Basic - Electronics Paper 2020 Soln (Kapil Gupta)

Q-1(a) Difference btw Carbon resistor & Wire Wound Resistor.

Ans.

Carbon Resistor	Wire wound Resistor
① → It's Power rating is from 0.25W to 2W	→ It's power rating is from 1W to 200W.
② It Can be use at high frequencies.	→ It Can't be use at high frequencies.
③ It has high tolerance and hence accurate value of resistance Can be obtained	→ It has low tolerance so accurate value of resistance can't be obtained.
④ It has low stability and reliability.	→ It has higher order of stability & reliability.
⑤ It is small in size and light in weight.	→ It has big size so can't use for many applications.
⑥ It has low temperature cofficient value.	→ It has high temperature cofficient value.

(b) Explain briefly Capacitor filter Circuit.

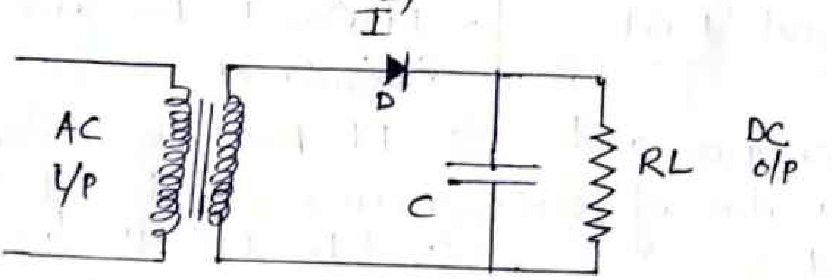
Ans:- It is the circuit in which first element is a capacitor Connected in parallel with output of the rectifier in a linear power supply.

The capacitor increases the DC voltage and (↓)es the ripple voltage component of output. The Capacitor is often followed by other alternating series and parallel filter element to further reduce ripple voltage, or adjust DC output voltage.

It may also followed by voltage regulator which virtually eliminates any remaining ripple voltage and adjust the DC Voltage output very precisely to match the DC Voltage required by the circuit.

Process :→ During the time the rectifier is conducting and the potential is higher than the charge across capacitor, the capacitor will store energy from the transformer, when output of the rectifier falls below the charge on capacitor.

the capacitor will discharge energy into circuit. Since rectifier conduct current only in forward direction any energy discharged by capacitor will flow into load. This results in output of a DC voltage upon which is superimposed a waveform reffered to as a ~~smooth~~ sawtooth wave. The crests of sawtooth wave will be more rounded when DC resistance of transformer secondary is higher.



⇒ Capacitor Filter using Half Wave and Full Wave Rectifier.

© (i). <u>Diffusion Current</u> :→ The current in a semi-conductor caused by the ~~semi-conductor~~ diffusion of charge carriers (holes/e^-) is called Diffusion current.

This is the current which is due to transport of charges occuring beacuse of non-uniform concentration of charged particles in a semi-conductor

It is necessary to consider the part of diffusion current when describing many semiconductor devices. Ex:- The current near the depletion region of a p-n junction is dominated by the diffusion current. Inside the depletion region is ~~balanced with both~~ diffusion current and drift current are present. At equilibrium in a p-n junction the forward diffusion current in the depletion layer is balanced with a reverse drift current so that net current is zero.

(2) <u>Drift Current</u> :→ Drift current is the electric current or movement of charge carriers which is due to applied electric field, often stated as ~~at~~ Electromotive force over a given distance.

when an electric field is applied across a semiconductor material, a current is produced to flow of charge carriers.

In a p-n junction diode, e^- and holes are minority charge carriers in p-region and n-region the diffusion current which flows from the p-to n region is balanced by equal and opposite drift current.

In a biased P-n junction, the drift current is independent of biasing as the no. of minority carrier is independent of biasing voltages. But as minority charge carriers can be thermally generated, drift current is temp. dependent.

① Drift Current density due to free electrone

$$\boxed{J_n = q n \mu_n E} \ (A/cm^2)$$

② Drift current density due to holes.

$$\boxed{J_p = q n \mu_p E} \ (A/cm^2)$$

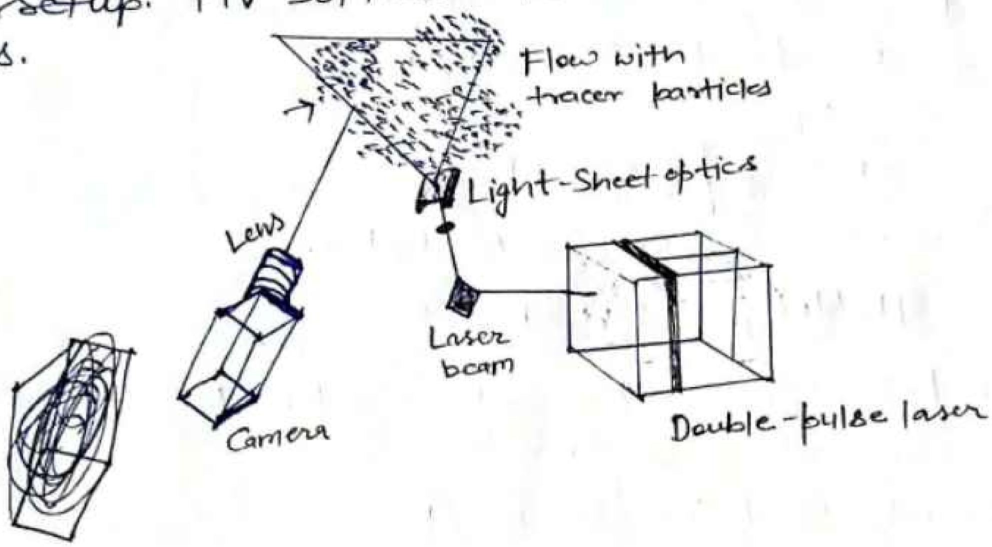
n = no. of holes / free e^- per cubic centimeter
μ_n = Mobility of e^- in cm^2/Vs
μ_p = Mobility of holes in cm^2/Vs
E = Applied electric field intensity. V/cm
q = e^- charge 1.6×10^{-19} Coloumb

