V. Review of electricity and electronics:

Electricity:

Determination of power, energy, AC & DC current- resistance – volts,- ohm's law- cycles - earthing- fuse- transformers types- cum ratio- transformers and stabilizers- uninterrupted power supply(UPS)- electrolysis- basic concept. electrolytes application in medicine , distillation apparatus parts and principle. Medical electronics semi conductors- principles of diodes- rectifiers- oscillators- photoelectric emission integrated circuits.

DETERMINATION OF POWER

The time rate of doing work is called power.

The SI unit of power is joules per second (J/s), also called the watt (W) (after James Watt, the inventor of the steam engine): 1 W = 1 J/s = 1 $kg.m^2/s^3$

The symbol W (not italic) for watt should not be confused with the symbol W(italic) for work.

A unit of power in the British engineering system is the horsepower (hp): 1 hp = 746 W

A unit of energy (or work) can now be defined in terms of the unit of power.

One kilowatt hour (kWh) is the energy converted or consumed in 1 h at the constant rate of 1 kW = 1 000 J/s. The numerical value of 1 kWh is 1 kWh = (103 W)(3 600 s) =3.60 106 J

It is important to realize that a kilowatt hour is a unit of energy, not power. When you pay your electric bill, you pay the power company for the total electrical energy you used during the billing period. This energy is the power used multiplied by the time during which it was used. For example, a 300-W light bulb run for 12 h would convert (0.300 kW)(12 h) = 3.6 kWh of electrical energy.

ENERGY

Energy can never be created or destroyed. Energy may be transformed from one form to another, but the total energy of an isolated system is always constant. From a universal point of view, we can say that the total energy of the Universe is constant.

CURRENT

The motion of the charges in the rearranging process constitutes a current, but it is of short duration only and is called a transient current. If we wish to maintain a continuous current in a conductor, we must continuously maintain a field or a potential gradient within it. If the field is always in the same direction, even though it may fluctuate in magnitude, the current is called direct. If the field reverses direction periodically, the flow of charge reverses also and the current is alternating. Direct and alternating currents are abbreviated to DC and AC respectively.

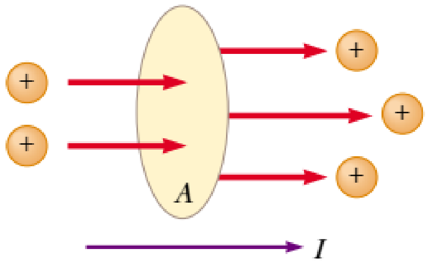
DIRECT CURRENT

The current is the rate at which charge flows through this surface. If Q is the amount of charge that passes through this area in a time interval *t*, the average current I_{av} is equal to the charge that passes through A per unit time:

If the rate at which charge flows varies in time, then the current varies in time; we define the instantaneous current I as the differential limit of average current:

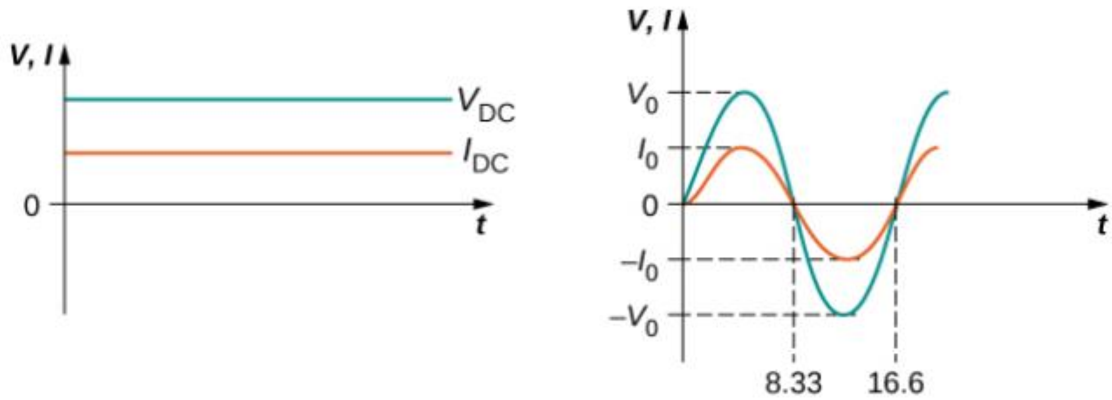
The SI unit of current is the ampere (A):

That is, 1 A of current is equivalent to 1 C of charge passing through the surface area in 1 s. The charges passing through the surface in Figure can be positive or negative, or both. It is conventional to assign to the current the same direction as the flow of positive charge. In electrical conductors, such as copper or aluminium, the current is due to the motion of negatively charged electrons. Therefore, when we speak of current in an ordinary conductor, the direction of the current is opposite the direction of flow of electrons.



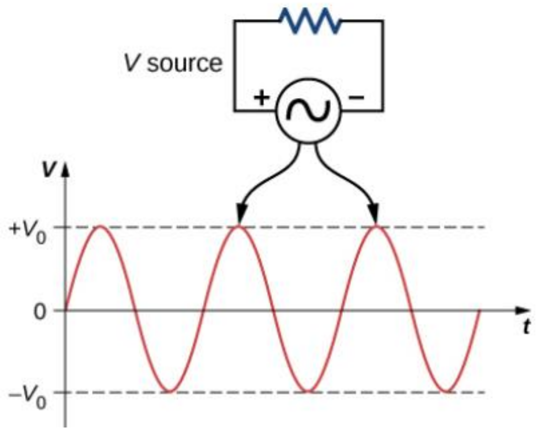
A.C. CURRENT

Alternating current (ac) is the flow of electric charge that periodically reverses direction. An ac is produced by an alternating emf, which is generated in a power plant, as described in Induced Electric Fields. If the ac source varies periodically, particularly sinusoidally, the circuit is known as an ac circuit. Examples include the commercial and residential power that serves so many of our needs



The voltage fluctuates sinusoidally with time at a fixed frequency, as shown, on either the battery terminals or the resistor. Therefore, the ac voltage, or the "voltage at a plug," can be given by $V = V_0 \sin \omega t$.

where V is the voltage at time t, V_0 is the peak voltage, and ω is the angular frequency in radians per second. For this simple resistance circuit, $I = V / R$, so the ac current, meaning the current that fluctuates sinusoidally with time at a fixed frequency, is $i = i_0 \sin \omega t$. where i is the current at time t and i_0 is the peak current and is equal to V_0/R . For this example, the voltage and current are said to be in phase, meaning that their sinusoidal functional forms have peaks, troughs, and nodes in the same place. They oscillate in sync with each other, as shown in Figure



RESISTANCE

Resistance is a measure of the opposition to current flow in an electrical circuit. Resistance is measured in ohms, symbolized by the Greek letter omega (Ω). Ohms are named after Georg Simon Ohm (1784-1854), a German physicist who studied the relationship between voltage, current and resistance. He is credited for formulating Ohm's Law.

All materials resist current flow to some degree. They fall into one of two broad categories:

Resistance is a measure of the opposition to current flow in an electrical circuit. Resistance is measured in ohms, symbolized by the Greek letter omega (Ω). Ohms are named after Georg Simon Ohm (1784-1854), a German physicist who studied the relationship between voltage, current and resistance. He is credited for formulating Ohm's Law.

All materials resist current flow to some degree. They fall into one of two broad categories:

Conductors: Materials that offer very little resistance where electrons can move easily. Examples: silver, copper, gold and aluminum.

Insulators: Materials that present high resistance and restrict the flow of electrons. Examples: Rubber, paper, glass, wood and plastic.

Resistance measurements are normally taken to indicate the condition of a component or a circuit.

- The higher the resistance, the lower the current flow. If abnormally high, one possible cause (among many) could be damaged conductors due to burning or corrosion. All conductors give off some degree of heat, so overheating is an issue often associated with resistance.
- The lower the resistance, the higher the current flow. Possible causes: insulators damaged by moisture or overheating.

Many components, such as heating elements and resistors, have a fixed-resistance value. These values are often printed on the components' nameplates or in manuals for reference.

When a tolerance is indicated, the measured resistance value should be within the specified resistance range. Any significant change in a fixed-resistance value usually indicates a problem.

"Resistance" may sound negative, but in electricity it can be used beneficially.

Examples: Current must struggle to flow through the small coils of a toaster, enough to generate heat that browns bread. Old-style incandescent light bulbs force current to flow through filaments so thin that light is generated.

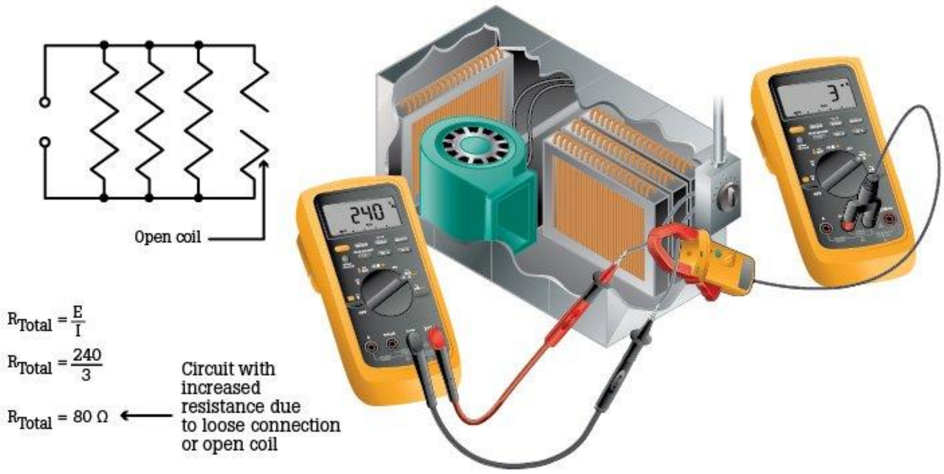
Resistance cannot be measured in an operating circuit. Accordingly, troubleshooting technicians often determine resistance by taking voltage and current measurements and applying Ohm's Law:

E = I x R

That is, volts = amps x ohms. R stands for resistance in this formula. If resistance is unknown, the formula can be converted to R = E/I (ohms = volts divided by amps).

