# EEE263

exam এ 2 ধরনের diode এর ~~মডেল~~ Model ব্যবহার করতে হবে

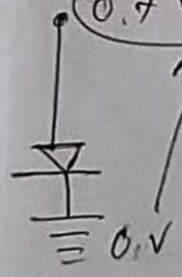
- → const. voltage drop (0.7 V for Si diode)
- → Ideal diode (No voltage drop)

] Fwd bias

Reverse bias → Open ckt ধরবে।

4] $\because$ 0.7 V drop

0.7 V হতে হবে




$$I_1 = \frac{5 - V_a}{5}\ mA = \frac{4.3}{5}\ mA$$

$$I_2 = \frac{\cancel{V_a - 0.7}\ V - (-5)}{\cancel{5}\ 10}\ mA$$

$$= \frac{(V_a - 0.7) - (-5)}{10}\ mA \quad \left[\because V = V_a - 0.7\ V\right]$$

5] $V_a = 0.7$ V

$$I_1 = \frac{5 - 0.7}{10}\ mA$$

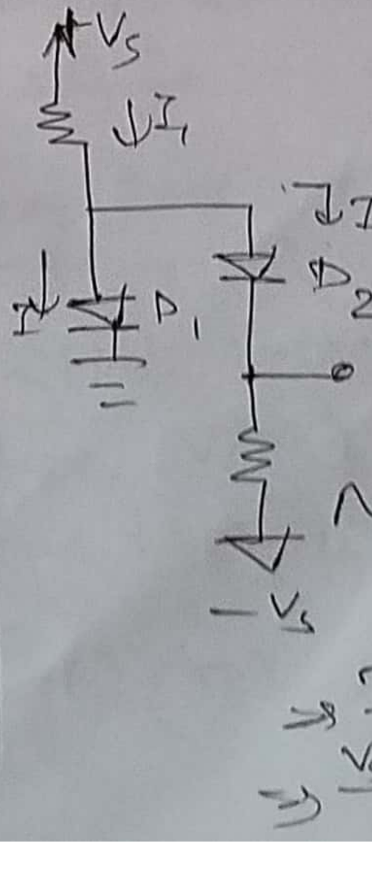
$$= 0.43\ mA$$

$$I_2 = \frac{V - (-5)}{5}$$

$$= \frac{0.7 - 0.7 - (-5)}{5}$$

$$= 1\ mA$$

THINK YOURSELF :




$$I_1 = \frac{V_S - 0.7}{R_1} > 0$$

$$\therefore V_S > 0.7\ V$$

$$I_2 = \frac{V_S}{R_2} > 0$$

Now, for $D_1, D_2$ → fwd bias

$$I = I_1 - I_2 > 0$$

$$\Rightarrow I_1 > I_2$$

$$\Rightarrow \frac{V_S - 0.7}{R_1} > \frac{V_S}{R_2}$$

$\Rightarrow \frac{R_2}{R_1} > \frac{V_s}{V_s - 0.7}$

$\therefore \frac{R_2}{R_1} > 1$

$\therefore R_2 > R_1$ → both diodes fwd bias

and, $I_1 - I_2 \leq \cancel{0}$ → $D_1$ reverse bias

$\Rightarrow \boxed{R_2 \leq R_1}$ → $D_2$ fwd bias

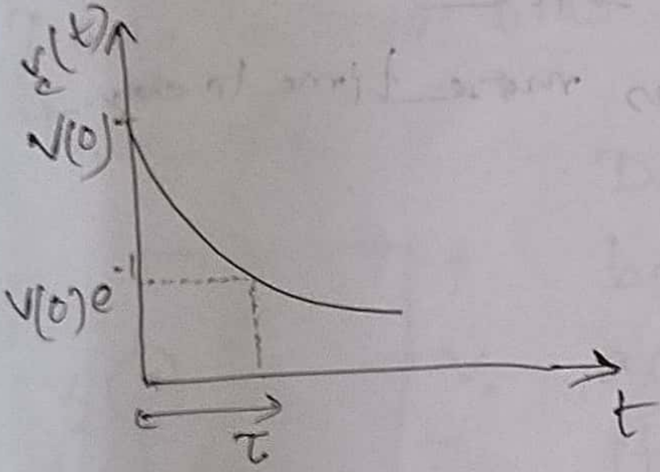
<u>L02</u> online Yt + This note

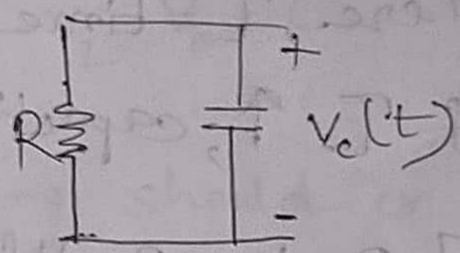
breakdown — 2 type
- Zener Breakdown
- Avalanche "

## Time const. of an R-C Ckt:

If a capacitor has initial voltage $v(0)$ and it has a resistor across it, then capacitor voltage,

$$v_c(t) = v(0)e^{-t/\tau}$$



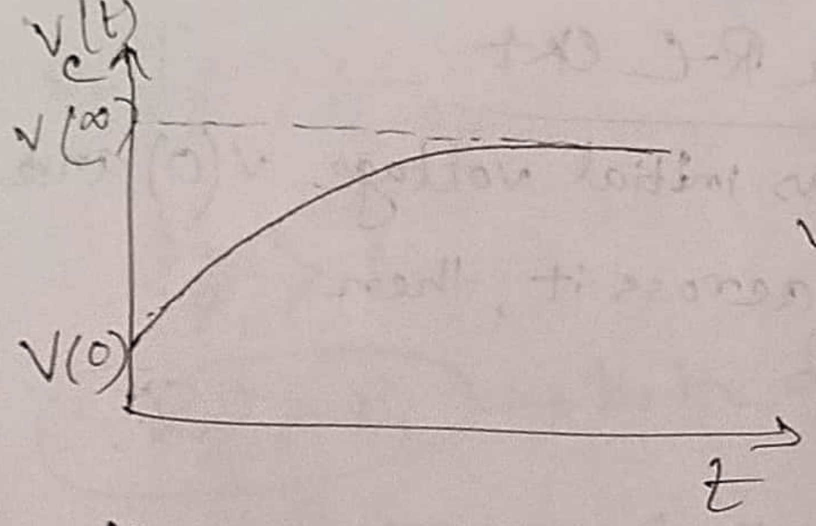



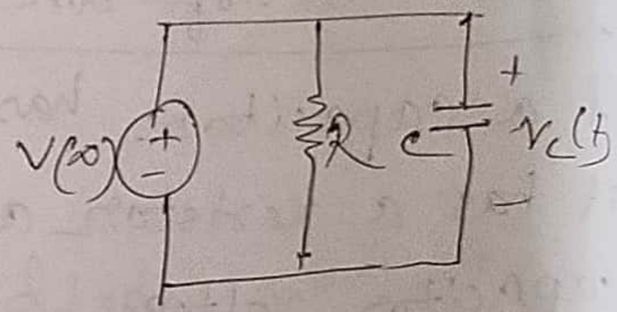

When $t = \tau$, $v_c(t) = v(0)e^{-1}$

time const ↑ capacitor charge 2to time ↑
(also " discharge " time ↑)

