GEORGIA INSTITUTE OF TECHNOLOGY
School of Electrical and Computer Engineering

ECE 3050-B
Fall 2001

First Test
September 21, 2001

Closed Book and Notes

General Instructions:

1. Write on one side of the paper. (1 Pt.)

2. Put answers to all questions in the spaces provided on the test. (1 Pt.)

3. Show all work for full credit on questions requiring calculations. No credit will be given for answers alone, without supporting work.

4. Problems and questions are weighted as indicated. The maximum score is 100 points.

5. If you need more paper (provided in class), unstaple test and, when finished, arrange the test in order. Place the extra pages with supporting work in the test behind the page where the problem appears. Staple the entire test together so that there are no loose pages. (1 Pt.)

TEST SCORE: ___________________________ / 100

I certify that I have neither given nor received any assistance while taking this test from anyone.

_____________________________ (Signature) (1 Pt.)

Place a check mark in the box if you observed any suspicious actions while taking this test.
Problem 1 – (24 Points)

![Image of a circuit diagram]

a) For the circuit drawn above, under what conditions are diodes D1 and D2 on - assuming a constant voltage-drop model ($V_0 = 0.7$ V)?

D1 = on

\[-1.3 \leq V_o \leq -0.7 \text{ V} \] (5 pts)

D2 = on

\[-0.7 < V_o < 0 \text{ V} \] (5 pts)

b) Draw the transfer curve (-5 V < $V_{in}$ < 5 V). Where are the breakpoints (BP)? What are the slopes of each range? Note: there may be less than 4 breakpoints and less than 4 slope values.

BP1 \[ V_i = -2.25 \text{ V} \] (5 pts)

Slope 1 = $V_2$ (5 pts)

BP2 \[ V_i = -2.25 \text{ V} \] (5 pts)

Slope 2 = 0 (5 pts)

BP3 \[ V_i = -2.25 \text{ V} \] (5 pts)

Slope 3 = -

BP4 \[ V_i = -2.25 \text{ V} \] (5 pts)

Slope 4 = -

[Additional diagrams and calculations provided]
Problem 2 – (24 Points)

a) For the circuit drawn above, determine its quiescent bias point—assuming that $V_{BE}$ is roughly 0.7 V.

\[ V_C = 10 \text{ V} \]
\[ V_0 = 0.7 \text{ V} \]
\[ V_E = 0.3 \text{ V} \]
\[ I_C = 4.78 \text{ mA} \]
\[ I_B = 8.35 \text{ mA} \]
\[ I_E = 4.25 \text{ mA} \]

b) What region is the BJT operating in? **SATURATION**

Why? $V_{BE} = 0.18 \text{ V}$

$$5V = \frac{I_b(5\text{ k})}{10\text{ k}} + V_{BE} + \frac{I_b(1+\beta)}{10\text{ k}} \Rightarrow I_b = \frac{5 - 0.7}{5 \text{ k} + (5)10\text{ k}} = 0.835 \text{ mA}$$

\[ I_c = 8.35 \text{ mA} \]
\[ I_e = (1+\beta)I_b = 4.25 \text{ mA} \]

\[ V_E = I_e(10\text{ k}) = 4.26 \text{ V} \]
\[ V_b = V_E + V_{BE} = 4.26 + 0.7 = 4.96 \text{ V} \]
\[ V_c = 10 - I_c(2.5\text{ k}) = 10 - 5.22 \text{ V} = \]
Problem 3 — (24 Points)

For the circuit drawn above, what is the transfer function—assuming an ideal amplifier?

\[ A_v = \frac{\frac{R_2}{R_1}}{\frac{S}{RC_1} + 1} \]

\[ \frac{V_o}{V_i} = -\frac{R_2}{R_1 + \frac{1}{C_1S}} = -\frac{R_2}{R_1} \frac{S}{R_1} \frac{1}{S} \frac{R_C}{S + 1} \]

(b) Draw the corresponding Bode plot (gain and phase). Label key gains (dB), frequencies, slopes, and phase levels if \( R_1 = 10 \, k\Omega, \, C_1 = 10 \, nF, \) and \( R_2 = 100 \, k\Omega. \)

(c) What type of filter is it? **HIGH PASS**
Problem 4 – (24 Points)

\[
\begin{align*}
V_D &= 4 \quad (3 \text{ pts}) \\
V_G &= 1.897 \text{ V} \quad (3 \text{ pts}) \\
V_S &= 1 \text{ V} \quad (3 \text{ pts}) \\
I_D &= 10 \text{ mA} \quad (3 \text{ pts}) \\
I_G &= 0 \quad (3 \text{ pts}) \\
I_S &= 10 \mu A \quad (3 \text{ pts}) \\
\end{align*}
\]

a) For the circuit drawn above, determine its quiescent bias point assuming the amplifier is ideal.

\[
\begin{align*}
V_D &= 4 \\
V_G &= 1.897 \text{ V} \\
V_S &= 1 \text{ V} \\
I_D &= 10 \text{ mA} \\
I_G &= 0 \\
I_S &= 10 \mu A \\
\end{align*}
\]

b) What region is the MOSTET operating in? **SATURATION** (3 pts)

Why? \[V_{GS} = 3 \text{ V} > V_{BS} - V_T = 0.197 \text{ V} \] (3 pts)

\[V_S = 1 \text{ V} \Rightarrow \text{ideal amp} \]

\[I_D = \frac{V_S}{100k} = 10 \text{ mA} = I_S = I_G \]

\[I_G = 0 \]

\[V_A = 5 \text{ V} - I_D (100k) = 5 - 1 = 4 \text{ V} \]

\[V_{GS} = 3 \text{ V} \quad \text{assume saturation} \]

\[\begin{align*}
V_{GS} &= \frac{V_S - V_T}{(1 + \lambda V_D)} \\
\lambda &= \frac{50 \mu A}{10} \quad (V_{GS} - 0.5 \text{ V})^2 \\
V_{GS} &= 0.897 \text{ V} \\
\end{align*} \]

\[V_G = V_S + V_{GS} = 1.897 \text{ V} \]

\[V_{GS} = 3 \text{ V} > V_{BS} - V_T = 0.197 \text{ V} \]

\[I_S = 10 \mu A \] (3 pts)
Extra Credit – (5 Points)

Write the netlist for Problem 1 - draw the corresponding schematic with all nodes and components labeled -.

\[ V_i \quad R_i \quad 50k \quad d_1 \quad v_0 \quad a \quad \text{diode} \quad V_i \quad a \quad 2k \quad d_1 \quad b \quad v_0 \quad \text{diode} \quad R_2 \quad b \quad 0 \quad 100k \quad R_0 \quad v_o \quad 0 \quad 100k \quad \text{model diode} \quad d \]