Semiconductor

What is p-n junction ?

A p-n junction is a semiconductor junction formed by combining two different types of semiconductor materials p type and n type. It is the basic building block of various electronic device such as diodes, transistor and integrated circuit.

In a p-n junction, the p-type semiconductor is dopped with impurities that introduce positively charged carries called "holes" while the n-type is doped with impurities that .... called "electrons". When this two region brought into contract, a diffusion of carriers occurs due to the difference in concentration resulting in the formation of a depletion region at the junction. When forward bias voltage is applied to the p-n junction, it reduces the width of the deplation region, allowing the carriers to flow across the junction and enabling current flow.
(preventing n-type)

What do you understand by semiconductor?

A semiconductor is a material that has an electrical conductivity between that of a conductor and an Insulator. Semiconductor are typically solid state material, most commonly composed of elements from group III and V from the periodic table, known as compound semiconductor. Semiconductor have a conductivity that can be modified by adding impurities called doping. The external electrical field, behaviour of a semiconductor is primarily determined by its atomic structure and the arrangement of its e^-. Most commonly used semi-- is Si but other material like Ge, gallium arsenide (GaAs) and many more are also used. In a pure or intrinsic form, semi---- have a balanced number of e^- and positively charged holes in their atomic structure. This balance ~~number of~~ allows only a small amount of electrical current to flow through them.

Why we use semiconductor? Disscuss some properties.....

Semiconductor is a material which has an electrical conductivity between conductor and insulator. Semiconductor are the brain of modern electronics. It is an essential componant of electronic devices, enabling advances of communications, computing, health care, military systems, transportation and other applications. This property allows for precies control of electrical current flow. Again diods and transistor are made of semiconductor. Diods allows current to flow one direction and transistor amplify or switch electrical signals. Semiconductor can be fabricated into extreamly small size, allowing for the miniaturization EC. This miniaturization is the foundation of IC or microchip. Again semi... offer efficient control and utilization of electrical energy. Semi... also used in various sensing and detection applications. In a word, we use semiconductor devices in our every steps of life. This feature make semi.. essential for a wide range of electronic devices and tecnology.

properties :

(1) The resistivity of a semiconductor is less than an insulator but higher than a conductor.

(2) Semiconductors show a negetive temparature coefficient of resistance. In simple words, the resistance of the semiconductor decreases as the temparature increases.

(3) At zero (0K), semiconductor behaves a insulator. As the temparature increases it works as a conductor.

(4) The conductivity of the semiconductor increases when impurities are added.

Effect of temparature :

At absolute zero : At absolute zero temparature, all the electrons are tightly held by the semiconductor atom. The inner orbit electrons are bound whereas the valance electrons are engaged in co-valent bonding. At this temparature, the covalent bonds are very strong and there are no free electrons. Therefore it behaves a perfect insulator. The valance band is filled and there is a large energy gap between valance band and conduction band. Therefore, no valance e^- can reach the conduction band to become free e^-.

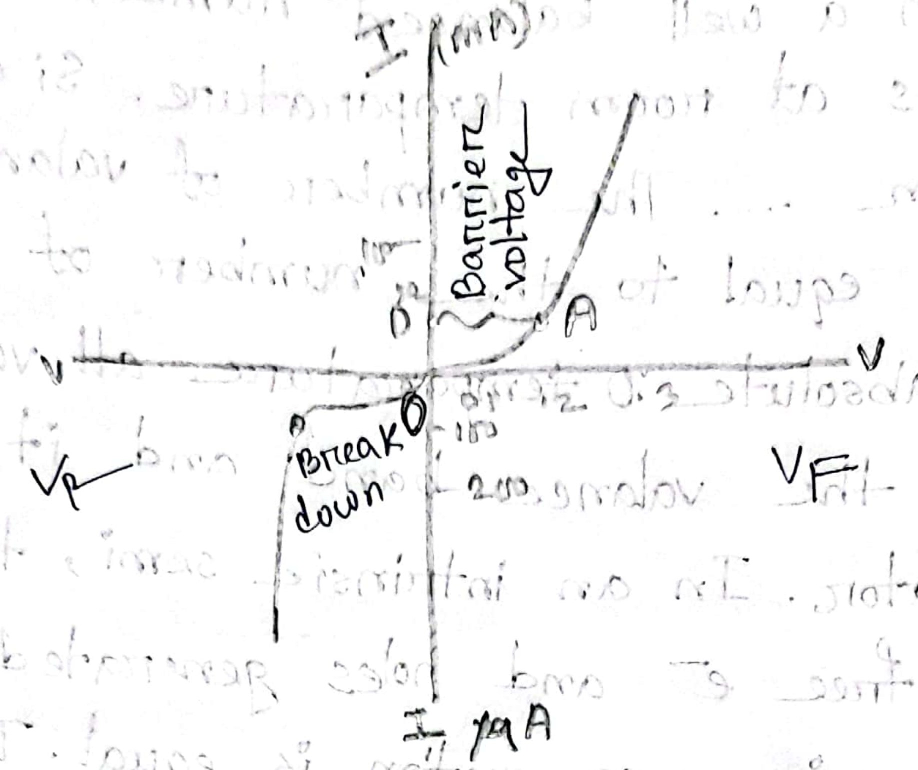
Above absolute zero : When the temparature is raised, some of the co-valent bonds in the semiconductor break due to the thermal energy supplied. As the temparature raised some of valance electrons acquire sufficient energy to enter into the conduction band and thus become free electrons. These free e^- will constitute electrict current. It may be noted that each time a valance e^- enters into the conduction band, a hole is created in the valance band.

Extrinsic Semi: is a type of semiconductor material that has been intentionally modified by adding impurities to its structure. These impurities known as dopands. The conductivity of an intrinsic semiconductor depends on the surrounding temparature. At room temparature it exhibits a low conductivity. To make it more ~~swi~~ ~~sw~~ suitable for any electronic devices dopping is needed. While adding impurities, a small amount of suitable impurity is added to pure material, increasing its conductivity. It is also called impurity semiconductor or dopped semiconductor.

Intrinsic Semicon: It is a pure semiconductor material with a well balanced number of e^- and holes at room temparature. Si and Ge are common .... The number of valance electrons is equal to the number of valance holes. At absolute 0 temparature all valance e^- are in the valance band and it behaves as an insulator. In an intrinsic semi, the number of free e^- and holes generated by intrinsic carrier generation is equal. Therefore, the electrical conductivity of an intrinsic semiconductor is relatively low compared to conductor but higher than insulators.

