V.P. & R.P.T.P.SCIENCE COLLEGE
PHYSICS DEPARTMENT

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6TH SEMESTER B.Sc. PHYSICS
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PRACTICAL VIVA VOCE BOOK

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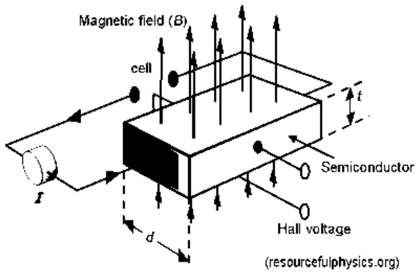
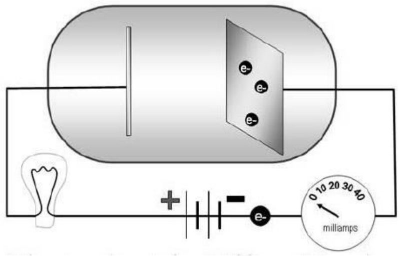
V.P. & R.P.T.P. SCIENCE COLLEGE

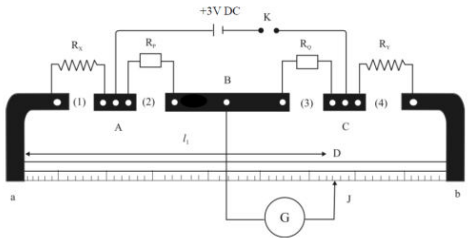
VALLABH VIDYANAGAR

B. Sc. Semester-6

Physics Practical -VIVA-VOCE







1	Searl's Goniometer	PHY09

What do you mean by a coaxial system of lenses?
When a number of lenses having a common principal axis are used, then this combination is called a coaxial system of lenses.
Define: Optical System.
A collection of mirror, lenses, prism and other devices, placed in some specified configuration, which reflect, refract, disperse absorb, polarize or otherwise act on light.
What do you understand by cardinal points of a coaxial system?
The six points of an optical viz. two principal points, two focal points and two nodal points are called the cardinal points.
What are principal points?
The principal points are a pair of conjugate principal axis for which linear, transverse, magnification is unity and positive.
Define focal points.
The points to which rays that are initially parallel to the axis of lens of lens mirror or other optical system are converged or from which they appear to diverge. **OR**
First, focal point is an object point on the principal axis of an optical system for which the image points lies at infinity.
The second focal is an image point on the principal axis of an optical system for which the object point system for which the object points lies at infinity.
What are nodal points?
Nodal points are a pair of conjugate points having unit positive angular magnification. **OR**
A pair of points on the axis of an optical system such that an incident ray passing through one of them / results in parallel emergent ray passing **through the other.**
How will you mark the position of cardinal points of the lens system or optical diagram?
First of all, the positions of nodal points or principal points (They coincide as medium on both side is air.) are marked with respect to the corresponding lens. Now the focal points are marked at distances equal to the combined focal lengths from the corresponding principal points.
What is the importance of these points?
The points are of great importance in the image formation by a coaxial lens system because the procedure is greatly simplified.
When a s ystem of two lenses works as a plane parallel glass plate? Explain

Refer to OPTICS Units of S.Y. B.Sc.

2	Power Amplifier	PHY08

Audio Power Amplifier:

An amplifier does always not amplify in same extend as its input. It may response differently for AC and DC. Hence, another way of representing gain is the ratio of change of output signal in respect of change in input signal. That means how much change occurred in output signal for certain change in input or control signal. The gain of amplifier can be calculated easily by taking ratio of rms value of output and input signals but it is not justified technique for AC signal.

Decibel Gain or dB Gain:

Although amplifier gain does not have any unit as it is ratio of same unit signals, but if any one tries to represent the gain in logarithmic scale then it will have a unit. Generally the gain expressed in logarithmic scale will have a unit called decibel which is one tenth fraction of bel. The name of this unit that is "bel" comes from the name Alexander Graham Bell, the famous Scottish inventor who is well known for his invention of telephone systems.

Now, decibel gain is defined in terms of the common (base 10) logarithm of a power ratio that means if the conventional gain of an amplifier is P_{output} / P_{input}, then this gain is expressed in decibel scale as $10\log(P_{output} / P_{input})$.

If we show the table below, it will be more clearly understood.

Gain as ratio	Gain as decibel
100	20 dB
10	10 dB
1	0 dB
0.1	– 10 dB
0.01	– 20 dB
0.001	– 30 dB

Why should we use Bel Scale or Decibel Scale to represent Gain?

The human hearing skill is logarithmic in nature. For doubling perceived intensity of sound, the sound power must be increased by 10 times. That means the gain of amplifier which controls sound intensity must have gain of 10 for doubling perceived intensity of sound which is in bel scale 1 bel and in decibel scale 10 decibel. In other words a power gain of 1 bel translates to a doubling in the perceived intensity of the sound. The perfect use of bel scale is in Richter scale which measures intensity of earthquake. 6 Richter earthquakes is 10 times more powerful than a 5 Richter earthquake, and a 4 Richter earthquake is 1/10 as powerful as 5 Richter earthquake. Logarithmic scale is also popularly used to measure concentration of hydrogen ions in a chemical solution. One pH difference in this scale means 10 folds difference in hydrogen ions concentration in a solution. It is now clear to us that where variation of gain is huge it is preferable to use logarithmic scale instead of conventional ratio scale so that tremendous range of expression can be afforded by a relatively small span of numerical values. Not only that, in cascaded amplifier the overall decimal gain is calculated by summing up individual decimal gain of amplifier instead of multiplying them as in the case of ratio gain. This makes equations and related calculations simpler and easier.

Suppose one amplifier has gain of 3 and another has 5 and these two amplifiers are connected in cascaded manner. Overall gain of the system is 3X5 = 15. Now in logarithmic or dB scale these gain are $10\log3 = 4.77$ dB and $10\log5=6.99$ dB respectively. In decibel scale this overall gain is $10\log15 = 11.76$ dB which is nothing but 4.77 + 6.99. Thus we have seen how overall gain can be calculated by adding individual gain instead of multiplying them.

Amplifiers:

Analog amplifiers are cataloged by how much current flows during each wave cycle. Measured in degrees, 360º means current flows 100% of the time. The more current, the more inefficient and the more heat generated.

Class A

The amplifier conducts current throughout the entire cycle (360º). The Class A design is the most inefficient and is used in low-power applications as well as in very high-end stereo. Such devices may be as little as 15% efficient, with 85% of the energy wasted as heat.

Class B

The current flows only 180º for half the cycle, or two transistors can be used in a push-pull fashion, each one operating for 180º. More efficient than Class A, it is typically used in low-end products.

Class AB

Combines Class A and B and current flows for 180º to 200º. Class AB designs are the most widely used for audio applications. Class AB amplifiers are typically about 50% efficient.

Class C

Operating for less than half of one wave cycle (100º to 150º), Class C amplifiers are the most efficient, but not used for audio applications because of their excessive distortion.

Class G

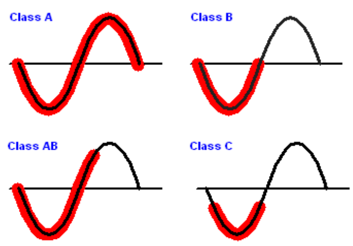
A variation of the Class AB design that improves efficiency by switching to different fixed voltages as the signal approaches them.

Class H

An enhancement of the Class G amplifier in which the power supply voltage is modulated and always slightly higher than the input signal.

Current Flowing

The red indicates how much of the time current is flowing through one wave cycle.



Questions:

State various types of amplifiers.

What is the function of a power amplifier?

What do you mean by class A operation of amplifier?

Which is the other mode of operation of amplifier? Explain them.

Define gain of an amplifier.

Explain variations of Gain with frequency. What are lower and upper cut-off (i,e,half-power) frequencies of an amplifier? Explain.

What is bandwidth of an amplifier? State its significance.

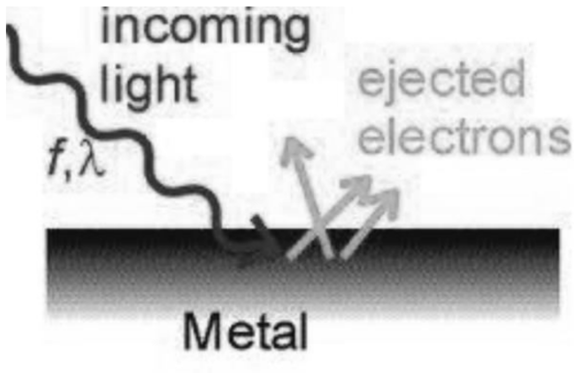
3	**DETERMINATION OF PLANCK CONSTANT *h* BY LED**	**PHY09**

What is h ?

Quantum theory evolved as a new branch of theoretical physics during the first few decades of the 20th century in an endeavor to understand the fundamental properties of matter. It began with the study of the interactions of matter and radiation. Certain radiation effects could neither be explained by classical mechanics, nor by the theory of electromagnetism. In particular, physicists were puzzled by the nature of light. Peculiar lines in the spectrum of sunlight had been discovered earlier by Joseph Von Fraunhofer (1787-1826). These spectral lines were then systematically cataloged for various substances, yet nobody could explain why the spectral lines are there and why they would differ for each substance. It took about one hundred years, until a plausible explanation was supplied by quantum theory. In contrast to Einstein's Relativity, which is about the largest things in the universe, quantum theory deals with the tiniest things we know, the particles that atoms are made of, which we call "subatomic" particles. In contrast to relativity, quantum theory was not the work of one individual, but the collaborative effort of some of the most brilliant physicists of the 20th century, among them Niels Bohr, Erwin Schrodinger, Wolfgang Pauli, and Max Born. Two names clearly stand out: Max Planck (1858- 1947) and Werner Heisenberg (1901-1976). Planck is recognized as the originator of the quantum theory, while Heisenberg formulated one of the most eminent laws of quantum theory, the Uncertainty Principle, which is occasionally also referred to as the principle of Indeterminacy. Around 1900, Max Planck from the University of Kiel concerned himself with observations of the radiation of heated materials. He attempted to draw conclusions from the radiation to the radiating atom. On basis of empirical data, he developed a new formula which later showed remarkable agreement with accurate measurements of the spectrum of heat radiation. The result of this formula was so that 'energy is always emitted or absorbed in discrete units, which he called quanta'. Planck developed his quantum theory further and derived a universal constant, which came to be known as Planck's Constant. The resulting law states that the energy of each quantum is equal to the frequency of the radiation multiplied by the universal constant: E = f x h, where f is frequency of the emitted photons and h is called as Planck's Constant (~6.63 x 10-34 Js). The discovery of quanta revolutionized physics, because it contradicted conventional ideas about the nature of radiation and energy.

Photoelectric Effect

The photoelectric effect is a quantum electronic phenomenon in which electrons are emitted from matter after the absorption of energy from electromagnetic radiation such as X-rays or visible light. The emit ted electrons can be referred to as photoelectrons in this context. The effect is also termed the Hertz Effect, due to its discovery by Heinrich Rudolf Hertz, although the term has generally fallen out of use. Study of the photoelectrice ffect led to important steps in understanding the quantum nature of light and electrons and influenced the formation of the concept of wave– particle duality. The term may also refer to the photo conductive effect (also known as photo conductivity or photo resistivity), the photo voltaic effect, or the photo electrochemical effect.



The photons of the light beam have a characteristic energy determined by the frequency of the light. In the photo emission process, if an electron absorbs the energy of one photon and has more energy than the work function, it is ejected from the material. If the photon energy is too low, the electron is unable to escape the surface of the material. Increasing the intensity of the light beam does not change the energy of the constituent photons, only the number of photons. Thus the energy of the emitted electrons does not depend on the intensity of the incoming light, but only on the energy of the individual photons. Electrons can absorb energy from photons when irradiated, but they follow an "all or nothing" principle. All of the energy from one photon must be absorbed and used to liberate one electron from atomic binding, or the energy is re-emitted. If the photon energy is absorbed, some of the energy liberates the electron from the atom, and the rest contributes to the electron's kinetic energy as a free particle.

Laws of Photoelectric Emission

1. For a given metal & frequency of incident radiation, rate at which photoelectrons are ejected is directly proportional to the intensity of incident light.
2. For a given metal, there exists a certain minimum frequency of incident radiation below which no photoelectrons can be emitted. This frequency is called the threshold frequency.
3. Above the threshold frequency, the maximum kinetic energy of the emitted photo electron is independent of the intensity of the incident light but depends on the frequency of the incident light.
4. The time lag between the incidence of radiation and the emission of a photo electron is very small, less than 10-9 seconds.

Planck's Constant :

Planck‘s Constant relates the energy of light photons to their frequency. It also shows up in De Broglie‘s relation for the wavelength of matter waves and Schrodinger‘s Equation. Thus, the number is of fundamental importance in 20th century physics. A common device, the light emitting diode or LED, could be designed only because some engineers understood quantum science. Thus, knowledge of the value of Planck‘s Constant is ―hidden in the LED. An LED begins to emit light when the voltage applied to it creates a large enough energy difference between the two electronic states in the parts of the diode for an electron transition to release one quantum of light at the wavelength of the LED. So to determine Planck's constant we can use Light Emitting Diodes (LED).

Diodes today come in a variety of colors. Each color is achieved by having a slightly different semiconductor material. We can choose a number of LEDs, with different colors including Blue, Green, Red and Orange. The experiment is based on the fact that the energy of the photon relates to its frequency as:

$E = h \times \boldsymbol{\nu}$,

where, E is the energy of photon, h is the Planck's constant and $\boldsymbol{\nu}$ is the frequency of the emitted photons.

When the diode first emits light the voltage across the diode V_0 , is just enough to give energy to electrons to jump between two energy levels. Therefore ;

$\mathbf{V_0.e = h \times \nu}$ where e is the electron charge and V_0 is the threshold voltage.

Therefore by measuring the voltage across the diode when the first light is observed for a number of diodes we can determine the Planck constant.

The relation between the maximum wavelength, λ, and the turn on voltage V_0 is;

$$E = h\nu = hc/\lambda \text{....................(1)}$$

$$E = eV_0 \text{.............................(2)}$$

From (1) and (2) we get,

$$hc/\lambda = eV_0 \text{ or } h = eV_0\lambda/c \text{...................(3)}$$

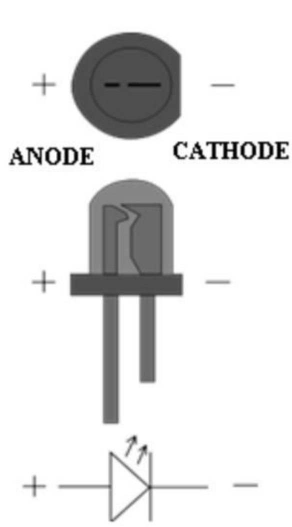
Where, h is Planck's constant, e is the electronic charge, V_0 is Threshold voltage, λ is wavelength of LED and c is the velocity of light.

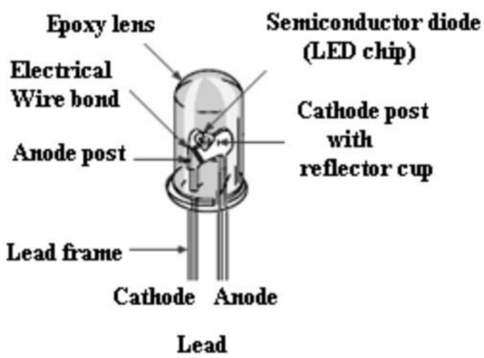
Significance of the size of Planck's constant :

Expressed in the SI units of joule seconds (J·s), the Planck constant is one of the smallest constants used in physics. The significance of this is that it reflects the extremely small scales at which quantum mechanical effects are observed, and hence why we are not familiar with quantum physics in our everyday lives in the way that we are with classical physics. Indeed, classical physics can essentially be defined as the limit of quantum mechanics as the Planck constant tends to zero. In natural units, the Dirac constant is taken as 1 (i.e., the Planck constant is 2π), as is convenient for describing physics at the atomic scale dominated by quantum effects.

Semiconductor Diode:

It is widely used in many areas of electronics today. Although they use the same basic structure of an area of p-type material meeting an area of n-type material, there are many different t ypes of diode that are available in today's electronics scene. Whatever the type of diode, the basic idea of the diode is important in the electronics industry today, whether it be used for the production of commercial or industrial equipment, of for use by the hobbyist, or anyone studying electronics. Diode A diode is the simplest sort of semiconductor device. Broadly speaking, a semiconductor is a material with a varying ability to conduct electrical current. Most semiconductors are made of a poor conductor that has bad impurities (atoms of another material) added to it. The process of adding impurities is called doping. In the case of LEDs, the conductor material is typically aluminum-gallium-arsenide (AlGaAs). In pure aluminum-gallium-arsenide, all of the atoms bond perfectly to their neighbours, leaving no free electrons (negatively-charged particles) to conduct electric current. In doped material, additional atoms change the balance, either adding free electrons or creating holes where electrons can go. Either of these additions make the material more conductive. A semiconductor with





extra electrons is called N-type material, since it has extra negatively-charged particles. In N-type material, free electrons move from a negatively-charged area to a positively charged area. A semiconductor with extra holes is called P-type material, since it effectively has extra positively-charged particles. Electrons can jump from hole to hole, moving from a negatively-charged area to a positively-charged area. As a result, the holes themselves appear to move from a positively-charged area to a negatively-charged area.

Light Emitting Diode:

The light emitting diode or LED is one of the most popular types of diode. When forward biased with current flowing through the junction, light is produced. The diodes use component semiconductors, and can produce a variety of colour, although the original colour wasA light-emitting diode (LED) is a semiconductor device that emits visible light when an electric current passes through it. The light is not particularly bright, but in most LEDs it is monochromatic, occurring at a single wavelength. The output from an LED can range from red (at a wavelength of approximately 700 nanometers) to blue-violet (about 400 nanometers) Colours of Light Emitting Diodes LEDs are available in many colours such as: red, orange, amber, yellow, green, blue and white. Blue and white LEDs are much more expensive than the other colours. The colour of an LED is determined by the semiconductor material, not by the colouring of the 'package' (the plastic body). LEDs of all colours are available in uncoloured packages which may be diffused (milky) or clear (often described as 'water clear'). The coloured packages are also available as diffused (the standard type) or transparent.

How can a Diode Produce Light?

