

Analog Circuits:-

1

* Electronics :- is a branch deals with flow of charge carriers in Diodes, BJT's, FET's which are made of semi conductors

* Electrical :- deals with flow of charge carriers in metals

Example of semiconductor is "silicon" consists of P-type & N-type

* type of circuits in Electronics

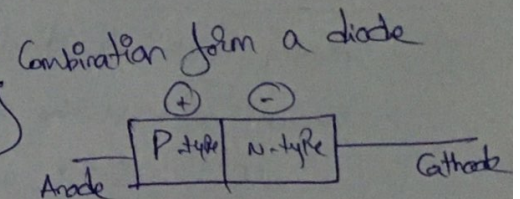
Analog circuits \rightarrow BJT/FET/OP-Amp
 Digital circuits \rightarrow Gates/mux/counter/Registers/MP's
 mixed signal circuits \rightarrow ADC/DAC
 i/p may be Analog/digital & o/p may be Analog/digital

> Diode Circuits:-

(a) Small signal equivalent of Diode:-

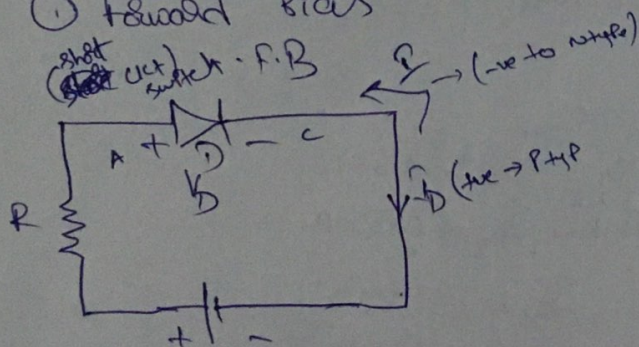
\rightarrow Diode is a semiconductor device which is made of 2-type of materials (P-type & N-type).

P-type has excess of holes (+)
 N-type has " " electrons (-)



\rightarrow It is operated in 2-ways which depends on polarity of direction.

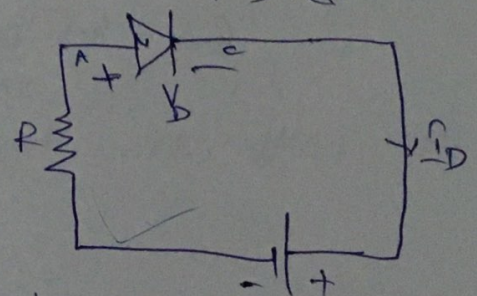
(1) Forward Bias



+ve Polarity of Battery Connected to P-type all the holes are repelled by the polarity of Diode and -ve polarity is Connected to N-Side all the electrons are repelled in N-Side of Diode i.e. Current direction is in Reverse

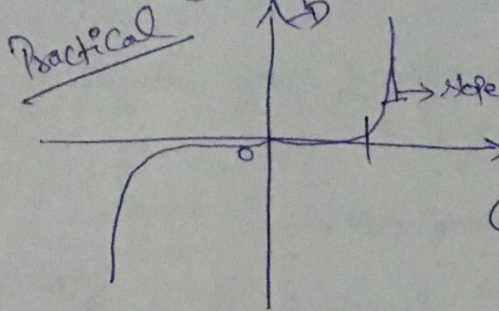
(2) Reverse Bias

R.B (open ckt)



P-Side to -ve Polarity & N-Side to +ve Polarity
 i.e. all the holes of P-Side attracted by -ve Polarity & all the electrons are attracted by +ve Polarity so that charge carriers are different direction no current direction so $I_D = 0$
 for practical application I_D is (nA)

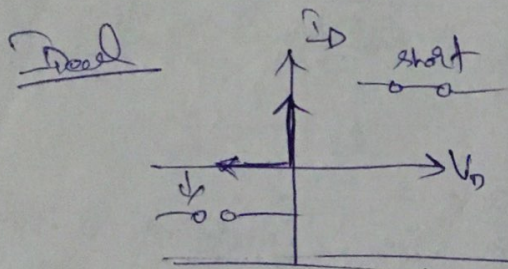
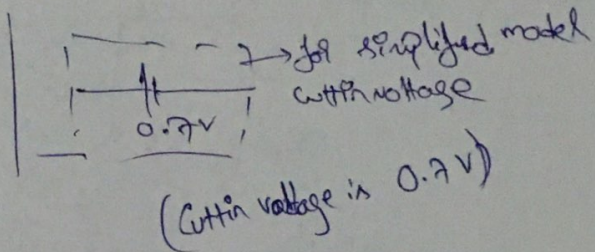
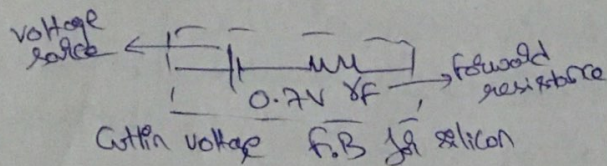
Characteristic of diode :-