③ Reverse Saturation Current :→ The current in P-n junction diode when diode is reverse biased, is called reverse saturation current.
Electrones in P side diffuses towards n side and holes from n side diffuses towards p side. due to which a small amount of current flows across the junction i.e. known as leakage current or reverse saturation current.

④ PIV :→ (Particle image velocimetry) :→ PIV is an imaging technique to measure the velocity distribution within the plane defined by laser light-sheet. It is used in various fluid dynamics researches.

Main difference btw PIV and other technique is that PIV produces 2-D or even 3-D vector fields, while the other techniques measures velocity at a point. During PIV the particle concentration is such that it is possible to find indivisual particles in a image but not with certainity to track it btw images.

Typical PIV apparatus consist of a camera, a strobe or laser with an optical arrangement to limit the physical region illuminated normally a cylinderical lens to convert a light beam to a line), a synchronizer to act as an external trigger for control of camera and laser, the seeding particles and fluid under investigation. A fiber optic Cable or liquid light guide may connect the laser to the lens setup. PIV Software is used to post-process the optical images.



⑤ Mean Lifetime of Carrier :→ Mean carrier liftetime is defined as average time it takes for a minority carrier to recombine. The process through which it is done is typically known as minority carrier recombination.

The dependence of carrier lifetime on the Carrier density is expressed as:-

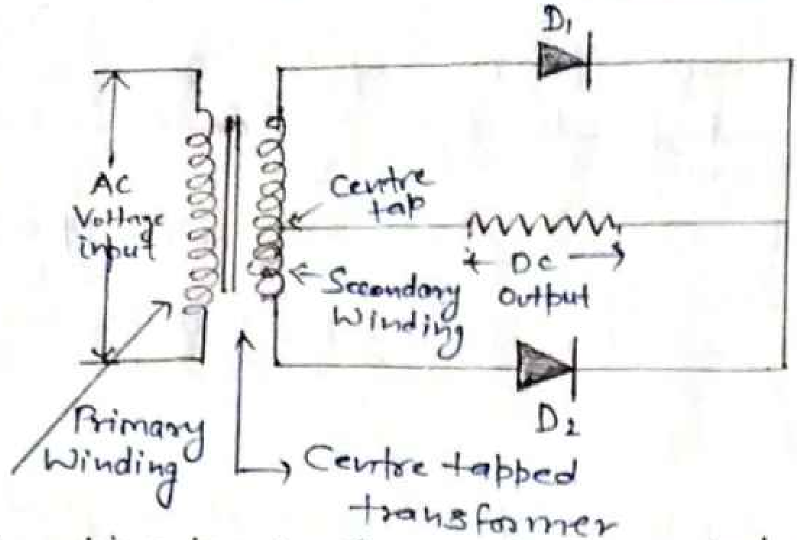
$$\boxed{\frac{1}{T_n(N)} = A + BN + CN^2}$$

Here A, B, C are non-radioactive, readiactive and Augar recombination cofficients and $T_n(N)$ is carrier lifetime.

Q-2 Working of Centre tapped full wave rectifier:- & derive expression for avg. DC current & rms load Current.

Ans:- A Full wave rectifier is a circuit which converts an ac voltage into a pulsating DC voltage. It uses two diodes of which one conducts during one Half cycle while the other conducts during the other half cycle of applied DC voltage.

When an additional wire is connected across the exact middle point of secondary winding of a transformer. It is called a centre tapped transformer. wire is adjusted that is at zero volts forming the neutral point for winding.



The centre tapped full wave rectifier is made up of AC source, a centre tapped transformer two diodes and a load resistor.

Construction :- AC Source is Connected to primary winding of Centre tapped transformer. A centre tap (additional wire) connected @ exact middle of the Secondary winding divides the input voltage into two parts.

The upper part of secondary winding is connected to diode D_1 and lower part of secondary winding is connected to Diode D_2. Both diode D_1 & D_2 are connected to a common load R_L with the help of a Centre tap transformer. The Centre tap is generally considerd as ground point or zero voltage referance point.

Working :- When input AC voltage is applied, the secondary winding of centre tapped transformer divides the input AC voltage into two parts positive(+)ve & (-)ve.

