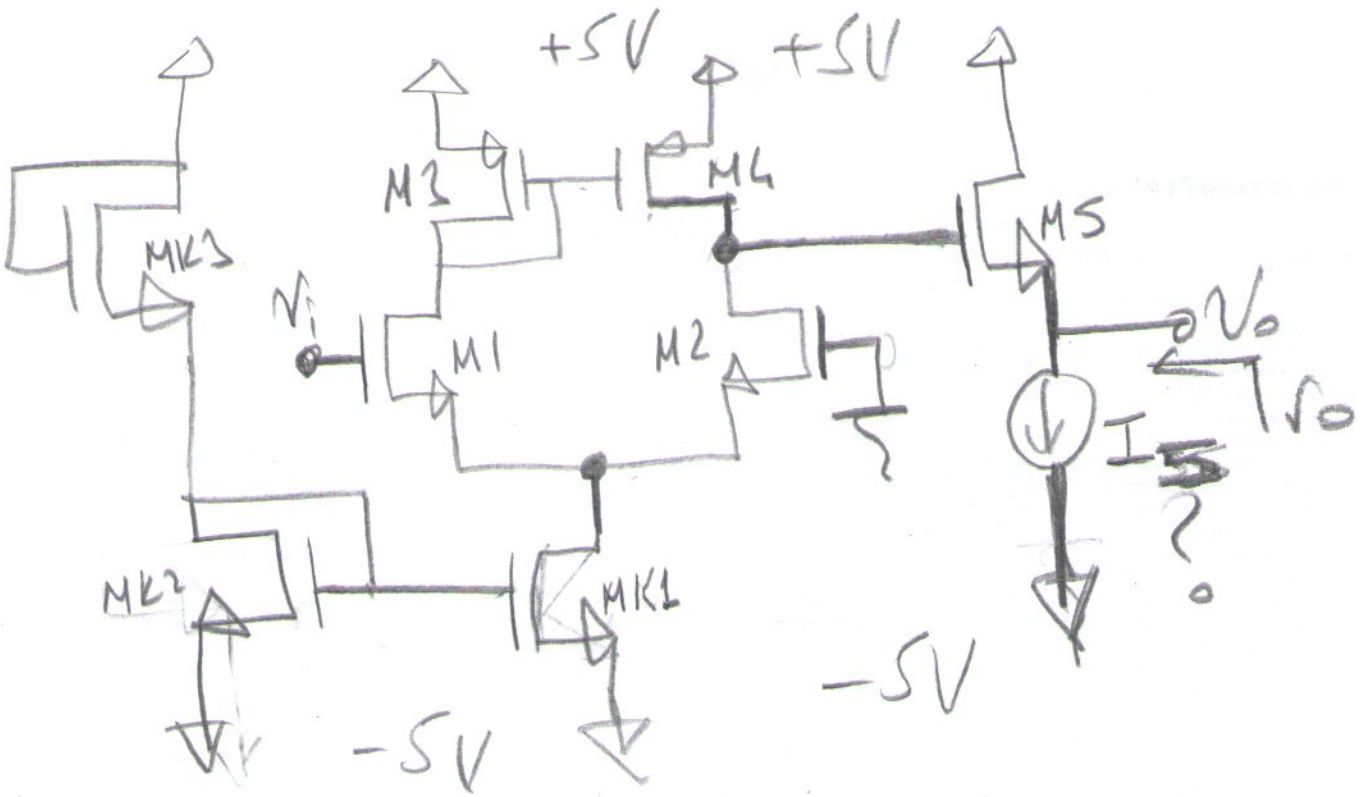

$\beta_1 = \beta_2 = \beta_3 = \beta_4 = 2mA/V^2 = \beta_5$

$I_{D1Q} = I_{D2Q} = 1mA = I_{D3Q} = I_{D4Q}$

$V_{A1} = V_{A2} = V_{A3} = V_{A4} = 50V$

$V_{TH1} = V_{TH2} = |V_{TH3}| = |V_{TH4}| = 0,5V = V_{TH5}$

$V_{K1} = 50V$

a) Find I_5 in order to obtain $V_{ODC} = 0V$.

$- V_{GS2} = \sqrt{\frac{2I_{D2Q}}{\beta_2}} + V_{TH2} = 2V \rightarrow V_S = 0 - 2 = \underline{-2V}$

$V_{SD4} + V_{DS2} = 5 - (-2) = 7V$

$\beta_2 = \beta_4$ $V_{A2} = V_{A4}$ $|V_{TH4}| = V_{TH2}$, ~~$I_{DS2Q} = I_{DS4Q}$~~ $\Rightarrow$

$\rightarrow V_{DS2} = V_{SD4} \rightarrow V_{DS2} = 1,5V \rightarrow V_{O2} = 1,5V$

$V_{O2} = V_{G5} = 1,5V$, $V_{SS} = V_O = 0V$ $\rightarrow V_{GS5} = 1,5V \rightarrow I_{DS} = I_5 = \frac{\beta_5}{2}(V_{GS5} - V_{THS})^2$

$= 1mA$

b) Find $\frac{V_o}{V_i}$.

$$\frac{V_o}{V_i} = \frac{V_{ss}}{V_{ps}} \cdot \frac{V_{d2}}{V_i} = \frac{V_{ss}}{V_{ps}} \cdot A_d$$

$$A_d = \frac{1}{2} g_{m2}(r_{o2} // r_{o4})$$

$$g_{m2} = \sqrt{2\mu_n C_{ox} I_{D2}} = 2mS$$

$$r_{o2} = \frac{V_{A2}}{I_{D2}} = 50k \qquad r_{o4} = \frac{V_{A4}}{I_{D4}} = 50k$$

$$A_d = 2mS \cdot 25k = 50$$

$$\frac{V_o}{V_i} = \frac{g_{m5} R_{ss}}{1 + g_{m5} R_{ss}} \cdot 50 = 50$$

$R_{ss} = \infty$ (current source)

c) find r_o

$$r_o = \frac{1}{g_{m5}} = \frac{1}{\sqrt{2\mu_p C_{ox} I_{D5}}} = 500\Omega$$

d) find CMRR of the circuit.

CMRR = 1 (Simple input, Simple output)

Note that one of the inputs of the differential pair is at ground.

CMRR of the differential pair.

$$CMRR = g_{m1}(r_{o2} // r_{o4}) \cdot 2 \cdot g_{m3} R_{ss}$$

$g_{m3} = 2mS$, $R_{ss} = \frac{50V}{2mA} = 25k$

$$\approx 2mS \cdot 25k \cdot 2 \cdot 2mS \cdot 25k = 5K \cong 74dB$$