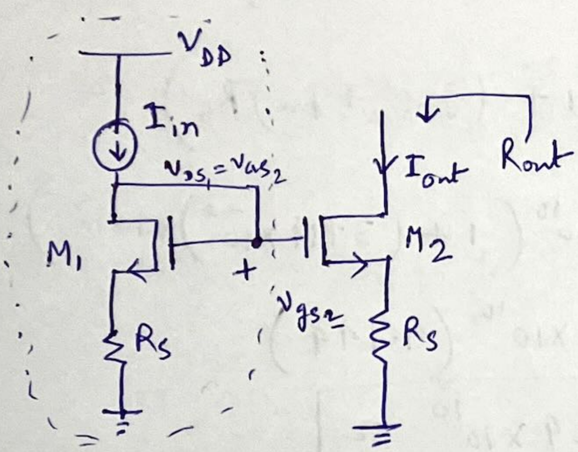
Solution: Quiz-2

P1

Q.1



Given, $I_{in} = 100\mu A$

$\left(\frac{W}{L}\right)_1 = \left(\frac{W}{L}\right)_2 = \frac{10}{.2} = 50$

$R_S = 1k\Omega$

$g_{mb} = 0.2\, g_m$

$\mu C_{ox} = 110\, \mu A/V^2$

$\lambda = 0.15\, \mu m/V$

This is a current mirror circuit and $M_1 = M_2$

Therefore $I_{out} = I_{in}$

$$r_{o2} = \frac{1}{\lambda I_D} = \frac{1}{0.15\times10^{-6} \times 100\times10^{-6}}$$

$$= \frac{1\times10^{+12}}{15}\,\Omega$$

$$= 6.67\times10^{+10}\,\Omega$$

As the left half of the circuit appears open,

$$R_{out} = r_{o2} + \left\{\left[1+(g_{m2}+g_{mb2})r_{o2}\right] R_S \right\}$$

As $(g_{m2}+g_{mb2})\, r_{o2} \gg 1$

$$R_{out} \simeq r_{o2} + \left\{(g_{m2}+g_{mb})\, r_{o2} R_S\right\}$$

If some one doesn't approximate here, that is also ok.

$$= r_{o2}\left[1+(g_{m2}+g_{mb2})R_S\right] \quad \text{—— (1)}$$

Here $g_{m2} = \sqrt{2\mu C_{ox}(W/L)\, I_{in}}$

$$= \sqrt{2\times110\times\left(\frac{10}{.2}\right) 100\times10^{-12}}$$

$$= 10^{-6}\left(\sqrt{2\times110\times50\times100}\right)$$

$$= 1.048\times10^{-3}\ \Omega^{-1}$$

$\therefore g_{mb2} = 0.2\times1.048\times10^{-3}\ \Omega^{-1} = \cancel{2.096\times10^{-3}\ \Omega^{-1}}$

=0.2096*10^-3 moh

Putting r_{o2}, g_{m2} and g_{mb2} and R_S in eqn. (1)

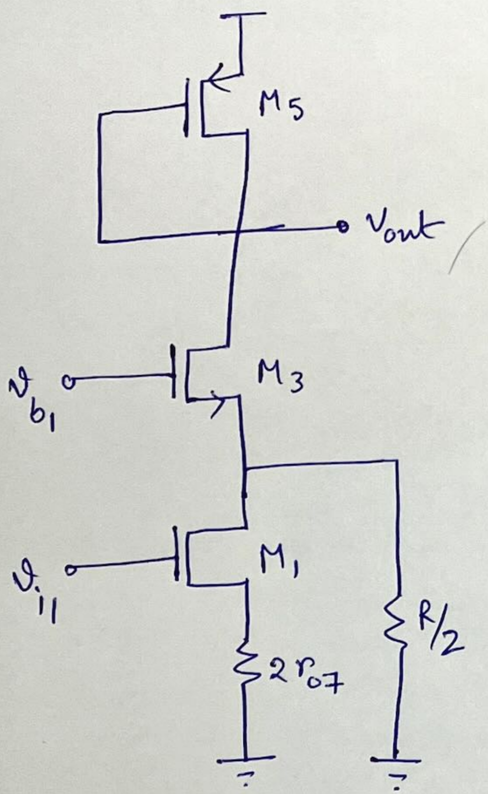
$$R_{out} = r_{o2}\left(1 + (g_{mb_2} + g_m) R_S\right) \Omega$$

$$= 6.67 \times 10^{10}\left(1 + (\overset{1.257}{\cancel{3.144}} \times 10^{-3}) \times 1 \times 10^{3}\right)$$

