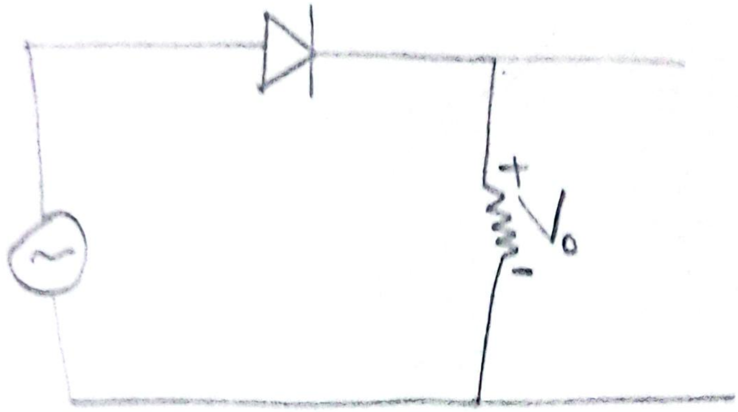
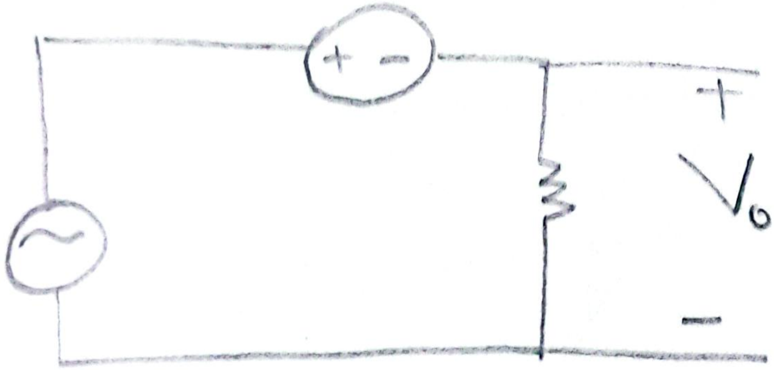
CSE-251 6/4/25

lecture-10

Rectifier



When the diode is on,



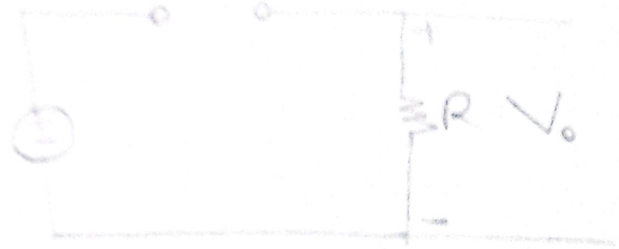
$V_o = V_{in} - V_{Do}$

$I = \frac{V_{in} - V_{Do}}{R}$

For the diode to be on,

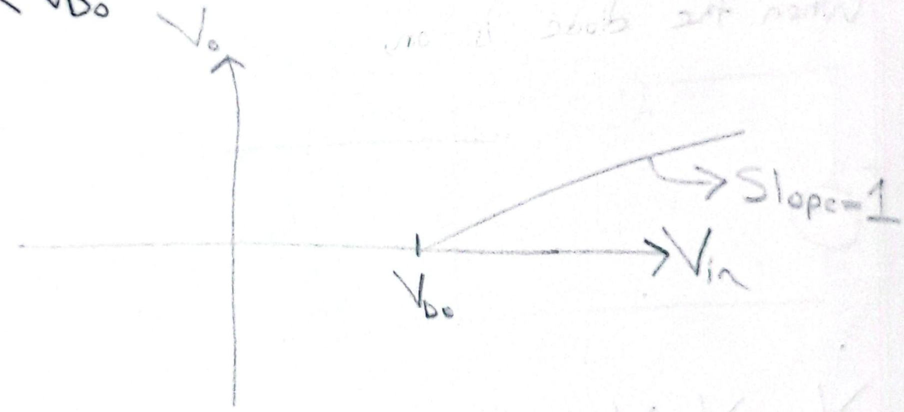
$V_{in} > V_{Do}$

When the diode is off.