Examples: In an electric heater circuit, as portrayed in the two illustrations below, resistance is determined by measuring circuit voltage and current, then applying Ohm's Law.

Example of normal



circuit resistance

Volt

One volt is defined as the difference in electric potential between two points of a conducting wire when an electric current of one ampere dissipates one watt of power between those points. It is also equal to the potential difference between two parallel, infinite planes spaced one meter apart that create an electric field of one newton per coulomb. Additionally, it is the potential difference between two points that will impart one joule of energy per coulomb of charge that passes through it. It can be expressed in terms of SI base units (m, kg, s, and A) as:

V = potential energy / charge = J/C = $kg.m^2 / A.s^3$

It can also be expressed as amperes times ohms (current times resistance, Ohm's law), webers per second (magnetic flux per time), watts per ampere (power per unit current, definition of electric power), or joules per coulomb (energy per unit charge), which is also equivalent to electron volts per elementary charge:

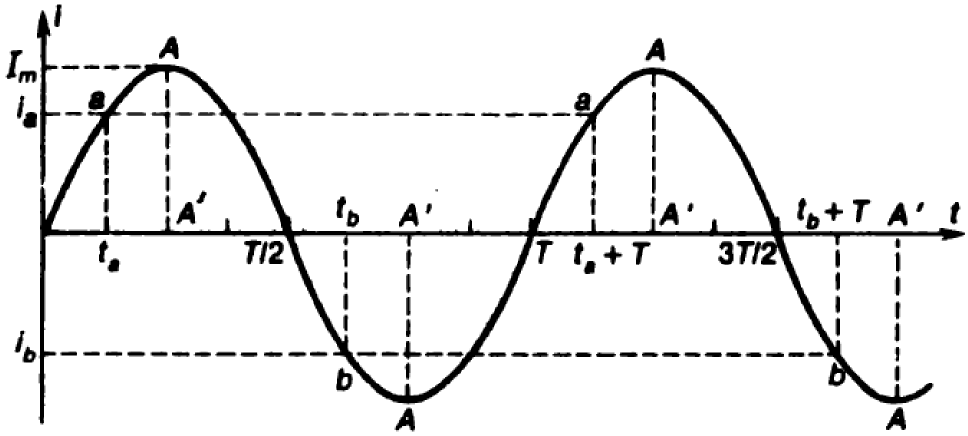
V = A.Ω = Wb/s = W/A = J/C = eV/e.

Ohm's law

The current in any segment of the conductor is proportional to the potential difference across this segment. Representing the proportionality factor between the current / and the voltage V in the form 1/R, we can write Ohm's law in the form R = V / I, The larger the value of R, the smaller the current for the same voltage across the conductor ends. For this reason, the quantity R was termed electric resistance of the conductor, or simply resistance. Resistance depends on the properties of a conductor. Ohm's law can also be written in the form V = IR.
For a given voltage V between the ends of conductors having different resistances R, the current is the smaller, the higher the resistance. Thus, an increase in the conductor resistance signifies an increase in the number of obstacles to the motion of electric charge carriers in the conductor under the action of the applied voltage.

CYCLES

Let us consider in greater detail the curve representing the time dependence of an industrial current (or voltage). First of all, it is evident that this current (or voltage) varies periodically, i.e. each instantaneous value of these quantities, say, the one corresponding to point a (or point b), is repeated in the same period of time. In other words, the current (or voltage) runs during this time interval through all possible values and returns to the initial value, i.e. completes one oscillation. The time interval during which the current (voltage) performs a complete oscillation and assumes the previous (in magnitude and sign) instantaneous value is called the period of the alternating current. It is usually denoted by T. For lighting circuits in the USSR and in many other countries, T = 1/50 s, and since the current reverses its direction twice during a period, the industrial current changes its direction 100 times per second. The maximum value which can be assumed by an alternating current (voltage) of any direction is known as the amplitude of this quantity. In Fig., the amplitudes of current and voltage are denoted by *Im* and Um, while their instantaneous values, by i and u.



The number of complete oscillations (cycles) of a sinusoidal current or voltage performed per unit time is called the frequency of the corresponding quantity and is denoted by υ. obviously, we have υ = 1/T (or) T = 1/υ

For the unit of frequency, we take a frequency equal to one oscillation per second. This unit is called the hertz (Hz) after the German physicist H. Hertz (1857-1894). Thus, the industrial alternating current has the frequency of 50 Hz. Instead of frequency υ, the quantity ω= 2πυ = 2π/Tis also introduced. It is known as the cyclic, or circular frequency of current (voltage). This quantity is equal to the number of complete oscillations (cycles) performed over 2π seconds.

As long as we deal with only one sinusoidal alternating current or voltage, the frequency and the amplitude are complete and exhausting characteristics of these quantities since the reference point for time can be taken arbitrarily. If, however, we have to compare two or more such quantities, we must take into account the fact that they may attain their maximum values at different instants of time.

EARTHING

It refers to the connection of the metal parts of electrical equipment with earth. The metal structure which is earthed is connected by a continuous conduction path of low resistance wire to the earthly electrode. The electrode may be a small plate of cooper or an metallic conductor of large area in contact with earth. It must be earthed at sufficient depth to ensure moist contact in all-weather condition.

The earth is regarded zero potential and if any equipment is connected to the earth by means of low resistance conductor, it is maintained at zero potential. Suppose an insulation break down occurs, the metallic part of the equipment cannot rrise above the earth potential.

FUSE

It is simply a metal resistor or a wire connected in series with the equipment. When the current in the circuit exceeds the rated value of the fuse, the temperature of the wire become high enough to melt it and fuse burns out and open the circuit. Fuses are rated according the the value of the current, which they will conduct without burning out. Fuse ratings are usually expressed in amperes with difference in wire thickness. It is made either with tin-lead alloy, aluminium, lead or copper. It ranges are 5A, 15A and 30A ratings

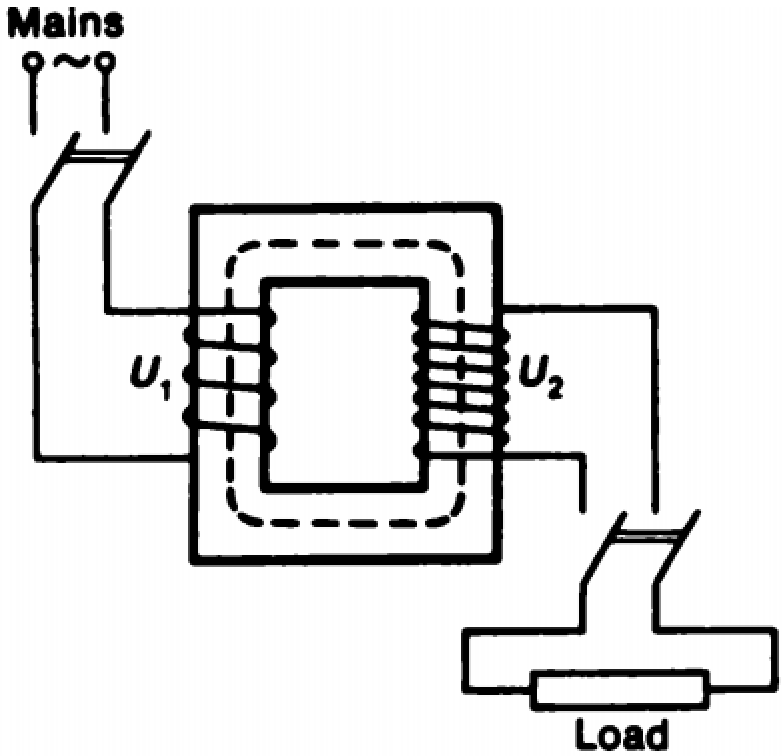
TRANSFORMER TYPES

In practical applications of alternating current, it is often necessary to alter the voltage supplied by a generator. In some cases, a voltage of thousand or million volts is required, while in other cases a low voltage of a few volts is sufficient. It would be very difficult to carry out such transformations for a direct current, but an a.c. voltage can be transformed (increased or decreased) quite easily almost without any loss o f energy. This is the main reason behind the utilization of alternating and not direct current in the overwhelming majority of cases.

