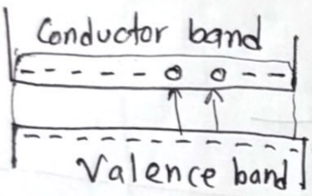
CSE251 22.10.24

Diode

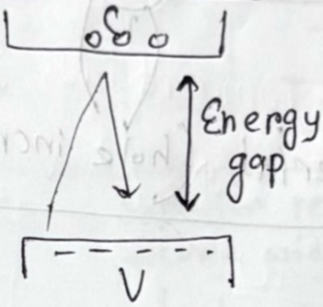
Conduction band
Valance band

Conductor

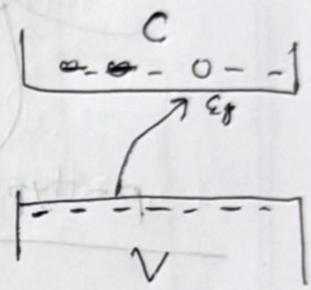


Electrons can create bond on its own

Insulator



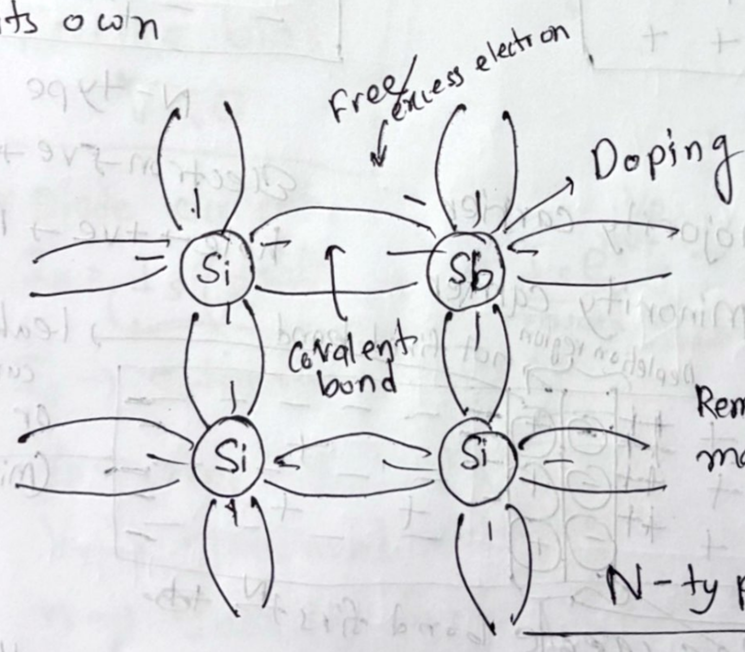
Semiconductor



Electrons cannot create bond on its own. So volt has to be applied.

Ge → 0.67 eV

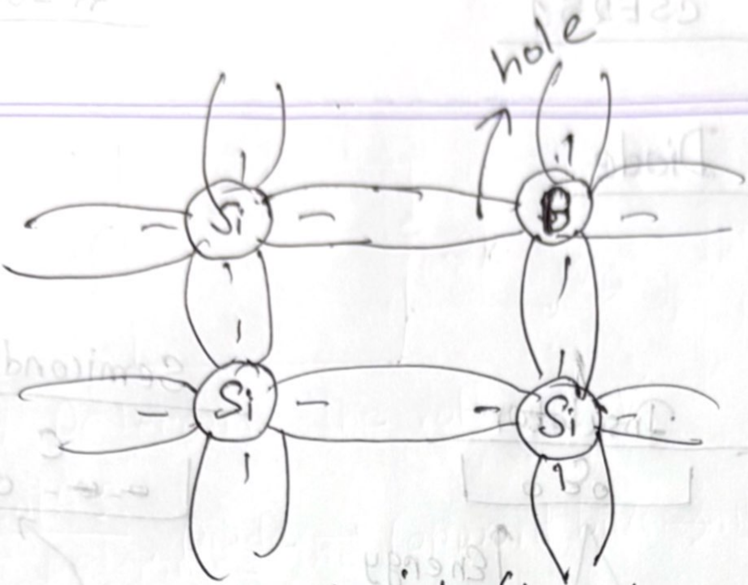
Si → 1.1 eV



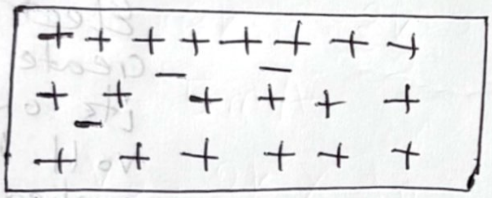
Remove or add electron to make current flow

N-type material (e^- increase)

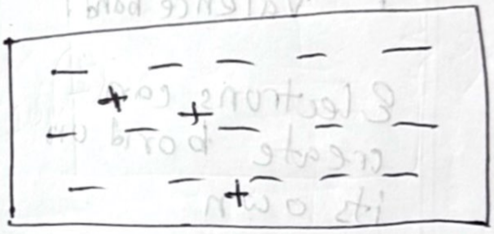
* Intrinsic material → no impurity
* ~~Extensi~~ Extrinsic material → impure → Dope



p-type material (hole increase)



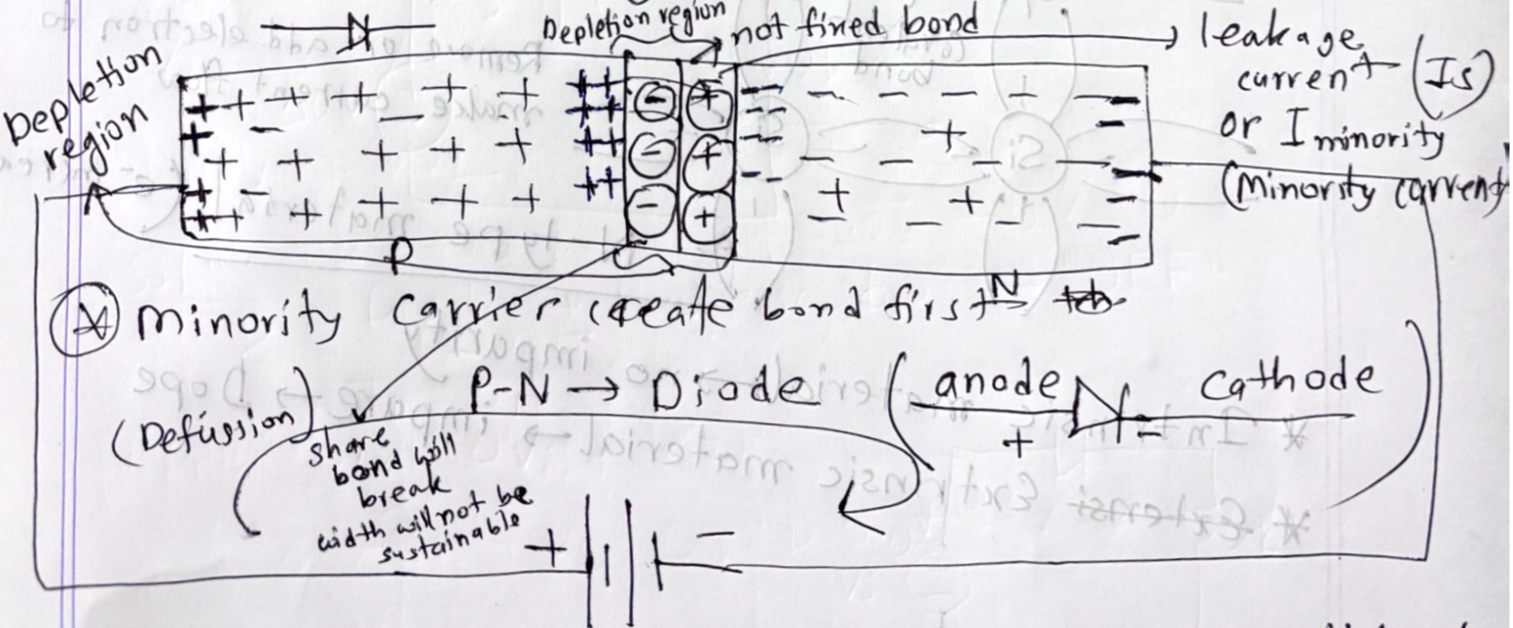
p-type



N-type

hole → +ve → Mojority carrier
Electron → -ve → Minority carrier

Electron → -ve → Mojority
hole → +ve → Minority



After defussion current will increase at an exponential rate

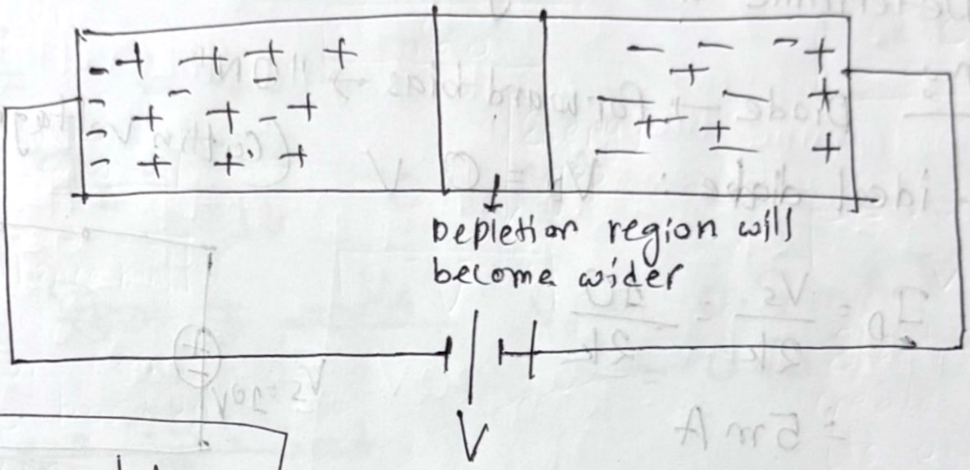
Cut-in Voltage – The voltage at which a diode's forward current increases rapidly

Cut-off voltage – The voltage at which a battery is considered fully discharged and further discharge could cause harm

$I_D = I_{majority} - I_{minority}$

Forward bias $V > 0$

* If we remove the battery it will be back to it's previouse state. Then $V = 0 \rightarrow$ Cutoff



Reverse bias $V < 0$

* Diode current:

$$I_D = I_s\left(e^{\frac{V_D}{nV_T}} - 1\right) = \underbrace{I_s e^{\frac{V_D}{nV_T}}}_{\text{Forward bias current}} - \underbrace{I_s}_{\text{Reverse bias current}}$$

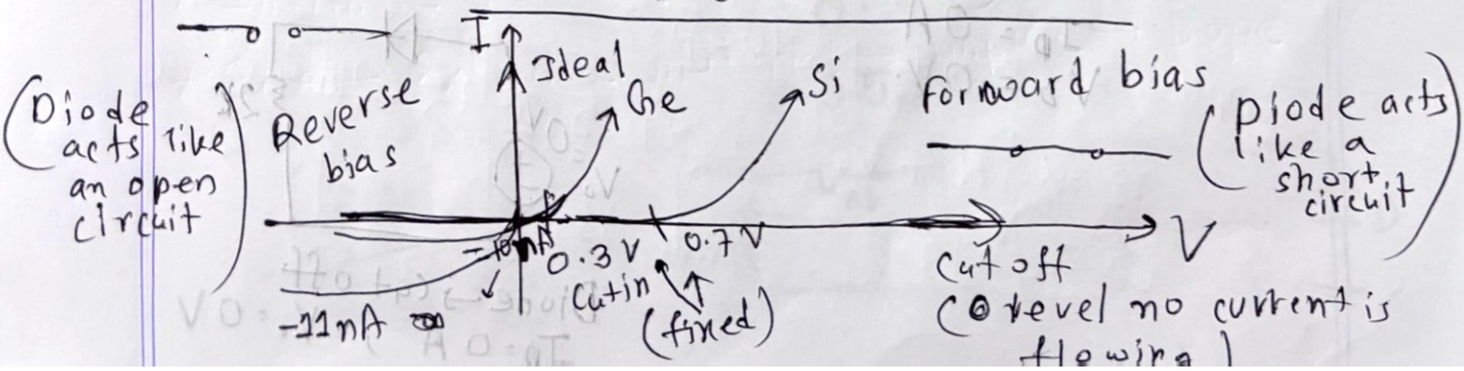
$I_s \rightarrow$ Saturation current

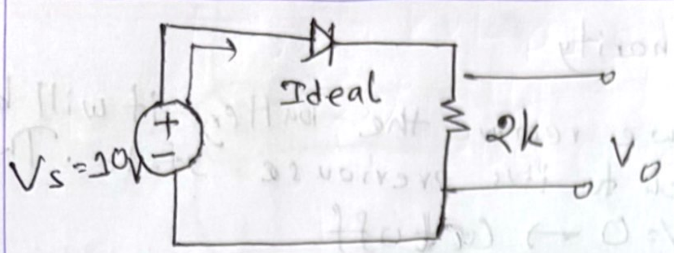
$V_D \rightarrow$ Applied voltage

$V_T \rightarrow$ Thermal voltage

$n \rightarrow$ Ideality factor (1 or 2) (Depends on the material)

