Sol:

Q2A

a) $g_{m1} = \sqrt{K_N' \left(\frac{W}{L}\right)_1 I_{C6}} = 100\,\mu A/V \Rightarrow \left(\frac{W}{L}\right)_1 = 25$

$CMRR \simeq 20\log_{10}(2 g_{m1} R_{EE}) = 80\,dB \Rightarrow R_{EE} = 50\,M\Omega$

$r_{o6} = \frac{V_A}{I_{C6}} = 13\,M\Omega$ $\quad r_{E6} = \frac{V_T}{I_{C6}} = 2.6\,K\Omega$ $\quad r_{\pi 6} = \beta r_{E6} = 260K\Omega$ $\quad g_{m6} = \frac{1}{2.6K\Omega}$

$R_{EE} = r_{o6}(1 + g_{m6} R_{eff})$ $\quad R_{eff} = r_{\pi 6} \| R_2$

$\Rightarrow R_{eff} = 7.4K\Omega \ll r_{\pi 6} \Rightarrow R_2 \simeq 7.4\,K\Omega$

$R_2 = \frac{V_T}{I_{C6}} \ln \frac{I_{C5}}{I_{C6}} \Rightarrow I_{C5} = 172.2\mu A = \frac{0 - 0.7 + |V_{EE}|}{R_1} \Rightarrow R_1 = 25\,K\Omega$

b) i) $r_{o2} = \frac{2}{\lambda_n I_{C6}} = 20\,M\Omega$ $\quad r_{o4} = \frac{2}{\lambda_p I_{C6}} = 16.7\,M\Omega$ $\quad r_{o2} \| r_{o4} = 9.1\,M\Omega$

$A_{dm} = + g_{m1}(r_{o2} \| r_{o4}) = 910$

$CMRR = \left|\frac{A_{dm}}{A_{cm}}\right| \Rightarrow |A_{cm}| = \frac{A_{dm}}{CMRR} = 0.09$

ii) $P_D = V_{DD} \times I_{C6} + |V_{EE}| \times (I_{C5} + I_{C6}) = 0.96\,mW$

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Q2B Procedure same as Q2A.

a) $\left(\frac{W}{L}\right)_1 = 20$ $\quad R_{EE} = 62.5M\Omega$ $\quad r_{o6} = 16.25\,M\Omega$ $\quad r_{E6} = 3.25K\Omega$ $\quad r_{\pi 6} = 325K\Omega$

$R_{eff} = 9.25K\Omega \ll r_{\pi 6} \Rightarrow R_2 \simeq 9.25\,K\Omega$ $\quad I_{C5} = 137.8\mu A \Rightarrow R_1 = 24K\Omega$

b) i) $r_{o2} = 25\,M\Omega$ $\quad r_{o4} = 20.8\,M\Omega$ $\quad r_o = 11.27K$ $\quad A_{dm} = 901.3$

$\Rightarrow |A_{cm}| = 0.09$

ii) $P_D = 0.6\,mW$

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