Devices with the help of which the a.c. voltage is transformed are known as transformers. A schematic diagram of a transformer is shown in Figure. Every transformer has an iron core bearing two coils (windings). The ends of one winding are connected to an a.c. source, say, the mains with a voltage U_v The loads, viz. devices consuming electric power, are connected to the ends of the second winding in which an alternating voltage U_2 differing from axis created. The winding connected to a current source is known as the primary, while the winding connected to the load is called the secondary. If the voltage across the primary (the voltage of the source) is higher than the voltage across the secondary, i.e. $U_l > U_2$, we have a step-down transformer. If on the contrary $U_x < U_2$, we have a step-up transformer. When a transformer is connected to an a.c. source, say, to the mains, the alternating current in the primary produces an alternating magnetic field one of whose lines is shown in Figure by the dashed curve. Since the two windings have a common iron core, almost all the lines of this magnetic field pass through the windings. In other words, the two windings are pierced by the same magnetic flux. The same emf is induced in each turn of the windings (both primary and secondary) when this magnetic flux changes. The total emf ξ induced in each winding is equal to the product of the emf ε induced in a turn and the number N of turns in the corresponding winding. If the primary contains N_1 turns and the secondary has N_2 turns, the emf's induced in them are $\xi_1 = \varepsilon N_1$ and $\xi_2 = \varepsilon N_2$ respectively, i.e.

$$\frac{\xi_1}{\xi_2} = \frac{N_1}{N_2}$$

In the so-called no-load operation of a transformer, i.e. when no load is connected to the secondary winding and there is no current in it, the voltage U_2between the ends of the secondary is equal to the emf ξ_2 induced in it. As to the emf ξ_1 induced in the primary, according to Lenz's law, it always opposes the external voltage U_1, applied to the primary, and for no-load operation it is almost equal to U_1,



Schematic diagram of a transformer.

Thus, the ratio of the voltages across the terminals of the windings for the no-load operation of a transformer is approximately equal to the ratio of the emf's induced in them:

$$\frac{U_1}{U_2} = \frac{\xi_1}{\xi_2} = \frac{N_1}{N_2}$$

This ratio is known as the transformation ratio and is denoted by K

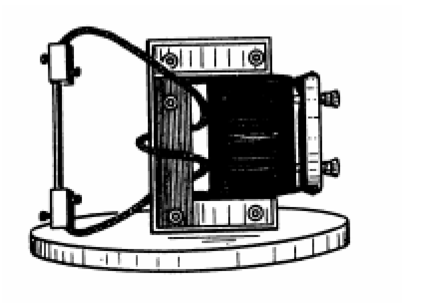
$$K = \frac{N_1}{N_2} = \frac{U_1}{U_2}$$

[If, for example, the primary contains 2500 turns and the secondary 250 turns, the transformation factor is equal to 10. Connecting the primary to a source supplying the voltage U_1 = 1000 V, we obtain the voltage U_2 = 100 V in the secondary.]

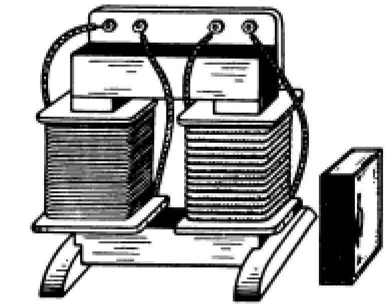
Transformers are designed so that with a normal load, when we can neglect the no-load current I_0 in comparison with the working current I_1 the currents in the primary and secondary are almost inversely proportional to the corresponding voltages**:**

$$\frac{I_2}{I_1} = \frac{U_1}{U_2}$$

Therefore, if the voltage U_2 is much smaller than U_1, very strong currents can be obtained in the secondary of such a step-down transformer. Transformers of this type are used in electric welding. Figure shows, by way of example, a step-down transformer with a secondary formed by a single turn. The voltage $U_2$of this transformer is very low, but the current in the secondary is so strong that it heats a thick copper rod to the red-hot state.



A step-down transformer producing a very large current.



A low-power transformer. A match box is shown on the right for comparison.

Thus, a transformer is an apparatus transferring energy from the circuit of the primary to the secondary. This transfer inevitably involves some losses (viz. the energy lost on heating the windings, on Foucault currents and on the magnetization reversal in the iron core). The efficiency of a transformer is the ratio of the power consumed in the secondary circuit to the power taken from the mains. The difference between these quantities constitutes useless losses. In order to reduce energy losses due to the heating of cores by Foucault currents, the cores are built up from insulated steel laminations stacked together, and to reduce losses due to the heating of cores caused by magnetization reversal the cores are made of special grades of steel characterized by small losses. As a result, compared with the power transformed, the transformer losses are usually quite small and the efficiency of transformers is very high. It attains 98-99% for large transformers and about 95% for small ones.

Low-power transformers (tens of watts) which are mainly used in laboratories and for domestic purposes are very small in size (Figure). Big high-power transformers operating with hundreds and thousands of kilowatts are huge constructions. They are usually placed in a steel tank filled with a special mineral oil (Figure). The oil improves the cooling conditions and serves as an insulating material. The terminals of the transformer windings are brought out to the upper cover of the tank through stacked insulators.

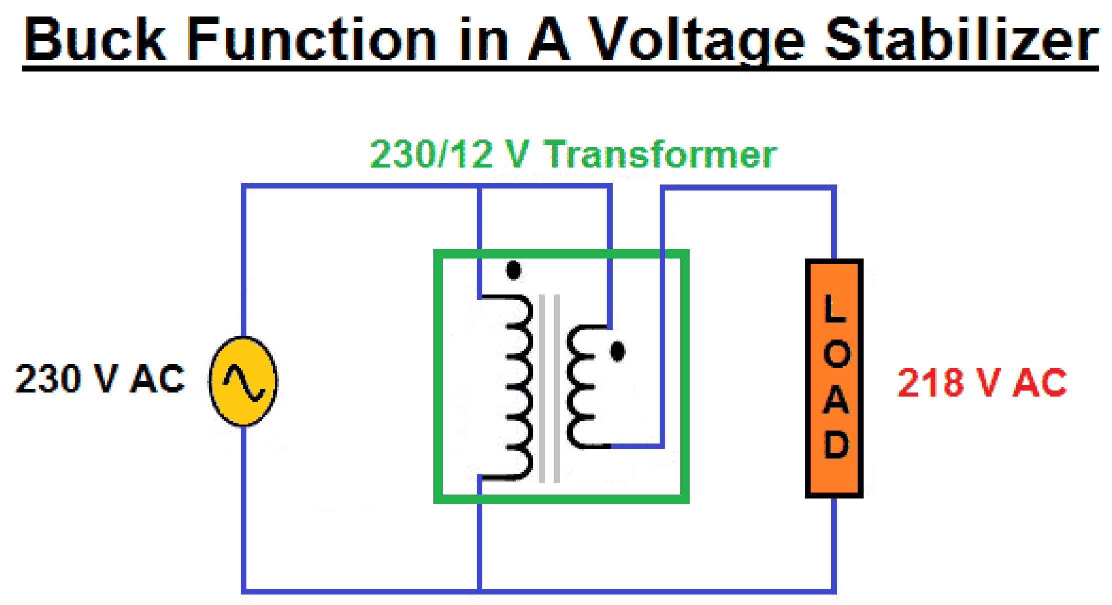
STABILIZERS

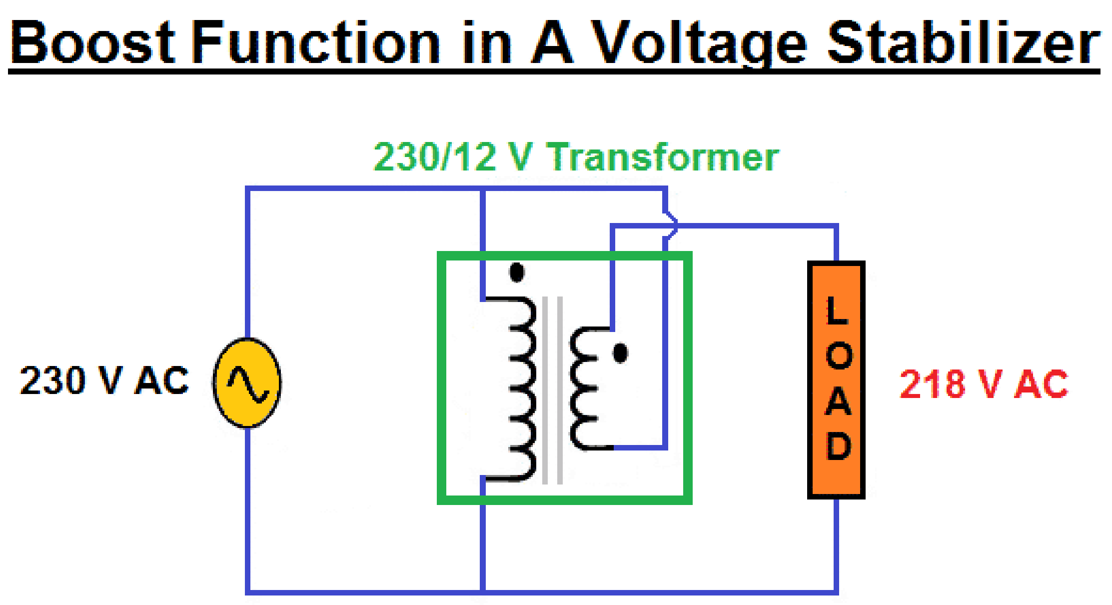
A Voltage Stabilizer is an electrical device which is used to provide a constant voltage output to a load at its output terminals irrespective of any change/ fluctuation in the input i.e. incoming supply.

The basic purpose of a Voltage Stabilizer is to protect the electrical/ electronic gadgets (for example – Air conditioning Unit, Refrigerator, TV, etc.) from the probable damage due to Voltage Surge/ fluctuations, Over Voltage and Under Voltage conditions.

The basic work of a Voltage Stabilizer is to carry out two necessary functions i.e. Buck and Boost function. Buck and Boost function is nothing but the regulation of a constant voltage from over voltage and under voltage circumstances. This Buck and Boost function may be carried out manually with the help of selector switches or automatically with the help of additional electronic circuits.

In Buck function, the polarity of transformer’s secondary coil is connected in such a way that the applied voltage to the load is resultant of Subtraction of Primary and secondary coil’s voltage. There’s switching circuit in the Voltage Stabilizer. Whenever it detects Over Voltage in the Primary Supply, the connection of the Load is manually/ automatically shifted to the ‘Buck’ mode configuration with the help of Switches/ Relays.





