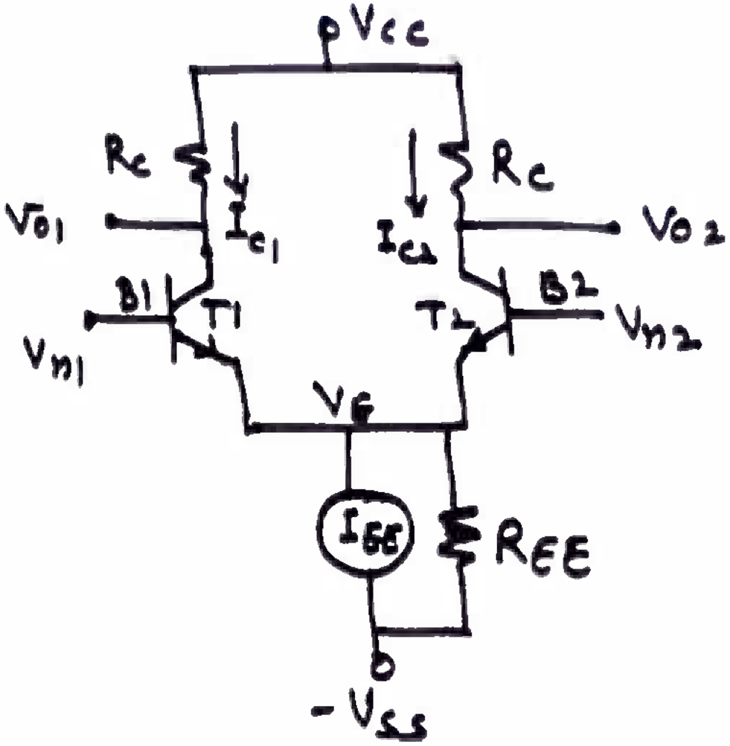
Bipolar Diffamp



$V_{B1} - V_{B2} = v_{id}$

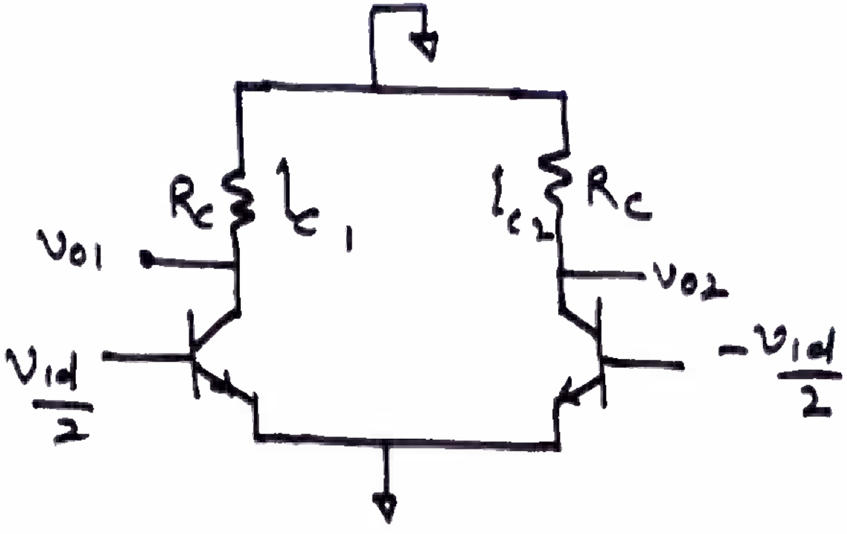
Hence we apply

$v_{in1} = \frac{v_{id}}{2}$ & $v_{in2} = -\frac{v_{id}}{2}$

to keep $v_{id} = v_{in1} - v_{in2}$ intact.