" " ↑ voltage decay slow, time

If a capacitor has initial voltage $v(0)$ and a voltage src with voltage $v(\infty)$ is connected to the capacitor at time $t=0$, then capacitor voltage, $v_c(t) = v(0)e^{-t/\tau} + v(\infty)(1 - e^{-t/\tau})$

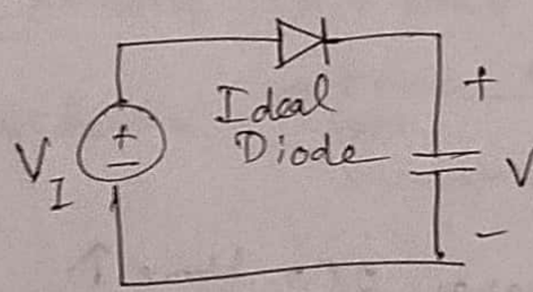


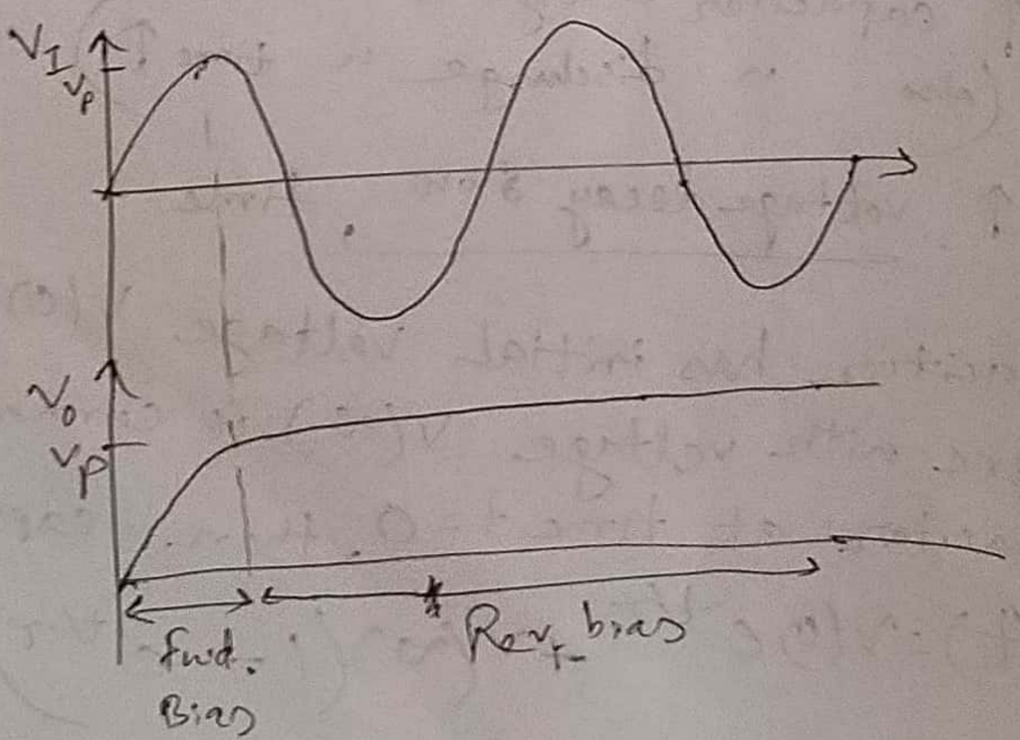




Here, $\tau$ = time const = RC

If $\tau \uparrow$, capacitor takes more time to charge

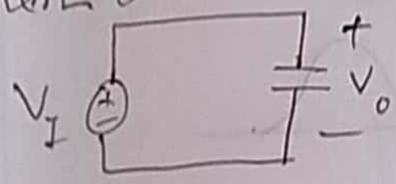
## Peak Rectifier:



Diode in Fwd. bias when $V_I - V_0 > 0$

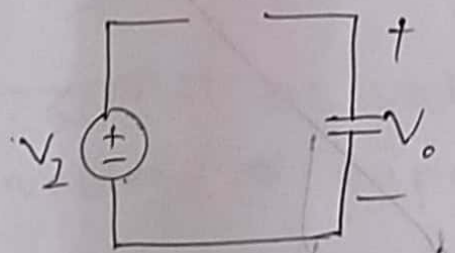
Then ckt.




charging occurs

Diode in rev. bias when $V_I - V_0 \le 0$

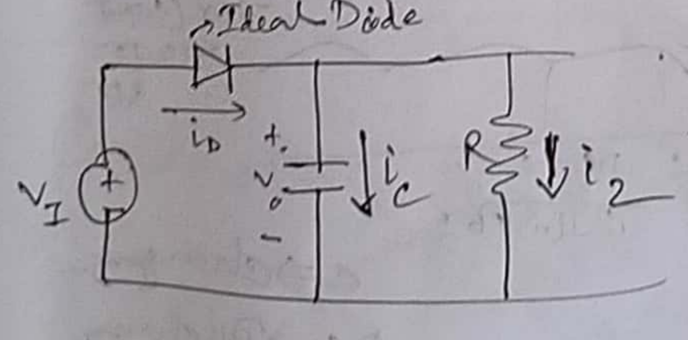
Then ckt.