The above figure depicts the connection of a transformer in ‘Boost’ function. In Boost function, the polarity of transformer’s secondary coil is connected in such a way that the applied voltage to the load is resultant of Addition of Primary and secondary coil’s voltage.
Initially manually operated/ selector switch operated Voltage Stabilizers came in the market. These type of stabilizers used electro-mechanical relays for selection of desired voltage. With advancement of technology, added electronic circuits came into existence and the Voltage Stabilizers became automatic. Then came the Servo based Voltage Stabilizer which is capable of stabilizing the voltage continuously, without any manual intervention. Now, IC/ Micro

controller based Voltage Stabilizers are also available which can perform additional functions too.

The Voltage Stabilizers can be broadly categorized into three types. They are:

Relay Type Voltage Stabilizers
Servo based Voltage Stabilizers
Static Voltage Stabilizers

UNINTERRUPTIBLE POWER SUPPLY

An Uninterruptible Power Supply (UPS) is defined as a piece of electrical equipment which can be used as an immediate power source to the connected load when there is any failure in the main input power source.

In a **UPS**, the energy is generally stored in flywheels, batteries, or super capacitors. When compared to other immediate power supply system, UPS have the advantage of immediate protection against the input power interruptions. It has very short on-battery run time; however this time is enough to safely shut down the connected apparatus (computers, telecommunication equipment etc) or to switch on a standby power source.

UPS can be used as a protective device for some hardware which can cause serious damage or loss with a sudden power disruption. Uninterruptible power source, Battery backup and Flywheel back up are the other names often used for UPS. The available size of UPS units ranges from 200 VA which is used for a solo computer to several large units up to 46 MVA.

Major Roles of UPS

When there is any failure in main power source, the UPS will supply the power for a short time. This is the prime role of UPS. In addition to that, it can also able to correct some general power problems related to utility services in varying degrees. The problems that can be corrected are voltage spike (sustained over voltage), Noise, Quick reduction in input voltage, Harmonic distortion and the instability of frequency in mains.

Types of UPS

Generally, the UPS system is categorised into On-line UPS, Off- line UPS and Line interactive UPS. Other designs include Standby on-line hybrid, Standby-Ferro, Delta conversion On-Line.

Off-line UPS

This UPS is also called as Standby UPS system which can give only the most basic features. Here, the primary source is the filtered AC mains (shown in solid path in figure 1). When the power breakage occurs, the transfer switch will select the backup source (shown in dashed path in figure 1). Thus we can clearly see that the stand by system will start working only when there is any failure in mains. In this system, the AC voltage is first rectified and stored in the storage battery connected to the rectifier.

When power breakage occurs, this DC voltage is converted to AC voltage by means of a power inverter, and is transferred to the load connected to it. This is the least expensive UPS system and it provides surge protection in addition to back up. The transfer time can be about 25 milliseconds which can be related to the time taken by the UPS system to detect the utility voltage that is lost. The block diagram is shown below.

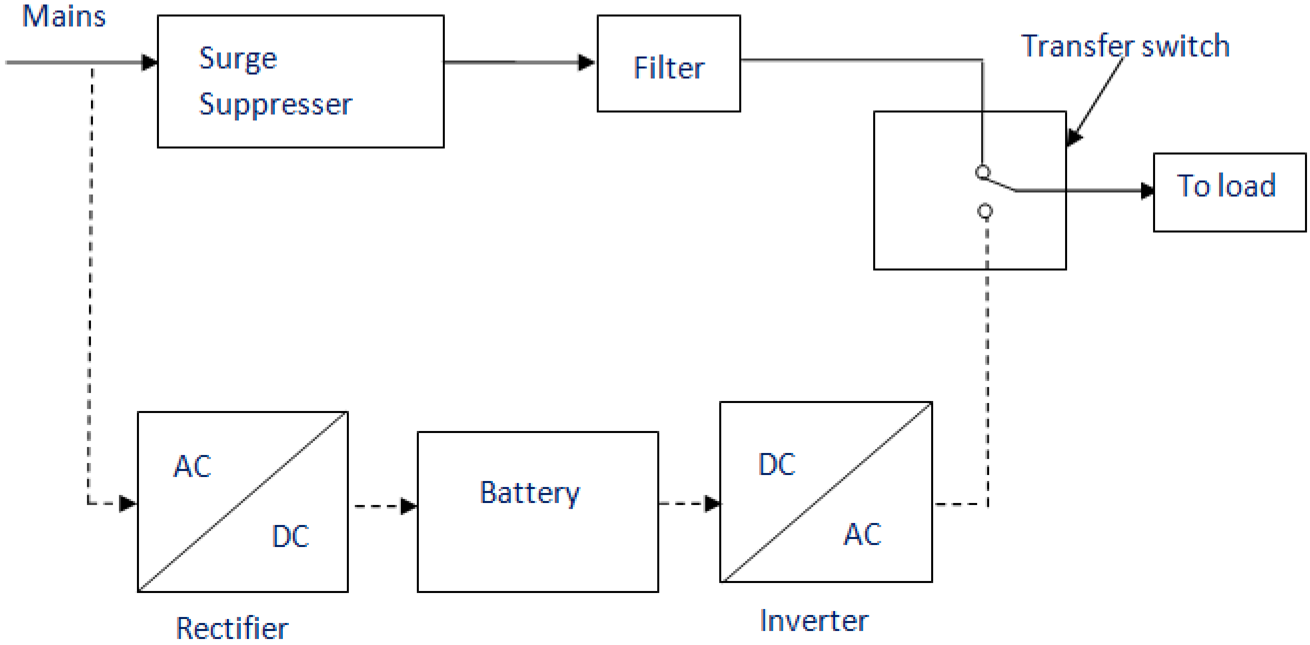


Figure 1

On-line UPS

In this **type of UPS**, double conversion method is used. Here, first the AC input is converted into DC by rectifying process for storing it in the rechargeable battery. This DC is converted into AC by the process of inversion and given to the load or equipment which it is connected (figure 2). This type of UPS is used where electrical isolation is mandatory. This system is a bit more costly due to the design of constantly running converters and cooling systems. Here, the rectifier which is powered with the normal AC current is directly driving the inverter. Hence it is also known as Double conversion UPS. The block diagram is shown below.

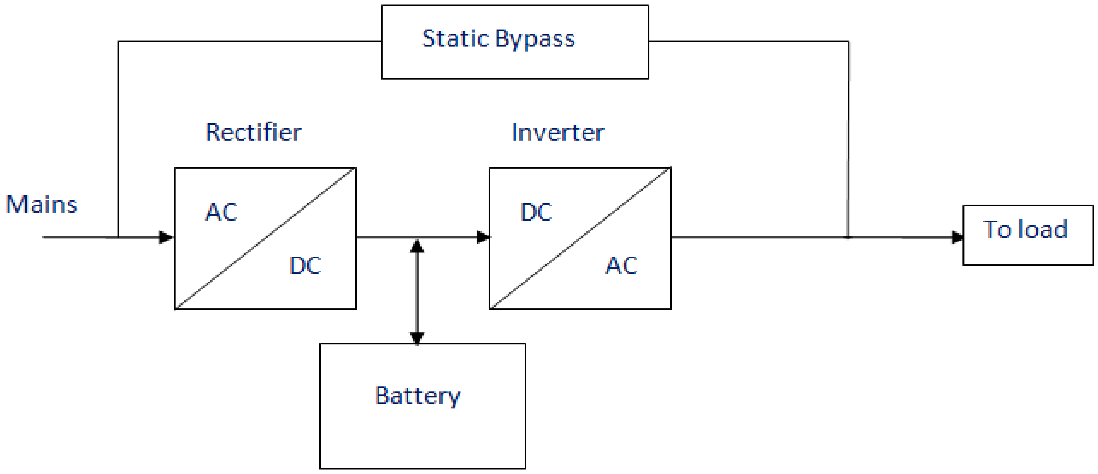


Figure 2

When there is any power failure, the rectifier have no role in the circuit and the steady power stored in the batteries which is connected to the inverter is given to the load by means of transfer switch. Once the power is restored, the rectifier begins to charge the batteries. To prevent the batteries from overheating due to the high power rectifier, the charging current is limited. During a main power breakdown, this UPS system operates with zero transfer time. The reason is that the backup source acts as a primary source and not the main AC input. But the presence of inrush current and large load step current can result in a transfer time of about 4-6 milliseconds in this system.

Line Interactive UPS
For small business and departmental servers and webs, line interactive UPS is used. This is more or less same as that of off-line UPS. The difference is the addition of tap changing transformer. Voltage regulation is done by this tap-changing transformer by changing the tap depending on input voltage. Additional filtering is provided in this UPS result in lower transient loss. The block diagram is shown below.

