National Exams December 2019

17-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 an 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.

Marking Scheme

1. 20 marks total (4 parts, 5 marks each)
2. 20 marks total (4 parts, 5 marks each)
3. 20 marks total (3 parts, a)7 marks, b)7 marks, c) 6 marks)
4. 20 marks total (4 parts, 5 marks each)
5. 20 marks total (3 parts, a) 7 marks, b) 6 marks, c) 7 marks)
6. 20 marks total (4 parts, 5 marks each)
7. 20 marks total (4 parts, 5 marks each)

Question 1 (20 marks)

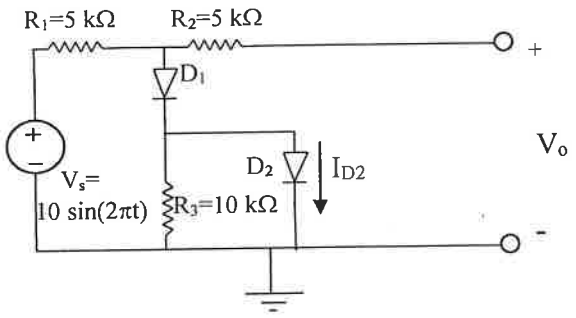

Figure 1. All diodes have a forward voltage drop V_D=0.7V.

The circuit shown in Figure 1 is in steady state:

a) What maximum reverse voltage rating would you choose for the diodes?
b) Which diode has the largest peak power dissipation? What power rating would you choose for this diode?
c) Sketch V_s and V_o as a function of time, indicating peak voltages.
d) Sketch current I_{D2} as a function of time, indicating peak values.

Question 2 (20 marks)

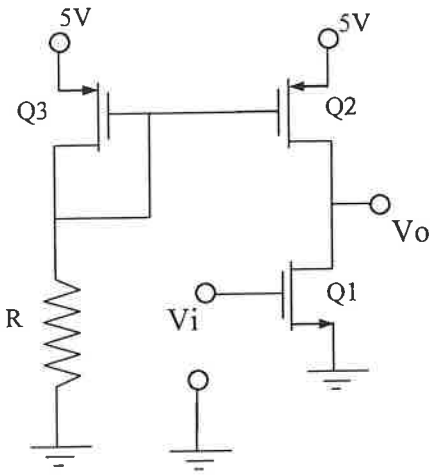

Figure 2 $k_n'(W/L)=3k_p'(W/L)=1$ mA/V^2, $V_{tn}=|V_{tp}|=1.0$V, $V_A=80$V assume $\lambda=0$.

For the circuit shown in Figure 2:

a) Find a value for R that will result in $I_{D,Q3}=0.5$mA?
b) Draw a small signal equivalent model for the circuit.
c) Find the input and output resistances of the circuit.
d) What is the small signal AC gain of the circuit?

Question 3 (20 marks)

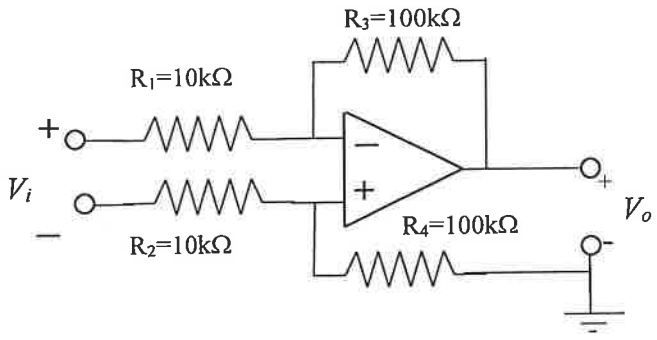

Figure 3. $+V_s$=15V, $-V_s$=-15V, I_s=100mA from each supply, V_{in}=1V@1kHz.

For the circuit shown in Figure 3:

a) Find voltage gain $|A_v|$ in dB
b) Draw an equivalent circuit for the amplifier including component values
c) What is the maximum input possible without clipping of the output waveform?

Question 4(20 marks)

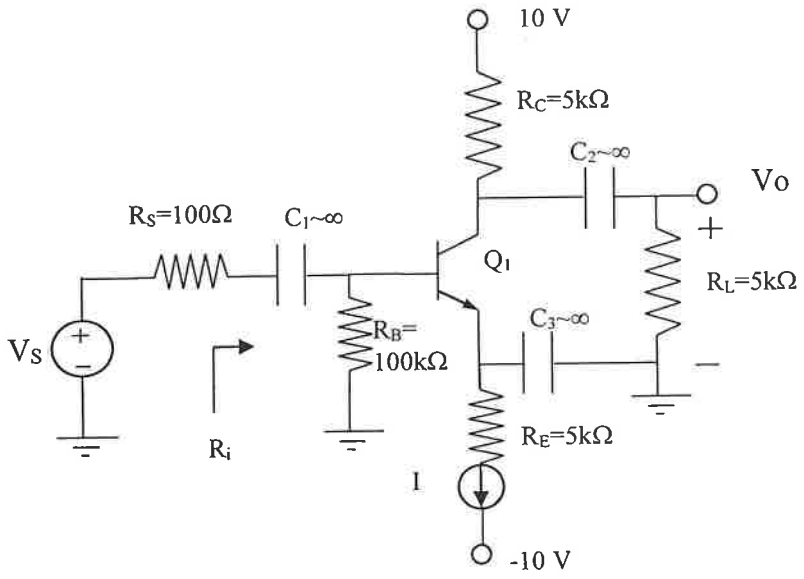

Figure 4. I=1mA, β=100, V_A=100V, V_T=25mV.