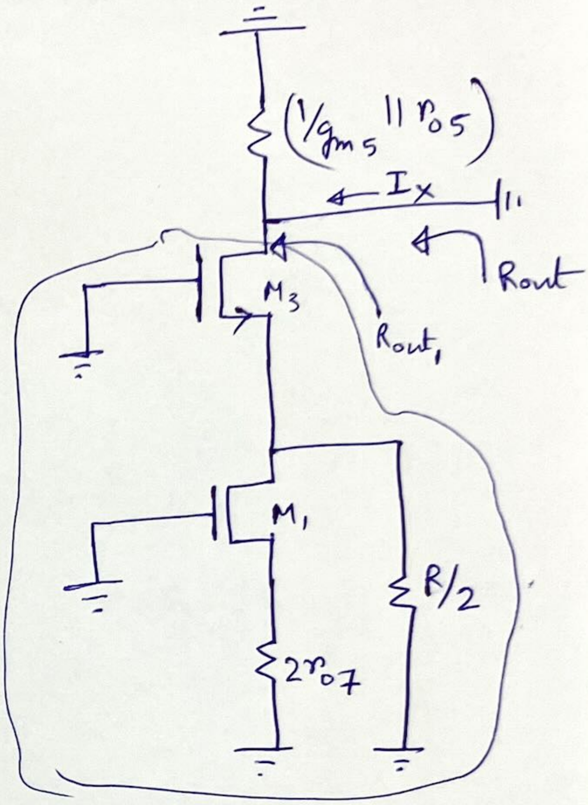
$$= 6.67 \times 10^{10} (\overset{2.257}{\cancel{4.144}})$$

$$\therefore \boxed{R_{out} = \cancel{26.64 \times 10^{10} \Omega}}$$ 15.05*10^10 ohm

Q.2 As given, assuming symmetry, we can analyse the diff. amplifier using half-circuit method. The half-circuit will be



For o/p resistance the equivalent $\Longrightarrow$ small signal ckt.



$$R_{out} = \left(\frac{1}{g_{m5}} \parallel r_{o5}\right) \parallel R_{out_1}$$

$$= \frac{1}{g_{m5}} \parallel R_{out_1}$$

[As $g_m r_o >> 1$ for all MOS devices

$$R_{out_1} = \left[(1+g_{m3}r_{o3}) \cdot \left\{R/2 \parallel \left[(1+g_{m1}r_{o1})2r_{o7} + r_{o1}\right]\right\}\right] + r_{o3}$$

$$\simeq \left(g_{m3} r_{o3} \cdot \frac{R}{2}\right) + r_{o3}$$ [As $g_m r_o >> 1$ for all MOS devices]

$$\boxed{\therefore R_{out} = \frac{1}{g_{m5}} \parallel \left\{\left(g_{m3} r_{o3} \frac{R}{2}\right) + r_{o3}\right\}}$$

Q.3

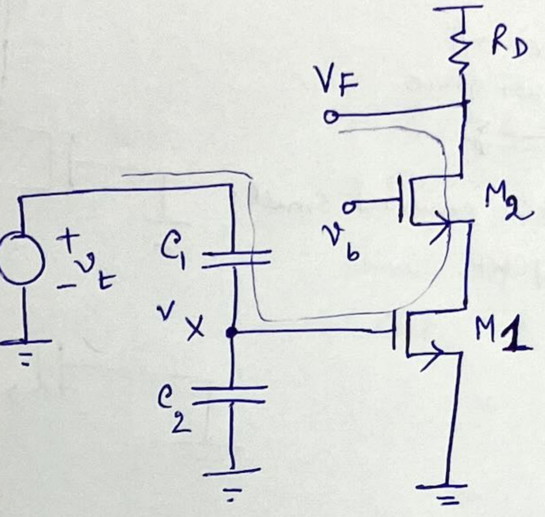
(a) For single stage Source-Follower CMOS amplifier Miller's approximation decreases the i/P capacitance.

