Course Project : EE618 ~~* I am doing th~~

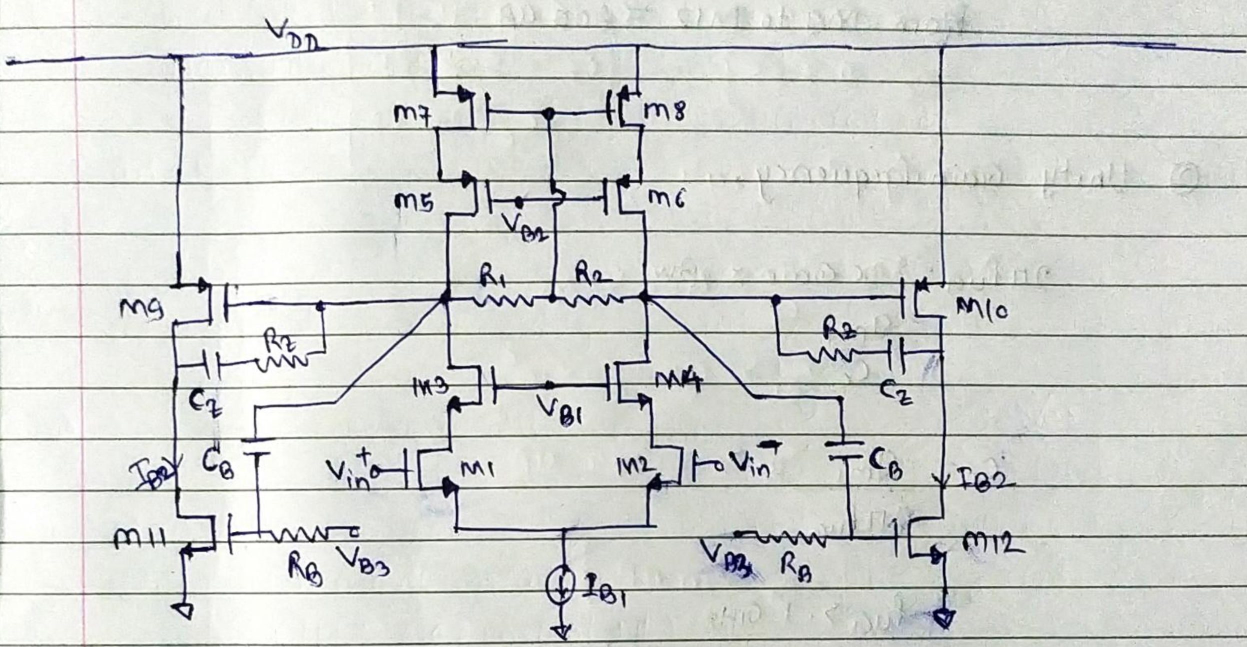
OTA Design

Roll No : 19D070076

* PTM 130 nm CMOS model :

* Bulk and source of PMOS are shorted & bulk of NMOS is connected to gnd (0V)

A) Pseudo class AB design :



Parameters obtained from simulation :

$V_{tn} = 0.3V$ $K_n = 0.419 \frac{mA}{V^2}$ $V_{tp} = 0.262V$ $k_p = 0.06 \frac{mA}{V^2}$	Estimated values of λ for $L = 0.2\,\mu m$ $\lambda_n \approx \lambda_p = 0.08$

Now

① DC voltage gain $= A_v > 70$ dB | $R_1 = R_2 = R$

Note : we first assume current given in paper expression for total A_v is

$$A_v = \left\{ g_{m1,2} \left\{ \left[g_{m3,4}\, r_{o3,4}\, r_{o1,2} \parallel g_{m5,6}\, r_{o5,6}\, r_{o7,8} \parallel R \right] \right\} \right\} \times g_{m9,10}\, r_{o9,10}\, r_{o11,12}$$

$\rightarrow$ eq^n ①

current in transistor

from M1 to M8 = 750 μA

from M9 to M12 = 400 μA

② Unity Gain frequency.