During positive half-cycle of Input AC signal, the terminal 'A' become (+)ve, terminal 'B' become (-)ve and centre tab is grounded (zero volts). The positive terminal A is connected to the p-side of diode D_1 & (-)ve ~~to diode D_2~~. terminal B is connected to n-side of diode D_1 so diode D_1 is forward biased during the (+)ve half cycle and allows electric current through it.

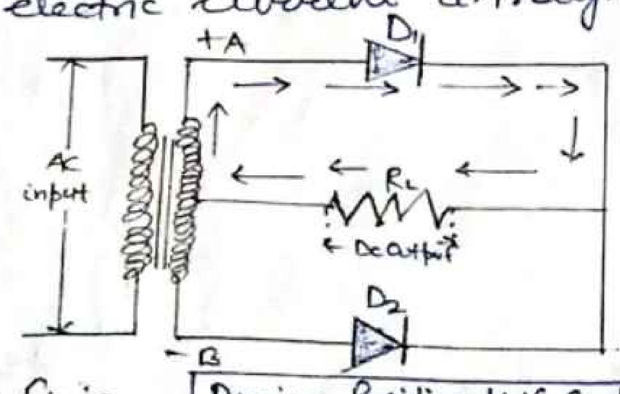
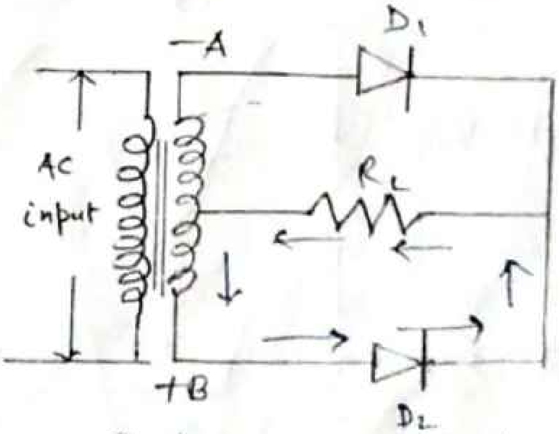


Fig :- During Positive Half Cycle

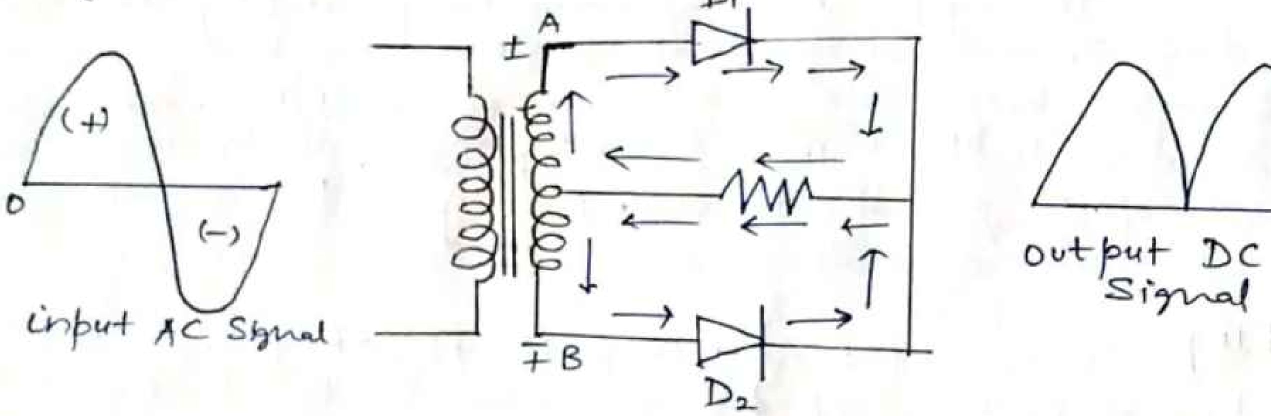


During (-)ve Half Cycle

On the other hand, (-)ve terminal B is Connected to P side of diode D_2 and (+)ve terminal A is connected to n-side of diode D_2. So the D_2 is reverse biased during (+)ve half cycle and does not allow electric current through it. D_1 supplies DC current to load R_L. The DC current produced at load R_L will return to secondary winding through a centre tap

