$$A_v = \frac{v_o}{v_i} = \frac{+(1+h_{fc})R_L I_b}{h_{ie} I_b + (1+h_{fe}) I_b R_L}$$

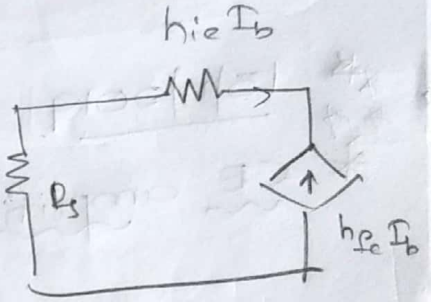
$$= \frac{(1+h_{fe})R_L I_b}{(h_{ie}+(1+h_{fe})R_L) I_b}$$

$$= \frac{(1+h_{fe})R_L}{h_{ie}+(1+R_{fe})R_L} \cong 1$$

$$Y_o = I_o / V_o \Big|_{V_s=0}$$

$$= \frac{\cancel{I_b(1+h_{fe})}}{\cancel{(1+h_{fe})R_L I_b}}$$

$$= \frac{\cancel{(R_s+h_{ie})I_b}}{}$$



$$Y_o = \frac{I_o}{v_o} = \frac{(1+h_{fe})I_b}{(R_s+h_{ie})I_b} = \frac{1+h_{fe}}{R_s+h_{ie}}$$

