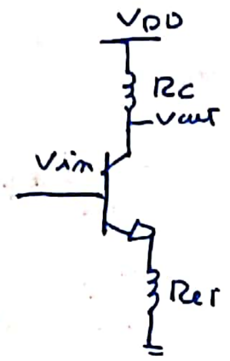
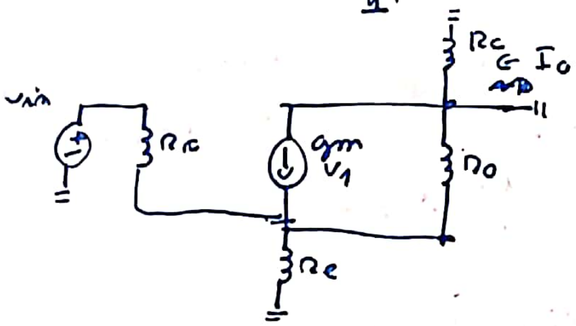
common emitter degeneration




Transcondutância ~~vs~~ $\frac{I_{out}}{V}$

output node is shorted

$\frac{I_o}{V_{in}}$




$I_o = + gm V_1$

$V_1 = V_{in} - V_A$

$I_o = - gm$

$V_A = gm V_1 r_e$

$V_A = gm v_{in} r_e - gm V_A r_e$

$V_A(1 + gm r_e)$

$V_A = \frac{gm v_{in} r_e}{(1 + gm r_e)}$

$V_1 = \frac{V_A}{gm r_e}$

$I_o = gm \times \frac{V_A}{gm r_e} \times \cancel{gm}$

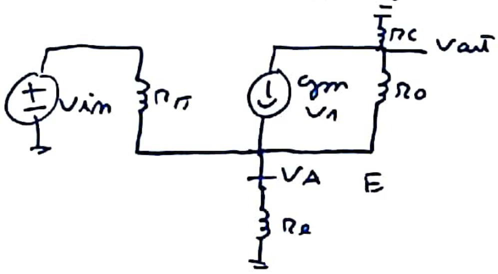
$I_o = gm \times \frac{V_A}{\cancel{gm r_e}} \times \frac{gm v_{in} r_e}{(1 + gm r_e)}$

$\frac{I_o}{V_{in}} \simeq \frac{gm}{(1 + gm r_e)}$

Base current is neglegenciated

$I_B << I_C$

voltage gain




$$-\frac{V_{out}}{r_c} + \frac{V_{in} - V_A}{r_\pi} = \frac{V_A}{r_e}$$

$$-\frac{V_{out}}{r_c} + \frac{V_{in}}{r_\pi} = V_A\left(\frac{r_e + r_\pi}{r_e r_\pi}\right)$$

$$\frac{-V_{out} r_\pi + V_{in} r_c}{r_c r_\pi} = V_A\left(\frac{r_e + r_\pi}{r_e r_\pi}\right)$$

$v_1 = V_{in} - V_{out}$

$$V_A = \frac{-V_{out} r_\pi r_e + V_{in} r_c r_e}{r_c(r_e + r_\pi)}$$

sum of currents at Vout

$-g_m V_1$

$$-g_m V_{in} + g_m V_A - \frac{V_{out}}{r_o} + \frac{V_A}{r_o} - \frac{V_{out}}{r_c} = 0$$

$$-V_{out}\left(\frac{1}{r_o} + \frac{1}{r_c}\right) - g_m V_{in} + V_A\left(g_m + \frac{1}{r_o}\right)$$

$$-V_{out}\left(\frac{1}{r_o} + \frac{1}{r_c} + \left(g_m + \frac{1}{r_o}\right)\frac{r_\pi r_e}{r_c(r_e + r_\pi)}\right) - V_{in}\left(g_m - \left(\frac{1}{r_o} + g_m\right) \times \frac{r_c r_e}{r_c(r_e + r_\pi)}\right) = 0$$

