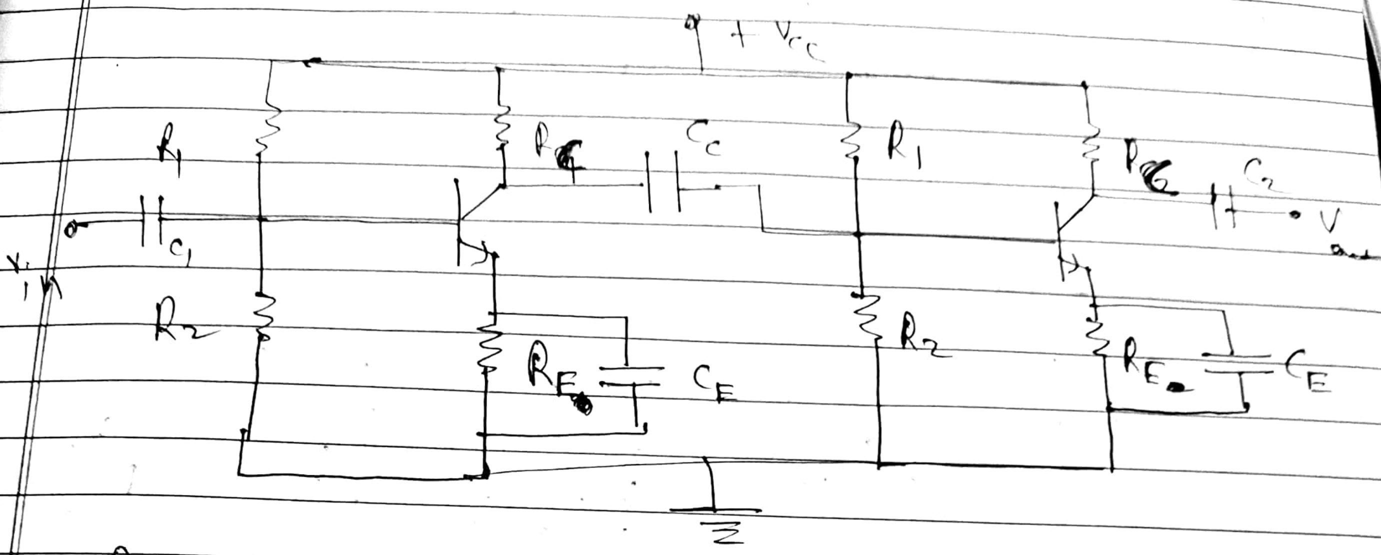
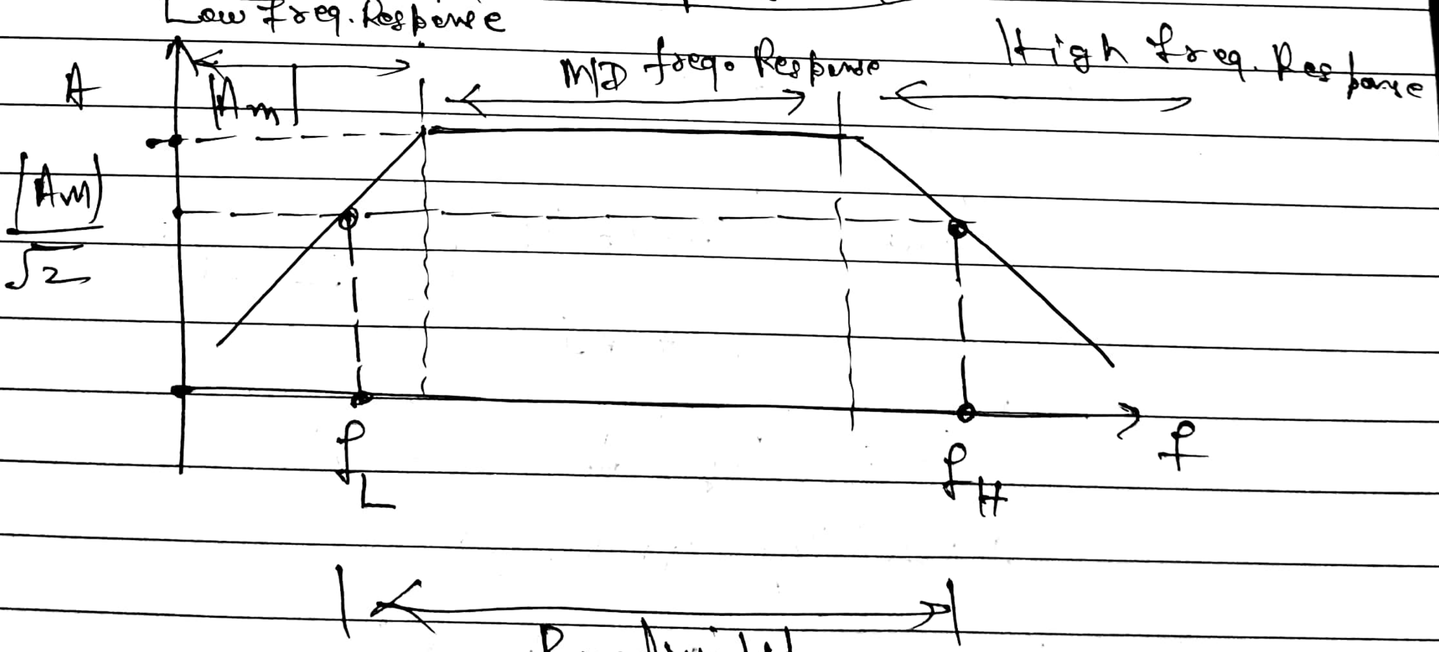
RC Coupled Amplifier



