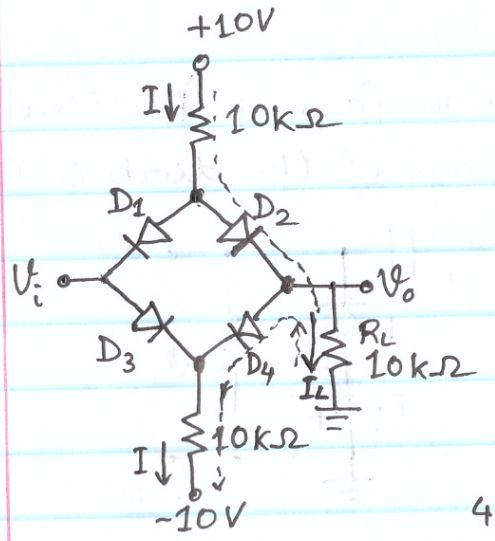
Sol^n:

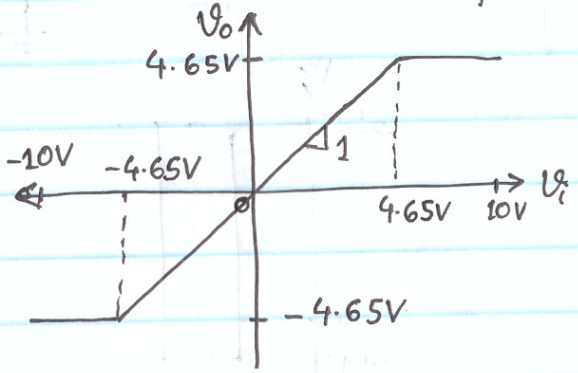


For, $v_i > 0$, D_1 & D_4 are off.

$$I_L = I = \frac{10 - 0.7}{20 \times 10^3} = 0.465\,mA$$

$$v_o = I_L R_L = 0.465 \times 10^{-3} \times 10 \times 10^3$$
$$= 4.65\,V$$

$\therefore v_o = v_i$ for $v_i = \pm 4.65\,V$

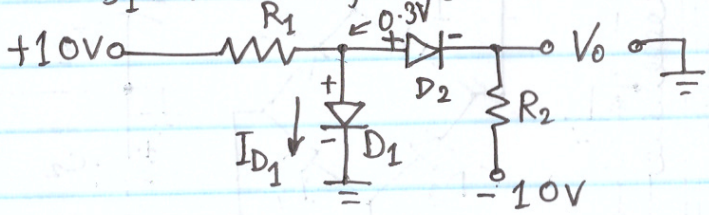


Similarly, while $v_i < 0$, D_2 & D_3 are off.

$$-I_L = I = \frac{10 - 0.7}{20k} = 0.465\,mA$$

& $-v_o = -I_L . R_L = -4.65\,V$

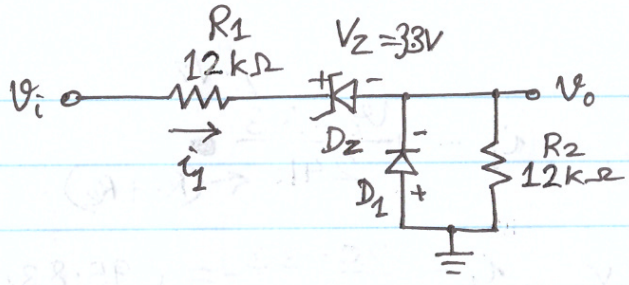
18. Find I_{D_1} & V_o if $V_\gamma = 0.3\,V$, $R_1 = 6.8k\Omega$ & $R_2 = 12k\Omega$



Sol^n: While, D_1 & D_2 are ON, $V_o = +3 - 3 = 0V$ (Ans)

Now, $I_{D_1} = \frac{10 - 0.3}{6.8k} - \frac{0 - (-10)}{12k} = 0.593\,mA$ (Ans)

19.



$V_\gamma = 0$

$v_i = -20V$ to $+20V$

Plot: v_o Vs v_i (&) i_1 Vs v_i

Sol^n: During, $v_i = 0$ to $-20V$, zener & normal D are conducting (FB) $\Rightarrow V_{o\,(-20V \text{ to } 0V)} = 0$

For, $v_i = 0$ to $+3.3V$, zener is in reverse blocking mode (not in breakdown) $\Rightarrow i_1 = 0$ & $V_{o\,(0-3.3V)} = 0$

For, $v_i > 3.3V$, Z-diode enters into brk-down state.

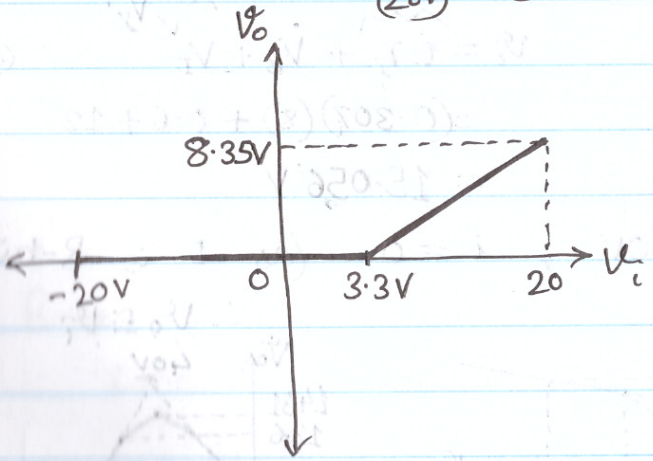
$$i_1 = \frac{v_i - 3.3}{12k + 12k} \quad A$$

&, $$V_{o\,(3.3 \text{ to } 20V)} = \left[\frac{v_i - 3.3}{12k + 12k}\right](12k)_{R_1} = \frac{v_i - 3.3}{2}$$

At, $v_i = +20V$,

$$i_1 = \frac{20 - 3.3}{24k} = 695.83\,\mu A$$

$$V_{o(20V)} = 8.35V$$



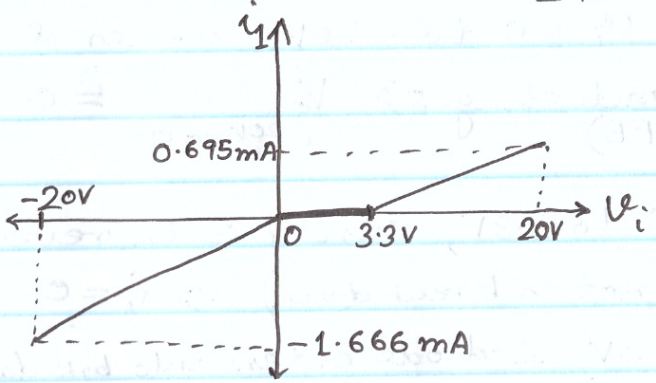
For, $v_i < 0$, $v_o = 0V$ & $-i_1 = \frac{0 - v_i}{12k} = \frac{0-(-20)}{12k}$

R_1

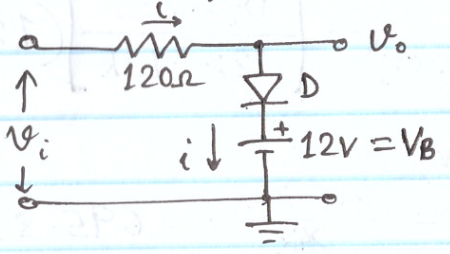
$i_1 = -1.666\,mA$

For, $v_i > 3.3V$, $i_1 = \dfrac{v_i - 3.3}{24k}$ (V_Z, R_1+R_2)

At, $v_i = +20V$, $i_1 = \dfrac{20-3.3}{24k} = 695.83\mu A$



20. If $V_\gamma = 0.6V$, $r_f = 8\Omega$, $v_i = \pm 40V$, plot v_o Vs. v_i.



Draw v_o if v_i is a triangular wave of $\pm 40V$.

Sol^n. For, $v_i = +40V$, $i = \dfrac{40 - 0.6 - 12}{120+8} = \underline{214.06}\ mA$

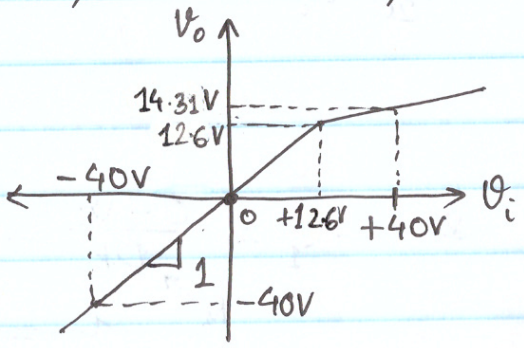
$v_o = i.r_f + V_B + V_D$ ($V_D = V_\gamma$) @ D_1 is FB