I-V characteric curve



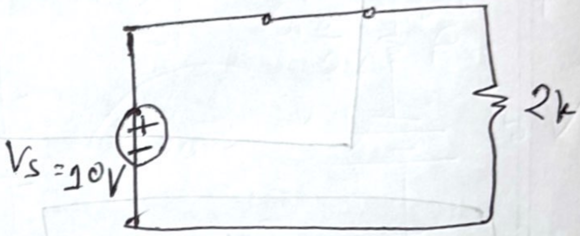


Determine the voltage V_0

Sol^n: Diode → forward bias → "ON"

(Cuttin voltage = V_0)

For ideal diode : $V_D = 0\ V$



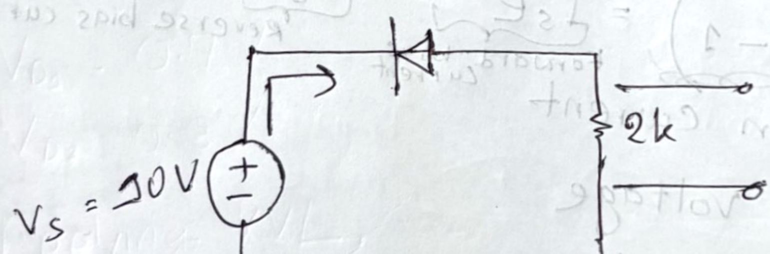
$$I_D = \frac{V_s}{2k} = \frac{10}{2k}$$

$$= 5 mA$$

$$V_0 = 2k \times I_D$$

$$= 2k \times 5mA$$

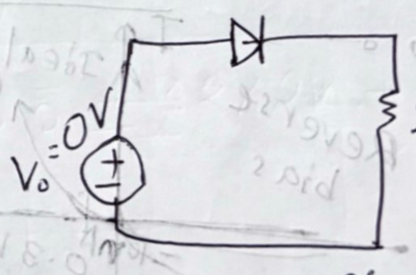
$$= 10\ V$$



Sol^n: Diode → Reverse bias → "OFF"

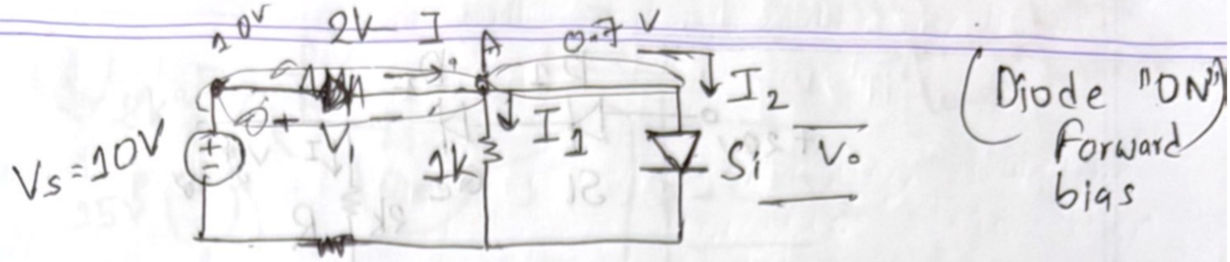
$I_D = 0 A$

$V_0 = 0V$.



Diode → cut off

$I_D = 0\ A$, $V_0 = 0V$



Determine I, I_1, I_2 and V_1

$\boxed{1k \parallel \text{Diode}}$

Soln: $V_D = 0.7V$

$$I_2 = \frac{0.7}{1k} = 0.7 mA \quad \therefore \quad V_o = 0.7 mA \times 1 = 0.7V$$

$$\cancel{I = \frac{V_s}{...}}$$

$$\cancel{I_1 = \frac{10}{2k} = 5mA}$$

$$\therefore \cancel{I_1 = I - I_2 = 4.3 mA}$$

$$V_1 = 10 - 0.7 = 9.3V$$

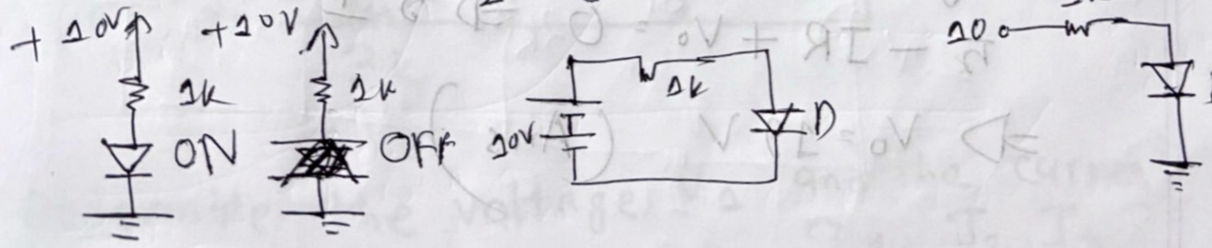
Applying KVL,

$$-10 + V_1 + 0.7 = 0$$
$$V_1 = 9.3V$$

$$I = \frac{V_1}{2k} = \frac{9.3}{2k} = 4.65 mA$$

Applying KCL at node A,

$$I = I_1 + I_2 \Rightarrow 4.65 = 0.7 + I_2$$
$$\therefore I_2 = 3.95 mA$$



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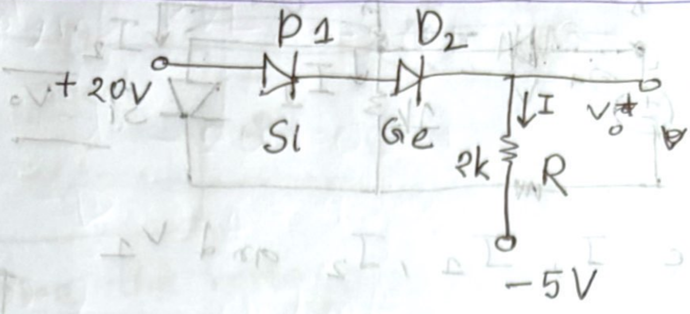
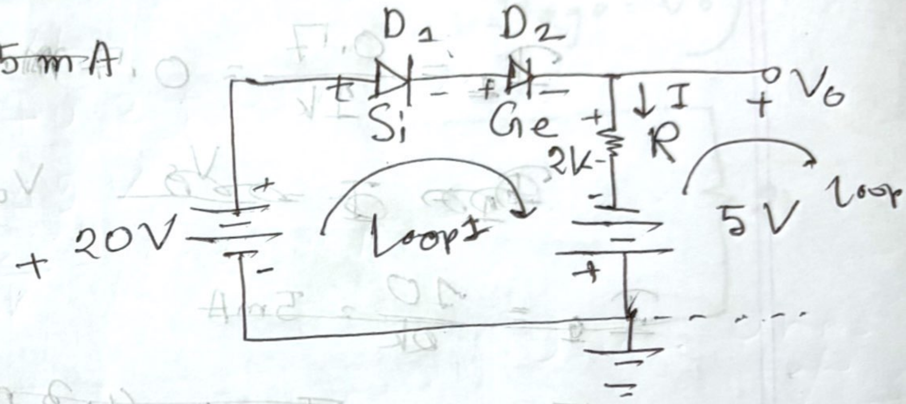


Determine the current I and the voltage V_o

~~$I = \frac{-5}{2k} = -2.5\,mA$~~

~~Applying KVL, -5~~



D_1 and D_2 → forward bias → "ON"

$V_{D_1} = 0.7V$

$V_{D_2} = 0.3V$

Applying KVL,

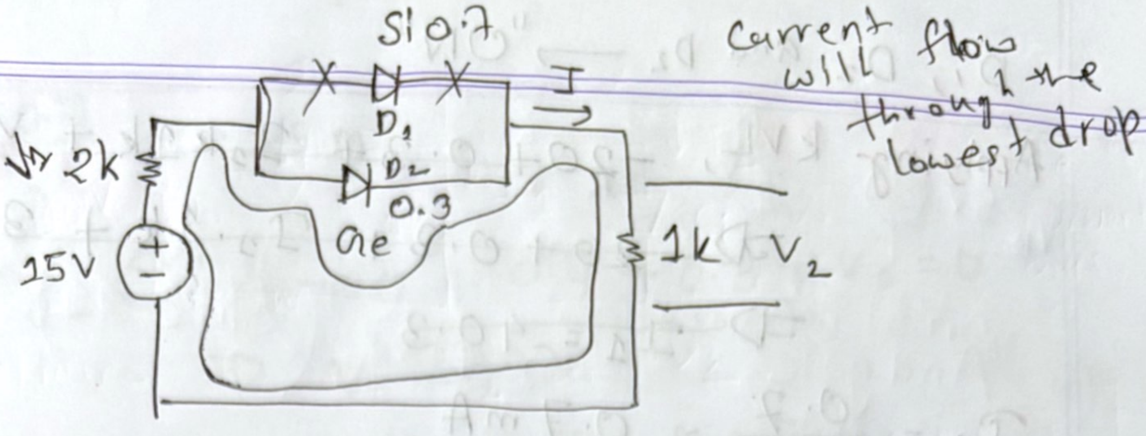
$$-20 + 0.7 + 0.3 + I2k - 5V = 0$$

$\Rightarrow I = 12\,mA$ (Ans)

Applying KVL, (loop 2)

$$5 - IR + V_o = 0 \Rightarrow 5 \pm 12 \times 2k + V_o = 0$$

$\Rightarrow V_o = 19\,V$ (Ans)



Determine I and the voltage V_1 and V_2

$D_1 \rightarrow OFF$

$D_2 \rightarrow ON$

Applying KVL,

$$-15 + I2k + 0.3 + I1k = 0$$

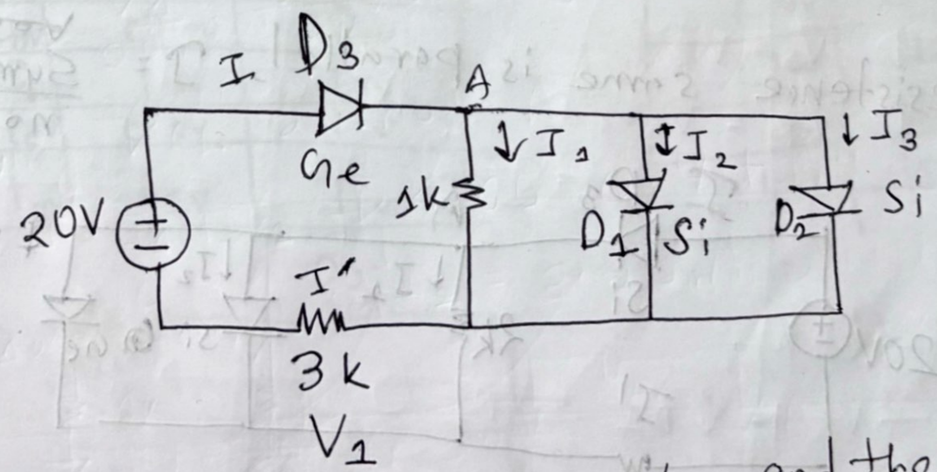
$$\Rightarrow I3k = 14.7$$

$$\therefore I = 4.9 \, mA \approx 5 \, mA$$

Using Ohm's law,

$V_1 = I2k = 5mA \times 2k = 10V$ (Ans)

$V_2 = I1k = 5mA \times 1k = 5V$



Determine the voltage V_1 and the currents I_1, I_2, I_3

D_1, D_2 and D_2 $\longrightarrow$ "ON"

