SOLUTIONS:

Problem 1:

From specification @ $T_C = 25\ ^\circ C$ $V_{GTMax} = 0.8\,V$ and $I_{GTMax} = 200\ \mu A$

$\rightarrow\ R_{GG} = \dfrac{15 - 0.8}{200\ \mu} = 71k\Omega$

b) $I_F = \frac{80-1.6}{40} = 1.96\,A, V_F = V_{TM} = 1.6\,V \rightarrow P = IV = 1.96 * 1.6 = 3.136W$

c) $V_{GT} = .8,\ I_G = 200\ \mu A\ \rightarrow P = 160\ \mu W$

Problem 2:

a)Upper portion of potentiometer = 500*(1 - 0.1) = 450 Ω
Lower portion of potentiometer = 500*0.1 = 50 Ω

$V_{TM} = 1.6\,V,\ V_{GT} = V_{AC}\left(\dfrac{50}{500 * 2}\right) = 4\sin(2\pi * 60 * t)$

$\rightarrow V_F = \begin{cases} 1.6V & t_0 < t < t_1,\ t_2 < t < t_3 \\ V_{AC} & otherwise \end{cases}$

Where $t_3 = \frac{1}{60} * n\ , t_1 = \frac{1}{120} * n$ and

$V_g = 2.5 = 4\sin(60 * 2\pi t_0)$

$\dfrac{2.5}{4} = \sin(60 * 2\pi t_0)$

$60 * 2\pi t_0 = \sin^{-1}\left(\dfrac{2.5}{4}\right)$

$t_0 = \dfrac{0.675}{120\,\pi} + \dfrac{n}{60}$

Then it is simple to see that

$t_3 = \dfrac{3.817}{120\,\pi} + \dfrac{n}{60}$

b) $V_{RMS} = \frac{80-1.6}{\sqrt{2}} = 55.43, \rightarrow\ I_L = \frac{V_{RMS}}{R_L} = 2.772\ A_{RMS}$

$P_{fullwave} = V * I_L = 1.6 * 2.772 = 4.4352\ W_{RMS}$

$P_{average} = P_{fullwave} * time\ Triac\ is\ on = 4.4352 * \dfrac{2\pi - 0.675 * 2}{2\pi} = 3.482\ W_{RMS}$

c) Quadrants 1 and 3

Problem 3:

Turn on voltage 2 V so at 2π/8 we need, $2 = \frac{R_1}{R_1+40000} * 170 \sin\left(\frac{\pi}{4}\right) \rightarrow$ $R_1 = 676.77\ \Omega$

Problem 4:

$V_{GS} = 0$ and assuming JFET is operating in saturation:

$$I_D = I_{DSS} * \left(1 - \frac{V_{GS}}{V_p}\right)^2 = 100\ \mu A \rightarrow V_{out} = I_D * R = 100\ \mu A * 10\ K\Omega = 1\ V$$

$V_{DS} = 5 - 1 = 4\ V > V_{GS} - V_p$, initial assumption is correct

Problem 5:

a)

$V_{GSH} = 20\ mV, assume\ V_{DS} > V_{GS} - V_P$

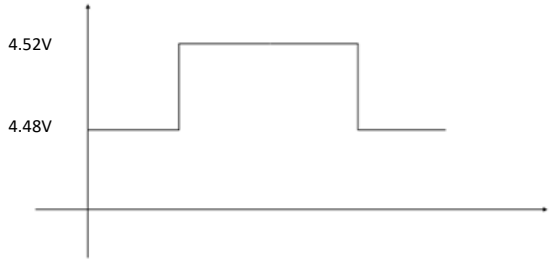
$$V_{out1} = 5 - I_D * 5k = 5 - I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2 * 5k = 4.48\ V$$

$Verify \rightarrow V_{DS} > V_{GS} - V_P \rightarrow 4.48 > 1.02$

$V_{GSL} = -20\ mV, assume\ V_{DS} > V_{GS} - V_P$

$$V_{out1} = 5 - I_D * 5k = 5 - I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2 * 5k = 4.52\ V$$

$Verify \rightarrow V_{DS} > V_{GS} - V_P \rightarrow 4.52 > 1.02$



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

Problem 6:

V_{out} = JFET V_{DS}, so the JFET is in saturation

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

$$\rightarrow \frac{350 * 10^{-6}}{2} * \left(\frac{W}{12}\right)(5 - 3 - 0.5)^2 = 100 * 10^{-6} * \left(1 - \frac{-0.5}{-1}\right)^2 \rightarrow W = 0.762\ \mu m$$

Problem 7:

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

$$g_o = \frac{\partial I_D}{\partial V_{DS}} = \lambda * I_{DSSP0}\left(\frac{W}{L}\right)\left(1 - \frac{V_{GS}}{V_P}\right)^2$$ 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 8:

Guess Saturation

$$I_{DQ} = I_{DSS_{p0}}\frac{W}{L}\left(1 - \frac{V_{GS}}{VP}\right)^2 = 30\mu\left(\frac{10}{15}\right)\left(1 - \frac{0}{1}\right)^2 = 20\mu A$$

$$V_{DS} = V_{out} = -5 + 20 * 10^{-6} * 50000 = -4V \rightarrow V_{DS} < V_{GS} - V_P\ assumption\ validated$$

$$A_V = -g_m * 50000 = \frac{2}{1}\left(\frac{20\mu}{1 - \frac{0}{1}}\right)50000 = 2\frac{V}{V}$$

Problem 9:

a) $A_V = \left(\frac{R_{in1}}{R_{impede} + R_{in1}}\right)A_{V1}\left(\frac{R_{in2}}{R_{o1} + R_{in2}}\right)A_{V2}\left(\frac{R_{load}}{R_{o2} + R_{load}}\right) = \left(\frac{4}{4+2}\right)(-10)\left(\frac{20}{20+0.5}\right)(-20)\left(\frac{0.5}{5+0.5}\right) =$ 11.83 V/V

b) $A_V = \left(\frac{R_{in2}}{R_{impede} + R_{in2}}\right)A_{V2}\left(\frac{R_{in1}}{R_{o2} + R_{in1}}\right)A_{V1}\left(\frac{R_{load}}{R_{o1} + R_{load}}\right) = \left(\frac{20}{20+2}\right)(-20)\left(\frac{4}{4+5}\right)(-10)\left(\frac{0.5}{0.5+0.5}\right) =$ 40.4 V/V