① → when we apply 0 volts there is no current flow as we reach cut-in voltage then conduction starts and after cut-in voltage conduction will be huge so F.B acts like short circuit

② R.B :- when we apply less than 0 volts when we increase R.B voltage at some point diode will break down. (open circuit)

→ To use this diode for calculation purpose we choose cut-in voltage above 0 in to a linear piece wise model as slope. ~~Cut-in voltage~~



(Cut-in voltage is 0.7V)

Problems :-

Q) Consider practical diodes, find I_{D1}, I_{D2} ?

Sol:- current across the resistor is

$$I = \frac{0.7V}{3.5k\Omega} = 0.2mA$$

$$I_{D1} = I - 4.3k\Omega = ?$$

$$10V - 0.7V - 0.7V - 4.3k\Omega \times I_{D1} = 0$$

$$8.6 - 4.3 I_{D1} = 0$$

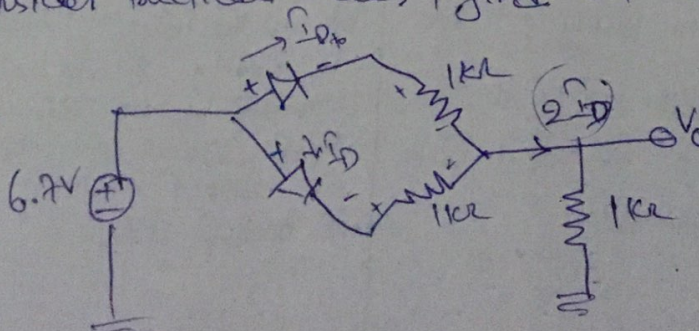
$$I_{D1} = 2mA$$

from KCL current law :- $I_{D1} = I_{D2} + I_{3.5k\Omega}$

$$2mA = I_{D2} + 0.2mA$$

$$I_{D2} = 2 - 0.2 = 1.8mA$$

eg:-2 Consider practical diodes, find out values of V_0 & I_0



from KCL
 $V_0 = 1 \times 2 I_0$
 $V_0 = 2 I_0$

$$V = IR$$

$$6.7V - 0.7V - 1I_D - V_o = 0$$

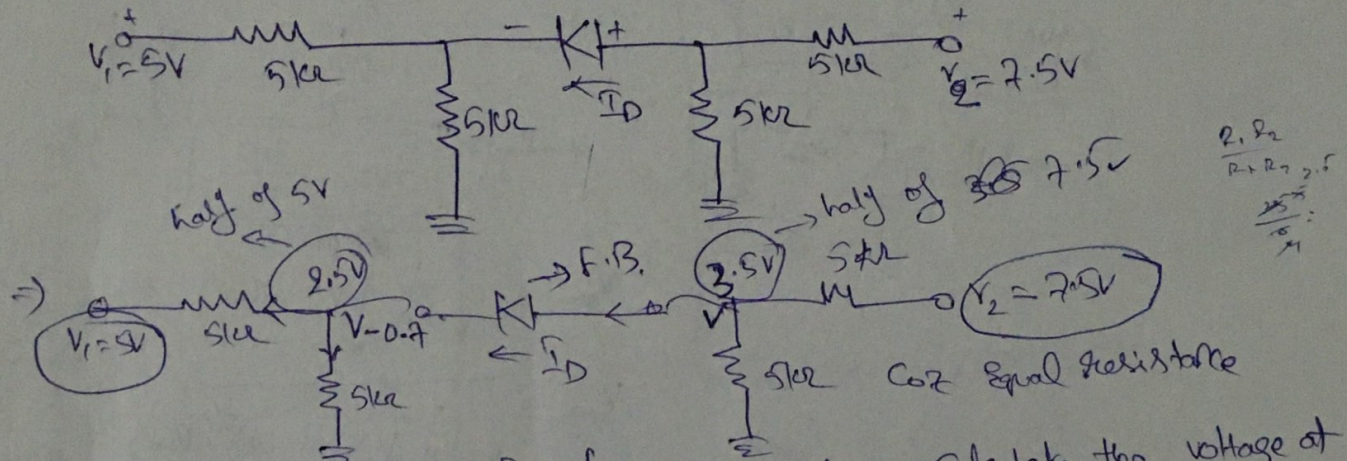
$$6V - I_D - V_o = 0 \quad (\because V_o = 2I_D)$$