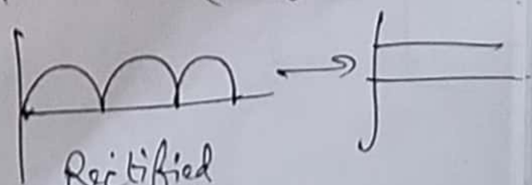

Discharging should occur, but there is no resistor across capacitor so that it can discharge i.e. $R = \infty$, so $\tau = \infty$,

∴ capacitor holds its voltage indefinitely

~~Rea~~ Peak Rectifier with Load Resistance :

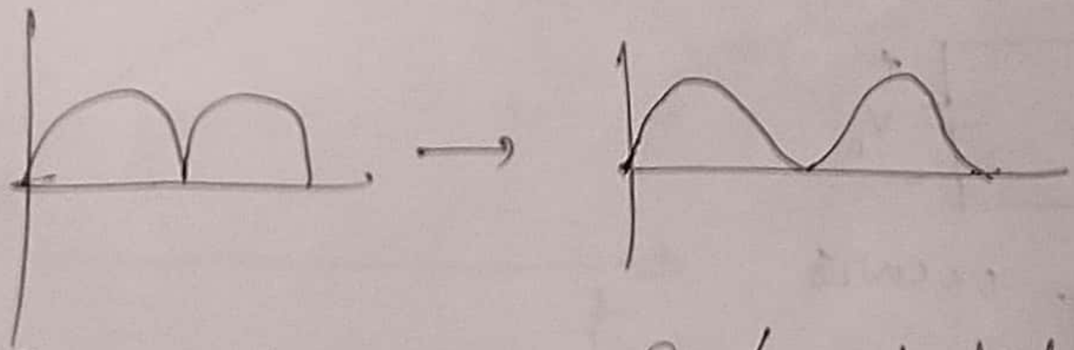



capacitor লাগাবো main কারণ :



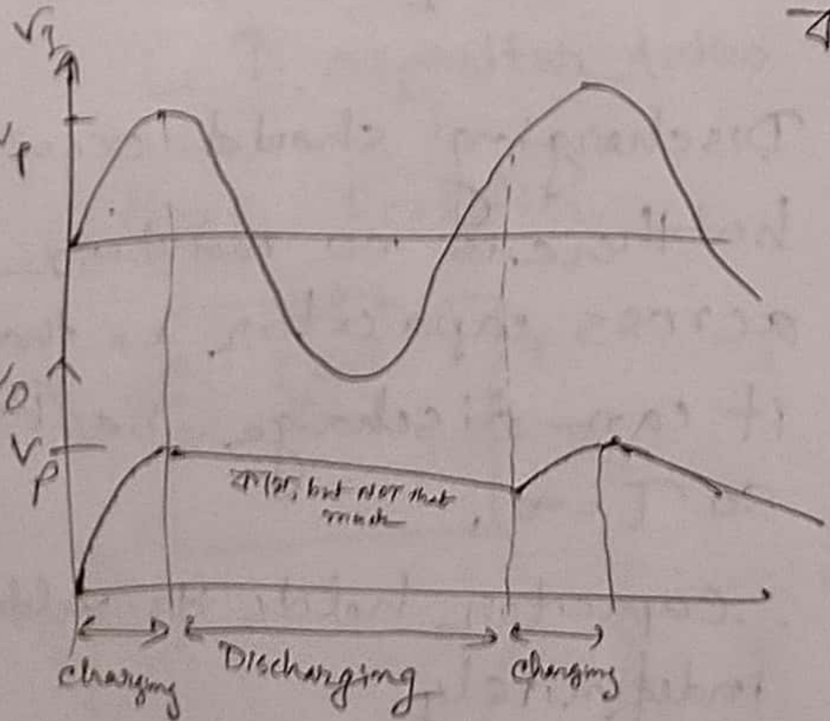
Rectified signal

But, what we get, is,



~~যদি time to di~~

যদি (time to discharge) $>> T$ করাতে পারি, তাহলে



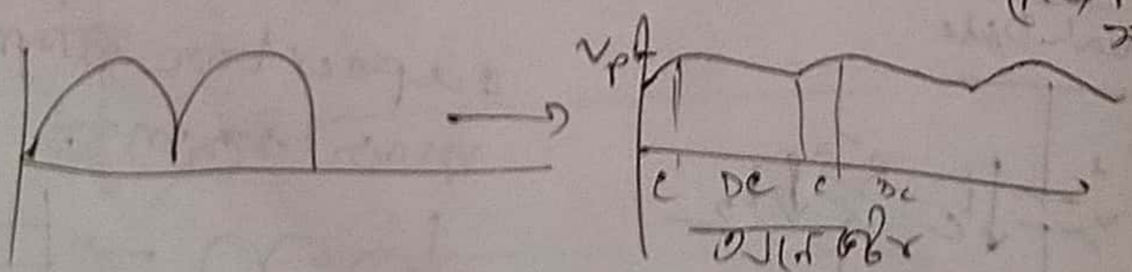

How to achieve that?

$\tau \uparrow$ (time to discharge) $\uparrow$

needs target

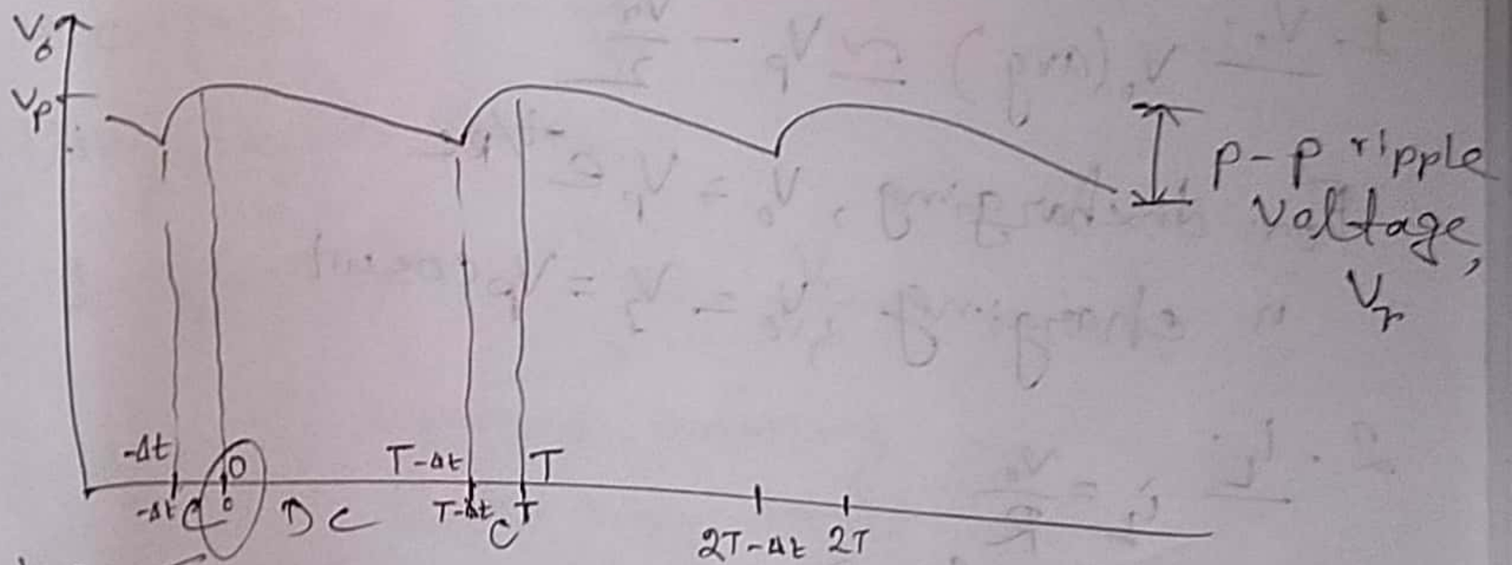
অর্থাৎ দীর্ঘতর $(RC)\uparrow$ ckt. বানানোর সময় খেয়াল রাখতে হবে