For the circuit shown in Figure 4:

a) Find V_C, V_B and V_E.
b) Draw a small signal equivalent circuit and find the model parameter values.
c) Find the small signal input resistance R_i and output resistance Ro.
d) Find the open circuit voltage gain for the amplifier and the loaded voltage gain.

Question 5 (20 marks)

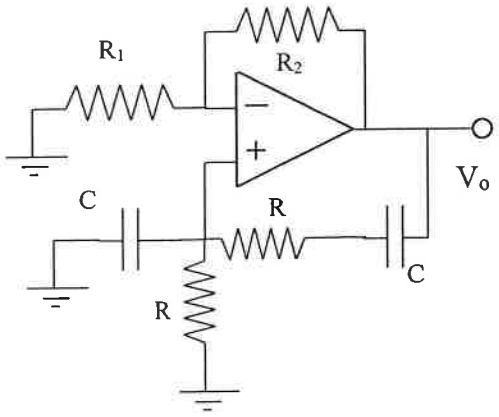

Figure 5. R=10kΩ, C=0.1μF

For the circuit shown in Figure 5:

a) What is the condition for oscillation of the output?

b) What are the frequency and amplitude of the output signal?

c) Choose component values R_1 and R_2 to sustain oscillation.

Question 6 (20 marks)

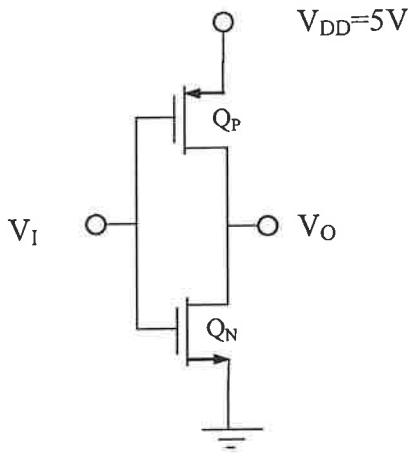

Figure 6 k_n'=50 μA/V^2, k_p'=20 μA/V^2, V_{tn}=-V_{tp}=1V, C_{ox}=1fF/μm^2, V_{DD}=5V.

a) If the minimum gate length for this technology is 1 μm, size Q_N and Q_P to obtain a symmetric transfer characteristic.

b) Sketch the voltage transfer characteristic, indicate the region of operation of each transistor in each region of the characteristic.

b) Estimate the maximum capacitance this circuit can drive with a propagation delay of less than 200 ps.

d) Based on this inverter technology synthesize a circuit to execute $Y = \overline{AB}$.

Question 7 (20 marks)

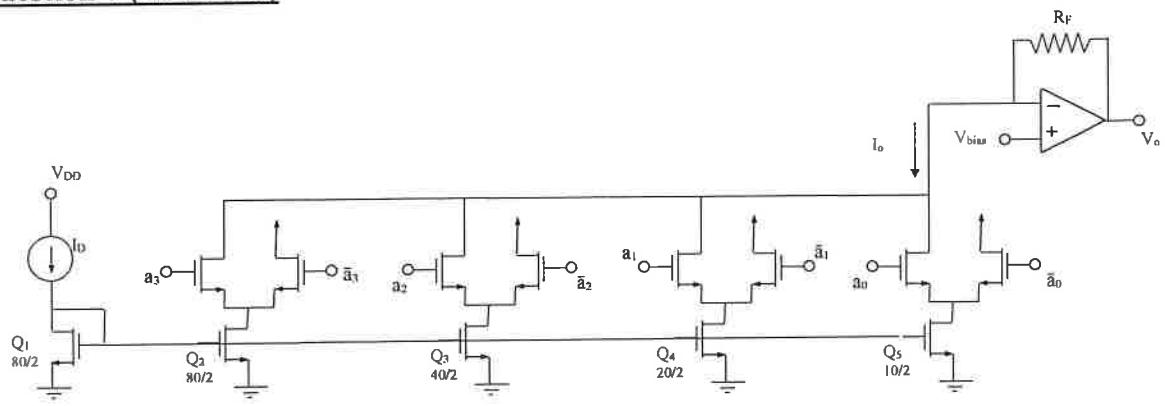

Figure 7. I_D=0.8mA, R_F=1kΩ, V_{DD}=5V, V_{bias}=2V
V_t=1V, k'=40 μA/V^2. Transistor W/L ratios are shown.

a) What is a common name for the circuit shown in Figure 7? Briefly explain how it works.

b) Calculate V_{GS} for Q_1. Calculate the drain currents for Q_2-Q_5.

c) If a_3-a_0 are connected to V_{DD}, find I_o. For each value of A_{in}=0000 to A_{in}=1111 determine the output V_o.

d) What are the limitations of the application of this circuit?