself.

However, it is not true that piezoelectric sensors can only be used for very fast processes or at ambient conditions. In fact, numerous piezoelectric applications produce quasi-static measurements, and other applications work in temperatures higher than 500 °C.

Piezoelectric sensors can also be used to determine aromas in the air by simultaneously measuring resonance and capacitance. Computer controlled electronics vastly increase the range of potential applications for piezoelectric sensors.

Piezoelectric sensors are also seen in nature. The collagen in bone is piezoelectric, and is thought by some to act as a biological force sensor. Piezoelectricity has also been shown in the collagen of soft tissue such as the Achilles tendon, aortic walls, and heart valves.

Sensor design



Metal disks with piezo material, used in buzzers or as contact microphones

Based on piezoelectric technology various physical quantities can be measured the most common are pressure and acceleration. For pressure sensors, a thin membrane and a massive base are used, ensuring that an applied pressure specifically loads the elements in one direction. For accelerometers, a seismic mass is attached to the crystal elements. When the accelerometer experiences a motion, the invariant seismic mass loads the elements according to Newton's second law of motion .

The main difference in working principle between these two cases is the way they apply forces to the sensing elements. In a pressure sensor, a thin membrane transfers the force to the elements, while in accelerometers an attached seismic mass applies the forces. Sensors often tend to be sensitive to more than one physical quantity. Pressure sensors show false signal when they are exposed to vibrations. Sophisticated pressure sensors therefore use acceleration compensation elements in addition to the pressure sensing elements. By carefully matching those elements, the acceleration signal (released from the compensation element) is subtracted from the combined signal of pressure and acceleration to derive the true pressure information.

Vibration sensors can also harvest otherwise wasted energy from mechanical vibrations. This is accomplished by using piezoelectric materials to convert mechanical strain into usable electrical energy

Principle of Operation:

Depending on the way a piezoelectric material is cut, three main types of operations can be distinguished.

1. Transversal effect

2. Longitudinal effect

3. Shear effect.

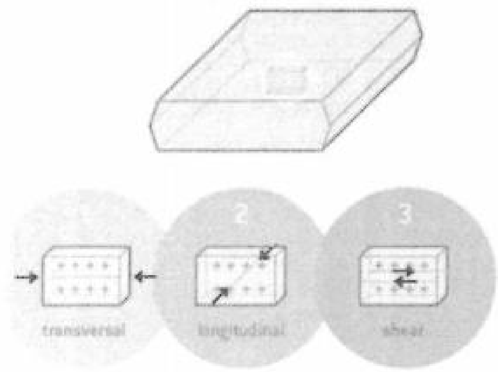


Figure 2: Gallium phosphate sensing elements

A gallium phosphate crystal is shown with typical sensor elements manufactured out of it. Depending on the design of a sensor different "modes" to load the crystal can be used: transversal, longitudinal and shear (arrows indicate the direction where the load is applied). Charges are generated on both "x sides" of the element. The positive charges on the front side are accompanied by negative charges on the back.

Transverse effect:

A force is applied along a neutral axis and the charges are generated along the d11 direction. The amount of charge depends on the geometrical dimensions of the respective piezoelectric element. When dimensions a, b, c apply:

$C_y = -d_{11} \times F_y \times b/a$

Where a is the dimension in line with the neutral axis and b is in line with the charge generating axis

Longitudinal effect:

The amount of charges produced is strictly proportional to the applied force and is independent of size and shape of the piezoelectric element. Using several elements that are mechanically in series and electrically in parallel is the only way to increase the charge output. The resulting charge is:

$C_x = d_{11} \times F_x \times n$

Where

d_{11} = piezoelectric coefficient [pC/N]

F_x = applied Force in x-direction [N]

n = number of elements

Shear effect:

Again, the charges produced are strictly proportional to the applied forces and are independent of the element's size and shape. For n elements mechanically in series and electrically in parallel the charge is:

$C_x = 2 \times d_{11} \times F_x \times n$

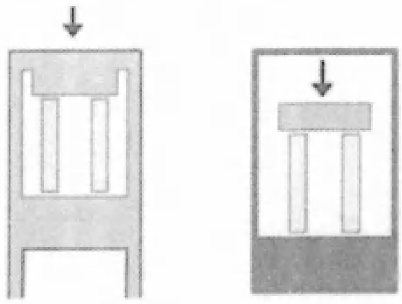
In contrast to the longitudinal and shear effect, the transverse effect opens the possibility to fine tune sensitivity depending on the force applied and the element dimension. Therefore, Piezo crystal sensors almost exclusively use the transverse effect since it is possible to reproducibly obtain high charge outputs in combination with excellent temperature behaviour.