Now we get



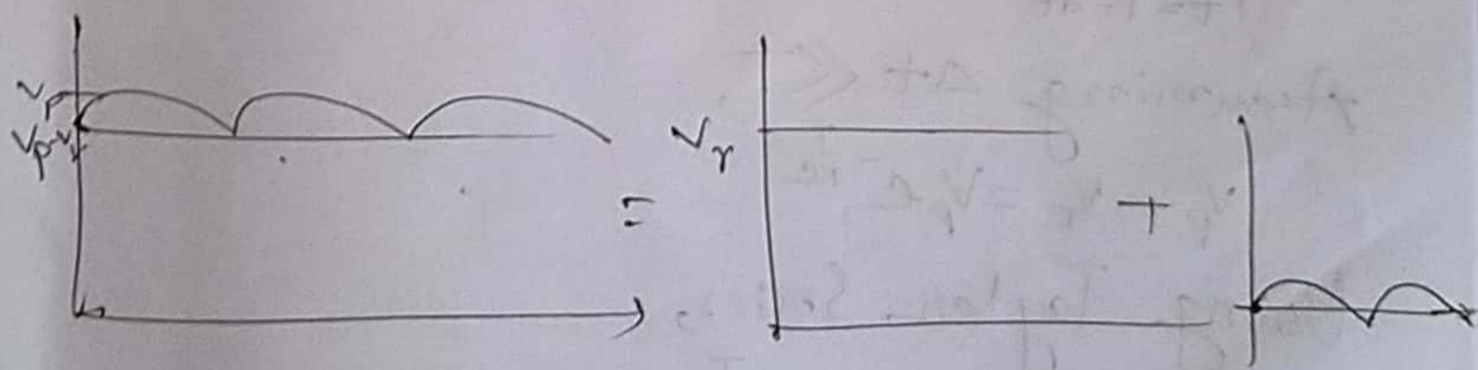

C ⇒ charging...

DC ⇒ Discharging...

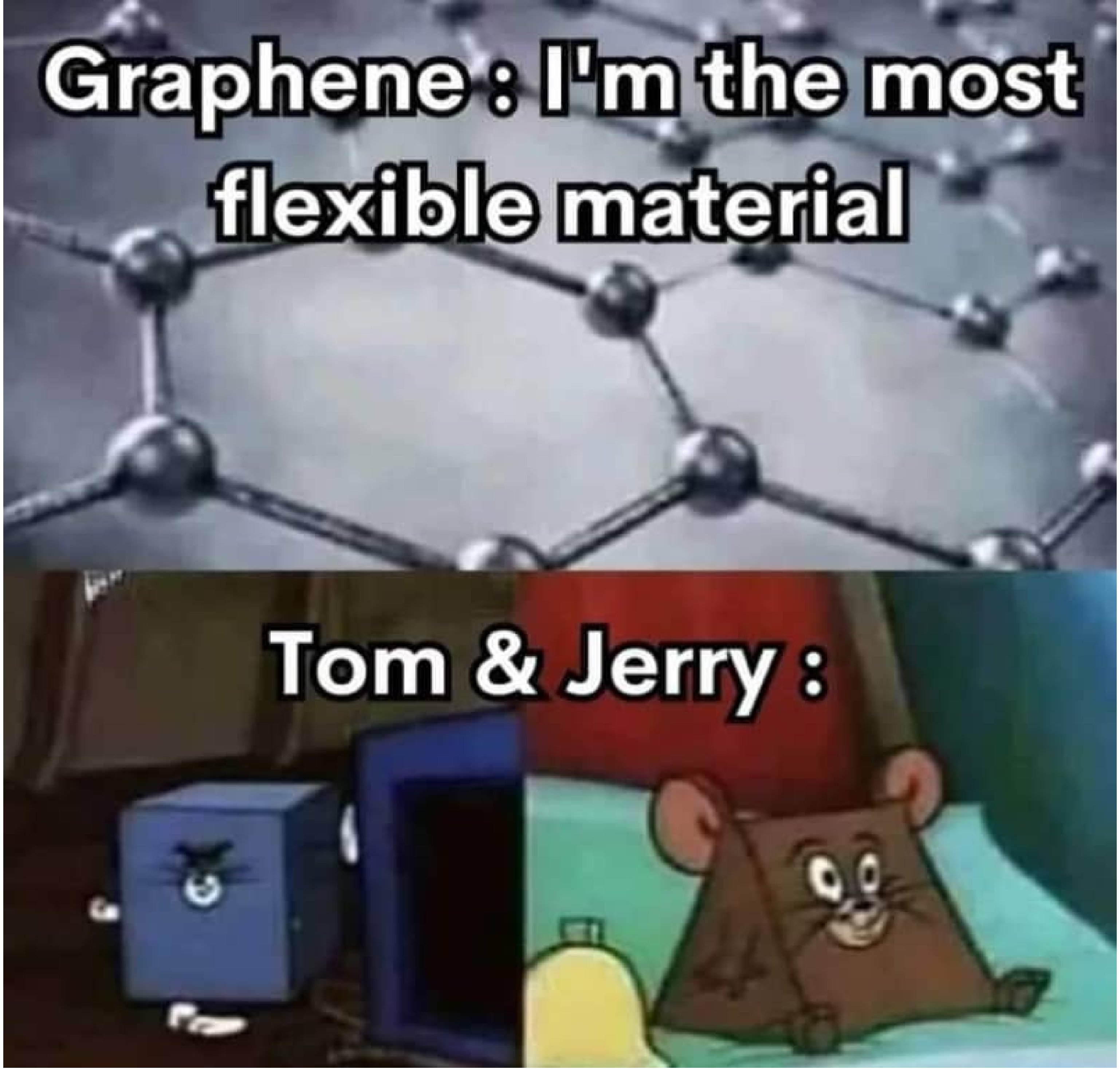



কোনো rectifier এর ripple voltage যত কম
ঐ " তত ভালো।

কোনো DC voltage এর উপর ছোট মানের AC voltage কে superimpose করা হয়, " " "
" " ripple voltage বলে




Conduction interval : Time Duration of a
($\Delta t$) cycle when Diode conducts.