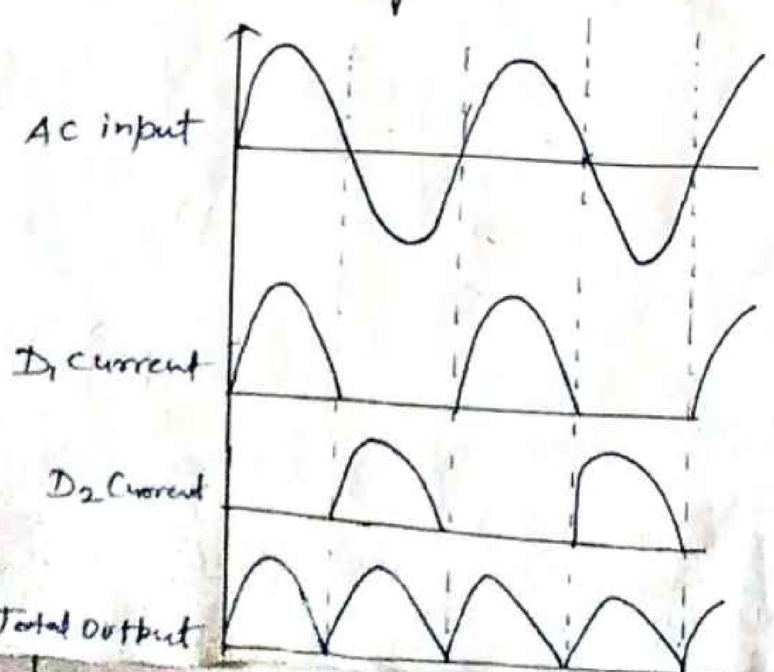
During (+)ve Half cycle, current flows only in upper part of the circuit while lower part carries no current because Diode D_2 is reverse biased. Thus During (+)ve half cycle of input AC signal only diode D_1 allows electric current while D_2 doesn't allow electric current.

During the (-)ve Half cycle of input AC signal terminal A become (-)ve & B become (+)ve and centre tap is grounded. -A is connected to P side of D_1. (+B) is to n-side of D_1 so D_1 is reverse biased during (-)ve Half cycle & doesn't allow current through it.



Thus Diode D_1 allows electric current during the (+)ve half cycle and D_2 allows electric current during (-)ve half cycle of input AC signal. As the result both half cycles are allowed. So output DC voltage is almost equal to input AC voltage. But a small voltage is wasted at D_1 & D_2 to make them conduct.

⇒ Output Waveform of Full wave Rectifier



① **Ribble Factor:-** It is used to measure amount of ripples present in output DC signal. A high ripple factor indigates a high pulsating DC Signal while a low ripple factor indicates a low pulsating DC Signal.

Ripple factor is defined as ratio of ripple voltage to pure DC voltage.

$$\boxed{\gamma = \sqrt{\left(\frac{V_{rms}}{V_{DC}}\right)^2 - 1}}$$

generally we consider $\gamma = 0.48$

② **Rectifier Efficiency:→** It is the ratio of DC output power to AC input power.

$$\boxed{\eta = \frac{\text{Output } P_{DC}}{\text{input } P_{AC}}}$$

generally we consider $\eta = 81.2\%$.

③ **PIV (Peak Inverse voltage):→** It also known as peak reverse voltage. It is the maximum voltage a diode can withstand in reverse bias condition. If the applied voltage is grater than peak inverse voltage then the diode will permanently destroyed.

$$\boxed{PIV = 2V_{s\,max}}$$

④ **DC Output Current:→** At the output load resistor R_L, both diode D_1 and diode D_2 current flow in same direction. So the output current is sum of D_1 & D_2 current.

$$\boxed{I_{o/p} = I_{D_1} + I_{D_2}}$$

Current produced by $D_1 = I_{max}/\pi$

" " " $D_2 = I_{max}/\pi$

So $$\boxed{I_{o/p} = \frac{2I_{max}}{\pi}}$$

∴ (Here I_{max} = Max. DC load current)

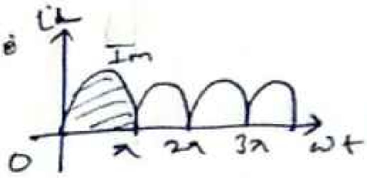
⑤ DC output Voltage :→ DC output Voltage appears at load resistor R_L is given as :-

$$\boxed{V_{DC} = \frac{2V_{max}}{\pi}}$$

∴ (Here $V_{max.}$ = Max. Secondary voltage)

⑥ Average or mean value of load current :→

$$I_{DC} = \frac{\text{area under load current over full cycle}}{\text{Period of cycle}}$$



$i_L = i_m \sin \omega t$

$$\Rightarrow \frac{\int_0^{\pi} I_m \sin \omega t \, d(\omega t)}{\pi}$$

$$\Rightarrow \frac{I_m}{\pi} \int_0^{\pi} \sin \omega t \, d(\omega t)$$

$$\Rightarrow \frac{I_m}{\pi} (-\cos \pi - \cos 0)$$

$$\boxed{I_{DC} \Rightarrow 2\frac{I_m}{\pi}}$$

⑦ R.M.S. Value of load current :-

$$I_{rms} = \sqrt{\frac{\text{area of square of load current over full cycle}}{\text{Period of Squared waveform}}}$$

$$I_L^2 = I_m^2 \sin^2 \omega t$$

$$\Rightarrow \sqrt{\frac{\int I_L^2 \, d(\omega t)}{T}}$$

$$\Rightarrow \sqrt{\frac{\int_0^{\pi} I_m^2 \sin^2 \omega t \, d(\omega t)}{\pi}}$$

$$\boxed{I_{rms} \Rightarrow \frac{I_m}{\sqrt{2}}}$$

⑧ V_{rms} :-

$$V_{rms} = I_{rms} \cdot R_L = \frac{V_m}{\sqrt{2}}$$

Q What is regulated Power Supply?

