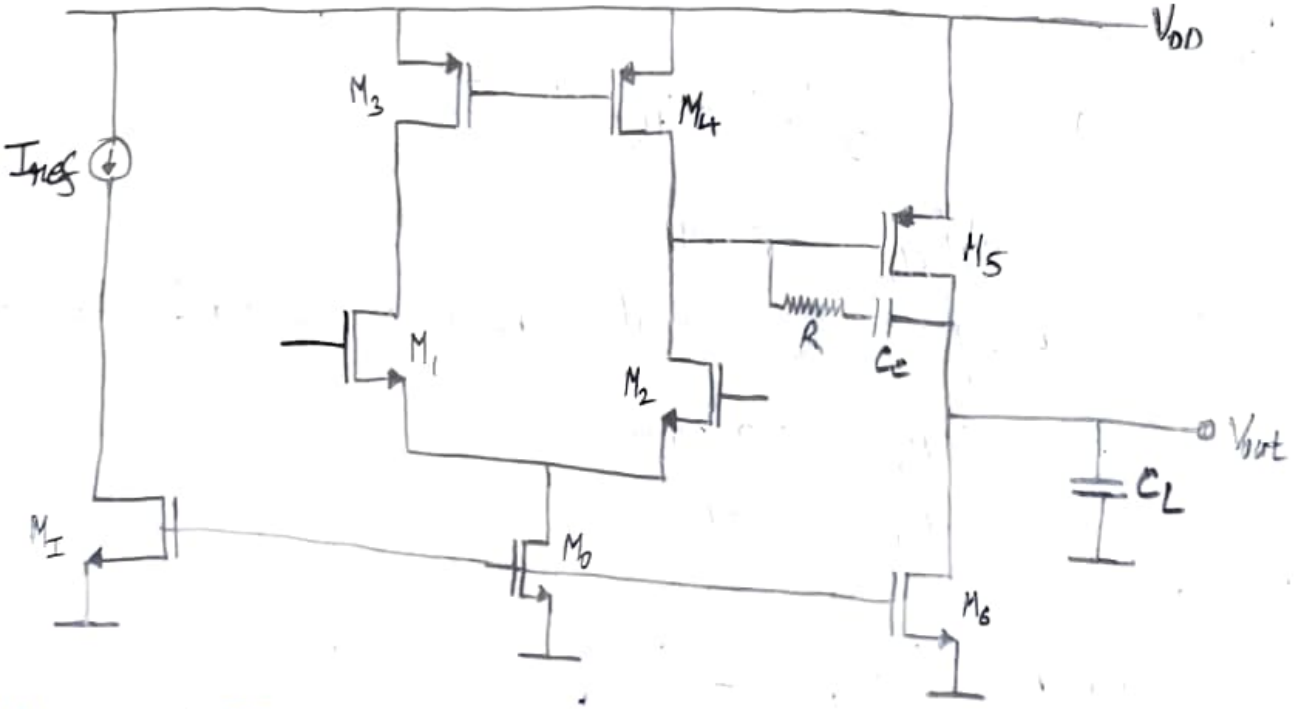
Design for 2 Stage OP-AMP

Specifications :-

1. DC gain > 60dB
2. Process = 180nm
3. Phase margin of 60°
4. ICMR(+) = 1.6V
5. ICMR(-) = 0.8V
6. Load capacitance = 10pf
7. V_{DD} = 1.8V
8. $\mu_n C_{ox}$ = 230μA/V²
9. $\mu_p C_{ox}$ = 100μA/V²
10. $(V_T)_N$ = 0.37V
11. $|(V_T)_P|$ = 0.39V
12. Overdrive of each transistor = 200mV

Circuit Diagram :-



Choose M. I_{ref} = 40μAmp

for M_1 :-

$$I_{M_1} = 20\mu A$$

$$20\mu A = \frac{230\mu}{2} (W/L)_{M_1} (0.2)^2$$

$$(W/L)_{M_1} = 4.3478$$

Choose $L_{M_1} = 0.9\mu$, $W_{M_1} = 3.913\mu$ } Same values for M_2 as well.