Light is a form of energy that can be released by an atom. It is made up of many small particle-like packets that have energy and momentum but no mass. These particles, called photons, are the most basic units of light. Photons are released as a result of moving electrons. In an atom, electrons move in orbitals around the nucleus. Electrons in different orbitals have different amounts of energy. Generally speaking, electrons with greater energy move in orbitals farther away from the nucleus. For an electron to jump from a lower orbital to a higher orbital, something has to boost its energy level. Conversely, an electron releases energy when it drops from a higher orbital to a lower one. This energy is released in the form of a photon. A greater energy drop releases a higher-energy photon, which is characterized by a higher frequency. As we saw in the last section, free electrons moving across a diode can fall into empty holes from the P-type layer. This involves a drop from the conduction band to a lower orbital, so the electrons release energy in the form of photons. This happens in any diode, but you can only see the photons when the diode is composed of certain materials. The atoms in a standard silicon diode, for example, are arranged in such a way that the electron drops a relatively short distance. As a result, the photon's frequency is so low that it is invisible to the human eye -- it is in the infrared portion of the light spectrum. This isn't necessarily a bad thing, of course: Infrared LEDs are ideal for remote controls, among other things

Physical function of LED:

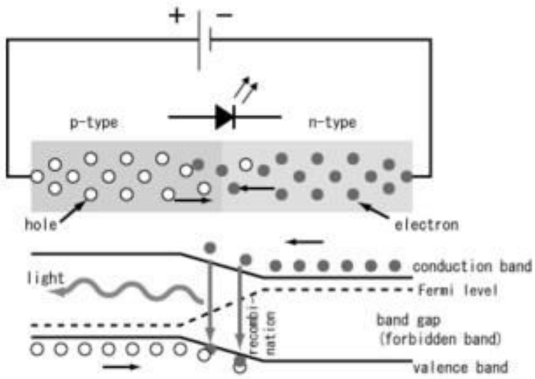
Like a normal diode, the LED consists of a chip of semiconducting material impregnated, or doped with impurities to create a p-n junction. As in other diodes, current flows easily from the p-side, or anode, to the n-side, or cathode, but not in the reverse direction. Charge-carriers-electrons and holes flow into the junction from electrodes with different voltages. When an electron meets a hole, it falls into a lower energy level, and releases energy in the form of a photon. The wavelength of the light emitted, and therefore its colour, depends on the band gap energy of the materials forming the p-n junction. In silicon or germanium diodes, the electrons and holes recombine by a non-radiative transition which produces no optical emission, because these are indirect band gap materials. The materials used for the LED have a direct band gap with energies corresponding to near-infrared, visible or near-ultraviolet light. LED development began with infrared and red devices made with gallium arsenide. Advances in material science have made possible the production of devices with ever-shorter wavelengths, producing light in a variety of colours. LEDs are usually built on an n-type substrate, with an electrode attached to the p-type layer deposited on its surface. P-type substrates, while less common, occur as well. Many commercial LEDs, especially GaN/InGaN, also use sapphire substrate. Substrates that are transparent to the emitted wavelength, and backed by a reflective layer, and light spreading layer, increase the LED efficiency. The refractive index of the package material should match the index of the semiconductor, otherwise the produced light gets partially reflected back into the semiconductor, where it may be absorbed and turned into additional heat, thus lowering the efficiency. This type of reflection also occurs at the surface of the package if the LED is coupled to a medium with a different refractive index such as a glass fiber or air. The refractive index of most LED semiconductors is quite high, so in almost all cases the LED is coupled into a much lower-index medium. The large index difference makes the reflection quite substantial (per the Fresnel coefficients), and this is usually one of the dominant causes of LED inefficiency. Often more than half of the emitted light is reflected back at the LED-package and package-air interfaces. The reflection is most commonly reduced by using a dome-shaped (half-sphere) package with the diode in the center so that the outgoing light rays strike the surface perpendicularly, at which angle the reflection is minimized. An anti-reflection coating may be added as well. The package may be cheap plastic, which may be coloured, but this is only for cosmetic reasons or to improve the contrast ratio; the colour of the packaging does not substantially affect the colour of the light emitted. Other strategies for reducing the impact of the interface reflections include designing the LED to reabsorb and re-emit the reflected light (called photon recycling) and manipulating the microscopic structure of the surface to reduce the reflectance, either by introducing random roughness or by creating programmed moth eye surface patterns

More about LEDs:

In modern era we are highly familiar with the term **LED**. It stands for **light emitting diode**. These are mainly used for making indicators and various other types of lightning. In 1962 first this type of light appeared to the market. Which was low intensity red light, now the modern versions of this type of lights are visible, ultraviolet, inferred etc. In **LED** electrical energy is converter in to optical energy. These are example of electro-luminescence, the process in which emission of photos takes place by the recombination of excess electrons and holes in a direct band gap semiconductor. The main advantages of using these are the low energy consumption, longer lifetime, strong build, smaller size etc.

Working of LED or Light Emitting Diode:

In LED s the electrical energy is converted in to optical energy. The main mechanism of working is injection electro luminescence. In injection electro luminescence, the carrier are injected zacross a p-n junction. Now the recombination of excess electrons and the holes can result photon emission if the semiconductor used, is a direct band gap semiconductor. In direct band gap semiconductor, transition between the two allowed bands can take place with no change in crystal momentum.



When across the p-n junction, a voltage is applied then electrons and the holes are injected across the depletion region and they become excess minority carriers. These recombine with majority carriers when these minority carriers diffuse this in to neutral semiconductor region. This recombination process in direct band gap material results the emission of photons. The output photon intensity is directly proportional to the ideal diode diffusion current which is proportional to the recombination rate.

The wave length of output optical signals depends upon the band gap energy. The output wave length can be engineered within certain limits by using compound semiconductors, so that a particular color can be observed, provided the output is in visible range.

Application of LED or Light Emitting Diode

•In motorcycle and bicycle lights. •In traffic lights and signals. •In message displaying boards.
•In light bulbs and many more.

i) Indicators and signs:- traffic signals, exit signs, light weight message, displaying box, Lighting.

Light Emitting Diode lamps have become highly popular and as the energy consumption is very low for them, they are also being made by LED s. In 2001, the Italian village Torraca was the first place to convert all its lighting to LED. In television and computer/laptop displaying, LEDs are used.

iii) Non visual application:- Communication, sensor are the main area of non visual application of LEDs.

COLOUR	ENERGY	FREQUENCY in Tera Hertz*	WAVELENGTH in nanometres
red	lowest	435 - 495	685 - 605
orange		495 - 515	605 - 585
yellow		515 - 535	585 - 560
green	middle	535 - 630	560 - 475
blue		630 - 660	475 - 455
indigo		660 - 680	455 - 440
violet	highest	680 - 740	440 – 405

* a Tera Hertz is a billion billion cycles (or complete wavelengths) passing by per second

	Color	Wavelength [nm]	Semiconductor material
	Infrared	$\lambda > 760$	Gallium arsenide (GaAs) Aluminium gallium arsenide (AlGaAs)
	Red	$610 < \lambda < 760$	Aluminium gallium arsenide (AlGaAs) Gallium arsenide phosphide (GaAsP) Aluminium gallium indium phosphide (AlGaInP) Gallium(III) phosphide (GaP)
	Orange	$590 < \lambda < 610$	Gallium arsenide phosphide (GaAsP) Aluminium gallium indium phosphide (AlGaInP) Gallium(III) phosphide (GaP)
	Yellow	$570 < \lambda < 590$	Gallium arsenide phosphide (GaAsP) Aluminium gallium indium phosphide (AlGaInP) Gallium(III) phosphide (GaP)
	Green	$500 < \lambda < 570$	**Traditional green:** Gallium(III) phosphide (GaP) Aluminium gallium indium phosphide (AlGaInP) Aluminium gallium phosphide (AlGaP) **Pure green:** Indium gallium nitride (InGaN) / Gallium(III) nitride (GaN)
	Blue	$450 < \lambda < 500$	Zinc selenide (ZnSe) Indium gallium nitride (InGaN) Silicon carbide (SiC) as substrate Silicon (Si) as substrate—under development
	Violet	$400 < \lambda < 450$	Indium gallium nitride (InGaN)
	Purple	multiple types	Dual blue/red LEDs, blue with red phosphor, or white with purple plastic
	Ultraviolet	$\lambda < 400$	Diamond (235 nm) Boron nitride (215 nm) Aluminium nitride (AlN) (210 nm) Aluminium gallium nitride (AlGaN) Aluminium gallium indium nitride (AlGaInN)—down to 210 nm
	Pink	multiple types	Blue with one or two phosphor layers: yellow with red, orange or pink phosphor added afterwards, or white with pink pigment or dye.
	White	Broad spectrum	Blue/UV diode with yellow phosphor

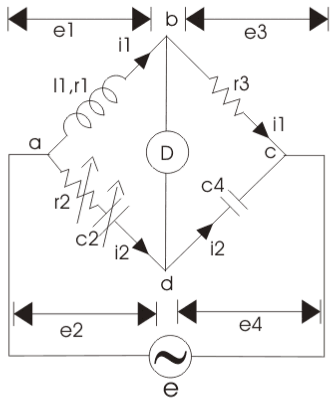
We have various bridges to measure inductor and thus quality factor, like Hay's bridge is highly suitable for the measurement of quality factor greater than 10, Maxwell's bridge is highly suitable for measuring medium quality factor ranging from 1 to 10 and Anderson bridge can be successfully used to measure inductor ranging from few micro Henry to several Henry. So what is the need of **Owen's bridge**?

The answer to this question is very easy. We need a bridge which can measure inductor over wide range. The bridge circuit which can do that, is known as Owen's bridge. It is ac bridge just like Hay's bridge and Maxwell bridge which use standard capacitor, inductor and variable resistors connected with ac source for excitation. Let us study **Owen's bridge circuit** in more detail.

Theory of Owen's Bridge

An Owen's bridge circuit is given below.

The ac supply is connected at a and c point. The arm ab is having inductor having some finite resistance let us mark them r_1 and l_1. The arm bc consists of pure electrical resistance marked by r_3 as shown in the figure given below and carrying the current i_1 at balance point which is same as the current carried by arm ab. The arm cd consists of pure capacitor having no electrical resistance.The arm ad is having variable resistance as well as variable capacitor and the detector is connected between b and d. Now how this bridge works? this bridge measures the inductor in terms of capacitance. Let us derive an expression for inductor for this bridge.



Here l_1 is unknown inductance. And c_2 is variable standard capacitor.

Now at balance point we have the relation from ac bridge theory that must hold good i.e.

$$z_1 z_4 = z_2 z_3$$

Putting the value of z_1, z_2, z_3 and in above equation we get,

$$(r_1 + j\omega l_1) \cdot \frac{1}{j\omega c_4} = \left(r_2 + \frac{1}{j\omega c_2}\right) \cdot r_3$$

Equating and then separating the real and the imaginary parts we get the expression for l_1 and r_1 as written below:

$$l_1 = r_2 r_3 c_4 \; and \; r_1 = \frac{r_3 c_4}{c_2}$$

Advantages of Owen's Bridge:

(1) The for inductor l_1 that we have derived above is quite simple and is independent of frequency component. (2) This bridge is useful for the measurement of inductor over wide range.

Disadvantages of Owen's Bridge:

(1) In this bridge we have used variable standard capacitor which is quite expensive item and also the accuracy of this is about only one percent. (2) As the measuring quality factor increases the value of standard capacitor required increases thus expenditure in making this bridge increases.

Questions:

Explain what is a inductor?

Define the inductance of a inductor.

On what factors the inductance of a inductor depends?

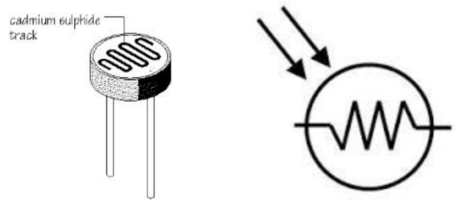
Define one henry.

What kind of this bridge? AC or DC?

Explain balance condition of the bridge.

A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a LDR, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it. LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically.

Photoresistors (also often called phototransistors or CdS photoconductive photocells; use 'photocell' for digikey) are simple resistors that altar resistance depending on the amount of light place over them. More light means less resistance. Photoresistors are probably the most common, the most affordable and the easiest of all robot sensors to implement. Not only useful for photovore robots and color sensors, but could also act as an optical switch (non-mechanical button) too. For example, wave your hand in front of the robot to block the light in front of it thereby activating something.



To use them as a sensor, measure the voltage drop across the resistor with the analog port of your microcontroller (because a change in resistance means a change in voltage). There are two ways to implement photoresistors

Working Principle of LDR:

A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity (Hence resistivity) reduces when light is absorbed by the material.When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy is incident on the device more & more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing and hence it is said that the resistance of the device has decreased.This is the most common working principle of LDR

Characteristics of LDR

LDR's are light dependent devices whose resistance decreases when light falls on them and increases in the dark. When a light dependent resistor is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as 1012 Ω. And if the device is allowed to absorb light its resistance will decrease drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular LDR.

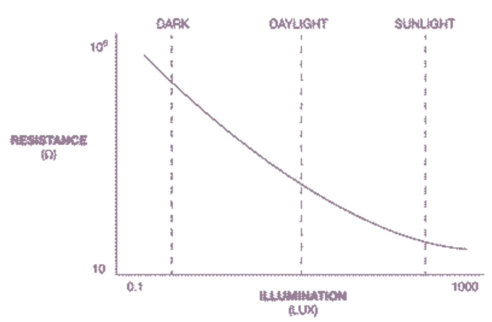


Figure 1 The resistance of a photoresistor falls dramatically as you illuminate it.

Light source Illumination	LUX
Moonlight	0.1
60W Bulb at 1m	50
1W MES Bulb at 0.1m	100
Fluorescent Lighting	500
Bright Sunlight	30,000

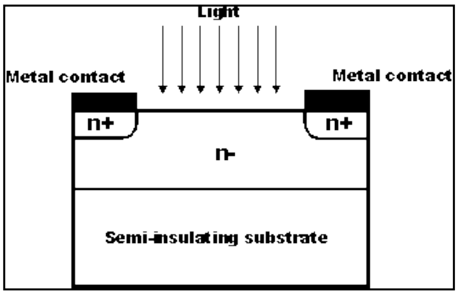
Photocells or LDR's are non linear devices. There sensitivity varies with the wavelength of light incident on them. Some photocells might not at all response to a certain range of wavelengths. Based on the material used different cells have different spectral response curves.

When light is incident on a photocell it usually takes about 8 to 12ms for the change in resistance to take place, while it takes seconds for the resistance to rise back again to its initial value after removal of light. This phenomenon is called as resistance recovery rate. This property is used in audio compressors. Also, LDR's are less sensitive than photo diodes and photo transistor. (A photo diode and a photocell (LDR) are not the same, a photo-diode is a p-n junction semiconductor device that converts light to electricity, whereas a photocell is a passive device, there is no p-n junction in this nor it "converts" light to electricity).

Types of Light Dependent Resistors: Based on the materials used they are classified as:
i) Intrinsic photo resistors (Un doped semiconductor): These are pure semiconductor materials such as silicon or germanium. Electrons get excited from valance band to conduction band when photons of enough energy falls on it and number charge carriers increases.
ii) Extrinsic photo resistors: These are semiconductor materials doped with impurities which are called as dopants. Theses dopants create new energy bands above the valence band which are filled with electrons. Hence this reduces the band gap and less energy is required in exciting them. Extrinsic photo resistors are generally used for long wavelengths.

Construction of a Photocell:

The structure of a light dependent resistor consists of a light sensitive material which is deposited on an insulating substrate such as ceramic. The material is deposited in zigzag pattern in order to obtain the desired resistance & power rating. This zigzag area separates the metal deposited areas into two regions. Then the ohmic contacts are made on the either sides of the area. The resistances of these contacts should be as less as possible to make sure that the resistance mainly changes due to the effect of light only. Materials normally used are cadmium sulphide, cadmium selenide, indium antimonide and cadmium sulphonide. The use of lead and cadmium is avoided as they are harmful to the environment.



Applications of LDR

LDR's have low cost and simple structure.
They are often used as light sensors. They are used when there is a need to detect absences or presences of light like in a camera light meter. Used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyor belt, etc. The resistance of light dependent resistor falls as the illuminance increases.They can be used to build a simple, low cost photometric device.

They appear to work well with medium to high light levels (greater than 10 lux). Unlike photodiodes they do not saturate at high light levels. The spectral response is similar to that of the human eye with the greatest sensitivity being in the green range (approx. 500 - 550 nm). The relationship between illuminance and resistance is non-linear being a straight line when plotted on a log-log graph. Whilst some suppliers do provide datasheets, information can be limited to the range of resistance at at light levels and a typical resistance at some representative point. Thus it can be necessary to perform some form of calibration, although without reference to some absolute standard, the results should be used for measuring relative illuminance, rather then absolute illuminance.

Calibration of a LDR: The relationship between illuminance and resistance is given by:

$$\frac{I}{I_o} = \left(\frac{R}{R_o}\right)^A$$

I_O and R_O are the reference values of illuminance and resistance respectively, in the example below they are 100 lux and 20k respectively. The problem is to obtain the value of A which will allow us to determine illuminance from resistance which can be readily measured with a meter.
Typically the value of A is in the range -0.7 to -0.9.