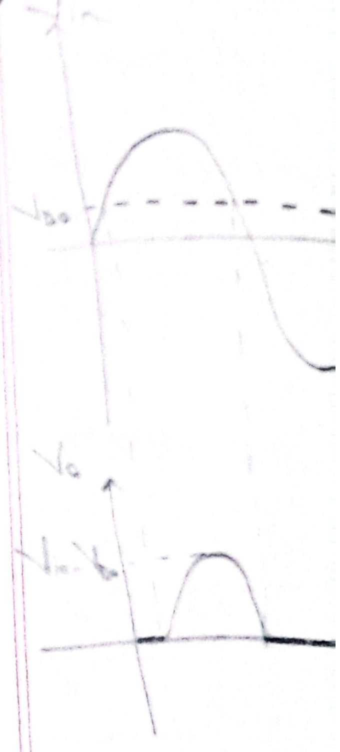
$V_o = 0$

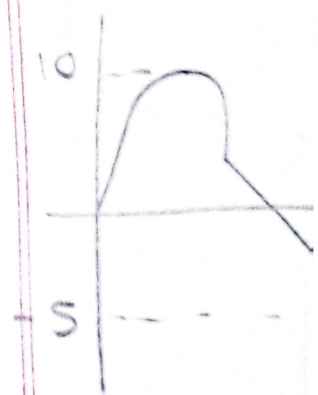
$V_{in} < V_{D0}$



VTC graph of Rectifier if Diode is on

1) Draw the V_o vs



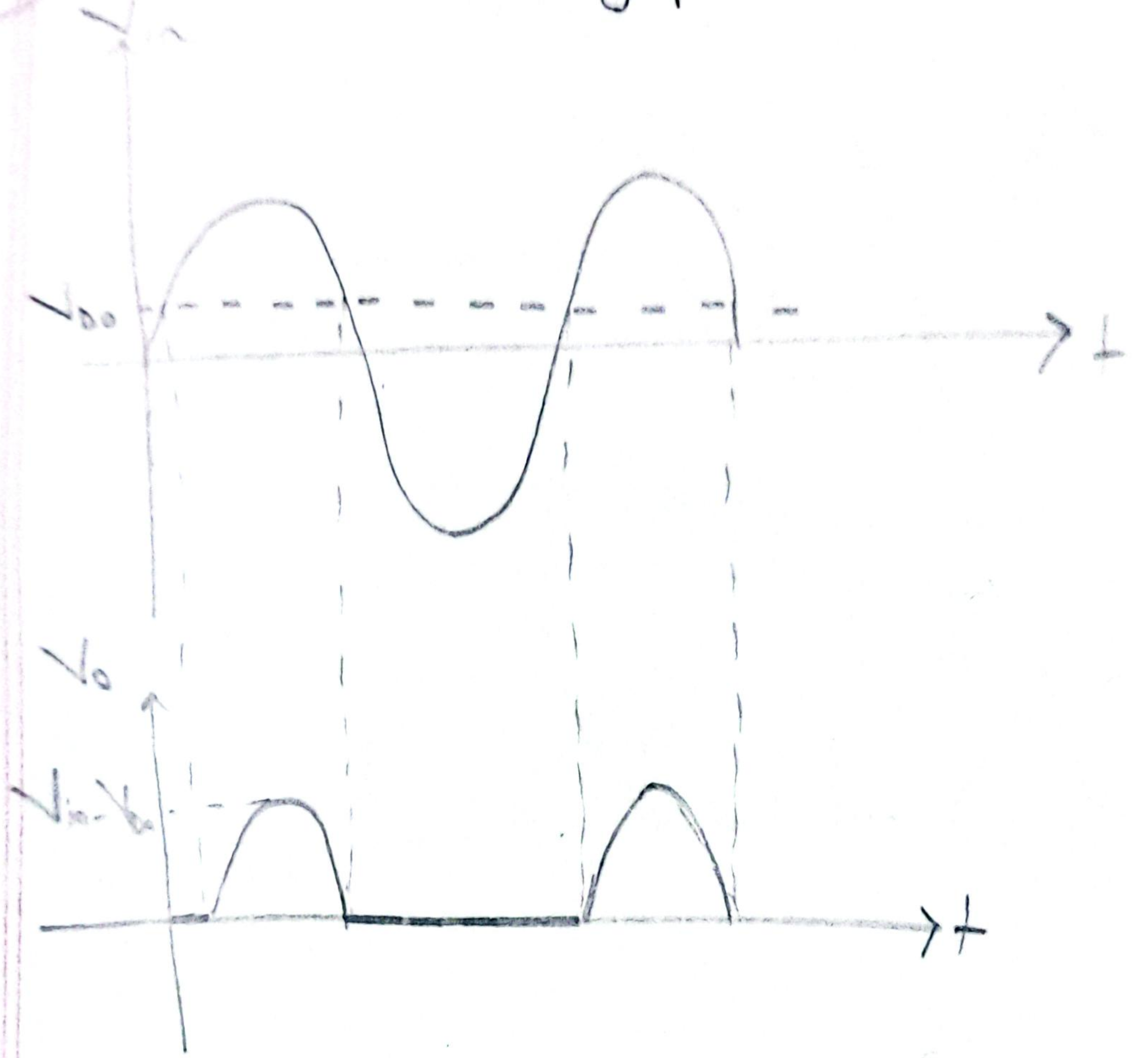


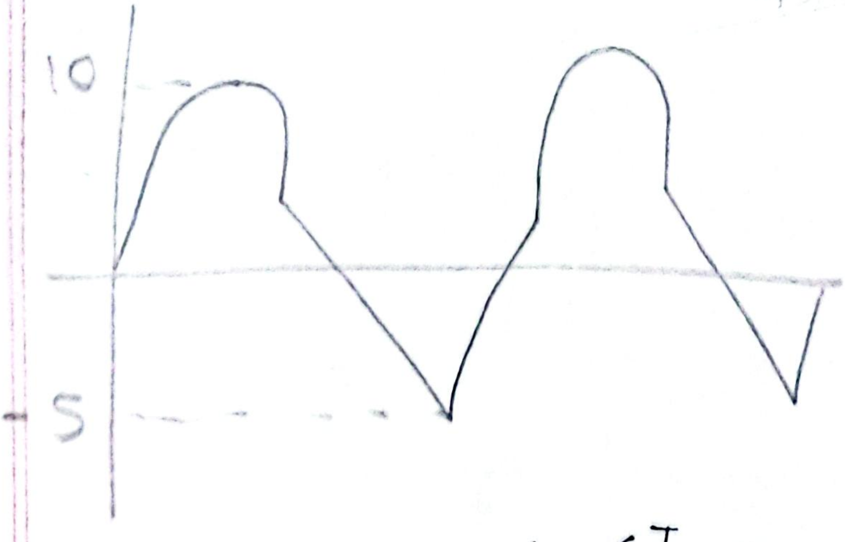
average of

V(ave

V_M = Input

1) Draw the V_o vs t graph from V_{in} vs t graph

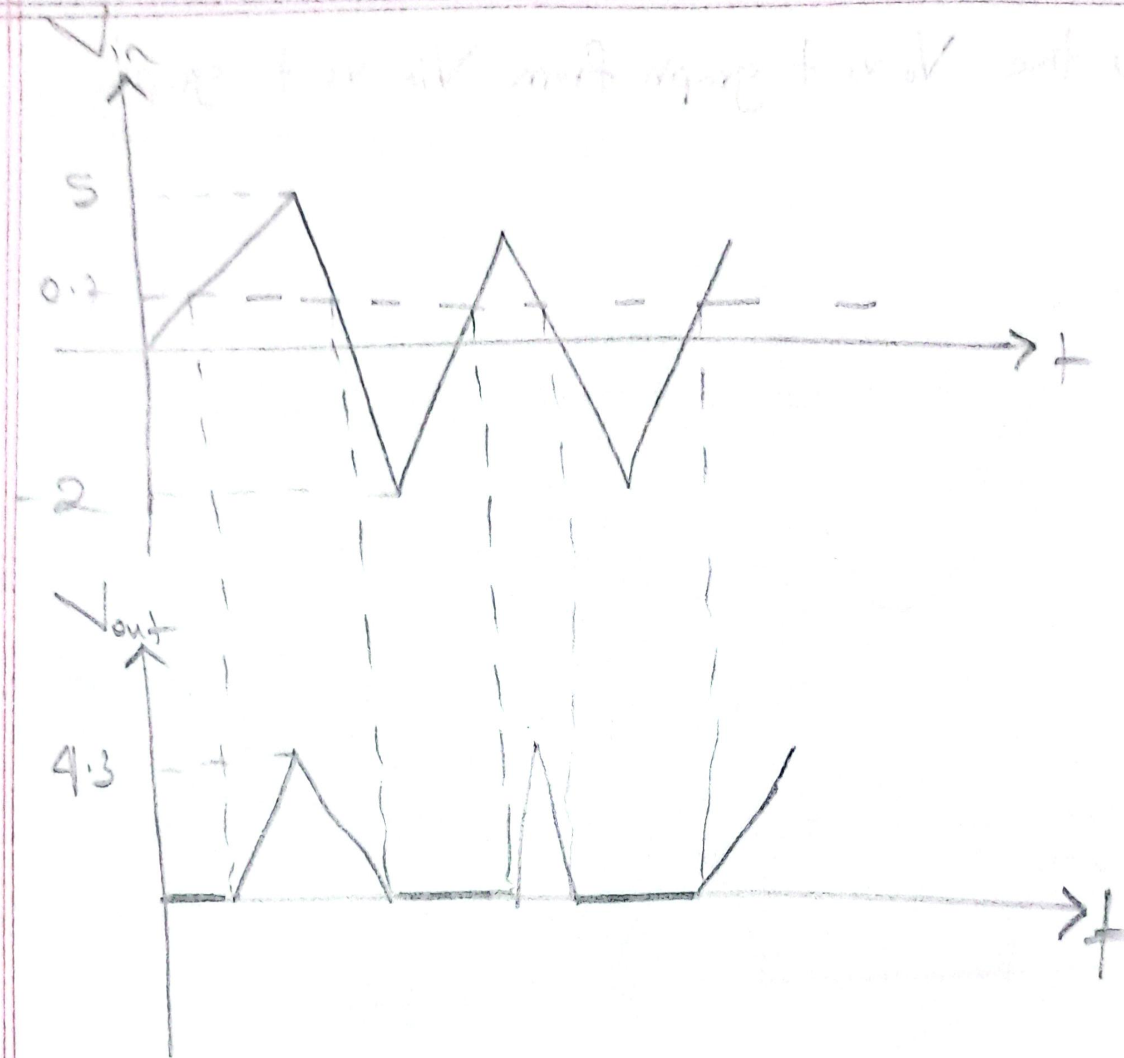




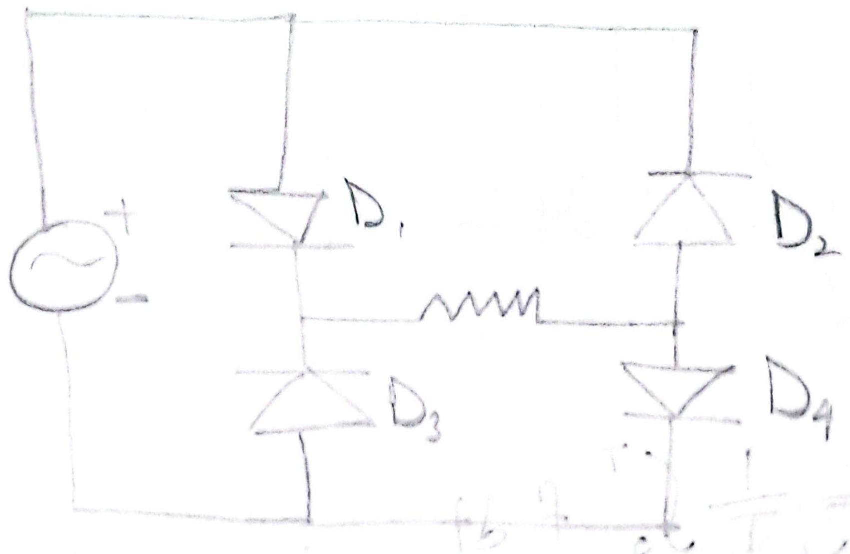
average of $f = \frac{1}{T}\int_0^T f\,dt$