for M_4 :-

$$20\mu = \frac{100\mu}{2} (W/L)_{M_4} (0.2)^2$$

$$(W/L)_{M_4} = 10.$$

Choose $W_{M_4} = 9\mu$, $L_{M_4} = 0.9\mu$ } Same values for M_3 as well

for M_0 :-

$$40\mu = \frac{230\mu}{2} (W/L)_{M_0} \cdot (0.2)^2$$

$$(W/L)_{M_0} = 8.695.$$

After fine tuning, the final values of W and L are :-

$$W_{M_0} = 8.8264\mu$$
$$L_{M_0} = 0.7\mu$$

for M_I :-

Ideally, $(W/L)_{M_I} = (W/L)_{M_0}$, but after fine tuning,

$$W_{M_I} = 7.8264\mu$$
$$L_{M_I} = 0.9\mu$$

For M_5 :- [Common-Source stage]

$$40\mu = \frac{100\mu}{2}(W/L)_{M5}(0.2)^2$$

$$(W/L)_{M5} = 20$$

After fine-tuning,

$$W_{M5} = 16.29\mu$$

$$L_{M5} = 0.9\mu$$

For M_6 :-

$W_{M6} = 8.8264\mu$ } Same as M_0
$L_{M6} = 0.9\mu$ } (Current mirror)

Observed Gain of Differential pair :-

V_{p-p} of output = 27.41mV

V_{p-p} of input = 0.2mV

$$\text{Gain} = \frac{(V_{p-p})_o}{(V_{p-p})_I} = 137.05$$

Gain in dB :- $20\log(137.05) = 42.737\text{dB}$

Overall Gain of 2-Stage OTA :-

V_{p-p} of output = 1.318V

V_{p-p} of input = 0.2mV

$$\text{Gain} = \frac{(V_{p-p})_o}{(V_{p-p})_I} = \frac{1.318}{0.2m} = 6590$$

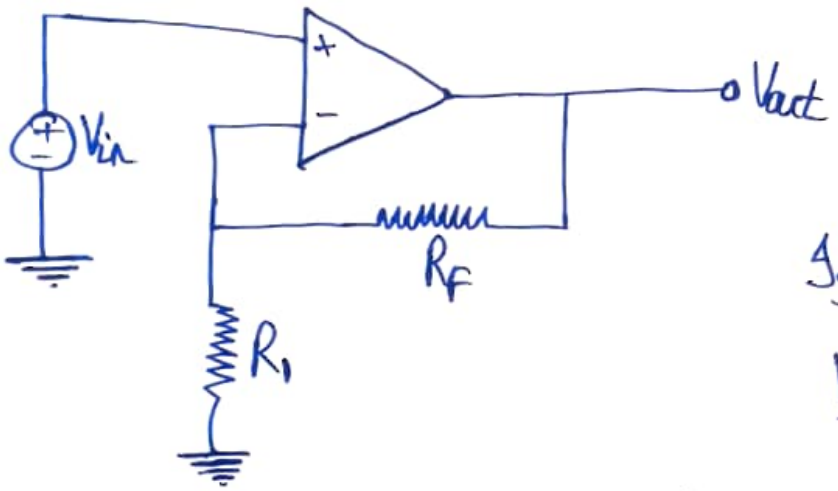
Gain in dB :- $20\log(6590) = 76.377\text{dB}$

Observed gain cross-over frequency $= 17.599\text{MHz}$

$PM = 180° + (-122.7°)$

$= 57.3°$

After feedback connection :-



$\frac{V_{out}}{V_-} = 1 + R_f/R_1$

If we take $R_f = R_1$

$\frac{V_{out}}{V_-} = 2$

choose $R_f = R_1 = 1\text{Meg}\Omega$

Location of Dominant pole .:- $\frac{1}{A_2 C_c (g_{o5} \| g_{o6})}$

$= 12\text{KHz}$

Practical gain $= 1.97$.