National Exams **December 2008**

98-Comp-A1, Electronics

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to indicate, with the answer, a clear statement of any assumptions made.

2. This is a OPEN BOOK exam.
   Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper.
   The first 5 questions as they appear in the answer book will be marked.

4. Each question is of equal value.

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Question 1 (20 marks)

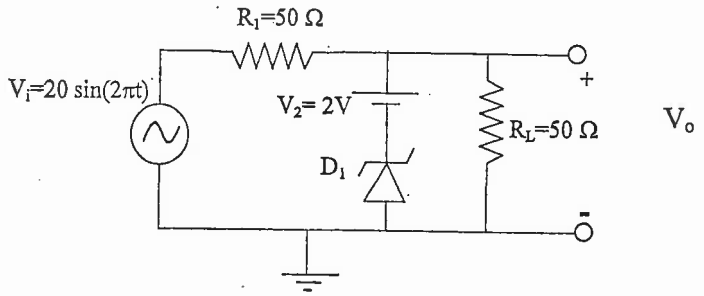

Figure 1. Assume the diodes can be replaced by piece-wise linear models with V_D=0.7V, R_S=10Ω for forward biased diodes, and V_Z=5V, R_Z=10Ω for Zener operation.

For the circuit shown in Figure 1:

a) Sketch V_i and V_o as a function of time, indicating peak voltages.

b) What are the peak forward and reverse currents through D_1?

c) What power rating would you specify for the diode?

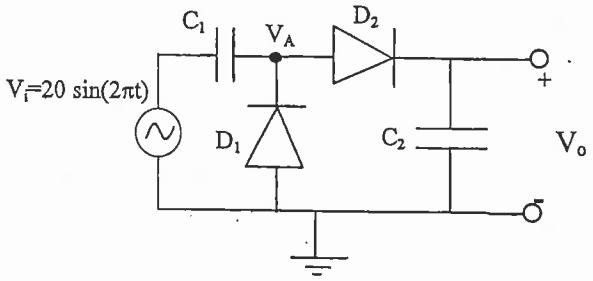

Figure 2. Assume the diodes have a voltage drop V_D=0.7V when conducting. The circuit is in steady state and C_1=C_2.

For the circuit shown in Figure 2:

d) Sketch V_A as a function of time.

e) Sketch V_o as a function of time.

f) Determine the peak inverse voltage across each diode.

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Question 2 (20 marks)

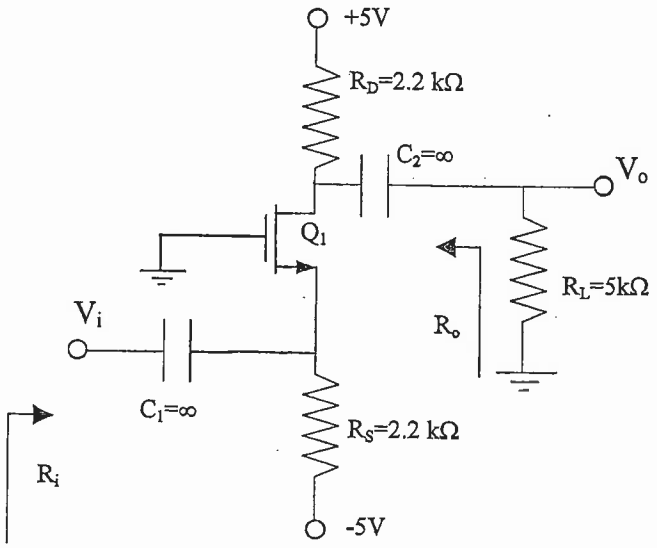

Figure 3. K_n=50 μA/V^2, K_p=20 μA/V^2 V_{tn}=-V_{tp}=1V

For the circuit shown in Figure 3:

a) Calculate the dc bias point, indicating V_{DS}, V_{GS} and I_D for the transistor.

b) Draw a small signal ac equivalent circuit.

c) Find the voltage gain V_o/V_i.

d) Find the input resistance R_i, as indicated in the Figure.