CC Exact

$$A_i = \frac{-h_{fc}}{1+h_{oc}R_L}$$

$$Z_i = h_{ic} + A_i h_{rc} R_L$$

$$A_v = \frac{A_i}{Z_i} R_L$$

$$Y_o = h_{oc} - \frac{h_{fc} h_{rc}}{R_s + h_{ic}}$$

CC Approx

$$A_i = -h_{fc} = 1+h_{fe}$$

$$Z_i = h_{ie} + (1+h_{fe})R_L$$

$$A_v = \frac{(1+h_{fe})R_L}{h_{ie}+(1+h_{fe})R_L} \cong 1$$

$$Y_o = \frac{1+h_{fe}}{R_s+h_{ie}}$$

Scanned by CamScanner

CE - CC

$h_{ic} = h_{ie}$

$h_{fc} = -(1 + h_{fe})$

$h_{oc} = h_{oe}$

$h_{rc} \simeq 1$

CE - CB

$h_{ib} = \frac{h_{ie}}{1 + h_{fe}}$

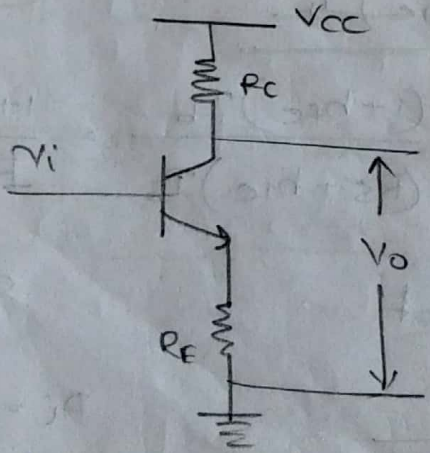
$h_{fb} = \frac{-h_{fe}}{1 + h_{fe}}$

$h_{ob} = \frac{h_{oe}}{1 + h_{fe}}$

$h_{rb} = \frac{h_{ie} h_{oe}}{1 + h_{fe}} - h_{re}$

** 13/11/2019 Wednes day

* CE amplifier with R_E :-

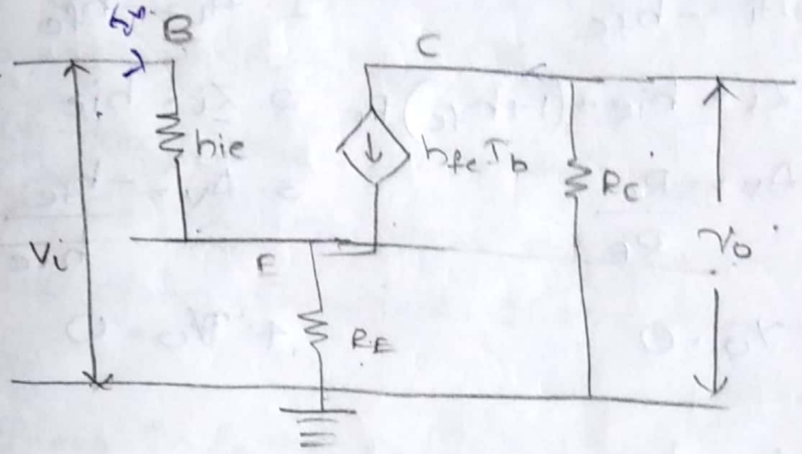


→ Here R_E provides stability as w.r.t when a bypass capacitor is considered in ckt (across R_E), the voltage gain depends on h-parameters.

→ Hence, voltage gain is not stabilised.

→ If C_E is not present (only R_E is present) voltage gain may be stabilized which is independent of transistor parameters.

(c) Analysis :



$$A_i = \frac{I_o}{I_i} = \frac{-h_{fe} I_b}{I_b} = -h_{fe}$$

$$Z_i = \frac{V_i}{I_i} = \frac{h_{ie} I_b + (1+h_{fe}) I_b R_E}{I_b}$$

$$= h_{ie} + (1+h_{fe}) R_E$$

$$A_V = \frac{V_o}{V_i} = \frac{\cancel{h_{fe} I_b + (1+h_{fe}) I_b R_E}}{\cancel{h_{ie} I_b + (1+h_{fe}) I_b R_E}}$$

$$= \frac{-h_{fe} I_b \cdot R_C}{h_{ie} I_b + (1+h_{fe}) I_b R_E}$$

$$= \frac{-h_{fe} \cdot R_C}{h_{ie} + (1+h_{fe}) R_E}$$

Since $h_{ie} <<< (1+h_{fe}) R_E$

Neglect h_{ie}

$$= \frac{-h_{fe} R_C}{(1+h_{fe}) R_E} \cong \frac{-R_C}{R_E}$$

$Y_o = 0$

CE With R_E	CE With bypass
1. $A_i = -h_{fe}$	1. $A_i = -h_{fe}$
2. $Z_i = h_{ie} + (1+h_{fe})R_E$	2. $Z_i = h_{ie}$
3. $A_v = -\frac{R_C}{R_E}$	3. $A_v = \frac{-h_{fe}}{h_{ie}} \times R_L$
4. $Y_o = 0$	4. $Y_o = 0$

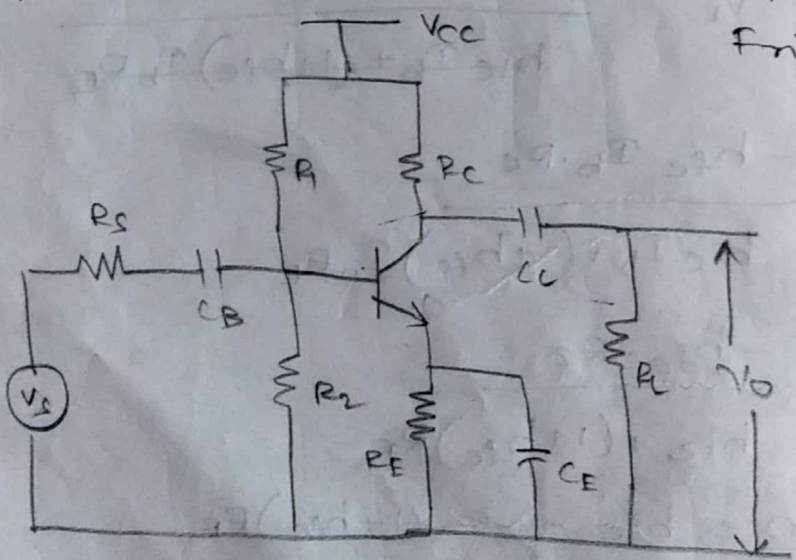
(•) Advantages :

→ Input impedance is high.

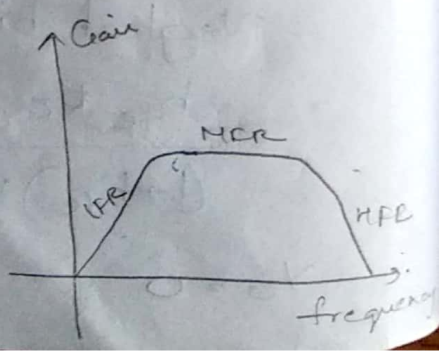
→ Voltage gain is independent of h-parameters. Hence, gain is stabilised.