CamScanner

V-I Characteristic Curve:



Zero Bias: In zero bias condition, no external voltage is applied to the junction. Hence the potential barrier at the junction doesn't permit current flow.

Forward bias: At som forward voltage 0.7 for Si and 0.3 for Ge, the potential barrier is almost eliminated and current start flowing. From this instance the current increases with the increase of forward voltage. At OA region current increases at very slowly due to potential barrier. Once external voltage exceeds the potential barrier voltage, the potential barrier is eleminated and the junction behaves as an ordinary conductor.

Reverse bias: In reverse bias, potential barrier is increased. Minority carriers are present in the junction which creates reverse saturation current flows in the begining. If the applied voltage increases rapidly, there is increased kinetic energy. In this state diode breaks down. And the voltage is called Breakdown voltage. This may destroy the diode.

suddin increase of reverse current

Dopping and why it is done?

The process of adding impurities to the pure semiconductor to increase the conductivity of a semiconductor. In semiconductor they have very little conductivity because the band gap between valance and conduction band is large.

To get a significant amount of conductivity, we need to increase the temparature of the semiconductor to a higher value. ~~Doping~~ But it is imposible to use semi- device at very high temparature.

Doping can increase the conductivity by a significant amount at room tempa-

~~bd~~

Break down voltage : It a refers to the minimum voltage required for an insulating material to undergo a disruptive electrical breakdown, allowing current to flow through it. When the voltage across an insulating material exceeds its breakdown voltage, the insulator can no longer resist the electric field and starts to conduct electricity.

PIV : PIV stands for Peak Inverse Voltage. It is a parameter commonly used to specify the maximum voltage that can be applied in the reverse direction across a diode or a rectifier without causing permanent damage to the device. When a diode is reverse bias, it operates in a region where it blocks the current flow untill a certain threshold is reached. If the reverse voltage of the diode, voltage exceed the PIV rating break down it can lead to an electrial ~~damage~~ and parmanent damage to the diode.

Knee voltage: The knee voltage known as turn-on voltage. It refers to the minimum forward voltage required for a diode to start conducting current significantly. In the forward bias condition, when the voltage applied across the diode exceeds the knee voltage. the diode begins to conduct current. The knee voltage varies depending on the type of diode and the material used. Sillicon diodes typically have a knee voltage around 0.6 to 0.7 volts, while Ge diods have a lower knee voltage around 0.2 to 0.3. Below the knee voltage, the diode has a high resistance and minimal current flows.

Diode

What is cristal diode?

A crystal diode also known as a crystal detector or a point contact diode, is a type of diode that uses a metal wire or a point contact on a semiconductor crystal to creat a rectifying junction. This junction allows current to flow in only one direction while blocking in the other direction. Crystal diodes were similar to other diods. Crystal diodes were commonly used in early radio tecnology, particularly in crystal radios.

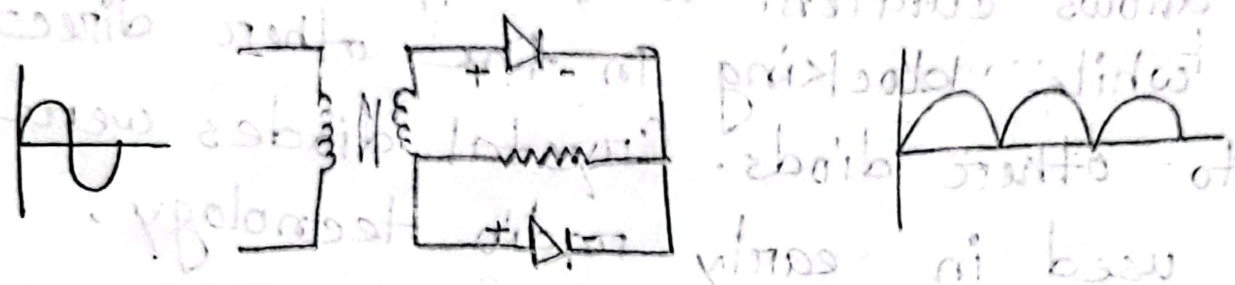
What is ripple factor?

The ripple factor is defined as the ratio of the RMS value of an alternating current component in the rectifed output to the average value of rectified output.

$$RF = \frac{\text{RMS value of Ac component}}{\text{Average value of rectifier output}}$$

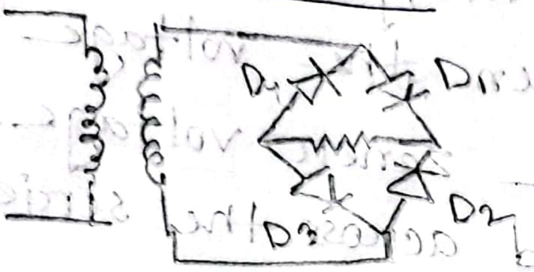
A lower ripple factor indicates better filtering and smoother output. A higher ripple factor implies a large AC component compared to the DC component, resulting in a less stable output.

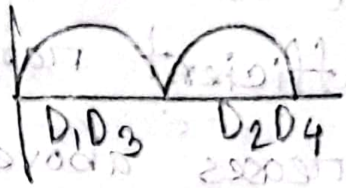
Central Tap :



AC voltage is applied across the input terminal of a central tap rectifier. During the (+) half cycle the voltage of the upper end becomes positive relative to the central tap and the upper diode is getting forward bias allowing current to flow through the R_L and back to the transformer. During the (−) half cycle AC voltage at the lower end becomes positive relative to the central tap. And the lower end becomes forward bias allowing current to flow through R_L and back to the resistance. The output voltage of the rectifier is equal to the peak value of the Ac input.

Full wave bridge:



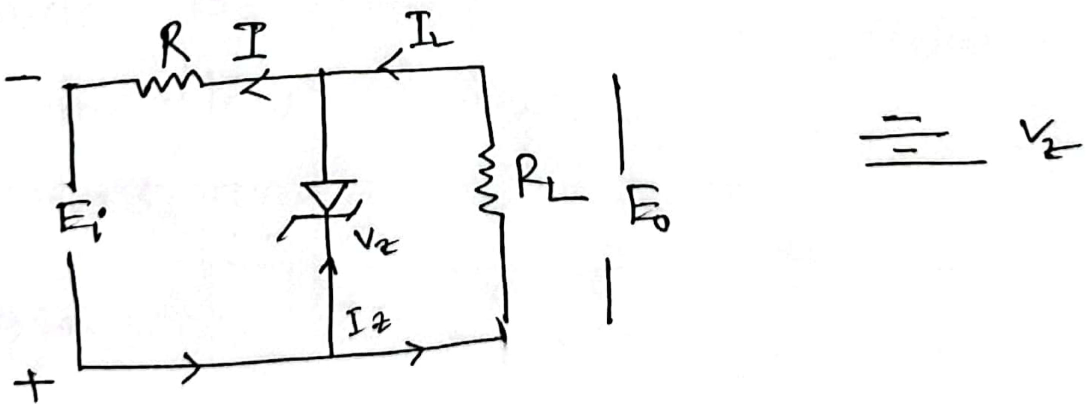


(+) half cycle, Ac input waveform. diods D1 and D3 becomes forward bias and allow current to flow through them. At the same time D_2 and D4 gets reverse bias and don't conduct current. (−) cycle, D_2 D4 forward

