CuirrentSourceMOS

Monday, April 4, 2016 2:59 PM

$$I_E = (1+\beta) I_B$$
$$= \frac{1+\beta}{\beta} I_C$$

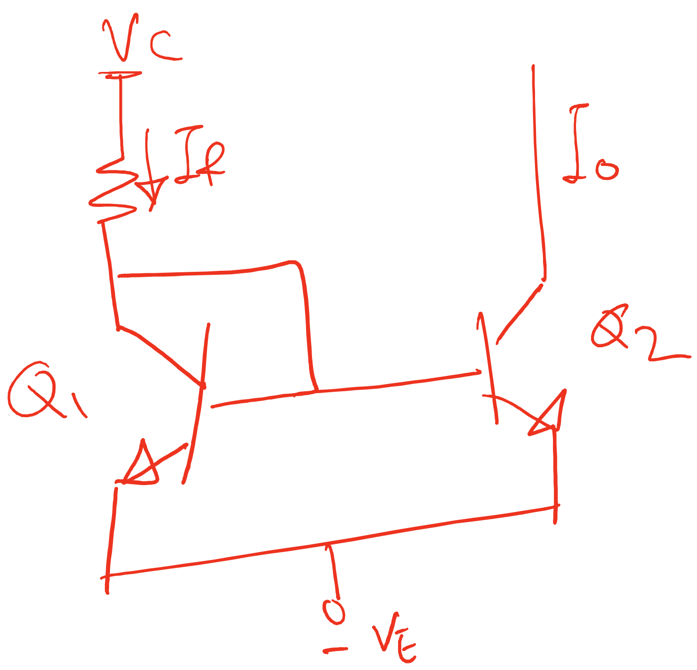
$$V_{BE_1} = V_{BE_2} + I_{E_2} R_E$$

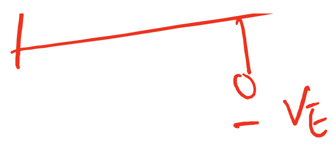
$$V_{BE_1} - V_{BE_2} = I_{E_2} R_E \qquad I_{C_2} = I_0$$
$$= \frac{1+\beta}{\beta} I_{C_2} \times R_E$$

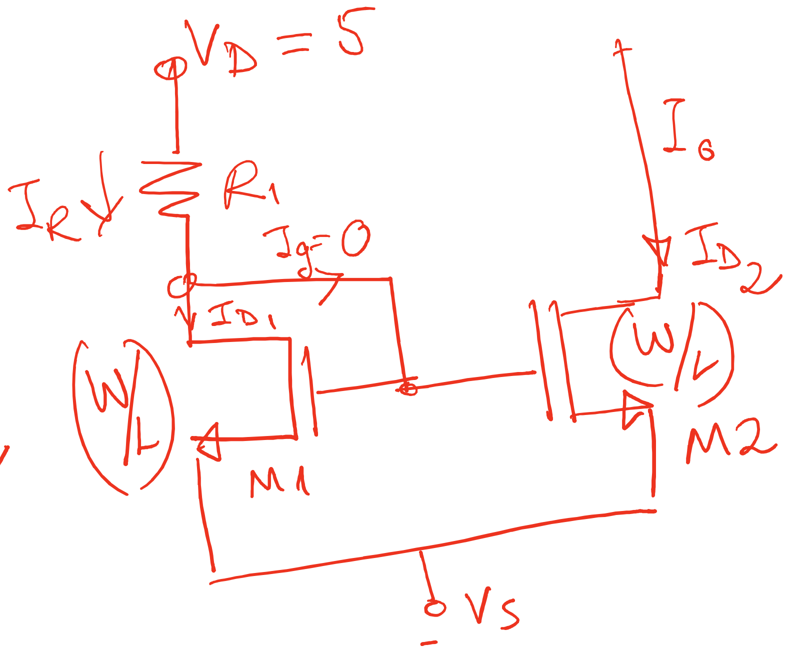
$$\frac{I_{C_1}}{I_{C_2}} \simeq \frac{I_S e^{V_{BE1}/V_T}}{I_S e^{V_{BE2}/V_T}} = e^{\frac{V_{BE_1} - V_{BE2}}{V_T}}$$

$$\boxed{V_{BE_1} - V_{BE_2} = V_T \ln \frac{I_{C_1}}{I_{C_2}} = \frac{1+\beta}{\beta} I_{C_2} R_E}$$

$$I_R = I_{C_1} + I_{B_1} + I_{B_2}$$
$$= I_{C_1} + \frac{I_{C_1}}{\beta} + \frac{I_{C_2}}{\beta}$$
$$= I_{C_1}\left(1 + \frac{1}{\beta}\right) + \frac{I_{C_2}}{\beta}$$
$$\therefore 1mA = I_{C_1}\left(1 + \frac{1}{100}\right) + \frac{0.05}{100}$$
$$I_{C_1} = 990 \mu A$$







