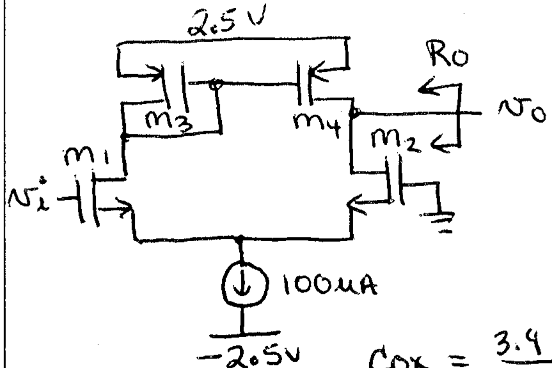
EEC 210 | SOLUTION TO HW #6

(1)



$I_1 = I_2 = I_3 = I_4 = 50\,\mu A$

$R_o = r_{o2} \| r_{o4}$

From (1.163) $V_{An} = \dfrac{L_{eff}}{dX_d/dV_{DS}} = \dfrac{1-2(0.12)}{0.08} = 9.5$

$|V_{Ap}| = \dfrac{1-2(0.18)}{0.04} = 16$

$r_{o2} = \dfrac{9.5}{50\mu} = 190\,K\Omega \quad r_{o4} = \dfrac{16}{50\mu} = 320\,K\Omega$

$C_{ox} = \dfrac{3.9 \times 8.854 \times 10^{-14}}{150 \times 10^{-8}\,cm} = 2.3 \times 10^{-7}\,F/cm^2$

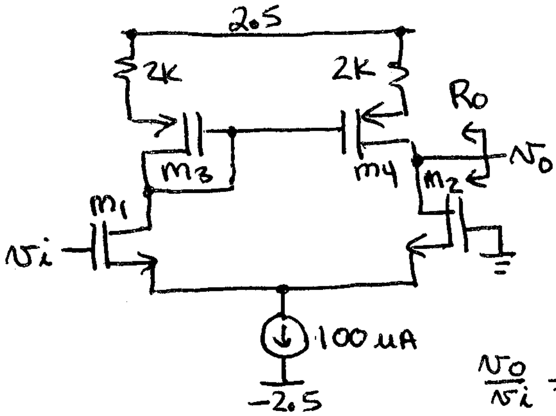
$K_n' = 2.3\times10^{-7}(550) = 127\,\mu A/V^2$

$g_{m1} = \sqrt{2(127)\dfrac{50}{1-2(0.12)}\,50} = 914\,\mu A/V = G_m$

$\dfrac{v_o}{v_i} = +G_m R_o = 0.914\,(190 \| 320) = \boxed{109} \qquad R_o = 190K \| 320K = \boxed{119\,K\Omega}$

SPICE gives $v_o/v_i = 142$ and $R_o = 138\,K\Omega$

(2)



$K_p' = 2.3\times10^{-7}(250) = 58\,\mu A/V^2$

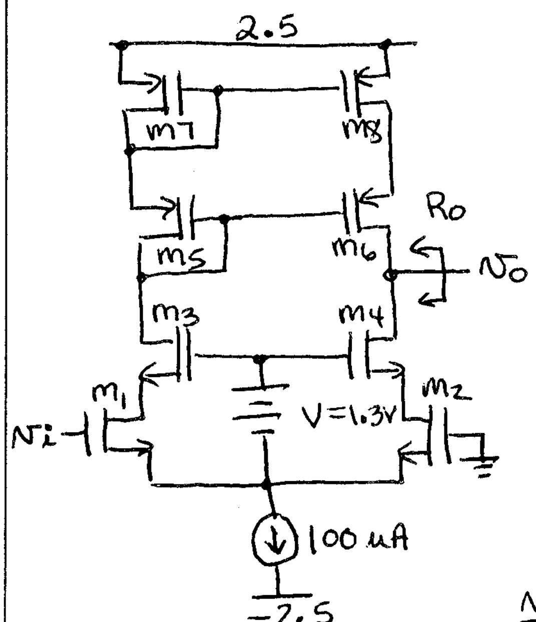
$R_o = r_{o2} \| r_{o4}(1 + g_{m4}(2K))$

$g_{m4} = \sqrt{2(58)\dfrac{100}{1-2(0.18)}(50)} = 952\,\mu A/V$

$R_o = 190K \| \left[320K(1 + (0.952)(2))\right]$
$= \boxed{158\,K\Omega}$

$\dfrac{v_o}{v_i} = G_m R_o = 0.914(158) = \boxed{144}$

(3)



In practice, V would be adjusted so that m_1 & m_2 barely operate in the active region.

$R_o = (g_{m6} r_{o6} r_{o8}) \| (g_{m4} r_{o4} r_{o2})$

$g_{m6} = \sqrt{2(58)\dfrac{100}{0.64}(50)} = 0.952\,mA/V$

$g_{m4} = \sqrt{2(127)\dfrac{50}{0.76}(50)} = 0.914\,mA/V$

$r_{o6} = r_{o8} = \dfrac{16}{50\mu} = 320\,K\Omega$

$r_{o4} = r_{o2} = \dfrac{9.5}{50\mu} = 190\,K\Omega$

$R_o = \left[(0.952)(320)^2\right] \| (0.914)(190)^2 = \boxed{24.7\,M\Omega}$

$\dfrac{v_o}{v_i} = G_m R_o = g_{m1} R_o$
$= 0.914(24.7\times10^3) = \boxed{22,600}$