INDIAN INSTITUTE OF TECHNOLOGY GANDHINAGAR

A
12 pages

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Course Number/Title: ______ Section: ______

I pledge that in this examination I will neither indulge in unfair means nor accept anyone else doing so.

Date: 15-11-25 Signature of Student: Sr

Q. No.	1	2	3	4	5	6	7	8	9	10	11	12	Total
Marks													

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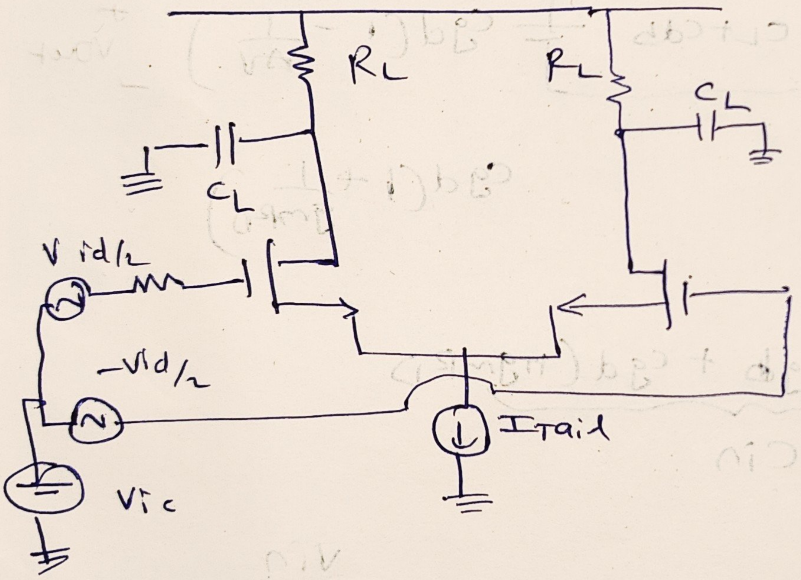


low freq gain = 5

$R_L = 1K$

$C_L = 50fF$

$R_S = 10K\Omega$

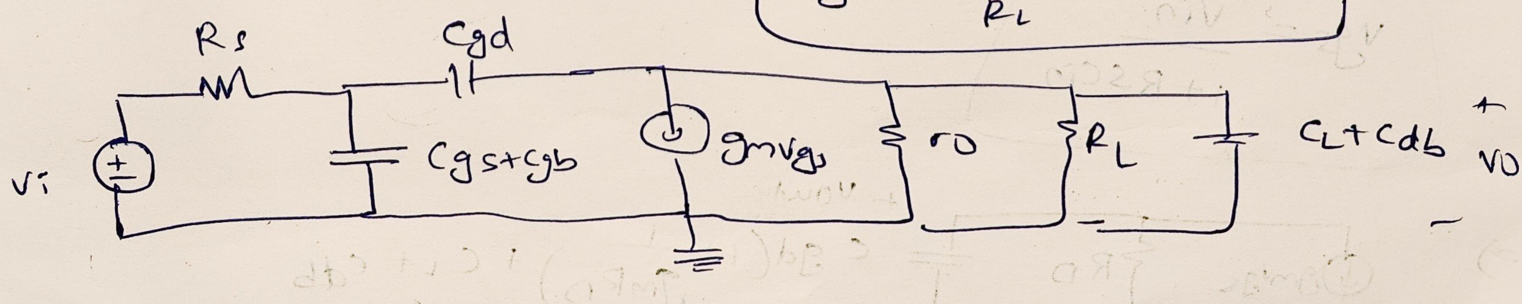
$I_{Tail} = 600mA$

$L = L_{min} = 0.18nm$

$$gain = g_m(R_L \| r_o) \approx g_m(R_L) = 5$$

$r_o >> R_L$

$$\boxed{g_m = \frac{5}{R_L} = 5ms}$$

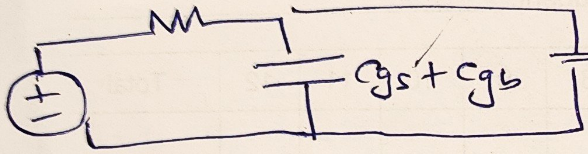


I would use miller compensation

low freq gain = $A_V = -g_m \underbrace{(r_o \| R_L)}_{R_D}$

$= -g_m R_D$

Input side

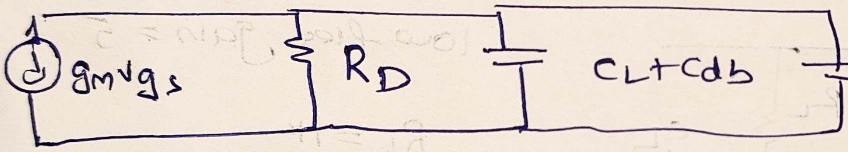


vin

$C_{gs} + C_{gb}$ $C_{gd}(1 - A_V)$ $+ \; v_{gs} \; -$

$= C_{gd}(1 + g_m R_D)$

Output side

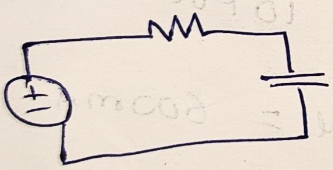


$g_m v_{gs}$ R_D $C_L + C_{db}$ $C_{gd}\left(1 - \frac{1}{A_V}\right)$ $+ \; V_{out} \; -$