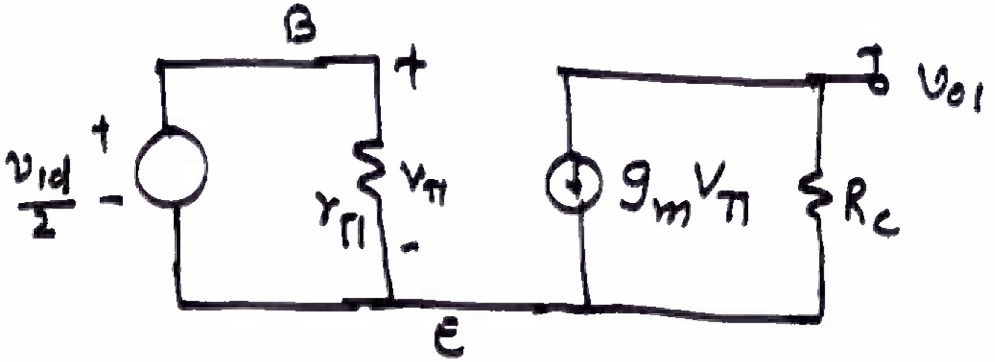
T1 has β ($g_m r_\pi$) which is same as for T2

AC Circuit equivalent for BJT DIFFAMP in two Modes of Inputs is shown below:



$i_{c1} = \Delta I_c$

$i_{c2} = -\Delta I_c$

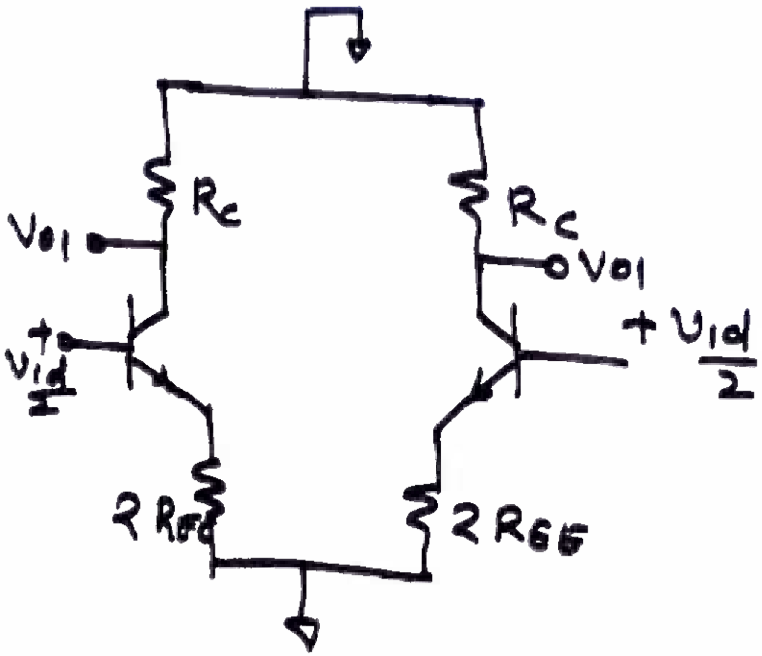


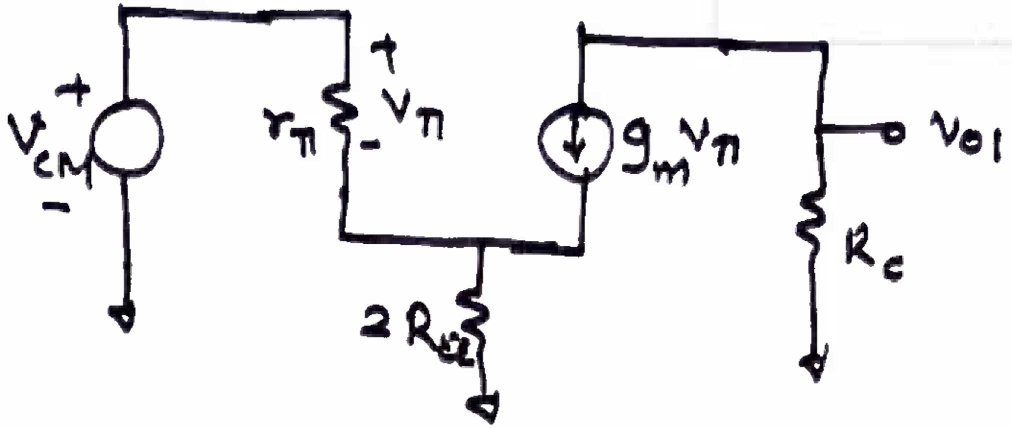
Difference Input

Clearly $V_\pi = \frac{v_{id}}{2}$

$$\therefore A_{vdd} = \frac{v_{o1}}{v_{id}/2} = \frac{-g_m V_\pi R_c}{v_{id}/2} = -g_m R_c$$

For common mode, the equ. ckt is





$$v_{cM} = \frac{v_{id}}{2}$$

$$A_{vcM} = \frac{v_{o1}}{V_{cM}} = \frac{-\beta R_c}{r_\pi + 2R_{EE}(\beta+1)} \simeq \frac{-R_c}{2R_{EE}}$$

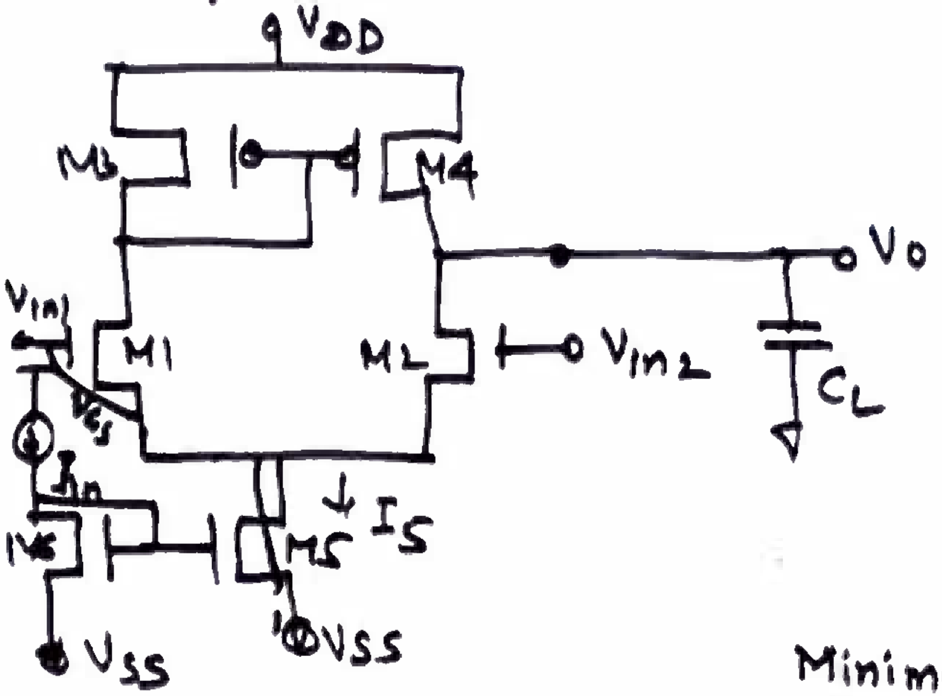
$$\therefore \text{CMRR} = \frac{A_{vdd}}{A_{vcM}} = \frac{-g_m R_c}{\left[\frac{-g_m R_c}{1+2g_m R_{EE}}\right]} = 1+2g_m R_{EE}$$

If $R_{EE} \to \infty$ CMRR → ∞

Else CMRR is finite and around 80-120db

Current Mirror CMOS Diffamp.

Example



Given $C_L = 5\ pf$

Slew Rate $\geq 10V/\mu s$.