$K_n' = 80\,\mu A/V$

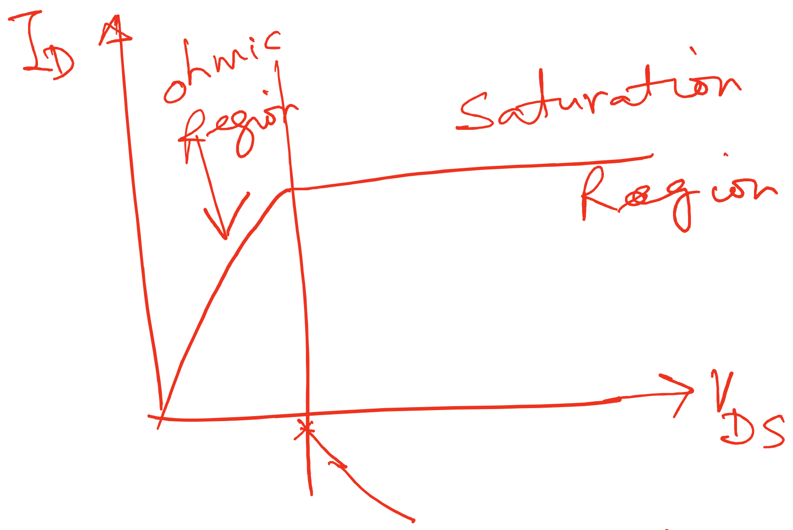
$V_T = 0.5V$

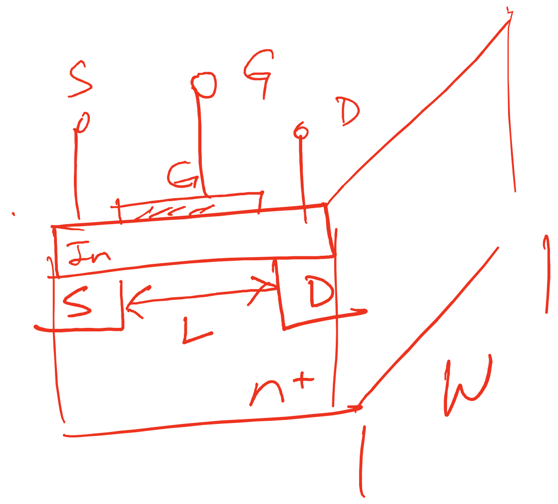
$I_R = 100\,\mu A$

$I_o = 10\,\mu A$

$V_{Dsat}/2 = 0.4V$

$I_{D_1} = I_R$ $\qquad$ $I_{D_2} = I_o$





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

Saturation condition

$V_{DS} \geq (V_{GS} - V_T)$

$V_{DS} = V_{GS}$ $\qquad$ $V_{DS} \geq (V_{GS} - V_T)$

$$I_D = K_n (V_{GS} - V_T)^2$$

$$= \frac{K_n'}{2}\left(\frac{W}{L}\right)(V_{GS} - V_T)^2 (1 + \lambda V_{DS})$$

$$I_D = \frac{K_n'}{2}\left(\frac{W}{L}\right)(V_{GS} - V_T)^2$$

$$V_{GS_1} = V_{GS_2}$$

$$V_{DS_2}|_{sat} = V_{GS_2} - V_T = 0.4V$$

$$V_{GS_2} = 0.4 + V_T = 0.4 + 0.5 = 0.9V$$

$$V_{GS_1} = 0.9V$$

$$\left(\frac{W}{L}\right)_1 = \frac{2 I_{D1}}{k_n' (V_{GS_1} - V_T)^2}$$

$$= \frac{2 \times 100\mu}{80\mu (0.9 - 0.5)^2} = 15.625$$

$$\left(\frac{W}{L}\right)_2 = \frac{2 \times 10\mu}{80\mu (0.9 - 0.5)^2} = 1.5625$$