Light Source:

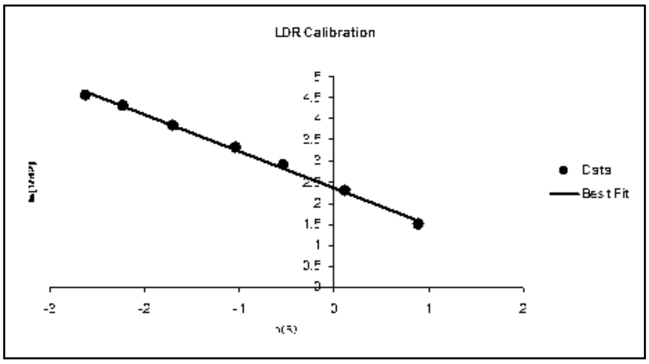
A convenient means of providing a variable light source is to use an incandescent light bulb and vary the intensity by taking measurements at different distances; the inverse square law can then be used to create a table of relative illuminances. The inverse square law is often expressed in this form:

$$\frac{I_1}{I_2} = \left(\frac{D_2}{D_1}\right)^2$$ Thus: $$I_2 = I_1\left(\frac{D_1}{D_2}\right)^2$$ f the illuminance of a light source is measured as 100 lux at a

distance of 1 metre, the illuminance at 2 metres will be 25 lux, the calculation is shown below:

$$I_2 = 100\left(\frac{1}{2}\right)^2 = 25$$

This allows us to use the square of the reciprocal of the distance as measure of relative illuminance and we can estimate the value of A in the equation above.The table shows a sample dataset of a LDR: A graph of these values looks like this:



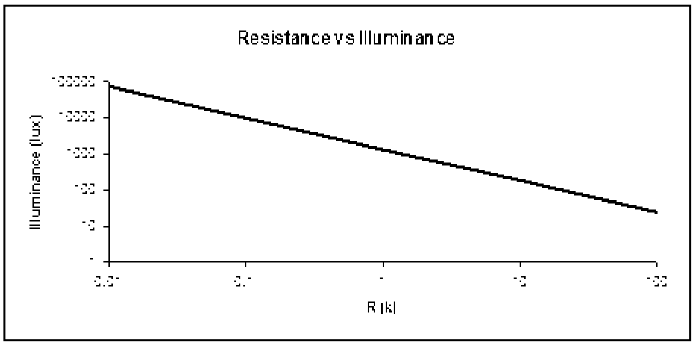
D (metres)	R (k)	$\ln(D^{-2})$	ln(R)
3.71	96.4	-2.622	4.569
3.04	74.4	-2.224	4.309
2.33	46.4	-1.692	3.837
1.68	27.6	-1.038	3.318
1.30	18.2	-0.525	2.901
0.94	10.0	-0.124	2.303

The slope of this line, which is the value of A is -0.87.

Using the value for A and the typical resistance gives a formula which allows a resistance measurement to converted into illuminance,for the test devices this is:

$$I = 100\left(\frac{R}{20}\right)^{-0.87}$$

This gives the log-log curve as shown,for illuminance and resistance.



6	WEIN BRIDGE OSCILLATOR	PHY08

Oscillators:

Oscillators are circuits that produce specific, periodic waveforms such as square, triangular,sawtooth, and sinusoidal. They generally use some form of active device, lamp, or crystal,surrounded by passive devices such as resistors, capacitors, and inductors, to generate theoutput.

TYPES:

There are two main classes of oscillator: relaxation and sinusoidal. Relaxation oscillators generate the triangular, sawtooth and other nonsinuoidal waveforms . Sinusoidal oscillators consist of amplifiers with external components used to generate oscillation, or crystals that internally generate the oscillation. The focus here is on sine wave oscillators, created using operational amplifiers op amps.

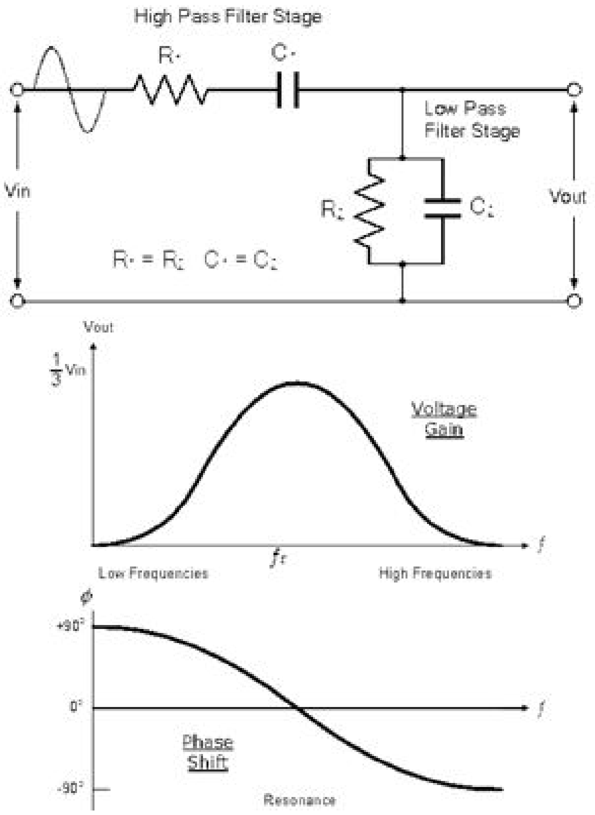
Sine wave oscillators are used as references or test waveforms by many circuits. A pure sine wave has only a single or fundamental frequency—ideally no harmonics are present. Thus, a sine wave may be the input to a device or circuit, with the output harmonics measured to determine the amount of distortion. The waveforms in relaxation oscillators are generated from sine waves that are summed to provide a specified shape.

The Wien Bridge Oscillator:

One of the simplest sine wave oscillators which uses a RC network in place of the conventional LC tuned tank circuit to produce a sinusoidal output waveform, is the **Wien Bridge Oscillator**.

The **Wien Bridge Oscillator** is so called because the circuit is based on a frequency-selective form of the Whetstone bridge circuit. The Wien Bridge Oscillator is a two-stage RC coupled amplifier circuit that has good stability at its resonant frequency, low distortion and is very easy to tune making it a popular circuit as an audio frequency oscillator but the phase shift of the output signal is considerably different from the previous phase shift **RC Oscillator**.

The **Wien Bridge Oscillator** uses a feedback circuit consisting of a series RC circuit connected with a parallel RC of the same component values producing a phase delay or phase advance circuit depending upon the frequency. At the resonant frequency fr the phase shift is 0^o. Consider the circuit shown.



RC Phase Shift Network :

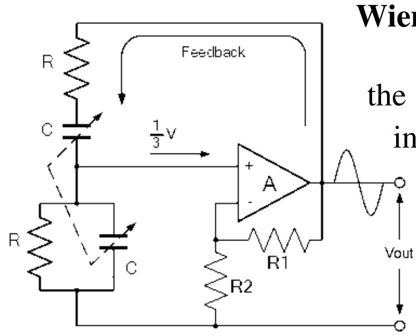
The RC network shown here, consists of a series RC circuit connected to a parallel RC forming basically a High Pass Filter connected to a Low Pass Filter producing a very selective second-order frequency dependant Band Pass Filter with a high Q factor at the selected frequency, fr.

At low frequencies the reactance of the series capacitor (C1) is very high so acts like an open circuit and blocks any input signal at Vin. Therefore there is no output signal, Vout. At high frequencies, the reactance of the parallel capacitor, (C2) is very low so this parallel connected capacitor acts like a short circuit on the output so again there is no output signal. However, between these two extremes the output voltage reaches a maximum value with the frequency at which this happens being called the *Resonant Frequency*, (fr). At this resonant frequency, the circuits reactance equals its resistance as Xc = R so the phase shift between the input and output equals zero degrees. The magnitude of the output voltage is therefore at its maximum and is equal to one (1/3) of the input voltage as shown.

It can be seen that at very low frequencies the phase angle between the input and output signals is "Positive" (Phase Advanced), while at very high frequencies the phase angle becomes "Negative" (Phase Delay). In the middle of these two points the circuit is at its resonant frequency, (fr) with the two signals being "in-phase" or 0^o. We can therefore define this resonant frequency point with the following expression.

Wien Bridge Oscillator Frequency: $f_r = \frac{1}{2\pi RC}$

Where: fr is the Resonant Frequency in Hertz, R is the Resistance in Ohms and C is the Capacitance in Farads. Then this frequency selective RC network forms the basis of the **Wien Bridge Oscillator** circuit. If we now place this RC network across a non-inverting amplifier which has a gain of $1+ R_1/R_2$ the following oscillator circuit is produced.



Wien Bridge Oscillator IC Circuit:

The output of the operational amplifier is fed back to both the inputs of the amplifier. One part of the feedback signal is connected to the inverting input terminal (negative feedback) via the resistor divider network of R1 and R2 which allows the amplifiers voltage gain to be adjusted within narrow limits. The other part is fed back to the non-inverting input terminal (positive feedback) via the RC Wien Bridge network.

The RC network is connected in the positive feedback path of the amplifier and has zero phase shift a just one frequency. Then at the selected resonant frequency, (fr) the voltages applied to the inverting and non-inverting inputs will be equal and "in-phase" so the positive feedback will cancel out the negative feedback signal causing the circuit to oscillate.

The voltage gain of the amplifier circuit MUST be equal too or greater than three "Gain = 3″ for oscillations to start. This value is set by the feedback resistor network, R_1 and R_2 and for a non-inverting amplifier this is given s the ratio $1+(R_1/R_2)$.

Also, due to the open-loop gain limitations of operational amplifiers, frequencies above 1MHz are unachievable without the use of special high frequency op-amps.

- With no input signal a Wien Bridge Oscillator produces continuous output oscillations.
- The Wien Bridge Oscillator can produce a large range of frequencies.
- The Voltage gain of the amplifier must be greater than 3.
- The RC network can be used with a non-inverting amplifier.
- The input resistance of the amplifier must be high compared to R so that the RC network is not overloaded and alter the required conditions.
- The output resistance of the amplifier must be low so that the effect of external loading is minimised.
- Some method of stabilizing the amplitude of the oscillations must be provided. If the voltage gain of the amplifier is too small the desired oscillation will decay and stop. If it is too large the output will saturate to the value of the supply rails and distort.
- With amplitude stabilisation in the form of feedback diodes, oscillations from the wien bridge oscillator can continue indefinitely.

7	BISTABLE MULTIVIBRATOR	PHY08

What is a Multivibrator Circuit?

An electronic circuit that generates non-sinusoidal waves (e.g. square, rectangular or saw tooth wave) is known as multivibrator.

An electronic oscillator consisting of two active devices, usually interconnected in an electrical network is called a multivibrator.

What is the purpose of this device?

The purpose of this device is to generate a continuous square wave. It stores information in binary form in a logic circuit.

How is it achieved?

It is achieved by applying a portion of the output voltage or current of each active device to the input of the other with the appropriate magnitude and polarity, so that the devices are conducting alternately far controllable periods.

What are different forms of multivibrator?

There are three different forms of multivibrator: (i) Free running multivibrator
(ii) Single shot multivibrator (iii) Bistable multivibrator

What is flip-flop multivibrator or bistable multivibrator?

A bistable multivibrator is that which requires two driving pulse for the production of each cycle of wave form.

What are non-sinusoidal waves?

The wave which does not have the curve as that of a sine curve is called non-sinusoidal waves. e.g. Square, rectangular, saw tooth waves are non-sinusoidal waves.

Among the non-sinusoidal oscillators, the square wave generator is very important.

Square waves are required for testing video amplifiers (Pulse amplifiers). Repetitive pulses find applications in radar & in triggering and many digital circuits.

ASTABLE MULTIVIBRATOR:

Working: Among the non-sinusoidal oscillators, the square wave generator is very important. Square waves are required for testing video amplifiers (Pulse amplifiers). Repetitive pulses find applications in radar and in triggering and many digital circuits.An astable (or free running) multivibrator generates square waves. It is a basic collector coupled transistors multivibrator. It is essentially a two-stage RC-coupled amplifier with the output of the first stage coupled to the input of the second stage, and the output of the second stage is coupled to the input of the first stage. Since the phase of a signal is reversed when amplified by a single stage of the CE amplifier it comes back to its original phase when passed

through two stages. Thus the signal feed-back to the base of either transistor is in the same phase as the original signal at its input. It amounts to positive feedback. In a multivibrator (also called relaxation Oscillator), the amount of feedback is very large. So large, that the transistors are driven between cut-off and saturation region almost instantaneously.
A transistor remains in either saturation or cut-off for a period determined by the time constant of the elements in the base circuit.

Monostable Multivibrator: Multivibrators are Sequential regenerative circuits either synchronous or asynchronous that are used extensively in timing applications. Multivibrators produce an output wave shape of a symmetrical or asymmetrical square wave and are the most commonly used of all the square wave generators. Multivibrators belong to a family of oscillators commonly called "**Relaxation Oscillators**".

Generally speaking, discrete multivibrators consist of a two transistor cross coupled switching circuit designed so that one or more of its outputs are fed back as an input to the other transistor with a resistor and capacitor (RC) network connected across them to produce the feedback tank circuit. Multivibrators have two different electrical states, an output "HIGH" state and an output "LOW" state giving them either a stable or quasi-stable state depending upon the type of multivibrator. One such type of a two state pulse generator configuration are called **Monostable Multivibrators**.

BISTABLE MULTIVIBRATOR:

As the name indicates, the bistable multivibrator has two stable states. Outwardly, the output looks the same as that of the astable multivibrator. The biggest difference between the two circuits is that the astable may or may not be triggered, but the bistable requires a trigger to operate. When the bistable receives a trigger of the proper amplitude and polarity, it changes states. It remains in that state until another trigger is received. At that time, it will change states again.

Because the bistable has two stable states, it is ideally suited for several applications in electronics. The closest mechanical analogy to a bistable multivibrator is a toggle switch. Momentary pressure in the form of a trigger pulse causes the output of the bistable to change states. That means the output changes from high to low, or low to high. In electronics, a toggle is a latch that maintains a condition once pressure or a signal is received. As the output stays at one state until another trigger pulse is received, the circuit remembers. That means the circuit can function as a memory storage device. Each time a trigger is applied to a bistable, it changes states, Figure 1 is a timing diagram for a bistable. Apply trigger #1 and the circuit changes states. Trigger #2 causes the circuit to return to its original state. The bistable multivibrator divides the frequency of the input signal in half. The major uses for the bistable multivibrator are as a memory storage device, timing circuit, frequency divider, and an electronic toggle switch.

The bistable multivibrator is called a FLIP-FLOP. That term describes the circuit operation. The output flips and flops as triggers are received, causing it to change states.

SUMMARY

This lesson continued the study of multivibrators and introduced you to bistable multivibrators.

Here are some important points to remember.

The bistable multivibrator:

1. Has two stable states 2. Requires an input trigger to change states 3.Has two outputs, Q and Q’
4.The outputs are always opposite
5.The output is taken from the collector of the transistors

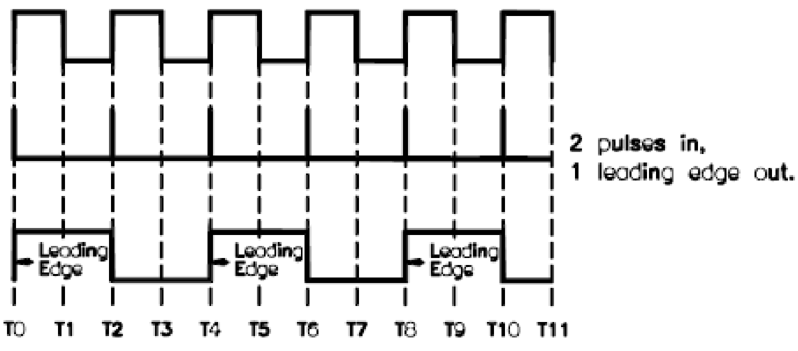


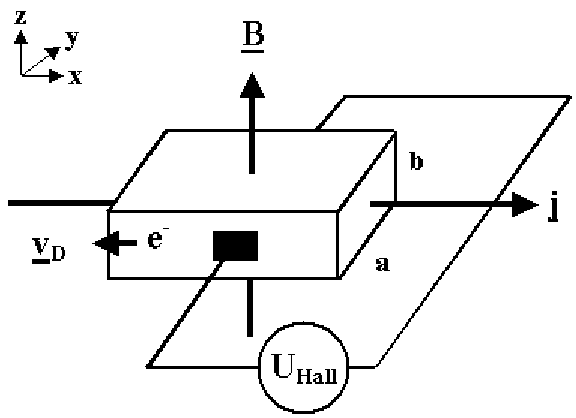
Figure 1. Bistable Multivibrator Timing Chart

The major uses of a bistable multivibrator are: Timing , Frequency divider, Memory storage device, Electronic toggle switch

A bistable multivibrator can also be called a flip-flop.

Define Hall Effect.

The **Hall effect** is the production of a voltage difference (the **Hall voltage**) across an electrical conductor, transverse to an electric current in the conductor and a magnetic field perpendicular to the current. It was discovered by Edwin Hall in 1879.The Hall coefficient is defined as the ratio of the induced electric field to the product of the current density and the applied magnetic field. It is a characteristic of the material from which the conductor is made, since its value depends on the type, number, and properties of the charge carriers that constitute the current.



Explain the situation with the help of diagram.

If current passes along X-direction of specimen (I_x) and the magnetic field be applied in Z-direction (B_Z) then a potential difference developed in Y-direction (V_y). This voltage is known as Hall voltage.

On what factors does the Hall voltage depends?

The Hall voltage depends on ; Applied magnetic field and amount of current passing through the sample.

On what does the direction of the Hall voltage depends?

The direction of the Hall voltage depends upon the nature of the charge carriers.

What do you mean by a hole?

When an electron moves from the valance band into the conduction band of a semiconductor, it leaves behind an unfilled state. The absence of an electron in the valance band is called positive hole.

Define Hall Coefficient. Give its practical unit.

Hall coefficient is numerically equal to Hall field produced by unit current density and unit field.It is measured in Columbus/cm^2.

How does the value of Hall coefficient change with the current through the specimen?

Hall coefficient decreases with the increase in current.

In which direction do you measure the value of b, used in formula for R_H?

The value of breadth of the crystal (b) is measure along Z-direction.

Define mobility of a charger carrier.

Mobility (μ) is defined as the drift velocity acquired in a unit electric field.

Define electric conductivity.

The electric conductivity (σ) is defined as the reciprocal of resistivity.

Is there any relation between mobility and electrical conductivity?

$$R_H = \frac{E_y}{I_x B_Z}.$$

Yes, the relation between mobility and electric conductivity = $R_H\,\sigma$, where .

Mention the importance of this experiment.

- The sign of the current carrying charge is determined.
- The number of charge carriers per unit volume can be investigated from Hall-coefficient R_H.
- The mobility is measured directly.
- It can be used to determine electronic structure of the substance. i.e. they are metals, semiconductors or insulators. (If $n < 10^{17}$ insulators, $10^{17} \le n \le 10^{20}$ semiconductor, $n \ge 10^{22}$ metallic.)
- The knowledge of Hall voltage developed enables us to measure high unknown magnetic field provided we know Hall constants for the slab used for it.
- It gives the concept of negative mass.