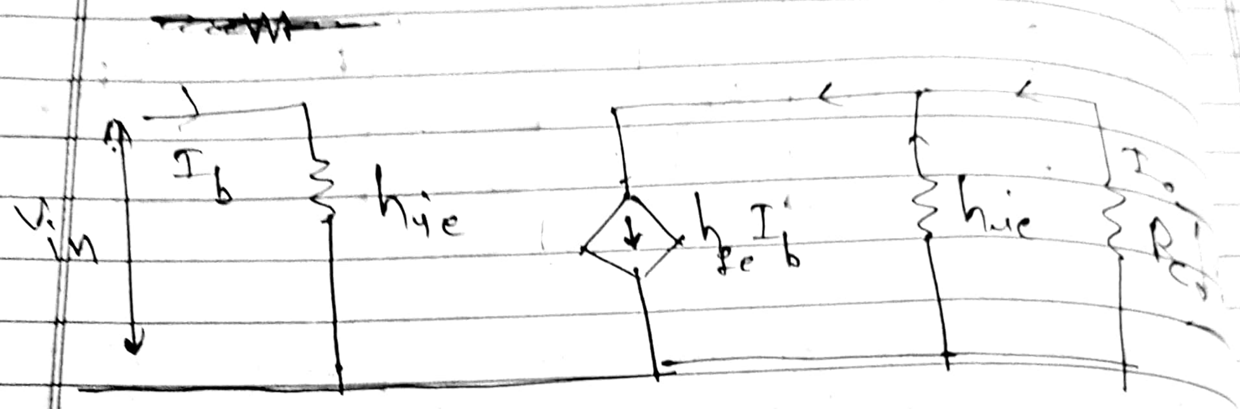
It consists of the two potential divider common emitter amplifier circuits as shown. The output of 1 produces & given to the other through the coupling capacitor (C_c). Following is the frequency response of the RC coupled amplifier.



$$= (f_H - f_L)$$

A = gain (Voltage) Vs frequency graph.

Case-1 Mid frequency analysis of the RC coupled amplifier



By Current Divider Rule

$$I_o = \frac{h_{ie}}{R_C + h_{ie}} \times h_{fe} I_b$$

$$\therefore V_{out} = I_o R_C$$

$$V_{out} = \frac{h_{ie} h_{fe} I_b}{R_C + h_{ie}} R_C \quad \text{--- (1)}$$

$$V_{in} = I_b h_{ie} \quad \text{--- (2)}$$

Dividing (1) by (2)

$$\frac{V_{out}}{V_{in}} = \frac{\dfrac{\cancel{h_{ie}} h_{fe} \cancel{I_b} R_C}{R_C + h_{ie}}}{\cancel{I_b} \cancel{h_{ie}}}$$