(b) We need negative feedback (1) to desensitization the gain from external factors.

or, (2) → We need -ve feed back to obtain high precision.

Q.3

(c) After setting the main i/p (ac) to zero, breaking the loop and injecting a test signal, the circuit in Fig. 3 will look as follows —



Gain of this ckt.

$$\frac{v_F}{v_X} = -G_m R_{out}$$

$$R_{out} = R_D \| \left((1+g_{m2} r_{o2}) r_{o1} + r_{o2}\right)$$

$$G_m = g_{m1}$$

$$v_X = v_t \times \left(\frac{C_1}{C_1+C_2}\right)$$

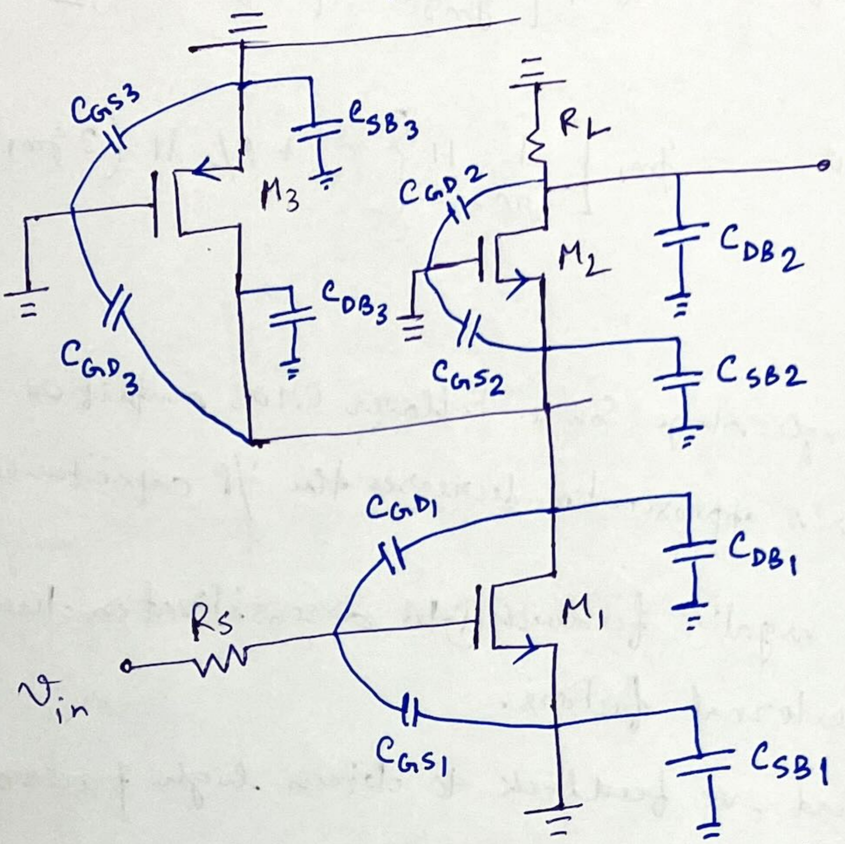
$$v_F = -v_X \left[R_D \,\|\, \left\{(1+g_{m2} r_{o2}) r_{o1} + r_{o2}\right\}\right] g_{m1}$$

$$= -v_t \left(\frac{C_1}{C_1+C_2}\right)\left[R_D \,\|\, \left\{(1+g_{m2} r_{o2}) r_{o1} + r_{o2}\right\}\right] \cdot g_{m1}$$