Applying KVL, ~~$-20 + 0.3 + I_1 \cdot 1k + V_1 = 0$~~

~~$\Rightarrow -20 + 0.3 + I_1 \cdot 1k + 3k \cdot 20 = 0$~~

~~$\Rightarrow I_1 = -40.3$~~

$$I_1 = \frac{0.7}{1k} = 0.7\ mA$$

Applying KVL,

$$-20 + 0.3 + 0.7 + V_1 = 0$$

$$\Rightarrow V_1 = 19\ V$$

$$\therefore I' = \frac{V_1}{3k} = 6.33\ mA = I$$

~~Using Ohm's law,~~

Applying KCL, $I = I_1 + I_2 + I_3$

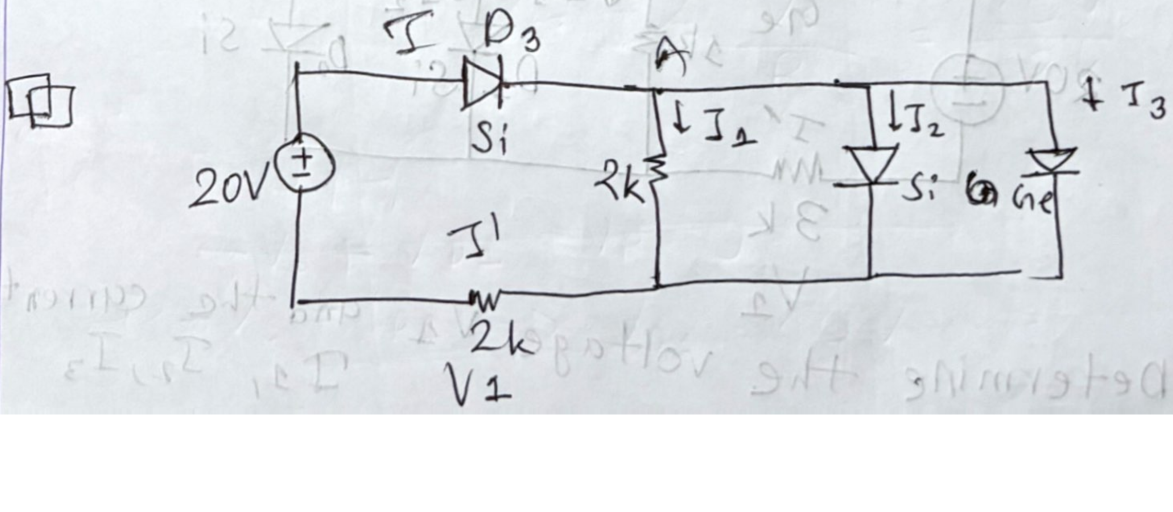
$$\Rightarrow I_2 + I_3 = I - I_1$$

$$= (6.33 - 0.7)\ mA$$

$$= 5.6\ mA$$

$$I_2 = I_3 = \frac{5.6}{2}\ mA = 2.8\ mA$$

If resistence same is parallel, $I = \frac{\text{Sum of current}}{\text{no. of branche}}$



Forward bias → short circuit
Reversed bias → open circuit

$I_1 = \frac{0.3}{2k} = 0.15\ mA$

Applying KVL, $-20 + 0.7 + 0.3 + V_1 = 0$

$\Rightarrow V_1 = 19V$

$I' = 9.5\ mA = I$

Here, $I_2 = 0\ mA$

Applying KCL, at A, $I = I_1 + I_2 + I_3$

$\Rightarrow I_3 = I - I_1 - I_2$

$= 9.5 - 0.15 - 0$

$= 9.35\ mA$

Logic "0" → 0V
Logic "1" → 5V

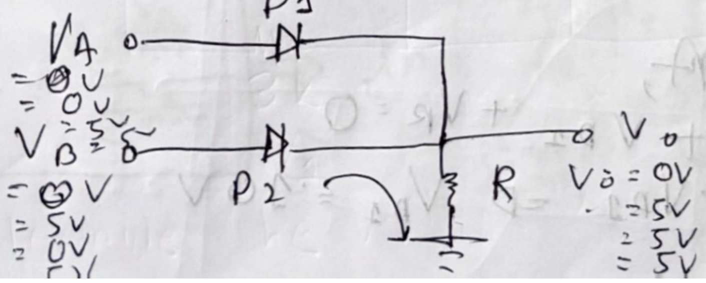
OR gate

A	B	Output
0_{0V}	0 0V	0_{0V}
0_{0V}	1 5V	1 5V
1_{5V}	0 0V	1 5V
1_{5V}	1 5V	1_{5V}

AND gate

A	B	Output
0_{0V}	0_{0V}	0_{V}
0_{0V}	1_{5V}	0_{0V}
1_{5V}	0_{0V}	0_{0V}
1_{5V}	1_{5V}	1_{5V}

This circuit is representing OR gate

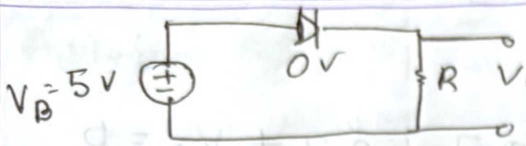


D_1 and D_2 ideal diode

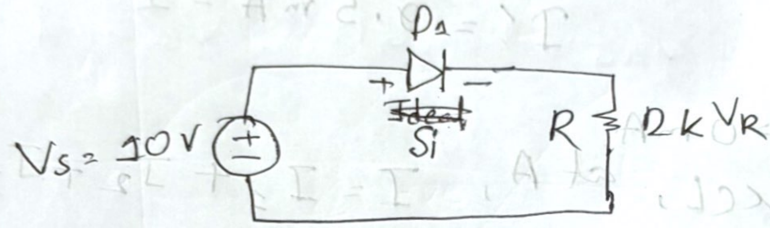
V_{D_1} and $V_{D_2} = 0V$

Scanned with CamScanner

(i) Maximum current will flow through diode if its short



(iv) Circuit representing And gate ⟶ HW (Slide 11)

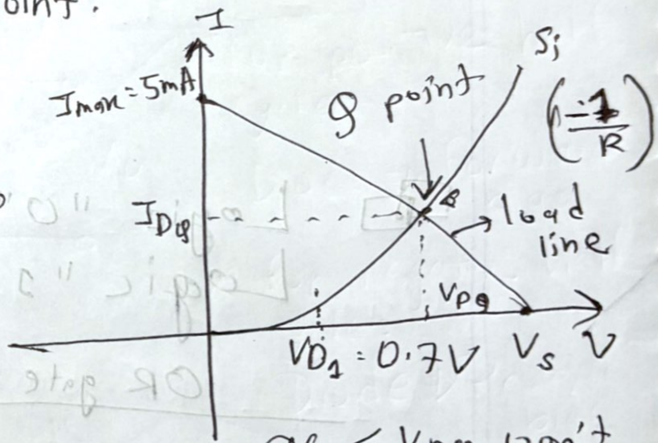


\# Draw the load line for the following circuit and determine the Q point.

Soln:

Applying KVL,

$-V_s + V_{D1} + V_R = 0$



(short diode) Let, $V_{D1} = 0V$

$\therefore -V_s + V_R = 0$

$\Rightarrow V_s = V_R$

$\Rightarrow V_R = V_s \Rightarrow I \times R = V_s$

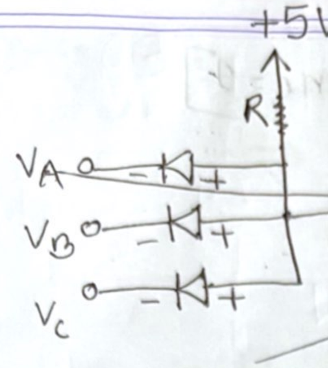
$\therefore I = \frac{V_s}{R} = \frac{10V}{2k} = 5mA$

* If < V_{DQ} won't operate properly

(Open diode) Let, $I = 0A$,

$-V_s + V_{D1} + V_R = 0$

$\Rightarrow V_s = V_{D1} \Rightarrow V_{D1} = 10V$



~~Current will flow throgh the diode with the lowest voltage. So if any of these is zero voltage then the output will be zero, which represents an AND gate.~~

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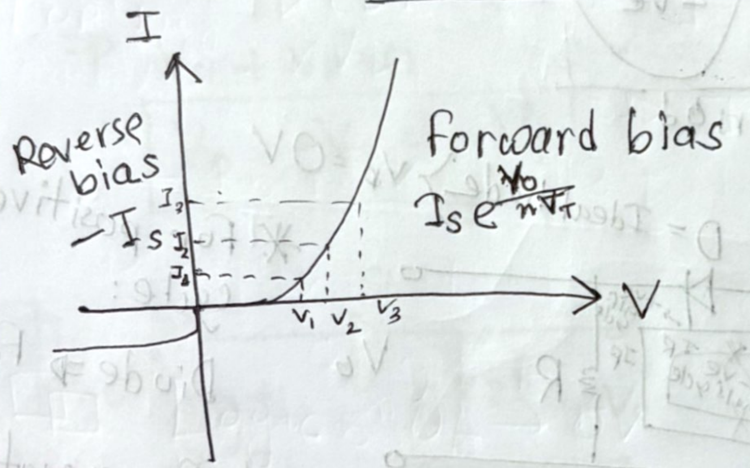


$I_S \rightarrow$ saturated current

~~$V_T \rightarrow$ Ideality of element~~

$$I = I_S \left(e^{\frac{V_D}{nV_T}} - 1 \right)$$

$$= \underbrace{I_S e^{\frac{V_D}{nV_T}}}_{\text{Forward bias}} \underbrace{- I_S}_{\text{Reverse bias}}$$

V_T = Thermal voltage

$= \dfrac{kT}{q}$ (25.3 ~ 26 mV) ~~difference~~

(use 26 for easy calculation)

Let, $n = 1$, $I_1 = I_S e^{\frac{V_1}{nV_T}}$

$$I_2 = I_S e^{\frac{V_2}{nV_T}}$$

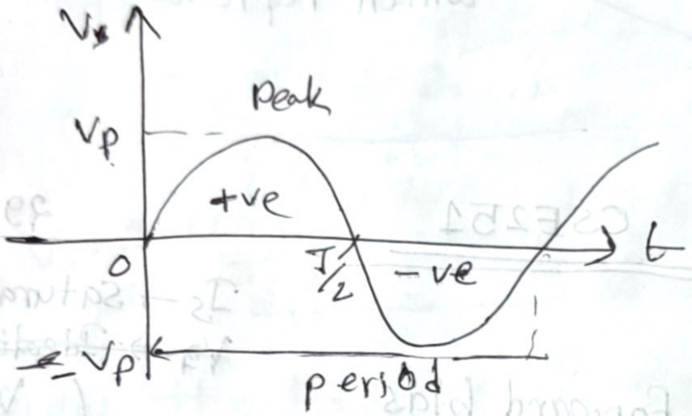
$$\boxed{\frac{I_2}{I_1} = \frac{e^{\frac{V_2}{nV_T}}}{e^{\frac{V_1}{nV_T}}}} \Rightarrow \ln\left(\frac{I_2}{I_1}\right) = \ln e^{\frac{(V_2 - V_1)}{V_T}}$$

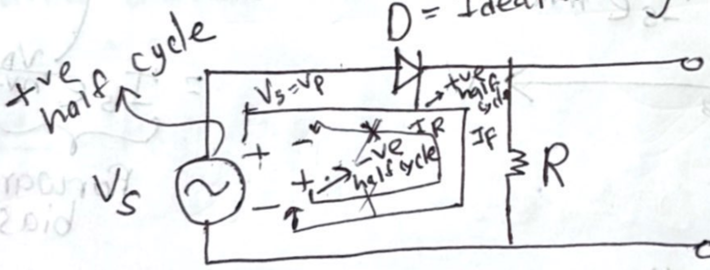
$$\Rightarrow \ln\left(\frac{I_2}{I_1}\right) = \frac{(V_2 - V_1)}{V_T} \ln e$$