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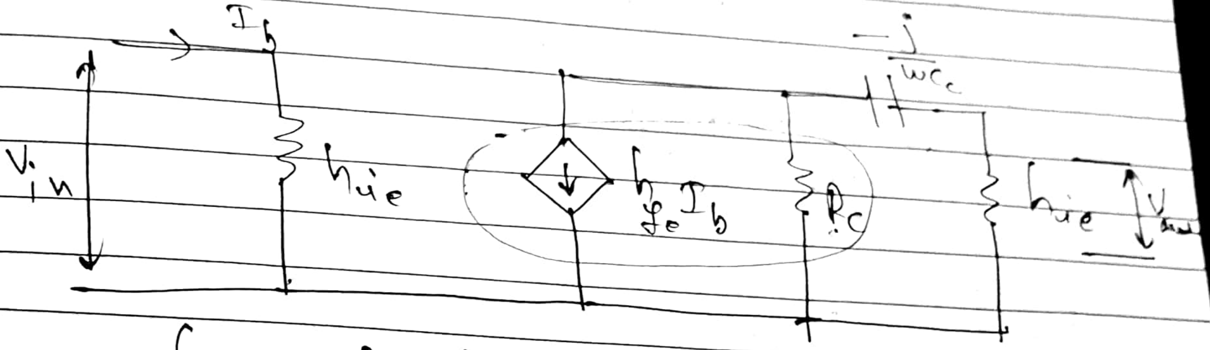
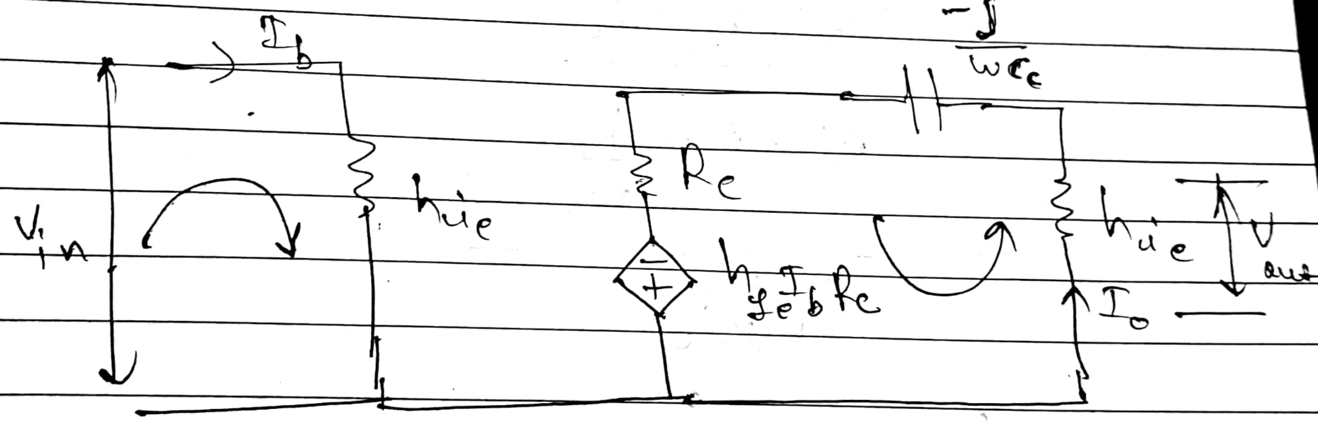
$$\boxed{A_{V_m} = \frac{h_{fe} R_c}{R_c + h_{ie}}}$$

Case-2 Low frequency analysis of RC-coupled amplifier. We now consider the capacitor in the circuit.



