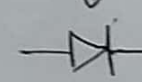
L9

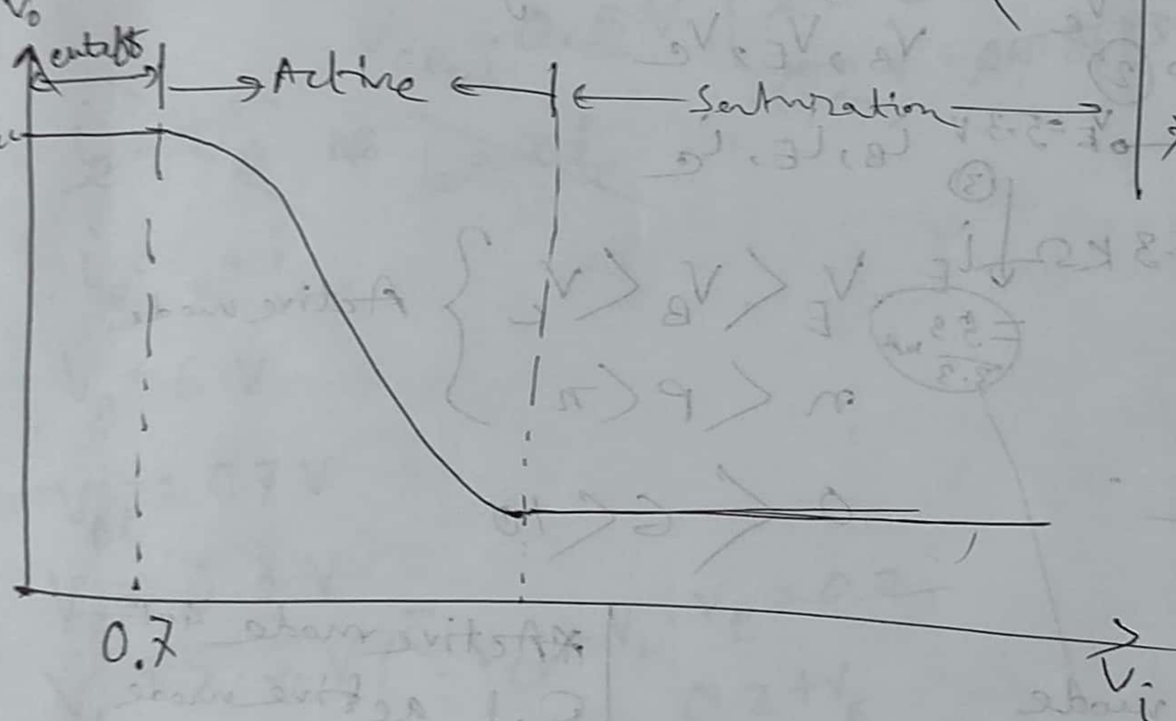
BJT

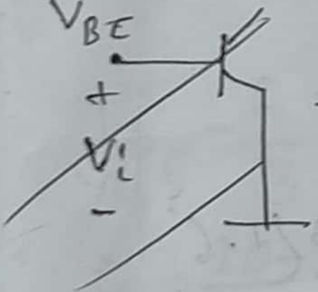
L1 → I-V characteristics → Input
→ Output

V_{cc} → src collector [illegible] connected
V_{BB} → " base " "
V_{EE} → " Emitter " " "

* BJT → 3 terminal device
* 3rd terminal is for control







Mode of operation

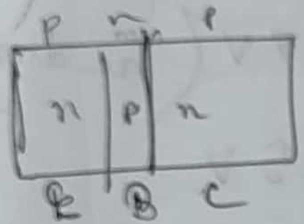
	E-B jnc	C-B jnc
Cut off	Rev	Rev
Active	Fwd	Rev
Reverse Active	Rev	Fwd
Saturation	Fwd	Fwd

Fwd = Forward Biased
Rev = Reverse "

Transfer Resistor = Transistor → BJT (Bipolar Junction Transistor)
→ FET (Field Effect Transistor)

For BJT: (Onset Vaccum Tube use করত হত ??)

