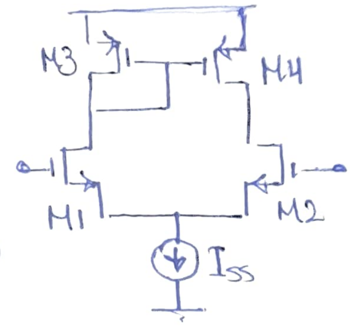
(1) For the shown amplifier.
If $C_L \gg C_p$ and it's required to double BW without changing the gain, the designer should



$\because A_v = g_m (r_{o2} \| r_{o4})$, $BW = \dfrac{1}{2\pi C_L (r_{o2} \| r_{o4})}$

$\therefore$ to double the BW $\rightarrow r_o$ must be halfed

$\because r_o = \dfrac{V_A}{I_D} \rightarrow I_D$ doubled $\rightarrow I_{SS}$ doubled

but $A_v \propto r_o$

$\therefore g_m$ must be doubled to keep A_v fixed

$$g_m = \sqrt{\mu_n C_{ox} \frac{W}{L} \cdot 2 I_D}$$

If $I_D \times 2 \rightarrow g_m \times \sqrt{2}$

$\therefore$ We should double the W $\rightarrow g_m \times \sqrt{2} \times \sqrt{2} \rightarrow g_m \times 2$

$\therefore$ double I_{SS} and double $W_{1,2}$

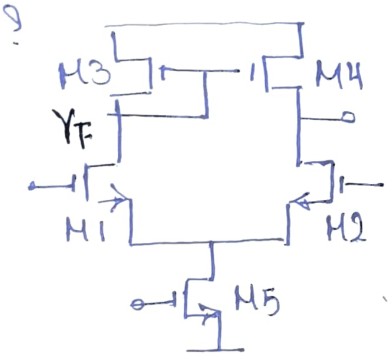
(2) If I_{SS} is decreased and W is changed such that V_{ov} is kept fixed, then the gain ...

$\because A_v = g_m \dfrac{r_o}{2}$ (assume $r_{o2} = r_{o4}$ for simplicity)

$\therefore A_v = \dfrac{2 I_D}{V_{ov}} \times \dfrac{V_A}{I_D} \times \dfrac{1}{2} = \dfrac{V_A}{I_D} \cdot \dfrac{I_D}{V_{ov}} = \dfrac{V_A}{V_{ov}} \neq f(I_D)$ ..

$\because V_A, V_{ov}$ is fixed $\rightarrow A_v$ remains unchanged.

(3) $V_{DD} = 2$, $V_{TH} = 0.4$ and $V_{ov} = 0.2$, then $V_{out} = ?$



$V_{out} = V_F = V_{DD} - V_{SG3,4} = 1.4\ V$

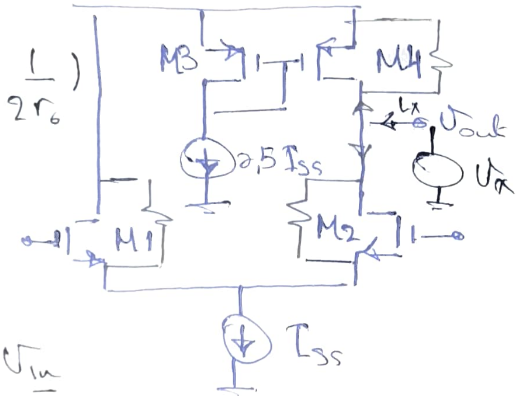
(4) it's required to improve the low freq CMRR without affecting the DC gain or the tail current source, the designer should

$$\because CMRR = \frac{g_{m1,2}(r_{o2} \parallel r_{o4})}{\text{DC gain}} \times \frac{2 g_{m3,4} R_{SS}}{\text{tail current source}}$$

$\therefore$ We need to improve $g_{m3,4}$

$\because g_m = \sqrt{\mu C_{ox} \frac{W}{L} \cdot 2 I_D}$ → We can improve by
→ Increase W
→ reduce L (not valid) as it affect tail current source.