$R_D = r_o \| R_L$

$C_{gd}\left(1 + \frac{1}{g_m R_D}\right)$

$\Rightarrow$



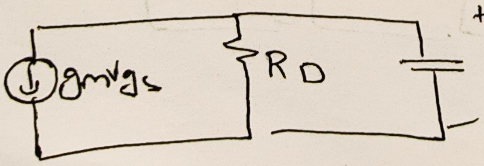
vin

$\underbrace{C_{gs} + C_{gb} + C_{gd}(1 + g_m R_D)}_{C_{in}}$

$$V_{gs} = \left[\frac{V_{in}}{R_s + \frac{1}{s(C_{in})}}\right] \frac{1}{s C_{in}} = \frac{V_{in}}{1 + R_s s C_{in}}$$

$$\boxed{V_{gs} = \frac{V_{in}}{1 + R s C_{in}}}$$

$\Rightarrow$



$g_m v_{gs}$ R_D $+ \; V_{out}$

$\underbrace{C_{gd}\left(1 + \frac{1}{g_m R_D}\right) + C_L + C_{db}}_{C_{out}}$

$$\frac{1}{X} = \frac{1}{R_D} + \frac{1}{sC_{out}}$$

$$X = \frac{sR_D C_{out} X}{R_D + sC_{out}X} \Rightarrow \frac{R_D}{1+R_D s C_{out}}$$

$$V_{out} = (g_m V_{gs})\left(\frac{sR_D C_{out}}{1+R_D + sC_{out}}\right)\left(\frac{1}{sC_{out}}\right)$$

$$= g_m\left(\frac{V_{in}}{1+R_s s C_{in}}\right)\left(\frac{sR_D C_{out}}{R_D + sC_{out}}\right)$$

$$V_{out} = g_m v_{gs}\left(\frac{R_D}{1+R_D s C_{out}}\right)$$

$$\Rightarrow \quad V_{out} = g_m\left(\frac{V_{in}}{1+R_s s C_{in}}\right)\left(\frac{R_D}{1+R_D s C_{out}}\right)$$

$$\text{Pole 1} = \frac{1}{R_s C_{in}} = \frac{1}{R_s\left(C_{gd}(1+g_m R_D) + C_{gs} + C_{gb}\right)}$$

$$\text{pole 2} = \frac{1}{R_D C_{out}} = \frac{1}{R_D\left(C_L + C_{db} + C_{gd}\left(1+\frac{1}{g_m R_D}\right)\right)}$$

$$R_D = r_o \,||\, R_L \approx R_L$$

$$\Rightarrow \quad \text{Pole 1} = \frac{1}{R_s\left(C_{gd}(1+g_m R_L) + C_{gs} + C_{gb}\right)}$$

$$\text{pole 2} = \frac{1}{R_D\left(C_L + C_{db} + C_{gd}\left(1+\frac{1}{g_m R_L}\right)\right)}$$

from plot ⇒ when $\frac{gm}{Id} = \frac{5\times10^{-3}}{300\times10^{-6}} = 16.66 ⇒$

$\boxed{L = 180nm}$

$\frac{Cgd}{Cgg} = 0.22$

From Transit freq plot ⇒ $f_T = 1.7\times10^{10} = \frac{gm}{2\pi\, Cgg}$

$Cgg = \frac{gm}{2\pi(1.7\times10^{10})} = \frac{5\times10^{-3}}{2\pi(1.7\times10^{10})}$

$= 4.68\times10^{-14}$

$\boxed{Cgg = 4.68\times10^{-14} F}$

$Cgd = (0.22)(Cgg) = 1.029\times10^{-14} F$

$\boxed{Cgd = 1.029\times10^{-14} F}$

cdb is very small relative to CL (0.4 to 0.8 fF)

$Cgs + Cgb + Cgd = Cgg$

$Cgs + Cgb = Cgg - Cgd = 10^{-14}(4.68 - 1.029)$

$\boxed{Cgs + Cgb = 3.651\times10^{-14}}$

Finally ⇒ $\omega p_1 = \frac{1}{(10\times10^{3})\left((1.029\times10^{-14})(1+5) + 3.651\times10^{-14}\right)}$

$= 10179153 09.446$

$= 1.017\times10^{9}$

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$$\omega p_2 = \frac{1}{(10^3)\left(50\times10^{-15} + (1.029\times10^{-14})\left(1+\frac{1}{5}\right)\right)}$$

$$= 16039006864.694$$

$$\boxed{\omega p_2 = 1.603\times10^{10}}$$

ωp_1 is dominant, ωp_2 is non-dominant

Now we should find W/L, V_{ov}, power.

From plot g_m/I_d v/s V_{ov} $\Rightarrow$ $V_{ov} = 0.01$

From plot g_m/I_d v/s I_d/W $\Rightarrow$ $\frac{I_d}{W} = 10$

$$W = \frac{300\times10^{-6}}{10} = 3\times10^{-5}$$

$W = 30\,\mu m$

$L = 180\,nm$

⇒ Square law

$$g_m = 5mS = 5\times10^{-3} = \frac{2I_D}{V_{OV}}$$

$$V_{OV} = \frac{2\,(300\times10^{-6})}{5\times10^{-3}} = 180\times10^{-7} = 0.18$$

$$\boxed{V_{OV} = 0.18}$$

$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{OV})^2 = 300\times10^{-6}$$

$$W = \frac{2(300\times10^{-6})(180\times10^{-9})}{(300\times10^{-6})(0.18)^2} = 0.0000111111$$

$$= 1.111\times10^{-5}$$

$$= 11.11\times10^{-6}$$

$$W = 11.11\,\mu m$$

$$\left(\frac{W}{L}\right) = 61.728 \qquad L = 180nm$$

	Square law	gm/Id method
Vov	0.18	0.01 (nearly zero)
W	11.11 µm	30 µm
L	180nm	180nm
Power	0.00108 1.08×10^{-3}	0.00108 1.08×10^{-3}

$= 1.017\times10^{1}$