* Low frequency response of BJT amplifiers :-

15/11/2019
Friday



	Low	Mid	High
Internal in cap.	O.C	O.C	S.C
External Capacitors	O.C	S.C	S.C



(i) Low frequency response:

→ The range of frequencies for which gain decreases as the frequency ↓s.

→ At low frequencies, external capacitors (C_b, C_c, C_e) & internal capacitors (C_{BE}, C_{BC}) are open circuited. Hence, o/p voltage is zero.

→ As the freq. ↑s, the external capacitances will allow the i/p signal. (As freq ↑s, reactance (X_c) ↓). Hence, o/p voltage ↑s.

→ At low frequencies, amplifier acts as high pass filter.

(ii) Mid frequency response:

→ The range of frequencies over which gain is constant is known as Mid frequency response.

→ In this region, external capacitors acts like S.C & internal capacitors like O.C.

→ Hence, the n/w acts like a resistor which is independent of frequency.

→ Therefore, gain is constant.

(iii) High frequency response:

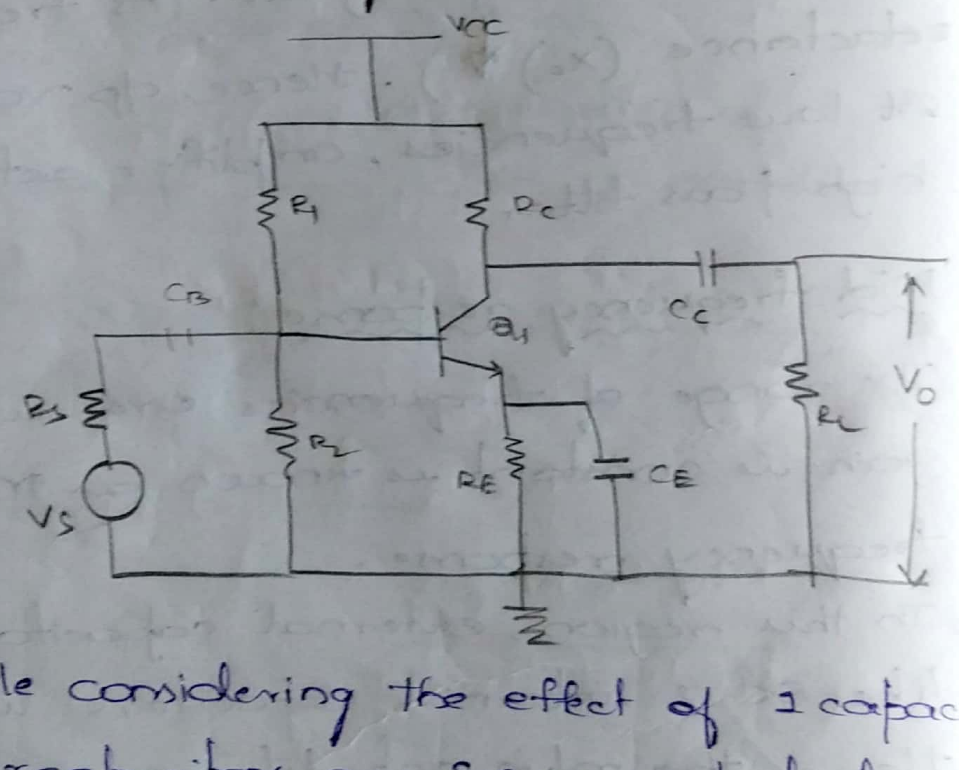
→ The range of frequencies for which gain decreases as the frequency ↑s.

→ At high frequencies, the internal & external capacitors act like a S.C.