* 2 ধরনের charge carrier → Majority
                          → Minority



for amplifier: Fwd. Active/Active
& Reverse Active mode ব্যবহৃত হয়
(Forward Active বেশি)

Switch → Saturation & Cut off mode

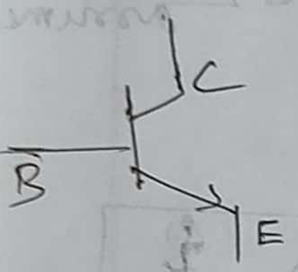
(1) Basic Circuit Configs:

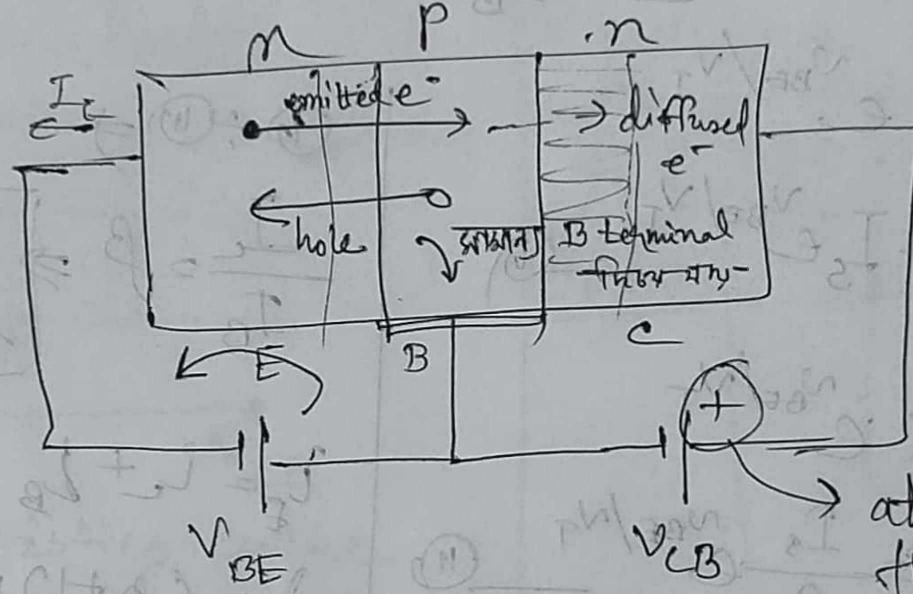
(i) CE (ii) CB (iii) CC → dummy, buffer (i/p → i_B, o/p → i_E)

→ CE = Common Emitter Config
CB = " Base "
CC = " Collector "

i/p: base input current (unless CB config)
o/p: collector current (" CC ")

BJT (Fwd. Active Mode)





attracts the e⁻ of base emitted from E

* diffusion হয় E থেকে (due to V_{CB}, ⇇ $\vec{E}$)
* কিছু e⁻, base (p type) এর h^+ এর সাথে combined হয়। Let, α সংখ্যক h^+ neutralized হয়েছে। ∴ α সংখ্যক h^+ কমে গেল। ∴ Base থেকে h^+ আসবে। (hence I_B)
* We want I_C ↑ ∴ base width ↓, collector width ↑
* V_{CB} ↑ depletion region (of B-C jnc) ↑

for this base width ↓, base doping ↓

base width ↓ → So that electrons don't wear out

base doping ↓ → to reduce recombination

$\therefore I_E = I_B + I_C \qquad I_B \ll I_C \quad \therefore I_E \approx I_C$ [Sometimes assumed]

$i_c \to I_c \propto e^{v_{BE}/V_T}$

$\Rightarrow i_c = I_S e^{v_{BE}/V_T}$ —— (i)

$i_B \to I_B \propto e^{v_{BE}/V_T}$

$\Rightarrow i_B = \frac{I_s}{\beta} e^{v_{BE}/V_T}$ —— (ii)