$$V(avg) = \frac{V_m}{\pi} - \frac{V_{D0}}{2}$$

V_m = input peak V_{D0} =



Full-wave Rectifier



Positive Half Cycle

- D_1 and D_4 will be on for positive half-cycle

$V_o = V_{in} - 2V_{Do}$

$\boxed{V_{in} > 2V_{Do}}$ → For V_o to be positive

Negative Half Cycle

$V_o = -V_{in} - 2V_o$

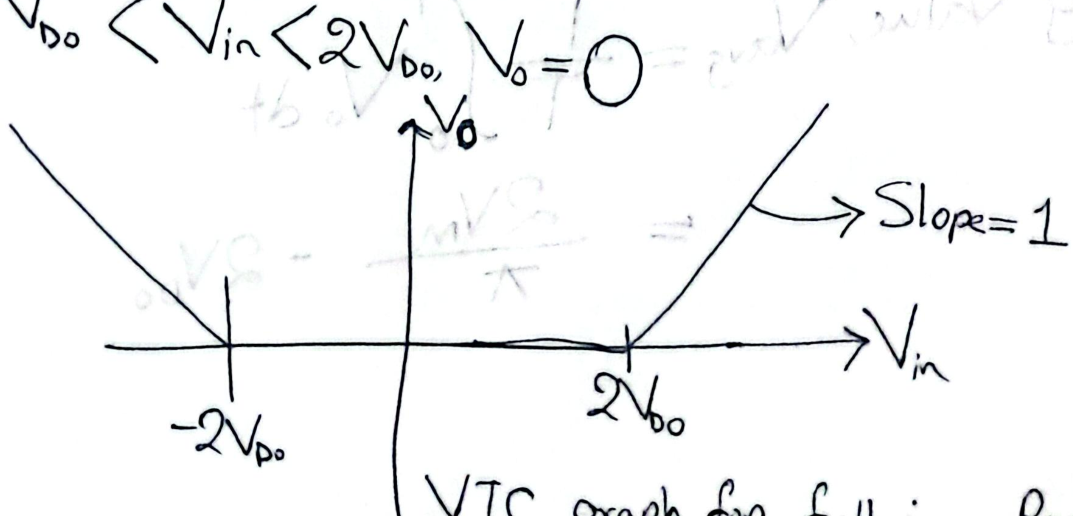
For,

$V_o > 0$

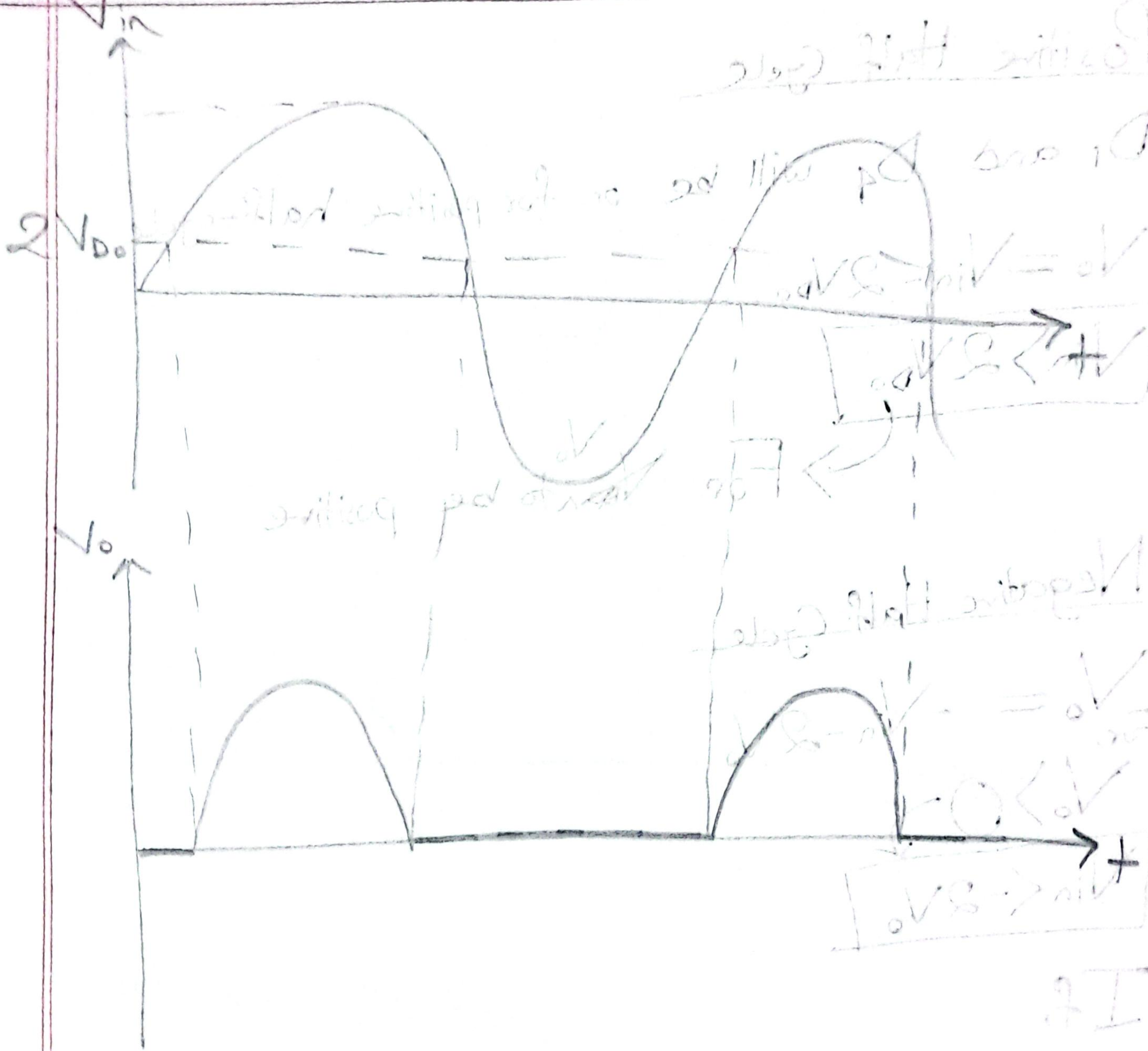
$\boxed{V_{in} < -2V_o}$

If,

$-2V_{Do} < V_{in} < 2V_{Do}$, $V_o = 0$

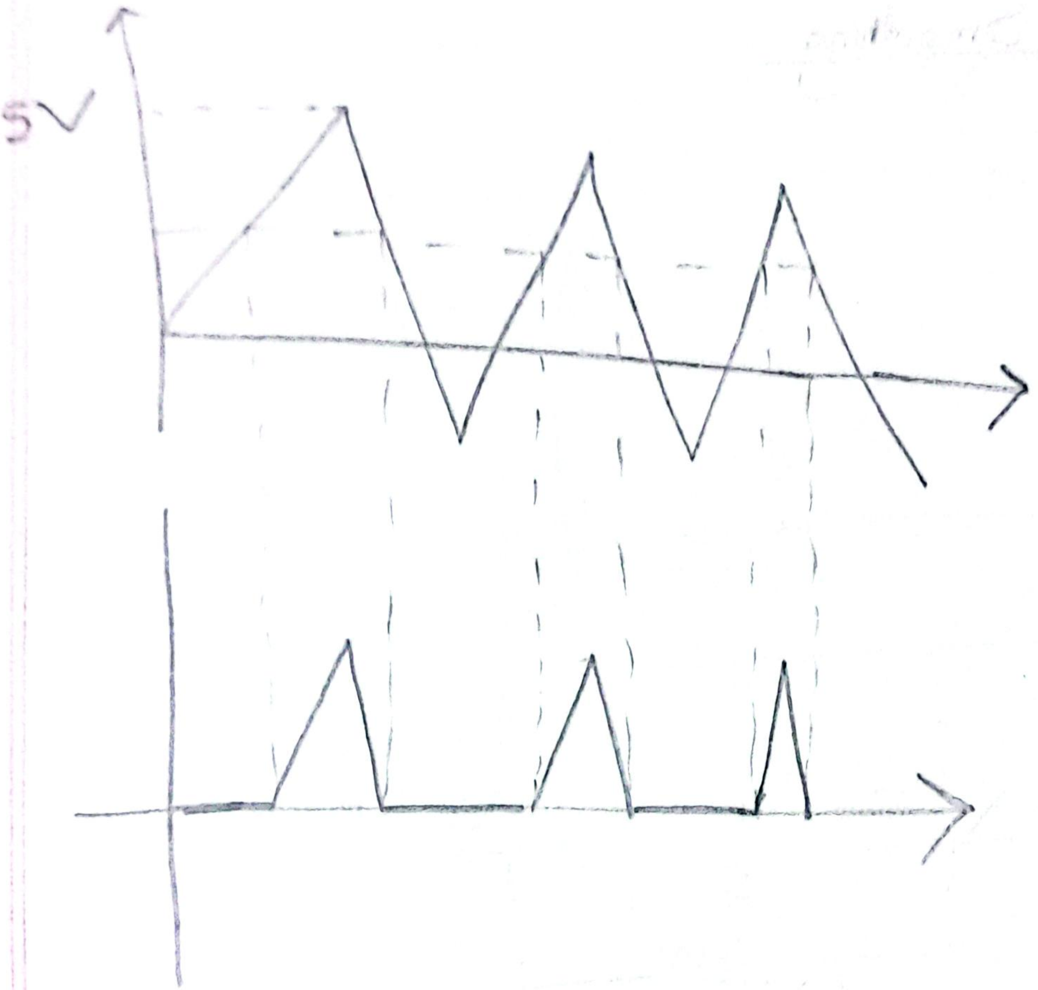


VTC graph for full wave Rectifier.



