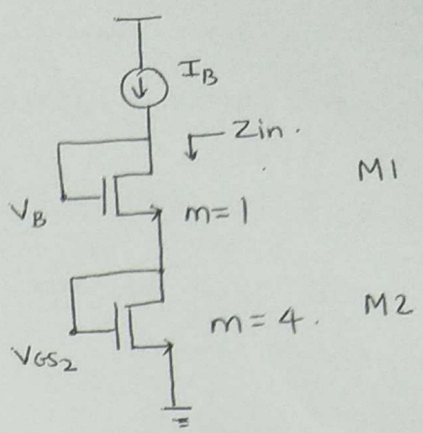
Q1.



$$z_{in} = \frac{1}{g_{m_1}} + \frac{1}{g_{m_2}} \quad 1$$

$$g_{m_1} = \sqrt{2\mu_n C_{ox}\frac{W}{L} I_B} = g_m \quad 0.5$$

$$g_{m_2} = \sqrt{2\mu_n C_{ox}\frac{4W}{L} I_B} = 2g_m \quad 0.5$$

$$Z_{in} = \frac{3}{2} \times \frac{1}{g_m} = \frac{1.5}{\sqrt{2\mu_n C_{ox}\frac{W}{L} I_B}} \quad 0.5$$

$$I_B = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS_1} - V_T)^2 \Rightarrow V_{GS_1} = \sqrt{\frac{2 I_B L}{\mu_n C_{ox} W}} + V_T \quad 0.5$$

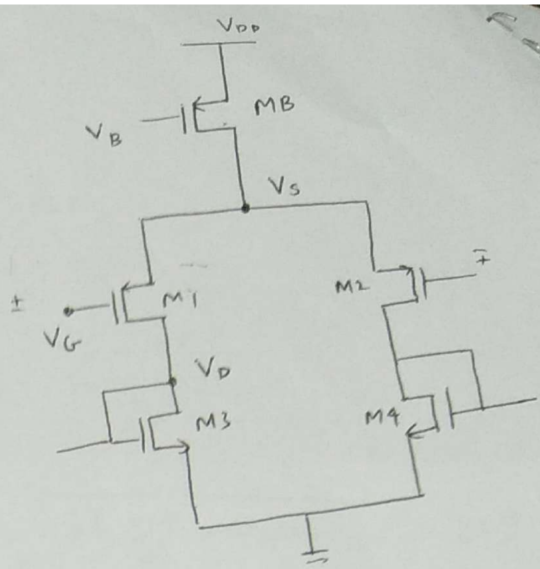
$$I_B = \frac{1}{2}\mu_n C_{ox}\frac{4W}{L}(V_{GS_2} - V_T)^2 \Rightarrow V_{GS_2} = \sqrt{\frac{2 I_B L}{\mu_n C_{ox}(4W)}} + V_T \quad 0.5$$

$$V_B = V_{GS_1} + V_{GS_2} \quad 1$$

$$= 2V_T + 1.5\sqrt{\frac{2 I_B L}{\mu_n C_{ox} W}} \quad 0.5$$

Scanned by CamScanner

Q2.



For calculating $V_{ICM}(max)$;

If $V_G \uparrow \Rightarrow V_S \uparrow$

$\therefore$ MB will be the first one to go to triode.

$\therefore$ At the limit

$V_S = V_{DD} - V_{dsat_p}$

$V_G = V_S - (V_{dsat_p} + V_{Tp})$ (To maintain current)

$\therefore V_{ICM}(max) = (V_{DD} - V_{dsat_p}) - (V_{dsat_p} + V_{Tp})$

$= V_{DD} - 2V_{dsat_p} - V_{Tp}$. 2.5

For calculating $V_{ICM}(min)$;

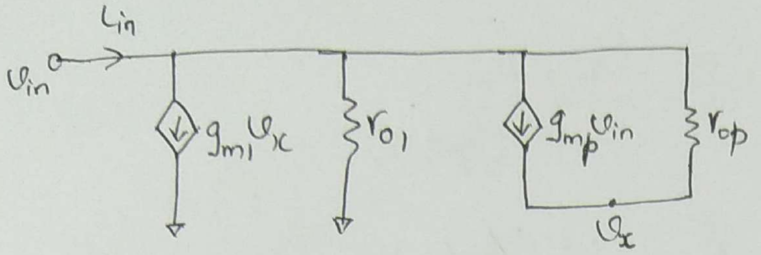
$V_D = V_{dsat_n} + V_{Tn}$

M1 will go to triode if V_G is decreased beyond $V_{ICM}(min)$.