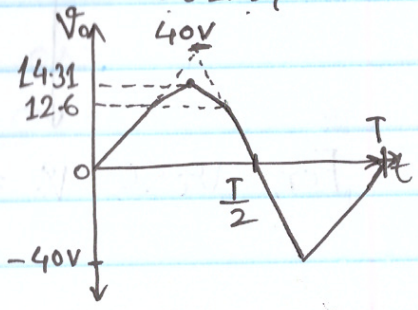
$= (0.214)(8) + 0.6 + 12$

$= 14.31V$

For, $v_i = -40V$, $i = 0$ (as D is R-biased)

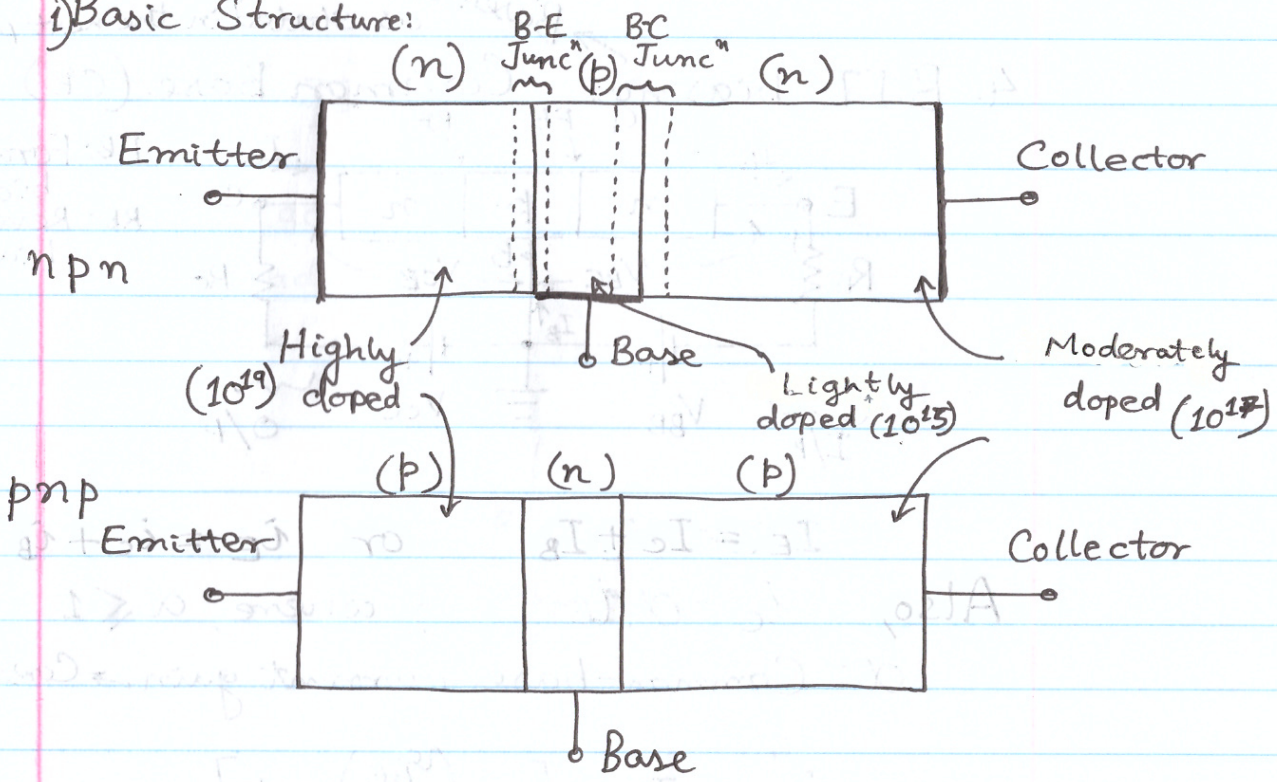
$\therefore v_o \cong v_i$



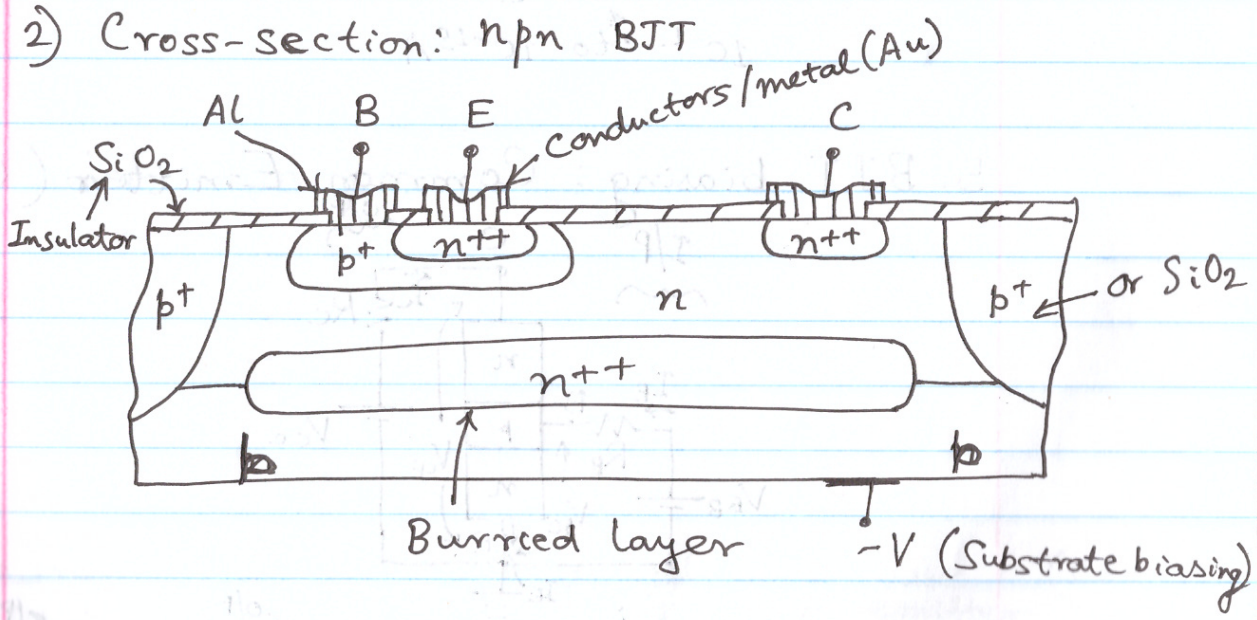


BJT
(Bipolar Junction Transistors)

1) Basic Structure:



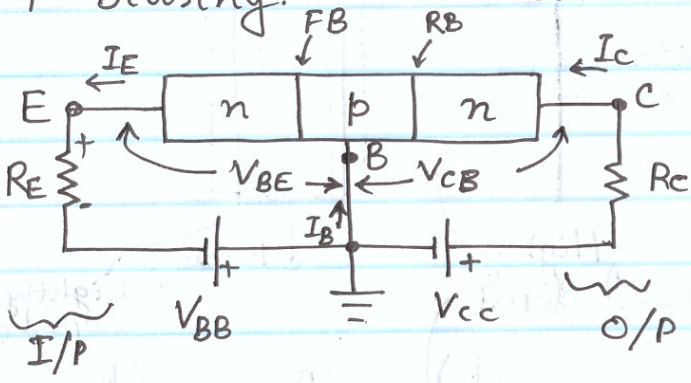
2) Cross-section: npn BJT



3) Types of BJTs:

1) n-p-n
2) p-n-p

4. BJT biasing: Common Base (CB) → Based on modes of operation, as stated in the next page.



FB: Forward biased
RB: Reverse biased

$I_C = \alpha . I_E$

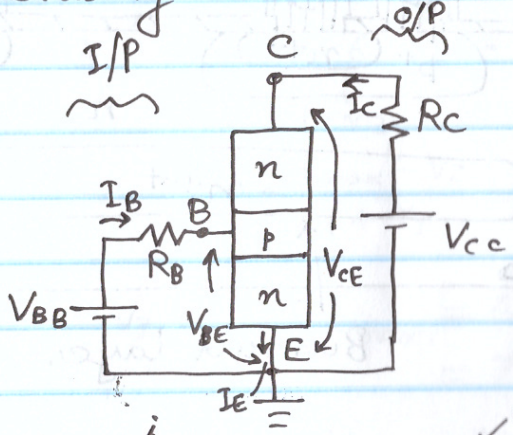
$i_C = \alpha . i_E$; where, $\alpha \leq 1$

α: Common-base current gain → Constant no.

