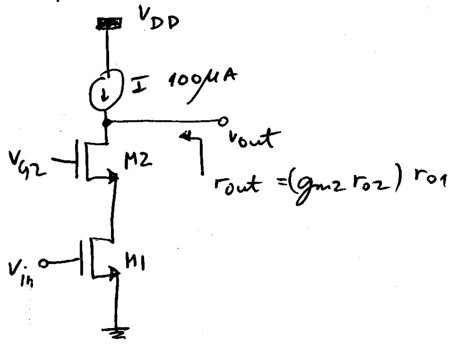
EL2 FP 3

Ex D7.24



Deseja-se

$g_{m1} = 1\,mA/V$

$R_o = 400\,k\Omega$

$L = ?$ 0.4 μm

$W = ?$ 5μm

$V_{G2} = ?$

maximum possible negative swing ΔV_{out} = ?

minimum V_{out} = ? 0.4 V ($= 2V_{ov}$)

$V_T = 0.5V$

$V'_A = 5V/\mu m$

$\mu_n C_{ox} = 400\,\mu A/V^2$

$V_{ov} = (v_{GS} - v_T) = 0.2\,V$

$$g_{m1} = \frac{2 I_D}{(V_{GS}-V_T)_{M1}} \Leftrightarrow I_D = \frac{g_{m1}(V_{GS}-V_T)}{2} = \frac{1\times10^{-3}\times0.2}{2} = 1\times10^{-4}\,A$$

$$r_{o1} = r_{o2} = \frac{V'_A \times L}{I_D}$$

$$g_{m2} = \frac{2 I_D}{(V_{GS}-V_T)_{M2}} = g_{m1} = 1\,mA/V$$

$$r_o = g_{m2}\, r_{o2}\, r_{o1} = g_{m2} \frac{V'_A L}{I_D} \frac{V'_A L}{I_D}$$

$$L = \sqrt{\frac{r_o I_D^2}{g_{m2}(V'_A)^2}} = \sqrt{\frac{400\times10^3 \times (100\times10^{-6})^2}{1\times10^{-3}\times(5\times10^6)^2}} = 0.4\,\mu m$$

$$I_D = \frac{1}{2}\mu_n C_{ox} \frac{W}{L}(V_{GS}-V_T)^2 \Leftrightarrow \frac{W}{L} = \frac{2 I_D}{\mu_n C_{ox}(V_{GS}-V_T)^2}$$

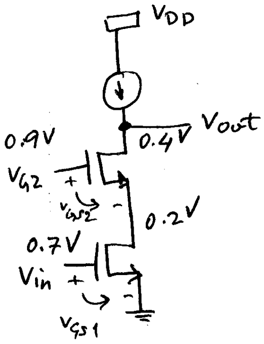
$$= \frac{2\times100\times10^{-6}}{400\times10^{-6}\times(0.2)^2} = 12.5$$

