

2025 Electronics II Exam-3 Reference Solution

23th May, 2025

1.

$$I_O = 0.5 \text{ mA}, \quad I_{B2} = \frac{0.5}{90} = 0.005556 \text{ mA}$$

$$I_{B1} = \frac{I_{B2}}{2} = 0.002778 \text{ mA}$$

$$I_{E3} = I_{B1} + I_{B2} = 0.008334 \text{ mA}$$

$$I_{B3} = \frac{0.008334}{61} = 0.0001366 \text{ mA}$$

$$I_{C1} = \frac{I_O}{2} = 0.25 \text{ mA}$$

$$I_{REF} = I_{C1} + I_{B3} = 0.2501366 \text{ mA}$$

$$R_1 = \frac{5 - 0.6 - 0.7 - (-5)}{0.2501366} = 34.78 \text{ k}\Omega$$

2

$$V_{GS3} = V_{GS4} = V_{GS5} \Rightarrow V_{GS3} = \frac{5}{3} \text{ V}$$

$$I_{REF} = 0.1 = \left(\frac{0.08}{2} \right) \left(\frac{W}{L} \right)_3 \left(\frac{5}{3} - 0.7 \right)^2 \Rightarrow \left(\frac{W}{L} \right)_{3,4,5} = 2.68$$

$$I_{O1} = 0.2 = \left(\frac{0.08}{2} \right) \left(\frac{W}{L} \right)_1 \left(\frac{5}{3} - 0.7 \right)^2 \Rightarrow \left(\frac{W}{L} \right)_1 = 5.35$$

$$I_{O2} = 0.3 = \left(\frac{0.08}{2} \right) \left(\frac{W}{L} \right)_2 \left(\frac{5}{3} - 0.7 \right)^2 \Rightarrow \left(\frac{W}{L} \right)_2 = 8.03$$

3.

$$g_{m1} = 2\sqrt{\left(\frac{k'_n}{2}\right)\left(\frac{W}{L}\right)_1} I_{D1} = 2\sqrt{\left(\frac{0.1}{2}\right)(20)(0.1)} = 0.6325 \text{ mA/V}$$

$$r_{o1} = \frac{1}{\lambda_n I_{D1}} = \frac{1}{(0.02)(0.1)} = 500 \text{ k}\Omega$$

$$R_{o2} = r_{o2} + r_{o3}(1 + g_{m2}r_{o2})$$

$$g_{m2} = 2\sqrt{\left(\frac{0.06}{2}\right)(80)(0.1)} = 0.9798 \text{ mA/V}$$

$$r_{o2} = r_{o3} = \frac{1}{(0.02)(0.1)} = 500 \text{ k}\Omega$$

$$R_{o2} = 500 + 500[1 + (0.9798)(500)] = 245,949 \text{ k}\Omega$$

$$A_v = -g_{m1}(r_{o1} \parallel R_{o2}) = -(0.6325)(500 \parallel 245,949) = -316$$

4.

$$I_{REF} = 50 = \left(\frac{40}{2}\right)\left(\frac{W}{L}\right)_1 (V_{SG1} - 0.6)^2$$

$$I_{REF} = \frac{1.75 - V_{SG1}}{R} = 50$$

$$V_{SD2}(\text{sat}) = 0.35 = V_{SG2} - 0.6 \Rightarrow V_{SG2} = 0.95 \text{ V}$$

$$R = \frac{1.75 - 0.95}{0.05} \Rightarrow \underline{R = 16 \text{ K}}$$

$$50 = \left(\frac{40}{2}\right)\left(\frac{W}{L}\right)_1 (0.95 - 0.6)^2 \Rightarrow \underline{\left(\frac{W}{L}\right)_1 = 20.4}$$

$$\frac{I_{O1}}{I_{REF}} = \frac{120}{50} = \frac{\left(\frac{W}{L}\right)_2}{(20.4)} \Rightarrow \underline{\left(\frac{W}{L}\right)_2 = 49}$$

$$\frac{I_{D3}}{I_{REF}} = \frac{25}{50} = \frac{\left(\frac{W}{L}\right)_3}{(20.4)} \Rightarrow \underline{\left(\frac{W}{L}\right)_3 = 10.2}$$

$$V_{DS5}(\text{sat}) = 0.35 = V_{GS5} - 0.4 \Rightarrow V_{GS5} = 0.75 \text{ V}$$

$$I_{O2} = \left(\frac{100}{2}\right)\left(\frac{W}{L}\right)_5 (0.75 - 0.4)^2 = 150 \Rightarrow \left(\frac{W}{L}\right)_5 = 24.5$$

$$\frac{I_{D4}}{I_{O2}} = \frac{I_{D3}}{I_{O2}} = \frac{25}{150} = \frac{\left(\frac{W}{L}\right)_4}{24.5} \Rightarrow \left(\frac{W}{L}\right)_4 = 4.08$$