Scanned with CamScanner

$$\Rightarrow \boxed{V_2 - V_1 = V_T \ln\left(\frac{I_2}{I_1}\right)} \quad [\ln e = 1]$$

$$V_2 - V_1 = 2.3 V_T \log\left(\frac{I_2}{I_1}\right)$$





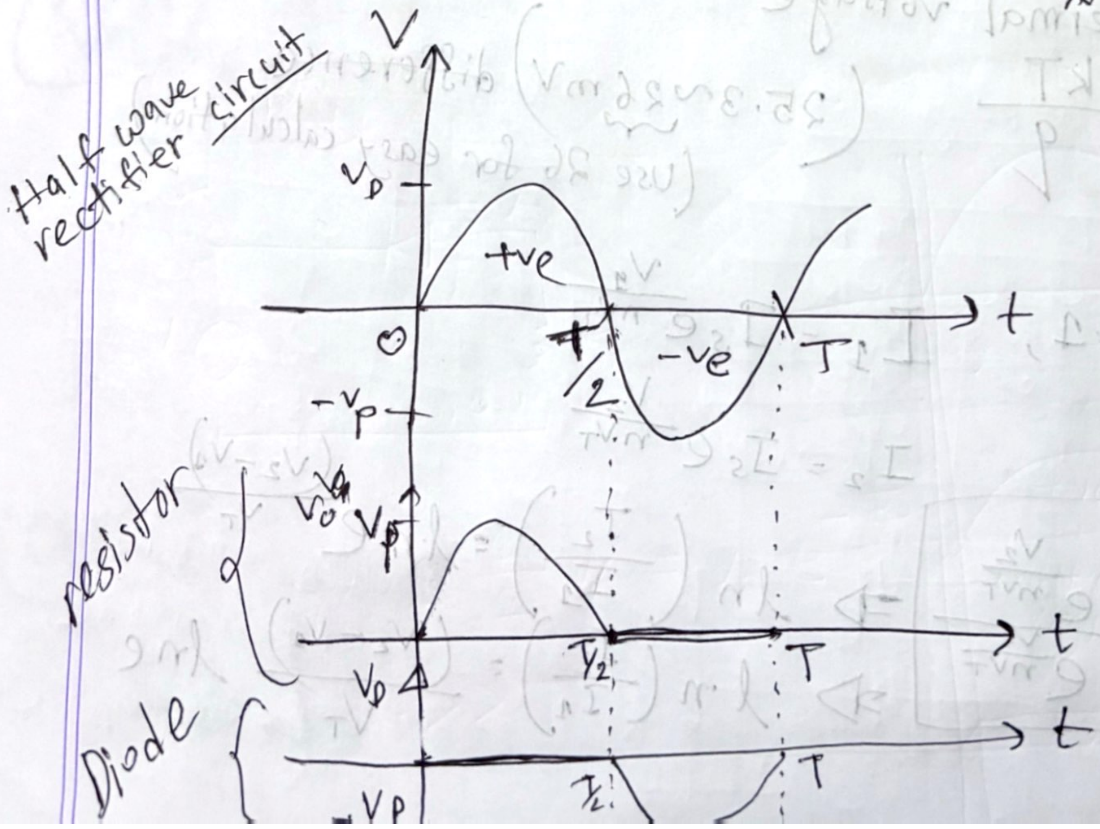
* For positive half cycle:

Diode ⇒ Forward bias

* For negative half cycle:

Diode ⇒ Reverse bias

Half wave rectifier circuit



For +ve halfcycle:

Applying KVL, $-V_p + V_D + V_o = 0$

$\Rightarrow V_o = V_p - V_D$ [$V_D = 0$ For ideal diode]

$\therefore \boxed{V_o = V_p}$ (sketch wave form)

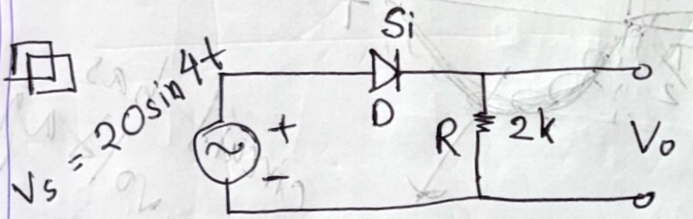
For -ve half cycle:

$V_s + V_D + V_o = 0$

$\Rightarrow V_s + V_D + I_R R = 0$ [$I_R = 0$ for revesed bias]

$\Rightarrow V_s + V_D = 0$

$\therefore \boxed{V_D = -V_s = -V_p}$



* Determine the output voltage V_o and sketch the output resistance and wave form acrross the diode.

$V_s = 20\sin 4t = \underline{20\angle 0^\circ}$
Only amplitude in electronics

$\Rightarrow -V_s + V_D + V_o = 0$

$\Rightarrow -V_s + 0.7 + V_o = 0$

$\Rightarrow -20\sin 4t + 0.7 + V_o = 0$

$\therefore V_o = 19.3\,V$

For -ve half cycle,

$\cancel{V_s + V_D + V_0}$

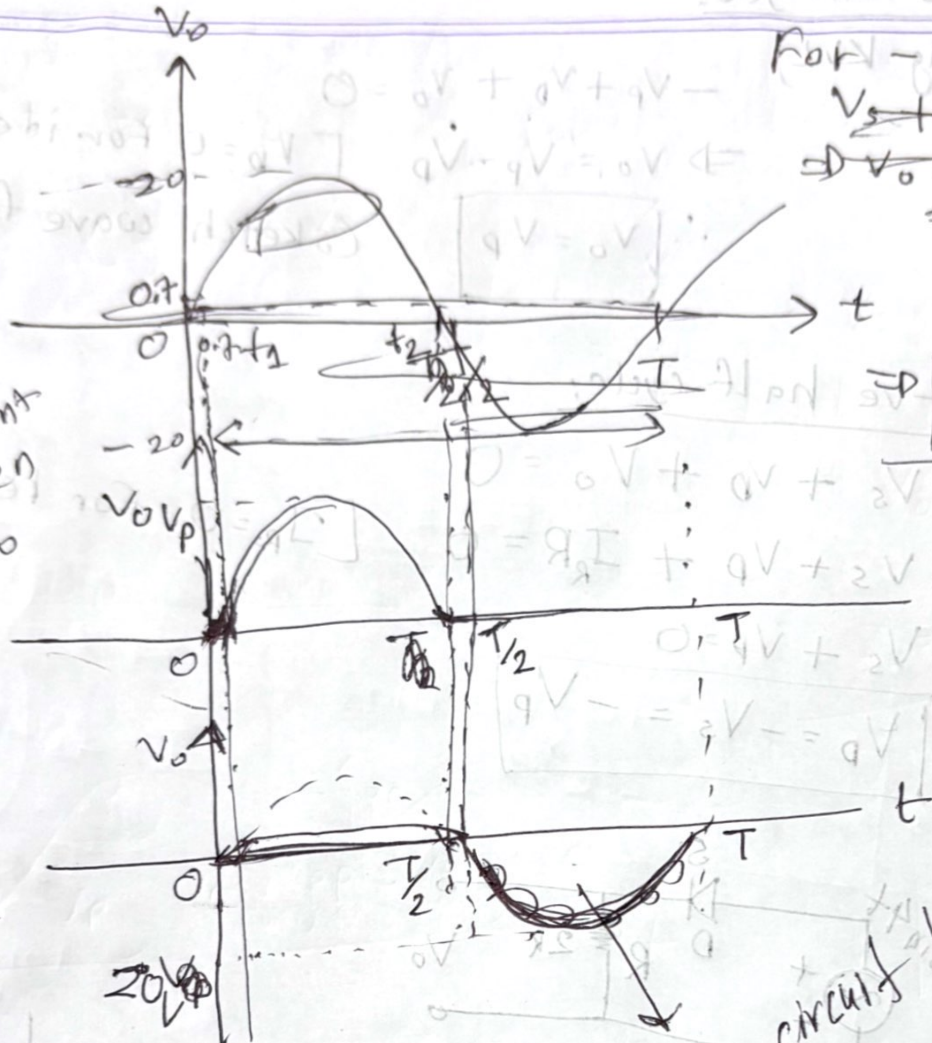
$\Rightarrow \cancel{V_0 = 20 + 0.7}$

$\cancel{= 20.7\,V}$ $\quad I_D = 0$

$\therefore V_0 = 0$

$V_s + V_D + V_0 = 0$

$\Rightarrow \boxed{V_D = -V_s = -20V}$

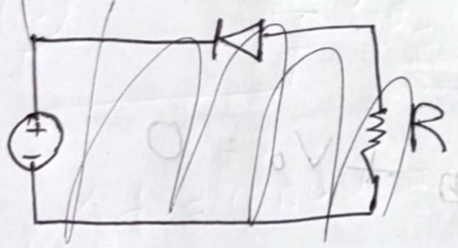


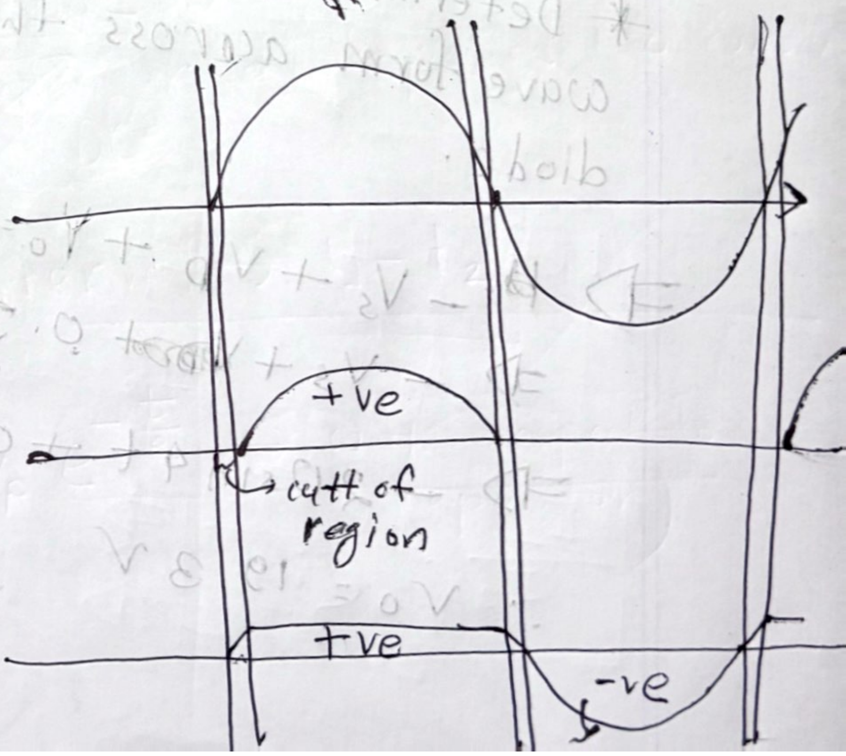
No current flow between (0-0.7V) so (0-0.7) is off

(0 - t_1) time → OFF

open circuit has max voltage

Clipper circuit





clipper circuit

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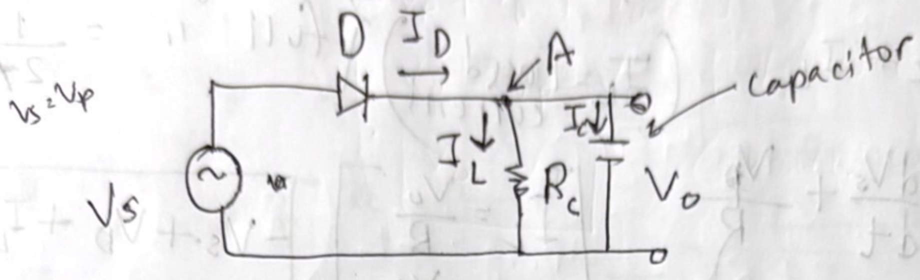
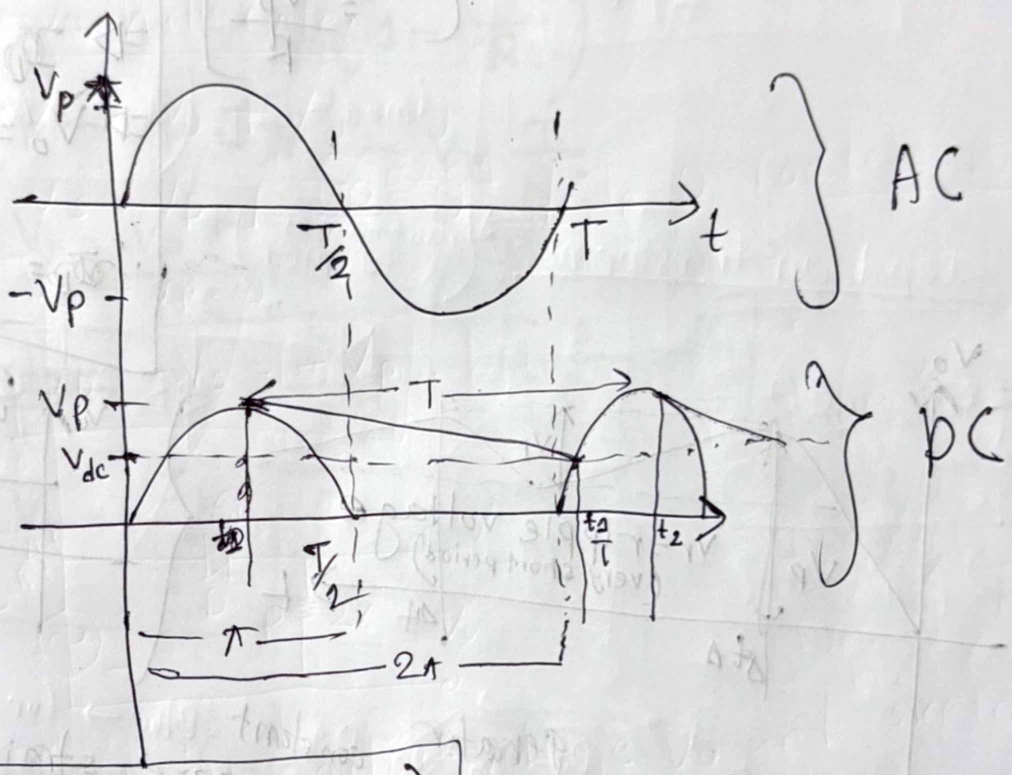
Half wave rectifier circuit