Ans:- Regulated Power supply is an embedded circuit. which converts unregulated AC into constant DC. with the help of a rectifier it converts AC supply to DC.

It's function is to supply a stable voltage (or less often current) to a circuit or device that must be operated with certain power supply limit.

The output from the regulated power supply may be alternating or unidirectional. It may also include compensation or variations in it's own power supply.

Ex:- · Mobile phone power adaptors
· Regulated power supplies in home appliances.
· Various amplifiers and oscillators

Q Explain everything about Zener Diode.

Ans:- A zener diode is specially desined, highly doped PN Junction diode. It is basically like an ordinary PN Junc diode but normally operated in reverse bias condn.

Working Principle :> When a pN Junc diode is reverse biased the depletion layer becomes wider. If this reverse biased voltage across the diode is increased continually the depletion layer becomes more & more wider. At same time there will be constant reverse saturation current due to minority carriers.

After certain reverse voltage across the junction. minority carrier gets sufficient kinetic Energy due to strong electric field. So free e⁻ with proper K.E. collides with stationary ions of deplation layer & knock out more free e⁻ also get sufficient K.E. due to same electric field. & similarly they create more free e⁻ by collision cumulatively.

So very soon huge free e⁻ get created in deplation layer and entire diode will become conductive. this breakdown of depletion layer is known as '<u>Avalanche Breakdown</u>'.

But it is not quite sharp. there is another type of breakdown in depletion layer which is sharper compared to avalanche breakdown. And it is called <u>Zener Breakdown</u>.

Zener Breakdown :→ when a PN Junction diode is highly doped the conⁿ of impurity atoms will be high in crystal. The higher concentration of impurity atoms causes higher conⁿ of ions in depletion layer hence for same applied reverse biased voltage, the width of depletion layer becomes thinner than that in a normally doped diode.

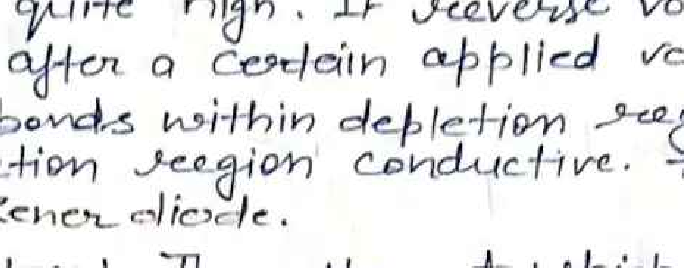
Due to this thinner depletion layer, voltage gradient or electric field strength across the depletion layer is quite high. If reverse voltage is continued to increase, after a certain applied voltage, electrons from Covalent bonds within depletion region comes out & make the depletion region conductive. This breakdown is called Zener diode.

Zener voltage :- The voltage at which this breakdown occurs is called Zener voltage.

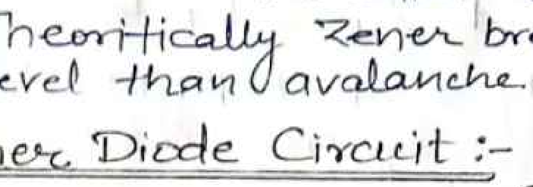
Theoritically Zener breakdown occurs at lower voltage level than avalanche in a diode.

Zener Diode Circuit :- Zener diode is a single diode Connected in a reverse bias. We have already stated that, A diode connected in reverse bias position in circuit (↓) in Fig①

Fig - ① →



Fig② (Circuit symbol)
↓



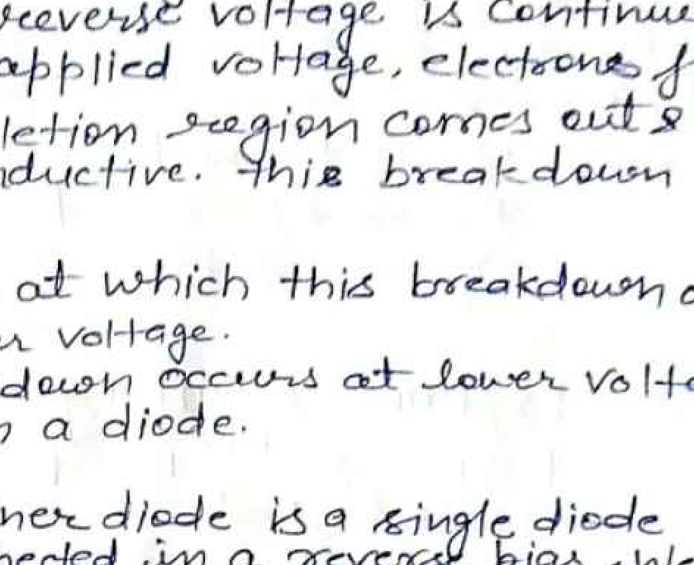


Fig-③
V-I Characteristic.

Characteristics of Zener Diode. :→ We look through graphical Presentation. Normally it is called "V-I characteristics".

Above Fig③ diagram is when it is connected in forward bias the diode act as a normal diode but when reverse voltage is grater than zener voltage a sharp breakdown take place. In V-I char. above V_Z Zener voltage is also known as Knee Voltage. b'coz at this point current increases rapidly.