$V_{DD} = -V_{SS} = 2.5\ V$

$\beta_n' = 110\ \mu A/V^2$, $\beta_p' = 50\ \mu A/V^2$

$V_{Tn} = 0.7V = |V_{Tp}|$

$\lambda_n = 0.04/V$ & $\lambda_p = 0.05/V$

Minimum frequency for Dominant Pole $\geq 100\ KHz$ (Bandwidth Minimum)

For Diffamp in DC case

$$I_{DS1} = I_{DS2} = \frac{I_S}{2}$$

CHOICE OF I_5

① From Maximum Power Dissipation of 1mW, we have

$$I_5 \cdot (V_{DD} - V_{SS}) \leq 1\,mW$$

or $\quad I_5 \leq \frac{1}{5} \times 10^{-3}$

$\therefore \quad I_5 \leq 200\,\mu A$ — PD requirement

② Slew Rate $SR \geq 10V/\mu s$

$$\text{Slew Rate} = SR = \frac{I_5}{C_L} \quad \text{or} \quad I_5 = SR \cdot C_L$$

$$\therefore \quad I_5 \geq 10 \times 10^6 \times 5 \times 10^{-12}$$

$$\geq 50\,\mu A$$

③ We assume Dominant Pole (Bandwidth is due to heavy Load Capacitance $C_L = 5pf$

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or $$f_{BW} = \frac{1}{2\pi R_{out} C_L}$$

But $$R_{out} = R_{o2} \| R_{o4} = \frac{1}{g_{o2}+g_{o4}}$$

$$= \frac{1}{\lambda_n \frac{I_{SS}}{2} + \lambda_p \frac{I_{SS}}{2}} = \frac{1}{(\lambda_n+\lambda_p) I_S/2} = \frac{2}{(0.04+0.05) I_S}$$

$$= \frac{22.22}{I_S}$$

∴ For $f_{BW} \geq 100$ kHz

$$100 \times 10^3 \geq \frac{I_S}{2\pi \times 22.22 \times 5 \times 10^{-12}}$$

or $I_S \geq 70\,\mu A$

To satisfy 'All THREE' Requirements

$$\boxed{\text{We choose } I_S = 100\ \mu A}$$

$\therefore \frac{I_S}{2} = 50\ \mu A$ In our further Calculation of Gain

Given $(W/L)_1 = (W/L)_2 = 18.4$

and $(W/L)_3 = (W/L)_4 = 8$

Then DC Gain $= g_{m_1} R_{out} = \dfrac{\sqrt{2\beta_n'\left(\frac{W}{L}\right)_1 I_S/2}}{(\lambda_n+\lambda_p)\, I_S/2}$

$$A_{vdo} = \frac{\sqrt{2\times 110\times 10^{-6}\times 18.4\times 50\times 10^{-6}}}{(0.09)\times \frac{100}{2}\times 10^{-6}} \simeq 100$$

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Given $V_{ICM_{min}} = -1.5\,V$

$$\therefore \quad -1.5 = V_{Dsat_5} + V_{SS} + V_{GS_1}$$

$$\text{or} \quad V_{Dsat_5} = 1 - V_{GS_1}$$

$$\text{But} \quad V_{GS_1} = \sqrt{\frac{I_5/2}{\frac{1}{2}\beta_n'(W/L)_1}} + V_{Tn}$$

$$= \sqrt{\frac{2\times 50\times 10^{-6}}{1\times 110\times 10^{-6}\times 18.4}} + 0.7$$

$$\therefore \quad V_{GS_1} \simeq 0.222 + 0.7 = 0.922\,V$$

$$\therefore \quad V_{Dsat_5} = 1 - 0.922 \simeq 0.08\,V$$

$$I_5 = \frac{1}{2}\beta_n'(W/L)_5 \, V_{Dsat_5}^2$$

$$2 \times 100 \times 10^{-6} = 110 \times 10^{-6} \left(\frac{W}{L}\right)_5 \times (0.08)^2$$

$\therefore (W/L)_5 \cong 300$ Too high !!