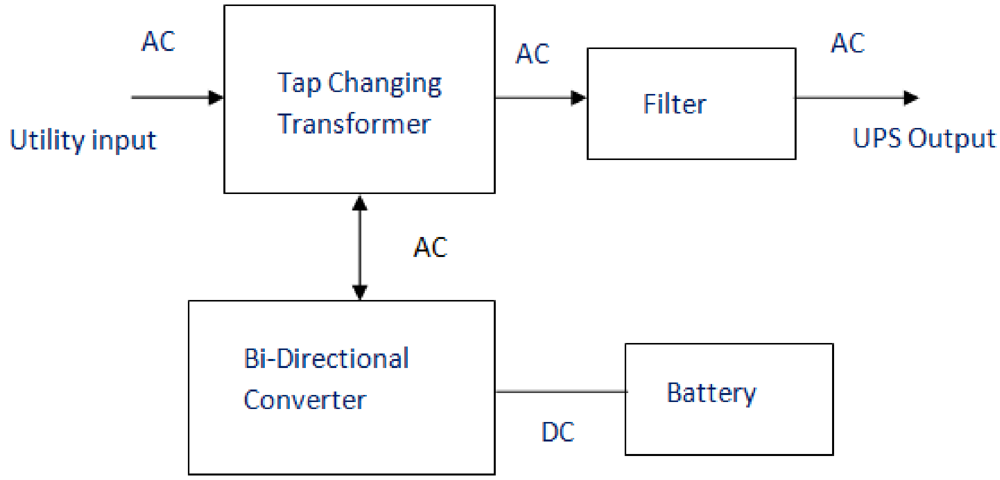


Figure 3

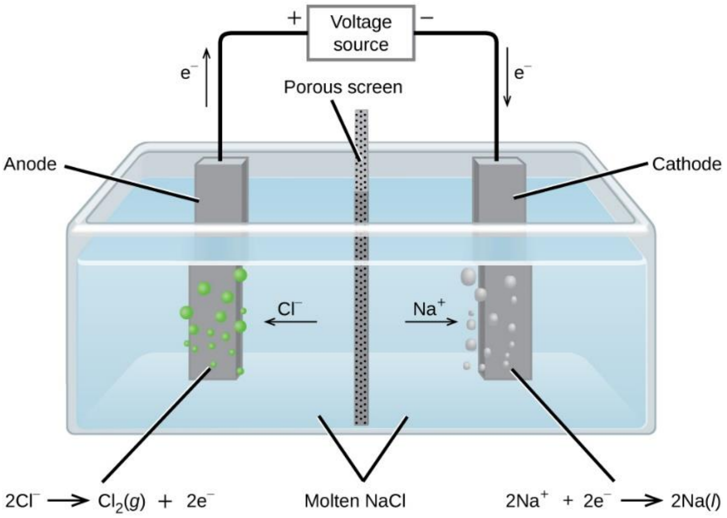
UPS Applications
Applications of a UPS include:

- Data Centers
- Industries
- Telecommunications
- Hospitals
- Banks and insurance

ELECTROLYSIS
Electrolysis is the decomposition of a compound using electricity. During electrolysis, electrical energy is converted into chemical energy to bring about a chemical change. The apparatus used for electrolysis is called an Electrolytic Cell and it consists of 3 main components:

Battery or Power Source
Electrodes
Electrolytes
It consists of two electrodes in an electrolyte. An electrode is essentially a rod or plate where electricity enters or leaves an electrolyte during electrolysis. An electrolyte could be an ionic compound in molten state or dissolved in aqueous solution, or an acid or alkali solution. Presence of mobile ions allows it to conducts an electric current and is decomposed in the electrolysis process.

A direct current power source or battery is connected to the electrodes. An electric current will flow through the electrolyte, decomposing it into simpler substances. Cathode is the negative electrode connected to the negative terminal of the battery or power source. Anode is the positive electrode connected to the positive terminal of the battery or power source. Cation, which is an ion having a positive charge, will be attracted to the negatively charged cathode and gets reduced. Anion, which is an ion having a negative charge, will be attracted to the positively charged anode and gets oxidised. Note that during electrolysis, reactions only occur at the electrodes and not inside the electrolyte. The reaction which takes place during electrolysis is a redox reaction. Oxidation occurs at the anode while reduction occurs at the cathode.



ELECTROLYTES AND ITS CLINICAL APPLICATIONS

Chemically, electrolytes are substances that become ions in solution and acquire the capacity to conduct electricity. Electrolytes are present in the human body, and the balance of the electrolytes in our bodies is essential for normal function of our cells and our organs.

Common electrolytes that are measured by doctors with blood testing include sodium, potassium, chloride, and bicarbonate. The functions and normal range values for these electrolytes are described below.

Chemically, electrolytes are substances that become ions in solution and acquire the capacity to conduct electricity. Electrolytes are present in the human body, and the balance of the electrolytes in our bodies is essential for normal function of our cells and our organs.

Common electrolytes that are measured by doctors with blood testing include sodium, potassium, chloride, and bicarbonate. The functions and normal range values for these electrolytes are described below.

Potassium

Potassium is the major positive ion (cation) found inside of cells. The chemical notation for potassium is K+. The proper level of potassium is essential for normal cell function. Among the many functions of potassium in the body are regulation of the heartbeat and the function of the muscles. A seriously abnormal increase in potassium (hyperkalemia) or decrease in potassium (hypokalemia) can profoundly affect the nervous system and increases the chance of irregular heartbeats (arrhythmias), which, when extreme, can be fatal.

Increased potassium is known as hyperkalemia. Potassium is normally excreted by the kidneys, so disorders that decrease the function of the kidneys can result in hyperkalemia. Certain medications may also predispose an individual to hyperkalemia.

Hypokalemia, or decreased potassium, can arise due to kidney diseases; excessive losses due to heavy sweating, vomiting, diarrhea, eating disorders, certain medications, or other causes.

The normal blood potassium level is 3.5 - 5.0 milliEquivalents/liter (mEq/L), or in international units, 3.5 - 5.0 millimoles/liter (mmol/L).

Chloride

Chloride is the major anion (negatively charged ion) found in the fluid outside of cells and in the blood. An anion is the negatively charged part of certain substances such as table salt (sodium chloride or NaCl) when dissolved in liquid. Chloride plays a role in helping the body maintain a normal balance of fluids.

The balance of chloride ion (Cl-) is closely regulated by the body. Significant increases or decreases in chloride can have deleterious or even fatal consequences:

Increased chloride (hyperchloremia): Elevations in chloride may be seen in diarrhea, certain kidney diseases, and sometimes in overactivity of the parathyroid glands.
Decreased chloride (hypochloremia): Chloride is normally lost in the urine, sweat, and stomach secretions. Excessive loss can occur from heavy sweating, vomiting, and adrenal gland and kidney disease.
The normal serum range for chloride is 98 - 108 mmol/L.

Bicarbonate

The bicarbonate ion acts as a buffer to maintain the normal levels of acidity (pH) in blood and other fluids in the body. Bicarbonate levels are measured to monitor the acidity of the blood and body fluids. The acidity is affected by foods or medications that we ingest and the function of the kidneys and lungs. The chemical notation for bicarbonate on most lab reports is HCO3- or represented as the concentration of carbon dioxide (CO2). The normal serum range for bicarbonate is 22-30 mmol/L.

The bicarbonate test is usually performed along with tests for other blood electrolytes. Disruptions in the normal bicarbonate level may be due to diseases that interfere with respiratory function, kidney diseases, metabolic conditions, or other causes.

DISTILLATION

Distillation refers to the selective boiling and subsequent condensation of a component in a liquid mixture. It is a separation technique that can be used to either increase the concentration of a particular component in the mixture or to obtain (almost) pure components from the mixture. The process of distillation exploits the difference in the boiling points of the components in the liquid mixture by forcing one of them into a gaseous state.

It is important to note that distillation is not a chemical reaction but it can be considered as a physical separation process. An illustration describing the laboratory setup that is generally used to execute this process is provided below.
The distillation performed on a laboratory scale often uses batches of the liquid mixture whereas industrial distillation processes are generally continuous, requiring a constant composition of the mixture to be maintained.

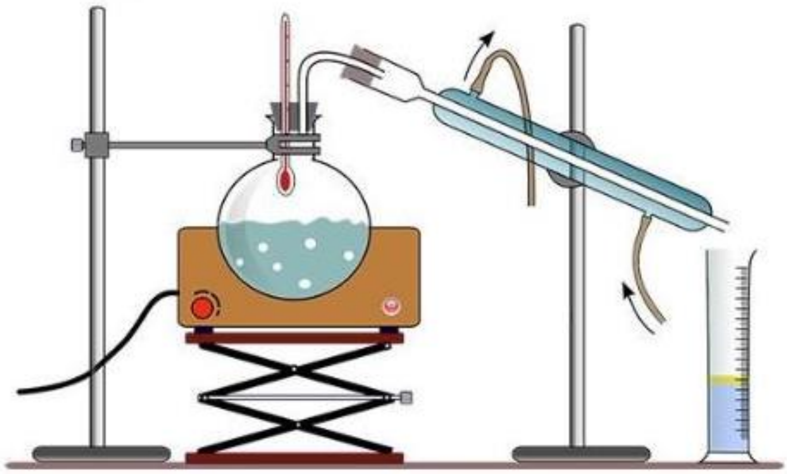
Role of Raoult's Law and Dalton's Law

The temperature at which the vapor pressure of a liquid becomes equal to the pressure of the surrounding area is known as the boiling point of that liquid. At this temperature point, the liquid is converted into its vapor form via the formation of vapor bubbles at its bulk.

It is important to note that the boiling point of the liquid changes with the pressure around it. For example, the boiling point of water at sea level is 100oC but its boiling point at an altitude of 1905 meters is 93.4oC (since the atmospheric pressure is relatively lower at high altitudes).

For a mixture of liquids, the distillation process is dependent on Dalton's law and Raoult's law. As per Raoult's law, the partial pressure of a single liquid component in an ideal liquid mixture equals the product of the vapor pressure of the pure component and its mole fraction. According to Dalton's law of partial pressures, the total pressure exerted by a mixture of gases is equal to the sum of the partial pressures of all the constituent gases.

When a mixture of liquids is heated, the vapor pressure of the individual components increases, which in turn increases the total vapor pressure. Therefore, the mixture cannot have multiple boiling points at a given composition and pressure.