$$R_1 = \frac{5 - V_{GS1}}{I_R} = \frac{5 - 0.9}{100\mu A}$$

$$= 41 k\Omega$$

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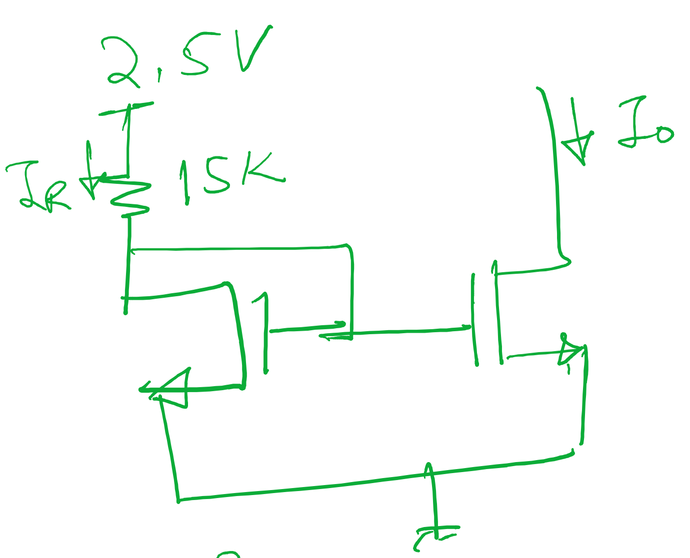
$V_{TN} = 0.5$

$k_n' = 80\mu A/V^2$

$\left(\frac{W}{L}\right) = 6$



$$\frac{I_{D1}}{I_{D2}} = \frac{\frac{k_n'}{2}\left(\frac{W}{L}\right)_1 (V_{GS_1} - V_T)^2}{\frac{k_n'}{2}\left(\frac{W}{L}\right)_2 (V_{GS_2} - V_T)^2}$$

$I_R = ?$

$I_o = ?$

$V_{DS_2}|_{sat} = ?$

$$I_{D1} = \frac{V_D - V_{GS1}}{R_1} = \frac{K_n'}{2}\left(\frac{W}{L}\right)\left(V_{GS1} - V_T\right)^2$$

$$\frac{2.5 - V_{GS1}}{15} = \frac{0.08}{2} \times 6 \left(V_{GS1} - 0.5\right)^2$$

$$2.5 - V_{GS1} = 3.6\left(V_{GS1}^2 - V_{GS1} + 0.25\right)$$

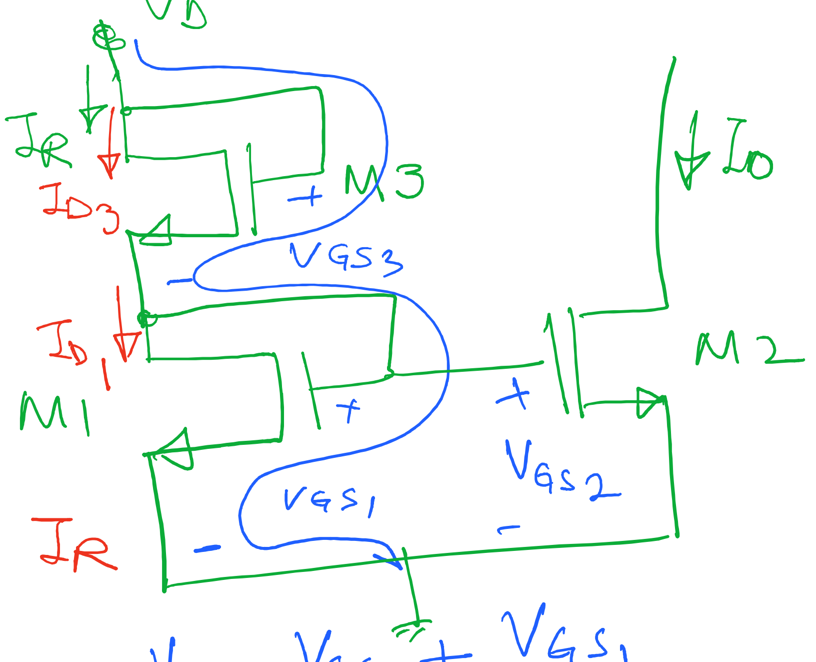
$$3.6 V_{GS1}^2 - 2.6 V_{GS} - 1.6 = 0$$