Zener diode as a voltage Stabilizer:

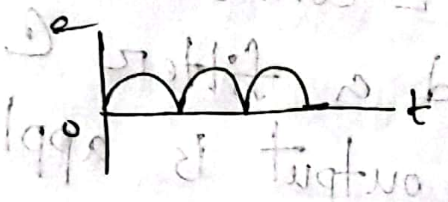
A zener diode is a type of diode that is design to operate an reverse break down mode.

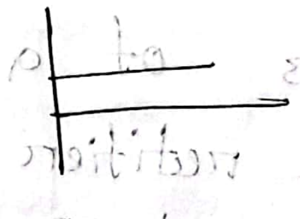
A zener diode can be used as a voltage regulator to provide a constant voltage from a source whose voltage may vary over sufficient range. When the voltage across load increases above the zener voltage, the excess voltage is dropped across the series resistance R. This will cause an increase in the value of total current I. This is because the ~~value~~ zener diode has a sharp break down voltage/region which allows it to regulate the voltage with high accuracy and low output impedence.

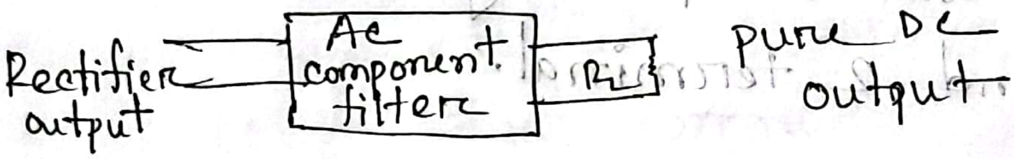


What is filter circuit?

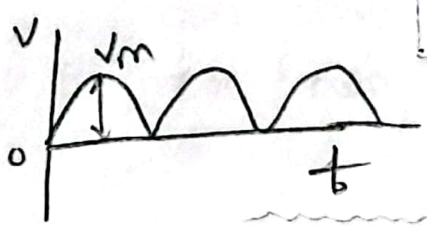
A filter circuit is a device which removes the Ac component of rectifier output but allows the Dc component to reach the load.

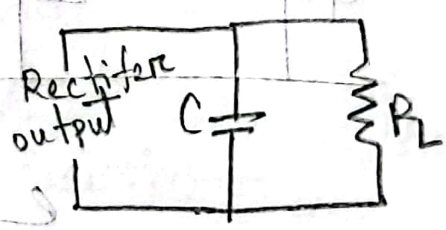


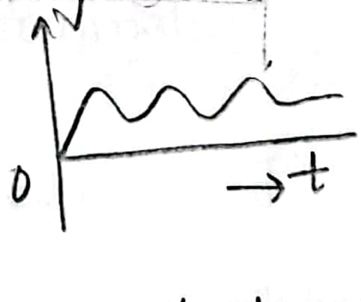




Capacitor filter: It consists of a capacitor C placed across the rectifier output in parallel with load R_L. The pulsating direct voltage of the rectifier is applied across the capacitor.

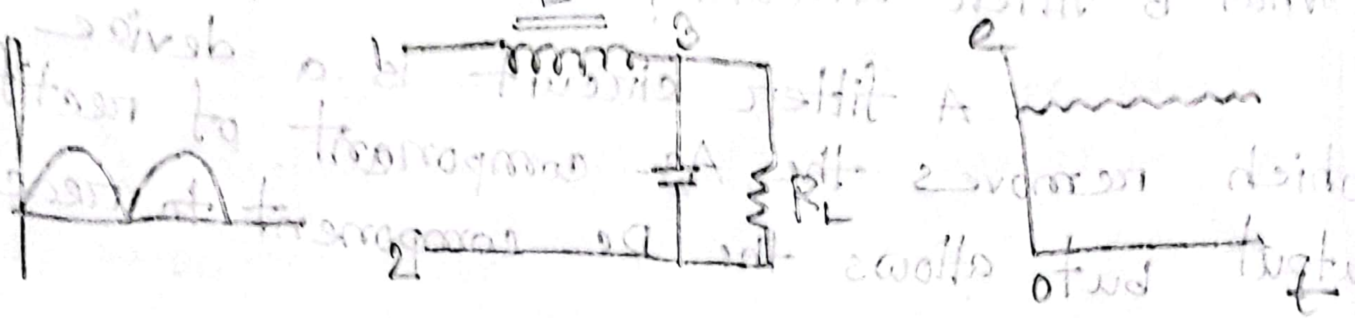






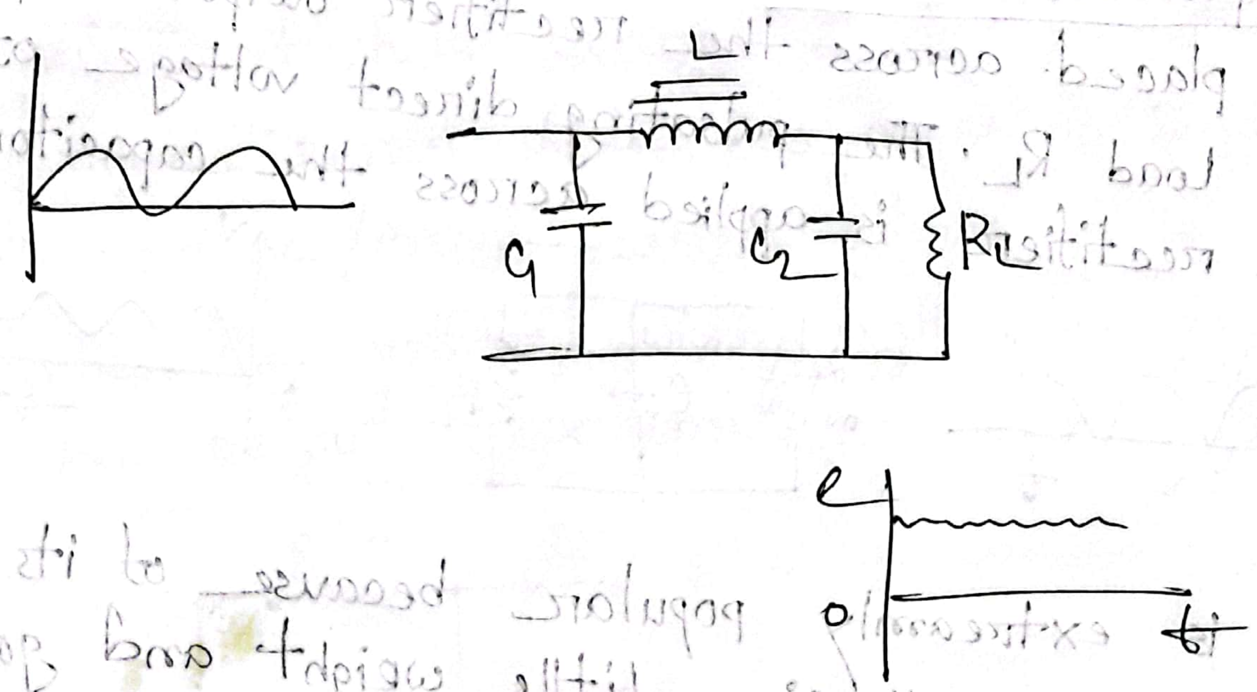
It is extreamly popular because of its low cost, small size, little weight and good characteristics. For small load currents, this type of filter is preferred.