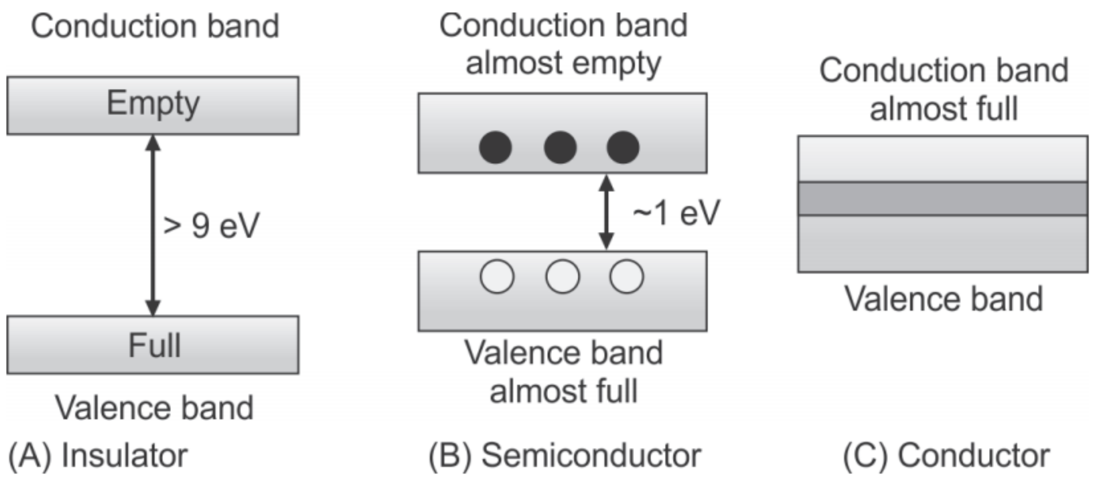


Why is it Impossible to Completely Purify a Mixture by Distillation?
At the boiling point of a mixture of liquids, all the volatile constituents boil. However, the quantity of a constituent in the resulting vapor is based on its contribution to the total vapor pressure of the mixture. This is why the compounds with higher partial pressures can be concentrated in the vapors whereas the compounds having low partial pressures can be concentrated in the liquid.

Since a component in the mixture cannot have zero partial pressure, it is impossible to obtain a completely pure sample of a component from a mixture via distillation. However, samples of high purity can be obtained when one of the components in the mixture has a partial pressure which is close to zero.

MEDICAL ELECTRONICS
CONDUCTORS, INSULATORS AND SEMICONDUCTORS
Substances in which electric charge moves freely are known as conductors. Substances, which do not allow charge to move freely through them, are known as insulators or dielectrics. The term insulator or conductor is only a relative term and nobody is perfectly insulating or conducting. Substances, which are having their conductivity intermediate between conductor and insulator, are known as semiconductors.
As per the band theory of conduction, matter is made up of three energy levels, namely, filled band, valence band, and conduction band. Valance band is the highest energy band whose electrons are tied up to individual atoms. It corresponds to the valence shell of a single isolated atom. The filled bands are below the valance band, and they do not contribute to electrical conduction. Hence, it is normally not included in the energy band diagrams.
The conduction band is above the valance band and the electrons are not tied to particular atoms. Hence, it offers free electrons for electrical conduction. The gap between the valance and conduction band is called forbidden gap, which is responsible for the conduction properties

of materials. Based on the forbidden gap width, materials may be classified as conductor, insulator and semiconductors



CONDUCTOR

In conductors, the highest electron energy levels are partially filled and hence its electrons are free to move. There is no forbidden gap between valance and the conduction band, hence electrons move easily from valance band to conduction band. Metals, such as copper, silver and aluminium are good electrical conductors.

INSULATOR

In insulators, the forbidden gap is large, > 9 eV and the electrons unable to flow to the conduction band. Hence, the conduction band is empty and no flow of electric current, e.g. oil, glass, rubber and plastic. At very high temperature, few electrons may move from the valance band, but the material undergo breakdown. This breakdown depends on the applied voltage and the thickness of the material. Hence, X-ray cables are made up of higher thickness of insulation material.

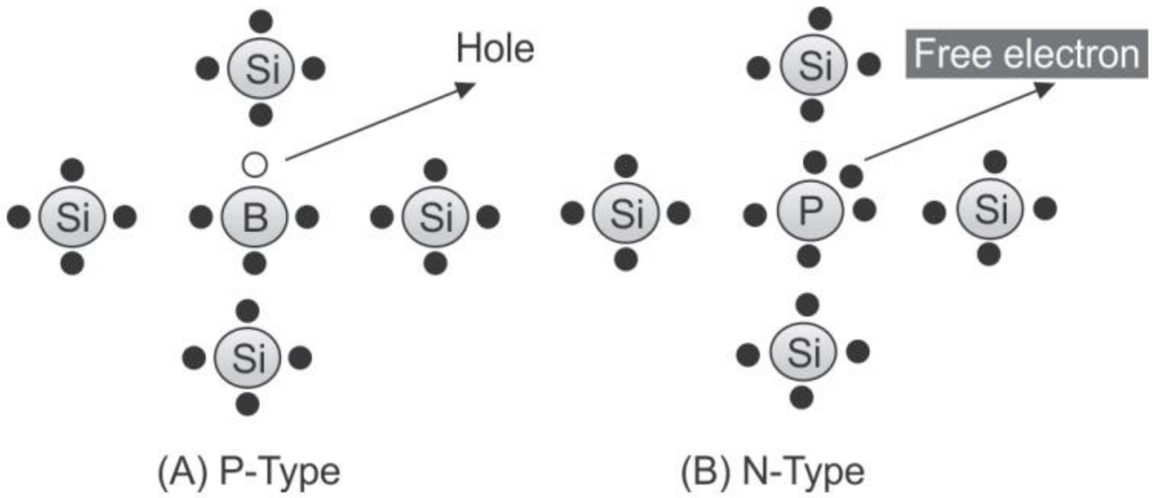
SEMICONDUCTOR

In semiconductors, the width of the forbidden band is 1 eV, e.g. germanium and silicon. At low temperatures, there is no electron flow from valance to conduction band due to lack of sufficient energy and they behave like an insulator. However, at room temperature, they utilize the internal energy of the system and gain > 1 eV energy. This is sufficient to offer electron flow from valance to conduction band, but in a limited way. As the temperature increases, number of electron also increases, resulting higher conductivity. As the electron leaves the valance band, holes are created, which also act like charge carriers. This type of conduction that takes place in a pure semiconductor is called intrinsic conduction.

The conducting property of a semiconductor can be modified by adding impurities to it, which is called doping. By doing so it is possible to create additional energy levels in the forbidden band, resulting higher conductivity. This type of conductivity made out of doping is called extrinsic conductors. There are two types of extrinsic conductors, namely, N-type and P-type (Figure). In N-type, there are extra-energy levels, which helps the electrons to move from the valance band to conduction band. In P-type semiconductor, the extra-energy level helps the holes to move, and offer higher electrical conduction.

N- type Semiconductor

When a pentavalent impurity such as phosphorous or arsenic is added to a pure silicon in the ratio 1:106, N-type semiconductor is formed. Four out of five valence electrons of the impurity phosphorous atom form covalent bonds with neighboring silicon atoms. The fifth electron is not associated with any covalent bond and it is free, responsible for conduction. In this type, the majority charge carriers are electrons and the minority charge carriers are holes. Since the impurity donates one electron to the conduction band, it is called donor impurity.

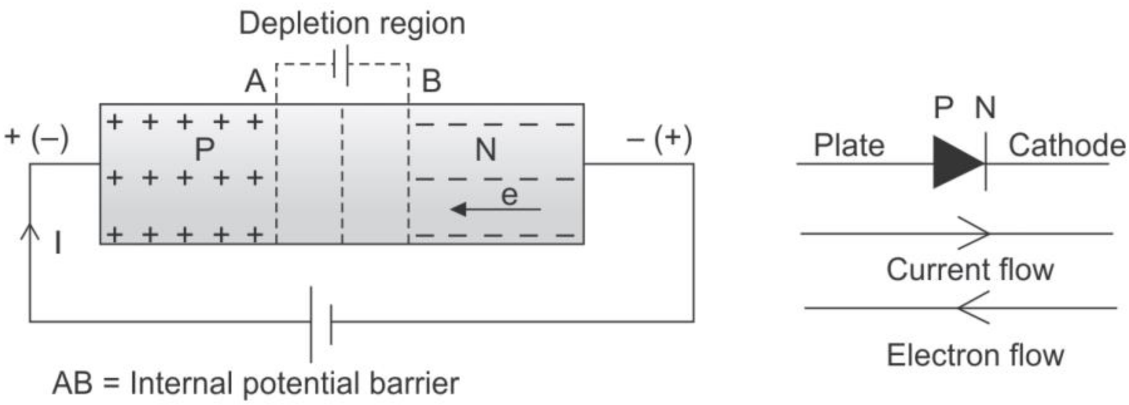


P-type Semiconductor

When a trivalent impurity such as boron is added to a pure silicon (Si), P-type semiconductor is formed. The three valence electrons of boron atom form covalent bands with the three neighboring silicon atoms. The fourth electron of the Si atom is unable to form a covalent bond with the boron atom. Hence, a vacancy is available in the fourth covalent bond. This vacancy is called hole (positive charge) which can accept electrons from other atoms. The majority charge carriers are holes and the minority charge carriers are electrons. Since, there is a hole in the impurity, it is called acceptor impurity.