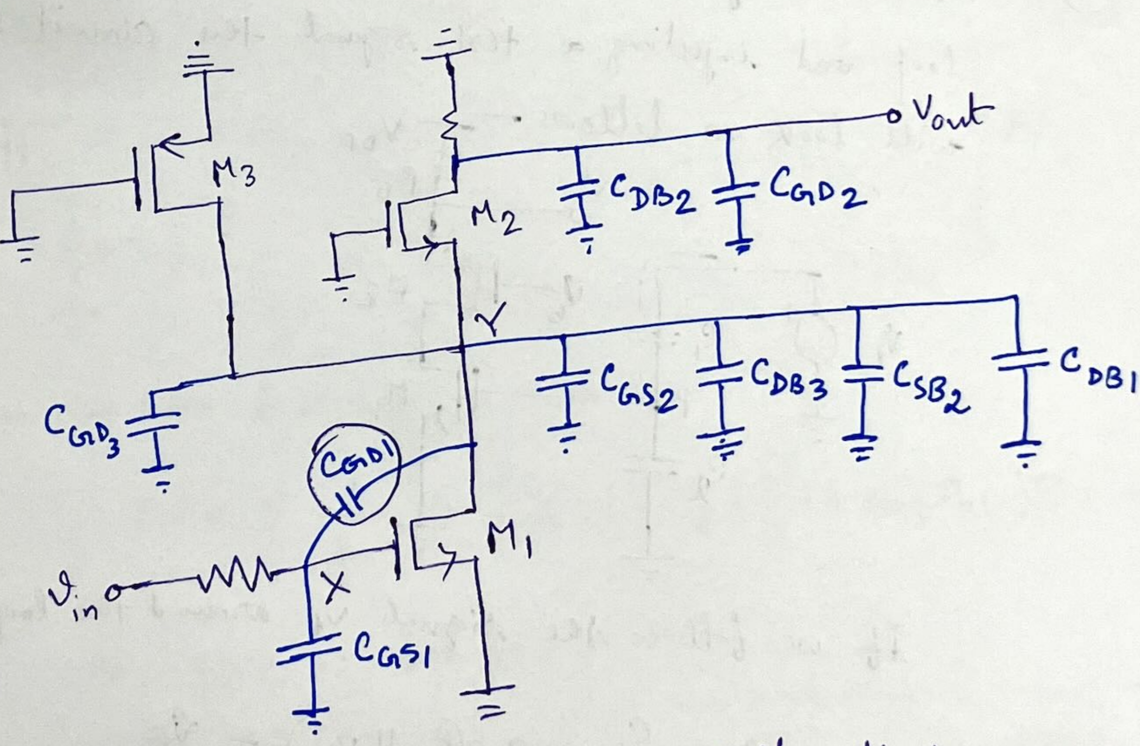
$$\therefore \text{Loop Gain} = -\frac{v_F}{v_t} = \left(\frac{C_1}{C_1+C_2}\right)\left[R_D \,\|\, \left\{(1+g_{m2} r_{o2}) r_{o1} + r_{o2}\right\}\right] g_{m1}$$

Q.4

If we draw all the capacitances for Fig. 4, we get and ground the independent dc sources



Removing and merging the capacitances, we get



Here C_{GD1} only experiences Miller effect.

There are three poles, which are —

$$\omega_{P_X} = \frac{1}{R_S\left(C_{GS_1} + \left(1 + \frac{g_{m1}}{g_{m2}}\right) C_{GD_1}\right)}$$

Because $A_V = -\, g_{m1}/g_{m2}$ (considering $\gamma = 0$ & $\lambda = 0$ for all MOS devices, as given)

$$\omega_{P_Y} = \frac{1}{1/g_{m2}\left[C_{DB_1} + C_{DB_3} + C_{GS_2} + C_{SB_2} + \left(1 + \frac{g_{m2}}{g_m}\right) C_{GD_1}\right]}$$

$$\omega_{P_{out}} = \frac{1}{R_L\left(C_{DB_2} + C_{GD_2}\right)}$$