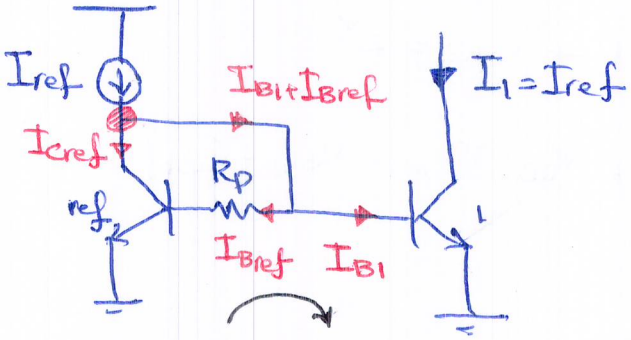
حل سوالات کوئیز دوم الکترونیک ۲ ترم سال تحصیلی اول ۱۴۰۲-۱۴۰۱

* حل سوال اول :



$$KVL: -V_{BE,ref} + R_p I_{B,ref} + V_{BE1} = 0$$

$$\Rightarrow V_T \ln \frac{I_1}{I_S} - V_T \ln \frac{I_{C,ref}}{I_S} = R_p \frac{I_{C,ref}}{\beta} \quad (I_1 = I_{ref})$$

$$\Rightarrow V_T \ln \frac{I_{ref}}{I_{C,ref}} = R_p \frac{I_{C,ref}}{\beta} \quad (1)$$

$$KCL: I_{ref} = I_{C,ref} + I_{B1} + I_{B,ref} = I_{C,ref} + \frac{I_{C,ref}}{\beta} + \frac{I_{ref}}{\beta}$$

$$\Rightarrow I_{ref}\left(1 - \frac{1}{\beta}\right) = I_{C,ref}\left(1 + \frac{1}{\beta}\right) \Rightarrow I_{C,ref} = \frac{\beta - 1}{\beta + 1} I_{ref} \quad (2)$$

$$(1),(2) \Rightarrow V_T \ln \frac{I_{ref}}{\frac{\beta-1}{\beta+1} I_{ref}} = R_p \times \frac{\beta-1}{\beta+1} I_{ref} \times \frac{1}{\beta}$$

$$\Rightarrow \left(V_T \ln \frac{\beta+1}{\beta-1}\right) \times \frac{\beta+1}{\beta-1} \times \frac{\beta}{I_{ref}} = R_p$$

* حل سوال دوم :

$$I_{M9} = \frac{1}{2} \mu_p C_{ox} \left(\frac{W}{L}\right)_9 (V_{SG} - |V_{TH}|)^2 = \frac{1}{2} \times 0.1 \times 5 (V_{SG9} - 1)^2$$

$$\Rightarrow V_{SG9} = V_{DD} - 7 I_{M9} = 10 - 7 I_{M9} \Rightarrow \frac{1}{2} \times 0.1 \times 5 (10 - 7 I_{M9} - 1)^2 \Rightarrow I_{M9} = 1\,mA$$

$$\Rightarrow V_{SG9} = 3 > V_{TH} \checkmark$$

$$I_{D8} = I_{D9} = I_{D7} = 1\,mA \quad , \quad I_{M6,5} = 4 \times I_{M7} = 4\,mA$$

$$\Rightarrow I_{M1,M2} = \frac{1}{2} I_{M6,5} = 2\,mA$$

$$\min\{V_G\} = V_{GS5} + V_{Dsat6} \quad (1)$$

$$I_{M5} = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L}\right)_5 (V_{GS5} - |V_{TH}|)^2 \Rightarrow 4 = \frac{1}{2} \times 0.4 \times 20 (V_{GS5} - 1)^2 \Rightarrow V_{GS5} = 2\,V$$

$$\Rightarrow V_{eff5,6} = 2 - 1 = 1\,V \quad (2)$$

$$(1),(2) \Rightarrow \min\{V_G\} = 2 + 1 = 3\,V$$

$I_{M1} = I_{M3} + I_o \Rightarrow I_{M3} = I_{M1} - I_o = 2 - 1.5 = 0.5\,mA$ (1

$|V_{eff3}| = V_{SG3} - |V_{TH}| \Rightarrow 1^V = V_{SG3} - 1 \Rightarrow V_{SG3} = 2^V$

$V_{in,max} = \min\{V_{DD} - V_{SG3} - V_{eff1} + V_{GS1},\ V_{DD} - V_{Io\,min} - V_{eff1} + V_{GS1}\}$

$= \min\{9, 10\} = 9^V$

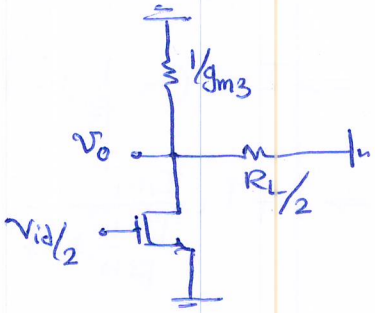
$V_{in,min} = V_{GS1} + 2V_{eff5} = 4^V$

$A_d = 1/2\, g_{m1} \times (1/g_{m3} \,||\, R_L/2)$ (2

$g_{m1} = 2I_{D1}/V_{eff1} = 4\,mA/V$,

$g_{m3} = 2I_{D3}/V_{eff3} = \frac{2\times0.5}{1} = 1\,mA/V$

$\Rightarrow A_d = 1/2 \times 4^m (1/1^m \,||\, 1^K) = 1^{V/V}$



$A_{cm} = \frac{1/g_{m3}}{1/g_{m1} + 2R_{EE}} = \frac{1/g_{m3}}{1/g_{m1} + 2r_{ds5}(1 + g_{m5} r_{ds6})}$

$r_{ds5} = r_{ds6} = \frac{1}{0.1 \times 4} = 2.5\,k\Omega$

$g_{m5} = \frac{2\times4}{1} = 8\,mA/V$

$\Rightarrow A_{cm} = \frac{1^K}{1/4^m + 2\times2.5^K \times 8 \times 2.5} \simeq 0.01$