$$2\pi f_{UG} = \text{DC Gain} \times BW$$

$$= \frac{g_{m1}}{C_c}$$

$$C_c = \frac{g_{m1}}{2\pi f_{UG}}$$

$\because f_{UG} > 1\ \text{GHz}$

$$\boxed{C_c < \frac{g_{m1}}{2\pi \times 10^9}}$$

③ Static power consumption

$$P = \cancel{1.5\,[2\times 400 + 2\times 750]}$$

$$\cancel{= 3.45\ \text{mW}}$$

$$\cancel{P < 4.5\ \text{mW}}$$

$$\boxed{P = 1.5\,[2\times I_{B2} + I_{B1}] < 4.5\ \text{mW}}$$

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④ Slew Rate

$$\frac{dV_{out}}{dt} = \frac{2I_{D1}}{C_c}$$

$$\boxed{I_{D12} \geq 2I_{D1}\left(1+\frac{C_L}{C_c}\right)}$$

$2I_{D1} = I_{B1}$

$I_{D12} = I_{B2}$

I_{B2}

$\boxed{\cancel{I_{B2} > I_{B1}\left(1+\frac{C_L}{C_c}\right)}}$ $\boxed{I_{B2} > I_{B1}\left(1+\frac{C_L}{C_c}\right)}$

⑤ Input referred noise.

$$V^2_{n,eq} = 2\left[V^2_{n,eq} + \frac{g^2_{m7}}{g^2_{m1}}\right]$$

$$= \frac{8KT\gamma}{g_{m1}}\left[1+\frac{g_{m7}}{g_{m1}}\right]$$

$g_{m7} \ll g_{m1}$

$$V^2_{n,eq} = \frac{16KT}{3} \times \frac{1}{g_{m1}}$$

$$g_{m1} > \frac{16KT}{3\times(100\times10^{-9})^2}$$

$g_{m1} > 2.192$ μS

$\boxed{\cancel{g_{m1}}}$

$\boxed{g_{m1} = 100 \text{ μS}}$

$(V_{GS})_1 = \frac{g_m}{I}$

* Using ~~slew rate~~ Unity gain freq^n eq^n

$$C_c < \frac{g_{m_1}}{2\pi \times 10^9}$$

$$C_c < \frac{10 \times 10^{-5}}{2\pi \times 10^9}$$

$C_c < 15.91$ fF

$$\boxed{C_c = 15 \text{ fF}}$$

using slew rate

$$\frac{I_{B_1}}{C_c} \geq 400 \text{ V}/\mu s$$

$$I_{B_1} \geq C_c \times 400 \times 10^6$$

$$I_{B_1} \geq 6.364 \ \mu A$$

$$\boxed{I_{B_1} = 20 \ \mu A}$$

$$I_{B_2} > I_{B_1}\left(1 + \frac{C_L}{C_c}\right)$$

$$I_{B_2} > 20\left(1 + \frac{0.5 \times 10^{-12}}{15 \times 10^{-15}}\right)$$

$$I_{B_2} > 20(33.3)$$

$$I_{B_2} > 666.6 \ \mu A$$

$$\boxed{I_{B_2} = 800 \ \mu A}$$

$$g_{m_1} = \sqrt{I_{B_1} K_n (W/L)_{1,2}}$$

$$\left(\frac{W}{L}\right)_{1,2} = \frac{g_{m_1}^2}{I_{B_1} K_n}$$

$$= \frac{(100)^2 \times 10^{-12}}{20 \times 10^{-6} \times 419 \times 10^{-6}}$$

$$\left(\frac{W}{L}\right)_{1,2} = 1.19 \simeq 1$$

$$\boxed{\left(\frac{W}{L}\right)_{1,2} = 1}$$

* Phase margin $= \phi$ ~~90° − tan⁻¹(...)~~

$$\phi = 90^\circ - \tan^{-1}\left(\frac{g_{m1}/C_c}{g_{m10}/C_L}\right) > 60^\circ$$

$$30^\circ > \tan^{-1}\left(\frac{g_{m1}/C_c}{g_{m10}/C_L}\right)$$

$$0.577 > \frac{g_{m_1}}{C_c} \times \frac{C_L}{g_{m10}}$$

$$g_{m10} > \frac{g_{m_1} \times C_L}{C_c \times 0.577}$$

$$g_{m10} > \frac{10^{-4} \times 0.5 \times 10^{-12}}{15 \times 10^{-15} \times 0.577}$$

$$g_{m10} > 5.77 \text{ mS}$$

$$\boxed{g_{m10} = 6 \text{ mS}}$$

* My teammate dropped this course so I have to do this alone. Hence no contribution table.