EE4086 Quiz 2

AUGUST 20, 1997

Professor Leach Name ______________________

Instructions. Print your name in the space above and on all quiz work sheets. Place a box around all answers. Write the word "over" if you continue your work on another page.

1. The diodes in Figure P1 are ideal. When the op-amp has feedback, assume that it is ideal with an open-loop gain that is infinite. When the op-amp does not have feedback, assume that $v_O = A(v_+ - v_-)$, where $A \to \infty$ in the final answer. Consider the following combination of diode states:

- D_1 an open and D_2 an open
- D_1 a short and D_2 a short
- D_1 an open and D_2 a short
- D_1 a short and D_2 an open

2. (a) One of these states is not possible. Which one is it?

   (b) Write the equation for v_O for each of the three remaining possible states.

   (c) Plot v_O versus v_I for each of the three equations and label the slopes and intercepts. On the plots, the intersections of the curves represent the diode switch points. Label both v_I and v_O at each switch point. With your pencil, darken the portions of the curves which apply to the circuit. On each darkened portion, label the states of D_1 and D_2.

3. Figure P2 shows an inverting amplifier with the offset current and voltage sources for the physical op-amp represented as external sources. It is given that -2 mV $\leq V_{IO} \leq +2$ mV, $-5\ \mu$A $\leq I_{IB} \leq 5\ \mu$A, $-0.2\ \mu$A $\leq I_{IO} \leq 0.5\ \mu$A. Solve for the maximum negative and positive DC offset voltages at the output. Assume that the op-amp is ideal. Explain your assumptions with your calculations.

4. The transfer function of a $4th$-order Butterworth low-pass filter as a function of normalized frequency $p = s/\omega_c$ is

$$\frac{V_o}{V_i} = \frac{1}{p^2 + 0.7654p + 1} \times \frac{1}{p^2 + 1.848p + 1}$$

   (a) How many poles does the transfer function have and are the poles real or complex? You must explain why they are real or complex.

   (b) Using log-log scales, sketch and label the Bode magnitude plots versus ω for each $2nd$-order term in the transfer function and the Bode plot for the product of the two terms.

   (c) For $s = j\omega$, how many derivatives of $|V_o/V_i|^2$ are zero at $\omega = 0$?

(d) What is the transfer function of a $4th$-order Butterworth high-pass filter?

5. A $2nd$-order Sallen-Key low-pass filter is shown in Figure P4. The design equations for the filter are

$$\omega_o = \frac{1}{R\sqrt{C_1 C_2}}$$
$$Q = \frac{1}{2}\sqrt{\frac{C_1}{C_2}}$$

It is desired to realize the $4th$-order Butterworth low-pass filter of the preceding problem for a -3 dB cutoff frequency of $f = 1000$ Hz. If $R = 10$ kΩ in each filter section, solve for the required capacitor values.

Figure P1.

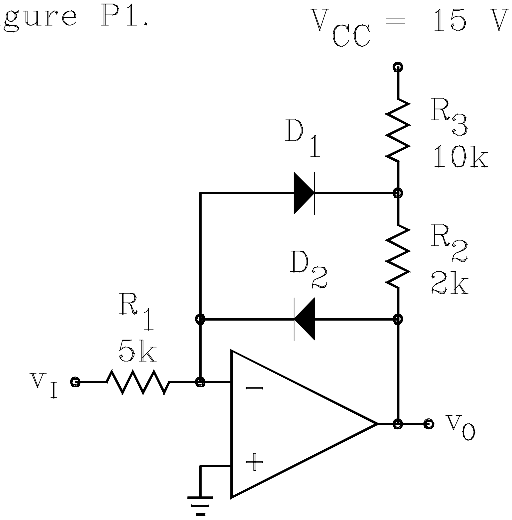

Figure P2.

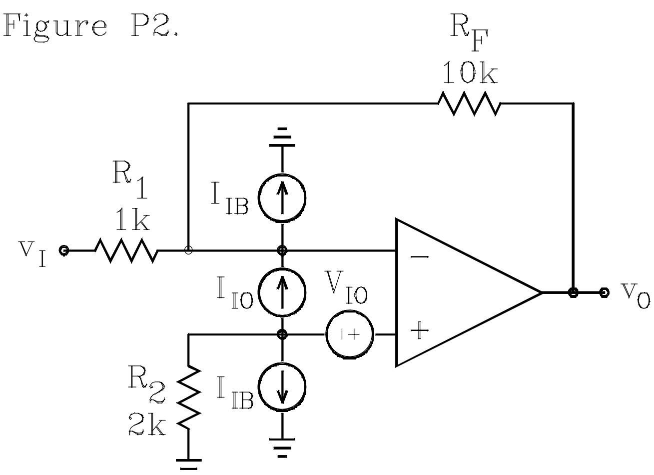

Figure P4.