Choke input filter:



It consists of a choke L connected in series with rectifier output and a filter C across the load. The pulsating output is applied across 1 and 2 terminal.

Capacitor input or π filter:



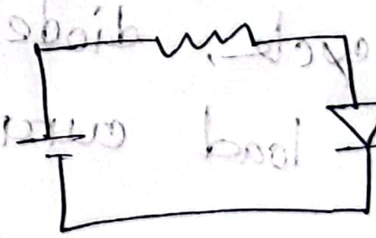
~~* Clipper circuit: also known as diode limiter is an electronic circuit that modifies the shape of a waveform by sllectively limiting or clipping its voltage amplitude.~~

Clipper circuit: are the circuit that clip off or removes a portion of an input signal, without causing any distortion to the remaining part of the waveform. Also known as clippers, limiters, slicers etc. It's a basically wave shaping circuit that control the shape of an output waveform.

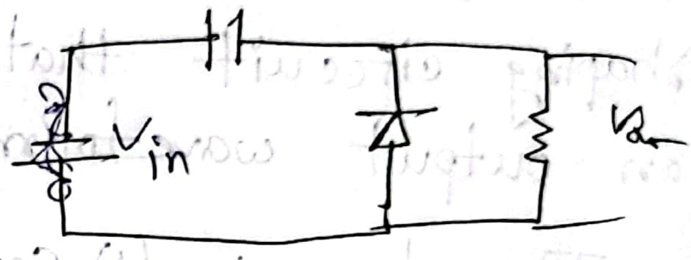
Two types: (1) Series clipper
(2) Shunt clipper

Series: The diode is connected in series with the load or output terminal.
It's two type:
1. Positive 2. negetive.

Shunt: parallel



Clamper Circuit : are the electronic circuits that shift the dc level of the Ac signal. Also known as DC voltage resistor or level shifter. These circuits are used to clamp an input signal to a different dc level. It basically adds dc component to the applied input signal in order to push the signal to either + or - side:



positive: diode and R_L are in parallel. reverse biasing of the diode will provide the output at the R_L.

negetive: (+) half cycle, diodes become forward that in results no load current at the output.
(-) half cycle, diodes becomes reverse.
This allows load current to appear at

* What is LED diode? Working principle.

A Led is a semiconductor device that emits light when an electrical current is passed through it. It is a type of diode specifically designed to emit light.

Working principle: The semiconductor material used in LED is composed two region – P type, n type. The p type region has an excess of positively charged particle called 'holes' while n-type carries "e^-". When a forward voltage applied to the LED, current beings to flow through LED. As the current flows through the junction the $\bar{e}$ from n-type and the holes from P-type start combine at the juncti. When an $\bar{e}$ combines with a hole, it falls to a lower energy level, releasing energy in the form of a ~~phothon~~ photon. The energy of the photon determines its colour.

What is photo diode?

A photodiode is a semiconduc device that converts light into an electrical current. It is a type of photodetector that is widely used in various application, light sensor, imaging device, optical system.

Working :

there are two regions: ntype and p type. it forming a p-n junction. This p-n junction creats a deplation region where there are no free charge carries. When light photons with sufficient energy strike the depletion region, they can be absorbed and their energy is transferred to the e^- in the valance band of the semiconductor material. This energy absorption causes the e^- to gain enough energy to break free from the atom, creating e^--hole pairs.

The electric field created by p-n junction causes free e^- to move towards the n - region, while the positive charged holes moves towards p region. This separation of charges generates an electric current, known as the photo current.

Transistor

Define transistor ?

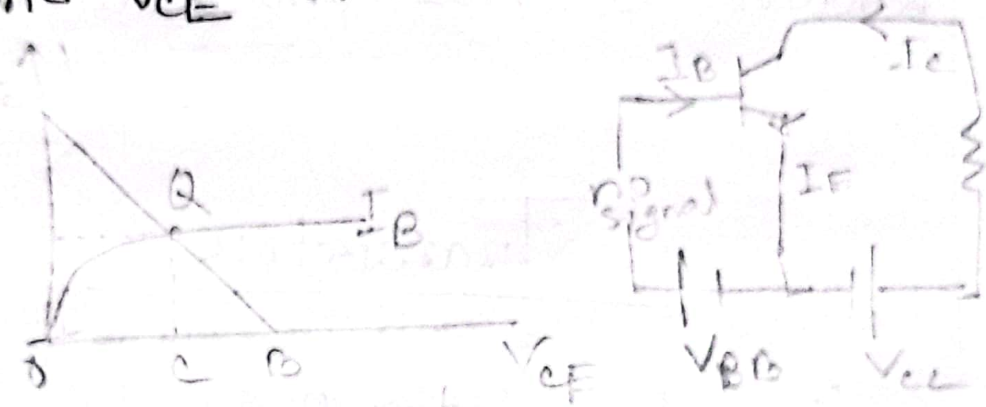
Transistor is a type of semi-conductor device that can be used to conduct and insulate electric current or voltage. A transistor is composed of three layers.

Base : Use to active the transistor

Collector : positive lead of the u

Emitter : negative lead.