$$i_E = I_{EO} \left[e^{\left(\frac{v_{BE}}{V_T}\right)} - 1 \right]$$

10^{-12} to 10^{-15} A

5. BJT biasing: Common Emitter (CE)



$i_E = i_C + i_B$; $i_C = \beta . I_B$ (β: O/P, I_B: I/P)

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

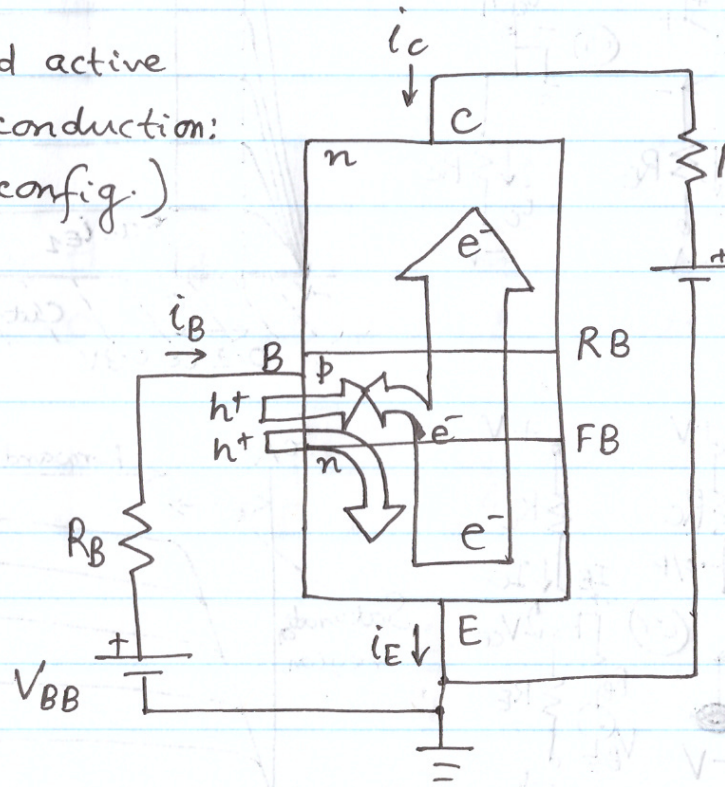
$\beta \gg 1$

β: Common emitter current gain.

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

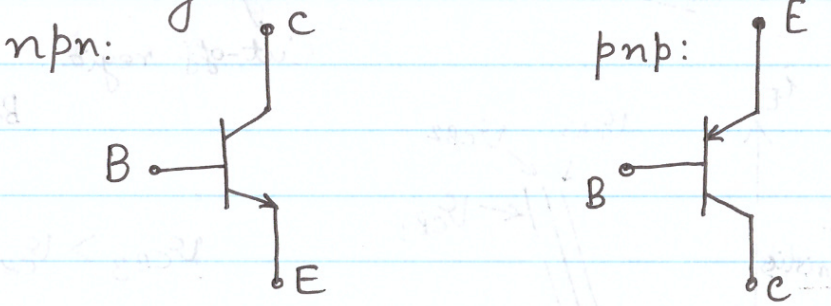
$$\alpha = \frac{\beta}{1+\beta} \qquad (\&) \quad \beta = \frac{\alpha}{1-\alpha}$$