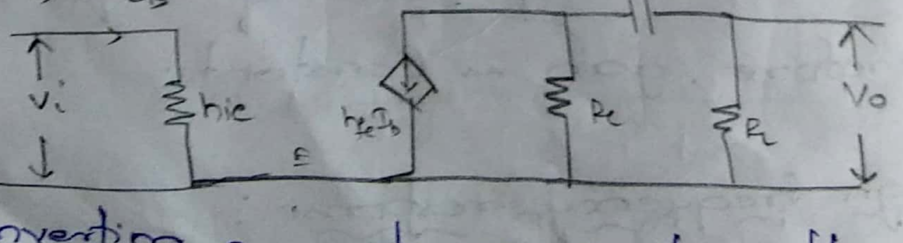
→ Due to the jn. capacitive effect, o/p voltage ↓s as freq ↑s.

→ In this region, amplifier acts like a low pass filter.

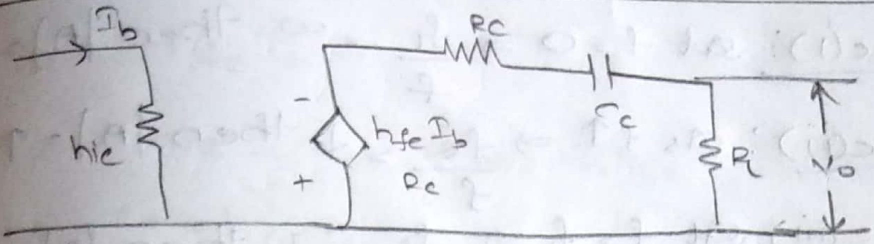
* Effect of coupling | blocking capacitor at low frequency :



→ While considering the effect of 1 capacitor other capacitors are S.C or neglected.



Converting current source to voltage source,



$$V_o = \frac{-h_{fe} I_B \cdot R_C \cdot R_L}{R_C + R_L + \frac{1}{j\omega C_c}}$$

$$V_i = +h_{ie} I_B$$

$$\frac{V_o}{V_i} = \frac{-h_{fe} R_C R_L}{\left(R_C + R_L + \frac{1}{j\omega C_c}\right)(+h_{ie})}$$

$$\frac{V_o}{V_i} = \frac{-h_{fe}}{\left(\left(\frac{1}{R_C} + \frac{1}{R_L}\right) + \frac{1}{j\omega C_c}\right)(+h_{ie})}$$

$$\frac{V_o}{V_i} = \frac{-h_{fe}(R_C \| R_L)}{h_{ie}\left[1 - \frac{j\omega_L}{\omega}\right]}$$

$$\frac{V_o}{V_i} = \frac{\frac{-h_{fe}}{h_{ie}} \times R_L'}{1 - j\frac{\omega_L}{\omega}} = \frac{A_{vm}}{1 - j\frac{f_L}{f}}$$

$$\omega_L = \frac{1}{C_c(R_L + R_C)} \Rightarrow f_L = \frac{1}{2\pi C_c(R_L + R_C)}$$

$$|A| = \frac{A_{vm}}{\sqrt{1 + \left(\frac{f_L}{f}\right)^2}}$$

$$\angle A = 180 + \tan^{-1}\left(\frac{f_L}{f}\right)$$

At $f_L = f \Rightarrow \angle A = 225^\circ$

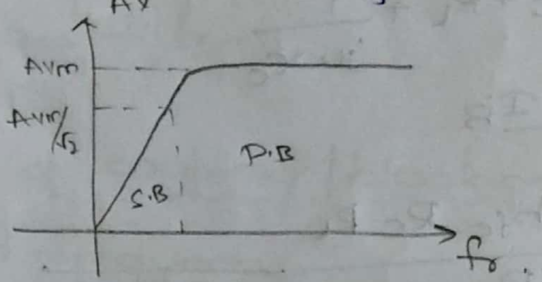
Scanned by CamScanner

→ **Case(i):** At $f = 0 \Rightarrow \frac{f_L}{f} = \infty$ then $|A| = 0$

Case(ii): As $f\uparrow \Rightarrow \frac{f_L}{f} = \downarrow$ then $|A| = \uparrow$

Case (iii) At $f = f_L \Rightarrow \frac{f_L}{f} = 1$ then $|A| = \frac{A_m}{\sqrt{2}}$