Operating point: refers to the specific biasing conditions or operating condition at which the transistor is designed to operate. It is also known as the quiescent point. The zero signal values of I_C and V_{CE} are known as Q point.



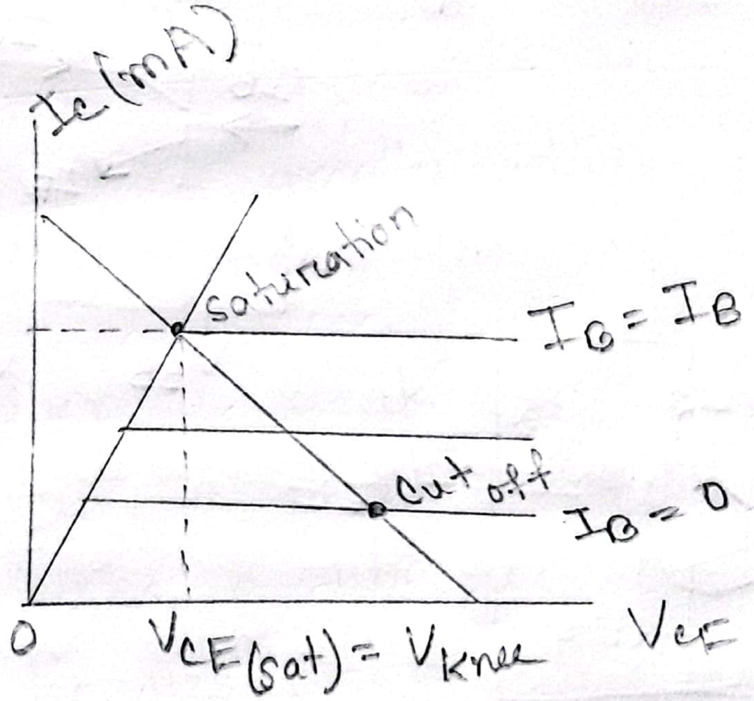
Cut off:

The point where the load line intersects the $I_B = 0$ curve is known as cut off. At this point, $I_B = 0$ and only small collector current exists. At cut off the B-E junction remains forward biased. C-E voltage is nearly to Vcc.

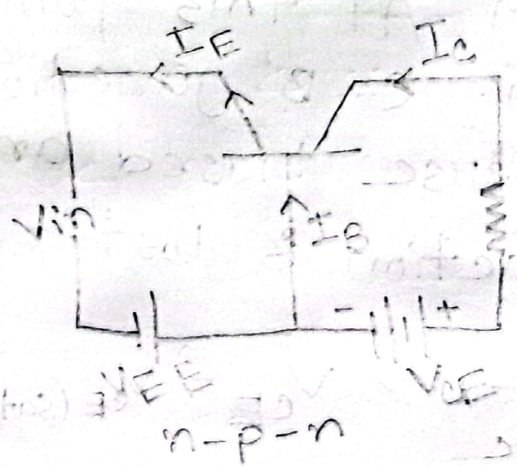
$$V_{CE} = V_{CC}$$

Saturation: The point where the load line intersects the $I_B = I_{B(sat)}$ curve is called saturation. At this point base current is maximum. C-B junction no longer remains reverse biased and normal transistor action is lost.

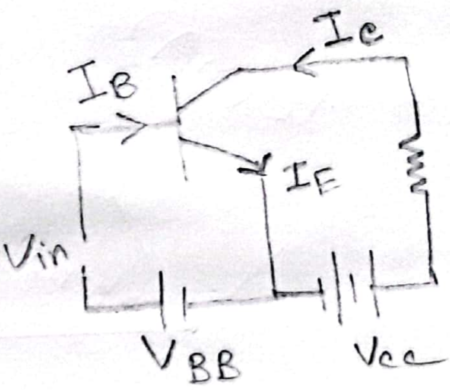
$$I_{C(sat)} \simeq \frac{V_{CC}}{R_C} \; ; \; V_{CE} = V_{CE(sat)} = V_{knee}$$



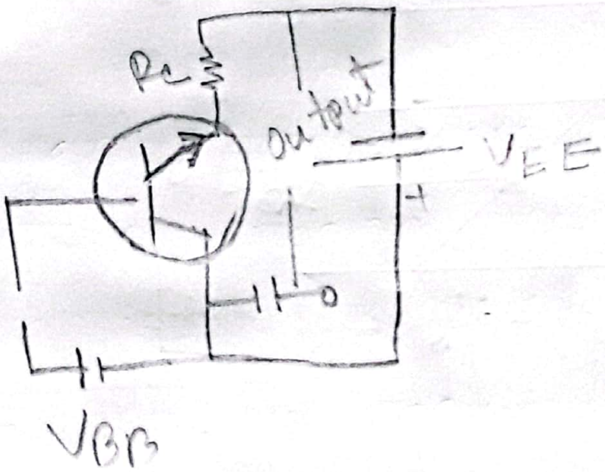
Common base:



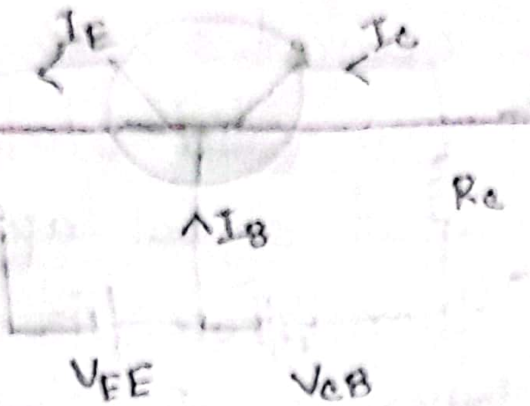
Common Emiter:



CC



* Transistor works as an Amplifier :



The input or weak signal is applied across emitter base and output is obtained to the R_C. The DC voltage V_{EE} is applied to the input circuit along with the input signal to achieve the amplification. V_{EE} keeps the E-B junction under the forward bias.

When a weak signal is applied to the input, a small change in single voltage causes a change in emitter current because the input circuit has very low resistance. This change is almost the same in collector current.

In the collector circuit, R_C of high value is connected. When collector current flows through such a high resistance, it produce a large voltage drop across it.

Transistor as a switch :

The transistor operates as a single pole single throw solid state switch.

When a zero input signal applied to the base of the transistor, it acts as a open switch. When a positive signal applied at the input terminal then it acts like a closed switch.

When transistor operating as switch, the cut off region the current through the transistor is zero. and voltage across to it, is maximum. In the saturation region the transistor current is maximum and voltage across is zero. Both on - off state power loss is zero.