9	e/m BY MEGNETRON METHOD	PHY07

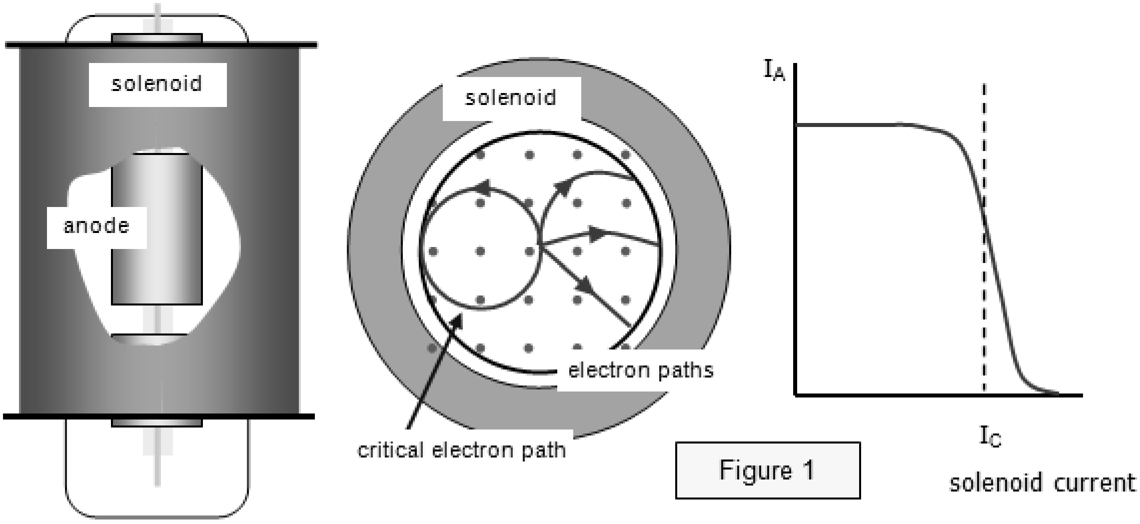


Figure 1

Magnetron Tube is a valve with a cylindrical anode surrounding a linear cathode (Figure 1). This type of valve is very difficult to buy for schools now but provides a simple way to determine e/m. A solenoid is placed over the valve with its axis coincident with that of the cathode. With no current in the coil of the solenoid the electrons emitted from the cathode travel in straight lines along a radius and are collected by the anode - a current (IA) flows in the valve. Now if a current is passed through the solenoid a magnetic field will be produced and the emitted electrons will begin to curve in the field - the radii of their paths becoming smaller and smaller as the current, and therefore the magnetic field is increased. Up to this point the anode current remains constant. Eventually a point will be reached for a solenoid current IC where the diameter of their path is just equal to the radius of the anode, any further increase in the solenoid current and the electrons will not hit the anode. There will then be a sudden drop in the anode current.
From the equations for centripetal force and kinetic energy of a charge in a magnetic field we have:

$$Bev = mv^2/r \quad \text{and} \quad \tfrac{1}{2}mv^2 = eV$$

Therefore $e/m = 2V/(B^2r^2)$ but if R is the radius of the anode (R = 2r) we have:

Magnetron: Specific charge : $e/m = 8V/[B^2R^2]$

Tthe magnetic field in the solenoid for the critical field is given by the equation:

$$B_c = \mu_o NI/(d^2+L^2)^{1/2}$$

(where d is the diameter of the coils and L their length). In the magnetron we must assume that the cathode is very narrow, so that the electric field at its surface is high. If we do this then we can also assume that the electrons experience most of their acceleration close to the cathode and so their velocity across the rest of the valve to the anode is uniform.

A magnetron is a thermionic valve with cylindical coaxial anode and cathode. Electrons emitted by the cathode travel radially to the anode (see Figure 1a), however in the presence of an axial magnetic field the electron paths become curved (Figure 1b). At a critical value of the magnetic field, the electron paths just touch the anode (Figure 1c), any further increase in magnetic field strength will result in the electrons not reaching the anode (Figure 1d) so the anode current falls to zero. Measurement of this critical field can be used to determine the specific charge.

The conditions for the critical case (Figure 1c) are that the radius of the electron orbit is half the anode radius of the magnetron, i.e.

$$r_e = \frac{r_a}{2}. \tag{1}$$

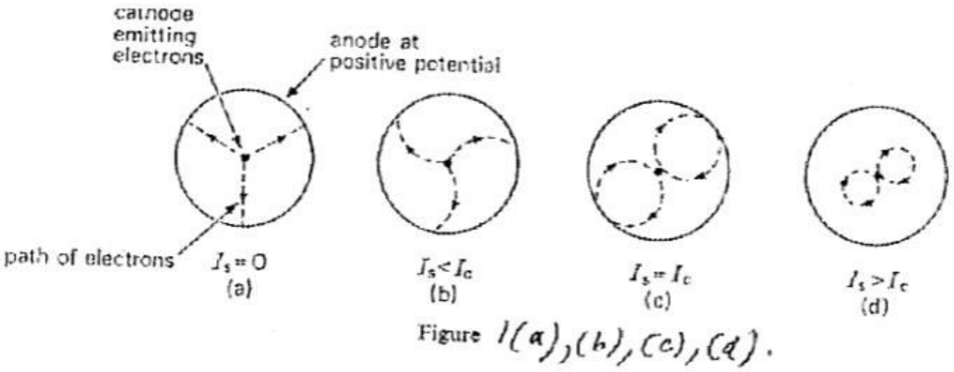


Figure 1: Electron paths inside the magnetron for different currents.

But for the the circular motion of an electron with speed v

$$\frac{m_e v^2}{r_e} = evB_c, \tag{2}$$

where e and m_e have their usual meanings and B_c is the critical magnetic field.

From conservation of energy

$$eV_a = \frac{1}{2} m_e v^2. \tag{3}$$

Combining these equations gives

$$\frac{e}{m_e} = \frac{2V_a}{B_c^2 r_e^2} = \frac{8V_a}{B_c^2 r_a^2}. \tag{4}$$

Hence, e/m_e can be found from a graph of B_c^2 against V_a.

10	SQUARE WELL POTENTIAL	PHY09

What is a wave function?
What is eigen value?
What is a square well potential?

Interferometers

An interferometer is an instrument for making precise measurements for beams of light of such factors as length, surface irregularities, and index of refraction. It divides a beam of light into a number of beams that travel unequal paths and whose intensities, when reunited, add or subtract (interfere with each other). This interference appears as a pattern of light and dark bands called interference fringes. Information derived from fringe measurements is used for precise wavelength determinations, measurement of very small distances and thicknesses, the study of spectrum lines, and determination of refractive indices of transparent materials. In astronomy, interferometers are used to measure the distances between stars and the diameters of stars.

In 1881 the American physicist A.A. Michelson constructed the interferometer used in the Michelson-Morley experiment.(see figure) The Michelson interferometer and its modifications are used in the optical industry for testing lenses and prisms, for measuring index of refraction, and for examining minute details of surfaces (microtopographies). The instrument consists of a half-silvered mirror that divides a light beam into two equal parts, one of which is transmitted to a fixed mirror and the other of which is reflected to a movable mirror. By counting the fringes created as the mirror is moved, the amount of movement can be precisely determined. Michelson also developed the stellar interferometer, capable of measuring the diameters of stars in terms of the angle, as small as 0.01" of an arc, subtended by the extreme points of the star at the point of observation.

The Fabry interferometer (variable-gap interferometer) was produced in 1897 by the French physicists Charle Fabry. It consists of two highly reflective and strictly parallel plates called an etalon. Because of the high reflectivity of the plates of the etalon, the successive multiple reflections of light waves diminish very slowly in intensity and form very narrow, sharp fringes. These may be used to reveal hyperfine structures in line spectra, to evaluate the widths of narrow spectral lines, and to redetermine the length of the standard meter.

Fizeau-Laurent surface interferometry system:The Fizeau-Laurent surface interferometer reveals departures of polished surfaces from a plane. The system was described by the French physicist A.-H.-L. Fizeau in 1862 and adapted in 1883 into the instruments now widely used in the optical industry. In theFizeau-Laurent system, monochromatic light (light of a single color) is passed through a pinhole and illuminates a reference plane and a workpiece directly below it. The light beam is perpendicular to the workpiece. By maintaining a slight angle between the surface of the workpiece and the surface of the plane of reference, fringes of equal thickness can be seen through a reflector placed above them. The fringes constitute a contour map of the surface of the workpiece, enabling an optical polisher to see and to remove defects and departures from flatness.

The Twyman-Green interferometer, an adaptation of the Michelson instrument introduced in 1916 by the English electrical engineer Frank Twyman and the English chemist Arthur Green, is used for testing lenses and prisms. It uses a point source of monochromatic light at the focus of a quality lens. When the light is directed toward a perfect prism, it returns to a viewing point exactly as it was from the source, and a uniform field of illumination is seen. Local imperfections in the prism glass distort the wave front. When the light is directed toward a lens backed by a convex mirror, it passes through the lens, strikes the mirror, and retraces its path through the lens to a viewing point. Imperfections in the lens result in fringe distortions.

Multiple Beam Interference

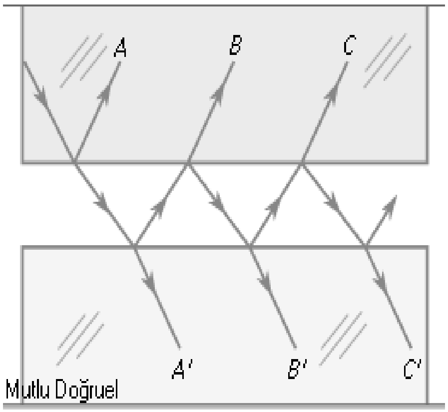
If the two inner surfaces of the plates shown in Figure are coated so as to make them reflect 80 percent or more of the incident light, then the resulting interference pattern will be caused by the superposition of many beams.

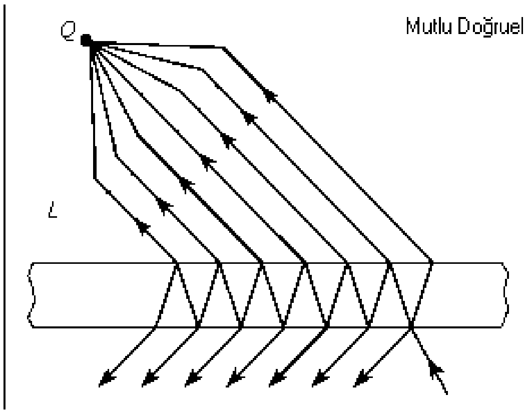
The below figure shows an arrangement for producing the fringes of constant inclination by multiple-beam interference. The amplitudes of successive beams are proportional to r, r squared, r cubed, etc. (r is the ratio of the intensity of the reflected light to that of the incident light for one reflection). The phase differences are ε, 2ε, 3ε, etc., in which

$$\varepsilon = (4\pi e \cos\theta)/\lambda.$$

These fringes are much sharper than those obtained with two-beam interference. With a large number of beams the intensity is extremely high when they are all in phase ($\varepsilon = 0$), but, even when the phase difference between any two successive beams (e.g., the first and the second) is quite small, the phase difference between the first and, say, the thirtieth beam is so large that the later beams in the series are in opposition to the earlier beams. Thus the intensity is relatively small except when the value of $\varepsilon$is close to one of the values 2πp (in which p is an integer). Multiple-beam fringes of constant inclination were used by Charles Fabry and Alfred Pérot in France for resolution of spectral lines having only small differences of wavelength. Multiple-beam fringes of constant thickness have been used by an English physicist, Samuel Tolansky, to detect surface irregularities down to less than a nanometre.

The Fabry-Perot Interferometer and Etalon





Until the development of all-dielectric multi-layer reflection coatings, which have low light-loss coefficients, the Fabry - Perot interferometer had very little application to the spectrometry of faint light sources, although it was used by Fabry and Buisson as early as 1911 on the relatively bright Orion nebula, though with lossy metallic layers.

The most common form that it has taken is with two plane parallel reflecting layers. However, there is an interesting spherical version which is not widely used. Here the more common version will be emphasised:

The Fabry-Pérot interferometer consists of two reflecting mirrors that can be either curved or flat.In the Fabry-Perot interferometer the seperation between two semi-silvered glass plates can be varied. One plate remains stationary with respect to the frame of the instrument whilst the other is mounted on a nut threaded on an accurate screw. The adjustment of the Fabry -Perot interferometer is in many ways similar to that of Michelson. In the Fabry - Perot interferometer, the multiple beam interference fringes from a plane parallel plate illuminated near normal incidance are used. The inner surfaces are coated with partially transparent films of high reflectivity and are parallel, so that they enclose a plane parallel plate of air. The plates themselves are made slightly prismatic, in order to avoid disturbing effects due to reflections at the outer uncoated surfaces.

Only certain wavelengths of light will resonate in the cavity: the light is in resonance with the interferometer if and only if $m(\lambda/2) = L$, where L is the distance between the two mirrors, m is an integer, and $\lambda$is the wavelength of the light inside the cavity. When this condition is fulfilled, light at these specific wavelengths will build up inside the cavity and be transmitted out the back end for specific wavelengths. By adjusting the spacing between the two mirrors, the instrument can be scanned over the spectral range of interest.The fringe profile may be plotted once a value of the reflection coefficient is known.

Consider a narrow, monochromatic beam from an extended source point making an angle (in air) of $\theta$with respect to the optical axis of the system. The single beam produces multiple coharent beams in the interferometer, and the emerging set of parallel rays are brought together at some point *P* in the focal plane of the converging lens *L*. The nature of the superposition at *P* is determined by the path difference between successive parallel beams; taking the refraction index for air as 1, the condition for brightness is

$$2t\cos\theta = m\lambda.$$

Other beams from different points of the source but in the same plane and making the same angle $\theta$with the axis satisfy the same path difference and also arrive at *P*. With *t* fixed, the above equation is satisfied

for certain angles θ, and the fringe system is the familiar concentric rings due to the focusing of fringes of equal inclination. When collimating lens is used between source and interferometer, every set of parallel beams entering the etalon must arise from the same source point. Here again, I used Pascal to plot the resultant profile:
A figure showing the circular fringe pattern

Applications Of Fabry-Perot Interferometers

The Fabry-Perot interferometers have a wide range of applications. All these applications, however, are either based on the study of the fine structure lines, or the comparison of wavelengths as discussed under the title "resolution", above. When a Fabry-Perot interferometer is illuminated by some quasi-monochromatic light, the intensity distribution of the transmitted light differs from its standart form and yields some information about the spectral distribution of the light used. If we imagine that their wavelength difference is gradually increased, and providing they do not differ too greatly in intensity, their presence will eventually be evident from the presence of two mutually displaced sets of maxima in the interference pattern. The components are then said to be *resolved* by the interferometer. In this way, Fabry and Perot were able to observe directly the fine structure of spectral lines which Michelson could only infer, and the Fabry-Perot interferometer has since played a dominant role in this branch of spectroscopy.

12	LVDT CHARACTERISTICS	PHY07

Instrumentation is the heart of industrial applications. Instrumentation is the art and science of measuring and controlling different variables such as flow, level, temperature, angle, displacement etc. A basic instrumentation system consists of various devices. One of these various devices is a **transducer**. A **transducer** plays a very important role in any instrumentation system. An electrical **transducer** is a device which is capable of converting the physical quantity into a proportional electrical quantity such as voltage or electric current. Hence it converts any quantity to be measured into usable electrical signal. This physical quantity which is to be measured can be pressure, level, temperature, displacement etc. The output which is obtained from the transducer is in the electrical form and is equivalent to the measured quantity. For example, a temperature transducer will convert temperature to an equivalent electrical potential. This output signal can be used to control the physical quantity or display it.

Note that any device which is able convert one form of energy into another form is called as a **transducer**. For example, even a speaker can be called as a transducer as it converts electrical signal to pressure waves (sound).But an electrical transducer will convert a physical quantity to an electrical one.

Types of Transducer

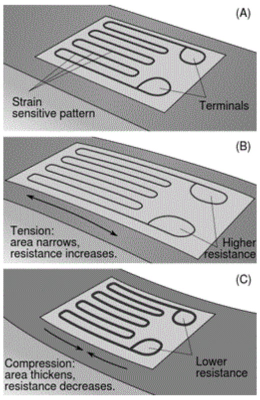
Types of Transducer based on Quantity to be Measured

• Temperature transducers (e.g. a thermocouple), Pressure transducers (e.g. a diaphragm)
• Displacement transducers (e.g. LVDT), Flow transducers.

Types of Transducer based on the Principle of Operation

• Photovoltaic (e.g. a solar cell), Piezoelectric, Chemical, Mutual Induction, Electromagnetic, Hall effect, Photoconductors

Types of Transducer based on Whether an External Power Source is required or not



Active Transducer

Active transducers are those which do not require any power source for their operation. They work on the energy conversion principle. They produce an electrical signal proportional to the input (physical quantity). For example, a thermocouple is an active transducer.

Passive Transducers

Transducers which require an external power source for their operation is called as a passive transducer. They produce an output signal in the form of some variation in resistance, capacitance or any other electrical parameter, which than has to be converted to an equivalent current or voltage signal. For example, a photocell (LDR) is a passive transducer which will vary the resistance of the cell when light falls on it. This change in resistance is

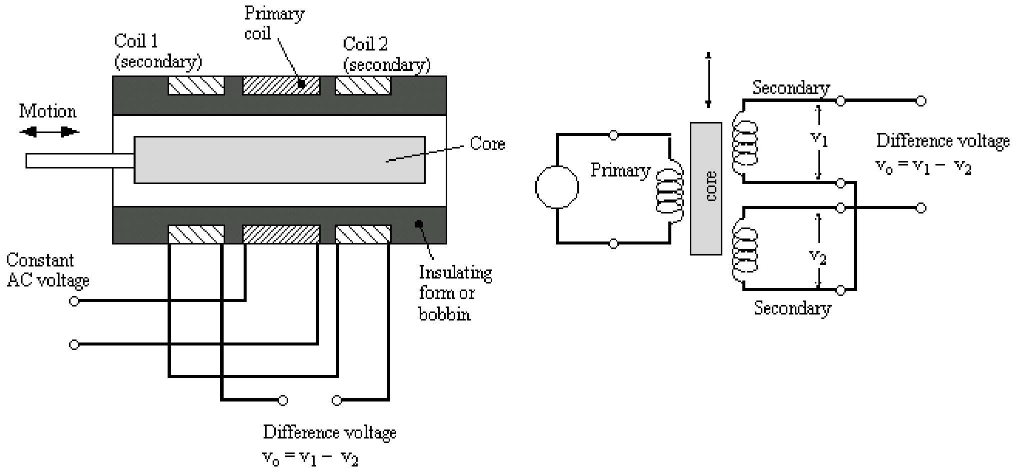
converted to proportional signal with the help of a bridge circuit. Hence a photocell can be used to measure the intensity of light.
Above shown is a figure of a bonded strain gauge which is a passive transducer used to measure stress or pressure. As the stress on the strain gauge increases or decreases the strain gauge bends or compresses causing the resistance of the wire bonded on it to increase or decrease. The change in resistance which is equivalent to the change in stress is measured with the help of a bridge. Hence stress is measured.

