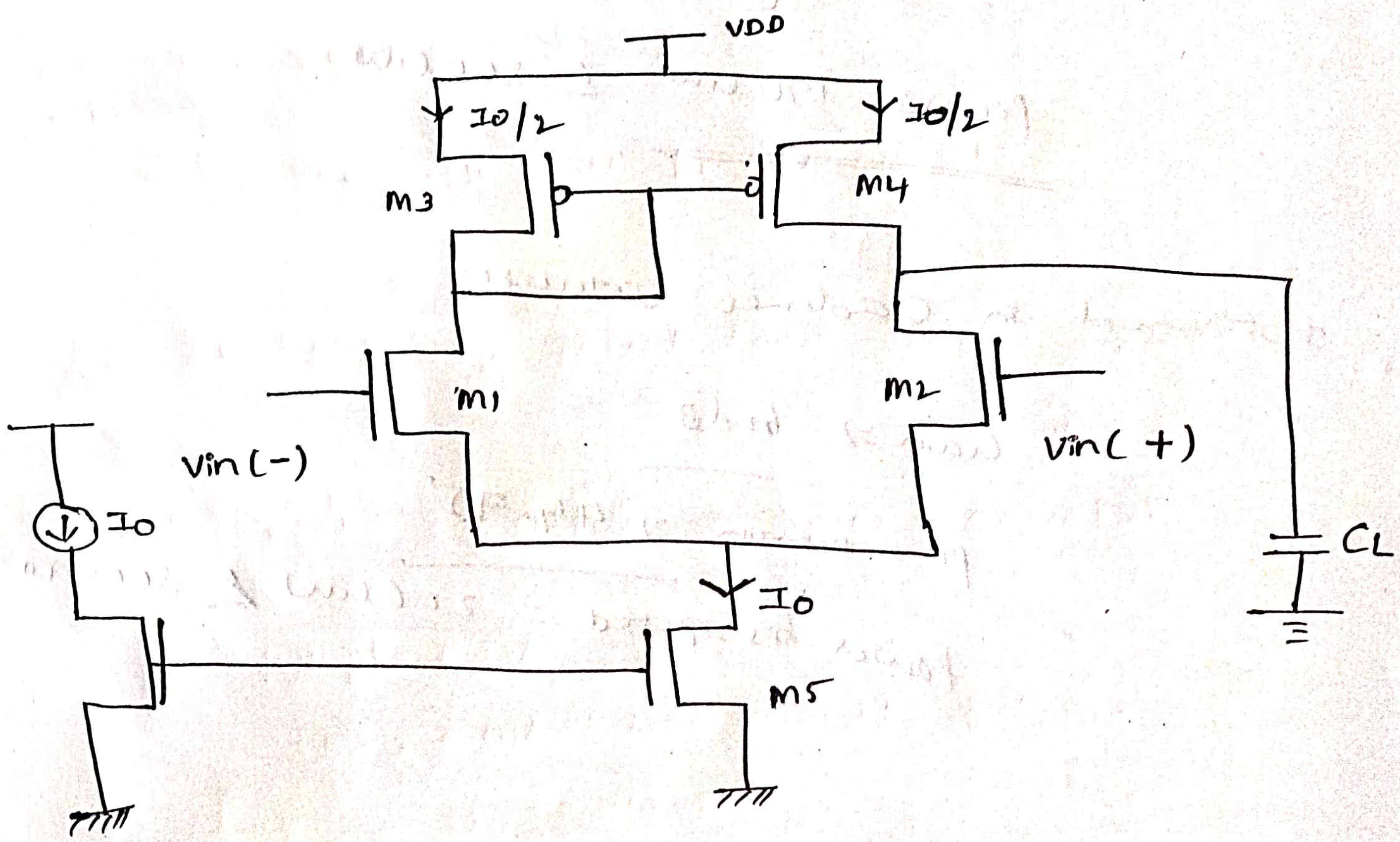
Differential Amplifier



* Specifications *

$V_{DD} = 1.8V$

$A_{DC} = 100 \Rightarrow 20\log_{10}100 \Rightarrow 40dB.$

$C_L = 10pF$

$SR = 5V/\mu sec$

$GBW \approx 5MHz.$

$$\left.\begin{array}{l} ICMR(+) = 1.6V \\ ICMR(-) = 0.8V \end{array}\right\}$$ Such that mosfets doesnot go into Triode region

from slew rate, $SR = dv/dt$

we know that $Q = CV$

$$I = \frac{dQ}{dt} = \frac{C\,dv}{dt}$$

$$\frac{I}{C} = \frac{dv}{dt}$$

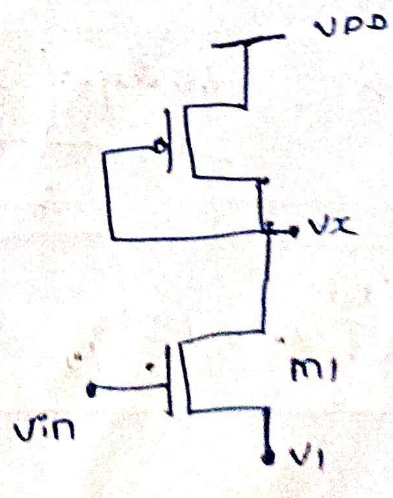
for output $\frac{I_0}{C_L} = \frac{dv}{dt}$ = slew rate.

$$I_0 = C_L\left(\frac{dv}{dt}\right)$$

$$I_0 = \left(10 \times 10^{-12}\right)\left(\frac{5V}{\mu sec}\right)$$

$I_0 \Rightarrow 50\mu A$

Let us take a part of circuit



for m1 to be in saturation

$V_{DS} > V_{gs} - V_{t1}$

$V_D > V_g - V_{t1}$

$V_x > 1.6 - 0.45$

$V_x > 1.15$

Let $V_x = 1.2$

$V_{DS3} = V_{DD} - V_X$

$V_{DS3} = 1.8 - 1.2$

$V_{DS3} = 0.6V$

As $I_0 = 50\mu A$

I_3 and I_4 will be $25\mu A$ each.