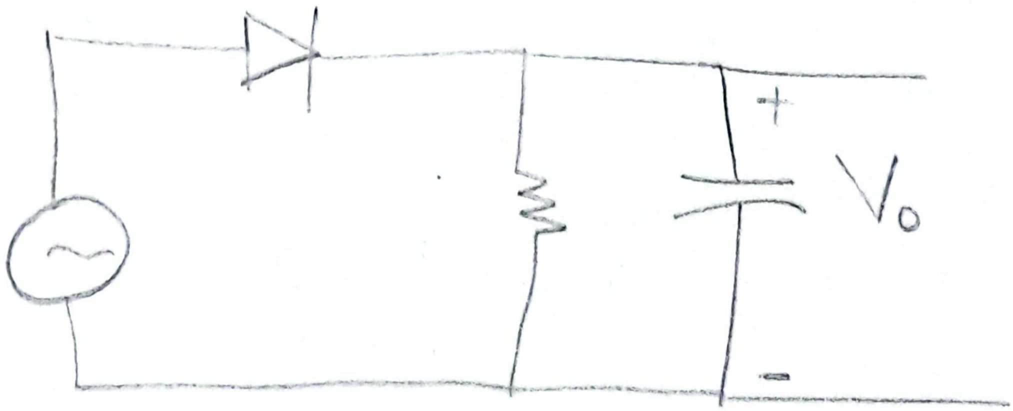
avg value, $V_{avg} = \frac{1}{T}\int_0^T V_o \, dt$

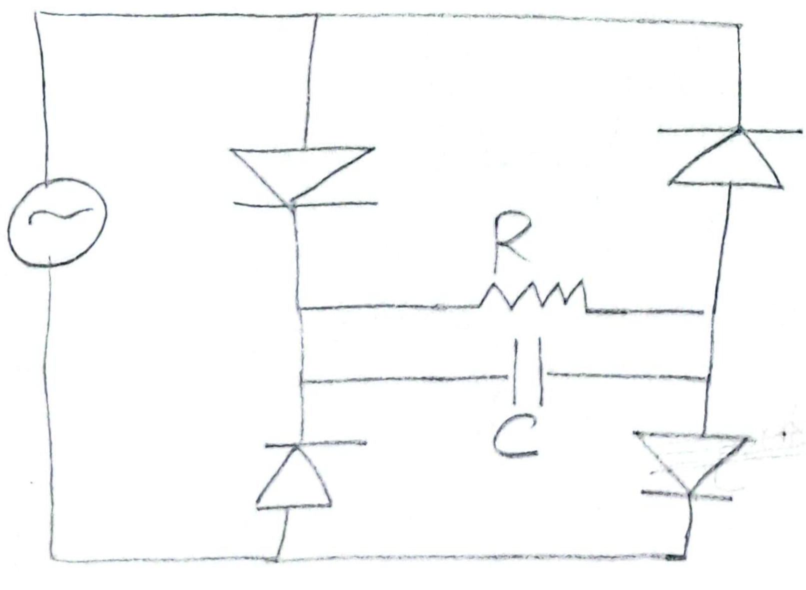
$$= \frac{2V_m}{\pi} - 2V_{Do}$$

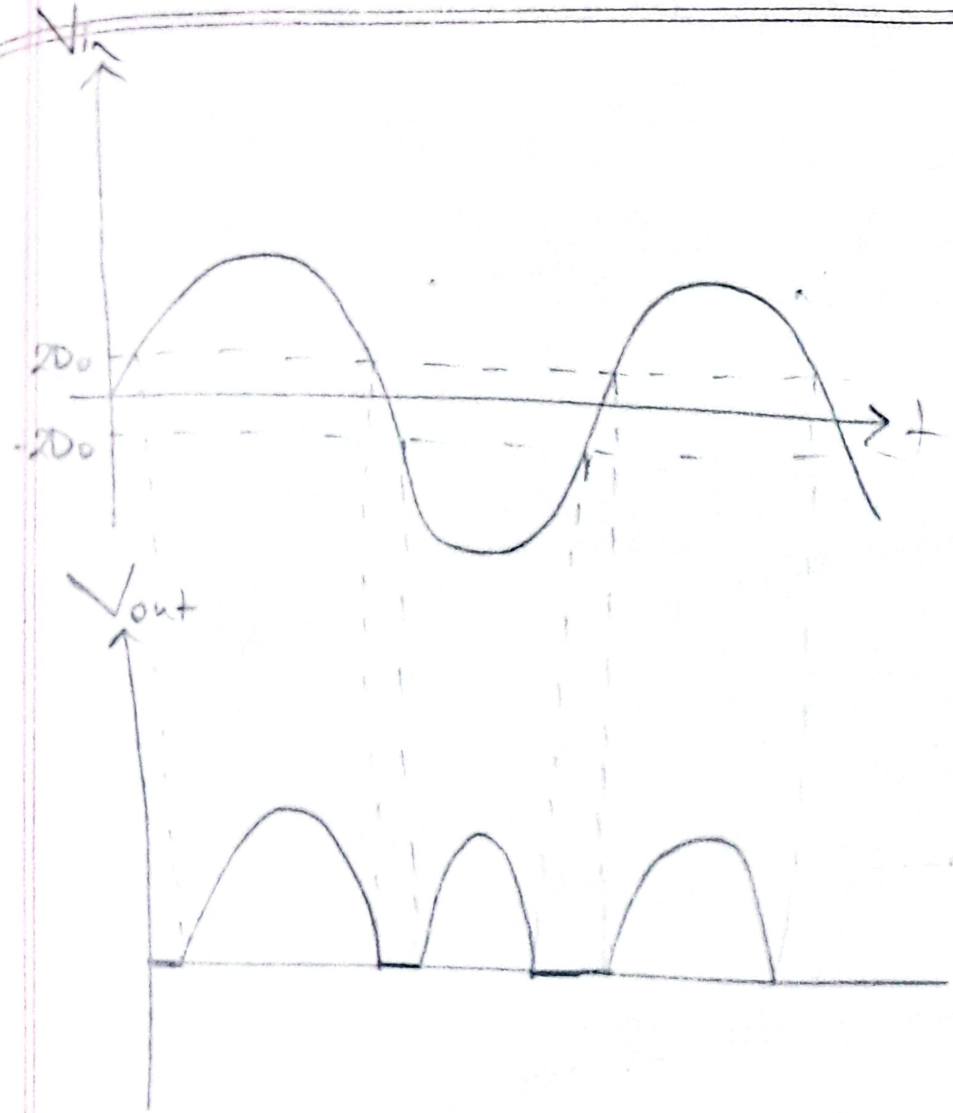


Capacitor Smoothing

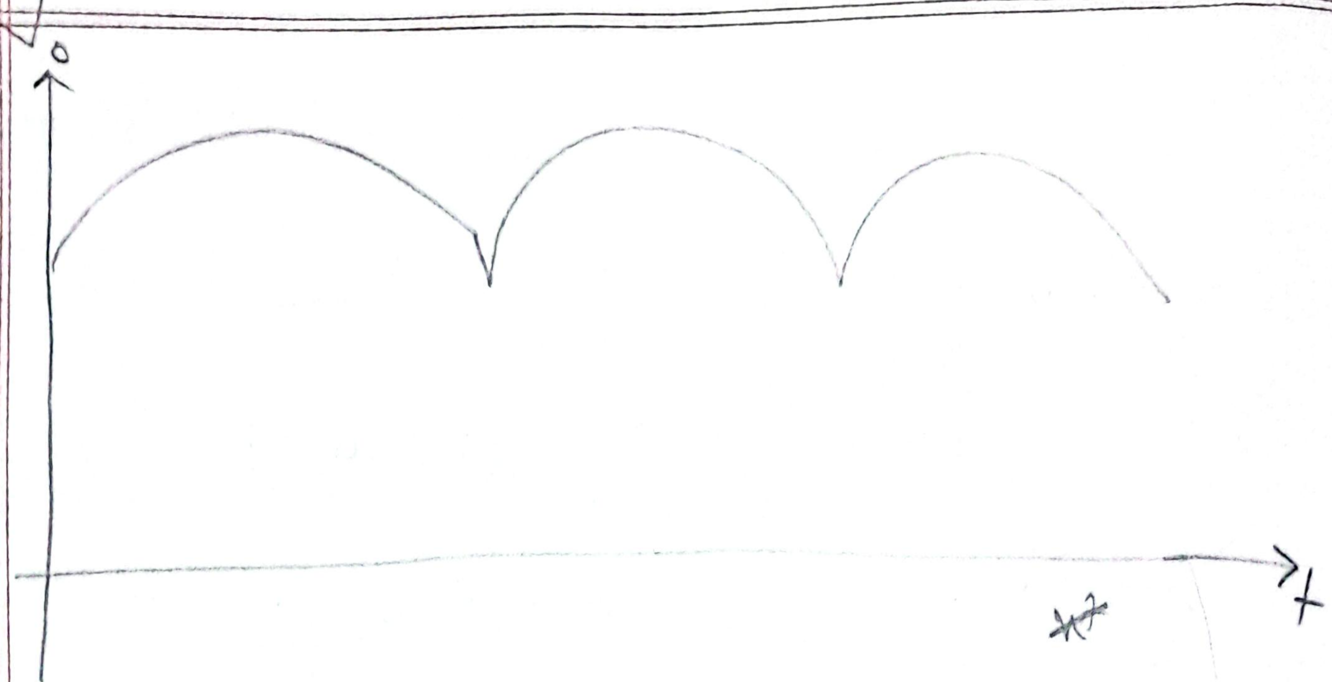
Capacitor Smoothing







V_{in}
20o
-20o
t
V_{out}



With capacitor

	Half-Wave	Full Wave	
Output Peak (V_P)	$V_M - V_{D0}$	$V_M - 2V_{D0}$	
Ripple frequency $f_R(f_o)$	f_1	$2f_1$	(This is output frequency)
V_{ripple} (peak-to-peak)	$\frac{V_P}{f_R \cdot R \cdot C}$	$\frac{V_P}{2f_R \cdot R \cdot C}$	f_R = Input frequency
$V_{ripple, rms}$	$\frac{V_{P(p-p)}}{2\sqrt{3}}$	$\frac{V_{P(p-p)}}{2\sqrt{3}}$	
V_{DC}	$V_P - \frac{V_{r(p-p)}}{2}$	$V_P - \frac{V_{r(p-p)}}{2}$	

