Problem Set 6 (Again)

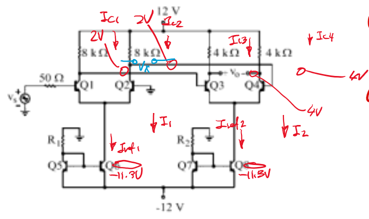
November 13, 2017 17:35

1. For the circuit in Figure 1, do the following:

a) Find the value of R_1 that will make $V_{C1} = V_{C2} = 2V$ and the value of R_2 that will make $V_{C3} = V_{C4} = 4V$. ($R_1 = 4.52k\Omega$; $R_2 = 2.83k\Omega$).

b) Using the values for R_1 and R_2 found in part a above, calculate A_M if the output is connected to an 8kΩ load. ($A_M = 8600V/V$)

c) Using R_1 calculated in part a above, find the CMRR for the input stage assuming that the second stage has been disconnected, that r_{o6} = 25kΩ (r_o of Q_6), and that one of the 8kΩ resistors is, in fact, 7.992kΩ and the other is, in fact, 8.008kΩ. (CMRR = 118dB)



Default Values: $\beta = 100$, $V_{BE} = 0.7V$

Figure 1.

Q_1, Q_2: $g_m = \frac{1.25mA}{25mV} = 0.050$ ℧, $r_\pi = 2000\Omega$

Q_3, Q_4: $g_m = \frac{2mA}{25mV} = 0.080$ ℧, $r_\pi = 1250\Omega$

a. $I_{C1} = \frac{12-2V}{8k\Omega} = 1.25mA$

$I_1 = I_{E1} + I_{E2} \approx 2(1.25)mA = 2.5mA$

current mirror:

$I_1 = \frac{I_{ref}}{1+\frac{2}{\beta}} \rightarrow I_{ref} = 2.55mA$

$\frac{11.3V}{R_1} = 2.55mA \rightarrow R_1 = 4.431k\Omega$

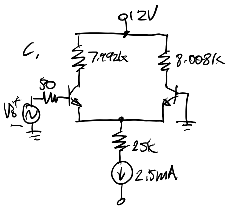
$I_{C3} = I_{C4} = \frac{8V}{4k\Omega} = 2mA$

$I_2 = 4mA$

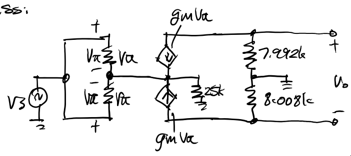
$I_2 = \frac{I_{ref2}}{1+\frac{2}{\beta}} \rightarrow I_{ref2} = 4.08mA$

$R_2 = \frac{11.3V}{4.08mA} = 2.77k\Omega$

c.



CMSS:



$V_\pi = \dfrac{\frac{V_\pi}{2} \cdot V_s}{\frac{V_\pi}{2} + R(1+\beta)}$

$A_{cm} = \frac{\Delta R_C}{2R} = \frac{16}{2(25k)} = 3.2\times10^{-4}$

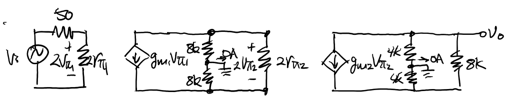
$A_d = -g_m \cdot R_C = 0.050 \cdot 8k = -400$

$CMRR = \frac{|A_d|}{|A_{cm}|} = \frac{400}{3.2\times10^{-4}} = 1.25\times10^6$

$\downarrow 20\log_{10}(\cdot)$

$= \boxed{122dB}$

b.



$V_o = -g_{m2} V_{\pi2} \cdot (8k // 8k)$

$= -(0.080)(4k)V_{\pi2}$

$2r_{\pi2} = 2(1250) = 2500$

$V_{\pi2} = -\frac{1}{2} g_{m1} V_{\pi1} \, (16k // 2r_{\pi2})$

$= -\frac{1}{2}(0.050)(2162.162)V_{\pi1}$

$V_{\pi1} = \frac{1}{2}\left(\frac{2r_{\pi1}}{2r_{\pi1}+50}\right)V_s$

$= 0.494V_s$

$V_{\pi2} = (-54.054)V_{\pi1}$

$= (-54.054)(0.494)V_s$

$= (-26.703)V_s$

$V_o = -(0.080)(4k)(-26.703)V_s$

$\boxed{\frac{V_o}{V_s} = 8545\, V/V}$