Graphene : I'm the most flexible material
Tom & Jerry :

1. $\underline{V_o}$: $V_o(avg) \simeq V_p - \frac{V_r}{2}$

For discharging, $V_o = V_p e^{-t/RC}$

" charging, $V_o = V_i = V_p \cos \omega t$

2. $\underline{i_L}$: $i_L = \frac{v_o}{R}$

$i_L(avg) = \frac{v_o(avg)}{R} = \frac{V_p - \frac{1}{2}V_r}{R} \simeq \frac{V_p}{R} = I_L$

$i_L(peak) = \frac{V_o(peak)}{R} = \frac{V_p}{R} = I_L$

3. $\underline{V_r}$:

$V_o\big|_{t=T-\Delta t} = V_p - V_r = V_p e^{-\frac{T-\Delta t}{RC}}$

Assuming $\Delta t \ll T$,

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

Using Taylor Series,

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

$V_r = V_p \frac{T}{RC} = \frac{V_p}{fRC} = \frac{I_L}{fC}$

4. $\underline{\Delta t}$: $V_o\big|_{t=-\Delta t} = V_p - V_r = V_p \cos(-\omega \Delta t) = V_p \cos(\omega \Delta t)$

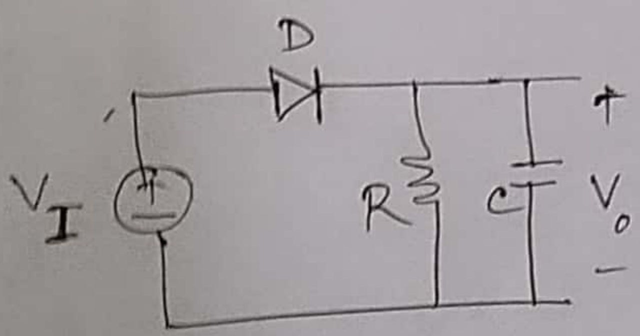
$$\Rightarrow \cos(\omega \Delta t) = 1 - \frac{V_r}{V_p}$$

Using Taylor Series,

$$1 - \frac{1}{2}(\omega \Delta t)^2 + \underbrace{\ldots}_{\text{ignored assuming } \omega \Delta t \text{ very small}} = 1 - \frac{V_r}{V_p}$$

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

5.



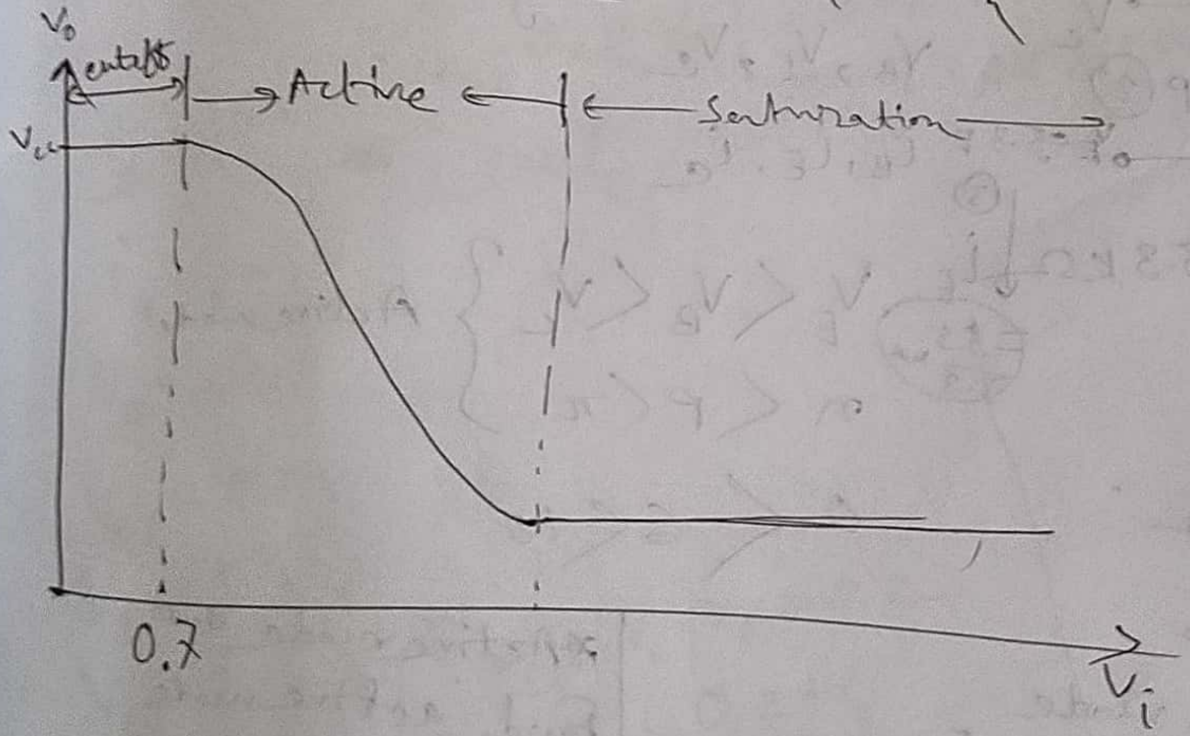
# BJT

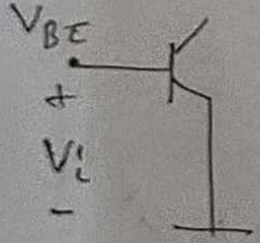
L1 → I-V characteristics → Input
→ Output

$V_{cc}$ → src collector [illegible] connected

$V_{BB}$ → " base " " "

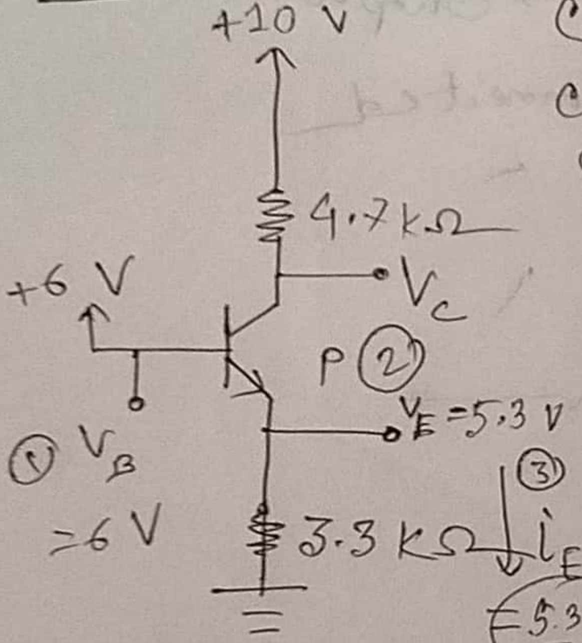
$V_{EE}$ → " Emitter " " "



## BJT Ckt. at DC

**Pr 1:**




Calculate all node voltages and current.