Q- Explain Cathode Ray Tube (CRT).

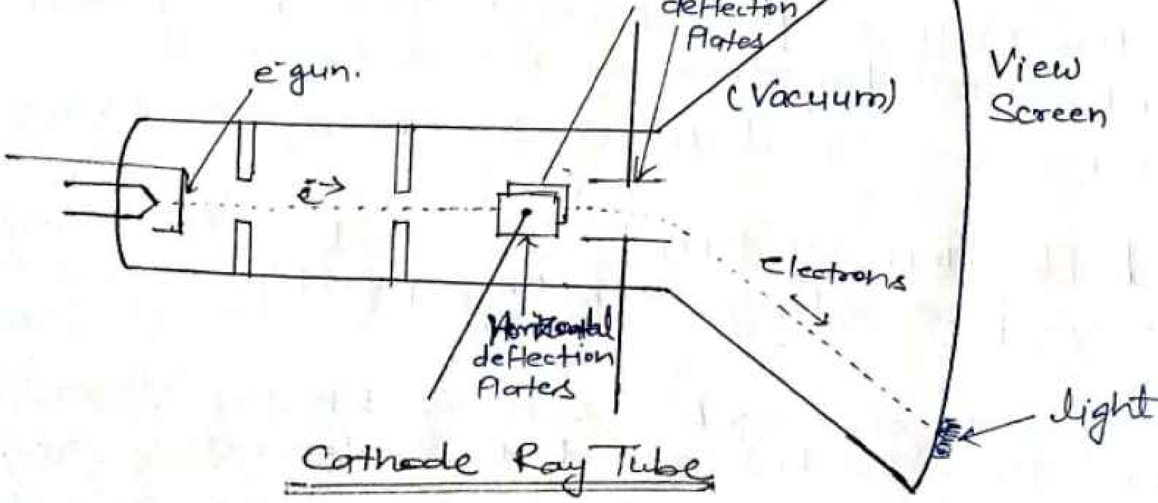
Ans:- A cathode ray tube is a specialized vacuumtube in which images are produced when an electrone beam strikes aphosphorescent surface.

Principle of & Working:- When two metal plates are connected to a high voltage source, the (-)vely charged plate called the cathode emitts an invisible ray. ~~the~~

The cathode ray is drawn out to positively charged plate called anode where it passes through a hole and continious traveling to the other end of tube. When the ray strikes the specially coated surface, the cathode ray produces a strong flourescence or bright light.

When an electric field is applied across cathode ray tube, cathode ray is attracted by the plate bearing (+)ve charges. therefore ~~the~~ cathode ray must consist of negatively charged particles. A moving charged body behaves like a tiny magnet. Also when the external magnetic field is reversed, the beam of electronics is deflected in opposite direction.

In a CR Tube the cathode is heated filament & it placed in a vacuum. The ray is a stream of electrons that naturally pour off a heated cathode into vacuum. Electrons are (-)ve and anode is (+)ve so it attracts the e⁻ pouring off the cathode.



Cathode Ray Tube

Construction
~~Operation~~ of CRT :→ Cathode ray tube is Computer display screen used to display output in a standard Composite video signal. It's working depends on movement of an e^- beam which moves back and forth across back of the screen. The source of e^- beam is e^- gun. gun is located in narrow cylinderical neck at extreme rear of a CRT which produces a steam of e^- through thermoinic emission usually. A CRT has a flourescent screen to display the output signal.

Operation of CRT :→ The operation of CRT monitor is very simple. A Cathode ray tube consist of one or more e^- guns. possibly internal electrostatic deflection plates, and a phosphorus target. CRT has 3 e^- beams - one for each (Red, Green, & Blue) is clearly shown in fig. The e^- beam produces a tiny bright visible spot when it strikes the phosphor coated screen. In every monitor CRT produces three Colour images which are primary colours. Here we used a 50Hz rate to eliminate the flicker by refreshing the screen.

Main Parts of CRT :-

① Electron gun :- It's role is to produce e^- at high and fixed velocity by thermionic emission.

A filament in cathode is heated to point where it's e^- becomes loose.
An anode with a high voltage applied to it accelerates the e^- towards the screen due to electrostatic attraction.
On the way, e^- pass through a series of control grids which control brightness of image produced.
The more (-)ve grid the darker image and vice-versa.

② Deflection system :- It's role is to control the image produced by controlling position that are e^- hits the screen.
It consists of two (⊥)ar sets of Electric / Magnetic fields.
This allows control over both horizontal & vertical axis.

By controlling the votage applied to fields it is possible to vary the deflection through Electrostatic Force / Motor effect.

Fluarescent Screen :→ It's role is to display where the electrons are hitting to CRT.

→ It is a screen coated with a material that emits light when struck by electrons. (↳ $ZnSO_4$ or Phosphorus)

Q- In a common emitter transistor if $\beta = 100$, $I_B = 50\mu A$ Compute the value of α, I_c, I_E.