Converting current source into voltage source



$$V_{in} = I_b h_{ie} \quad \text{—— (1)}$$

$$h_{fe} I_b R_c = I_o h_{ie} - \frac{j}{\omega C_c} I_o + R_c I_o$$

$$I_o = \frac{h_{fe} I_b R_c}{\left(h_{ie} + R_c - \frac{j}{\omega C_c}\right)}$$

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$$V_{out} = I_c\, h_{ie}$$

$$V_{out} = \frac{h_{fe} I_b R_c h_{ie}}{h_{ie} + R_c - \frac{j}{\omega C}}$$

Low frequency
Voltage gain

$$A_{v_e} = \frac{V_{out}}{V_{in}}$$

$$A_{v_e} = \frac{\dfrac{h_{fe} \cancel{I_b} R_c \cancel{h_{ie}}}{h_{ie} + R_c - \frac{j}{\omega C}}}{\cancel{I_b}\, \cancel{h_{ie}}}$$

$$A_{v_e} = \frac{(h_{fe} R_c)}{(h_{ie} + R_c) - \frac{j}{\omega C_c}}$$

Dividing Nr. &
Dr. by $(h_{ie} + R_c)$

$$A_{V_e} = \frac{\left(\frac{h_{fe} R_c}{h_{ie} + R_c}\right)}{1 - \frac{j}{\omega C_c (h_{ie} + R_c)}}$$

$$A_{V_e} = \frac{A_{V_m}}{1 - \frac{j}{\omega C_c (h_{ie} + R_c)}}$$

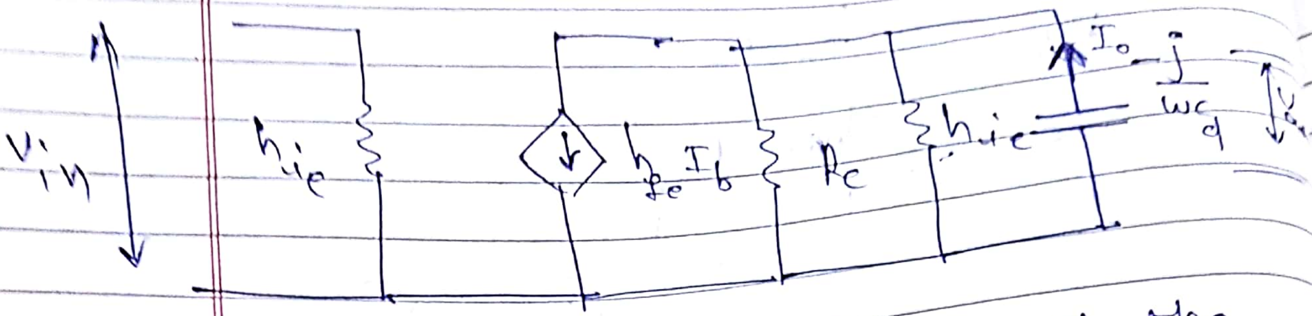
Taking its modulus we get

$$\boxed{|A_{V_e}| = \frac{|A_{V_m}|}{\sqrt{1 + \frac{1}{(\omega C_c (h_{ie} + R_c))^2}}}}$$

