Texas A&M University
Department of Electrical and Computer Engineering

ECEN 325 – Electronics

Spring 2012

Exam #2

Instructor: Sam Palermo

- Please write your name in the space provided below
- Please verify that there are 5 pages in your exam
- You may use one double-sided page of notes and equations for the exam
- Good Luck!

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Name: Sam Palermo

UIN:
Problem 1 (30 points)
For all the circuits below, use the constant-voltage-drop diode model (V_D=0.7V), V_a=25.9mV, and n=1.
a) Find V_{OUT}, I_D, and the small signal diode resistance, r_d. (10 points)

\[ \text{If Diode is reverse biased} \]
\[ V_{ox^-} = 10V \]
\[ V_x = 15V \]
\[ V_o = 5V \Rightarrow \text{Not consistent} \]

\[ \text{Diode must be forward biased} \]
\[ \text{KCL a+} \]
\[ V_X^\circ \]
\[ -1mA + \frac{V_X-10.7V}{5k} + \frac{V_X-10V}{5k} = 0 \]
\[ V_{OUT} = 10V \]
\[ \text{V_X} = 12.85V \]
\[ I_D = 439mA \]
\[ r_d = 60.2\Omega \]

Assume for the following circuit that **all diodes are forward biased**. Also assume that the capacitors act as AC shorts.
b) Derive an expression for the small-signal gain A_v=v_o/v_i. (10 points)
c) Calculate the value of I_1 for A_v=0.6 (10 points)

\[ \text{AC Equivalent Circuit} \]
\[ V_o = \frac{V_d}{r_{d_1} + r_{d_2}} = 0.6 \Rightarrow r_{d_1} = \frac{2}{3} r_{d_2} \]
\[ r_d = \frac{nV_t}{I_D} \Rightarrow I_1 = \frac{3}{2} I_{d_2} \]
\[ I_1 + I_{d_2} = \frac{5}{2} I_{d_2} = 1mA \]
\[ I_{d_2} = 0.4mA \]
\[ I_{d_1} = 0.6mA \]
\[ A_v \text{ Expression} = \frac{r_{d_2}}{r_{d_1} + r_{d_2}} \]
\[ I_1 (A_v=0.6) = 0.6mA \]
Problem 2 (30 points)
Assume for problem 2 that the transistor β=150, V_{BE}=0.7V, and V_{th}=25.9mV.

a) Calculate the DC values for V_C, V_B, V_E, I_C, I_B, and I_E. Compute the AC small signal parameters g_m, r_e, r_f. (20 points)

b) Give the maximum value of R_C such that the transistor remains in the active mode. (10 points)

\[ I_E = \frac{2.94V - 0.7V}{20k + \frac{706k}{151}} = 90.8\text{\mu A} \]

\[ I_B = \frac{I_E}{\beta+1} = \frac{90.8\text{\mu A}}{151} = 0.6\text{\mu A} \]

\[ I_C = \beta I_B = 90.2\text{\mu A} \]

\[ V_C = 10V - 90.2\text{\mu A} (39k\Omega) = 6.48V \]

\[ V_E = I_E R_E = 90.8\text{\mu A} (20k\Omega) = 1.82V \]

\[ V_B = V_E + 0.7V = 2.52V \]

To remain in active mode \( V_{CE} \geq 0.3V \)

\[ \text{min } V_C = V_E + 0.3V = 2.12V \]

\[ \text{Max } R_C = \frac{10V - 2.12V}{90.2\text{\mu A}} = 87.4k\Omega \]
Problem 3 (40 points)
Assume for problem 3 that the transistors are operating in active mode and that the capacitors act as AC shorts and that the transistors’ $r_o$ is infinite (can be neglected). For the 2-stage amplifier below, give expressions for the small signal parameters requested below.

\[
\begin{align*}
R_{\text{in1}} &= \frac{R_{B12}}{1} \left[ r_{\pi1} + (\beta+1) R_E1 \right] \\
R_{\text{out1}} &= R_C \\
R_{\text{in2}} &= \frac{R_{B34}}{1} \left[ r_{\pi2} + (\beta+1) R_E3 \|| R_L \right] \\
R_{\text{out2}} &= \frac{R_E3}{1} \left[ r_e2 + \frac{R_C||R_{B34}}{\beta+1} \right] \\
A_{v1} &= \frac{v_{o1}}{v_i} = -g_m \frac{R_C||R_{in2}}{1 + g_m R_E1} \\
A_{v2} &= \frac{v_o}{v_{o1}} = \frac{R_E3||R_L}{r_e2 + R_E3||R_L} \\
\text{Total } A_v &= \frac{v_o}{v_i} = A_{v1} \cdot A_{v2}
\end{align*}
\]