$W = 1\mu m$

SATURATION REGION

$V_{GS} > V_T$; $V_T = 0.5\,V$

$V_{GD} \leq V_T \iff V_{DG} \geq -V_T$

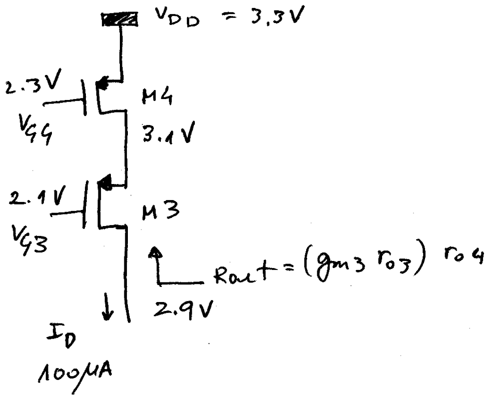


$(V_{GS} - V_T) = 0.2\,V \iff V_G - V_S - V_T = 0.2\,V$

$V_{G2} = 0.2\,V + V_S + V_T$

$V_{G2} = 0.2 + 0.2 + 0.5$

D 7.27



$\mu C_{ox} = 60\,\mu A/V^2$

$|V_T| = 0.8\,V$

$|V_A| = 5\,V$

$V_{OV} = 0.2\,V$

$\frac{W}{L} = ?$

$V_{G3} = 2.1\,V$

$V_{G4} = 2.3\,V$

$R_{out} =$

maximum $V_{out} = 2.9\,V$ $(= V_{DD} - 2V_{OV})$

$V_{SG} - V_T = V_{OV}$

$V_S - V_G - V_T = V_{OV}$

$V_S = V_{OV} + V_T + V_G \iff V_{DD} = V_{OV} + V_T + V_{G4}$

$\iff V_{G4} = V_{DD} - V_T - V_{OV} = 2.3\,V$

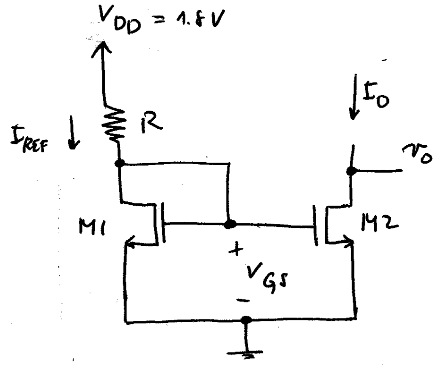
$V_{G3} = V_{S3} - V_T - V_{OV} = 2.1\,V$

$$I_D = \frac{1}{2} \mu C_{ox} \frac{W}{L} V_{ov}^2$$

$$\frac{W}{L} = \frac{2 I_D}{(\mu C_{ox}) V_{ov}^2} = \frac{2 \times 100 \times 10^{-6}}{60 \times 10^{-6} (0.2)^2} = 83.3$$

$$R_o = g_{m3} r_{o3} r_{o4} = \frac{2 I_D}{(V_{GS} - V_t)} \frac{V_A}{I_D} \frac{V_A}{I_D} = \frac{2 \times 5^2}{0.2 \times 100 \times 10^{-6}} = 2.5 M\Omega$$

D 7.46



$V_{DD} = 1.8\,V$

$I_{REF} = 100\,\mu A$

$I_O = 100\,\mu A$

$R = ?$

$M1 = M2$

$L = 0.5\,\mu m$

$W = 4\,\mu m$

$V_T = 0.5\,V \quad V_A' = 10\,V/\mu m$

$K_n = \mu C_{ox} = 400\,\mu A/V^2$

minimum possible for V_O = ?

$R_O = ?$

$\Delta V_O = +0.5V$

$\Delta I_O = ?$

$$I_1 = I_2 = \frac{1}{2}\mu C_{ox}\left(\frac{W}{L}\right)(V_{GS} - V_T)^2$$

$$(V_{GS} - V_T) = \sqrt{\frac{2I}{\mu C_{ox}(W/L)}} = \sqrt{\frac{2 \times 100 \times 10^{-6}}{400 \times 10^{-6} \times 8}} = 0.25\,V$$

$$V_{GS} = V_T + 0.25 = 0.75$$

$$R = \frac{V_{DD} - V_{GS}}{I} = \frac{1.8 - 0.75}{100 \times 10^{-6}} = 10.5\,K\Omega$$

$$R_O \simeq r_{O2} = \frac{V_A' \times L}{I} = \frac{10 \times 0.5}{100 \times 10^{-6}} = 50\,K\Omega$$

$$\frac{1}{r_o} = \frac{\partial I_D}{\partial V_{DS}} \longrightarrow \Delta I_D = \frac{1}{r_O} \Delta V$$

$$\Delta I_D = \frac{0.5V}{50 \times 10^3} = 10 \mu A$$

$$\frac{\Delta I_D}{I_D} \times 100\% = 10\%$$

minimum possible for V_O :

$$V_{GS} - V_T = 0.25$$

$$V_{GS} = V_T + 0.25$$

$$V_G - V_S = V_T + 0.25$$

$$V_G = V_S + V_T + 0.25 = 0.75\,V$$

$$V_{GD} \leq V_T$$

$$V_{DG} \geq -V_T$$

$$V_D \geq V_G - V_T$$

$$V_{D\,min} = V_G - V_T = 0.75 - 0.5 = 0.25\,V \quad (= V_{OV})$$