SEMICONDUCTOR DIODE

A semiconductor (solid state) diode consists of a P-type and an N-type semiconductors which are joined together (Fig.). Such an arrangement is called the P-N junction diode. When a P–N junction is formed, the holes diffuse from P region and electrons diffuse from N region due to thermal energy. As a result, the holes and electrons combine with each other and neutralize near the junction. After a short interval of time, a potential barrier is setup near the junction with immobile negative and positive ions which stops further diffusion. The above potential barrier which is created, when a P-N junction is formed is called internal potential barrier or depletion layer. The width of this barrier region is about 10^{-6} to 10^{-8} m.



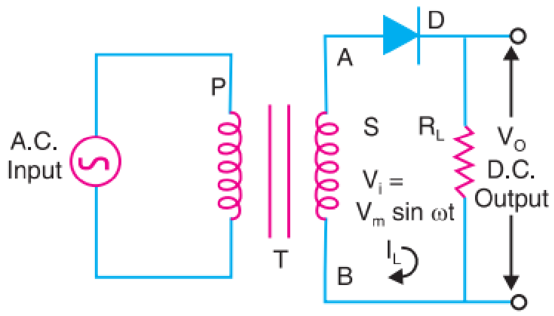
A battery is connected to the terminals of the diode. When P is positive and N is negative, the diode is said to be forward biased. Now, the holes in the P region are repelled from the positive terminal of the battery and moves towards the junction. Similarly, the electron move towards the junction. These ions penetrate the depletion region, thereby reducing the internal potential barrier. There is a continuous flow of electrons through the junction from N to P region, which will constitute a current. The current flow is in the order of mill amperes. When P is negative and N is positive, the diode is said to be reverse biased. Since the battery terminals attract both holes and electrons, the internal potential barrier is increased. Hence, there is no flow of electrons across the junction and there is no current flow. Only the minority carriers cross the junction constituting very low reverse saturation current. This current is of the order of microamperes. Thus, the PN junction diode allows the electron flow only when P is positive. This property is used for the conversion of AC into DC, which is called rectification.

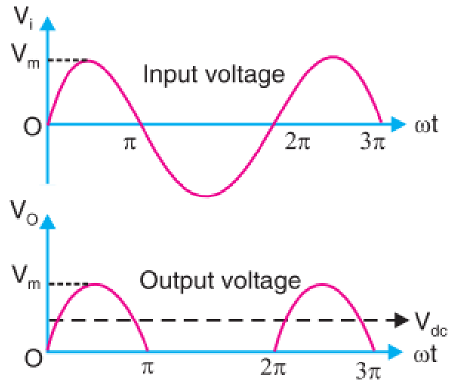
RECTIFIERS

Rectification is the process in which ac is converted into dc. The device which is used for rectification is called a rectifier. A junction diode allows a current to flow through it when it is forward biased. This property of diode is used for rectification. A half-wave rectifier is one which converts a.c. voltage into a pulsating voltage using only one half cycle of the applied a.c. voltage. A full wave rectifier is one which converts a.c. voltage into a pulsating voltage using full cycle of the applied a.c. voltage.

Diode as a Half-Wave Rectifier

Construction. Figure shows the circuit for a half-wave rectifier. T is a transformer. The primary of the transformer is connected to the ac mains. The diode D is connected across the secondary in series with a load resistance R_L.





Working. The primary of the transformer is connected to the ac mains. An ac voltage will be induced across the secondary. This voltage can be represented by $V_i = V_m \sin \omega t$.

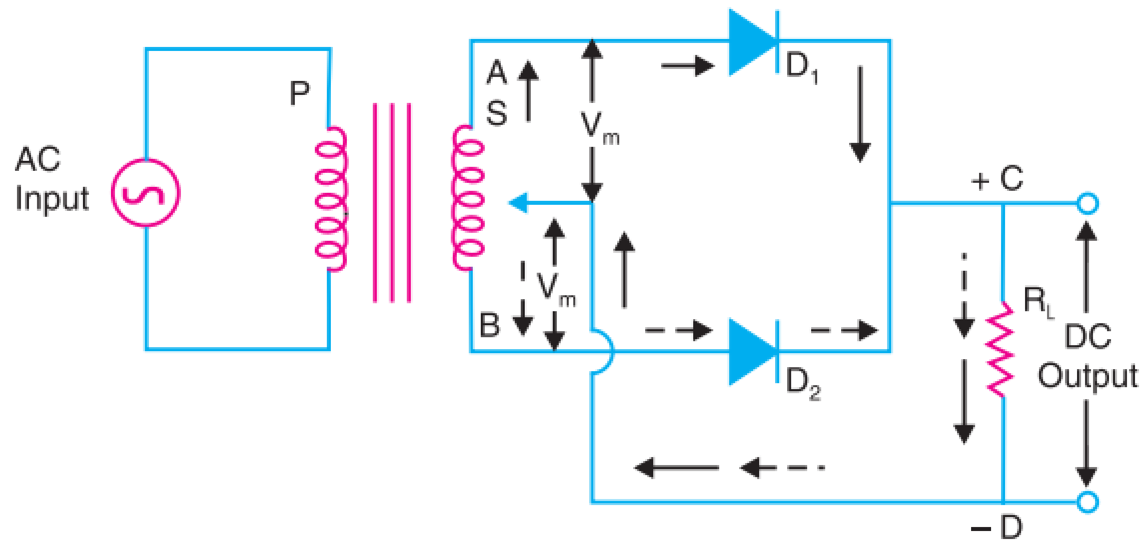
Figure shows the variation of this input voltage with time. V_m is the peak value. During the first half cycle of a.c., one end of the secondary, say A, becomes positive. Then the diode is forward biased. Hence current flows through the load R_L in the direction of arrows (Figure). The diode offers very little resistance when forward biased. Hence the p.d. across it is very small. The voltage across the load R_L is therefore practically the same as that across the secondary of the transformer, i.e., V_i. During the next half cycle, the end A becomes negative. The diode is now reverse biased. Therefore, no current flows through the load R_L. The voltage across the load is zero. This voltage in not a perfect dc. But it is unidirectional.

Full-Wave Rectifier

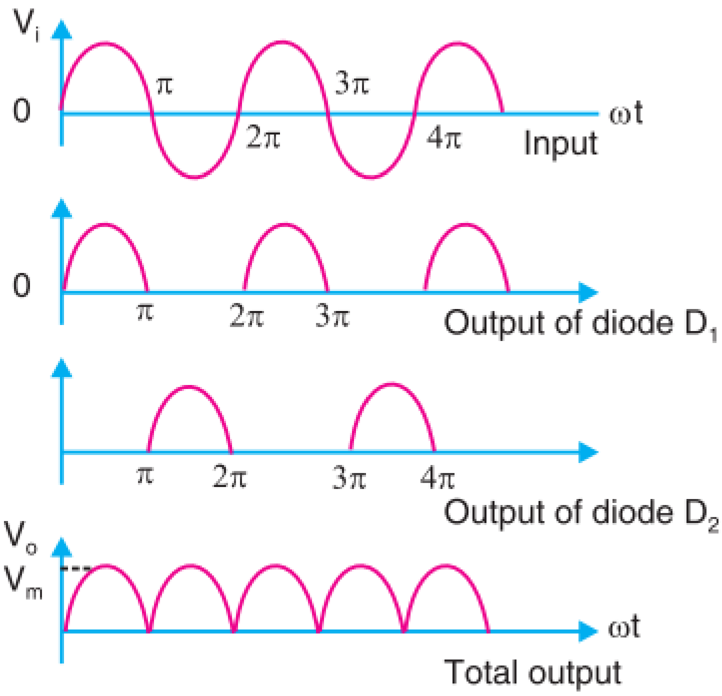
In a full-wave rectifier both halves of the input-cycle are used. There are two types of full-wave rectifiers: (1) Centre tapped full-wave rectifier, and (2) Bridge rectifier.

Centre tapped full-wave rectifier. A full wave rectifier circuit consists of two diodes D_1 and D_2 connected to the secondary of the step-down transformer. The input A.C. signal is fed to the primary of the transformer

Working. During the positive half-cycle of the secondary voltage, one end of the secondary, say A, becomes positive and end B becomes negative. So the diode D1 is forward biased, and diode D_2 is reverse biased.



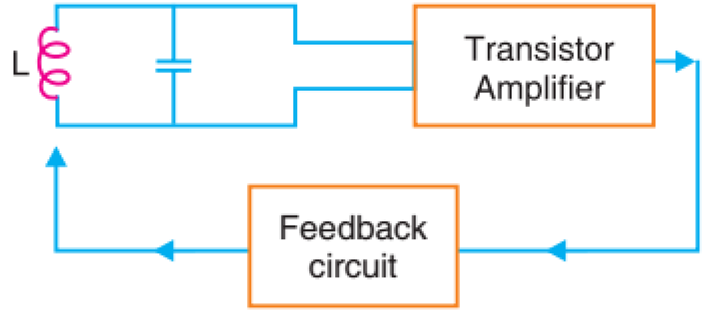
So the diode D_1 is forward biased, and diode D_2 is reverse biased. As a result of this, the diode D_1 conducts current whereas the diode D_2 does not conduct. Current through the load resistance flows from C to D producing output voltage V_0. The current is shown by solid arrows.
During the negative half cycle of AC input, end A becomes negative and end B positive. So the diode D_1 is reverse biased and the diode D2 is forward biased. As a result, the diode D_1 does not conduct and D_2 conducts current. Again current flows from C to D through the load resistance R_L producing output voltage V0. The current is shown by the dotted arrows.
Thus, during both the half cycles, current flows through the load in the same direction. The output voltage is developed across the load RL during the entire cycle. It is a pulsating D.C. voltage containing both A.C. and D.C. components. The input and the rectified output wave-forms are shown in Fig.