α = ~~C B~~ CB current gain

β = ~~C E~~ CE current gain

CB = Common Base

CE = Common Emitter

(i) ÷ (ii) $\Rightarrow$

$$\frac{I_c}{I_B} = \beta \Rightarrow \boxed{\beta = \frac{i_c}{i_B}}$$

$$i_E = i_c + i_B$$

$$\Rightarrow i_E = (\beta + 1) i_B$$

$$\therefore i_E = \left(\frac{\beta+1}{\beta}\right) i_c$$

$$\Rightarrow i_E = \frac{i_c}{\alpha}$$

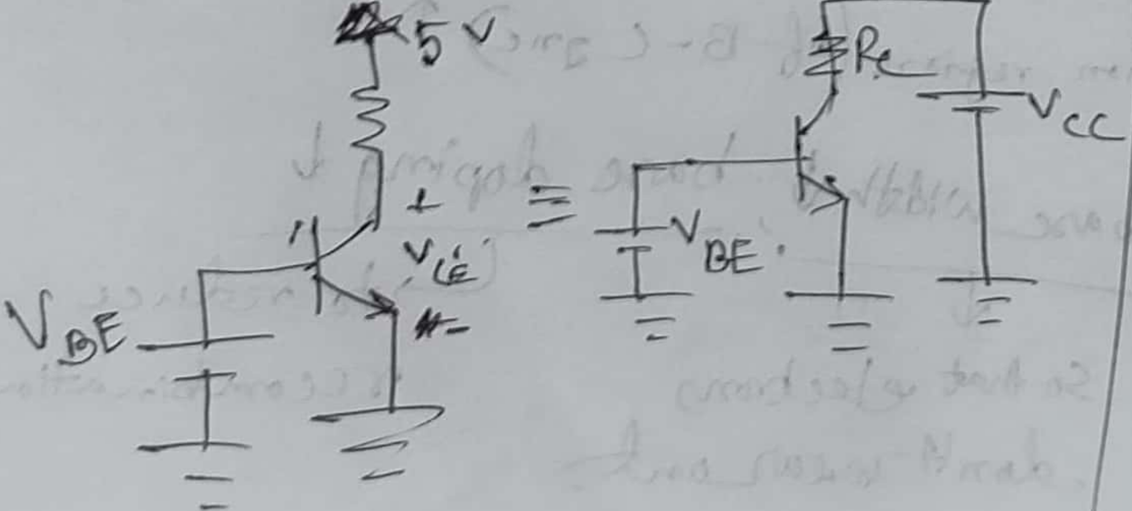
$\alpha = \frac{\beta}{\beta+1}$ (def^n)

$$\boxed{\alpha = \frac{i_c}{i_E}}$$

$i_c = \alpha i_E + I_{CBO}$

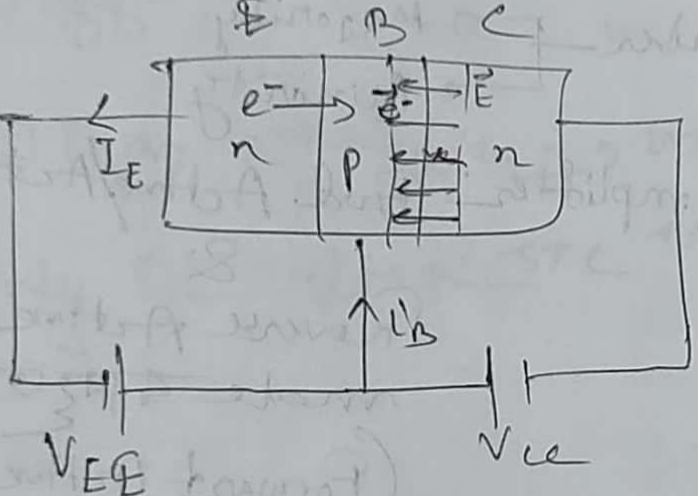
I_{CBO}: reverse saturation current (C-B junction)

$I_{CBO} \to$ can be ignored



Saturation Mode:

$\vec{E}$ = electric field



threshold voltage:

$V_{BE} = 0.7\,V$ (like diodes)

$V_{BC} = 0.5\,V$

$V_{CE} = V_{CB} + V_{BE}$

$= -V_{BC} + V_{BE}$

$= (-0.5 + 0.7)\,V = 0.2\,V$

$\therefore (V_{CE})_{sat} = 0.2\,V \rightarrow$ for ~~mathematical~~ mathematical problems

* V_{EE} = const থাকলে, V_{CC} বাড়ানো হলে, emitter থেকে base এ e^- এসে বিপরীতমুখী $\vec{E}$ face করবে। ∴ e will be attracted towards C. $\vec{E}\uparrow$ with the increase of V_{cc}, $\therefore i_c \downarrow$