SENSOR DESIGN

Based on piezoelectric technology various physical dimensions can be measured, the most important include pressure and acceleration. Figure 3 shows schematic configurations of those sensors in the transverse configuration. In both designs, the elements are thin cuboids that are loaded along their longest extension. For pressure sensors, a thin membrane with known dimensions and a massive base is used; assuring that an applied pressure specifically loads the elements in one direction. For accelerometers, a seismic mass is attached to the crystal elements. When the accelerometer experiences a motion, the invariant seismic mass loads the elements according to Newton's second law of motion.

$F=m*a$

Where F is force, m is mass, a is acceleration



(a) (b)

Figure 3: Schematic sensor design of pressure (a) and acceleration sensors (b)

In both piezoelectric pressure sensors (a) and piezoelectric accelerometers (b), the crystal elements are used in transversal mode. The main difference in the working principle between these two cases is the way forces are applied to the sensing elements. In a pressure sensor a thin membrane is used to guide the force to the elements, in accelerometers the forces are applied by an attached seismic mass. Sensors often tend to be sensitive to more than one physical dimension. Therefore, it sometimes becomes necessary to compensate for unwanted effects. For instance, sophisticated pressure sensors often use acceleration compensation elements. Those compensations are based on the fact that the measuring elements may experience both, pressure and acceleration events. A second measuring unit is added to the sensor assembly that only experiences acceleration events. By carefully matching those elements, the acceleration signal (coming from the compensation element) is subtracted from the combined signal of pressure and acceleration (coming of the measuring elements) to derive the true pressure information.

PIEZOELECTRIC ENERGY HARVESTING

The piezoelectric effect converts mechanical strain into electric current or voltage. This strain can come from many different sources. Human motion, low-frequency seismic vibrations, and acoustic noise are everyday examples. Except in rare instances the piezoelectric effect operates in AC requiring time-varying inputs at mechanical resonance to be efficient.

Most piezoelectric electricity sources produce power on the order of milli watts, too small for system application, but enough for hand-held devices such as some commercially available self-winding wristwatches. One proposal is that they are used for micro-scale devices, such as in a device harvesting micro-hydraulic energy. In this device, the flow of pressurized hydraulic fluid drives a reciprocating piston supported by three piezoelectric elements which convert the pressure fluctuations into an alternating current. As piezo energy harvesting has been investigated only since the late '90s, it remains an emerging technology. Nevertheless some interesting improvements were made with the selfpowered electronic switch at INSA School of engineering, implemented by the spin-off Arveni.

In 2006, the proof of concept of a battery-less wireless doorbell push button was created, and recently, a demonstrator showed that classical TV infra-red remote control can be powered by a piezo harvester. Other industrial applications appeared between 2000 and 2005 to harvest energy from vibration and supply sensors for example, or to harvest energy from shock. Piezoelectric systems can convert motion from the human body into electrical power. DARPA has funded efforts to harness energy from leg and arm motion, shoe impacts, and blood pressure for low level power to implantable or wearable sensors. The Nano brushes of Dr. Zhong Lin Wang are another example of a piezoelectric energy harvester. They can be integrated into clothing. Careful design is needed to minimize user discomfort. These energy harvesting sources by association have an impact on the body. The Vibration Energy Scavenging Project is another project that is set up to try to scavenge electrical energy from environmental vibrations and movements. Finally, a millimeter-scale piezoelectric energy harvester has also already been created.

The use of piezoelectric materials to harvest power has already become popular. Piezoelectric materials have the ability to transform mechanical strain energy into electrical charge. Piezo elements are being embedded in walkway to recover the "people energy" of footsteps. They can also be embedded in shoes to recover "walking energy".

MATERIALS

Two main groups of materials are used for piezoelectric sensors: piezoelectric ceramics and single crystal materials. The ceramic materials (e.g. PZT ceramic) have a piezoelectric constant /sensitivity that are roughly two orders of magnitude higher than those of single crystal materials and can be produced by an inexpensive sintering process. Unfortunately, their high sensitivity is always combined with a lack of long term stability. Therefore, piezoelectric ceramics are very often used wherever the requirements for measuring precision are not too high.The less sensitive single crystal materials (quartz, tourmaline and gallium phosphate) have a much higher - when carefully handled, almost infinite - long term stability. Additionally, some of them show excellent temperature behaviour (especially gallium phosphate and tourmaline).

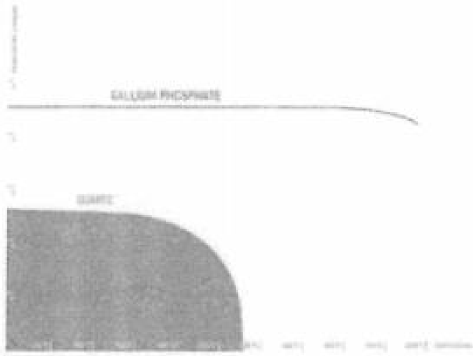


Figure 4: Piezoelectric coefficient vs. temperature

Piezoelectric coefficient of GaPO4 and quartz are shown versus temperature. Gallium phosphate offers better temperature characteristics and better temperature behaviour for many of its material constants including the piezoelectric coefficient, which is a measure for sensitivity.