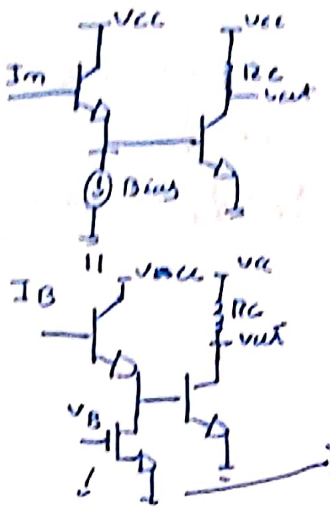
$$A_V = \frac{-g_m r_c(r_e + r_\pi) + \frac{1}{r_o} + g_m}{\left(\frac{1}{r_o} + \frac{1}{r_c}\right)(r_c(r_e + r_\pi)) + \frac{1}{r_o} + g_m} \times r_o$$

$$A_V = \frac{-g_m r_o r_c(r_e + r_\pi) + 1 + g_m r_o}{(r_c + r_o)(r_e + r_\pi) + 1 + g_m r_o}$$

gain equation

CCCE

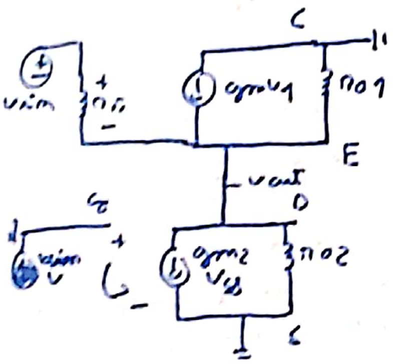
Common collector - common emitter




acts as a current source

I don't like to use perfect current sources to do calculations

1° stage

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current at Vout $\qquad v_1 = V_{in} - V_{out}$

$$-\frac{V_{out}}{r_{o2}} + \frac{-V_{out}}{r_{o1}} + g_{m1}v_1 - \frac{V_{out}-V_{in}}{r_\pi}$$

$$-\frac{V_{out}}{r_{o2}} - \frac{V_{out}}{r_{o1}} + g_m V_{in} - g_m V_{out}$$

$$-\frac{V_{out}}{r_\pi} + \frac{V_{in}}{r_\pi} = 0$$

$$V_{in}\left(g_{m1} + \frac{1}{r_\pi}\right) = V_{out}\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m1} + \frac{1}{r_\pi}\right)$$

$$\frac{V_{out}}{V_{in}} = \frac{g_{m1} + \frac{1}{r_\pi}}{\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m1} + \frac{1}{r_\pi}\right)} = A_{v1}$$

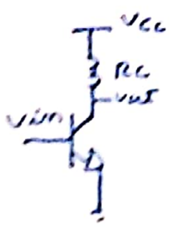
2° stage

$V_{in}' = V_{in} A_{v1}$

$\shortparallel$

$V_{out1}$

$$\frac{V_{out2}}{V_{in}} = A_{v1} \times \underline{A_{v2}}$$




$$A_{v2} = -g_{m3} \times R_C // R_{o3}$$

$$A_{v2} = \frac{-g_{m3} R_C R_{o3}}{R_C + R_{o3}}$$

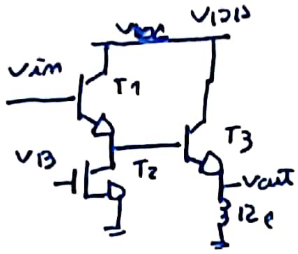
higher Input Resistance

-> more complex

-> less "Bandwidth"

$$A_v = \frac{-\left(g_{m1} + \frac{1}{r_\pi}\right) g_m R_C R_{o3}}{\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m1} + \frac{1}{r_\pi}\right)(R_C + R_{o3})}$$

comom collector - common· collector




1° stage amaylisis

$$Av_1 = \frac{gm_1 + \frac{1}{r\pi}}{\left(\frac{1}{r\pi} + \frac{1}{ro1} + gm_1 + \frac{1}{ro2}\right)}$$

2° stages analysis

$$Av_2 = \frac{\left(\frac{1}{r\pi_3} + gm_3\right)}{\left(\frac{1}{Re} + \frac{1}{r\pi_3} + \frac{1}{ro3} + gm_3\right)}$$

$$Av_1 \times Av_2 = \frac{\left(gm_1 \frac{1}{r\pi}\right)\left(\frac{1}{r\pi_3} + gm_3\right)}{\left(\frac{1}{Re} + \frac{1}{r\pi_3} + \frac{1}{ro3} + gm_3\right)\left(\frac{1}{r\pi} + \frac{1}{ro1} + gm_1 + \frac{1}{ro2}\right)}$$

Total circuit gain

→ It can Be easely observed That $Av_1 \times Av_2 < 1$

super Buffer stage with high input Impedance good To drive loads