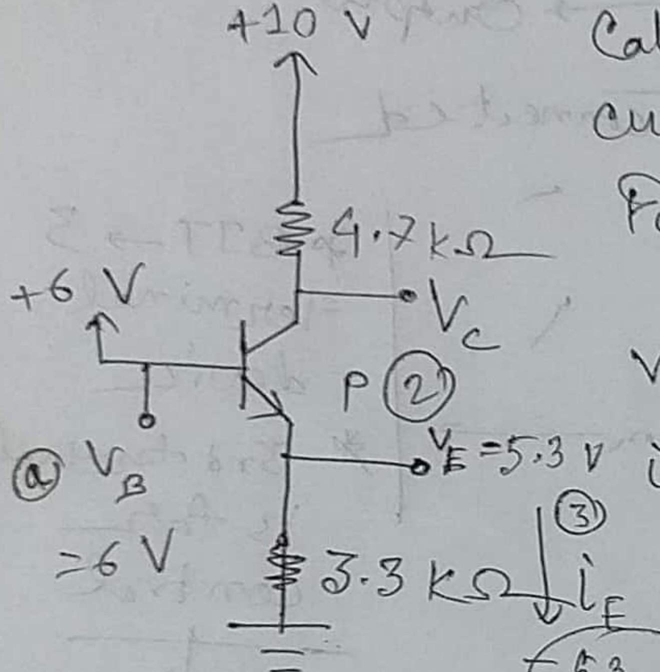
$$\beta = \frac{i_c}{i_B}$$

$i_c \downarrow\ \beta \downarrow$ হবে

$\therefore$ so $\beta \neq$ const, β কে β_{forced} দ্বারা denote করা হয়।

BJT Ckt. at DC L10 18/12/23

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

ⓐ $V_B = 6$ V

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

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

~~0 < 6~~

$0 < 6 < 10$

Assume, active mode

$V_{BE} = 0.7$ V [∵ B-E in fwd. bias]

Active mode মানে Fwd. active mode বুঝায়।

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

$3.3) 5.3 (1.6$
$\underline{3.3}$
200

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

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

ⓒ $V_C = 10 - 4.7 i_C$
$= 2.48$ V

We got → $V_E < V_B \nless V_C$
$5.3 < 6 \nless 2.48$

∴ Assumption wrong

Assuming, Saturation mode

$V_E < V_B > V_C$,

$\Rightarrow n < p \quad n$

Assume: for sat. mode:

$V_{CE_{sat}} \approx 0.2\,V$ [2 টাই fwd bias এ থাকলে 0.2 V এর মত হয়]

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

$i_E = i_B + i_C$

$V_B = 6\,V$

$V_{BE} = 0.7\,V$

$V_E = 5.3\,V$

$V_C = 5.5\,V$ $\left[\because V_{CE} = V_C - V_E = 0.2 \quad V_C = 0.2 + V_E = (0.2 + 5.3)\,V = \boxed{5.5\,V}\right.$

$\downarrow i_E = \frac{5.3}{3.3} = 1.6\,mA$

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

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

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

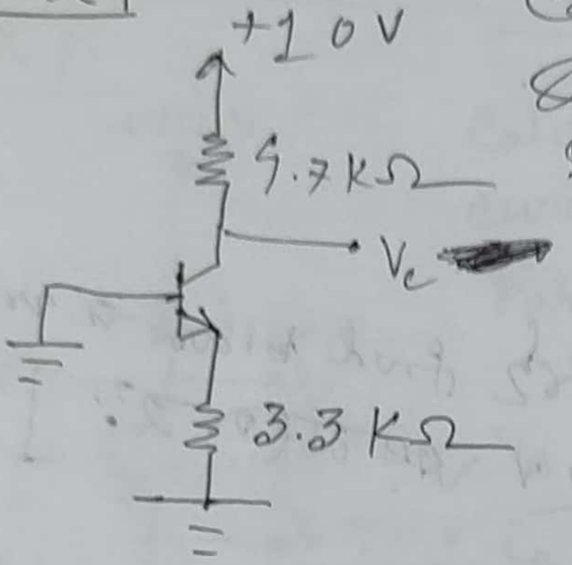
$\hookrightarrow \because$ sat. mode এ β আলাদা করে বের করা যায় না।

Pr2 |:

Calculate all node voltages & current.