$$V_{GS1} = \underline{\underline{1.12V}}, \quad \underline{\underline{-0.4V}}$$

$> V_T \qquad V_D <$

I_{D1}

$V_D = 5V$



$I_R = 100\mu$

$I_O = 10\mu$

$V_{DS2}|_{sat} = 0.4$

$K_n' = 80\mu A/V^2$

$V_T = 0.5$

$I_{D3} = I_{D1} = I_R$

$V_{GS3} = V_D - V_{GS1}$

$V_D = V_{GS3} + V_{GS1}$

$V_{DS2}|_{sat} = V_{GS2} - V_T = 0.4$

$V_{GS2} = 0.4 + 0.5 = 0.9V$

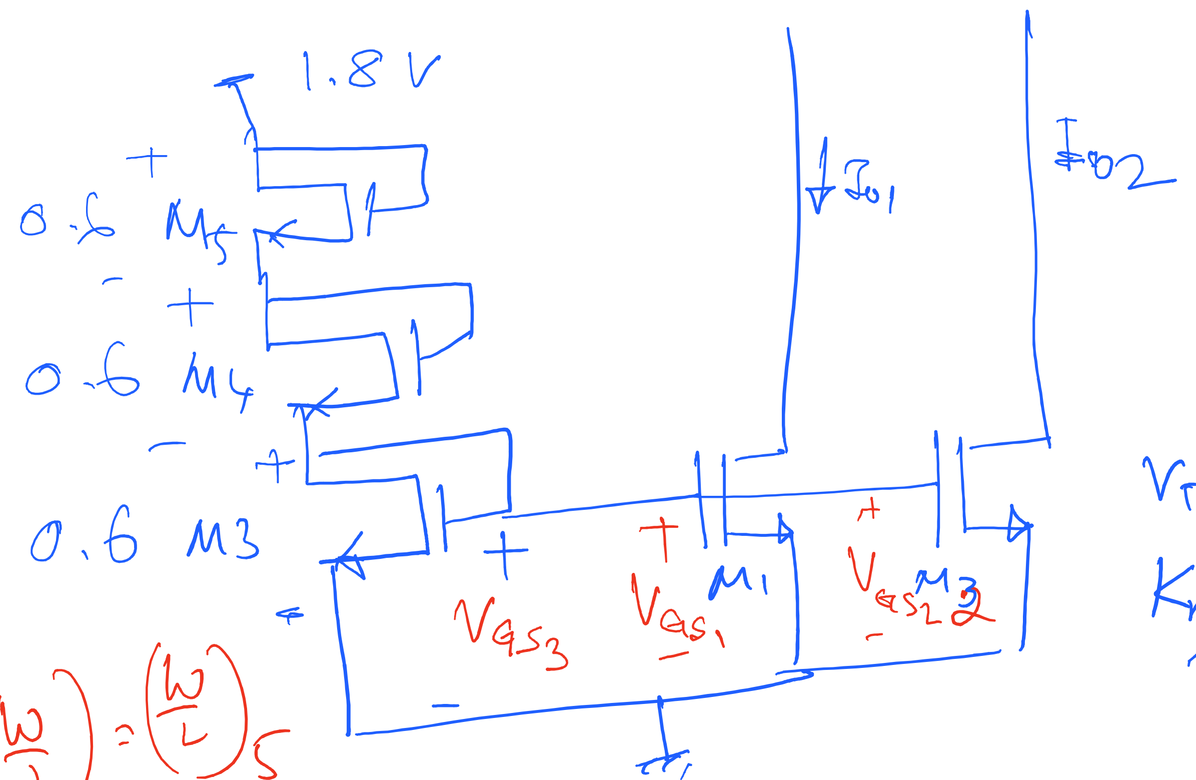
$= V_{GS1}$

$$\left(\frac{W}{L}\right)_1 = \frac{2 I_{D1}}{K_n' (V_{GS_1} - V_T)^2} = 15.625$$

$$\left(\frac{W}{L}\right)_2 = \frac{2 \cdot I_{D2}}{K_n' (V_{GS_2} - V_T)^2} = 1.5625$$

$$\left(\frac{W}{L}\right)_3 = \frac{2 I_{D3}}{K_n' (V_{GS_3} - V_T)^2}$$

Prob 10.66



$I_R = 0.1 mA$

$I_{O_1} = 0.2 mA$

$I_{O_2} = 0.3 mA$

$V_T = 0.7 V$

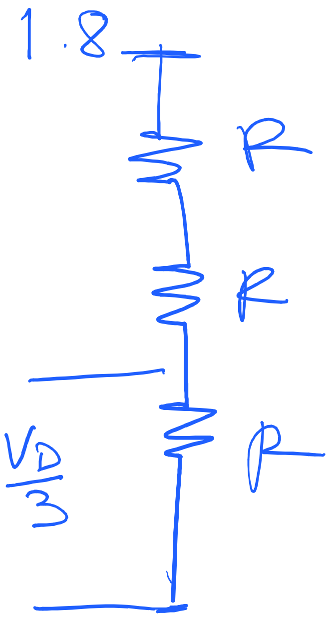
$K_n' = 80 \mu A/V^2$

$\lambda = 0$

$\left(\frac{W}{L}\right)_3 = \left(\frac{W}{L}\right)_4 = \left(\frac{W}{L}\right)_5$

$V_{GS_3} = V_{DS_3}$

$V_{GS_3} = V_{GS_1} = V_{GS_2}$



$\frac{V_D R}{3R} = \frac{V_D}{3}$

$\frac{V_D}{3} = \frac{1.8}{3} = 0.6V$