$\therefore V_S - V_{ICM}(min) - V_{Tp} = V_S - (V_{dsat_n} + V_{Tn})$

$V_{ICM}(min) = V_{dsat_n} + V_{Tn} - V_{Tp}$ 2.5

Q.3) Small signal Model



2

$$i_{in} = g_{m1} v_x + \frac{v_{in}}{r_{o1}} + \frac{(v_{in} - v_x)}{r_{op}} + g_{mp} v_{in}. \quad 1$$

$$v_x = (1 + g_{mp} r_{o2})\, v_{in}$$

$$\therefore\ i_{in} = \left[(1 + g_{mp} r_{op})\left(g_{m1} - \frac{1}{r_{o2}}\right) + g_{mp} + \frac{1}{r_{o2}}\right] v_{in}$$

$$\therefore\ \frac{i_{in}}{v_{in}} = g_{m1}(1 + g_{mp} r_{op})$$

$$\therefore\ Z_{in} \approx \frac{1}{g_{m1} g_{mp} r_{op}}$$

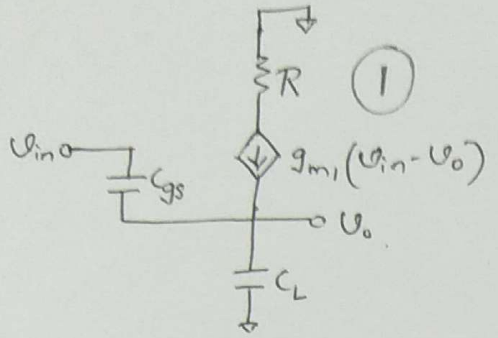
1, assuming $1 + g_{mp} r_{op} \approx g_{mp} r_{op}$

i.e $g_{mp} r_{op} \gg 1$.

For a simple current mirror, the input impedance $Z_{in} = \frac{1}{g_{m1}}$. 1

Transistor M_p, reduces the input impedance by a factor $g_{mp} r_{op}$ (self gain of M_p

Q4) Small signal Model



1

$$(v_o - v_{in})sC_{gs} + v_o sC_L - g_{m1}(v_{in} - v_o) = 0$$

$$\therefore A_v = \frac{v_o}{v_{in}} = \frac{g_m + sC_{gs}}{g_m + s(C_{gs} + C_L)}$$

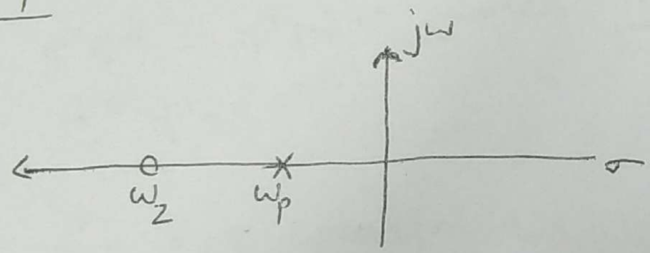
1

$$A_v = \frac{1 + s/(g_m/C_{gs})}{1 + s/\left(\frac{g_m}{C_{gs}+C_L}\right)}$$

$\therefore$ Left half plane zero, ω_z at $-g_m/C_{gs}$

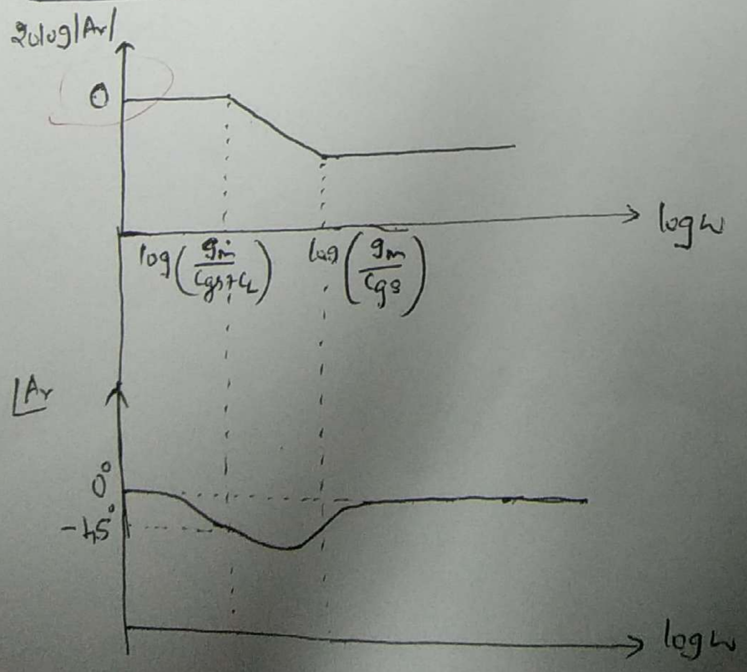
$\therefore$ Left half plane pole, ω_p at $-g_m/(C_{gs}+C_L)$

Pole-Zero plot



1

Bode - plot



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1