For active mode, assume $\beta = 100$

$V_B, V_E, V_C$

$i_B, i_E, i_C$

$= \frac{5.3}{3.3}$ mA

$\left.\begin{array}{l} V_E < V_B < V_C \\ n < p < n \end{array}\right\}$ Active mode

$\cancel{0 < 6}$

$0 < 6 < 10$

Assume,
active mode
$V_{BE} = 0.7$ V $\left[ \because \text{B-E in fwd. bias} \right]$

*Active mode বললে Fwd. active mode বুঝবো।

$i_E = \frac{5.3}{3.3} = 1.64$ mA

$33)\,53\,(1.6$
$\underline{33}$
$200$

$i_C = \alpha i_E = \frac{\beta}{1+\beta} i_E$

⑤ $\beta = \frac{i_C}{i_B} \Rightarrow i_B = \frac{i_C}{\beta} =$

⑥ $V_C = 10 - 4.7 i_C$
$= 2.48$ V

We got → $V_E < V_B < V_C$
$5.3 < 6 \not< 2.48$

∴ Assumption wrong

Assuming, Saturation mode

$V_E < V_B > V_C$

$\Rightarrow n < p \quad n$

Assume: for sat. mode:

$V_{CE_{sat}} = 0.2\,V$ [2 টাই find bias এ লাগবে 0.2 V এর মধ্যে হয়]

$\cancel{i_C = \beta i_B}$, $\cancel{i_C = \alpha i_E}$

$i_E = i_B + i_C$

$V_B = 6\,V$

$V_{BE} = 0.7\,V$

$V_E = 5.3\,V$

$V_C = 5.5\,V$ $\left[ \because V_{CE} = V_C - V_E = 0.2 \right.$

$V_C = 0.2 + V_E$

$= (0.2 + 5.3)\,V$

$= \boxed{5.5\,V}$

$i_E = \dfrac{5.3}{3.3} = 1.6\,mA$

$i_C = \dfrac{10 - 5.5}{4.7} = 0.96\,mA$

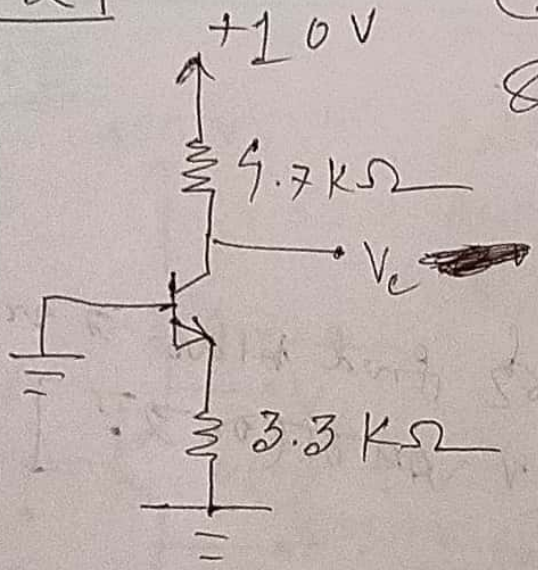
$i_B = i_E - i_C = 0.64\,mA$

$\beta_{forced} = \dfrac{i_C}{i_B} = \dfrac{0.96}{0.64} = 1.5$

$\because$ sat. mode এ $\beta$ আলাদা করে বের করা যায় না।

## Pr2:

Calculate all node voltages & current. For active mode, assume $\beta = 100$.




* Assumption এর জন্য
+10V
0V
0V
দিলাম।

Ans: $\cancel{V_E < V_B > V_C}$
~~n~~

| $V_E$ | $V_B$ | $V_C$ |
|---|---|---|
| n | p | n |
| 0 | 0 | 10 |

Rev  Rev

$\therefore$ Let's assume cut-off mode

$i_E = i_B = i_C = 0\,A$

$\therefore V_C = +10\,V$

$V_B = 0\,V$

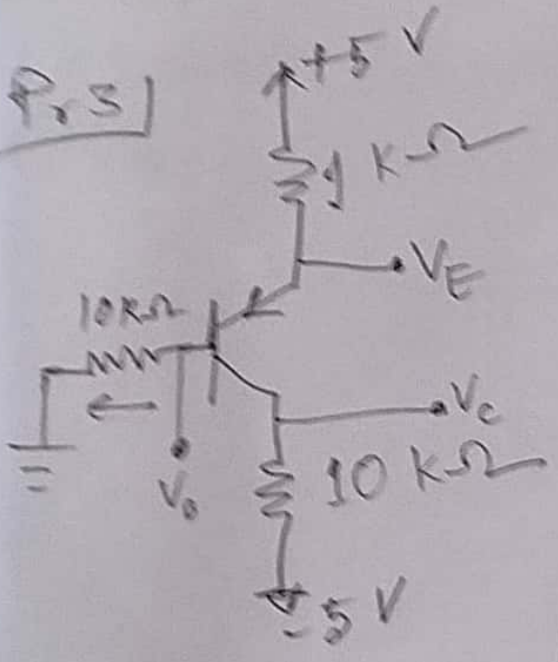
$V_E = 0\,V$

* active হলে -ve আসতো: সেটা ও দেখেন,

অথবা current direction দিয়েও assumption check করা যায়।

~~Pr3~~

Pr 5)




Calculate all node voltages and current.

For active mode, assume $\beta = 100$

~~Ans: Assuming saturation mode,~~

~~$V_{CE_{sat}} = 0.2\ V$~~

$\Rightarrow$ Assuming, active mode:

$i_B$ very small ($\mu A$ range)

$i_B \simeq 0$

$\therefore V_B \simeq 0\ V$

$V_E = 0.7\ V$ [$\because V_E$ এর ওপর]

$$i_E = \frac{5-0.7}{1} = 4.3\ mA$$

$\therefore i_C \simeq i_E$ [$\because i_B \simeq 0$]

$\therefore V_C = 10 i_C - 5$

$= 43 - 5 = 38\ V$

Now,

| E | B | C |
|---|---|---|
| p | n | p |
| 0.7 | 0 | 38 |

Fwd. Fwd.