Principle of LVDT:LVDT works under the principle of mutual induction, and the displacement which is a non-electrical energy is converted into an electrical energy. And the way how the energy is getting converted is described in working of LVDT in a detailed manner.

LVDT consists of a cylindrical former where it is surrounded by one primary winding in the centre of the former and the two secondary windings at the sides. The number of turns in both the secondary windings are equal, but they are opposite to each other, i.e., if the left secondary windings is in the clockwise direction, the right secondary windings will be in the anti-clockwise direction, hence the net output voltages will be the difference in voltages between the two secondary coil. The two secondary coil is represented as S1 and S2. Esteem iron core is placed in the centre of the cylindrical former which can move in to and fro motion as shown in the figure. The AC excitation voltage is 5 to 12V and the operating frequency is given by 50 to 400 HZ.

Working of LVDT:

Let's study the working of LVDT by splitting the cases into 3 based on the iron core position inside the insulated former.



(a) (b)

Case 1: On applying an external force which is the displacement, if the core reminds in the null position itself without providing any movement then the voltage induced in both the secondary windings are equal which results in net output is equal to zero i.e., Esec1-Esec2=0

Case 2: When an external force is appilied and if the steel iron core tends to move in the left hand side direction then the emf voltage induced in the secondary coil is greater when compared to the emf induced in the secondary coil 2.

Therefore the net output will be Esec1-Esec2

Case 3:When an external force is applied and if the steel iron core moves in the right hand side direction then the emf induced in the secondary coil 2 is greater when compared to the emf voltage induced in the secondary coil 1. therefore the net output voltage will be Esec2-Esec1

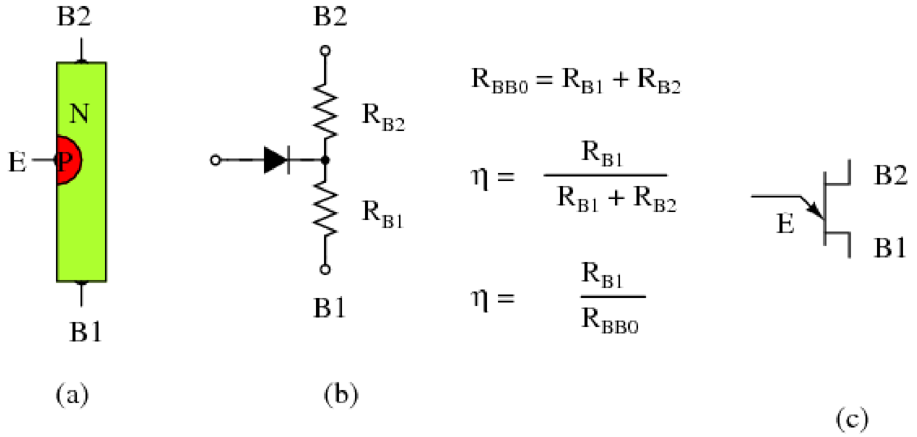
Advantages of LVDT:* Infinite resolution is present in LVDT* High output* LVDT gives High sensitivity* Very good linearity* Ruggedness* LVDT Provides Less friction* Low hysteresis* LVDT gives Low power consumption.

Disadvantages of LVDT:* Very high displacement is required for generating high voltages.* Shielding is required since it is sensitive to magnetic field.* The performance of the transducer gets affected by vibrations* Its is greatly affected by temperature changes.

Applications of LVDT: LVDT is used to measure displacement ranging from fraction millimeter to centimeter.=> Acting as a secondary transducer, LVDT can be used as a device to measure force, weight and pressure, etc..

A unijunction transistor (UJT) is an electronic semiconductor device that has only one junction. The UJT has three terminals: an emitter (E) and two bases (B1 and B2). The base is formed by lightly doped n-type bar of silicon. Two ohmic contacts B1 and B2 are attached at its ends. The emitter is of p-type and it is heavily doped. The resistance between B1 and B2, when the emitter is open-circuit is called interbase resistance.

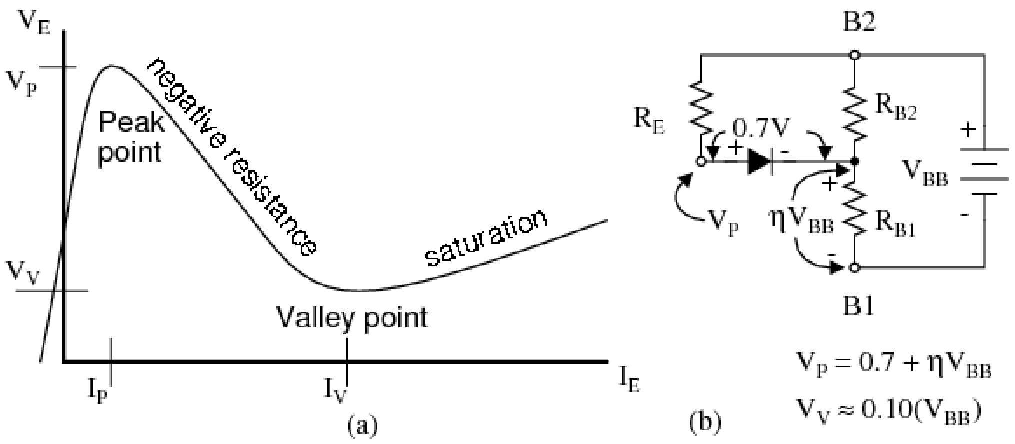
Although a unijunction transistor is not a thyristor, this device can trigger larger thyristors with a pulse at base B1. A *unijunction transistor* is composed of a bar of N-type silicon having a P-type connection in the middle. See Figure below(a). The connections at the ends of the bar are known as bases B1 and B2; the P-type mid-point is the emitter. With the emitter disconnected, the total resistance R_{BBO}, a datasheet item, is the sum of R_{B1} and R_{B2} as shown in Figure below(b). R_{BBO} ranges from 4-12kΩ for different device types. The intrinsic standoff ratio η is the ratio of R_{B1} to R_{BBO}. It varies from 0.4 to 0.8 for different devices. The schematic symbol is Figure below(c) .



Unijunction transistor: (a) Construction, (b) Model, (c) Symbol

The Unijunction emitter current vs voltage characteristic curve (Figure below(a)) shows that as V_E increases, current I_E increases up I_P at the peak point. Beyond the peak point, current increases as voltage decreases in the negative resistance region. The voltage reaches a minimum at the valley point. The resistance of R_{B1}, the saturation resistance is lowest at the valley point.

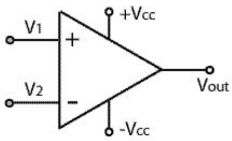
I_P and I_V, are datasheet parameters; For a 2n2647, I_P and I_V are 2μA and 4mA, respectively. [AMS] V_P is the voltage drop across R_{B1} plus a 0.7V diode drop; see Figure below(b). V_V is estimated to be approximately 10% of V_{BB}.

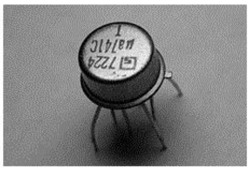


Unijunction transistor: (a) emitter characteristic curve, (b) model for V_P.

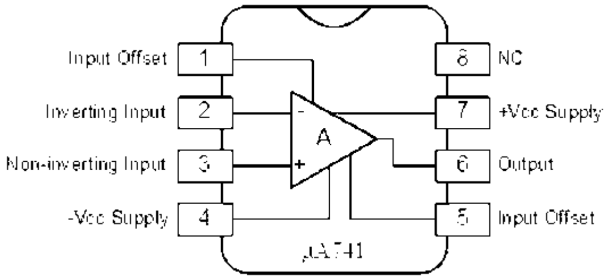
Operational Amplifiers :

An **operational amplifier** or **OP-AMP** is a DC-coupled voltage amplifier with a very high voltage gain. Op-amp is basically a multistage amplifier in which a number of amplifier stages are interconnected to each other in a very complicated manner. Its internal circuit consists of many transistors, FETs and resistors. All this occupies a very little space. So, it is packed in a small package and is available in the Integrated Circuit (IC) form. The term **OP-AMP** is used to denote an amplifier which can be configured to perform various operations like amplification, subtraction, differentiation, addition, integration etc. Example is the very popular IC 741. The symbol and its actual appearance in the IC form is show below. The symbol appears as an arrowhead which signifies that the signal is flowing from output to input.





An “ideal” or perfect Operational Amplifier is a device with certain special characteristics such as infinite open-loop gain Ao, infinite input resistance Rin, zero output resistance Rout, infinite bandwidth 0 to ∞ and zero offset (the output is exactly zero when the input is zero).
There are a very large number of operational amplifier IC’s available to suit every possible application from standard bipolar, precision, high-speed, low-noise, high-voltage, etc, in either standard configuration or with internal Junction FET transistors.



Operational amplifiers are available in IC packages of either single, dual or quad op-amps within one single device. The most commonly available and used of all operational amplifiers in basic electronic kits and projects is the industry standard **µA-741**.

Op-amp Parameter and Idealised Characteristics:

- **Open Loop Gain, (Avo)**

Infinite –Open-loop gain is the gain of the op-amp without positive or negative feedback and for an ideal amplifier the gain will be infinite but typical real values range from about 20,000 to 200,000.

- **Input impedance, (Z_{in})**

Infinite – Input impedance is the ratio of input voltage to input current and is assumed to be infinite to prevent any current flowing from the source supply into the amplifiers input circuitry (Iin = 0).

- **Output impedance, (Z_{out})**

Zero – The output impedance of the ideal operational amplifier is assumed to be zero acting as a perfect internal voltage source with no internal resistance so that it can supply as much current as necessary to the load. This internal resistance is effectively in series with the load thereby reducing the output voltage available to the load. Real op-amps have output-impedance in the 100-20Ω range.

- **Bandwidth, (BW)**

Infinite – An ideal operational amplifier has an infinite frequency response and can amplify any frequency signal from DC to the highest AC frequencies so it is therefore assumed to have an infinite bandwidth. With real op-amps, the bandwidth is limited by the Gain-Bandwidth product (GB), which is equal to the frequency where the amplifiers gain becomes unity.

- **Offset Voltage, (V_{io})**

Zero – The amplifiers output will be zero when the voltage difference between the inverting and the non-inverting inputs is zero, the same or when both inputs are grounded. Real op-amps have some amount of output offset voltage.

From these "idealized" characteristics above, we can see that the input resistance is infinite, so **no current flows into either input terminal** (the "current rule") and that the **differential input offset voltage is zero** (the "voltage rule"). It is important to remember these two properties as they will help us understand the workings of the **Operational Amplifier** with regards to the analysis and design of op-amp circuits.

However, real **Operational Amplifiers** such as the commonly available **uA741**, for example do not have infinite gain or bandwidth but have a typical "Open Loop Gain" which is defined as the amplifiers output amplification without any external feedback signals connected to it and for a typical operational amplifier is about 100dB at DC (zero Hz). This output gain decreases linearly with frequency down to "Unity Gain" or 1, at about 1MHz and this is shown in the following open loop gain response curve.

- **Working Principle of Op-amp:**

Open Loop Operation

As said above an op-amp has a differential input and single ended output. So, if two signals are applied one at the inverting and another at the non-inverting terminal, than an ideal op-amp will amplify the difference of the two applied input signals applied. The difference of the two applied input signals is called as differential input voltage. The output of an op-amp is given by the equation:

Where, V_0 is the voltage at the output terminal , A_{OL} is the open-loop gain and is constant (ideally). For the IC 741 it is 2 x 105. V_1 is the voltage at the non-inverting andV_2 is the voltage at the inverting terminal. $V_D = (V_1-V_2)$ is the differential input voltage.

It is clear from the above equation that the output will be non-zero if and only if the differential input voltage is non-zero, and will be zero if both V_1 and V_2 are equal. Note that this is an ideal condition, practically there are small imbalances in the op-amp. The open-loop gain of an op-amp is very high hence, very small applied differential input voltage will be amplified to a very large value.

Also note that it is true that if we apply a very small differential input voltage it is amplified to a very large value but this very large value at the output cannot go beyond the supply voltage of the op-amp. Hence it is not violating the law of conservation of energy.

Closed Loop Operation

The above explained operation of the op-amp was for open-loop i.e. without a feedback. In the closed loop configuration a feedback is introduced. This feedback is a part of an output signal fed back to the input. Hence, at the input where the feedback is given two signals will be simultaneously present. One of them is the original applied signal and the other is the feedback signal. The fed back signal can be in phase or out of phase with the original applied signal. If the original applied signal and the feedback signal are in phase with each other than it called as a positive feedback or a regenerative feedback. If the applied signal and the feedback signal are out of phase with each other than it is called as a negative feedback or a degenerative feedback. Each type of feedback, negative or positive has its own advantages and disadvantages. The output of a closed loop op-amp is given by the equation:

Where, V_0 is the voltage at the output terminal.A_{CL} is the closed loop gain of the op-amp which is determined by the feedback circuit connected to the op-amp.$V_D = (V_1-V_2)$ is the differential input voltage.

The feedback is said to be positive if part of the signal from the output terminal is given back to the non-inverting (+) terminal of the op-amp. Positive feedback is used in oscillators. The feedback is said to be negative if part of the signal from the output terminal is given back to the inverting (-) terminal of the op-amp. Negative feedback is used when op-amp's are to be used as amplifiers.

Applications: The integrated op-amp's offers all the advantages of IC's such as high reliability, small size, cheap, less power consumption. They are used in variety of applications such as Inverting & Non-inverting amplifiers, Unity gain buffer, Summing amplifier, Differentiator, Integrator, Adder, Instrumentation amplifier, Wien bridge oscillator, Filters etc.

BALLISTIC GALVANOMETER

What is the construction of Ballistic Galvanometer?
What is Ballistic galvanometer? What does it measure?
Which type BG are you using a moving coil or a moving magnet type?
Why do you place a key in parallel to the galvanometer?
What is damping and on what factors does it depend?
What is the use of a tape key connected across the ballistic galvanometer?

The ballistic galvanometer is usually employed to measure the quantity of charge flowing in a given circuit due to transient current.
it consists of a coil of copper wire wound on a non conducting frame which is suspended by a phosphor bronze strip between the poles of strong permanent magnet horse – shoe shape magnet . In order to increase the magnetic flux in the gap , the cylindrical soft iron – core is placed with in the coil. The pole pieces of the magnet are cylindrical concave in shape so that the magnetic field is radial in the narrow annular gap and is also perpendicular to the coil surface . The whole apparatus is covered in a shell to avoid disturbance from outside .Three leveling screws are provided below the base of the galvanometer . The deflection of the coil is measured by lamp and scale arrangement .

Note:- When large damping is present , the motion of the coil is non oscillatory and the moving coil galvanometer become dead beat . The construction and working of such a galvanometer is different from moving coil galvanometer.

Theory:-

In this method the resistance which is measured is connected in parallel with the capacitor C and the electronic voltmeter V. The capacitor is the charged up to some suitable voltage by means of the battery having the voltage V and is then allowed to discharge through the resistance.
The terminal voltage is observed over the considerable period of the time during discharge.
Let,
V = initialvoltage on the charged capacitor , v = instantaneous discharging voltage.
I =the discharging capacitor current through the unknown resistor at time "t".
Q = the charge still remaining in the capacitor.
I = dq/dt = -cdv/dt since [I=V/R]

$V/R + C\, dv/dt = 0$ …………(1)

$1/RC\, dt + 1/V\, .dV = 0$

Integratingboth sides

$t/RC + \log_e v + K = 0$ …….(2) Here K isconst. of integration

At initial condition, whenT=0 , v=V , From equ. (2)

$K = -\log_e V$

Now equ. (2) becomes, $t/RC + \log_e v - \log_e V = 0$

Therefore, $\log_e (v/V) = -t/RC$

$v/V = e^{-t/RC}$

$v = V^* e^{-t/RC}$

Takinglog on both sides, $\log_e v = \log_e V + \log_e e^{-t/RC}$

$R = t/C^* \log_e(V/v)$

$R = 0.4343^* t/C^* \log_{10}(V/v)$

Viva Questions:- 1)Why this method is called as loss of charge method?
2)What errors occur while performing this practical?

Define Logic Gate.
The circuits which use diodes and transistors to perform switching action are known as logic gates.
The logic gates are used in digital system like computer, data-processing control or digital communication system.
There are four logic circuit commonly uses: AND gate, OR gate, NOT gate and FLIP FLOP.
Counters:
Counter is the most useful and versatile subsystem of digital branch. Counter is going to count number of clock pulses applied to it. Maximum count that binary counter can count is 2^n- 1. Clock pulses occur at regular time interval, so that counter can be used to measure time or frequency. Digital counters are integrated circuits (ICs) that count events in computers and other digital systems. Because they must remember past states, digital counters include memory. Generally, digital counters consist of bistable devices or bistable multi vibrators called flip-flops. The number of flip-flops and the way in which they are connected determines the number of states and the sequence of states that digital counters complete in each full cycle.
Counters can be subdivided into 2 groups:
Asynchronous Counters AND Synchronous Counters
The way in which devices are clocked determines whether digital counters are categorized as synchronous or asynchronous. In synchronous devices (such as synchronous BCD counters and synchronous decade counters), one clock triggers all of the flip-flops simultaneously. With asynchronous devices, often called asynchronous ripple counters an external clock pulse triggers only the first first-flop. Each successive flip-flop is then clocked by one of the outputs (Q or Q') of the previous flip-flop. Digital counters are configured as UP (counting in increasing sequence), DOWN (counting in decreasing sequence) or Bidirectional (UP / DOWN).

- **Synchronous / Asynchronous counter can be subdivided into following subgroups:**
  Sequential Counters: States of counter are sequential.

1. Non-sequential Counters: Sequence or states of counter are sequential but irregular.
2. Regular Counters: In this counters, FFs are used. There is direct relation between number of states and number of FFs used i.e. N=2m.
3. Decade counter – counts through ten states per stage.
4. Up down counter – counts both up and down, under command of a control input.
5. Ring counter – formed by a shift register with feedback connection in a ring.
6. Johnson counter – a twisted ring counter.
7. Cascaded counter.