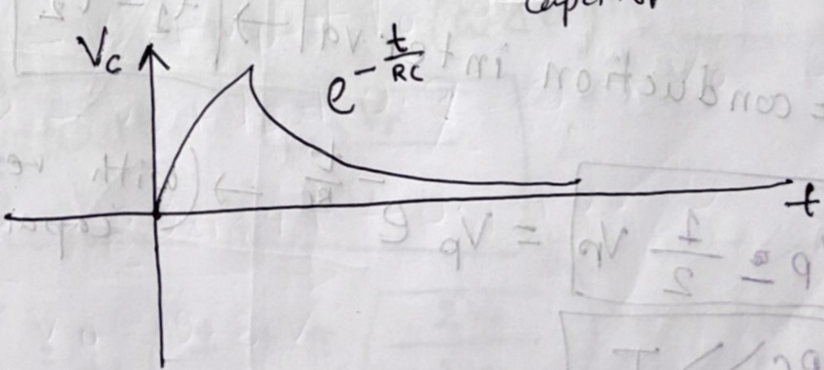




$$\boxed{V_{dc} = 0.318\,(V_p - V_D)}$$

$RC = \tau =$ time constant

Capcitor individually



Applying KCL at node A,

$I_D = I_C + I_L$ (I_L = Load current)

$= C\frac{dV_s}{dt} + \frac{V_p}{R}$

$\left[I_L = \frac{V_o}{R} = \frac{V_p}{R} \right]$

half cycle $= \frac{1}{\pi}$

full cycle $= \frac{1}{2\pi}$

$-V_s + V_D + I_L R = 0$

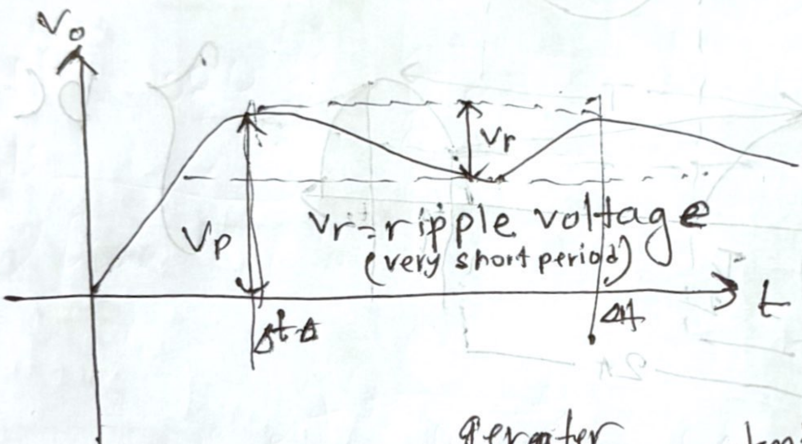
$\Rightarrow \cancel{I_D} \cancel{V_o = -(V_s + V_D)}$

$\Rightarrow V_o = V_s - V_D$

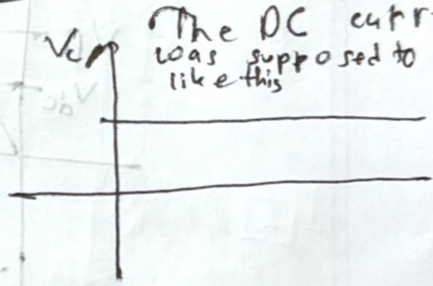
$= V_p - V_D$

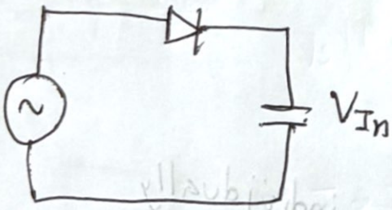
$\boxed{I_L R = V_o}$

$\therefore \cancel{I_D} =$



The DC current was supposed to be like this





(a) greater constant time ~~less~~ more straighened line

(b) capacitor is applied to convert in DC

Δt = conduction interval $\rightarrow \boxed{t_1 - t_2}$

$V_o = \boxed{V_p - \frac{1}{2} V_r} = V_p e^{-\frac{t}{RC}} \rightarrow$ (with ~~respect to~~ capacitor)

$\boxed{RC >> T}$

$\therefore V_o = V_p e^{-\frac{T}{RC}}$ (since $RC \gg T$ we can replace t by T)

$\Rightarrow V_o \doteq V_p - V_r$ $\left[e^{-\frac{T}{RC}} \simeq 1 - \frac{T}{RC} \right]$

$= V_p e^{-\frac{T}{RC}}$

$\Rightarrow V_p - V_r = V_p \left(1 - \frac{T}{RC}\right)$

$\Rightarrow \cancel{V_p} - V_r = \cancel{V_p} - V_p \frac{T}{RC}$

$\Rightarrow V_r = \frac{V_p T}{RC}$

$\Rightarrow V_r = \frac{V_p}{f RC}$ $\left[f = \frac{1}{T} \right]$

$\Rightarrow \therefore V_r = \frac{I_L}{fC}$ $\left[I_L = \frac{V_p}{R} \right]$

$\boxed{\text{Ripple depends on } RC}$

$V_s = V_p \cos(\omega \Delta t)$

ω = Angular frequency $= 2\pi f = 2\pi \frac{1}{T}$

Δt = conduction Interval

$\cos(\omega \Delta t) = 1 - \frac{1}{2} (\omega \Delta t)^2$

$$\boxed{\omega \Delta t = \sqrt{\frac{2V_r}{V_p}}}$$

$i_{D\,avg} = I_L \left(1 + \pi \sqrt{\frac{2V_p}{V_r}}\right)$

Average diode current

$$i_{D\,max} = I_L\left(1 + 2\pi\sqrt{\frac{V_p}{V_r}}\right)$$

↘ maximum diode current

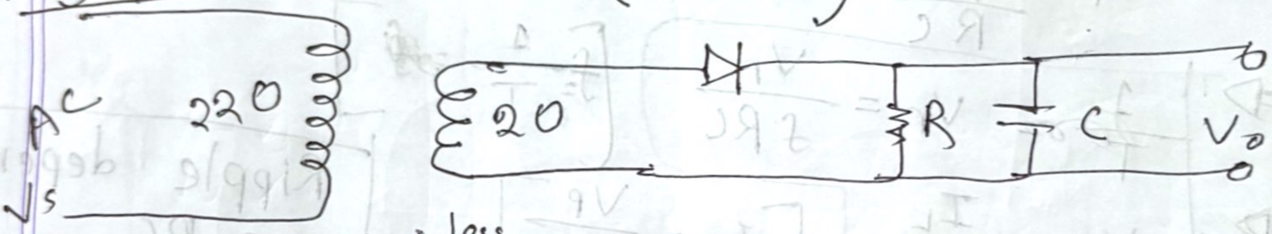
For full wave rectifier,

$$\boxed{V_r = \frac{V_p}{2fRC}}$$

$$\boxed{i_{D\,avg} = I_L\left(1 + \pi\sqrt{\frac{V_p}{2V_r}}\right)}$$

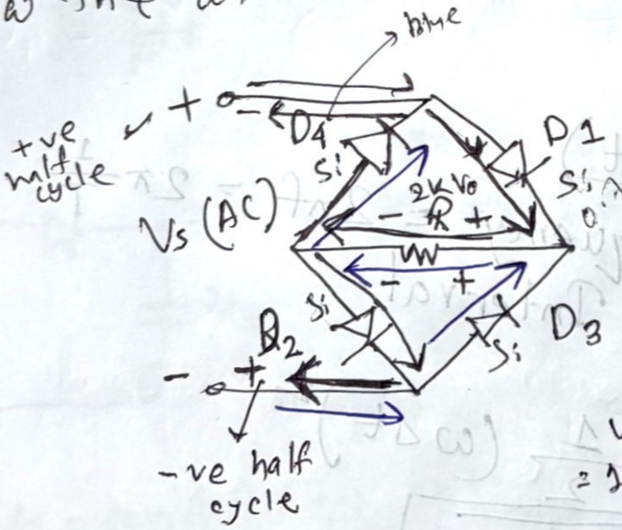
$$\boxed{i_{max} = I_L\left(1 + 2\pi\sqrt{\frac{V_p}{2V_r}}\right)}$$

Step down transformer : (also known as X former)



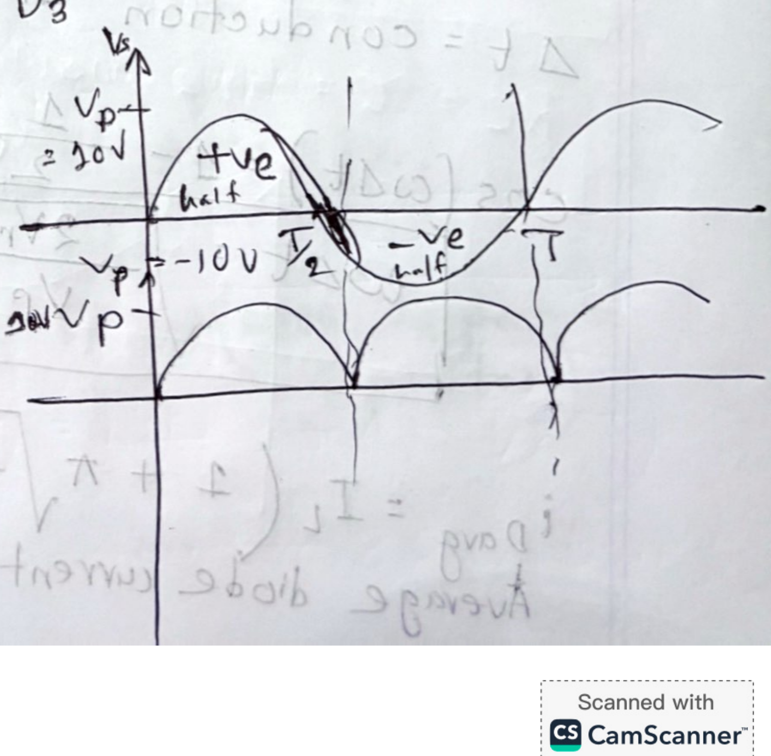
more → less

(X) Draw the wave form ~~and~~ across the R and write the wave equation



Blue → for negative half cycle

Black → for positive half cycle



full wave Rectifier circuit

$V_{dc} = 0.318\,(V_p - V_D) \rightarrow$ half

$V_{dc} = 2 \times \cancel{3.18}\; 0.318\,(V_p - 2V_D) \rightarrow$ Full (current ~~went to~~ flew through 2 diodes)