BJT	FET
Current control device	voltage control device
Bi-polar	Unipolar
Noice level high	Low
Size is big	Small
Input resistance less compare to JFET.	High.... compared to BJT
n-p-n, p-n-p	n, channel p channel

Biasing

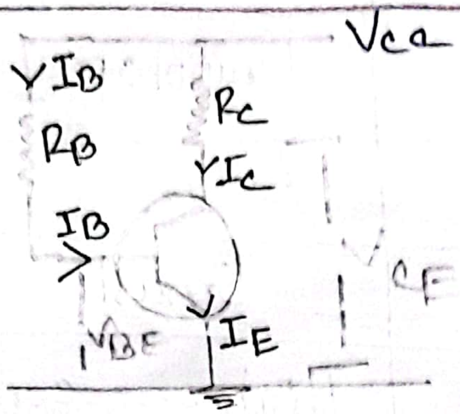
Faithful Amplification: The process of raising of the strength of a weak signal without any change in its general shape is known as faithful amplification.

To ensure this, 3 basic condition must be satisfied.

1. Proper zero signal collector current.
2. Minimum power V_{BE} at any instance
3. " " V_{CE} " " " .

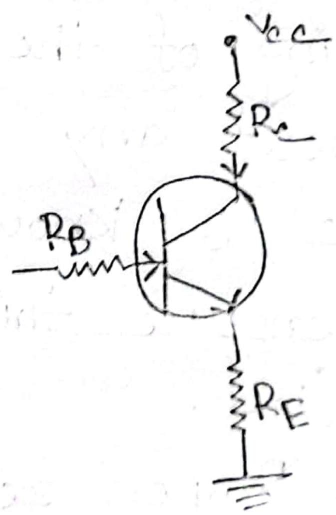
Types of Biasing:

Base bias:

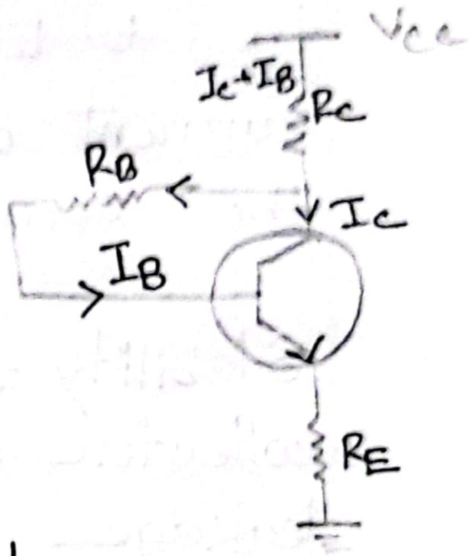


A resistor R_B of high resistance is connected in base. The required zero signal base current is provided by V_{CC}. The B-E junction is in forward bias. The required zero signal base current and hence the I_C can be made to flow by selecting the proper value of base resistor R_B.

Emitter bias:

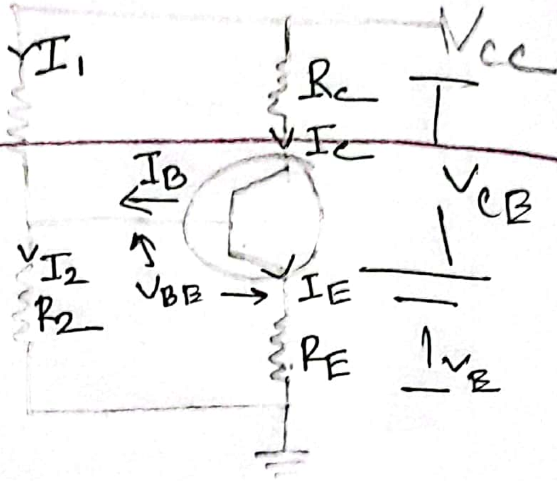


Collector feedback :



The base resistor R_B has its one end connected to base and other to the collector. The zero signal base current is determined by V_{BE}. V_{BE} is in forward bias and hence base current I_B flows through R_B. This causes the zero signal collector current to flow in the circuit.

Voltage devider :



Here two resistor R_1 R_1 and R_2 are employed, which are connected to V_{cc} and provide biasing. R_E employed in emiter that provide stabilization.

The voltage drop across R_2 forward bias the B-E junction. This causes the I_B current and hence I_c current flow in the zero signal conditions.

Stability factor: The rate of change of collector current I_c and the collector leakage current I_{co} at constant I_B and β is called stability factor.

$$S = \frac{dI_c}{dI_{co}}$$

The stability factor indicates the change in collector current I_c due to the change in collector leakage current I_{co}.

Transistor Biasing: The proper flow of zero signal collector current and the maintanace of proper collector-emitter voltage during the passage of signal is known as transistor biasing. ~~The~~

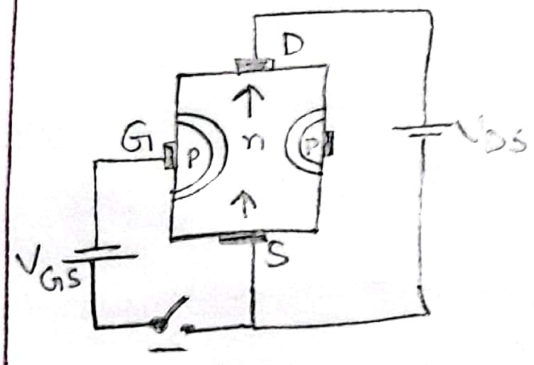
The basic purpose of transistor biasing is to keep the base-emitter junction properly forward biased and C-B junction properly reverse biased during the application of signal. If a signal of very small voltage is given to the input of BJT, it can't be amplified. Because for a BJT to amplify a signal two condition have to be meet.

1. The input voltage should exceed cut-in-voltage for the transistor to be ON.

2. The BJT should be in active region, to be operate as an amplifier.

FET

Working principle of FET:



(1)

When a voltage V_{DS} is applied between the drain and source terminal and voltage on the gate is zero. The two pn junction at the side of the bar establish deplation layer. The e^- will flow from source to drain through a channel between the deplation layer.

When a reverse voltage V_{GS} is applied between the gate and source the wide of the deplation layer increased. This reduces the width of the conducting channel and current flow from source to drain decreased. On the other hand, reverse voltage on the gate decreased, the width of the deplation layer also decreased. This increase the width of the conducting channel and hence source to drain current flow

Features of JFET:

The junction-gate field-effect transistor is one of the simplest type of FET. It are three terminal semiconductor device that can be used as switchs, amplifiers. JFETs are exclusively voltage control device.