OSCILLATORS
An oscillator is an electronic device for generating alternating current of a desired frequency. An oscillator converts dc power from the dc source to ac power at the load. Oscillation is achieved through positive feedback in amplifiers. The essential components of an LC oscillator are shown in Figure.

(i) Tank circuit. It is a parallel combination of inductor L and capacitor C. The frequency of oscillations in the circuit depends upon the values of inductance and capacitance.

$$f = \frac{1}{2\pi}\sqrt{\left(\frac{1}{LC}\right)}.$$



(ii) **Transistor amplifier.** The function of the amplifier is to amplify the oscillations produced by the tank circuit.

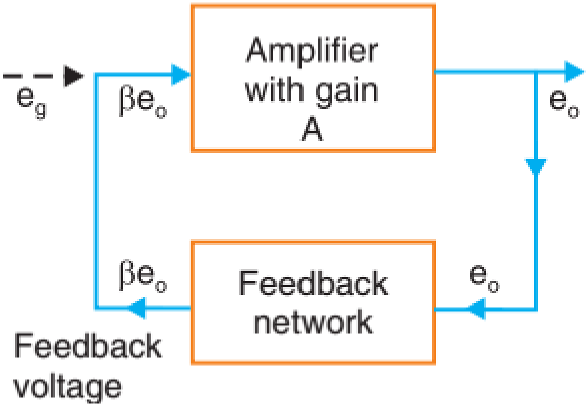
(iii) **Feedback circuit.** A positive feedback network to transfer a part of output energy to the tank circuit in proper phase. The amount of energy feedback is enough to compensate for the losses of energy in the LC circuit.

Condition for Self-Excitation (Barkhausen Criterion for Oscillations)

Consider a feedback amplifier (Fig. 58.32). Let A = voltage gain of amplifier without feedback, e_g = input voltage and e_0 = output voltage. Let the feedback network introduce a fraction β of the output into the input. If the feedback is positive, the voltage appearing at the input of the amplifier is $e_g + \beta e_0$. It is amplified A times by the amplifier to give the output e_0

$$\therefore \quad (e_g + \beta e_0)\,A = e_0$$

$$\text{or} \quad e_g = \frac{e_0\,(1 - \beta A)}{A}.$$



A is called open loop gain and Aβ is called feedback factor or loop gain. If βA = 1, $e_g = 0$, i.e., an output voltage is obtained without any input signal. Then the amplifier functions as an oscillator. Therefore, the condition for the maintenance of oscillations is βA = 1

(or) $\beta = \frac{1}{A}$

This equation is called 'Barkhausen criterion' for self-sustained oscillations. In practical oscillators, βA > 1.

In general, the amplifier gain A and the feedback factor β will be complex. This means that, satisfying the above involves two conditions:

(i) The magnitude of the product Aβ should be unity.

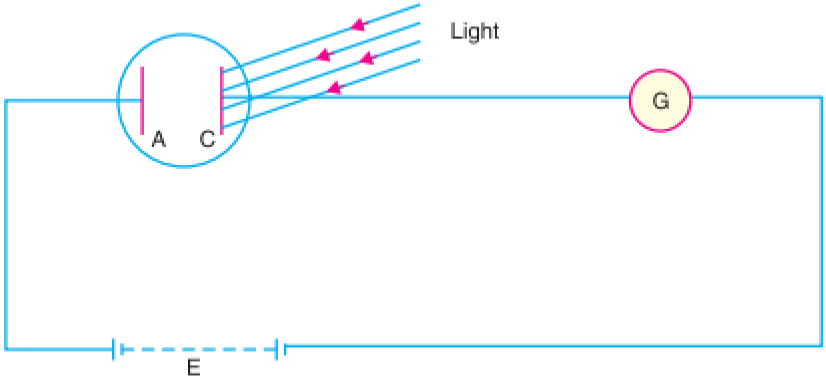
(ii) The product of the phase angles of the two should be zero or an integral multiple of 2π.

PHOTOELECTRIC EMISSION

Whenever light or electromagnetic radiations (such as X-rays, Ultraviolet rays) fall on a metal surface, it emits electrons. This process of emission of electrons from a metal plate, when illuminated by light of suitable wavelength, is called the photoelectric effect. The electrons emitted are known as the photoelectrons. In the case of alkali metals, photoelectric emission occurs even under the action of visible light. Zinc, cadmium etc., are sensitive to only ultraviolet light.

The Nature of Photo-particles

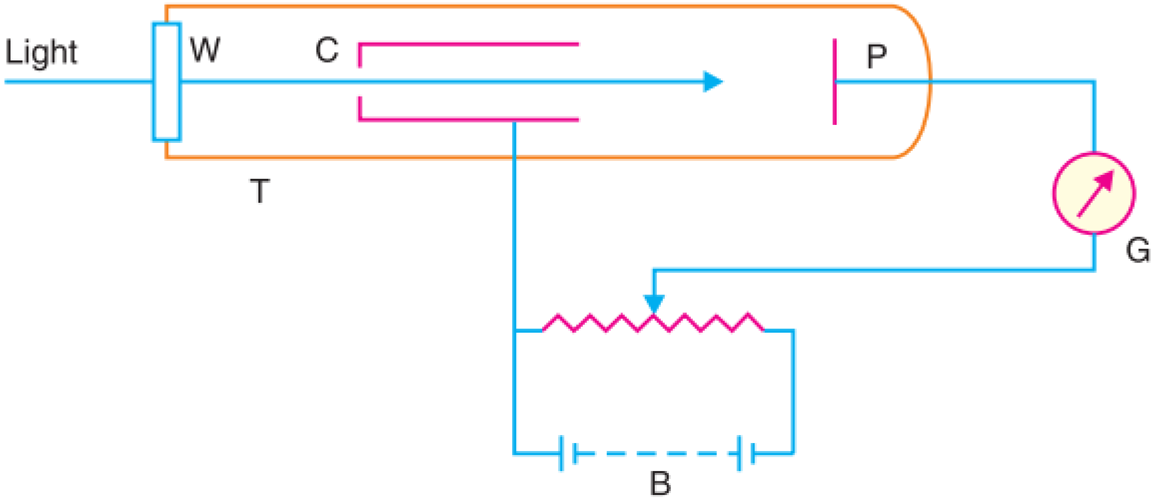
The arrangement used by Hallwachs is shown in Fig. The apparatus consists of two plates A and C placed in an evacuated quartz bulb.



The galvanometer (G) and battery (E) are connected as shown. When ultraviolet light is incident on the negative plate C, a current flows in the circuit as indicated by the galvanometer. But when light falls on the positive plate A, there is no current in the circuit. These observations show that photo particle must be negatively charged.

Experimental Investigations on the Photoelectric Effect

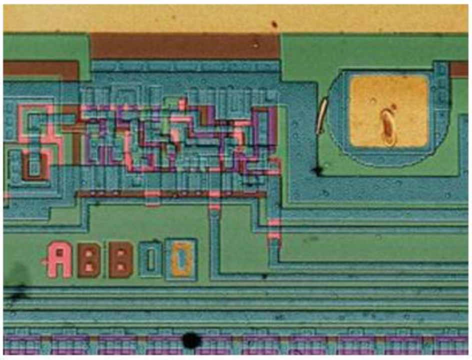
Photoelectric effect can be studied in detail with the help of the apparatus shown in Fig.



It consists of an evacuated glass tube T with a quartz window W. P is a photoelectrically sensitive plate. C is a hollow cylinder and it has a small hole that permits the incident light to fall on the plate P. P is connected to the negative end. C is connected to the positive terminal of a battery B. When light from some source falls on the plate P, the photoelectrons are ejected out of the plate P. These photoelectrons are attracted by the positively charged cylinder C. Hence a photoelectric current flows from P to C in the bulb and from C to P outside the bulb. This current can be measured from the deflection produced in the galvanometer G. It is found that the strength of the photoelectric current increases as the potential of C is more and more positive with respect to P. The deflection in G decreases when the potential of C is negative with respect to P. The results obtained can be summarised into four statements, which are known as the laws of photoelectric emission.

Laws of photoelectric emission. (i) For every metal, there is a particular minimum frequency of the incident light, below which there is no photoelectric emission, whatever be the intensity of the radiation. This minimum frequency, which can cause photoelectric emission, is called the threshold frequency.
(ii) The strength of the photoelectric current is directly proportional to the intensity of the incident light, provided the frequency is greater than the threshold frequency.
(iii) The velocity and hence the energy of the emitted photoelectrons is independent of the intensity of light and depends only on the frequency of the incident light and the nature of the metal.
(iv) Photoelectric emission is an instantaneous process. The time lag, if any, between incidence of radiation and emission of the electrons, is never more than 3 × 10–9 sec.

INTEGRATED CIRCUIT
An integrated circuit is just a package of electronic circuit in which both the active and passive components are fabricated on a small semiconductor chip.
Thus in an IC, a number of circuits containing many diodes, transistors, resistors, capacitors etc., are formed and connected within an extremely single tiny chip of semiconductor material. The typical size of an IC is 0.2 mm × 0.2 mm × 0.001 mm. The individual circuit components of an IC cannot be removed or replaced because each one of them is an integral part of the same semiconductor chip. The different components are isolated from each other by isolation diffusion within the crystal chip and are interconnected by an aluminium layer which serves as wires. Monolithic IC is the most commonly used one.



Integrated Circuit