Some of the commercial ICs used for design of Counters:

1. IC 7490-Decade Counter
2. IC 7492 Divide by 10 Counter
3. IC 7493 4 - bit binary Counter
4. IC 74190 Up -Down Decade Counter
5. IC74191 Binary Up-down Counter

BCD Counter
BCD stands for Binary Coded Decimal. A BCD counter has four outputs usually labeled A, B, C, D. By convention A is the least significant bit, or LSB. The easiest way to understand what a BCD counter does is to follow the counting sequence in truth table form.
A BCD counter or decade counter can be constructed from a straight binary counter by terminating the "ripple-through" counting when the count reaches decimal 9 (binary 1001). Since the next toggle would set the two most significant bits, a NAND gate tied from those two outputs to the asynchronous clear line will start the count over after 9.

Asynchronous Decade Counters

A common modulus for counters with truncated sequences is ten. A counter with ten states in its sequence is called a decade counter. The circuit below is an implementation of a decade counter. Once the counter counts to ten (1010), all the flip-flops are being cleared. Notice that only Q1 and Q3 are used to decode the count of ten. This is called partial decoding, as none of the other states (zero to nine) have both Q1 and Q3 HIGH at the same time.

Synchronous Decade Counters

Similar to an asynchronous decade counter, a synchronous decade counter counts from 0 to 9 and then recycles to 0 again. This is done by forcing the 1010 state back to the 0000 state. This so called truncated sequence can be constructed by the following circuit.

Clock Pulse	Q_3	Q_2	Q_1	Q_0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

Table 1: Sequence for Synchronous Decade Counter

- Q0 toggles on each clock pulse. Q1changes on the next clock pulse each time Q0=1 and Q3=0.
- Q2 changes on the next clock pulse each time Q0= Q1=1. Q3 changes on the next clock pulse each time Q0=1, Q1=1 and Q3=1 (count 7), or when Q0 =1 and Q3=1 (count 9).

Asynchronous counter circuit design is based on the fact that each bit toggle happens at the same time that the preceding bit toggles from a "high" to a "low" (from 1 to 0). Since we cannot clock the toggling of a bit based on the toggling of a previous bit in a synchronous counter circuit (to do so would create a ripple effect) we must find some other pattern in the counting sequence that can be used to trigger a bit toggle.

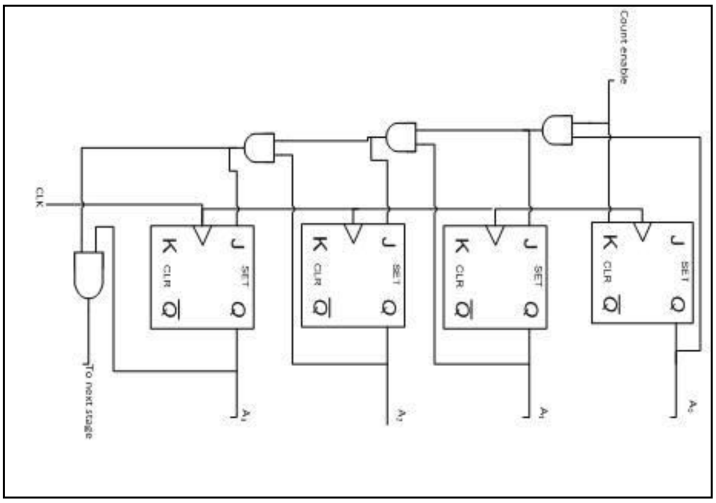


Fig. shows 4-bit Asynchronous Binary ounter

The result is a four-bit synchronous "up" counter. Each of the higher-order flip-flops are made ready to toggle (both J and K inputs "high") if the Q outputs of all previous flip-flops are "high." Otherwise, the J and K inputs for that flip-flop will both be "low," placing it into the "latch" mode where it will maintain its present output state at the next clock pulse. Since the first (LSB) flip-flop needs to toggle at every clock pulse, its J and K inputs are connected to Vcc or Vdd, where they will be "high" all the time. The next flip-flop need only "recognize" that the first flip-flop's Q output is high to be made ready to toggle, so no AND gate is needed. However, the remaining flip-flops should be made ready to toggle only when all lower-order output bits are "high," thus the need for AND gates.

To make a synchronous "down" counter, we need to build the circuit to recognize the appropriate bit patterns predicting each toggle state while counting down. Not surprisingly, when we examine the four-bit binary count sequence, we see that all preceding bits are "low" prior to a toggle (following the sequence from bottom to top).

Since each J-K flip-flop comes equipped with a Q' output as well as a Q output, we can use the Q' outputs to enable the toggle mode on each succeeding flip-flop, being that each Q' will be "high" every time that the respective Q is "low"

Taking this idea one step further, we can build a counter circuit with selectable between "up" and "down" count modes by having dual lines of AND gates detecting the appropriate bit conditions for an "up" and a "down" counting sequence, respectively, then use OR gates to combine the AND gate outputs to the J and K inputs of each succeeding flip-flop.

This circuit isn't as complex as it might first appear. The Up/Down control input line simply enables either the upper string or lower string of AND gates to pass the Q / Q' outputs to the succeeding stages of flip-flops. If the Up/Down control line is "high," the top AND gates become enabled, and the circuit functions exactly the same as the first ("up") synchronous counter circuit shown in this section. If the Up/Down control line is made "low," the bottom AND gates become enabled, and the circuit functions identically to the second ("down" counter) circuit shown in this section.

Ring counter

A ring counter is a type of counter composed of a circular shift register. If the output of a shift register is fed back to the input a ring counter results. There are two types of ring counters:

- A straight ring counter or Over beck counter connects the output of the last shift register to the first shift register input and circulates a single one (or zero) bit around the ring. For example, in a 4-register one-hot counter, with initial register values of 1000, the repeating pattern is: 1000, 0100, 0010, 0001, 1000... . Note that one of the registers must be pre-loaded with a 1 (or 0) in order to operate properly.
- A twisted ring counter (also called Johnson counter or Moebius counter) connects the complement of the output of the last shift register to its input and circulates a stream of ones followed by zeros around the ring. For example, in a 4-register counter, with initial register values of 0000, the repeating pattern is: 0000, 1000, 1100, 1110, 1111, 0111, 0011, 0001, 0000..

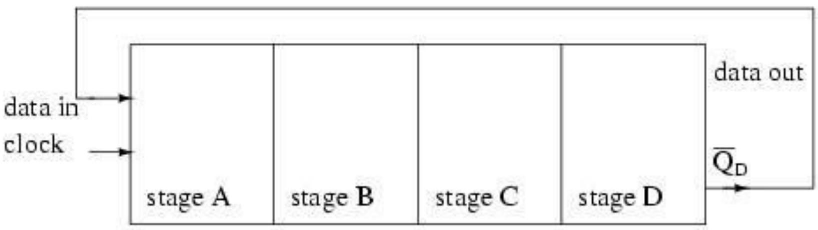


Fig. : Ring counter shift register, output fed back to input

The data pattern contained within the shift register will re-circulate as long as clock pulses are applied. For example, the data pattern will repeat every four clock pulses in the figure below. However, we must load a data pattern. All 0's or all 1's doesn't count. Is a continuous logic level from such a condition useful? We make provisions for loading data into the parallel-in/ serial-out shift register configured as a ring counter below. Any random pattern may be loaded. The most generally useful pattern is a single 1.

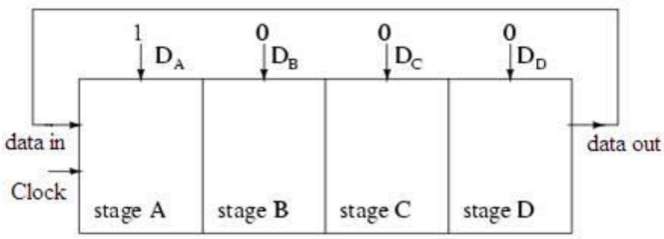


Fig. : Parallel In Serial Out Shift Register using Ring Counter

Loading binary 1000 into the ring counter, above, prior to shifting yields a viewable pattern. The data pattern for a single stage repeats every four clock pulses in our 4-stage example. The waveforms for all four stages look the same, except for the one clock time delay from one stage to the next. See figure below.

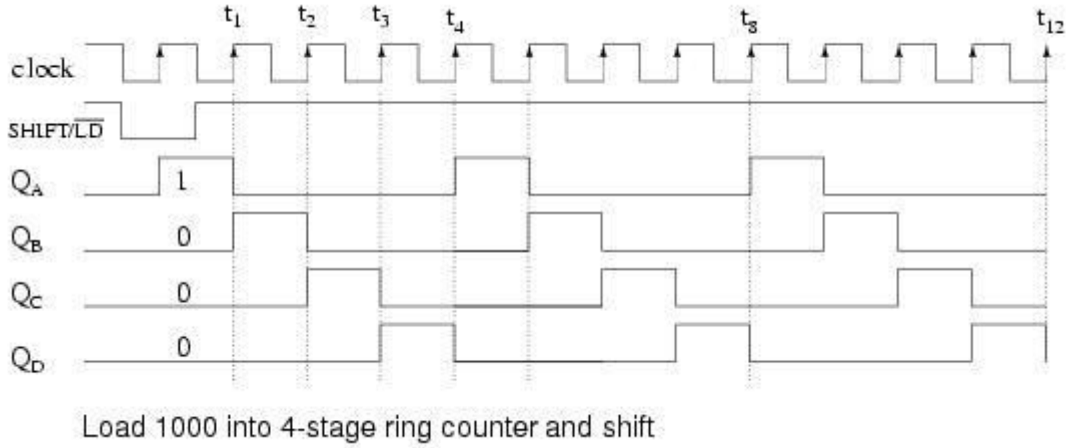


Fig.: Timing Diagram For Ring Counter

The circuit above is a divide by 4 counter. Comparing the clock input to any one of the outputs, shows a frequency ratio of 4:1. How may stages would we need for a divide by 10 ring counter? Ten stages would recirculate the 1 every 10 clock pulses.

An alternate method of initializing the ring counter to 1000 is shown above. The shift waveforms are identical to those above, repeating every fourth clock pulse. The requirement for initialization is a disadvantage of the ring counter over a conventional counter. At a minimum, it must be initialized at power-up since there is no way to predict what state flip-flops will power up in. In theory, initialization should never be required again. In actual practice, the flip-flops could eventually be corrupted by noise, destroying the data pattern. A "self correcting" counters, like a conventional synchronous binary counter would be more reliable.

The above binary synchronous counter needs only two stages, but requires decoder gates. The ring counter had more stages, but was self decoding, saving the decode gates above. Another disadvantage of the ring counter is that it is not "self starting". If we need the decoded outputs, the ring counter looks attractive, in particular, if most of the logic is in a single shift register package. If not, the conventional binary counter is less complex without the decoder.

The waveforms decoded from the synchronous binary counter are identical to the previous ring counter waveforms. The counter sequence is (QA QB) = (00 01 10 11).

Shift Registers

In digital circuits, a shift register is a cascade of flip flops, sharing the same clock, which has the output of any one but the last flip-flop connected to the "data" input of the next one in the chain, resulting in a circuit that shifts by one position the one-dimensional "bit array" stored in it, shifting in the data present at its input and shifting out the last bit in the array, when enabled to do so by a transition of the clock input. More generally, a shift register may be multidimensional, such that its "data in" input and stage outputs are themselves bit arrays: this is implemented simply by running several shift registers of the same bit-length in parallel.

Shift registers can have both parallel and serial inputs and outputs. These are often configured as serial-in, parallel-out (SIPO) or as parallel-in, serial-out (PISO). There are also types that have both serial and parallel input and types with serial and parallel output. There are also bi-directional shift registers which allow shifting in both directions: L → R or R → L. The serial input and last output of a shift register can also be connected together to create a circular shift register.

Shift registers are a type of sequential logic circuit, mainly for storage of digital data. They are a group of flip-flops connected in a chain so that the output from one flip-flop becomes the input of the next flip-flop. Most of the registers possess no characteristic internal sequence of states. All the flip-flops are driven by a common clock, and all are set or reset simultaneously. Contain several flip-flops in a row.

One bit is input at one end on each clock pulse. Each other bit moves one place to the right (or left). The outputs of each flip-flop are available simultaneously.

We can use shift registers for serial to parallel conversion. Input 8 bits on 8 pulses, then read data simultaneously.

A basic four-bit shift register can be constructed using four D flip-flops, as shown below. The operation of the circuit is as follows. The register is first cleared, forcing all four outputs to zero. The input data is then applied sequentially to the D input of the first flip-flop on the left (FF0). During each clock pulse, one bit is transmitted from left to right. Assume a data word to be 1001. The least significant bit of the data has to be shifted through the register from FF0 to FF3.

In order to get the data out of the register, they must be shifted out serially. This can be done destructively or non-destructively. For destructive readout, the original data is lost and at the end of the read cycle, all flip-flops are reset to zero.

To avoid the loss of data, an arrangement for a non-destructive reading can be done by adding two AND gates, an OR gate and an inverter to the system. The construction of this circuit is shown below.

The data is loaded to the register when the control line is HIGH (ie WRITE). The data can be shifted out of the register when the control line is LOW (ie READ).

For this kind of register, data bits are entered serially in the same manner as discussed in the last section. The difference is the way in which the data bits are taken out of the register. Once the data are stored, each bit appears on its respective output line, and all bits are available simultaneously. A construction of a four-bit serial in - parallel out register is shown below.

D0, D1, D2 and D3 are the parallel inputs, where D0 is the most significant bit and D3 is the least significant bit. To write data in, the mode control line is taken to LOW and the data is clocked in. The data can be shifted when the mode control line is HIGH as SHIFT is active high. The register performs right shift operation on the application of a clock pulse.

For parallel in - parallel out shift registers, all data bits appear on the parallel outputs immediately following the simultaneous entry of the data bits. The following circuit is a four-bit parallel in - parallel out shift register constructed by D flip-flops.

The D's are the parallel inputs and the Q's are the parallel outputs. Once the register is clocked, all the data at the D inputs appear at the corresponding Q outputs simultaneously.

The registers discussed so far involved only right shift operations. Each right shift operation has the effect of successively dividing the binary number by two. If the operation is reversed (left shift), this has the effect of multiplying the number by two. With suitable gating arrangement a serial shift register can perform both operations.

A bidirectional, or reversible, shift register is one in which the data can be shift either left or right. A four-bit bidirectional shift register using D flip-flops is shown below.

Registers

The register is a group of flip-flop. An n bit register consists of group of n flip-flops capable of storing n bits of binary information. Register may have the combinational gates that perform certain data processing tasks.

Register consists of group of flip-flops and gates that affect their transition.

Counter is a register that goes through the predetermined sequence of steps. The gates in the counter are connected in such a way as to produce the prescribed the sequence of binary steps. Counters are special type of registers.

Shift registers

Register capable of shifting its binary information in one or both directions is called shift registers. The logical configuration of the shift registers consists of the chain of flip-flops in cascade, with the o/p of one flip-flop connected to input of next flip-flop. All flip-flops receive common clock pulses which activate the shift from one stage to the next.

4 bit shift register

The output of the flip-flop is connected to the D input of the next flip-flop. Each clock pulse shifts the contents of the register one bit position to the right. The serial input data lines what goes into the leftmost flip-flop during the shift. The serial output is taken from the output of the right most flip-flops. Sometimes it is necessary to control the shift so that it occurs only with certain pulses but not with the others. This can be done by inhibiting the clock from the input of register to prevent it from shifting.

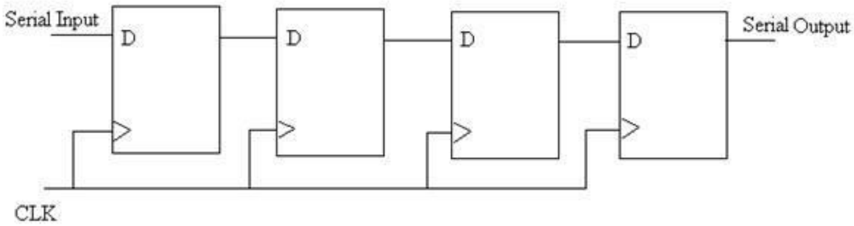
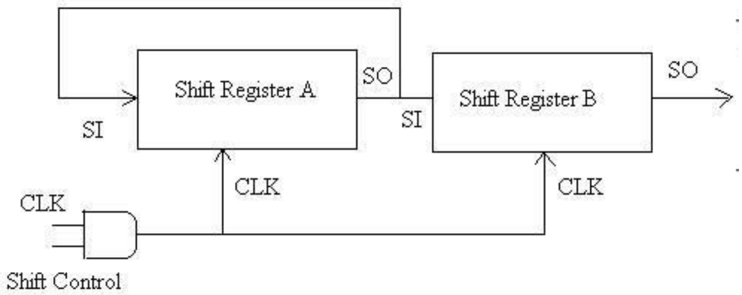


Fig.: 4-bit Shift Register

Fig. : Serial Transfer



The advantages of Asynchronous Counters:

- Asynchronous Counters can easily be made from Toggle or D-type flip-flops.
- They are called "Asynchronous Counters" because the clock input of the flip-flops are not all driven by the same clock signal.
- Each output in the chain depends on a change in state from the previous flip-flops output.
- Asynchronous counters are sometimes called ripple counters because the data appears to "ripple" from the output of one flip-flop to the input of the next.
- They can be implemented using "divide-by-n" counter circuits.
- Truncated counters can produce any modulus number count.

Disadvantages of Asynchronous Counters:

- An extra "re-synchronizing" output flip-flop may be required.
- To count a truncated sequence not equal to 2^n, extra feedback logic is required.
- Counting a large number of bits, propagation delay by successive stages may become undesirably large.
- This delay gives them the nickname of "Propagation Counters".
- Counting errors occur at high clocking frequencies.
- Synchronous Counters are faster and more reliable as they use the same clock signal for all flip-flops.

18	**BABINET COMPENSATOR**	**PHY09**

The Babinet compensator is a device for the production and analysis of elliptically and circularly polarised light. Actually, it acts as a quarter-wave plate for any wavelengths. We know that a quarter-wave plate produces a fixed path difference between the ordinary and extraordinary rays. So it can be used only for light of a particular wavelength for which it is constructed. Now for different wavelength ranges, quarter-wave plates of different thicknesses have to be used. This imposes limitations on the use of a quarter-wave plate. To overcome this limitation of a quarter-wave plate, a Babinet's compensator is used. The Babinet's compensator is an improved version of the quarter-wave plate and is used to produce and analyse the elliptically polarised light.

