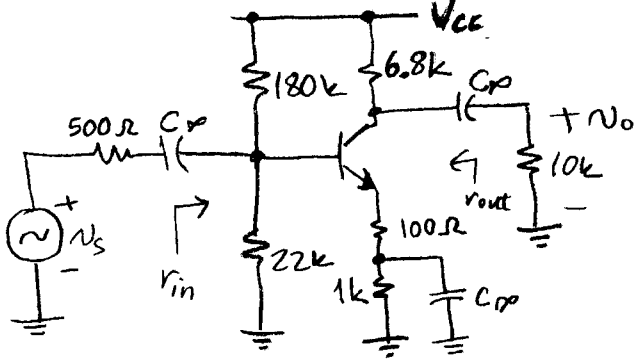
Electronics I * Midterm II * December 05, 2006 * 60 minutes

I have never given nor received any unauthorized help with this exam, nor do I have reason to believe that anybody else has.

ID number: SOLUTIONS *Name:* ERKAYA *Signature:* _____

1) Obtain a small-signal equivalent circuit for the amplifier given below. Then find the input resistance, output resistance and voltage gain of the amplifier.



$I_c = 1.5\,mA$

$\beta = 240$

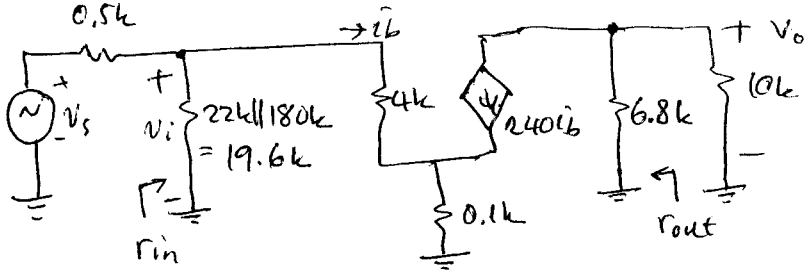
$g_m = \frac{I_c}{V_T} = \frac{1.5}{0.025} = 60\ mA/V$

$r_\pi = \frac{\beta}{g_m} = \frac{240}{60} = 4k\Omega$

$r_{in} =$ 11.54kΩ

$r_{out} =$ 6.8kΩ

$v_o/v_s =$ −33.13



$r_{in} = 19.6k \,||\, [4k + 0.1(240+1)] = 19.6k \,||\, 28.1k = 11.54k$

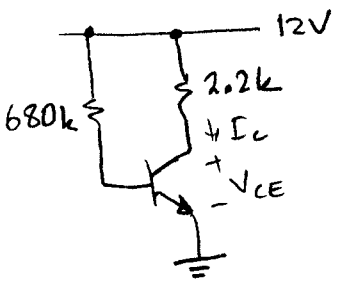
$r_{out} = 6.8k$

$$\left.\begin{aligned} v_o &= -240\, i_b\, (6.8 \,||\, 10) \\ v_i &= [4k + 0.1(240+1)]\, i_b \end{aligned}\right\} \frac{v_o}{v_i} = \frac{-240\,(6.8\,||\,10)}{28.1} = -34.57$$

$$\frac{v_o}{v_s} = -34.57\,\frac{11.54}{0.5 + 11.54} = -33.13$$

2) Find the operating points of the bipolar junction transistors in the circuits given below:

$\beta = 250$, $V_{BE} = 0.7\,V$



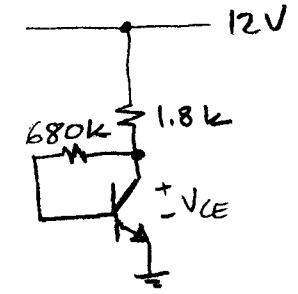
$I_C = \underline{4.154\,mA}$

$V_{CE} = \underline{2.86}$

$I_B = \frac{12 - 0.7}{680k} = 0.0166\,mA$

$I_C = \beta I_B = 4.154\,mA$

$V_{CE} = 12 - 2.2 \times 4.154 = 2.86\,V$



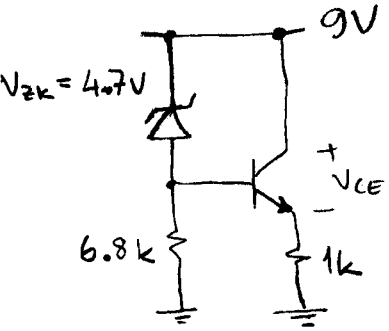
$I_C = \underline{2.5\,mA}$

$V_{CE} = \underline{7.5\,V}$

$I_B = \frac{12 - 0.7}{680 + 251 \times 1.8} = 0.01\,mA$

$I_C = 250 \times I_B = 2.5\,mA$

$V_{CE} = 12 - 1.8 \times 2.5 = 7.5\,V$



$I_C = \underline{3.6\,mA}$

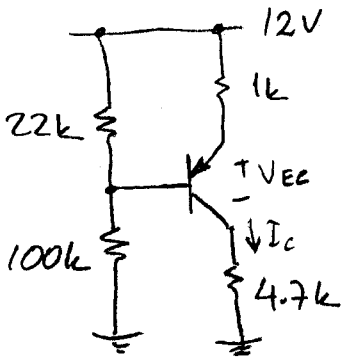
$V_{CE} = \underline{5.4\,V}$

$V_B = 9 - 4.7 = 4.3\,V$

$V_E = V_B - V_{BE} = 4.3 - 0.7 = 3.6V$

$I_E = \frac{3.6V}{1k} = 3.6\,mA.$ $I_C \simeq I_E$

$V_{CE} = 9 - 3.6 = 5.4V$



$I_C = \underline{1.47V}$

$V_{EC} = \underline{3.65V}$

$V_B = 12 \frac{100}{100+22} = 9.83\,V$

$V_E = V_B + 0.7 = 10.53V$

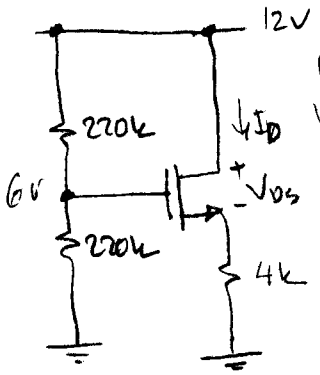
$I_E = \frac{12 - 10.53}{1k} = 1.47\,mA$

$I_C \simeq I_E$

$V_{EC} = 12 - 1 \times 1.47 - 4.7 \times 1.47$

$V_{EC} = 3.65\,V.$

3) Find the operating points of the field effect transistors in the circuits given below:



$K = 1\,mA/V^2$ $V_t = 1V$

$I_D = \underline{1\,mA}$

$V_{DS} = \underline{8V}$

$V_G = 12\,\frac{220}{220+220} = 6V$

$4I_D + V_{GS} = 6$

$4 \times 1 (V_{GS} - V_t)^2 + V_{GS} - 6 = 0$

$4(V_{GS}^2 - 2V_{GS}V_t + V_t^2) + V_{GS} - 6 = 0$

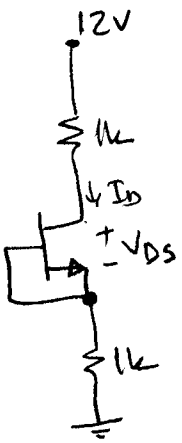
$4V_{GS}^2 - 7V_{GS} + 4 - 6 = 0$

$V_{GS1} = \frac{7 + \sqrt{49+32}}{8} = 2$ valid

$V_{GS2} = \frac{7 - \sqrt{49+32}}{8} = -\frac{2}{8} < V_t$ not valid

$I_D = 1(2-1)^2 = 1mA.$

$V_{DS} = 12 - 4 = 8V$



$I_{DSS} = 2mA$

$V_P = -2V$

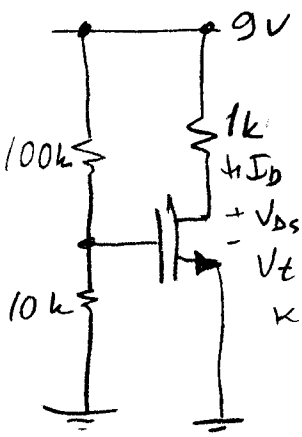
$I_D = \underline{2mA}$

$V_{DS} = \underline{8V}$

$V_{GS} = 0$

By definition of I_{DSS}, $I_{DD} = I_{DSS} = 2mA$

$V_{DS} = 12 - 1(1+1) = 8\,V$



$I_D = \underline{0}$

$V_{DS} = \underline{9\,V}$

$V_{GS} = 9\,\frac{10}{10+100} = 0,82\,V < V_t = 2V$

CUTOFF $\rightarrow$ $I_D = 0$

$V_{DS} = 9 - I_D \times 1 = 9\,V.$