DO DC operating point and find $\mu_n C_{ox}$ & $\mu_p C_{ox}$ parameters

Let $\mu_n C_{ox} = 300\mu A/V^2$ & $\mu_p C_{ox} = 60\mu A/V^2$

$|V_{thp}| = 0.5V$

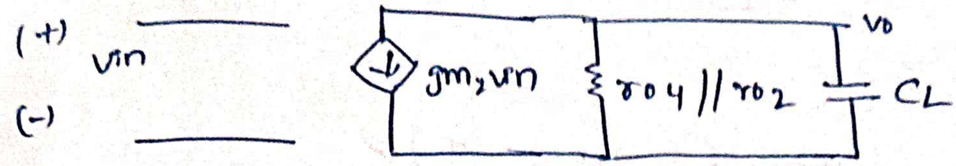
$V_{thn} = 0.4V$ from circuit's analysis.

$$I_3 = \mu_p C_{ox}\left(\frac{W}{L}\right) \frac{(V_{sg} - |V_{tp}|)^2}{2}$$

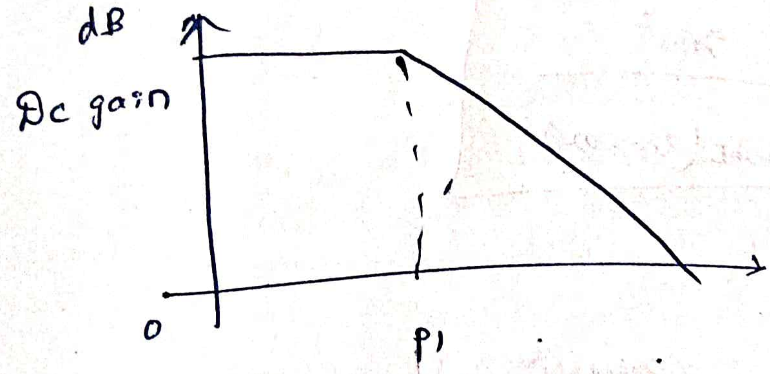
$$25\mu A = \frac{60\mu A/V^2\left(\frac{W}{L}\right)}{2}\left[0.6 - 0.5\right]^2$$

$$\boxed{\left(\frac{W}{L}\right)_3 = \left(\frac{W}{L}\right)_4 = 84}$$

from small signal parameters of mosfet,



$$\frac{vo}{ro_4 || ro_2} + \frac{vo}{\left(\frac{1}{sCL}\right)} + gm_2 \, vin = 0$$



$$\frac{vo}{vin} \Rightarrow \frac{-gm\,(ro_2 || ro_4)}{1 + sC_L\,(ro_2 || ro_4)} \Rightarrow \frac{\text{Dc gain}}{\left(1 + \frac{s}{p_1}\right)}$$

$$\text{Dc gain} \Rightarrow gm\,(ro_2 || ro_4)$$

$$GBW = \text{Dc gain}\,(p_1)$$

$$GBW = \frac{gm_1}{\underbrace{sCL}_{2\pi CL}} \qquad gm_1 \Rightarrow 5MHz\,(2\pi \times 10pF)$$

$$\boxed{gm_1 = 314u}$$

$$I_D = \mu n C_{ox}\left(\frac{W}{L}\right)\frac{(V_{gs}-V_{th})^2}{2}$$

$$\frac{\partial I_D}{\partial V_{gs}} = g_m = \mu n C_{ox}\left(\frac{W}{L}\right)\frac{(V_{gs}-V_{th})\cancel{2}}{\cancel{2}}$$

$$g_m^2 \Rightarrow 2 I_D \mu n C_{ox} \frac{W}{L}$$

*

$$\boxed{\left(\frac{W}{L}\right) = \frac{g_m^2}{2 I_D(\mu n C_{ox})}}$$

$$\left(\frac{W}{L}\right)_{1,2} \Rightarrow \frac{(314\mu)^2}{2(25\mu)(300\mu)} \Rightarrow 7$$

$$\boxed{\left(\frac{W}{L}\right)_1 = \left(\frac{W}{L}\right)_2 = 7}$$

for M5

$V_{in_{min}} > V_{gs1} + V_{dsat5}$

$$I_D = \frac{\mu n C_{ox} \left(\frac{W}{L}\right)}{2} (V_{gs1} - V_{th})^2$$

25uA

$V_{gs1} = 0.6V$

$V_{dsat} \leq 0.2$

To set $\left(\frac{W}{L}\right)_5$

$$\underset{50uA}{I_D} \Rightarrow \frac{\overset{300u}{\mu n C_{ox}} \left(\frac{W}{L}\right)}{2} (\overset{0.6}{V_{gs}} - \overset{0.4}{V_{th}})^2$$

$$\boxed{\left(\frac{W}{L}\right)_5 = 9}$$

After simulation

Gain is around $\simeq$ 35.7dB.

GBW = 4.8MHz.