Without Capacitor

	Half-Wave	Full-Wave
Peak Value V_p	$V_M - V_{D0}$	$V_M - 2V_{D0}$
Average Value V_{avg}/V_{Dc}	$\frac{V_M}{\pi} - \frac{V_{D0}}{2}$	$\frac{2V_M}{\pi} - 2V_{D0}$

V_M = input peak

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Lecture-11

Past Midterm questions

Fall-2022

4) $V_1 = 8\sin(100\pi t)$ $V_M = 8$

$R = 10\times10^3$

$V_{D0} = 0.8V$

$f_0 = 100Hz$

a) ~~Half~~ Full-wave rectifier is used

b) SKIP

c) Draw the two graph

d) $V_{DC} = \frac{2V_m}{\pi} - \cancel{\frac{V_{D0}}{2}}\ 2V_{D0}$

$= \cancel{\frac{8}{\pi} - \frac{0.8}{2}}$

$= \cancel{2.16}\ \cancel{2.146V}\ 3.5V$

$V_P = V_M - V_{D0} = \cancel{7.2V}\ 6.4V$

$$V_{r(p-p)} = \frac{5}{100} \times \cancel{7.2}$$

$$= \cancel{0.36V}\ 0.32V$$

e) $$V_{r(p-p)} = \frac{2V_p}{f_R \cdot R \cdot C}$$

$$0.36 = \frac{\cancel{7.2}\ 2 \times 6.4}{100 \times (10,000) \times C}$$

$$C = 2 \times 10^{-5}\ C$$
$$= 20\mu F$$

f) $$V_{dc} = V_p - \frac{V_{r(p-p)}}{2}$$

$$= \overset{6.4}{\cancel{7.2}} - \frac{0.3\cancel{6}2}{2}$$

$$= \cancel{7.02}\ 6.24V$$

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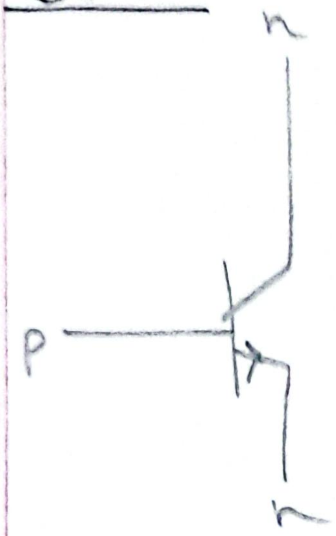
Lecture-15

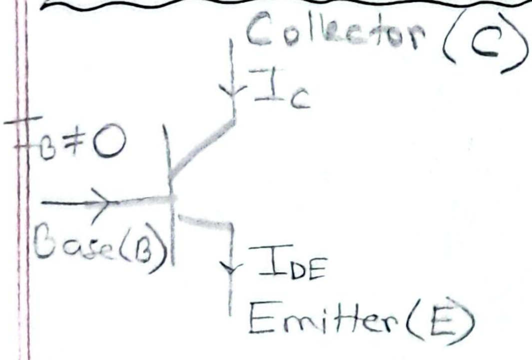
BJT

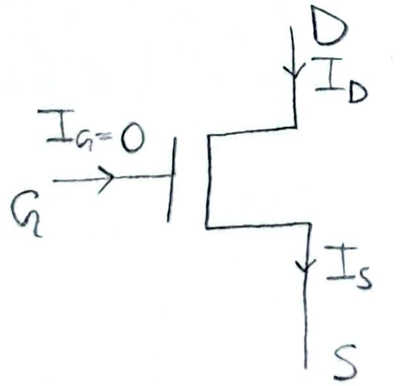


npn-BJT

pnp-BJT

BJT vs MOSFET





$I_B + I_C = I_E$

Since $I_G = 0$,
$I_D = I_S = I_{DS}$

- MOSFET is voltage controlled and BJT is current controlled.

MOSFET vs BJT (I-V graph)

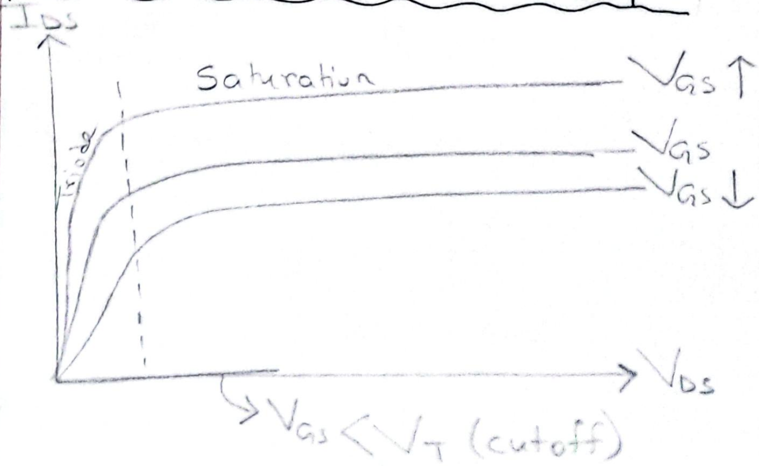
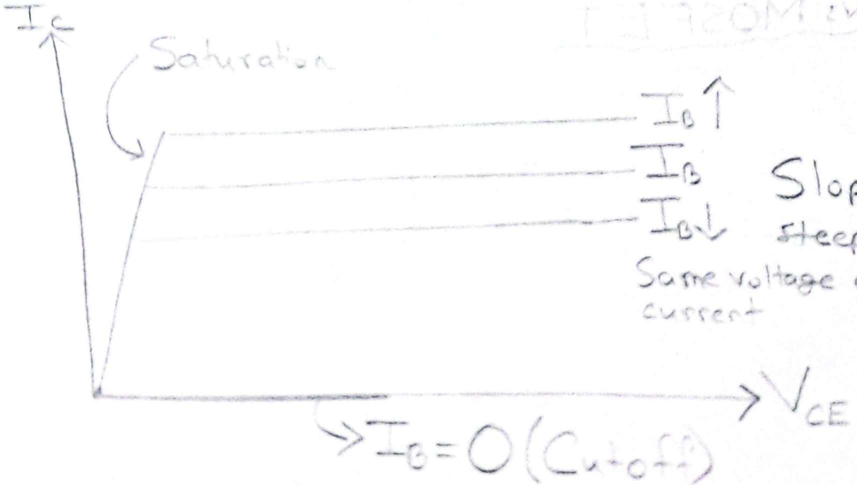


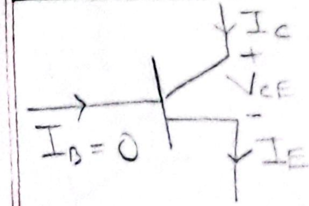
Fig: MOSFET graph



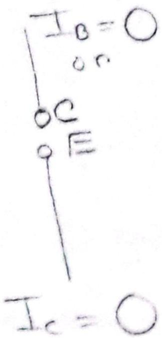
Slope same, steeper high

Same voltage gives more current

BJT-S Model

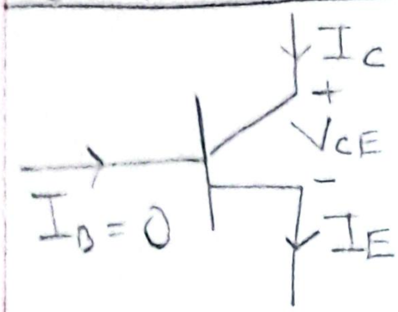


When $I_B < I_{Th}$

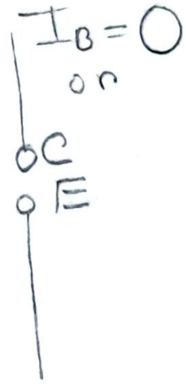


When $I_B > I_{Th}$

BJT-S Model



When $I_B < I_{Th}$



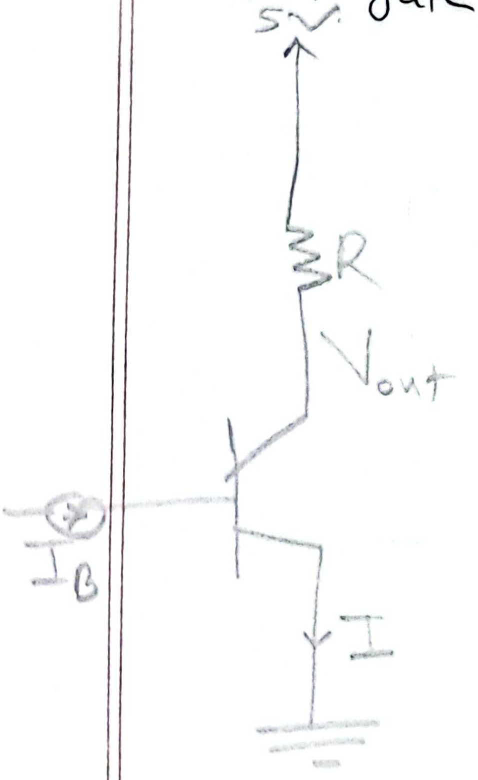
$I_C = 0$

When $I_B > I_{Th}$ (0.5mA)