Question 3 (20 marks)

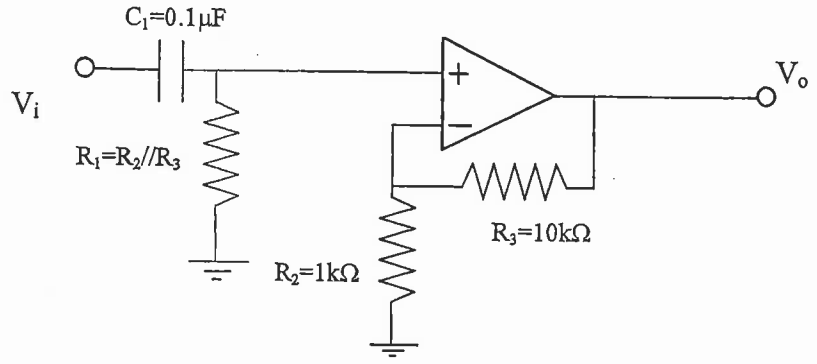

Figure 4. Assume the op-amp is ideal.

For the circuit shown in Figure 4:

a) Derive the transfer function $\frac{Vo(j\omega)}{Vi(j\omega)}$ for the circuit shown, assuming the op-amp is ideal.

b) Calculate the input impedance of the circuit shown. What is the purpose of R_1?

c) Sketch a Bode plot of the magnitude of the transfer function, showing all the important features.

d) Sketch a Bode plot of the phase of the transfer function, showing all the important features.

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Question 4(20 marks)

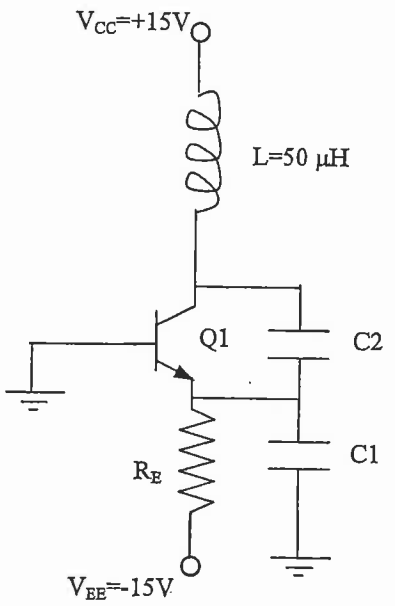

Figure 5. Neglect the transistor capacitances.

For the circuit shown in Figure 5:

a) Sketch the small signal ac equivalent circuit (using r_π and β to model the transistor).

b) Write ac node equations for the equivalent circuit.

c) Find an expression for the frequency of oscillation.

d) Choose values R_E, C_1 and C_2 for a 5MHz oscillator if the transistor has a minimum β=50 and I_C=1mA.

Question 5 (20 marks)

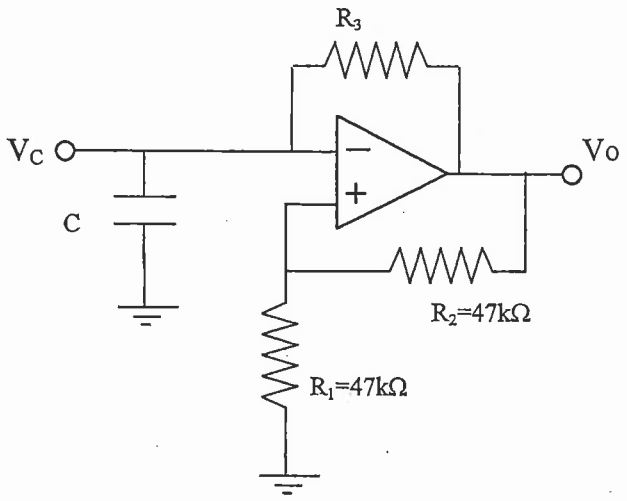

Figure 6. Assume the op-amp is ideal and can provide ±15 V output.