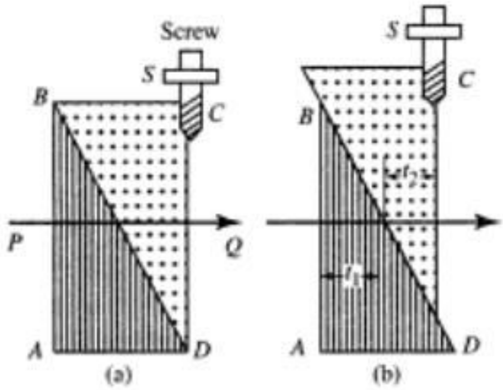


Fig. 4.32 Babinet compensator

Construction The Babinet compensator comprises of two small-angled wedge-shaped parts of quartz placed with their hypotenuses in contact to form a small rectangular block [see Fig. 4.32 (a)]. The optic axis of the left wedge is parallel to its refracting edge *AB* while the optic axis of the right wedge is perpendicular to the refracting edge *CD*. Thus, the optic axes of the two wedges are mutually perpendicular and also perpendicular to the incident beam *PQ*. One of the wedges is fixed while the other can be moved relative to the fixed wedge in its own plane by a micrometer screw *S*, as shown in Fig. 4.32 (b).

Theory Let a plane polarised light fall normally on the face *AB* of the first wedge with the plane of vibration inclined at a certain angle θ with the optic axis. The light beam is splitted up into the ordinary component (with vibrations perpendicular to the optic axis) and the extraordinary component (with vibrations parallel to the optic axis). We know that quartz is a positive crystal, so the ordinary component travels faster than the extraordinary component. On reaching the second wedge, the ordinary component now becomes extraordinary and the extraordinary component becomes the ordinary component because the optic axis is perpendicular to the first wedge. Therefore, the two components exchange their velocities in passing from one edge to the other edge. So the two wedges tend to cancel each other's effect.

Let μ_o and μ_e be the refractive indices of quartz for ordinary and extraordinary rays and t_1 and t_2, the thickness of the two wedges respectively traversed by a particular ray. Now the path difference introduced between the two components by the first wedge is $(\mu_e - \mu_o)\, t_1$ or an equivalent phase difference $\Delta_1 = (2\pi/\lambda)(\mu_e - \mu_o)t_1$. Now, the path difference introduced between the two components by the second wedge is $(\mu_o - \mu_e)t_2$, i.e., $-(\mu_e - \mu_o)t_2$ or a phase difference $\Delta_2 = (2\pi/\lambda)\,(\mu_o - \mu_e)t_2$. Thus, the resultant phase difference δ introduced by the compensator is given by

19	RESITTIVITY BT CAREY-FOSTER METHOD	PHY07

THEORY

At a constant temperature, the resistance, R of a conductor is proportional to its length L and inversely proportional to its area of cross section A.

$$R = \rho \frac{L}{A} \qquad (1)$$

where ρ is the resistivity of the conductor and its unit is ohmmeter.

A semiconductor has electrical conductivity intermediate in magnitude between that of a conductor and insulator. Semiconductor differs from metals in their characteristic property of decreasing electrical resistivity with increasing temperature.

According to band theory, the energy levels of semiconductors can be grouped into two bands, valence band and the conduction band. In the presence of an external electric field it is electrons in the valence band that can move freely, thereby responsible for the electrical conductivity of semiconductors. In case of intrinsic semiconductors, the Fermi level lies in between the conduction band minimum and valence band maximum. Since conduction band lies above the Fermi level at 0K, when no thermal excitations are available, the conduction band remains unoccupied. So conduction is not possible at 0K, and resistance is infinite. As temperature increases, the occupancy of conduction band goes up, thereby resulting in decrease of electrical resistivity of semiconductor.

Theory

Resistance : Resistance refers to the property of a substance that impedes the flow of electric current. Some substances resist current flow more than others. If a substance offers very high resistance to current flow it is called an insulator. If its resistance to current flow is very low, it is called a conductor. Resistivity refers to the ability of substances to resist current flow. Good conductors have low resistivity and insulators have high resistivity.

Resistance at the Molecular Level : Resistance to current flow occurs at the molecular level of substances. For example, a metal conductor, such as copper, consists of atoms having free electrons in their outer most shells. These free electrons ordinarily move randomly from one atom to another. However, if a potential difference, also called voltage, is applied across the conductor, such as with a battery, free electrons flow from the negative to the positive terminals. Electric current refers to the rate of flow of electric charge, which causes free electrons to flow. For extremely low resistivity, it As electrons move through the conductor, some collide with atoms, other electrons, or impurities in the metal. It is these collisions that cause resistance. The molecular makeup of a substance determines the number of collisions, or amount of resistance, to electron flow. Since the molecular makeup of copper provides is often used as a conductor in electric circuits.

Ohm's Law : In 1789-1854, German physicist George Simon Ohm formulated the relationships among voltage, current, and resistance into what is referred to as Ohm's law: according to this low "*The current in a circuit is directly proportional to the applied potential difference and inversely proportional to the resistance of the circuit.*" Therefore, voltage can be calculated using the formula: **E = I * R.**
Resistance can be calculated using the formula: **R = E/I .** It is important to note that adjusting voltage or current cannot change resistance. Resistance in a circuit is a physical constant and can only be modified by changing components, exchanging resistors for those rated at more or fewer ohms, or by adjusting variable resistors.

Measurement of Resistance :

Generally a *Meter bridge and Wheatstone bridge* are used for the measurement of resistance. But the accuracy *Meter bridge* and Wheatstone bridge decrease when the value of resistance is tends to their low value because the resistance of the connecting wires becomes comparable and comes an appreciable error.

Wheatstone bridge : It is used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component. Its operation is similar to the original potentiometer except that in potentiometer circuits the meter used is a sensitive galvanometer.

Carey Foster's Bridge : The ***Carey Foster's Bridge*** is used for the measurement of very low resistances, although it can be used to find the small differences between large resistances. Sensitivity of Carey foster bridge is the same as the sensitivity of the Wheatstone bridge as it uses the same fundamental principle. The bridge is balanced when the two pairs of resistances connected to the galvanometer bear the same ratio. This can happen even when all the four Resistances are not of the same order. It can be proved that the bridge is most sensitive when all the four Resistances are of the same order. In a meter bridge the Resistances of the two parts of the wire are of the same order as the unknown and known resistances are of the same order. For a given meter bridge this is not always possible for any arbitrary resistance. For example if I have to find the value of some unknown resistance of about 100 ohms with a metre bridge wire of say 4 ohms Resistance. Then the bridge will not be so sensitive. In Carey foster bridge this problem is over come by taking two standard resistances of the same order in addition so that they in series with the wire make the new ratio arms; similar arguments can be made for resistances of the order of fraction of ohms. The other advantage of the Carey foster bridge is that it eliminates the end resistances. As far as accuracy is concerned that would also depend upon the sensitivity of the galvanometer or detector.

Specific Resistance or Resistivity :

Specific resistance or resistivity is the resistance in ohms offered by a unit volume, of a substance against to the flow of electric current. Resistivity is the reciprocal of conductivity. A substance that has a high resistivity will have a low conductivity, and vice versa. Many tables of specific resistance are based on the resistance in ohms of a volume of a substance 1 foot in length and 1 circular mil in cross-sectional area. The temperature at which the resistance measurement is made is also specified

The resistance of a conductor having uniform area of cross section depends on the two factors, (a) length l and (b) area of cross section A.

(a) It is directly proportional to the length of the conductor i.e. $R \propto l$

(b) It is inversely proportional to the area of cross-section of the conductor i. e. $R \propto 1/A$.

If we combine the above two factors, we get $R = \rho\, l/A$ ……………………………(1)

Here the constant of proportionality ρ is called ***electrical resistivity*** or ***specific resistance*** of the conductor. The value of specific resistance depends upon the nature of the material of the conductor and its temperature. Above equation can be represent the resistance of the conductor in the terms of length, area of cross-section and resistivity of the material.

If $l = 1$, $A = 1$, then $R = \rho$ or $\rho = R$

Hence, we can say that the resistivity or specific resistance of the material of a conductor is equal to the resistance offered by a wire of this material of unit length and unit area of cross-section. From equation (1) we write that ………………………………..(2) Where: R is the resistance of the wire. l is the length of the wire, and A is the area of cross-section (πr2) According to the above formula the unit of the specific resistance is Ohm meter (Ω m). R = ρ Al A ρ = R l

Material	Copper	Aluminum	Tungsten	Carbon* (graphite)	Germanium	Glass
Resistivity (ohm-m)	1.6×10^{-8}	2.6×10^{-8}	5.6×10^{-8}	$3\text{-}60 \times 10^{-5}$	$1\text{-}500 \times 10^{-3}$	$1\text{-}10000 \times 10^{9}$

Robert A. Millikan performed a set of experiments which gave two important results:

(1) Electric charge is quantized. All electric charges are integral multiples of a unique elementary charge e.

(2) The elementary charge was measured and found to have the value $e = 1.60 \times 10^{-19}$ Coulombs.

Of these two results, the first is the most significant since it makes an absolute assertion about the nature of matter. We now recognize e as the elementary charge carried by the electron and other elementary particles. More precise measurements have given the value

$$e = (1.60217733 \pm 0.00000049) \times 10^{-19} \text{ Coulombs}$$

The electric charge carried by a particle may be calculated by measuring the force experienced by the particle in an electric field of known strength. Although it is relatively easy to produce a known electric field, the force exerted by such a field on a particle carrying only one or several excess electrons is very small. For example, a field of 1000 volts per cm would exert a force of only 1.6×10^{-14} N on a particle bearing one excess electron. This is a force comparable to the weight of 10^{-12} grams.

The success of the Millikan Oil-Drop experiment depends on the ability to measure small forces. The behavior of small charged droplets of oil, weighing only 10^{-12} gram or less, is observed in a gravitational and electric field. Measuring the velocity of fall of the drop in air enables, with the use of Stokes' Law, the calculation of the mass of the drop. The observation of the velocity of the drop rising in an electric field then permits a calculation of the force on, and hence the charge, carried by the oil drop.

Although this experiment will allow one to measure the total charge q on a drop, it is only through an analysis of the data obtained and a certain degree of experimental skill that the charges can be shown to be quantized. By selecting droplets which rise and fall slowly, one can be certain that the drop has a fairly small charge. A number of such drops should be observed and their respective charges q calculated. If the charges q on these drops are integral multiples of a certain smallest charge e, then this is an observation that charge is quantized.

Theory:

Initially the oil drops are allowed to fall between the plates in the absence of electric field. Due to gravity they accelerate first, but gradually slowdown because of air resistance.
The terminal velocity v_1 in the absence of an electric field is calculated as $v_1 = \frac{l_1}{t_1}$
where 'l_1' is the distance travelled by the oil drop and 't_1' is the time taken.

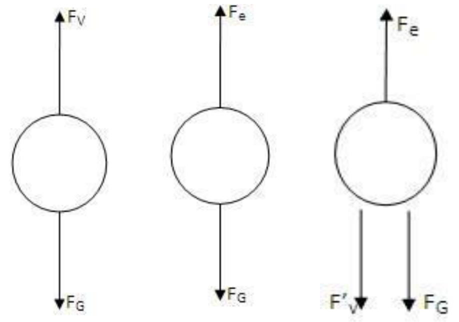
The drag force acting upon the drop is calculated from stokes's law and is given as $F_v = 6\pi\eta r v_1$

The apparent weight (true weight minus up thrust) for a perfectly spherical body is given by,

$$F_G = \frac{4}{3}\pi r^3 g(\rho - \rho_{air})$$

At terminal velocity the oil drop is not accelerating, so the total force acting on it must be zero $_V$-F_G=0. i.e.,

$$F_V = F_G$$



$$r^2 = \frac{9\eta v_1}{2g(\rho - \rho_{air})}$$

Where r-radius of oil drop, η-viscosity of air
V_1-terminal velocity, g-acceleration due to gravity
ρ-density of liquid, ρ_{air}-density of air

Now a field is produced in the bottom chamber with the supply voltage.
A likely looking drop is selected and kept in the middle of the field of view by adjusting the voltage.
If the electric forces F_e, balances the gravitational force F_G, the drop suspends in the air.
Then,

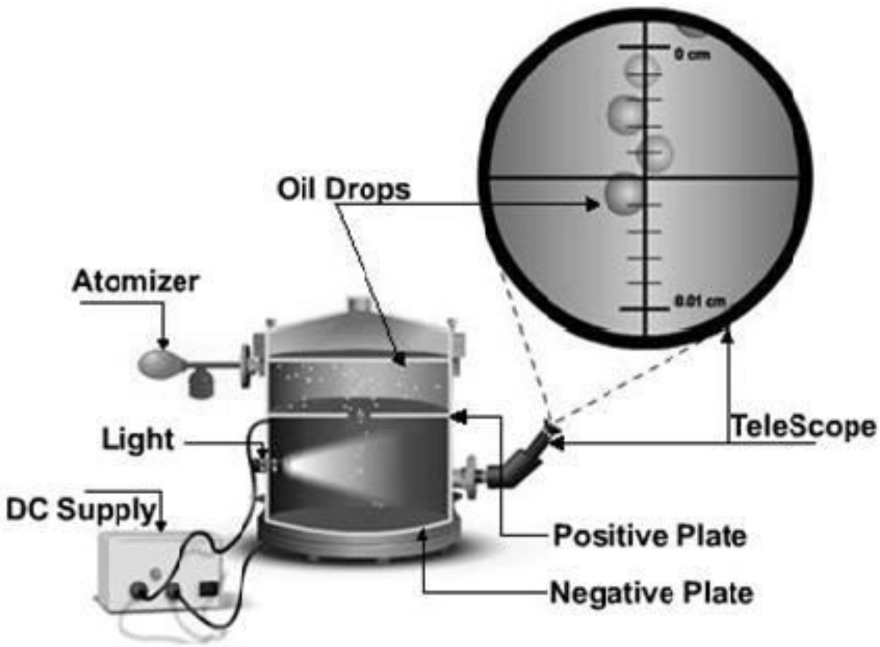
$$F_e = F_G \qquad qE = mg \qquad \frac{qV}{d} = mg$$

where V is the balancing potential and d is the distance between the plates.
If the applied electric force F_e is greater than the downward forces, some of the drops (the charged ones) will start to rise. Now the electric force will act upwards, gravity and viscous forces acts downwards. Corresponding terminal velocity v_2 is calculated as,

$$v_2 = \frac{l_2}{t_2}$$

where l_2 is the distance travelled by the oil drop and t_2 the time taken.
Now the total force acting on drop is $F_e - F'_v - F_G = 0$.
Hence $F_e = F'_v + F_G$
F'_V is the new viscous force under the action of electric field.

$$qE = 6\pi\eta r v_2 + 6\pi\eta r v_1 \qquad \frac{qV}{d} = 6\pi\eta r(v_1 + v_2) \qquad q = 6\pi\eta r(v_1 + v_2)\frac{d}{V}$$



Millikan repeated the experiment no. of times, each time varying the strength of X-rays ionizing the air. As a result no. of electrons attaching to the oil drop varied. Then he obtained various values for q,and is found to be a multiple of 1.6 x 10^{-19}C.

21	MICHELSON INTERFEROMETER	PHY09

What is interferometer?
Interferometer is a device used to determine the wave-length of light utilizing the phenomenon of interference of light.
Are two mirrors simply plane mirrors?
They are excellently optically plane and highly silvered polished plane mirrors.
What type of glass plates are G_1 and G_2?How are they mounted?
The two plates are optically flat glass plates of same thickness and of the same material. They are parallel to each other and inclined at an angle 45˚ with the two mirrors. G_1 is semi silvered at the face towards G_2. G_2 is known as compensating plate.
What type of fringes is observed?
The fringes may be straight, circular parabolic etc.depending upon the path difference between two rays and the angle between two mirrors.
How do you get the circular fringes?
The circular fringes are obtained when two mirrors are exactly perpendicular to each other.(or they are enclosed in air film of uniform thickness.)The screws provided at the back of mirror M_1 are adjusted for this purpose.
Where the circular fringes are formed?
They are formed at infinity and telescope is used to receive.
What are the localized fringes?
When the two mirrors are not exactly perpendicular to each other then either straight or parabolic fringes are obtained. These are known as localized fringes.

When the mirror is moved through a distance $\pi/2$ how many fringes appear or disappear?
One fringe.
What is intereference?
When the two waves superimpose each other, the resultant intensity is modified. This modification in the distribution of intensity in the region of superposition is called interference.
Is there any loss of energy in intereference phenomenon?
No, there is only re-distribution of energy.
What are the conditions for obtaining intereference of light?
The two sources should be coherent.(should vibrate in the same phase or must be a constant phase difference between them)

1. Two sources must emit waves of the same wavelength and time-period.
2. The sources should be monochromatic.
3. The amplitude of interfering waves should be equal or nearly equal.
4. What are ther intereference fringes?
2. They are alternatively bright and dark patches of light obtained in the region of superposition of two wave trains of light.

22	DETERMINATION OF LATTICE PARAMETERS	PHY09

Cathode Ray Oscilloscope | CRO:

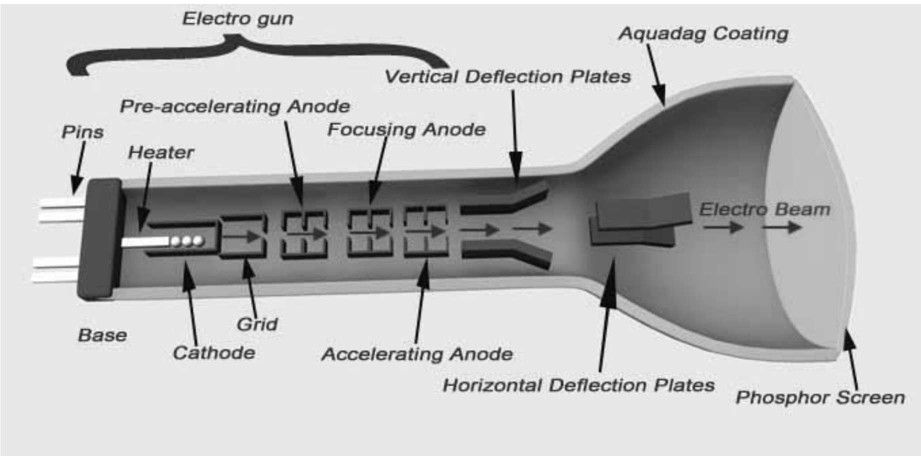
The cathode ray oscilloscope is an instrument which we use in laboratory to display measure and analyze various waveforms of various electrical and electronic circuits. Actually cathode ray oscilloscope is very fast X-Y plotters that can display an input signal versus time or other signal. Cathode ray oscilloscope uses luminous spot which is produced by striking the beam of electrons and this luminous spot moves in response variation in the input quantity. At this moment one question must be arise in our mind that why we are using only an electron beam? The reason behind this is low effects of beam of electrons that can be used for following the changes in the instantaneous values of rapidly changing input quantity. The general forms of cathode ray oscilloscope operate on voltages. So the input quantity that we have talked above is voltage. Nowadays, with the help of transducers it is possible to convert various physical quantities like current, pressure, acceleration etc to voltage thus it enable us to have a visual representations of these various quantities on cathode ray oscilloscope. Now let us look at the constructional details of the cathode ray oscilloscope.

