2020194, DHEERAJ, TUT-5

OS2) 10(4) a) $V_{DS} = V_D - V_S = 2.1 - 0 = 2.1V$

$V_{GS} = V_G - V_S = 3 - 0 = 3V$ & $V_{GS} - V_t = 3 - 1 = 2.05 \leq V_{DS}$

so saturation mode

(b) $V_{DS} = V_D - V_S = 0.1 - (-2) = 1.9V$; $V_{GS} = V_G - V_S = 2 - (-2) = 4V$; $V_{GS} - V_t = 4 - 2 = 2 > V_{DS}$

so triode mode

(c) $V_{SD} = V_S - V_D = 0 - (-3) = 3V$; $V_{SG} = V_S - V_G = 0 - (-1) = 1V$

here cut off mode

(d) $V_{SD} = V_S - V_D = 2 - (-1) = 3V$; $V_{SG} = V_S - V_G = 2 - 0 = 2V$; $V_{SG} + V_t = 2 - 1 = 1V$

$1V \leq V_{SD}$ so saturated mode

(e) $V_t = 2V$; $V_{GS} = 0 - (-3) = 3V$; as it is saturated so $V_{DS} > V_t$

now $V_{GS} - V_t = 3 - 2 = 1V$;

$V_D = V_{DS} + V_S > 1 - 3 = -2V$

(f) $V_t = -2V \rightarrow$ PChannel; $V_{SD} = V_S - V_D = 3 - (-1) = 4V$; $V_{SG} = V_S - V_G = 3 - 0 = 3V$; $V_{SG} + V_t = 3 - 2 = 1V$

$1V \leq V_{SD}$ so saturated mode

(g) $V_t = -2V \rightarrow$ P channel; $V_S = 3V$, $V_D = -3V$; $V_S - V_G < -V_t = +2V$

5.8) We know $n = \frac{5V}{(2.2 - 2.1)mA} = 50 k\Omega$; $r_A = n i_D = 50 k\Omega \left[\frac{4.3}{2}\right] = 107.5V$ $\left[i_D = \frac{2.1 + 2.1}{2}\right]$

$\lambda = \frac{1}{V_A} = 0.0093 V^{-1}$

5.9) Given: $V_t = -2V$, channel width $= 100 \mu m$, $L = 1 \mu m$, $\mu_n C_{ox} = 20 \mu A/V^2$, $\lambda = 0.01 V^{-1}$

$V_{GS} = V_{DS} = -5V$

Let $\mu_p = \frac{1}{2} \mu_n$, $k_p = \frac{1}{2} \times \frac{1}{2} \times 20 \times \frac{100}{3} = 166.74 A/V^2$

Now $V_{GS} - V_{DS} = -5V$, $i_D = k(V_{GS} - V_t)^2 (1 + \lambda V_{DS}) = 166.7 (-5 - (-2))^2 (1 - 0.01(-5)) = 166.7(3)^2$

$= 1.575 mA$