EE330 Spring 2018 HW11 Solutions TA: George Alphonse

Problem 1:

a) Choose $V_{GTMax} = 0.8\,V \; and \; I_{GT} = 200\;\mu A$

$\rightarrow \; R_{GG} = \dfrac{12 - 0.8}{200\;\mu} = 56k\Omega$

b) $I_F = \frac{50-1.6}{40} = \; 1.21\;A, V_F = \; 1.6 \rightarrow P = 1.21 * 1.6 = 1.936\;W$

c) $V_{GT} = \; .8, \; I_G = \frac{12-0.8}{56k} = 200\;\mu A \rightarrow P = 160\;\mu W$

Problem 2:

a)

Upper portion of potentiometer = 500*(1 - 0.1) = 450

Lower portion of potentiometer = 500*0.1 = 50

$V_{TM} = 1.6\,V, \;\; V_{GT} = V_{AC}\left(\dfrac{50}{500 * 2}\right) = 3\sin(2\pi * 60 * t)$

$\rightarrow \; V_F = \begin{cases} 1.6\,V; \;\; \frac{T}{4} + nT < t < \frac{T}{2} + nT, \frac{3T}{4} + nT < t < (n+1)T \\ Vcc; \;\; otherwise \end{cases}$

b)

$V_{RMS} = \dfrac{60 - 1.6}{\sqrt{2}} = 41.30, \rightarrow \; I_L = \dfrac{V_{RMS}}{R_L} = 2.065\;A$

$P = V * I_L = 1.6 * 2.065 = 3.304\;W$

c)

Quadrants 1 and 3

Problem 3:

Turn on voltage is 0.8 V so at 2π/8 we need, $0.8 = \frac{R_1}{R_1+10000} * 170\sin\left(\frac{\pi}{4}\right) \rightarrow \; R_1 = 67\;\Omega$

Problem 4:

$V_{GS} = 0\ and\ V_{DS} > V_{GS} - V_P \rightarrow V_{out} = I_{DSS} * 6k =$ 0.6 V

Problem 5:

a)

$V_{GSH} = 25\ mV, assume\ V_{DS} > V_{GS} - V_P$

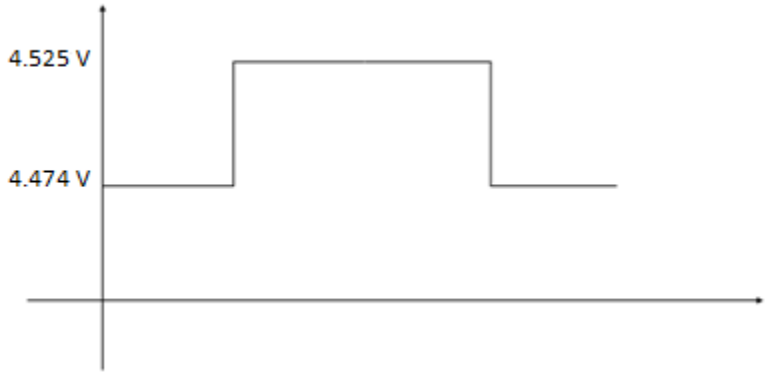
$$V_{out1} = 5 - I_D * 5k = 5 - I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2 * 5k = 4.474$$

$Verify \rightarrow V_{DS} > V_{GS} - V_P \rightarrow 4.474 > 1.025$

$V_{GSL} = -50\ mV, assume\ V_{DS} > V_{GS} - V_P$

$$V_{out1} = 5 - I_D * 5k = 5 - I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2 * 5k = 4.525$$

$Verify \rightarrow V_{DS} > V_{GS} - V_P \rightarrow 4.525 > 1.025$



b)

$V_{in} < V_{GSMax} =$ 0.3 V (From lecture slides)

Problem 6:

$$I = \frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)(V_G - V_{out} - V_{TN})^2 = I_{DSS} * \left(1 - \frac{V_{in}}{V_P}\right)^2$$

$$\rightarrow \frac{100 * 10^{-6}}{2} * \left(\frac{W}{8\mu}\right)(5 - 3 - 0.75)^2 = 100 * 10^{-6} * \left(1 - \frac{-0.5}{-1}\right)^2 \rightarrow W = 0.508\ \mu m$$

Problem 7:

$$g_m = \frac{\partial I_D}{\partial V_{GS}} = -2 * \frac{I_{DSSP}}{-V_P}\left(1 - \frac{V_{GS}}{V_P}\right)(1 - \lambda V_{DS}) \approx = 2 * \frac{I_{DSSP0}}{V_P}\left(\frac{W}{L}\right)\left(1 - \frac{V_{GS}}{V_P}\right)$$

$$g_o = \frac{\partial I_D}{\partial V_{DS}} = \lambda * I_{DSSP}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

Problem 8:

$$I_{DQ} = \frac{30\mu * 10}{15} * \left(1 - \frac{0}{1}\right)^2 = \frac{V_{outQ} - (-5)}{50k} \rightarrow V_{outQ} = -4\,V, I_{DQ} = 20\,\mu A$$

$$g_m = \frac{2}{V_P}\frac{I_{DQ}}{\left(1 - \frac{V_{GS}}{V_P}\right)} \rightarrow A_V = \frac{V_{out}}{V_{in}} = -g_m * 50k = 2\,V/V$$

Problem 9: