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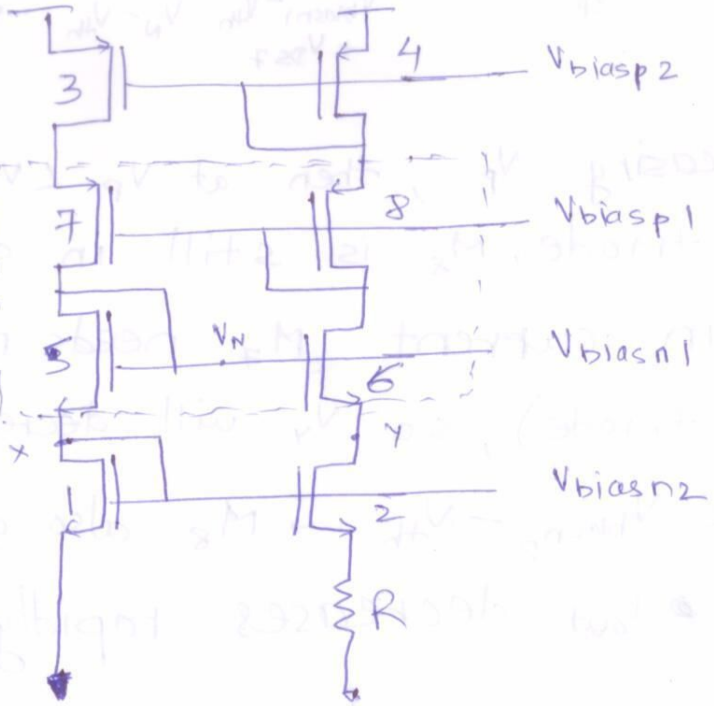
1

1. Simple cascode topology can be used.

→ Modification



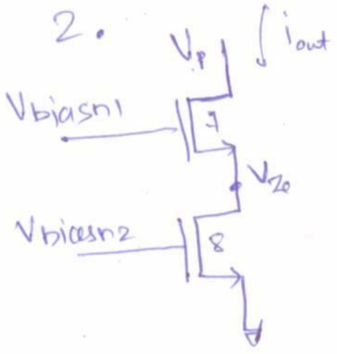
$V_x = V_N - V_{GS5}$

$V_y = V_N - V_{GS6}$

$\therefore$ ~~$V_x = V_y$ → channel length~~ ~~mo~~

$V_x = V_y \Rightarrow$ so same current through two branches.

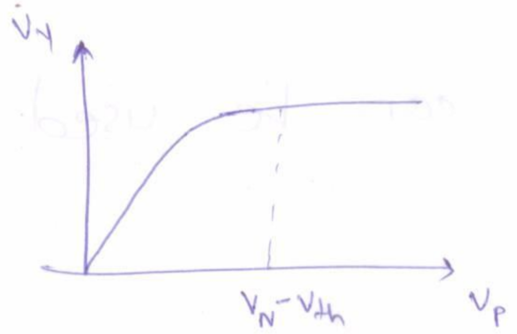
2.

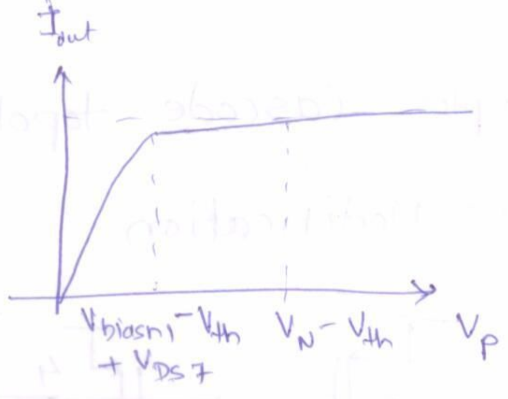


If it is used to bias as shown in fig.

$V_{P,min} = V_{OV} + V_{z0}$
$= V_{OV} + V_y$
$= V_{OV} + V_x$
$= V_{OV} + V_{GS}$
$= V_{OV} + V_{GS} - V_{th} + V_{th}$
$= V_{OV} + V_{OV} + V_{th}$

$\therefore V_{P,min} = 2V_{ov} + V_{th}$





If we keep decreasing V_P, then at $V_P < V_N - V_{th}$ M_7 will go to triode, M_8 is still in sat. But to maintain current M_7 needs more V_{GS} (as it is in triode), so V_Y will decrease. Eventually $V_y < V_{biasn_2} - V_{th} \rightarrow M_8$ also goes to ~~sat~~ triode and i_{out} decreases rapidly.

~~Low voltage~~

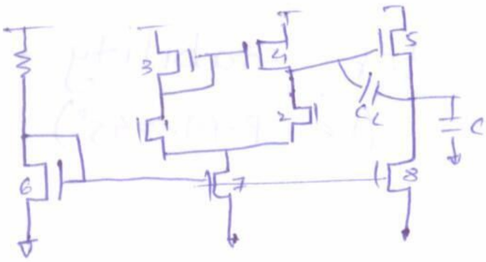
2. OP-AMP design.

Distributing currents as,

Bias circuit = 200 μ A

Differential pair = 800 μ A

CS stage = 1 mA



Also, $g_{m_1} = g_{m_5} = 1m$ (assuming)

$$\therefore \quad g_{m_5} = \sqrt{2 \beta_5 I_D}$$

$$\left(\frac{W}{L}\right)_5 = 12.5$$

$$I_{D_1} = I_{D_2} = \frac{800\mu}{2} = 400 \mu A$$

$$\therefore \left(\frac{W}{L}\right)_1 = \left(\frac{W}{L}\right)_2 = 10.41$$

$$r_{on_2} = \frac{1}{\lambda_n I_{D2}} = \frac{1}{0.01 \times 0.4m} = 250K$$

$$r_{op4} = \frac{1}{\lambda_p I_{D4}} = \frac{1}{0.0125 \times 0.4m} = 200K$$

$$R_{out1} = r_{on1} \parallel r_{op4} = 111K$$

$$r_{on8} = \frac{1}{\lambda_n I_{D8}} = \frac{1}{0.01 \times 1m} = 100K$$

$$r_{op5} = \frac{1}{\lambda_p \cdot I_{D5}} = \frac{1}{0.0125 \times 1m} = 80K$$

$$R_{out2} = 44K$$

dc. Gain $= g_{m_1} \cdot g_{m_2} R_{out1} \cdot R_{out2}$

$$\boxed{Gain = 4884}$$

For stability, $\omega_{P_2} = \dfrac{g_{m5}}{C_L} \geq \omega_{unity} = \dfrac{g_{m1}}{C_c}$

(i.e. P.M. = 45°)

$$g_{m5} = g_{m1}$$

$$\therefore C_c \geq C_L$$

$$C_c \geq 1.5p$$

$$\therefore \text{Choosing } \boxed{C_c = 2pF}$$

$$\boxed{\therefore \omega_{unity} = \frac{g_{m1}}{C_c} = 500 \text{ MHz}}$$

$$\omega_{-3} = \frac{1}{R_{out1}\left(1 + g_{m5} \cdot R_{out2}\right) \cdot C_c}$$

$$\boxed{\omega_{-3} = 100.100 \text{ KHz}}$$

$$V_{ov5} = \frac{g_{m5}}{\beta} = \frac{1m}{\mu_p C_{ox}\left(\frac{W}{L}\right)_5} = 2$$

CM for M_5 comes from first stage.

$\therefore$ Same $V_{thp} + V_{ov5} = V_{ov4} = |V_{GS4}| + V_{th} = V_{GS3}$

$$\therefore I_{D3} = 0.4m = \frac{1}{2} \beta_{P3} \left(V_{GS3} - V_{thp}\right)^2$$

$\left(\frac{W}{L}\right)_3 = 5$
$\left(\frac{W}{L}\right)_4 = 5$

$I_{bias} = \frac{1}{2} \times \beta_6 \left(V_{ov6} \right)^2 = 200\,\mu A \qquad V_{ov6} = V_{ov7} = V_{v,8}$

(3)

$\therefore \left(\frac{W}{L} \right)_6 = 3.33$

for, $I_{diff\_pair} = 0.8\,mA$, $\left(\frac{W}{L} \right)_7 = \left(\frac{W}{L} \right)_6 \times \frac{0.8}{0.2}$

$\boxed{\left(\frac{W}{L} \right)_7 = 13.33}$

for $I_{cs} = 1\,mA$ $\quad \left(\frac{W}{L} \right)_8 = \left(\frac{W}{L} \right)_6 \times \frac{1m}{0.2m} =$

$\boxed{\left(\frac{W}{L} \right)_8 = 16.16}$

V_{oswing} at CS $= 3 - (2 + 1) = 2V$

$V_{GS,6} = 1 + 0.8 = 1.8$

$\therefore 5 - IR = V_{GS,6}$

$\boxed{\therefore R = 16K}$

Performance obtained, →

Gain = 73 dB

$\omega_{-3} = 100.100$ KHz

$\omega_{unity} = 500$ MHz

$P_{diss} = 10$ mW

$C_c = 2$ pF

$R = 16\,K\Omega$

$C_{L(max)} = 1.5$ pf

sizings, are

$\left(\frac{W}{L} \right)_1 = \left(\frac{W}{L} \right)_2 = 10.41$

$\left(\frac{W}{L} \right)_3 = \left(\frac{W}{L} \right)_4 = 2.37$

$\left(\frac{W}{L} \right)_5 = 12.5$

$\left(\frac{W}{L} \right)_6 = 3.33$

$\left(\frac{W}{L} \right)_7 = 13.33$

$\left(\frac{W}{L} \right)_8 = 16.16$

~~V_{ov} remaining for M_7~~ assuming

$$V_{ov_2} = \frac{g_{m2}}{\beta_2} = \frac{1m}{120\mu \times \cancel{12.5}\ 10.41} = 0.8\,V$$

Assuming swing requirement at stage 1 is

$$|V_{GS5}| = V_{ov5} + |V_{th_p}|$$

$$= V_{ov4}$$

$$= |V_{GS4}| - |V_{thp}|$$

$$= |V_{GS3}| - |V_{tp}|$$

$$= V_{ov3}$$

$$= 2 + 0.9$$

$$V_{ov3} = 2.9\,V$$

$$I_{D3} = 0.4m = \frac{1}{2} \times 40\mu \left(\frac{W}{L}\right)_3 (V_{ov3})^2$$

$$\boxed{\left(\frac{W}{L}\right)_3 = \left(\frac{W}{L}\right)_4 = 2.37}$$

$\therefore V_{ov_4} = 2.9$

$$V_{ov_2} = \frac{g_{m2}}{\beta_2} = \frac{1m}{120\mu \times (10.41)} = 0.8$$

Assuming swing requirement at stage 1 = 0.3 V

$\therefore$ V_{ov} remaining for M_7,

$$V_{ov_7} = 5 - (2.9 + 0.8 + 0.3)$$

$$\boxed{V_{ov_7} = 1\,V}$$

Note that the design has been optimized for performance, not for power dissipation. Also all the parameters required are within specified limit.

Also swing at both the stages is ~~finite~~ valid. It is necessary to check this because g_{m_1} & g_{m_5} were assumed.