For +ve half cycle,

D_1 and $D_2 \rightarrow$ ON and D_3 and $D_4 \rightarrow$ OFF

For −ve half cycle,

D_3 and $D_4 \rightarrow$ ON and D_1 and $D_2 \rightarrow$ OFF

Determine V_o

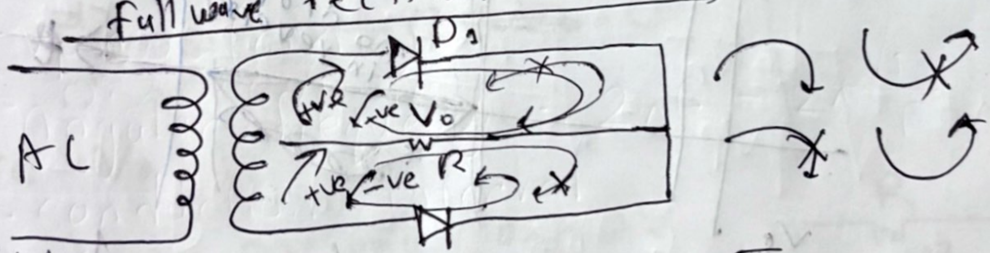
Applying KVL, (For +ve half cycle) $-V_s + V_{D1} + V_o + V_{D2} = 0$

$$\Rightarrow -10 + 0.7 + V_o + 0.7 = 0$$

$$\Rightarrow V_o = 8.6\ \text{V}$$

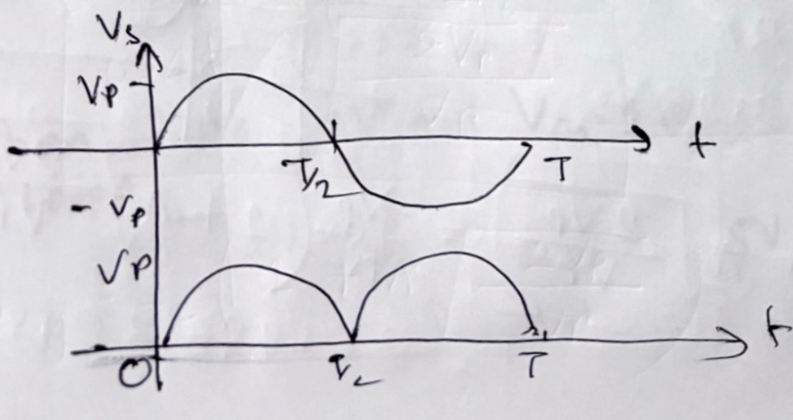
Similarly for −ve half cycle, $V_o = 8.6$ V

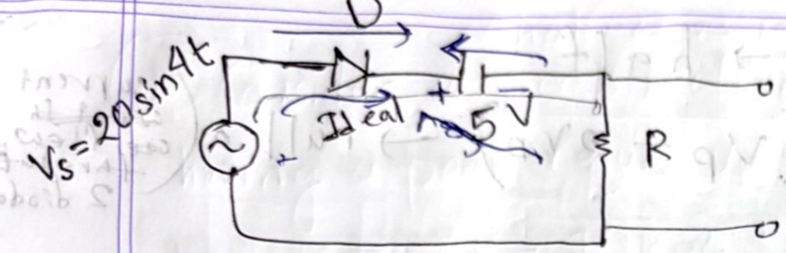
full wave rectifier circuit



For this,

$V_{dc} = (2 \times 0.318)\,(V_p - V_D)$ (1 diode used)

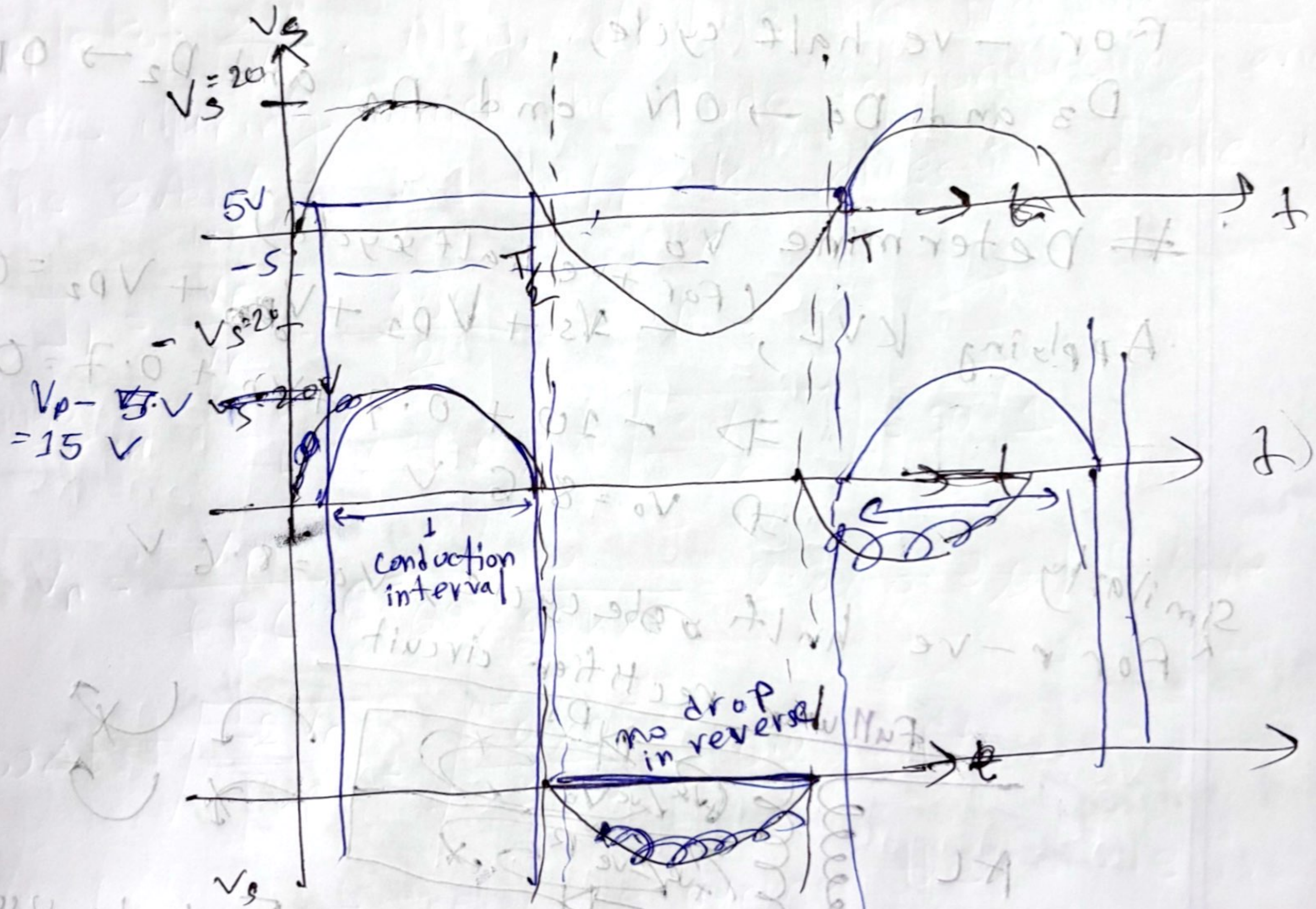




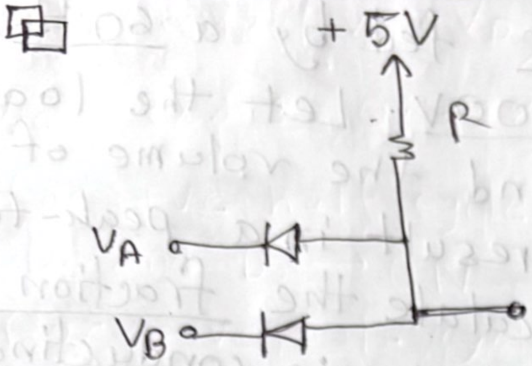
D → Reverse bia

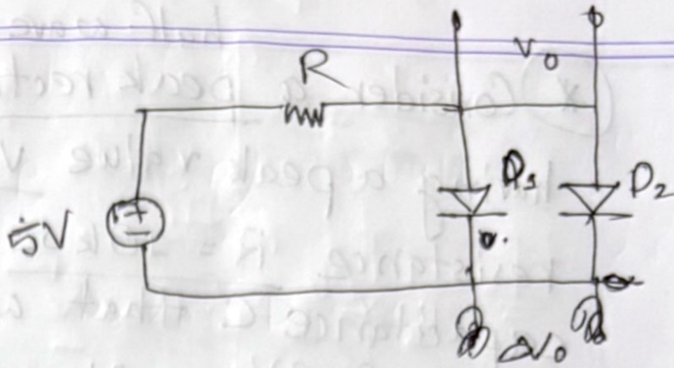
V_D → PIV = Peak inverse voltage

Draw the output wave form:



Only consider the direction of current





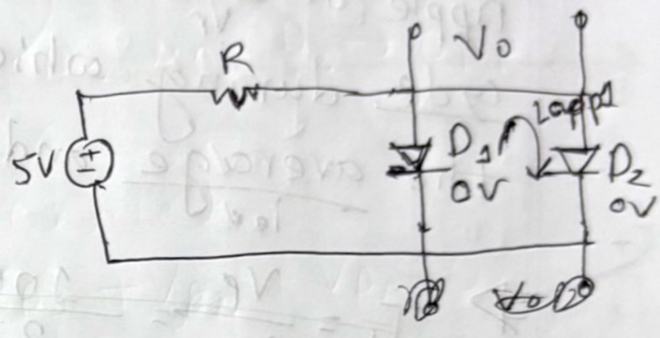
(i) When, $V_{D1} = 0V$ and $V_{D2} = 0V$

Applying KVL in Loop 1,

$$-V_{D1} + V_{D2} + V_o = 0$$

$$\Rightarrow -0 + 0 + V_o = 0$$

$$\therefore V_o = 0$$



(ii) When $V_{D1} = 1V$ and $V_{D2} = 0V$

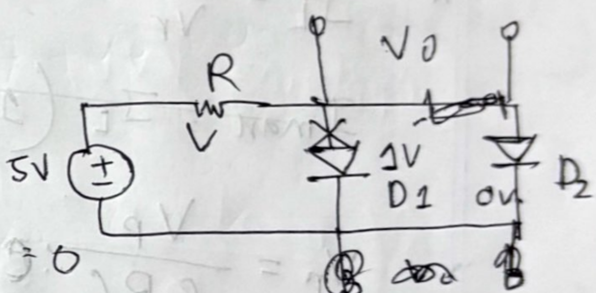
Applying KVL,

$$-5 + V + V_{D2} = 0$$

$$\Rightarrow -5 + V + 0 = 0$$

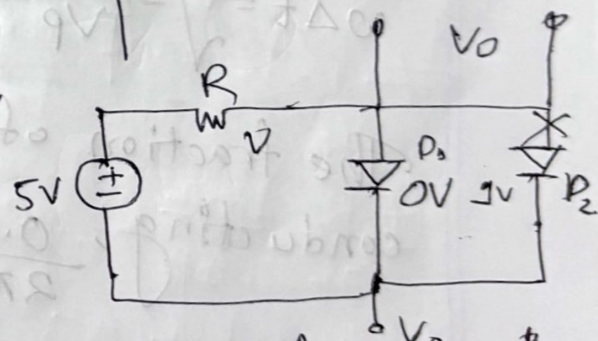
$$\therefore V = 5V$$

Here $V_o = V_{D2} = 0V$



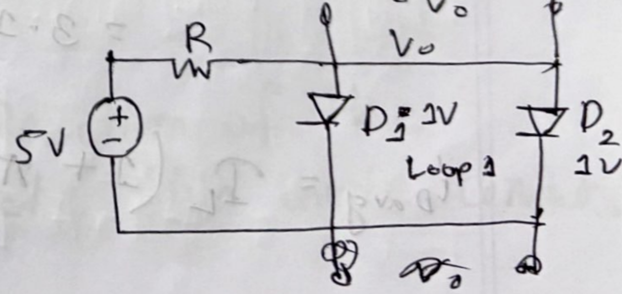
(iii) When $V_{D1} = 0V$ and $V_{D2} = 1V$

So Here $V_o = V_{D1} = 0V$



(iv) When $V_{D1} = 1V$ and $V_{D2} = 1V$

for Loop 1, –



Quiz 1 ⟶ 12/11/2024 (Tuesday)

CSF251 05.11.24

half wave rectifier

(*) Consider a peak rectifier fed by a 60 Hz sinusoid having a peak value $V_p = 100V$. Let the load resistance $R = 10k\Omega$. Find the volume of the capacitance C that will result in a peak-to-peak ripple of $\frac{2V}{V_r}$. Also, calculate the fraction of the cycle during which the diode is conducting and the average and the peak values of diode current
i_{av} max

⇒ $\cancel{I_L = \frac{V_p}{V_r} = \frac{100}{2} = 50A}$

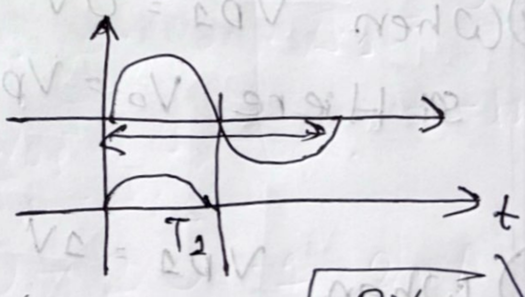
$\cancel{I_{max} = I_L \left(1 + 2\pi \left(\sqrt{\frac{V_p}{V_r}}\right)\right) = 50 \left(1\right.}$