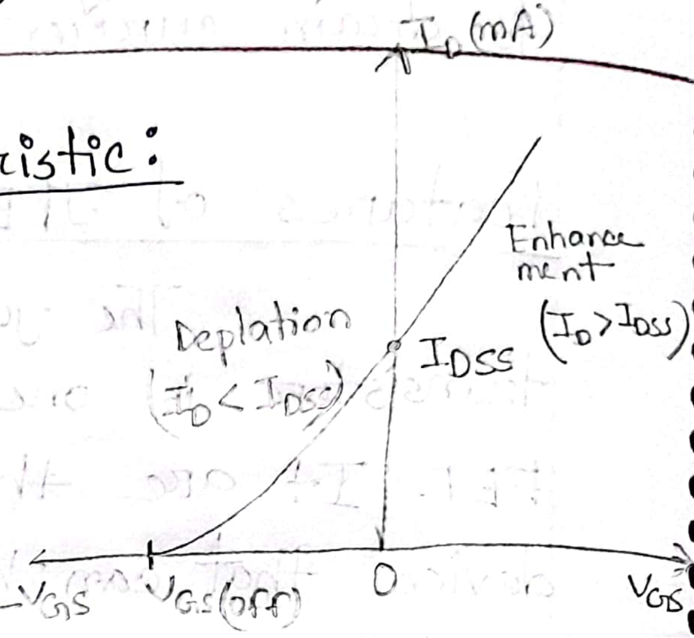
1. always operated with gate source p-n junction at reverse biased.
2. the gate current is zero.
3. Since there is no get current,

$$I_D = I_S.$$

4. is a three terminal voltage control semiconductor device.
5. I_D is controlled by changing the channel width.

6 The JFET must be operated between $V_{GS} = 0V$ and $V_{GS(off)}$.

D mosfet characteristic:



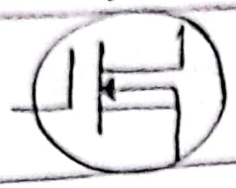
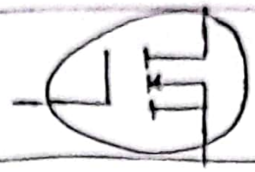
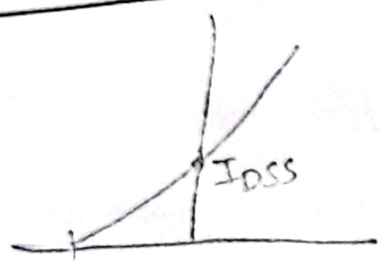
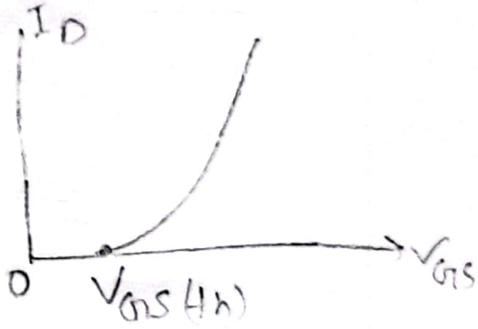
(1) The point on the curve where $V_{GS} = 0$, $I_D = I_{DSS}$. It is excepted because I_{DSS} is the value of I_D when gate and source terminal are sorted. $V_{GS} = 0$

(2) As V_{GS} goes negetive, I_D decreases below the value of I_{DSS} till I_D reaches 0 when $V_{GS} = V_{GS(off)}$.

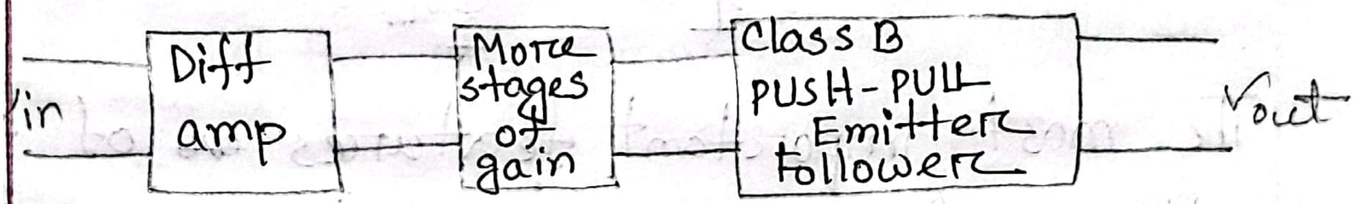
(3) When V_{GS} is positive, I_D increases above of I_{DSS}.

E-MOSFET:

D-MOS Vs E-MOS :

D-MOS	E-MOS
	
It operates in deplation and enhancement mood.	Only Enhancement mood.
Commonly used in gate bias, self bias, zero bias, voltage-divider.	Gate bias, voltage-divider, Drain - feedback bias.
	

OP-Amp: An operational amplifier is a circuit that can perform such mathematical operations as addition, substruction, integration and differentiation. An op-amp is a multistage amplifier. An op-amp has very high input impedence and low output impedence.



Block diagram of OP-Amp

Characteristic OP-Amp:

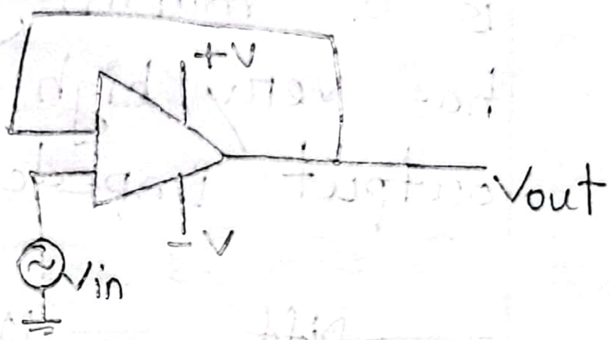
(1) It is ~~an~~ a multistage amplifier. The input stage of an OP-amp is a differctial amplifier stage.

(2) It has inverting input and a nonenverting output.

(3) A high input impedence and low output impedence.

(4) A large open loop voltage gain, typically 10^5.

Voltage Follower: The voltage follower arrangement is a special case of non-inverting amplifier where all the output voltage is fedback to the inverting input.