$V_{CE} = 0$

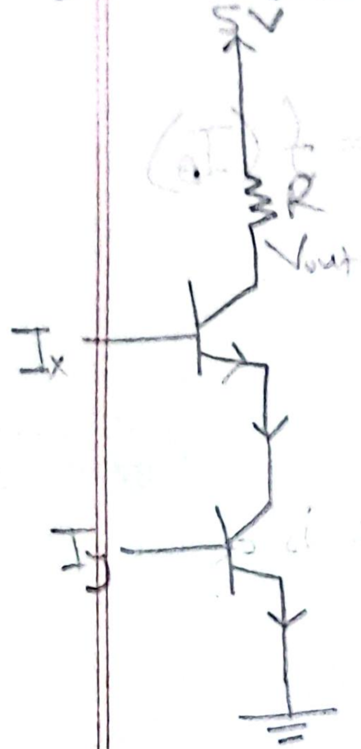
Logic Function with BJT

1) NOT gate

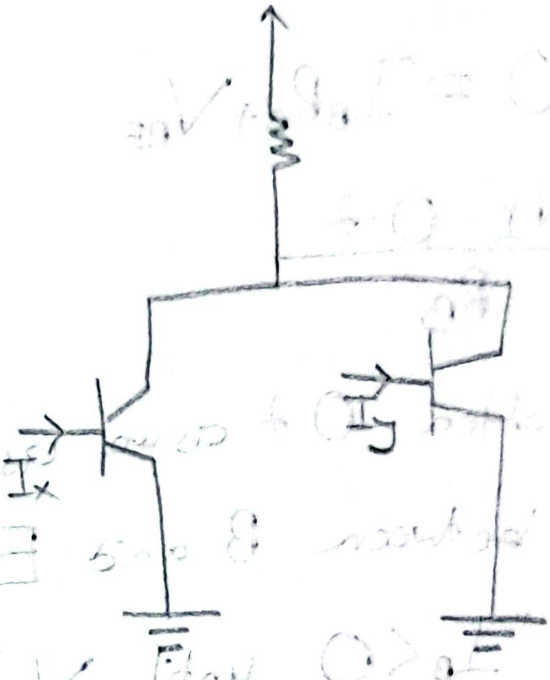


NOT gate with BJT / inverter

2) NAND gate



3) NOR gate



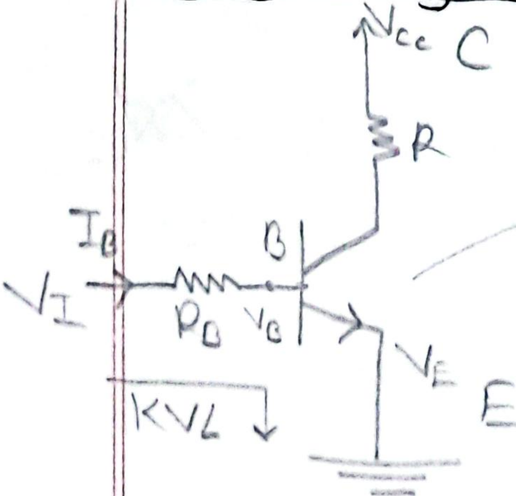
NOR gate

NAND gate

Drawback of BJT

1) We cannot cascade BJT directly
2) No current source exist to drive BJT

V to I using R



→ Voltage Controlled BJT

KVL:

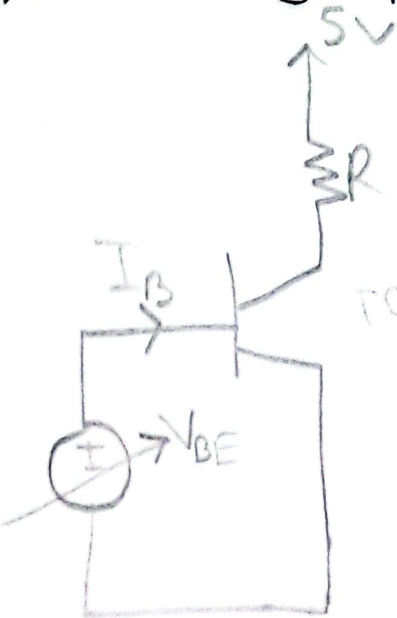
$$V_I - 0 = I_B R_B + V_{BE}$$

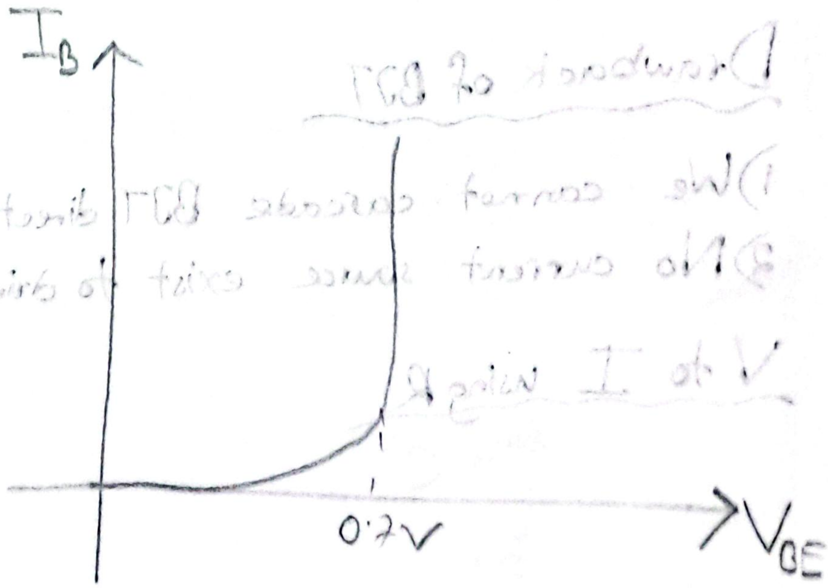
$$V_{BE} = f(I_B)$$

$$I_B = \frac{V_I - 0.7}{R_B}$$

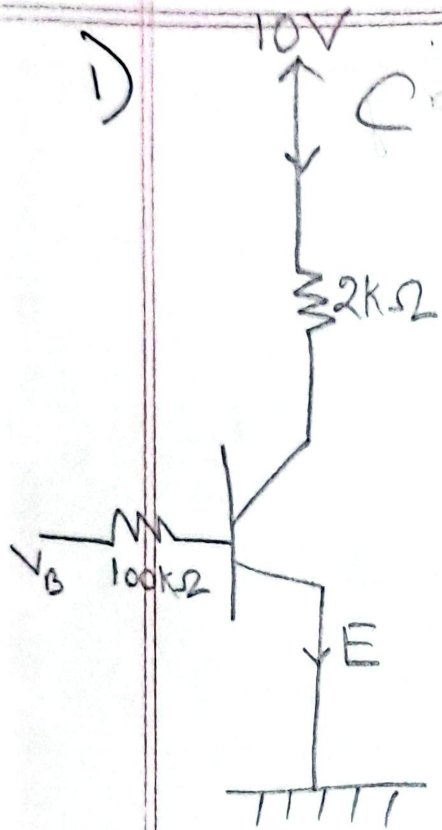
- V_{BE} is often 0.7 as we assume there is a diode between B and E.
- Hence $I_B < 0$ until $V_I < 0.7$

I-V graph of BJT





1)



Given,

$I_{Th} = 0.2mA$

Q) Find V_{In} for $I_B \geq I_{Th}$

If BJT is ON,

$V_{BE} = 0.7$

$V_B = I_B R_B + 0.7$

$V_B = (0.2 \times 100) + 0.7$

$= 20 + 0.7$

$= 20.7$

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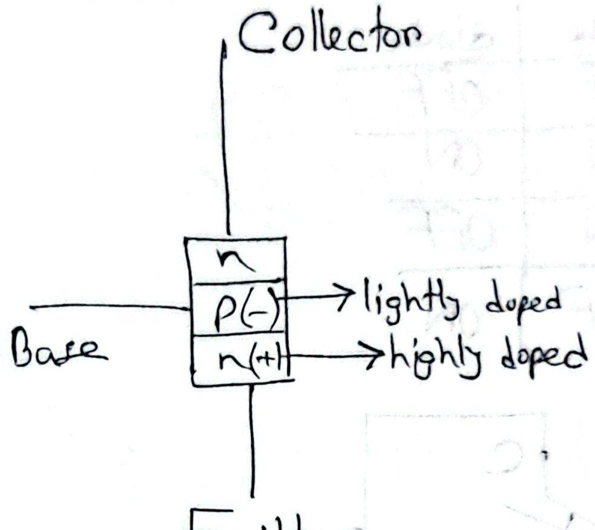
Circuit diagram