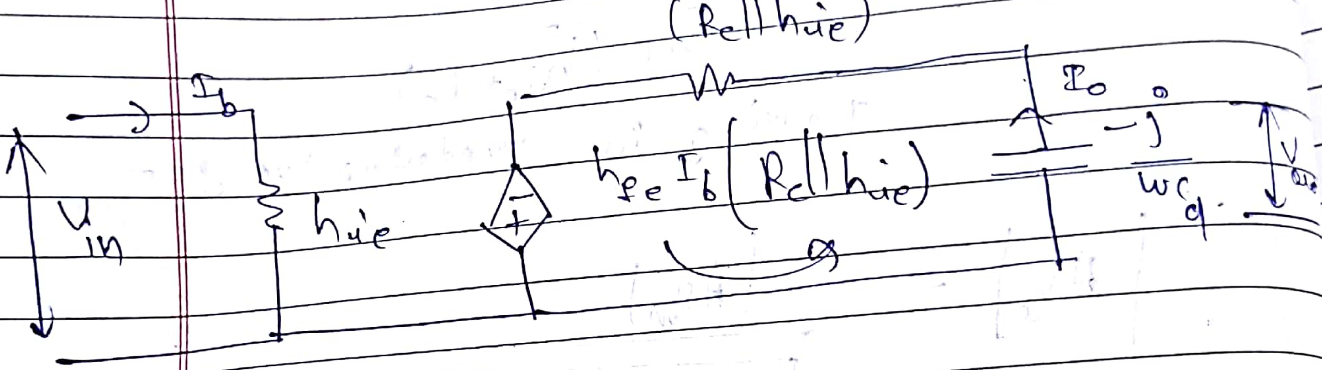
Cutoff frequency is

$$\boxed{f_L = \frac{1}{2\pi C_c (h_{ie} + R_c)}}$$

<u>Case-3</u> High frequency analysis of the amplifier



Let C_d = Diffusion capacitance of the transistor pn-junction



$$\boxed{V_{in} = I_b h_{ie}} \quad \text{--- (1)}$$

K.V.L in the output loop

$$h_{fe} I_b (R_c \| h_{ie}) = \frac{-\hat{j}}{wC_d} I_o + (R_c \| h_{ie}) I_o$$

$$I_o = \frac{h_{fe} I_b (R_c \| h_{ie})}{(R_c \| h_{ie}) - \frac{\hat{j}}{wC_d}}$$

$$V_{out} = I_o \left(\frac{-\hat{j}}{\quad} \right)$$

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$$V_{out} = \frac{h_{fe} I_b (R_c \| h_{ie})}{(R_c \| h_{ie}) - \frac{j}{\omega C_d}} \cdot \left(-\frac{j}{\omega C_d} \right)$$

$$V_{out} = \frac{h_{fe} I_b (R_c \| h_{ie})}{\left(\frac{(R_c \| h_{ie})}{(-j/\omega C_d)} + 1 \right)}$$

$$V_{out} = \frac{h_{fe} I_b \left(\frac{R_c h_{ie}}{R_c + h_{ie}} \right)}{\left(j \frac{R_c h_{ie} \omega C_d}{(R_c + h_{ie})} + 1 \right)}$$

$$V_{out} = \frac{V_{in} \left(\frac{h_{fe} R_c}{R_c + h_{ie}} \right)}{1 + j (R_c \| h_{ie}) \omega C_d}$$

$$A_{v_h} = \frac{V_{out}}{V_{in}} = \frac{A_{v_m}}{1 + j (\omega C_d)(R_c \| h_{ie})}$$

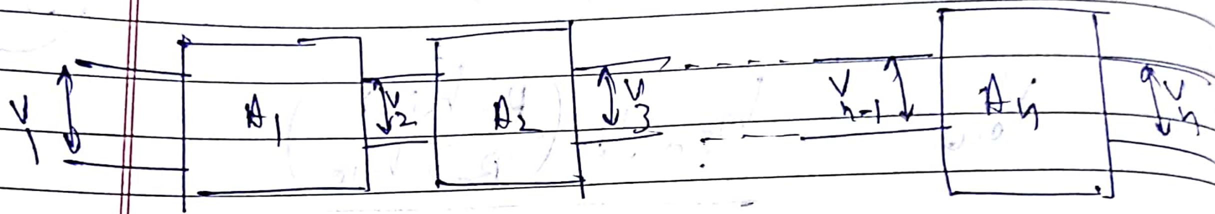
$$|A_{v_h}| = \frac{|A_{v_m}|}{\sqrt{1 + (\omega C_d (R_c \| h_{ie}))^2}}$$

Upper cutoff freq.

~~$f_H = 2\pi R_c$~~

$$\boxed{f_H = 2\pi \left(R_c \,||\, h_{ie}\right) C_q}$$

CASCADED AMPLIFIER



$$A_1 = \frac{V_2}{V_1} \text{ —— (1)}$$

$$A_2 = \frac{V_3}{V_2} \text{ —— (2)}$$

$$\vdots$$

$$A_n = \frac{V_n}{V_{n-1}} \text{ —— (n)}$$

Multiplying

(1) × (2) ---- × (n)

$$A_1 A_2 \cdots A_n = \frac{\cancel{V_2}}{V_1} \times \frac{\cancel{V_3}}{\cancel{V_2}} \times \frac{\cancel{V_4}}{\cancel{V_3}} \times \cdots \times \frac{V_n}{V}$$

$A_1 A_2 \dots A_n = \frac{V_n}{V_1} = A$ (overall gain)

$\therefore \boxed{A = A_1 A_2 A_3 \dots A_n}$

CASCODE AMPLIFIER

If we connect common emitter amplifier in cascade with the common base amplifier, then it is known as cascode amplifier.