Sol^n We know that $\boxed{\beta = I_c / I_B}$ & $\boxed{\alpha = \frac{\beta}{1+\beta}}$

so $I_c = \beta * I_B$

$I_c = 100 \times 50 \times 10^{-3}$

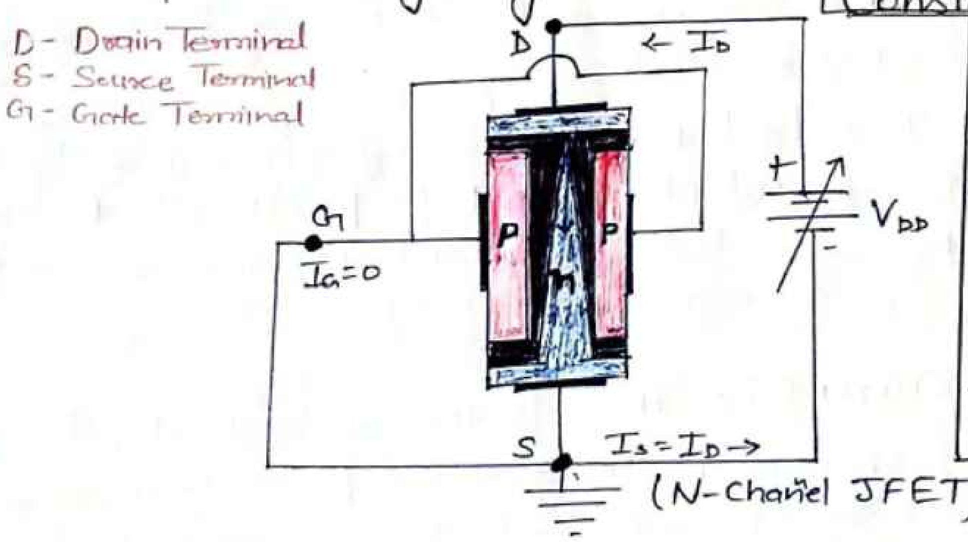
$= 5 mA$

$\boxed{I_e = I_c + I_b}$

$I_e = 5 + 0.005 = 5.005 mA$

$\alpha = \frac{\beta}{1+\beta} = \frac{100}{101} = 0.99$

Q- Explain everything about n- channel JFET.



(N-Chanel JFET)

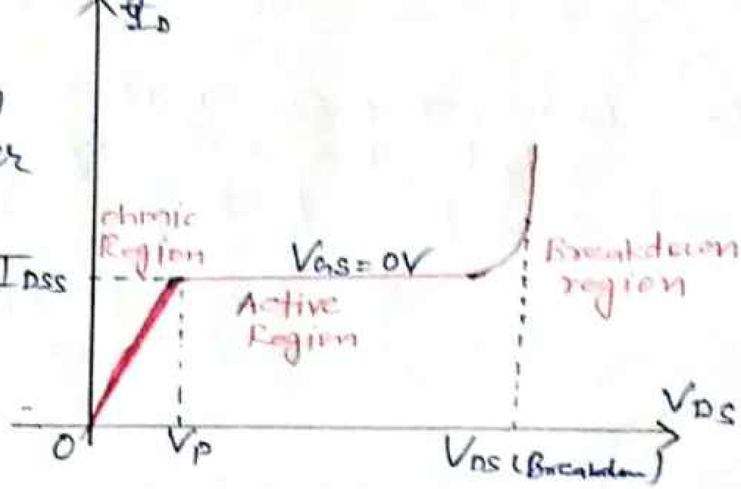
Construction :- There is a channel of n-type semi-conductor material in it. The Gate region is highly doped p-type region. A Voltage is applied across channel i.e. btw drain & source terminal. Firsty we will short circuit gate to gate terminal with Source terminal. and ground Commonly

Now slowly increase drain circuit voltage from V_{DD} to Zero.

⇒ Process :- The drain to source current or simply saying drain current increases linearly as the channel will have a resistance but it is not perfectly constant at that region of characteristic.

As the voltage of n- channel is (+)ve in respect of zero potential gate region. the gate to channel PN Junction will be in reverse biased. As result there becomes a reverse biased depletion layer along junction.

By (↑)ing drain voltage the depletion layer towards it gets more thicker. The reise of resistance is more prominent at higher drain potential so characleristic curve drawn against current and drain voltage.



At a certain voltage depletion layer towards touches each other at that point curve gets nearly horizontal. And depletion layer don't perfectly touch each ~~other~~ to block the channel rather there will be a narrow opening btw layers to flow drain current.

Channel Modulation :- If we further (↑)es the drain voltage depletion layer will try to (↑)es it's thickness. but they can't touch each other. rather depletion layer more towards source terminal get closer and (↑)es the effective length of narrow channel opening. This process is known as Channel Modulation.