For active mode, assume

$\beta = 100$.



* Assumption এভাবে:

+10V

0V | 0V বসাল।

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

~~n~~

* active ধরলে -ve আসবে :- সেটাই ঠিক হবে না,

অবশ্য current direction দিয়েও assumption check করার জন্য।

V_E	V_B	V_C
n	p	n
0	0	10

Rev   Rev

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

$i_E = i_B = i_C = 0\ A$

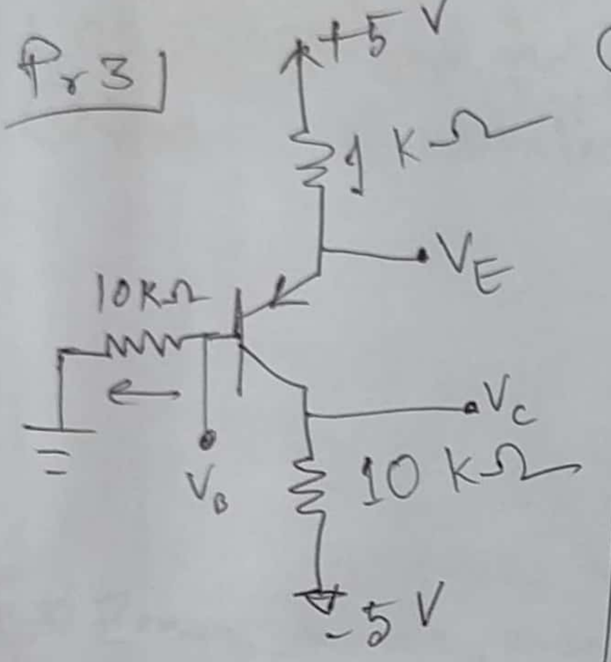
$\therefore V_C = +10\ V$

$V_B = 0\ V$

$V_E = 0\ V$

~~Pr3~~

Pr 3]



Calculate all node voltages and current.

For active mode, assume $\beta = 100$

~~Ans: Assuming saturation mode~~

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

⇒ Assuming, active mode:

i_B very small (μA range) → $i_B \simeq 0$

$\therefore V_B \simeq 0$ V

$V_E = 0.7$ V [∵ V_E বড় হবে]

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

$\therefore i_c \simeq i_E$ [∵ $i_B \simeq 0$]

$\therefore V_C = 10 i_c - 5$

$= 43 - 5 = 38$ V

Now,

E	B	C
p	n	p
0.7	0	38

Fwd. Fwd.

∴ Assumption was wrong

~~(Ans)~~

Assume saturation mode

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

$V_{EB} = 0.7$ V

$i_E = i_B + i_C$

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

Current dir:

$\cancel{5-(V_B+0.7)}$ $\quad i_B = \frac{V_B}{10}$ mA

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

$\Rightarrow$

$$i_C = \frac{V_C+5}{10} = \frac{V_B+5.5}{10} \text{ mA}$$

$i_E = i_B + i_C$

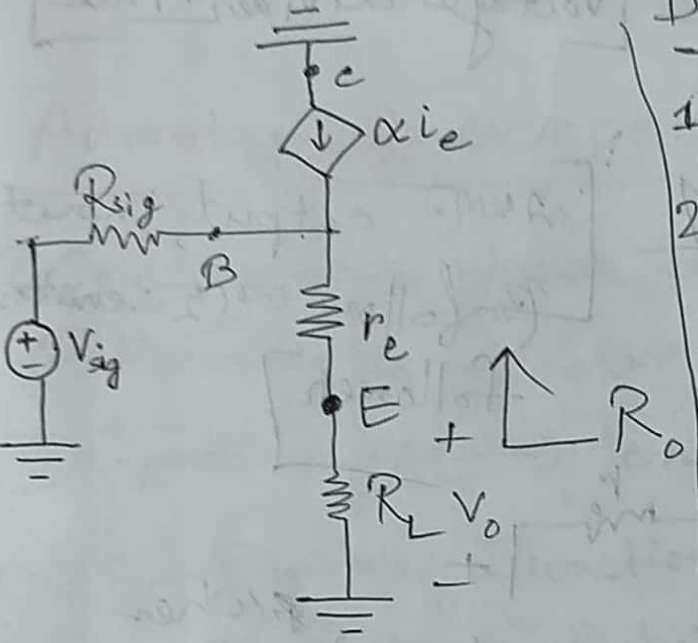
$\Rightarrow \cancel{\frac{V_B}{10}}\, 5 - V_E = \frac{V_B}{10} + \frac{V_B}{10} + \frac{5.5}{10}$

$\Rightarrow 5-0.7-V_B = 0.2V_B + 0.55$

$\Rightarrow V_B = \boxed{}$ V

?