$$6V - I_D - 2I_D = 0$$

$$I_D = \frac{6}{3} = 2mA$$

$$\therefore V_o = 2 \times I_D = 2 \times 2 = 4V //$$

Ex:-3 Consider a practical diode, find the value of current I_D .



To find out Diode is F.B / R.B we need to calculate the voltage at nodes

If Diode voltage is $V_D > 0.7$ it is F.B.

$V_D < 0.7$ it is R.B.

from KCL

$$\frac{7.5 - V}{5} = \frac{V}{5} + I_D$$

$$7.5 - V = V + 5I_D$$

$$2V + 5I_D = 7.5V \rightarrow (a)$$

$$I_D = \frac{V - 0.7}{5} + \frac{V - 0.7 - 5}{5}$$

$$5I_D = 2V - 6.4V \rightarrow (b)$$

from Eq (a)

$$2V + 2V - 6.4 = 7.5$$

$$4V = 13.9$$

$$V = \frac{13.9}{4} = 3.4V //$$

$$\therefore I_D = \frac{2 \times 3.4 - 6.4V}{5} = 0.08mA //$$

Applications of Diode Circuits:-

① Rectifiers:-

Converts AC to DC.

② Clippers:- (to clip away voltage)

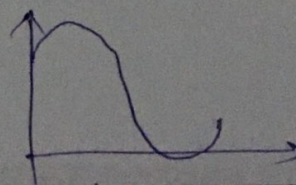
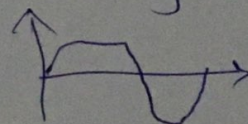
+ve
-ve
Both side

③ Clampers:-

+ve
-ve

Center tapped

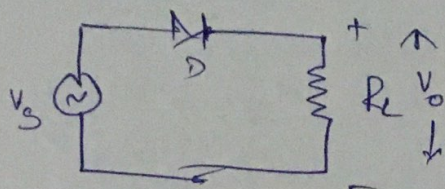
Bridge



④ Voltage multipliers
give Peak voltage as a multiple of voltage no:-

2) Rectifiers:-

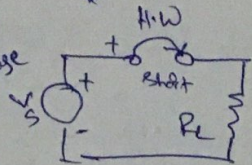
Half wave Rectifier:-



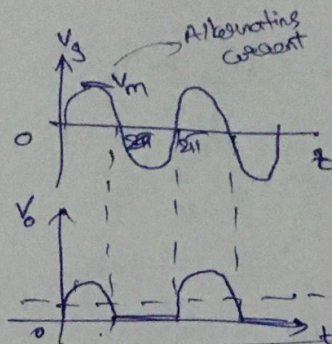
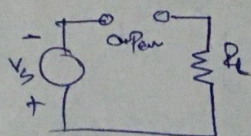
$$V_s = V_m \sin \omega t$$

Peak voltage / max voltage

+ve half



-ve half



AC voltmeter gives V_{rms} value
DC " " " V_{dc} value

$$V_{dc} = \frac{1}{2\pi} \int_0^{2\pi} V_o \cdot dt = \frac{1}{2} \int_0^{\pi} V_m \sin \omega t \cdot d(\omega t)$$

$$\Rightarrow V_{dc} = \frac{V_m}{\pi}$$

Similarly:-

$$I_{dc} = \frac{I_m}{\pi}$$

$$V_{rms} = \sqrt{\frac{1}{2\pi} \int_0^{2\pi} V_o^2 \cdot d(\omega t)}$$

$$V_{rms} = \sqrt{\frac{1}{2\pi} \int_0^{\pi} (V_m \sin \omega t)^2 \cdot d(\omega t)}$$