$V_r = \frac{V_p}{fRC} \therefore C = \frac{100}{60 \times 10k \times 2} = \cancel{83} \; 83.3 \mu f$

$\omega \Delta t = \sqrt{\frac{2V_r}{V_p}} = \sqrt{\frac{2\times 2}{100}} = 0.2 \text{ rad}$

The fraction of the cycle during the diode is conducting, $\frac{0.2}{2\pi} \times 100\%$

$= 3.18\%$



$i_{D avg} = I_L \left(1 + \pi\sqrt{\frac{2V_p}{V_r}}\right) = \frac{V_p}{R}\left(1 + \pi\sqrt{\frac{2V_p}{V_r}}\right)$

$= \cancel{85.428} \; 324.15 \text{ mA}$

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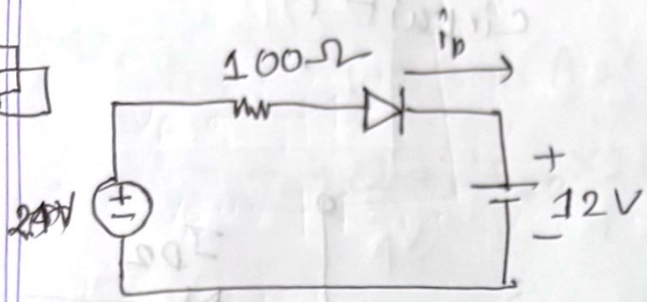
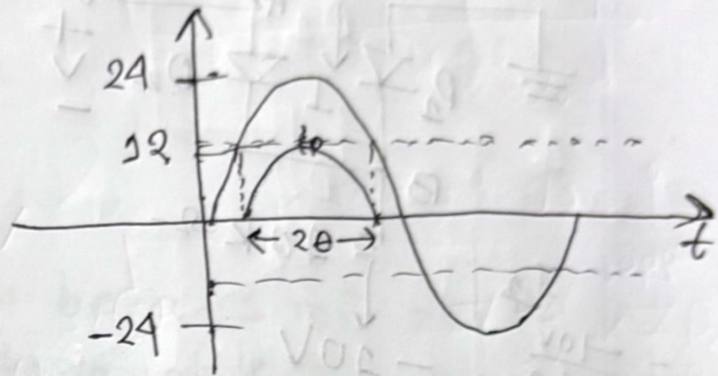
Reverse bias voltage = summation of all voltages

$$i_{D\,max} = I_L\left(1 + 2\pi\sqrt{\frac{V_P}{V_r}}\right) = \cancel{454.288\ mA}$$
$$= 638.318\ mA$$



V_S



$2\theta = ?$

$i_D = ?$ (forward)

$V_D = ?$ (reverse)

$\boxed{\text{Considering ideal diode}}$

Applying KVL, $-V_s + 100 i_D + V_D + 12 = 0$

$\Rightarrow -24 + 100 i_D + 0 + 12 = 0$

$\Rightarrow i_D = 0.12 = I_L$

reverse bias → max current

(summation of all voltages)

Reverse bias voltage, $V_D = \cancel{V_s + V_B} = 24 + 12$

~~$-V_s - 12 - V_D + 100 i_D = 0$~~

$= 36V$

$= PIV$

(a) $24\cos\theta = 12$

$\Rightarrow \theta = \cos^{-1}\left(\frac{12}{24}\right)$

$= 60°$

$\therefore 2\theta = 2 \times 60° = 120°$ → fraction of the cycle the diode conducts

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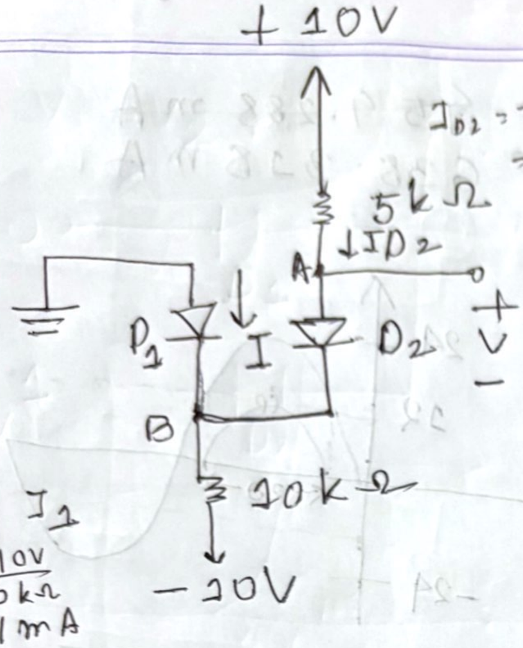
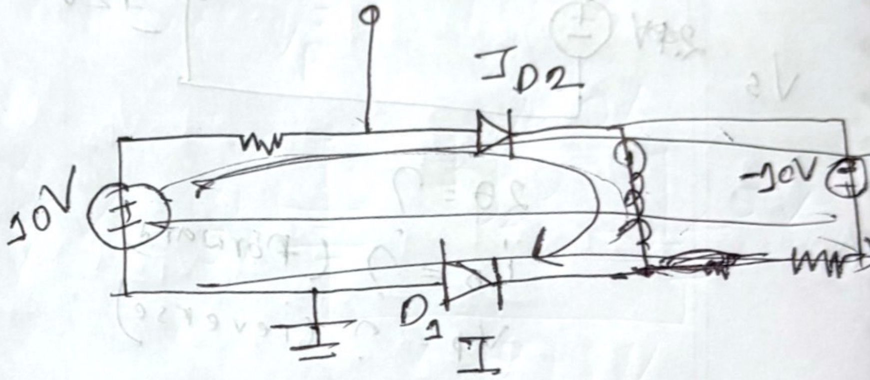


$I_{D2} = \frac{10V}{5k\Omega} = 2\,mA$

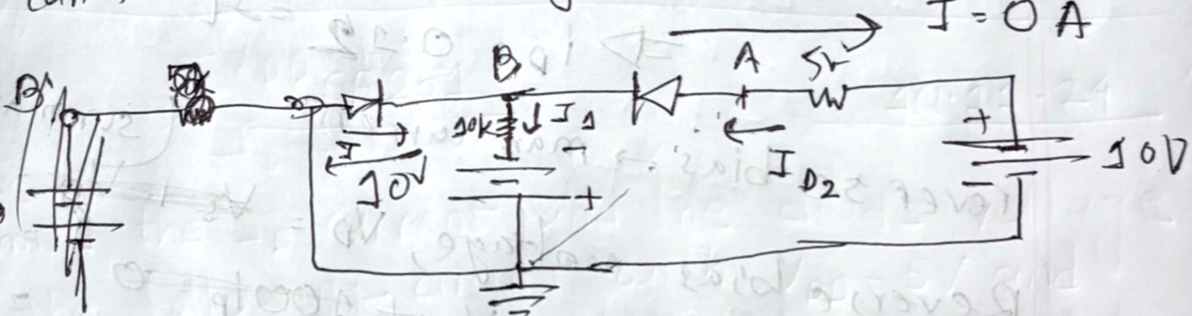
$I_1 = \frac{-10V}{10k\Omega} = -1\,mA$

What difficulties are associated with multi-diode circuit ?



~~Applying KVL,~~ $\cancel{-10 + V_D - 10 -}$

Current can't flow from the ground



$I_{D_2} = \frac{10-0}{5k} = 2mA$

$$I_1 = \frac{0-(-10)}{10} = 1\,mA$$

Applying KCL at B, $I + I_{D2} = I_1$

$\Rightarrow I = I_1 - I_{D2}$

$= (-1-2)\,mA$

$= -1\,mA$

[For $I = -1mA$ Diode $\Rightarrow$ "OFF"]

Applying KVL,

$$-10 + 10 i_{D2} + 0 + 5 i_{D2} - 10 = 0$$

$$\Rightarrow i_{D2} = 1.33 \, mA$$

$$\therefore V = -10 + I_{D2} \times 10k = -10 + 1.33 \times 10k$$
$$= 3.3 \, V$$

\# A silicon diode said to be a 1 mA device displays a forward voltage of 0.7 V at a current of 1mA. Evaluate the junction constant I_s. What scaling constants would apply for a 1A diode of the same manufacture that conducts 1A at 0.7 V?

$$I = I_s \left(e^{\frac{V_D}{nV_T}} - 1 \right)$$

$$= I_s e^{\frac{V_D}{nV_T}}$$

$$\left[V_T = 25.3 \, mV - 26 \, mV = 25 \, mV \right]$$

$$\therefore I_s = \frac{I}{e^{\frac{V_D}{nV_T}}}$$

$$= \frac{1 \times 10^{-3}}{e^{\frac{0.7}{1 \times 25 \times 10^{-3}}}} \quad [n = 1]$$

$$= 6.9 \times 10^{-16} \, A$$

$$I_s = \underline{6.9 \times 10^{-13}} \, A \quad [\text{when } I = 1 \, A]$$

1000 times
(scaling factor)

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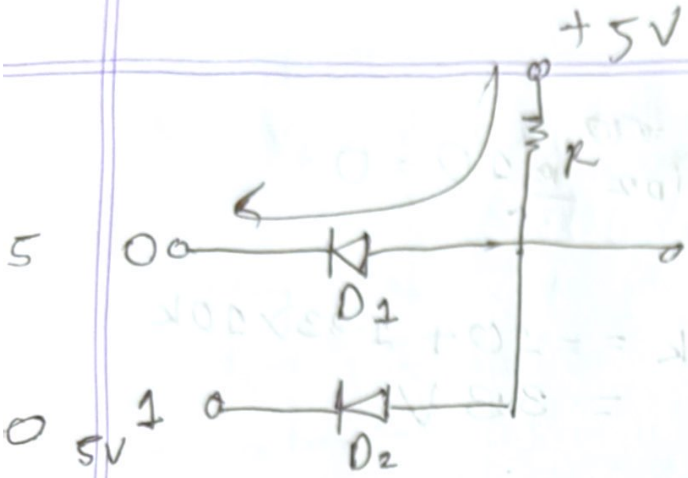
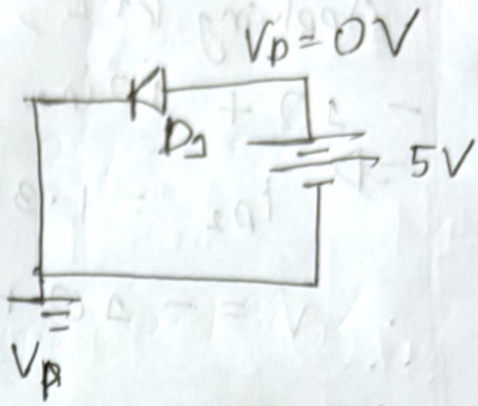
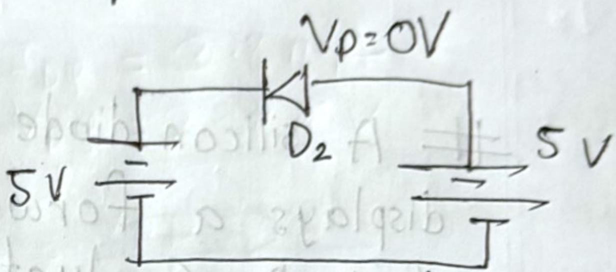


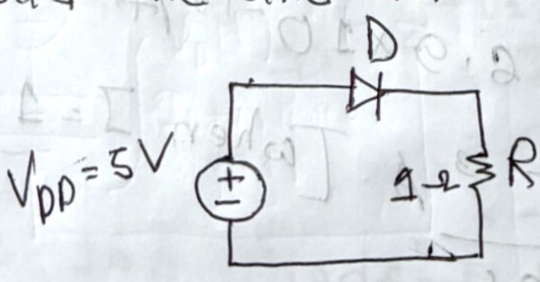




$V = 5 + 5V$
$= 10V$

CSE 251 — 10.11.24

\# Determine the I_D current and the diode voltage V_D for the following circuit with $V_{DD} = 5V$ and $R = 1k\Omega$. Assume that the diode has a current of 1mA and at a voltage of 0.7V. Draw the load line and find V_{DQ} and I_{DQ}.