[আমার কয়েকটা class missed]



Derive:

1) R_{in} ① $R_{in} = (\beta+1)(r_e+R_L)$

2) R_o

3) A_v

4) A_{v_o}

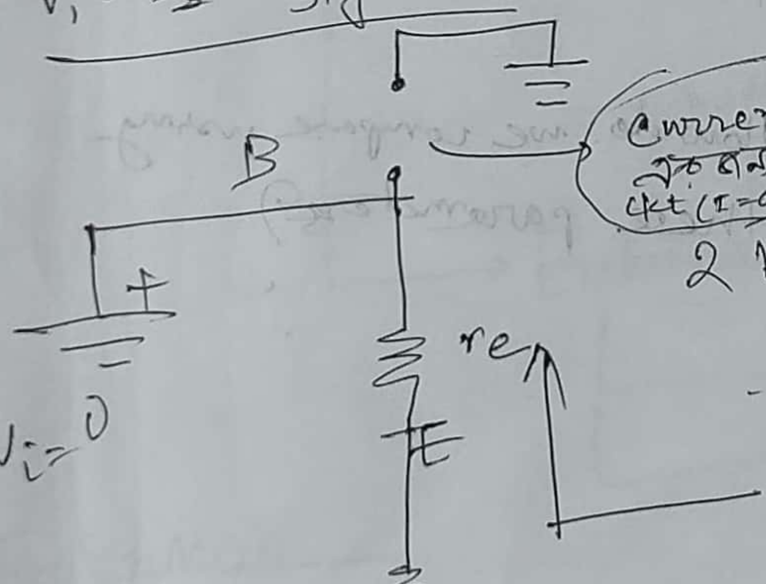
5) G_v

① $R_{in} = (\beta+1)(r_e + R_L)$

⑪ R_o বের করতে গেলে:

V_i কে ~~so~~ short করলে,

$V_i = \cancel{\ } V_{sig} = 0$



Current src খুলে দিলে open ckt (I=0)

2 টা terminal → gnd

$\therefore \Delta V = 0 - 0 = 0$

$\boxed{\therefore R_o = r_e}$

Self Study

CB Amplifier

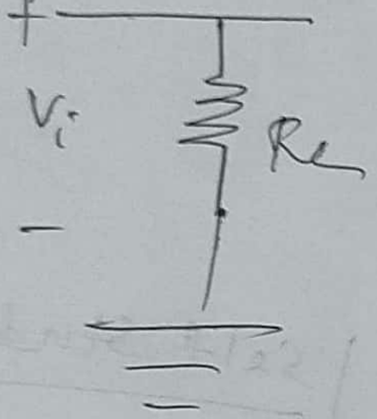
CE ″ with Emitter Resistance

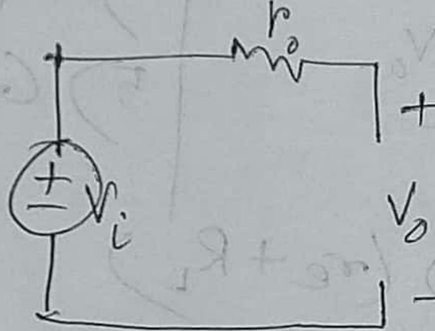
Derive Expression

→ Sedra & Smith

(iii) $A_v = \frac{v_L}{v_i} = \frac{R_L}{r_e + R_L}$ [voltage divider rule]

(iv) $A_{v_0} = A_v \Big|_{R_L \to \infty} = 1$ [এখানে output, input ~~কে~~ follow করে (∴ emitter follower]





$V_o \longrightarrow$ when $R_L \to \infty$ Open ckt.

THINK:

Why will we use

1) CC/Emitter follower?

2) Input resistance
3) Output "

} How do we compare using these parameters?)

[BJT Done]