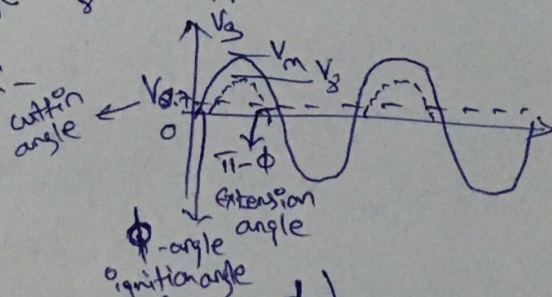
$$V_{rms} = \frac{V_m}{2}$$

Similarly

$$I_{rms} = \frac{I_m}{2}$$

when circuit voltage $V_s \ll V_m$

In Practical Case:-



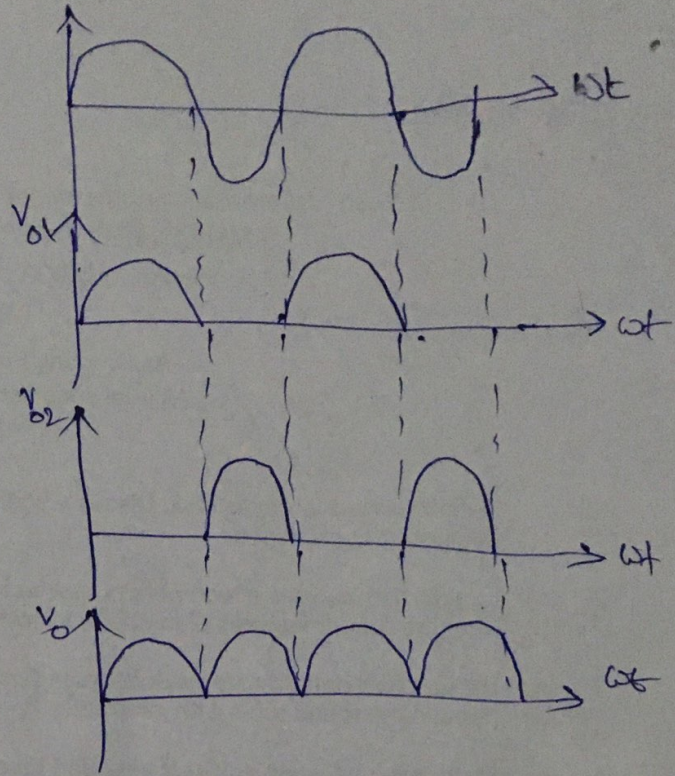
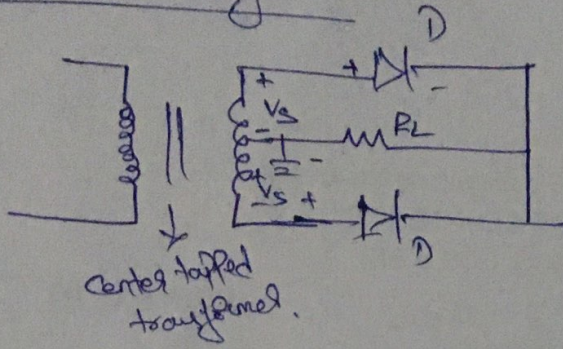
$$\text{Firing angle } \phi = \sin^{-1} \left(\frac{V_s}{V_m} \right)$$

$$\text{Conducting angle} = (\pi - \phi)$$

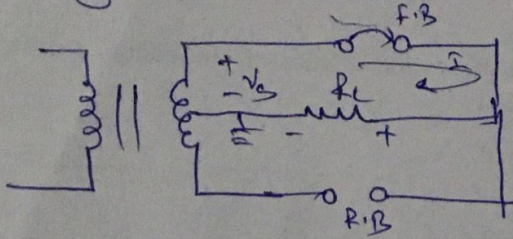
Use of Rectifiers:- is to derive DC Power from an AC supply (AC to DC Converter)

Rectifier is an electrical device that converts alternate current, which periodically reverses direction to direct current, which follow only one direction.