$\therefore$ Assumption was wrong

~~Ans~~

Assume saturation mode

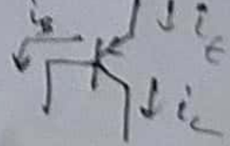
$V_{EC_{sat}} = 0.2\ V$

$V_{EB} = 0.7\ V$

$i_E = i_B + i_C$

$$i_E = \frac{5 - V_E}{1\ k\Omega} = (5 - V_E)\ mA$$

Current dir



$5-(V_B+0.7)$

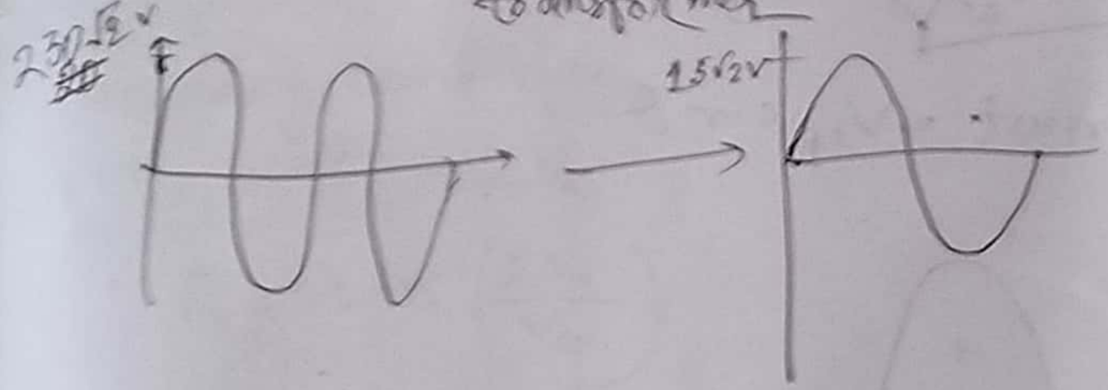
$$\Rightarrow \frac{V_B}{10}+\frac{V_B+0.5+5}{10} \left[\because i_E=i_B+i_C\right]$$

$\Rightarrow$

# EEE263

## Rectifier

230 V (rms) 50 Hz $\xrightarrow[\text{down transformer}]{\text{step}}$ 15 V (rms) AC $\xrightarrow{\text{Rectifier}}$ DC $\xrightarrow{\text{filter}}$ $\xrightarrow{\text{voltage regulator ckt}}$





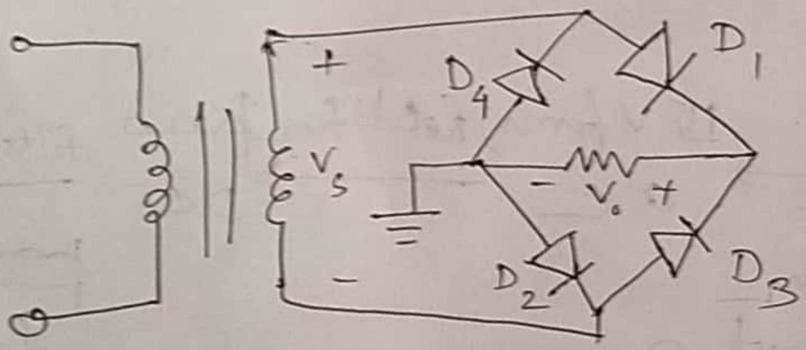
Rectifier
- Half-wave rectifier
- Full-wave "
  - Center-tapped
  - Bridge

## Rectifier:

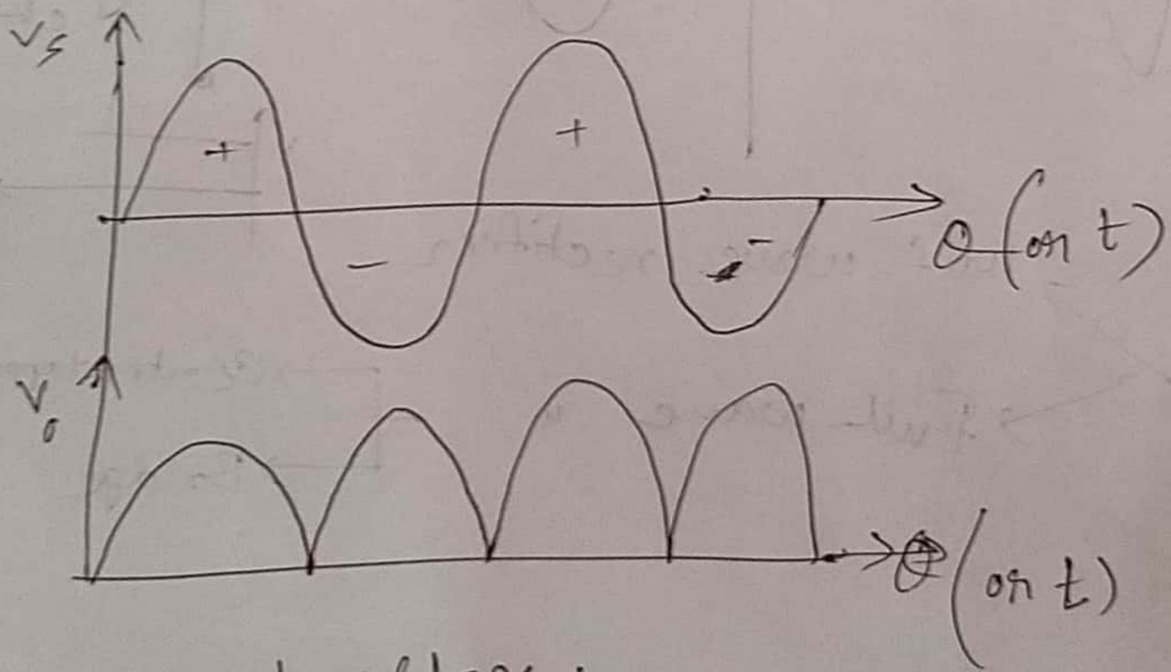
### Specs:

1. peak current < diode current rating
2. peak inverse voltage (PIV) < diode breakdown voltage
3. Avg output voltage
4. Conduction angle

# Bridge Rectifier




$V_s = V_{sp} \sin \omega t = V_{sp} \sin \theta$




## output voltage:

Assume there is a voltage drop $V_D$ across diode in Fwd. bias.