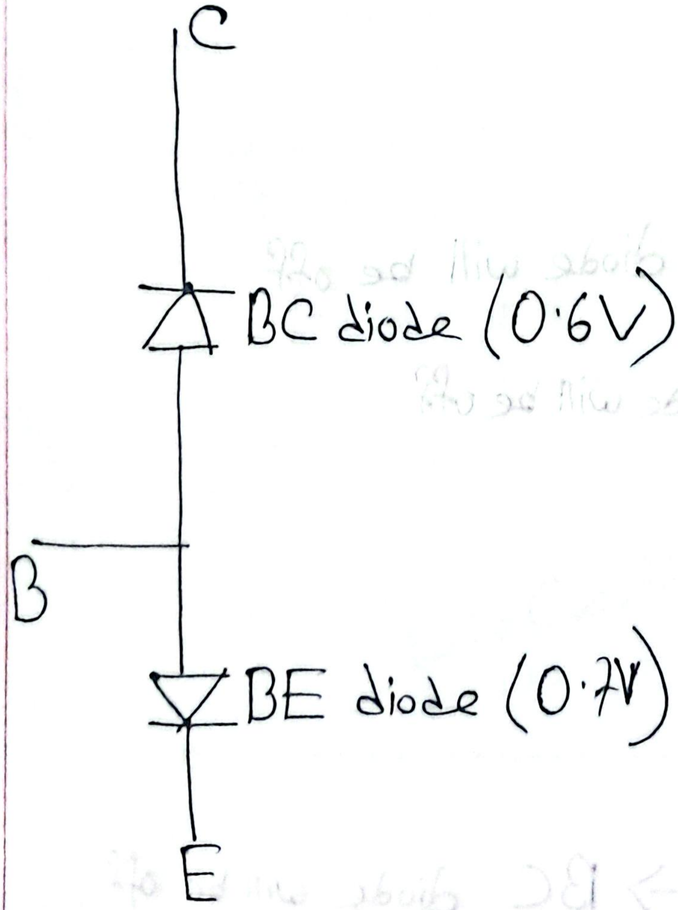
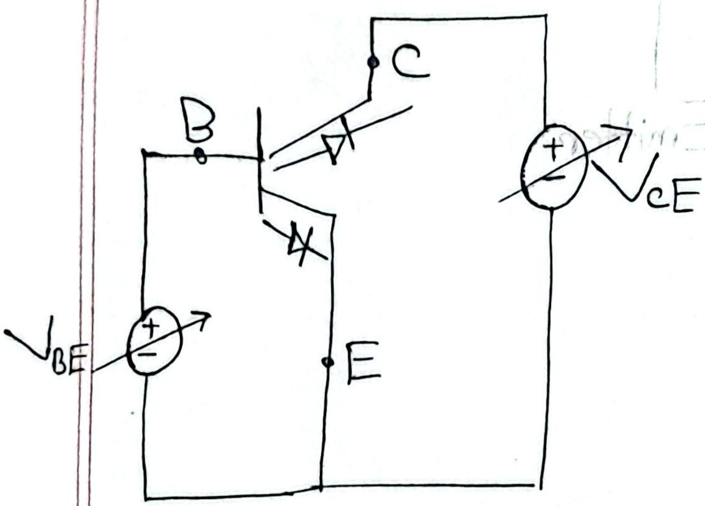


Fig: Diode Equivalent Circuit

	BE diode	BC diode
Cutoff	OFF	OFF
Saturation	ON	ON
Active	ON	OFF
Reverse-Active	OFF	ON