Application:

This piezoelectric sensor is designed for use in domestic electric appliances, AV. equipment, OA equipment, communication equipment, measuring equipment and general electronic equipment. Check with us separately, for use in equipment which needs high reliability.(Such as automobiles, aircraft, medical equipment and space equipment).

PRECAUTIONS FOR HANDLING

• Precautions for Safety

i. Fail-safe Design for Equipment: In application of the piezoelectric sensor, it is recommended that equipment shall be protected by adding a protective and/or retarding design circuit against deterioration and failures of the piezoelectric sensor.

ii. Operating Temperature Ranges Preheating temperature : 175 o C.This piezoelectric sensor shall not be operated beyond the specified "Operating Temperature Range"in the Specifications.

iii. Changes/Drifts in Voltage Sensitivity: It shall be noted that voltage sensitivity of the piezoelectric sensor may drift depending IC applied (the type names, the manufacturer) and resistance values of external resisters and the circuit design.

iv. Stray Capacitance: Stray capacitance and insulation resistance on printed circuit board may cause abnormalities of the piezoelectric sensor such as the voltage sensitivity and the frequency characteristic. Attention shall be paid to those abnormalities above mentioned in circuit design.

v. Direct Voltage Avoid directly applying a direct voltage to the piezoelectric sensor.

PROHIBITED APPLICATIONS

i. "Flow Soldering" shall not be applied to the piezoelectric sensor.

ii. "Ultrasonic Cleaning" and "Ultrasonic Welding "shall not be applied to the piezoelectric sensor for preventing them from electrical failures and mechanical damages.

iii. Avoid water washing after soldering.

Application Notes

1. Handling precautions

a) Abnormal/excess electrical stresses such as over voltage spikes and electrostatic discharges may cause electrical deterioration's and failures of the piezoelectric sensor and affect reliability of the devices.) If the product is drooped or a strong stress is applied to it, it may break. Do not use the products which strong stress has been applied.

2. Automated Assembly for automatic inserting, make sure to make inserting checks by Means of the inserting machine in advance. In inserting the product, unsuitable chucking force or inserting speed may apply so excessive impulse to break the product.Avoid inserting using mechanical-chuck-type inserting machine. Also, for the inserting machine using other method, select the low speed.

3. Soldering in PC boards and washing after soldering

a) The product is applicable to refold soldering. Conditions of the soldering temperature and time are recommended.

i. Preheating temperature: 175oC

ii. Preheating time: 1~2 minutes

iii. Soldering temperature: 220oC

iv. Soldering time: 20 sec max.

v. Peak temperature: 250oC max.

a) Take care that a soldering iron does not contact with the product body (out case).For manual soldering, the maximum soldering temperature and time should be 300C and seconds.

b) Rosin-based and non-activated soldering flux is recommended. The content of halogen in the flux shall be 0.1 wt. or less.

c) Post Soldering Cleaning Application of ultrasonic cleaning is prohibited. Cleaning conditions such as kinds of cleaning solvents, immersion times and temperatures etc. shall be checked by experiments before production.

MAINTENANCE AND USE IN ENVIRONMENT

Avoid maintenance and use in the following environments.

i. Corrosive gaseous atmospheres (Cl_2 , NH_3 , SO_2 , O_2 etc.)

ii. Dusty places

iii. Places exposed to direct sunlight

iv. Places over which water is splashed

v. To be exposed directly to water.

vi. Places exposed to briny air.

vii. Places apt to be affected by static electricity or electric field strength.

1. Long Term Storage The piezoelectric sensor shall not be stored under severe conditions of high temperatures and high humidifies. Store them indoors under 40oC max, and 75% RAH max. Use them within one year and check the solder ability before use. And avoid maintenance and use in the following environments.

i. Corrosive gaseous atmospheres (Cl2 , NH3 , SO2 , Ox etc.)

ii. Places exposed to direct sunlight

iii. Places where dew is apt exposed to condense

The design is subject to change for improvement of quality.

Chapter IV :

ADVANTAGES

- Simple circuitry.
- Cheap in cost.
- Highly reliable.
- No need of micro controllers.
- Can be operated under +9 Volts or +12Volts.
- Piezo electric sensor used in the circuitry can handle high temperature of the order 80°C.
- Easily operated.
- It uses readily available, low-cost components.

Chapter V : APPLICATIONS

- It can be used as protective shield to the locker to avoid the robbery.

- It can be used as door bells.
- It can be used to safeguard motor vehicles.

Chapter VI : CONCLUSION

Whenever a mechanical input is given as the input for piezoelectric material those variations converted into electrical variations and when it is interfaced with a circuit which amplifies, rectifies, filters those signals and buzzer is produced.