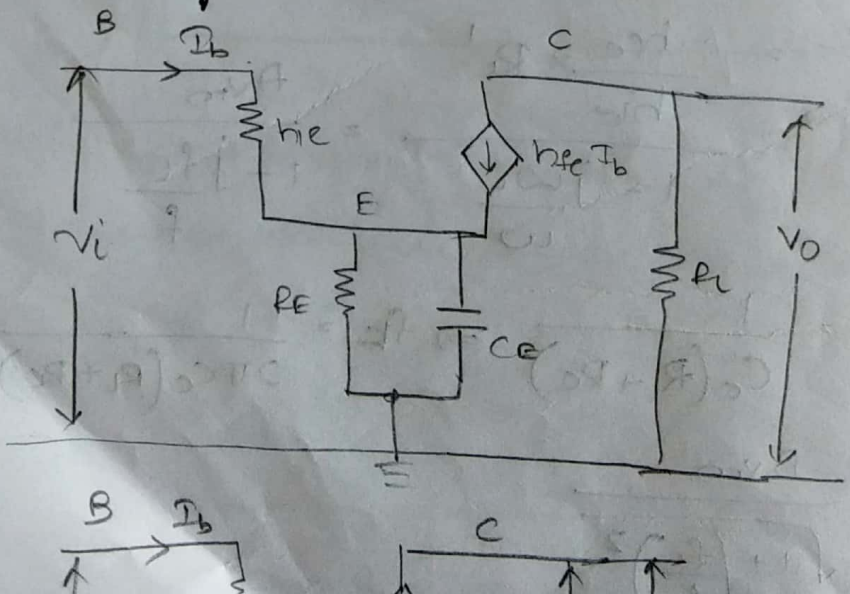
Case -(iv): At $f = \infty \Rightarrow \frac{f_L}{f} = 0$ then $|A| = A_{vm}$

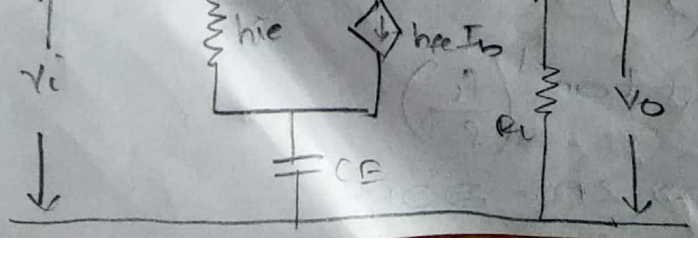


→ |||ly for C_B, $A = \frac{A_{vm}}{1 - j\frac{f_L}{f}}$

$$f_L = \frac{1}{2\pi C_b (R_s + R_i)}$$

* **Effect of bypass capacitor at low frequency:-**





$$v_o = -h_{fe} I_b R_L$$

$$v_i = h_{ie} I_b + (1+h_{fe}) I_b X_{CE}$$

$$\frac{v_o}{v_i} = \frac{-h_{fe} I_b R_L}{h_{ie} I_b + (1+h_{fe}) I_b X_{CE}}$$

$$\frac{v_o}{v_i} = \frac{-h_{fe} R_L}{h_{ie} + (1+h_{fe}) X_{CE}}$$

$$\frac{v_o}{v_i} = \frac{\frac{-h_{fe} R_L}{h_{ie}}}{1 + \left(\frac{1+h_{fe}}{h_{ie}}\right) X_{CE}}$$

$$\frac{v_o}{v_i} = \frac{A_{vm}}{1 + \left(\frac{1+h_{fe}}{h_{ie}}\right) X_{CE}}$$

$$\rightarrow \frac{v_o}{v_i} = \frac{A_{vm}}{1 + \frac{1+h_{fe}}{h_{ie}} \times \frac{1}{j\omega C_E}}$$

$$\frac{v_o}{v_i} = \frac{A_{vm}}{1 - j\frac{\omega_L}{\omega}}$$

where $\omega_L = \dfrac{(1+h_{fe})}{h_{ie} C_E}$

$$f_L = \frac{g_m}{2\pi C_E} \quad \left[\because \frac{h_{fe}}{h_{ie}} = \frac{\frac{I_c}{I_b}}{\frac{V_{be}}{I_b}} = g_m\right]$$

→ If 3 different lower frequencies are obtained then the overall lower cut off frequency is the highest among three.