$V_{BE} < 0.7$ then BE diode will be off

$V_{CE} < 0.7$ then CE diode will be off

$V_{BC} < 0.7$

$(V_B - V_C) < 0.6$

$(V_B - V_E) - (V_C - V_E)$

$\therefore$ If

$\boxed{V_{CE} > V_{BE} - 0.6} \longrightarrow$ BC diode will be off

1) Cutoff

BE diode off

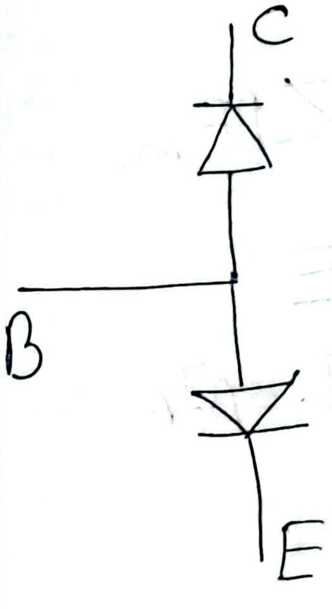
$V_{BE} < 0.7$

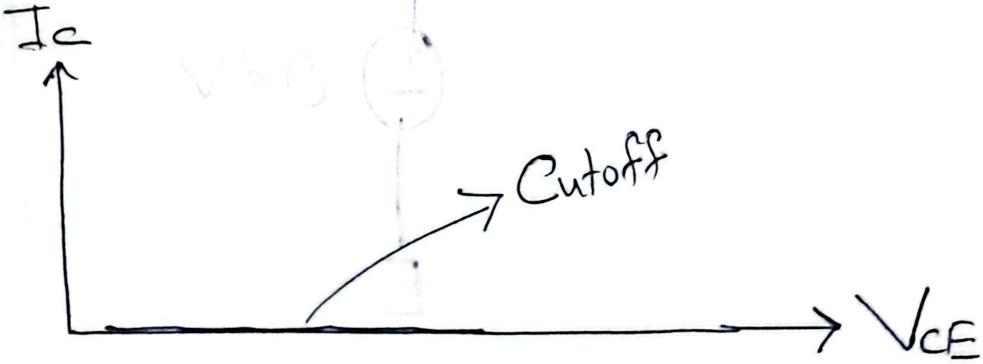
BC diode off

$V_{CE} > V_{BE} - 0.6$

Condition for cutoff,

$I_B = I_C = I_E = 0$





ii) Active

BE ON

$I_B > 0$

BC off

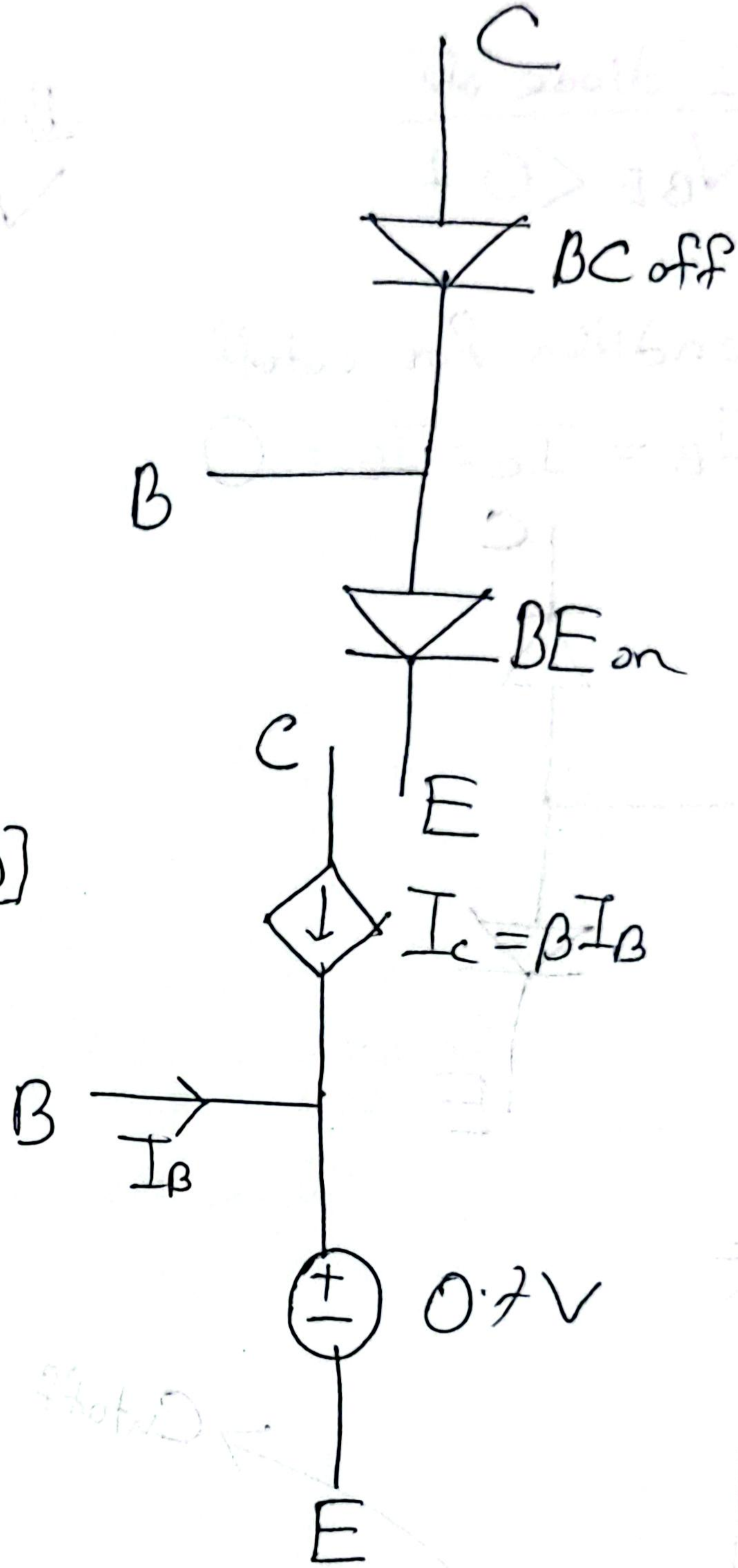
$V_{CE} > V_{BE} - 0.6$

In active mode

$$\boxed{I_C = \beta I_B}$$

β = Constant [50~200]

$\beta \sim 80$



For all modes,

$$I_E = I_B + I_C$$

For active mode,

$$I_E = I_B + \beta I_B$$

$$I_E = I_B(1+\beta)$$

$$\cancel{I_E}$$

$$I_E = \frac{I_C}{\beta} + I_C$$

$$I_E = \left(1 + \frac{1}{\beta}\right) I_C$$

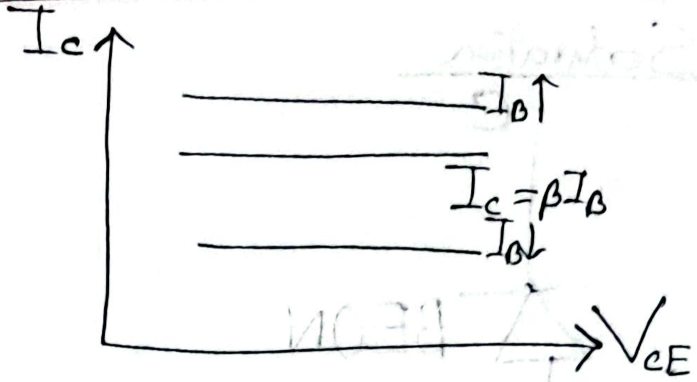
$$I_E = \frac{1+\beta}{\beta} I_C$$

$$\boxed{\begin{aligned} \alpha &= \frac{\beta}{1+\beta} \\ I_C &= \alpha I_E \end{aligned}}$$

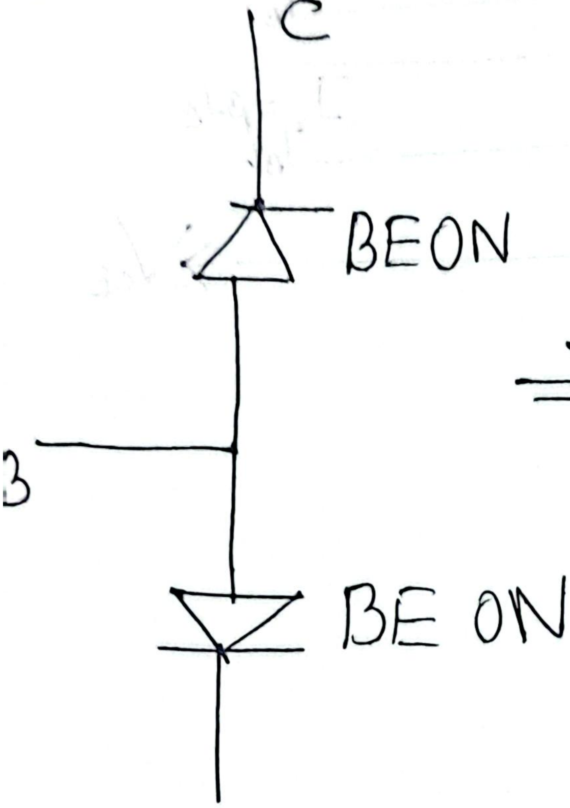
If $\beta = 100$

$$I_C = 100 I_B$$

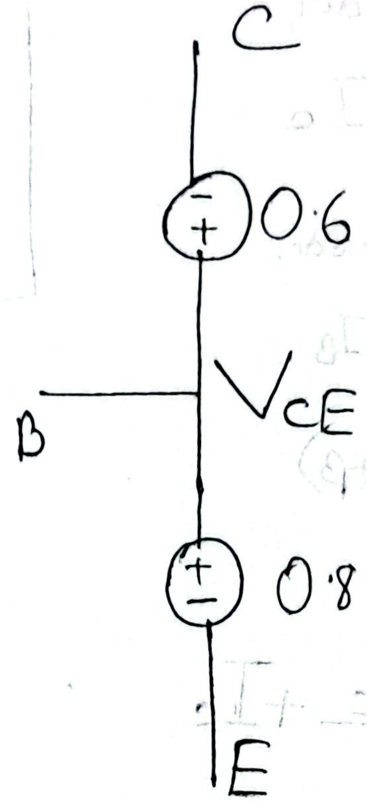
$$I_E = 0.99 I_C$$



III) Saturation



$\Rightarrow$



$$V_{CE} = \cancel{V_C - V_E}$$
$$= -V_C + V_E$$
$$= -0.6 + 0.8$$
$$= 0.2V$$

F

Cutoff	Triode	Saturation
$V_{GS} < V_{th}$	$V_{DS} < V_{ov}$	$V_{DS} > V_{ov}$

For Active,

$$\beta = \frac{I_c}{I_B}$$

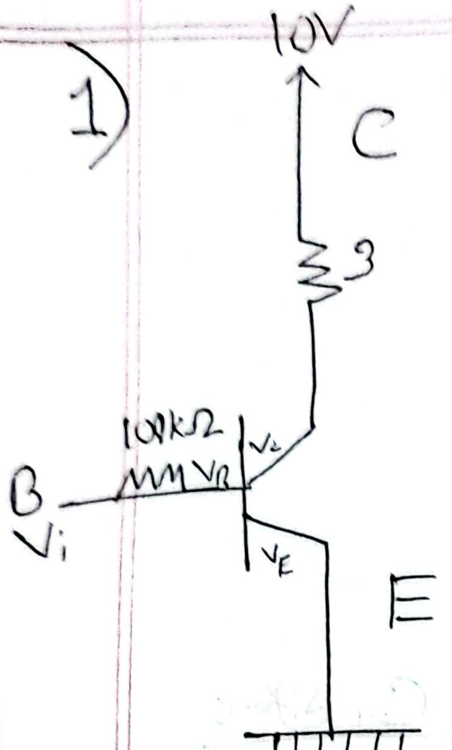
For saturation,

$$\frac{I_c}{I_B} < \beta$$

Summary

State	Equation	Conditions
Cutoff	$I_c = I_B = I_E = 0$	$V_{BE} < 0.7$ $V_{CE} < 0.5$
Active	$V_{BE} = 0.7$ $\frac{I_c}{I_B} = \beta$ $I_E = \alpha I_c$ $\alpha = \frac{\beta}{1+\beta}$	$V_{CE} > 0.2V$ $V_i = I_B R_B + V_{BE}$ $I_c = \beta I_B$ $I_E = \beta I_B + I_B$
Saturation	$V_{BE} = 0.8V$ $V_{CE} = 0.2V$	$\frac{I_c}{I_B} < \beta$

1)



$V_{in} = 1V$ $\quad \beta = 100$

$\therefore$ ~~$V_B = 1V$~~

$V_E = 0V$

Assumming Cutoff,

$V_B = 1V$ (Since, $i_B = 0$)

$V_C = 10V$ (Since $i_C = 0$)

$V_E = 0V$ (Since ground)

$V_{BE} = V_B - V_E$

$= 1V > 0.7$

$V_{BC} = V_B - V_C$

$= 1 - 10$

$= -9V < 0.5$

Since $V_{BE} > 0.7$ the BJT is not in cutoff

Assumming Active mode,

$V_{CE} > 0.7V$

$V_{BE} = 0.7V$

$V_B - V_E = 0.7$

$V_B - 0 = 0.7$

$V_B = 0.7V$

$I_C = \beta I_B$

$$I_B = \frac{V_B - V_{in}}{100}$$

$$= \frac{1 - 0.7}{100}$$

$= 0.003mA$

$I_C = 0.3mA$

$I_E = 0.99 \times 0.3$

$= 0.297mA$

$$\frac{10 - V_C}{3} = 0.3$$

$V_C = 9.1V$

$V_{CE} = 9.1V$

Since $V_{CE} > 0.2$, BJT is in active mode