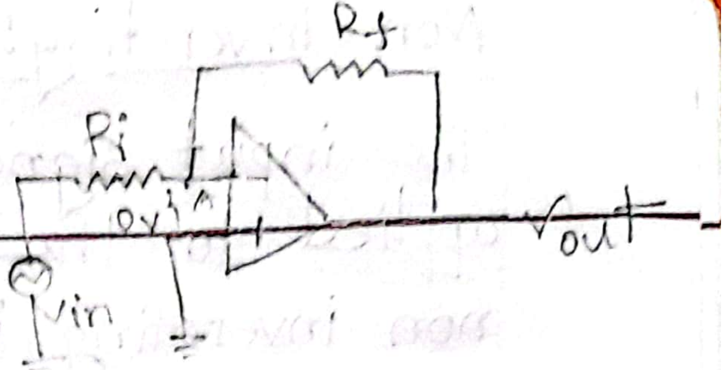


The voltage gain.

$$A_{CL} = 1 + \frac{R_f}{R_i} = 1 + \frac{0}{R_i}$$
$$= 1$$

The most important features ~~are~~ of the voltage follower configuration are it's very high input impedence and low output impedence. These feature make it a nearly buffer amplifier

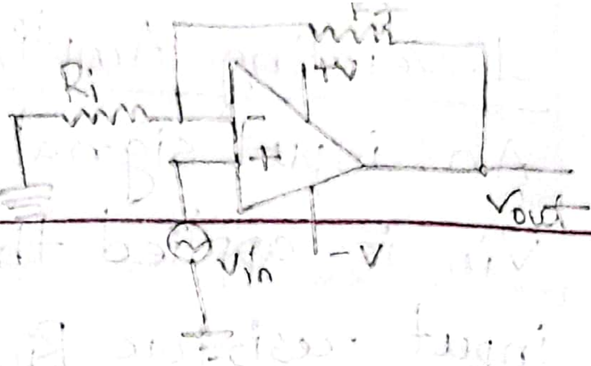
Inverting Amplifier:



An input signal Vin is applied through input resistor Ri to the minus input. The output is feedback to the same minus input through feedback resistor Rf. The (+) input is grounded. The resistor Rf provides the negative feedback. Since the input is applied to the inverting input (-), the output will be inverted as compared to the input.

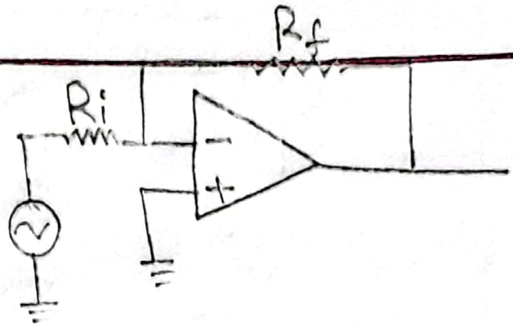
Voltage gain: An OP-amp has an infinite input impedence. It means there is zero current at the inverting input. If there is zero current through the input impedence, then there must no voltage drop between the inverting and non-inverting inputs. Voltage of the inverting input is zero the other input is grounded.

Non-inverting:



The input signal is applied to the non inverting input.
The output is applied back to the input through the feedback circuit formed by feedback resistor R_f and input resistance R_i. R_f and R_i form a voltage divider at the inverting input (-). This produces negetive feedback in the circuit. And R_i grounded. Since the input signal is applied to the non-inverting (+) input, the output signal will be noninverted, the output will be in phase with the input signal.

* What is the need of negetive feedback in an OP-amp?



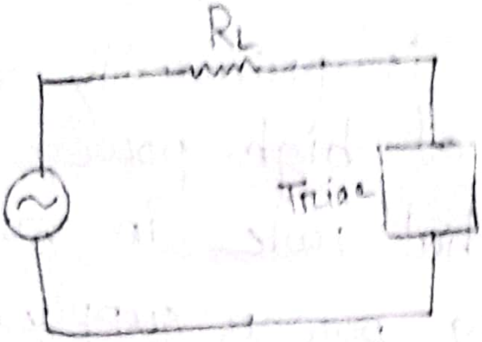
An op-Amp is almost always operated with negetive feedback. The reason is simple. The open-loop voltage gain of an OP-amp is very high. Therefore an extreamly small input voltage drives the OP-amp into its saturation output stage. With negetive feedback, the voltage gain can be reduced and controlled so that OP-amp can function as a linear amplifier. In addition to providing a controlled and stable gain, negetive feedback also provides for control of the input and output impedence and amplifier bandwidth.

Operation of op-amp Integrator.
" " " " " differentiator.

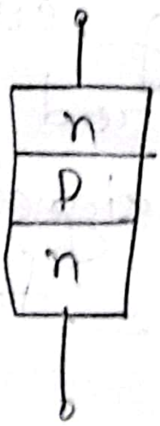
Power Electronics

The branch of electronics which deals with the conversion, control of power at 50Hz (supply frequency) is known as power electronics. Power electronics is primarily focoused on the handling of high power levels. It playes a crutial role in various application including power supply, electric motor device, renewable energy system etc. The main components and devices used in power electronics including power semiconductor devices such as diodes, transistor etc.

Triac : The triac is a three terminal semiconductor & switching device which can control alternating current in a load. These are triggered into conduction by low energy gate signal. Triac is a contraction of Triode for Alternating current. It is a bidirectional device that belongs to the thyristor family and is basically a diac with gate terminal used to control the turn-on conditions of the device.



The Diac: The diac is a two-terminal three layer bidirectional device which can be switched from its OFF state to ON state for either polarity of applied voltage. The diac can be ~~either~~ constructed in either n-p-n or p-n-p.



Symbol

Importance of power electronics:

Power electronics is an essential part of many devices and systems in one or more of their phases. Power electronic convert electrical energy of one type into another. It plays a significant role in various aspects of our modern society.

Energy Efficency: Power electronics enables efficient energy conversion, which is vital for reducing energy waste. By improving energy efficiency, power electronics contributes to sustainable development and lowers the environmental impact of power generation and consumption.

Renewable Energy Integration: Power electronics play a critical role in the integration of renewable energy source such as solar, wind power into electrical grid.

These sources generates electricity in different form and Power electronics facilities their conversion and integration into the grid. It enables efficient power transfer, power quality management, making renewable source more reliable and compatible with existing power infrastructure.

Electric trasportation: The growing demand of electrical vehicle(EV) and the development of changing infrastructure on PE. EVs require efficient power conversion and control their motor drives, battery charging and energy management system. PE enables fast charging, regenarative breaking, efficient power transfer etc. and sustainability of electric transportation.

Industrial Application : PE is widely used in industrial purposes and manufacturing. It ~~facilates~~ facilitates motor control, variable speed drives, robotics, optimizing energy consumption and enhancing productivity. PE also enables power quality improvement, reducing harmonics and enhancing the stability and reliability of industrial power system.

In summary, PE is of immense importance in today's world. It enables energy efficiency, facilitates the integration of renewable energy, enhance consumer electronic and many other sectors. By advancing PE technology, we can address energy challenges, reduce environmental impact and sustainable development.