Construction of Cathode Ray Oscilloscope

The main part of cathode ray oscilloscope is cathode ray tube which is also known as the heart of cathode ray oscilloscope.

Let us discuss the construction of cathode ray tube in order to understand the construction of cathode ray oscilloscope. Basically the cathode ray tube consists of five main parts and these main parts are written below:

1. Electron gun.
2. Deflection plate system.



Internal Structure of CRT

3. Fluorescent screen.
4. Glass envelope.
5. Base.

Now we discuss each of the above part in detail :

Electron Gun: It is the source of accelerated, energized and focused beam of electrons. It consists of six parts namely heater, a cathode, a grid, a pre-accelerating anode, a focusing anode and an accelerating anode. In order to obtain the high emission of electrons the layer of barium oxide (which is deposited on the end of cathode) is indirectly heated at moderate temperature.The electrons after this passes through a small hole called control grid which is made up of nickel. As the name suggests the control grid with its negative bias, controls the number of electrons or indirectly we can say the intensity of emitted electrons from cathode. After passing through the control grid these electrons are accelerated with the help of pre-accelerating and accelerating anodes. The pre-accelerating and accelerating anodes are connected to a common positive potential of 1500 volts. Now after this the function of the focusing anode is to focus the beam of the electrons so produced. The focusing anode is connected to adjustable voltage 500 volts.

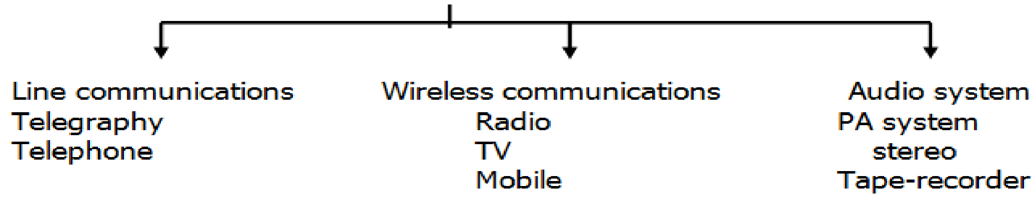
What is electronics?

The word 'electronics' is derived from ELECTRON mechanICS.

"The electronics means the study of the behavior of an electron under different conditions of externally applied fields". OR
"The field of science and engineering which deals with electron devices and their utilization".

What are the applications of electronics?
The major fields of application of electronics are

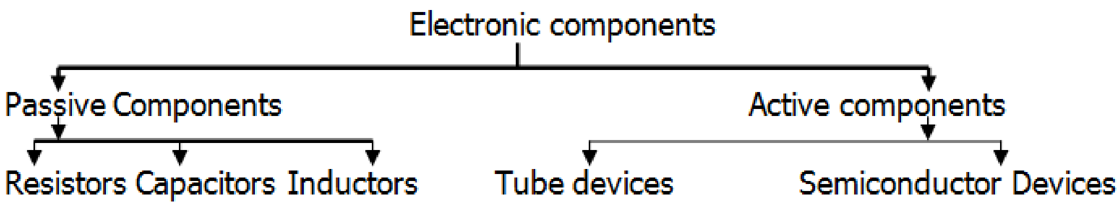
- ***Communications and Entertainment***



- **Defense** (Radar, Guided missiles, Coded communications)
- **Industry** (Automatic control system, Heating and Welding , Computers)
- **Medical** (X-rays, EM)
- **Instrumentation** (precision measuring instruments, VTVM, CRO, pH meter)

ELECTRONIC COMPONENTS

What are the basic components of any electronic circuit?



Define Passive Components?
The components of the circuit, which are not capable of amplifying or processing electrical signals by themselves. e.g. Resistors, Capacitors and Inductors

What are active components in a circuit?
The components of the circuit which can process or amplify the input signal are called active components.

INDUCTORS
Define inductors and inductance.
When current flow through a wire that has been coiled, it generates a magnetic field. This magnetic field reacts so as to oppose any change in current. This reaction of magnetic field, trying to keep the current flowing at a steady rate, is known as 'inductance'. The force is developed is called 'inductor'. **Define self induction.**
For medium with constant permeability, magnetic flux linked with the circuit is proportional to current flowing through it.
$\phi \alpha\ i$ or $\phi = Li$, if $i=1$ then $\phi = Li$
L is self inductance. It is defined as flux linked with coil when unit current flows through it.

(ii) $\varepsilon\ \alpha\ -\frac{di}{dt}$ or $\varepsilon = -L\frac{di}{dt}$ if $\frac{di}{dt} = 1$ then $\varepsilon = L$

Self inductance is defined as emf induced in the circuit when the rate is of change of current is unity.

RESISTORS

What is a resistor? What is a resistance?

Resistor is a component in an electrical or electronic circuit that is present because of electrical resistance.

The flow of charge (or current) through any materials, encounters an opposing force. This opposing force is called resistance of the materials.

The natural property of a substance which opposes the flow of current through it is called resistance.

It is measured in ohm. If one ampere of current flow through a circuit at an applied emf of one volt, the resistance of the circuit is said to be one ohm.

Two types of resistors 1. Fixed resistors and 2. Variable resistors.

Electrical conductivity is reciprocal of the electrical resistivity (σ).

Materials	Electrical resistivity [Ohm-m]	Electrical conductivity [S/m]	Classification
Glass	1.7×1011	5.88×10-12	Insulators
Hard Rubber	1.0×1016	1.0×10-16	Insulators
Germanium	6.5×10-1	1.54	Semiconductors
Silicon	2.0×103	5.0×10-4	Semiconductors
Copper	1.7×10-8	5.88×107	Conductors
Aluminum	2.6×10-8	3.85×107	Conductors

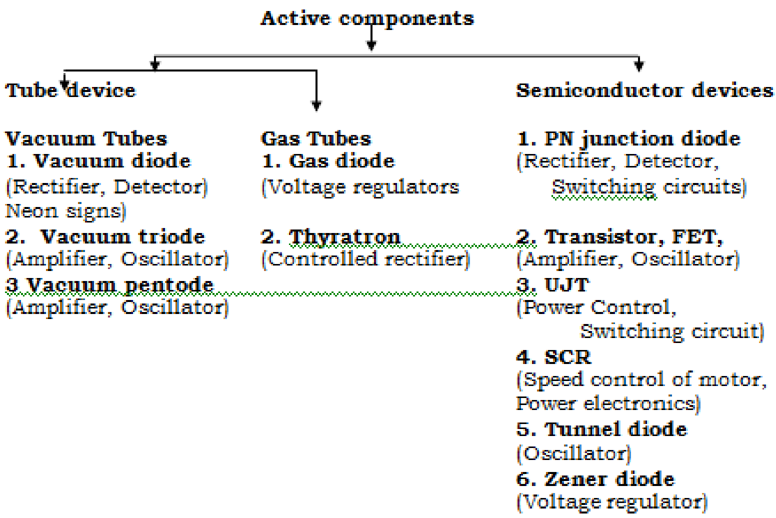
Insulator electrical resistivity varies 10^9 to 10^{16} Conductor's electrical resistivity about 10^8

Semiconductors electrical resistivity varies 10^{-1} to 10^3

ACTIVE COMPONENTS

Give some examples of active components of the circuit?

The active components can be classified into two groups.



SEMICONDUCTOR PHYSICS

What is a semiconductor?

A semiconductor is a solid material whose electrical resistivity is higher than that of a conductor and lower than that of an insulator.

What are the characteristic of semiconductors?

- The electrical resistivity of a semiconductor is higher than that of a conductor and lower than that of an insulator.
- The electrical resistance of a semiconductor decreases with increase in temperature over a particular temperature range.

- The electrical conductivity of a semiconductor can be increased by a large value by addition of a small amount of suitable impurity.

AMPLIFIERS

Advantages of Common Base Amplifier

- A CB amplifier is not so sensitive to variations in transistor parameters as CE transistor connections. A transistor in CB connection can operate at much higher frequency than in CE connection.

Disadvantages of Common Base Amplifier

- The input resistance is the lowest and the output resistance is the highest of the three configurations. Therefore, to couple one stage to another it is necessary to use a step down matching transformer.
- It has current gain less than 1 and voltage gain is high. Hence, power gain is not high; it is approximately equal to voltage gain.

Advantages of Common Emitter Amplifier

- The CE amplifier is widely used amplifier. It has good current and voltage gains. It has highest power gain of the three basic amplifiers.
- The difference between its input and output impedances is not very large. Therefore, CE amplifier circuits can be connected in cascade, without matching of input and output impedances with transformers.

Disadvantages of Common Emitter Amplifier

The frequency response of the CE amplifier is inferior to that of the other two amplifier circuits because of large input capacitances.

Advantages of Common Collector Amplifier

- It has high current gain. It has moderate power gain. Its input resistance is high.

Disadvantages of Common Collector Amplifier

- Its voltage gain is little less than 1. Its output resistance is low.

QUESTIONS BANK

SEMICONDUCTOR PHYSICS

1. Name at least two conductors, two insulators and two semiconductors? Give the order of conductivities of these materials.
2. Define intrinsic and extrinsic semiconductors?
3. Define doping.
4. Define N-type semiconductor (donor type semiconductor).
5. Define P-type semiconductor (accepter-type semiconductor).
6. Explain what is a hole?
7. Explain why pentavalent impurity atom is known as donor-type impurity?
8. Explain why trivalent impurity atom is known as acceptor-type impurity?

CONDUCTION IN SEMICONDUCTORS

1. In pure (intrinsic) semiconductor, explain the mechanism of conduction by electrons and holes.
2. Explain the Fermi level in a semiconductor having impurities.
3. With the help of energy band structure, explain the insulator, semiconductor and insulator.
4. Distinguish between p and n type of semiconductor through energy band diagram, clearly showing energy gap and Fermi level.
5. What is the purpose of doping in a semiconductor? How does it change the characteristics of semiconductor?
6. Explain the significance of diffusion current in semiconductor?
7. What is meant by the potential barrier across a junction? What is its significance?

PN JUNCTION DIODE

1. What do you mean by a p-n junction diode?

2. Draw the symbol of p-n junction diode.
3. What is a depletion layer?
4. Explain how depletion layer is formed?
5. Draw the circuit showing forward biasing of p-n junction diode.
6. Draw the circuit showing reverse biasing of p-n junction diode.
7. Explain the action of pn junction under forward bias.
8. Explain the action of pn junction under reverse bias.
9. Why a junction diode offers very high resistance in reverse biased mode?
10. Why a junction diode offers very low resistance in forward biased mode?
11. What are the applications of PN junction diode?
12. Explain V-I Characteristics of a P-N diode.
13. Define i) Static Characteristic, ii) Dynamic Characteristics. iii) Transfer Characteristics.
14. State the applications of diodes.
15. Define Breakdown voltage.
16. Define the terms (a) Maximum power current and (b) Peak Inverse Voltage (PIV).

BIPOLAR JUNCTION TRANSISTOR

1. Draw the symbols of pnp and npn Transistors.
2. Explain the functions of emitter, base and collector.
3. Show by means of a diagram, how you normally connect external batteries in pnp /npn transistor.
4. Explain the action of pnp/npn transistor with neat diagram.
5. Enlist the three transistor configurations. [CE/CB/CC]
6. Define the parameters α and β. Show that it is always less than unity. Obtain the relation between them.

TRANSISTOR BIASING

1. State different methods of biasing.
2. For a self bias circuit, derive an expression for the stability factor S.
3. Explain fixed biasing in case of pnp/npn transistor. Draw the necessary diagram.
7. State the advantages and disadvantages of fixed biasing method of a transistor.
8. What do you understand by stabilization of operating point?
9. Define stability factor.
4. Discuss the causes for bias instability in a transistor
5. Define Q-point. Explain how it is established in emitter bias circuit?
6. What is stability factor? Discuss the three stability factor associated with instability of collector current.
7. Discuss the two biasing circuit used in Linear integrated circuit. Bring out their merits and demerits.
8. Why biasing is needed for transistor? State the requirements of biasing circuit.
9. Which two points are necessary to draw the dc load line?
10. What is the utility of dc load line?
11. Explain Q point on load line. Write a note on operating point.
12. Draw the (i) Input (ii) Output (iii) Transfer characteristics of a transistor.

TRANSISTOR AMPLIFIERS

1. What do you mean by an amplifier?
2. What are coupling capacitor and why are they required?
3. Define current gain and voltage gain.
4. Draw the frequency response characteristics of an amplifier.
5. Define cutoff frequencies. Define bandwidth of an amplifier.
6. What should be the input resistance of an ideal amplifier? Why?
7. What should be the output resistance of an ideal amplifier? Why?
8. Describe the conversion efficiency of an ideal amplifier.
9. Explain how the operating point is located for CE amplifier.

10. What are the different classes of amplifier?
11. What is a load line and operating point?
12. Discuss graphical method for the working of a transistor amplifier in CE mode.
13. Discuss advantages of graphical method.

CONCEPT OF FEEDBACK

1. What do you mean by feedback in amplifiers?
2. State the types of feedback.
3. State the advantages of negative feedback.
4. State clearly the difference between the regenerative and degenerative feedback.
5. Discuss the general characteristics of negative feedback.
6. Derive an expression for the input resistance of voltage series feedback topology.
7. Draw a feedback amplifier in block diagram form. Identify each block and explain its function.
8. With a neat sketch, describe the concept of feedback in amplifier.
9. What is the effect of Feedback on Input impedance, Output impedance, band width.

TRANSISTOR AT LOW FREQUENCY

1. Obtain Hybrid parameter model of a transistor.
2. What are the advantages of using hybrid model to represent the transistor?
3. Explain how the h-parameters can be obtain from the static characteristics of the transistor.
4. Draw the hybrid model of a transistor & explain the significance of each element.
5. Obtain h-parameter model of a transistor.
6. Explain the method of obtaining base voltage, base current, collector voltage & collector current wave form using graphical analyses.
7. What are the advantages of h-parameters.

TRANSISTOR AT HIGH FREQUENCY

1. Derive expression for transistor conductance g_m and conductance $g_{b'e.}$
2. Derive expression for transistor input conductance $g_{b'e}$ and feedback conductance $g_{b'c}$

MULTISTAGE AMPLIFIER

3. Explain different types of distortions in amplifier.
4. How are amplifiers classified? Discuss them briefly.
5. Classify the various transistor amplifiers.

OSCILLATORS

1. Explain the working of an oscillator? Oscillators
2. Explain Barkhausen’s criterion for self sustained oscillations.
3. Which basic principle is used in LC Tank circuit oscillator? Explain why LC circuit is called as a Tank circuit.
4. What is the main advantage of using CE amplifier?
5. State and explain the condition for sustained oscillation.
6. Why LC Tank circuit is called an oscillator?
7. With the help of neat diagram, explain the working of small signal single stage RC coupled CE amplifier.
8. Describe the Hartley oscillator. Obtain the resonant frequency of Hartley oscillator
9. Distinguish LC Tank circuit oscillator and Hartley oscillator.

LOGIC GATES

1. Define Logic gate. Explain with examples positive and negative logic.
2. Enlist the basic Logic gates.
3. Give the symbol and logical expression of AND/OR/NOT/NAND/NOR/Ex-OR gate. Write truth table of each.
4. State De-Morgan's first theorem. State De-Morgan's second theorem.
5. What do you mean by Flip-Flops? State the types of Flip-Flops.
6. Explain construction of AND/OR/NOT/NAND/NOR/Ex-OR gate.
7. Explain the working of R-S FF, J-K FF, D FF.
8. Explain why NAND/NOR gate is called as universal building block.

OPERATIONAL-AMPLIFIER

1. What is differential amplifier?
2. List the characteristics of an ideal Op-amp.
3. Define the terms wrt OP-AMP: CMRR (ii) PSRR iii) output offset volatage iv) Slew rate (v) input bias current.
4. With the necessary circuit diagram, explain the measurement of A_v, R_o, V_{ios}, input offset current, CMRR, Slew rate of an Op-amp and explain.
5. Explain how to measure the differential input resistance R_i of an Op-amp.
6. Explain the significance of virtual ground in an Op-amp circuit.
7. Describe a method of measuring CMRR of an Op-amp.
8. List characteristics of an ideal op amp.
9. Draw the circuits of inverting amplifier and non- inverting amplifiers. Obtain the output expression for voltage gain.
10. Explain how op-amp can be configured as an adder and integrator? Obtain the output expressions for both.
11. Explain an op-amp follower. What are its special features and where it is used?
12. Show how op-amp can be used as subtractor. Obtain an expression for its output.

APPLICATIONS OF OP-AMP

1. Draw the circuit of a differential instrumentation amplifier using a transducer bridge and explain its features. Also derive the expression for its output voltage.
2. Explain the operation of sample and hold circuit.
3. Explain the working of a first order low-pass butter worth filter.
4. Explain the operation of positive peak detector with relevant waveforms.
5. What are the advantages of active filters over passive filters. Design first order high pass filter at a cut-off frequency of 400Hz and a pass band gain of 2.
6. Draw an Op-amp Schmitt trigger and explain its operation.
7. Draw a 4-bit D/A converter using R-2R resistors. Explains its working.
8. Explain the principle of operation of a R-2R ladder type D/A converter.
9. Draw and explain inverting and non-inverting comparators.
10. How op-amp can be used as clipper and clamper circuits.
11. Explain the working of an Op-amp positive clipper
12. Write a short note on absolute value of output circuits.