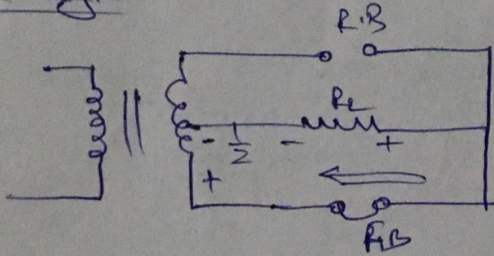
full wave Rectified:-



the half (Equivalent ckt)



-ve half:-



DC voltage in f.w. Rectifier is

$$V_{dc} = \frac{2V_m}{\pi} ; I_{dc} = \frac{2I_m}{\pi}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} ; I_{rms} = \frac{I_m}{\sqrt{2}}$$

3) Clippers:- is a wave shaping ckt remove the wave (or) clipper away (or) remove portion of wave form.

Types:-

the clippers

-ve "

Combination clippers

Parallel clippers

series "



When load is connected in parallel to diode ckt is

Biased clippers (voltage source present)

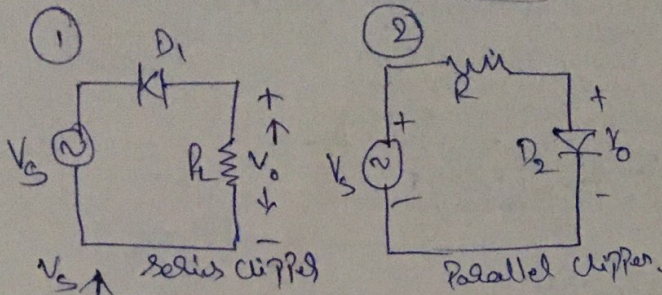
unbiased " (no voltage source)



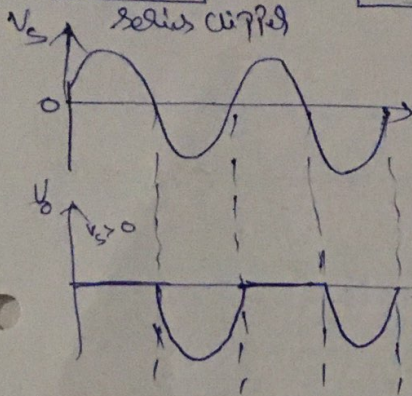
With load & diode ckt & voltage source are connected means it is Biased clippers.

② With load & diode ckt no voltage source.

Un biased Positive clippers:-



when $V_s > 0$ then D_1 - off
 $V_s < 0$ then D_1 - ON

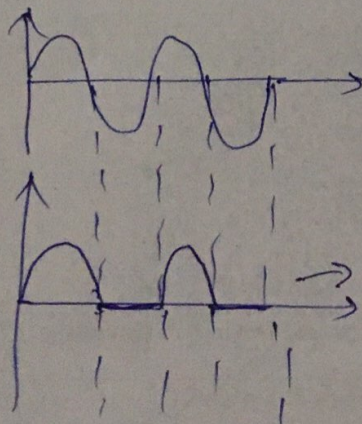
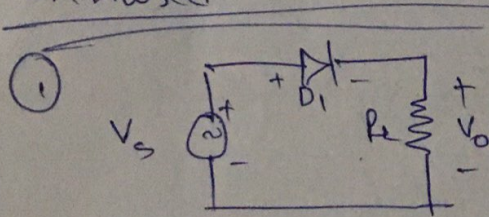


→ the side is clipped it is the clipped.

In ckt (2)

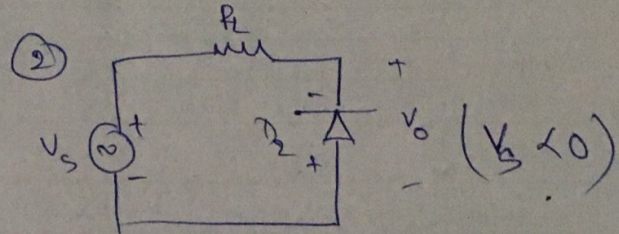
$V_s^+ \rightarrow V_o^+$ when D_2 is conducting $V_o = 0$
 D_2 is open ckt ($V_o = V_s$)

Un biased -ve clippers:-



$V_s > 0 \rightarrow D_1$ - ON ($V_s = V_o$)
 $V_s < 0 \rightarrow D_1$ - off

→ -ve side clipped it is -ve clipped



In ckt (2) Voltage across diode

$V_s^+ \rightarrow V_o^-$ the D_2 - conducting $V_o = 0$

D_2 is open ckt ($V_o = V_s$)

→ series clipper means diode is taken ~~across the~~ in series with the
 → Parallel " " o/p is taken across the diode - R.