For the circuit shown in Figure 6:

a) Evaluate $V_C(t)$.

b) Show the switching frequency is $f=1/(2R_3Cln(3))$.

c) Choose values for R_3 and C to implement a 10kHz oscillator, if the amplifier input bias current is 0.5 μA.

Question 6 (20 marks)

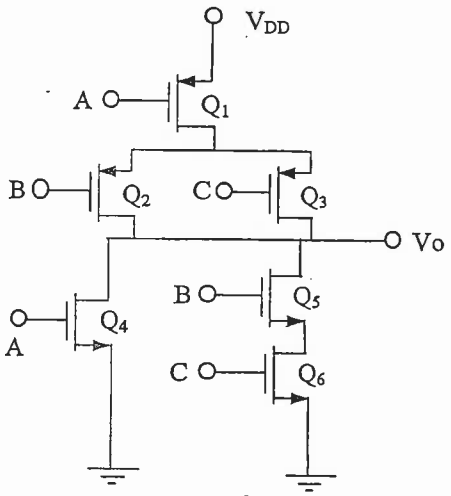

Figure 5. K_n=50 μA/V^2, K_p=20 μA/V^2 V_{tn}=-V_{tp}=1V

a) Draw a truth table for the circuit in Figure 5, indicating the state (off/on) of the transistors, and write the Boolean expression for Vo.

b) For an inverter with a symmetrical transfer characteristic and a 2μm channel length, the ratio (W/L) for N-channel transistors is 2, and for p-channel transistors is 5. If the same 2μm technology is used for the circuit in Figure 5, find the appropriate W/L ratios for the transistors.

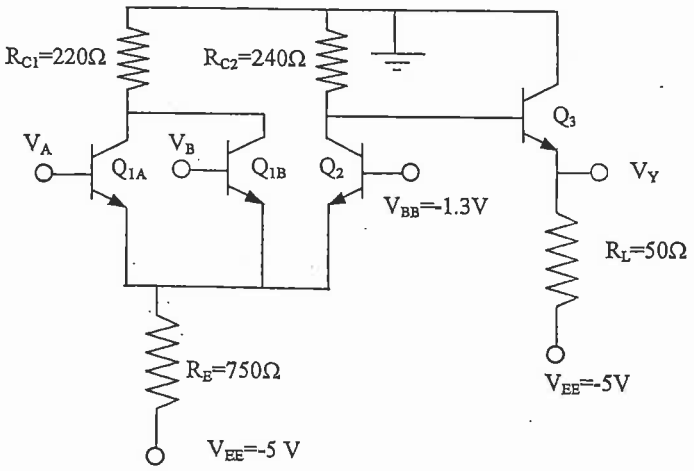

Figure 6. β is very large, V_{BE}=0.7V

For the circuit shown in Figure 6:

c) Find V_Y if V_A=V_B= -2 V.

d) Find V_Y if V_A= 0V and V_B= -2 V. What logic function does this circuit implement?

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Question 7 (20 marks)

An analog signal between 0V and +10V must be converted to an 8 bit digital signal.

a) What is the resolution of the converter in volts?

b) If the input signal is 4V, what is the digital signal value?

c) What is the error in quantization of an input signal of 4.1V?

d) If a flash converter is selected as the conversion circuit, sketch the circuit and provide a brief description of its operation. What is the advantage of this circuit over other conversion circuits?

e) If a dual-slope converter is selected, sketch the circuit and provide a brief description of its operation. What is the advantage of this circuit over other conversion circuits?

Marking Scheme

1. 20 marks total	(a) 4 (b) 4 (c) 2 (d) 3 (e) 3 (f) 4
2. 20 marks total	(a) 6 (b) 4 (c) 6 (d) 4
3. 20 marks total	(a) 7 (b) 3 (c) 5 (d) 5
4. 20 marks total	(a) 5 (b) 5 (c) 5 (d) 5
5. 20 marks total	(a) 7 (b) 6 (c) 7
6. 20 marks total	(a) 5 (b) 5 (c) 5 (d) 5
7. 20 marks total	(a) 3 (b) 3 (c) 4 (d) 5 (e) 5