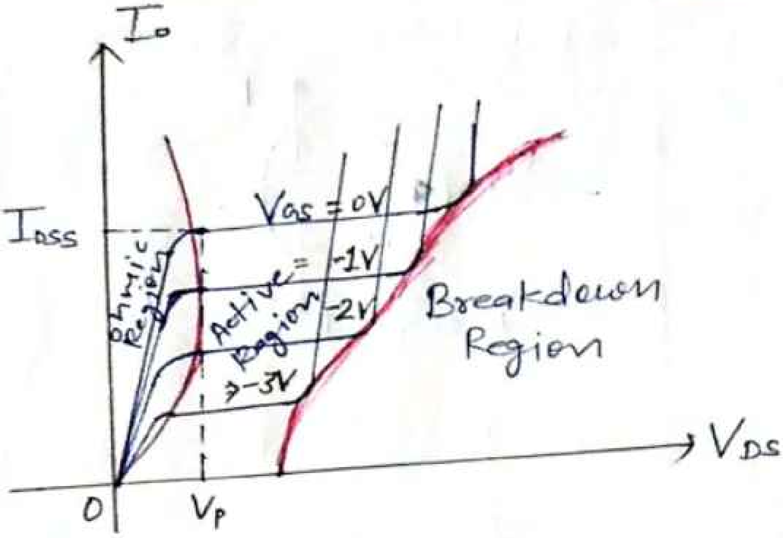
Pitch-off Voltage :- Due to this process effective resistance of channel gets (↑)esed and it almost proportional to increment of drain voltage so drain current become almost Constant. that voltage is known as pitch-off voltage.

Shorted-Gate Drain Current :→ The drain current at pitch-off voltage when Gate terminal is in ground potential, is denoted as I_{DSS} and known as Shorted-Gate Drain current.

Break-down Region :→ Now if we go on increasing drain voltage. even after fix value the depletion layer get broken out and drain current gets suddenly reises. this region is known as breakdown region.

Ohmic/Linear Region :→ Portion of the curve where drain current (↑)es with (↑)ing drain voltage linearly.

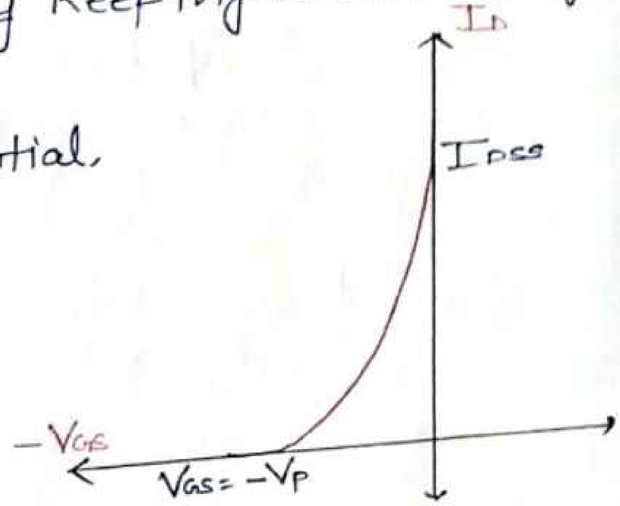
Active Region :→ The portion where drain current reemains almost Constant.



The entire curve against drain current and drain voltage for applied (-) Gate voltage is shifted below the zero gate voltage curve.

Transfer characteristic of N channel JFET :-

The transfer characteristics is drawn btw gate voltage and drain current by keeping drain voltage at pinch-off value.



When the gate is in zero potential, the maximum drain current flowing through transistor is shorted gate drain current (I_{DSS})

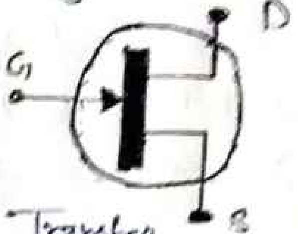
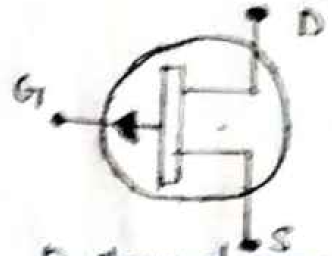
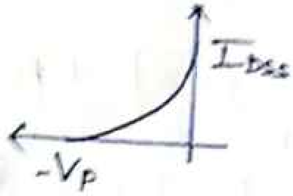
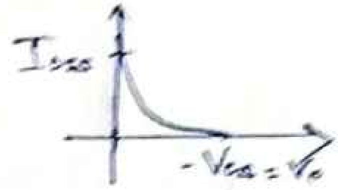
Now as the (-)ve potential of gate (↑)es the corresponding drain current get (↓)es. then it also comes to zero.

gate to Source Cut-off ~~Voltage~~ :→ The negative gate terminal voltage at which drain current becomes zero for applied drain to source voltage same as pinch-off voltage is called gate to source cut-off voltage V_{GS} (off).

Q- Differentiate n-channel & p-channel JFET.

Ans:-

	N-channel JFET	P-channel JFET.
①	Current Conduction takes place due to e^-.	Due to holes.
②	Mobility of e^- large	Poor mobility of e^-.
③	It's transconductance is large.	It's transconductance is small.
④	It is less noisy	Comperatively more noisy.

⑤ N-channel JFET is superdior in circuit application.	It is less superior.
⑥ It's symbol is 	P-channel JFET's Symbol
⑦ It's Transfer characterastic curve is 	It's transfer char. curve is 
⑧ It is made up by n-type semiconductor material & two small p-type regions near the channel.	It is made up by p-type semiconductor material & two small n-type regions near the channels.