$V_s = V_0 + 2V_D$

$V_0 = V_s - 2V_D$

$= V_{sp} \sin\theta - 2V_D$

when, $V_o > 0$, then current flow হবে।

$V_s \rightarrow$ input

$V_o \rightarrow$ output $\rightarrow$ এর across এ

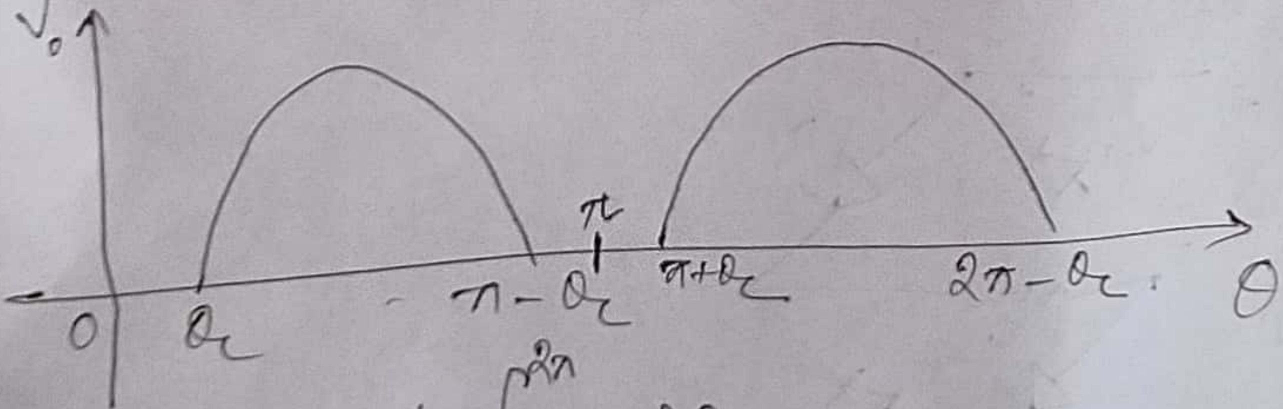
দিয়ে $I \approx 0$ (খুব কম) হলে $V \approx 0$ হবে.

$V_{sp}\sin\theta_L \rightarrow$ input voltage starting at $\theta_L$

boundary condition

$V_{sp}\sin\theta_L = 2V_D$

$\therefore \theta_L = \sin^{-1}\left(\frac{2V_D}{V_{sp}}\right)$




$$V_o(\text{avg}) = \frac{1}{2\pi}\int_0^{2\pi} V_o \, d\theta$$

$$= \frac{2}{2\pi}\int_0^{\pi} V_o \, d\theta$$

$$= \frac{1}{\pi}\int_{\theta_L}^{\pi-\theta_L} V_o \, d\theta = \frac{1}{\pi}\int_{\theta_L}^{\pi-\theta_L}\left(V_{sp}\sin\theta - 2V_D\right) d\theta$$

$$= \frac{1}{\pi}\left[V_{sp}(-\cos\theta) - 2V_D\theta\right]_{\theta_c}^{\pi-\theta_c}$$

Now, $\theta = \sin^{-1}\left(\frac{2V_D}{V_{sp}}\right)$

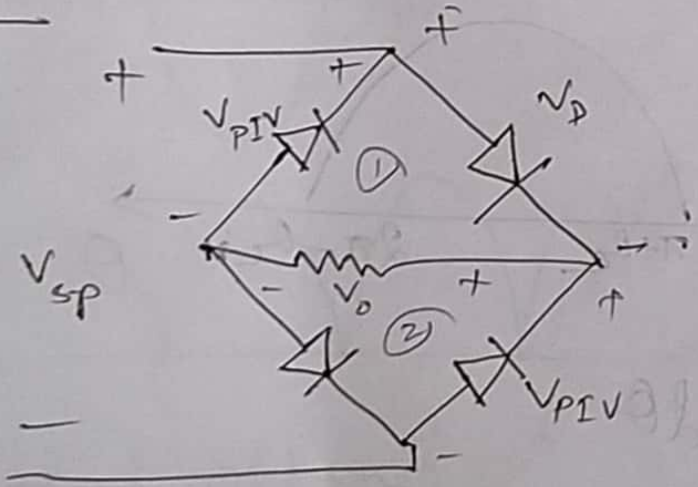
~~$2V_D << \theta_c$~~

$2V_D >> \theta_c$ (assuming $\theta_c$ very small)

$$\simeq \frac{1}{\pi}\int_0^{\pi}(V_{sp}\sin\theta - 2V_D)\,d\theta$$

$$= \boxed{\frac{2}{\pi}V_{sp} - 2V_D}$$

PIV :




$$V_{PIV} = (V_D + V_o)_{max} \quad [\text{KVL in } 1]$$

$$= (V_D + V_s - 2V_D)_{max}$$

$$= (V_s - V_D)_{max}$$

$$= V_{sp} - V_D$$

<u>output peak current</u>/ peak current through any diode

$$i_{peak} = \frac{V_{o,peak}}{R}$$

$$= \frac{(V_S - 2V_D)_{max}}{R}$$

$$= \frac{V_{sp} - 2V_D}{R}$$

| | $V_o$ | PIV | $V_o$ (avg.) | peak current through diode | Total angle per cycle when $V_o = 0$ |
|---|---|---|---|---|---|
| H.W. | $V_S - V_D$ | $V_{sp}$ | $\frac{V_{sp}}{\pi} - \frac{V_D}{2}$ | $\frac{V_{sp} - V_D}{R}$ | $\pi + 2\sin^{-1}\left(\frac{V_D}{V_{sp}}\right)$ |
| FW(CT) | $V_S - V_D$ | $2V_{sp} - V_D$ | $\frac{2V_{sp}}{\pi} - V_D$ | $\frac{V_{sp} - V_D}{R}$ | $4\sin^{-1}\left(\frac{V_D}{V_{sp}}\right)$ |
| FW(Bridge) | $V_s - 2V_D$ | $V_{sp} - V_D$ | $\frac{2V_{sp}}{\pi} - 2V_D$ | $\frac{V_{sp} - 2V_D}{R}$ | $4\sin^{-1}\left(\frac{2V_D}{V_{sp}}\right)$ |

<u>Problem:</u> A FW-rectifier circuit with a $1\,k\Omega$ load operates $120\,V$ (rms) 60 Hz household supply through a 5 to 1 transformer having a center-tapped secondary winding. It uses 2 Si diodes that can be modeled to have a 0.7 V drop of all currents.


О676ТУ