(5) Assume symmetry and all transistors have same V_A. The gain of the shown amp is



$$\because i_x = i_4 + i_2 = \frac{V_x}{r_{o4}} + \frac{V_x}{2r_{o1,2}} = V_x\left(\frac{1}{r_o} + \frac{1}{2r_o}\right)$$

$$\because R_{out} = \frac{V_x}{i_x} = \frac{2}{3} r_o$$

$$\because G_m = \frac{i_{out,sc}}{V_{GS}} \rightarrow i_{out,sc} = g_{m2} V_{gs2} = g_{m2} \frac{V_{in}}{2}$$

$$\therefore G_m = \frac{g_{m2}}{2}$$

$$\therefore A_v = \frac{g_m r_o}{3}$$

(6) $V_{DD} = 2$, $V_{TH} = 0.4$, $V_{ov} = 0.2$, $V_{id} = 5mV$ then $V_{out} = ?$

$$\because V_{out} = V_{out,CM} + v_{out} = V_{DD} - V_{SG3,4} + A_v \cdot v_{id}$$

$$\because A_v = g_m \frac{r_o}{2} = \frac{V_A}{V_{ov}} = 50$$

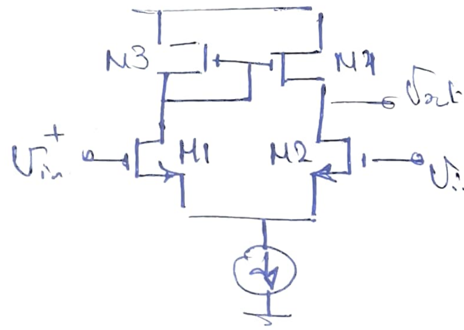
$$\therefore V_{out} = 1.4 + 25mV = 1.65 V$$

(7) $V_{DD} = 2$, $V_{ov} = 0.2$ → max peak to peak output swing is ...

$$\because 2V_{ov} \leq V_{out} \leq V_{DD} - V_{ov}$$

$$\therefore 0.4 \leq V_{out} \leq 1.8 \longrightarrow \text{max Swing} = 1.8 - 0.4 = 1.4V$$

(8) If I_{SS} is decreased and the sizing is kept fixed then the gain --



$$A_V = G_m R_{out} = g_m \frac{r_o}{2} = \frac{V_A}{V_{ov}}$$

If $I_{SS} \downarrow$, $V_{ov} \downarrow$

where $I_D = \mu C_{ox} \frac{W}{L} V_{ov}^2$

∴ A_V will increase

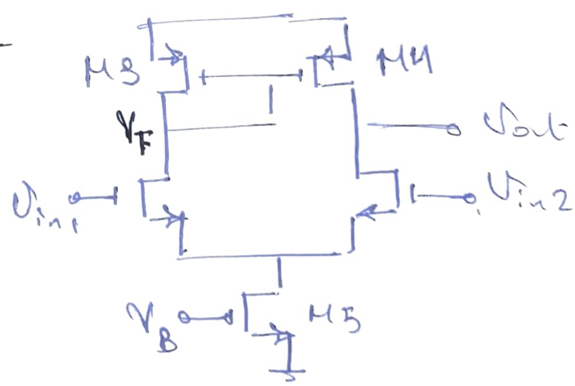
(9) If $V_{DD} = 2V$, $V_{TH} = 0.4V$ and $V_{ov} = 0.2V$, The max CM input voltage is -- V

$$V_{ICM\,max} = V_{GS1,2} - V_{ov1,2} - V_{GS3,4} + V_{DD}$$

$$= \cancel{V_{TH}} + \cancel{V_{ov}} - \cancel{V_{ov}} - \cancel{V_{TH}} - V_{ov} + V_{DD}$$

$$= 2 - 0.2 = 1.8V$$

(10) If $V_{DD} = 2V$, $V_{TH} = 0.4$, $V_{ov} = 0.2$; $V_A = 10V$ and $V_{in1} = 1V$, if V_{out} is connected to V_{in2}, then the voltage at V_{out} is..



∵ $V_F = V_{DD} - V_{SG3,4} = 2 - 0.4 - 0.2$

$V_F = 1.4$

∵ $V_{out} = V_{in2}$

∴ $V_{offset} = 1.4 - \cancel{0.1}\ 1 = 0.4V$

∵ $A_V = g_m \frac{r_o}{2} = \frac{V_A}{V_{ov}} = 50$

∴ input reffered offset $= \frac{0.4}{50} = 8mV$

∴ $V_{out} = 1 + 8mV = 1.008V$