۹۷۳۱۵۱۴ مه‌آذرگلی

ج۵)

الف)

$$I_{DQ} = k_p (V_{SG} + V_{TP})^2$$

$$0.75 = (0.5)(V_{SG} - 1)^2 \longrightarrow V_{SG} = 2.225\ (V)$$

$$5 = I_{DQ} R_S + V_{SG} \longrightarrow R_S = \frac{5 - 2.225}{0.75} \longrightarrow \boxed{R_S = 3.70\ k\Omega}$$

$$V_{SDQ} = 10 - I_{DQ}(R_S + R_D) \longrightarrow \boxed{R_D = 1.63\ k\Omega}$$

ب)

$$R_i = \frac{1}{g_m} \longrightarrow g_m = 2\sqrt{k_p I_{DQ}} = 2\sqrt{0.5 \times 0.75} = 1.225\ (mA)/V$$

$$\boxed{R_i = \frac{1}{1.225} = 0.816\ k\Omega}$$

$$\boxed{R_o = R_D = 1.63\ k\Omega}$$

ج)

$$i_o = \left(\frac{R_D}{R_D + R_L}\right)\left(\frac{R_S}{R_S + 1/g_m}\right) i_i = \left(\frac{1.63}{1.63 + 2}\right)\left(\frac{3.7}{3.7 + 0.816}\right) i_i$$

$$i_o = 0.368\, i_i = 1.84 \sin\omega t\ (mA)$$

$$V_o = i_o R_L = (1.84)(2) \sin\omega t = 3.68 \sin\omega t\ (mV)$$

ج۶)

الف)

$$I_{DQ1} = \frac{10 - V_{GS1}}{R_{S2}} = k_{n1}(V_{GS1} - V_{TN1})^2 \rightarrow 40 V_{GS1}^2 - 159 V_{GS1} + 150 = 0 \rightarrow$$

$$V_{GS1} = 2.435\ (V) \longrightarrow I_{DQ1} = 4(2.435 - 2)^2 \Rightarrow \boxed{I_{DQ1} = 0.757\ (mA)}$$

$$V_{DSQ1} = 20 - (10)(0.757) = \boxed{12.43\ (V)} \qquad \boxed{I_{DQ2} = 0.757\ (mA)}$$

$$V_{DSQ2} = 20 - (0.757)(15) = 8.65\ (V)$$

ب)

$$g_{m1} = g_{m2} = 2\sqrt{K I_{DQ}} = 2\sqrt{4(0.757)} = 3.48\ (mA/V)$$

$$V_o = -(g_{m2} V_{gs2})(R_D \| R_L)$$

$$V_{gs2} = (-g_{m1} V_{gs1} - g_{m2} V_{gs2})(R_{S1} \| R_{S2})$$

$$V_i = V_{gs1} - V_{gs2} \rightarrow V_{gs1} = V_i + V_{gs2}$$

$$V_{gs2} = \frac{-g_{m1} V_i (R_{S1} \| R_{S2})}{1 + g_{m2}(R_{S1} \| R_{S2}) + g_{m1}(R_{S1} \| R_{S2})}$$

$$A_v = \frac{V_o}{V_i} = \frac{g_{m1} g_{m2} (R_{S1} \| R_{S2})(R_D \| R_L)}{1 + (g_{m1} + g_{m2})(R_{S1} \| R_{S2})} = 1.42$$

$$R_{S1} = \frac{0.6}{0.1} = 6\,(k\Omega)$$

$$V_{D1} = 0.2\,(V) \longrightarrow R_{D1} = 20\,(k\Omega)$$

$$I_{DQ1} = k_{p1}(V_{GSQ1} + V_{TP})^2 \longrightarrow 0.1 = 0.4\,(V_{SGQ1} - 0.5)^2 \rightarrow V_{SGQ1} = 0.9\,(V)$$

$$I_{DQ2} = k_{n2}(V_{GSQ2} - V_{TN})^2 \longrightarrow 0.1 = 4(V_{GSQ2} - 0.4)^2 \rightarrow V_{GSQ2} = 0.9\,(V)$$

$$V_{G1} = 0.3\,(V) \longrightarrow R_1 = \frac{200 \times 3.6}{0.3} = 2400\,(k\Omega) \longrightarrow R_2 = 450\,(k\Omega)$$

$$V_{D1} = 0.2\,(V) \longrightarrow V_{S2} = -0.45\,(V) \longrightarrow R_{S2} = \frac{V_{S2} + 1.8}{0.3} = 4.5\,(k\Omega)$$

$$\begin{cases} A_V = \left(\frac{-g_{m1} R_{D1}}{1 + g_{m1} R_{S1}}\right)\left(\frac{g_{m2} R_{S2}}{1 + g_{m2} R_{S2}}\right) = \frac{2.191 \times 4.5}{1 + (2.191)(4.5)} = -3.11 \\ g_{m1} = 2\sqrt{k_{p1} I_{DQ1}} = 0.4\,(mA/V) \\ g_{m2} = 2\sqrt{k_{n2} I_{DQ2}} = 2.191\,(mA/V) \end{cases}$$

$$R_o = \frac{1}{g_{m2}} \| R_{S2} = 4.14\,(\Omega)$$