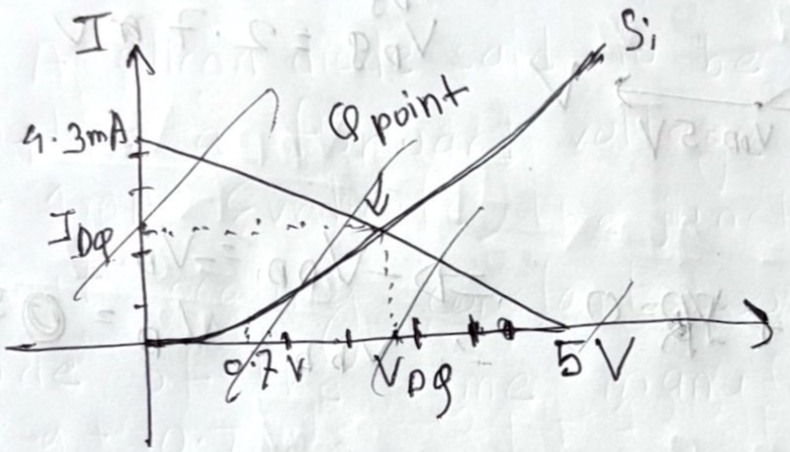
Using KVL, $-5 + 0.7 + I_D \, 1k\Omega = 0$

$\Rightarrow I_D = 4.3 \text{ mA} = I_2$

Now, Let $I_D = 0$ (open circuit)

$-5 + V_{D_1} + I_0 \, 1k\Omega = 0$

$\Rightarrow V_{D_1} = 5V$



$V_{DQ} = 2.7 \, V$

$I_{DQ} = 2.3 \text{ mA}$

$V_2 - V_1 = 2.3 V_T \log\left(\frac{I_2}{I_1}\right)$

$\Rightarrow V_2 = V_1 + 2.3 V_T \log\left(\frac{I_2}{I_1}\right)$ $\boxed{2.3 V_T = 60 \text{ mA if } I_2 = 10 I_1}$

$= \cancel{0.7 + 2.3 \times 25 \log\left(\frac{1 mA}{4.3}\right)}$

$= 0.7 + 0.06 \log\left(\frac{4.3 \text{ mA}}{1 \text{ mA}}\right)$

$= 0.738 \, V$

For, $I_2 = 4.3 \text{ mA}$, $V_2 = 0.738 V$ $\Rightarrow I_D = \frac{V_{DD} - V_D}{R} = \frac{5 - 0.738}{1k}$

$= 4.262 \text{ mA} = I_3$

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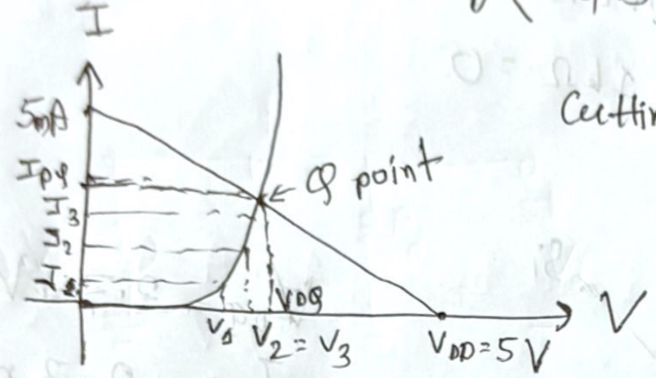
$$V_3 = V_2 + 2.3V_T \left(\frac{I_3}{I_2}\right)$$

$$= 0.738 + 0.06 \log\left(\frac{4.262}{4.3}\right) = 0.738\ V$$



Cuttin votage $= 0.738\ V$

$I_{DQ} = 3.8\ mA$

$V_{DQ} = 2.7\ V$

Let, $I_D = 0$

$$-V_{DD} + V_D + \cancel{IR} = 0 \Rightarrow -V_{DD} = -V_D$$

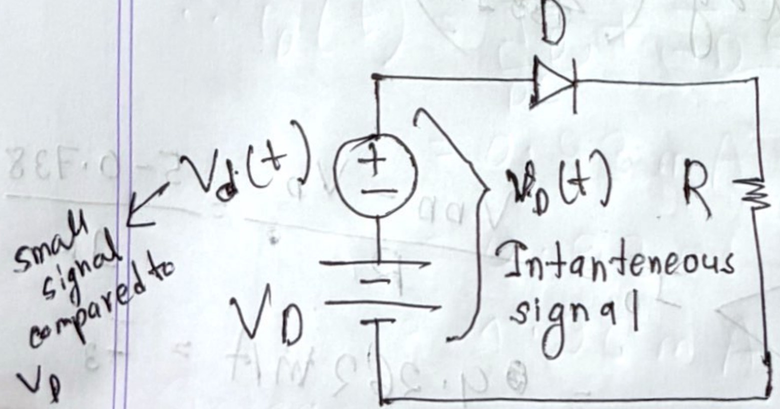
$$\therefore V_{DD} = V_D = 5V$$

Let, $V_D = 0$

$$-V_{DD} + 0 + I_D R = 0$$

$$\Rightarrow I_D = \frac{V_{DD}}{R} = \frac{5}{1k} = 5\ mA$$

Small Signal Model



$$v_D(t) = v_d(t) + V_D$$

For forward bias

$$I_D = I_s e^{\frac{V_D}{nV_T}}$$

$v_d \rightarrow AC$

$V_D \rightarrow DC$

$v_D \rightarrow AC + DC$

$$i_D = I_S e^{\frac{v_D}{nV_T}} = I_S \left[e^{\frac{V_d}{V_T}} \cdot e^{\frac{V_D}{V_T}} \right] \Rightarrow \cancel{I_D e}$$

$$= I_S e^{\frac{V_d + V_D}{V_T}} = I_S e^{\frac{V_d}{V_T}} e^{\frac{V_D}{V_T}}$$

$$= \underbrace{I_S e^{\frac{V_D}{V_T}}}_{DC} \cdot e^{\frac{V_d}{V_T}}$$

$$\left[I_D = I_S e^{\frac{V_D}{V_T}} \right]$$

$$\therefore i_D = I_D e^{\frac{V_d}{V_T}}$$

$$\Rightarrow \boxed{i_D(t) = I_D \left[1 + \frac{V_d}{V_T} \right]}$$

Intantenous diode current

$$\left[\frac{V_d}{V_T} << 1 \right]$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} +$$

Let, $x = \frac{V_d}{V_T}$

$$i_D(t) = I_D \left[1 + \frac{V_d}{V_T} \right] = I_D + \frac{I_D V_d}{V_T}$$

$$= \underbrace{I_D}_{DC} + \underbrace{V_d \boxed{\frac{I_D}{V_T}}}_{AC}$$

$\frac{V}{I} = R$

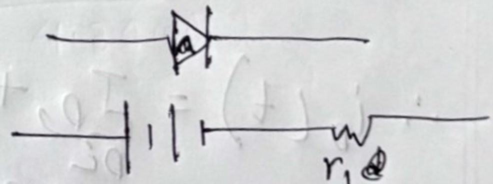
$V \cdot \frac{1}{R} = I$

$\boxed{V \cdot G = I}$

$$G_d = \frac{I_D}{V_T}$$

Diode internal resistance $r_d = \frac{V_T}{I_D} = \frac{26\,mV}{I_D}$

while using AC and DC together



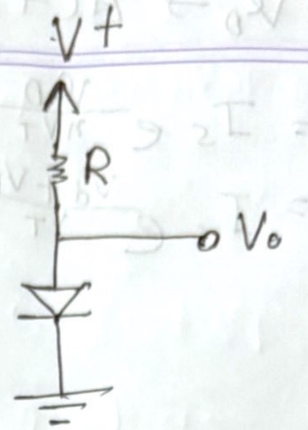
Si 0.7V

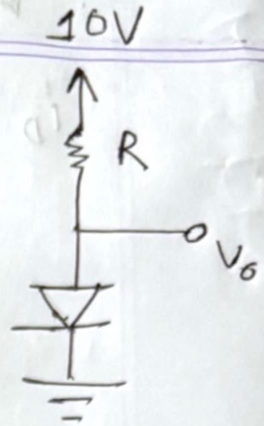
Ge 0.3V

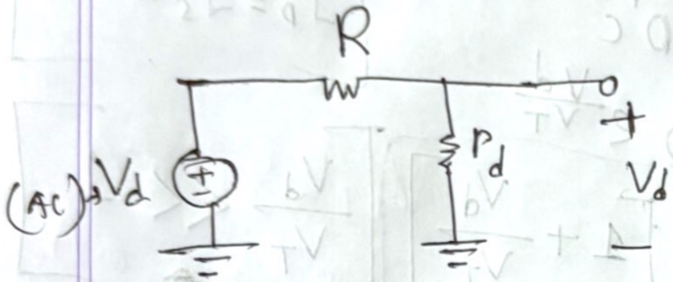
internal model when we use AC and DC together.

$$i_D(t) = I_D + I_D e^{\frac{V_d}{V_T}}$$

R = 10k
$V^+ = 10V$ dc
f = 60Hz
$V_{ac} = 1$-V peak $= V_{dp}$







$\cancel{I_D = I_S e^{\frac{V_D}{nV_T}}} = \cancel{\text{[illegible]}}$

$$I_D = \frac{V_{DD} - V_D}{R} = \frac{10 - 0.7}{10k} = 0.93\,\text{m[A]}$$

$r_d = \frac{V_T}{I_D} = 27.9\,\Omega$ $[V_T = 26mV]$

Using VDR,

$$V_d = \underbrace{1}_{V_{ac}} \times \frac{r_d}{R + r_d} = 1 \times \frac{27.9\,\Omega}{10000 + 27.9}$$

peak voltage

$= 2.78\,mV = 2.78 \times 10^{-3}\,V$

$$\therefore i_D(t) = \underbrace{I_D}_{DC} + \underbrace{I_D e^{\frac{V_d}{V_T}}}_{Ac}$$

$= 0.93\,mA + 0.93\,mA \times e^{\frac{2.78}{26}}$

$= 0.93\,mA + 1.03\,mA$

$= 1.96\,mA$

Internal resistance is created with respect to DC

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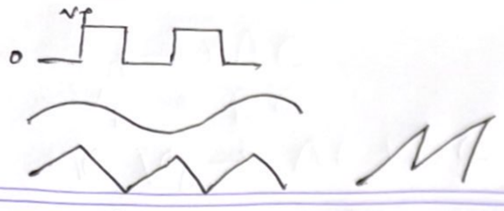
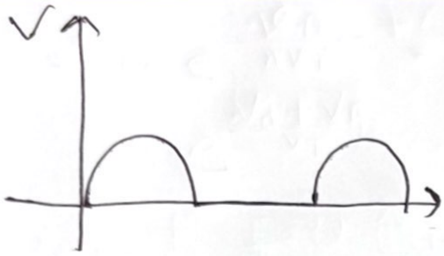
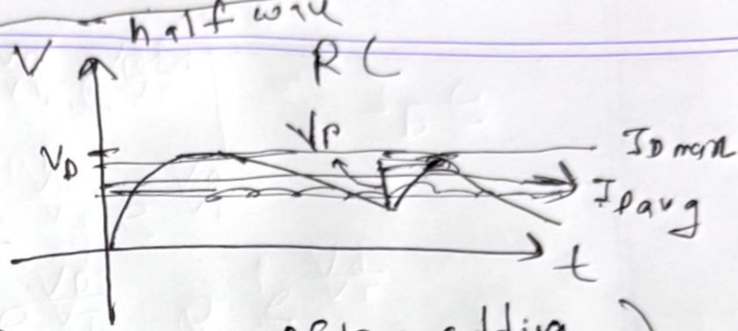
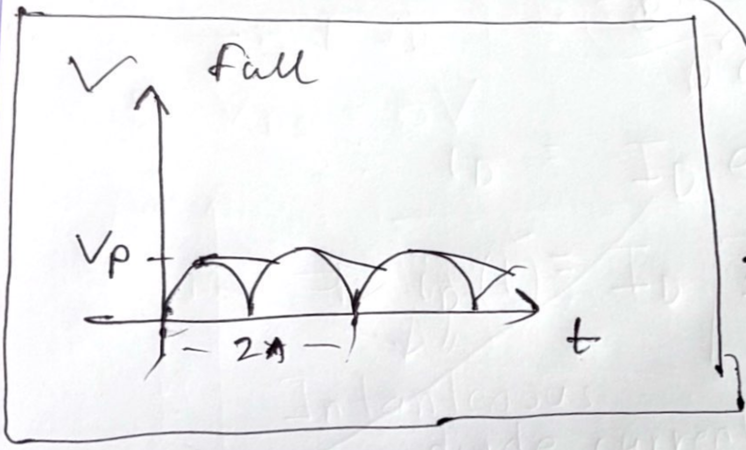


Small signal







V_{dc} = before ripple

$V_{dc} = 0.318\,(V_p - V_D)$