5. Forward active mode conduction: (CE config.)



$V_{CC} > V_{BB}$

6. BJT symbols:

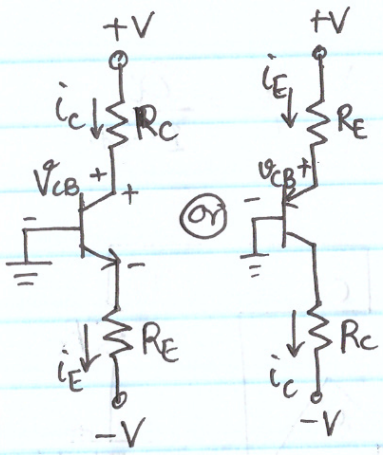


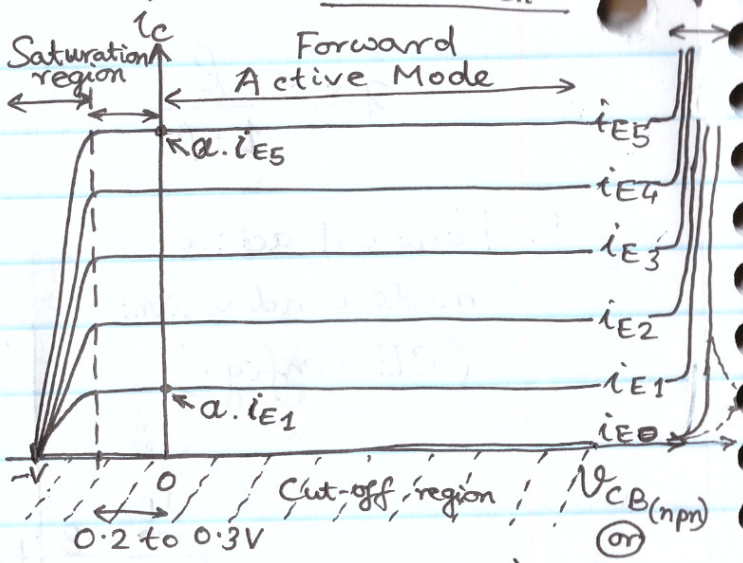
7. a. Transistor modes of operation: (BJT)
1) Common base (CB)
2) Common emitter (CE)
3) Common collector (CC)

b. Transistor (BJT) regions of operation:
1) Cut-off (OFF switch)
2) Saturation (resistor-like)
3) Active → Forward (ON switch with resistance) / Reverse (special resistor)
4) Breakdown (causes permanent damage)

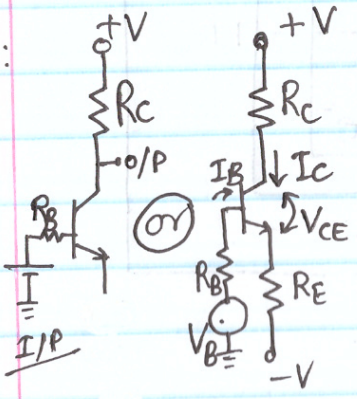
7c. V-I characteristics:

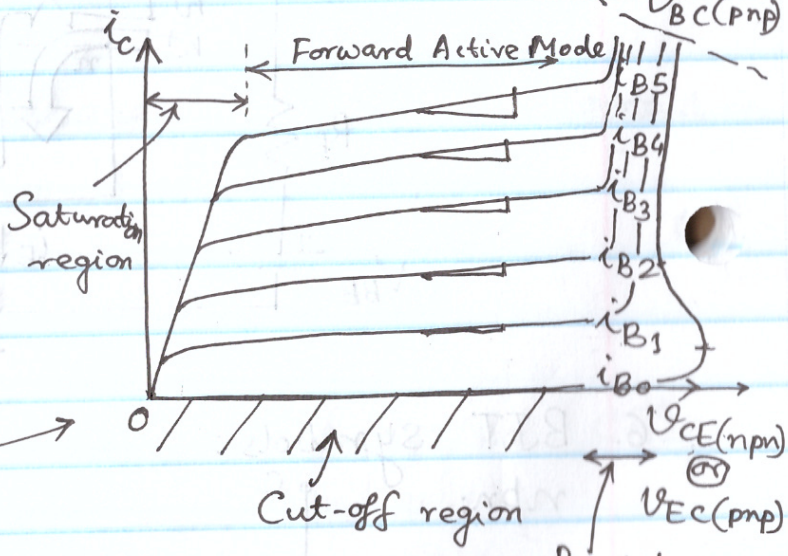
CB:



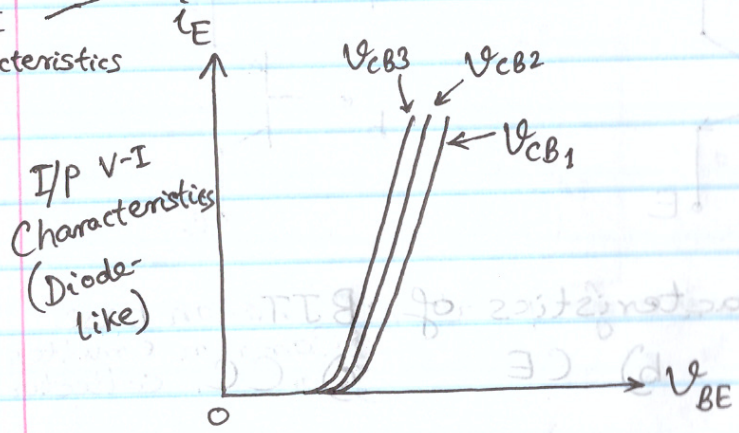


CE:

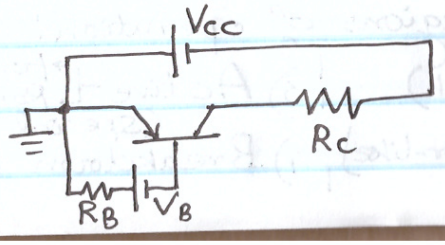




O/P V-I Characteristics



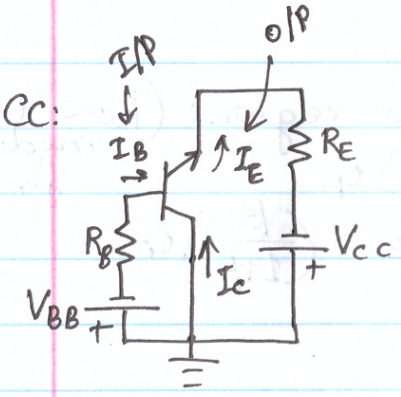
$V_{CB3} > V_{CB2} > V_{CB1}$

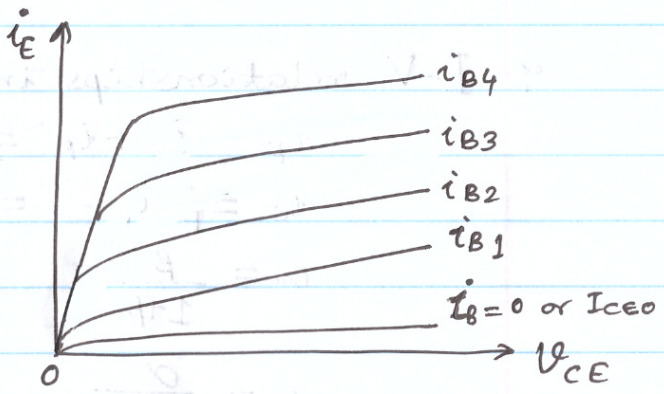


← CE config for pnp

BJT (cont.)

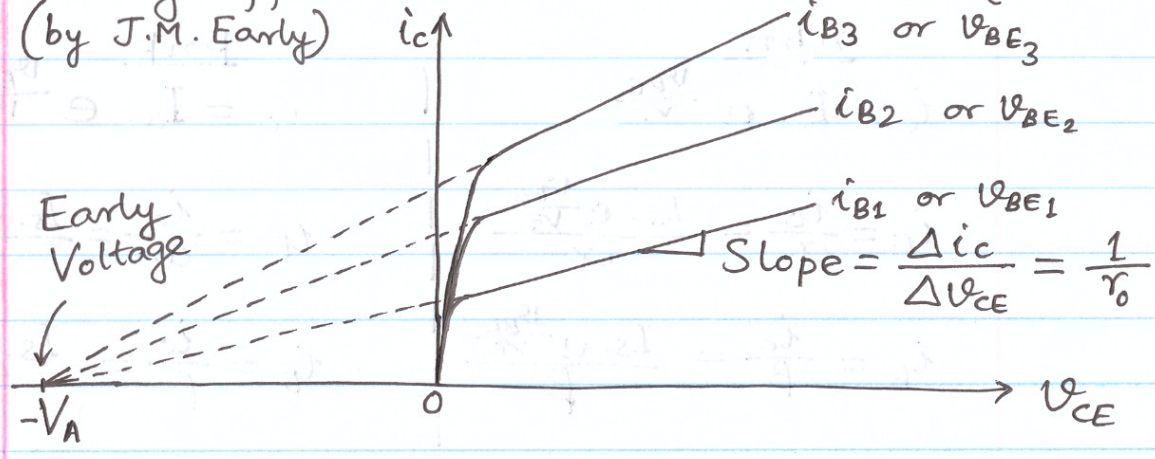
CC:





8. Early effect & base width modulation (CE):

(by J.M. Early)



r_o: O/P resistance

$$r_o \cong \frac{V_A}{I_C}$$

$$i_C = I_S \cdot e^{\left(\frac{v_{BE}}{V_T}\right)} \cdot \left(1 + \frac{v_{CE}}{V_A}\right)$$ ← While early effect is considered.

$|V_A|$: 50 to 300V (typically)

Base width modulation: $v_{BE} \uparrow$ $i_B \uparrow$ Junc^n width (CB) $\downarrow$

Width of base region $\uparrow$ $i_C \uparrow$