

Name: _____

Student #: _____

Lab Section: _____

CARLETON UNIVERSITY

FINAL
EXAMINATION
April 18, 2000

Duration: 3 hours

Department name and course number: Electronics 97.257

Course Instructor(s): L. Roy, N. Tait Number of students: 266

AUTHORIZED MEMORANDA:

CALCULATOR

Students MUST count the number of pages in this examination paper before beginning to write, and report any discrepancies immediately to a proctor. This question paper has

12 pages.

This examination question paper MAY NOT be taken from the examination room.

This exam consists of 5 questions, which should be answered on this exam paper in the space provided. Attempt all questions. Marks allocated to each question are indicated. The total number of marks for the examination is 65.

The solution must be clearly indicated. Multiple solutions or solutions that are not clearly identified, will be marked incorrect. Clearly state all assumptions made. Show your work.

Diode:

$$I_D = I_S \left(e^{V_D/nV_T} - 1 \right)$$

small signal resistance: $r_d = \frac{nV_T}{I_D}$

$$V_T = \frac{kT}{q} = 25mV \text{ at room temperature}$$

Bipolar Transistor:

Active mode operation: $V_{BE} = 0.7V$

Saturation mode operation: $V_{CE,sat} = 0.2V$

Operational Amplifier:

$$V_o = A(V_+ - V_-) \quad R_i = \infty \quad R_o = 0$$

MOSFET:

$$I_{DS} = K \left[(V_{GS} - V_T)V_{DS} - \frac{V_{DS}^2}{2} \right]$$

$$I_{DS} = K \frac{(V_{GS} - V_T)^2}{2} \quad K = \frac{W}{L} \bar{\mu} \hat{C}_{ox}$$

$$V_{DS,sat} = V_{GS} - V_T \quad g_m = K(V_{GS} - V_T)$$

1.) (12 marks) General short answer questions.

a) Which MOSFET amplifier configuration would you choose to obtain large positive voltage gain?

b) What is the difference between an enhancement and a depletion mode MOSFET?

c) What is the difference in the mode of operation of a Zener diode and a regular junction diode?

d) Describe three regions of operation for a n-channel MOSFET, in terms of the voltages that would be applied to the terminals.

e) Sketch I_C vs V_{CE} for a BJT for several values of V_{BE} , indicating modes of operation.

1.) Continued

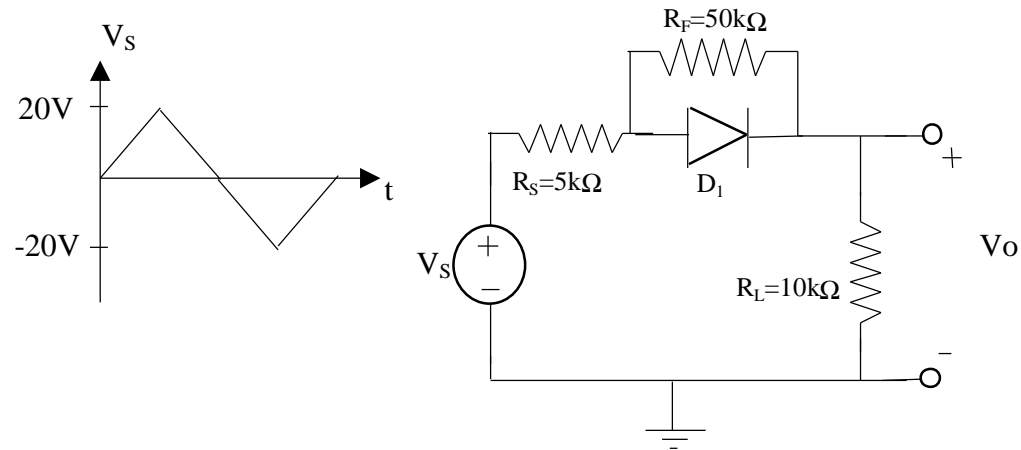
f) What is the body effect in a MOSFET?

g) Why is input resistance an important parameter for a voltage amplifier?

h) Is a transistor a linear device?

i) What is MOSFET an acronym for?

2.) (15 marks) Diodes.



a) For the circuit shown above V_s is a symmetrical triangular wave of 40V peak to peak and the diode has a voltage drop of 0.7V when conducting.

i) Over what range of values of V_s is the diode on? Express V_o in terms of V_s .

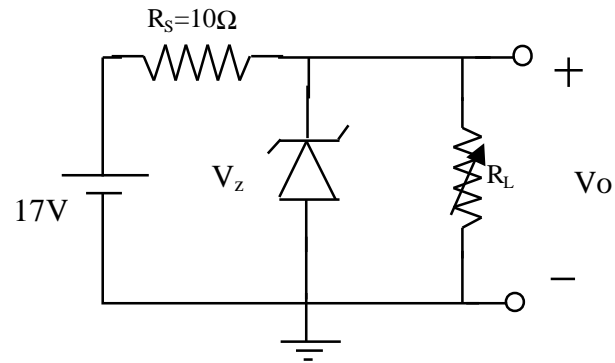
ii) Over what range of values of V_s is the diode off? Express V_o in terms of V_s .

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2.) Continued

iii) Sketch the output waveform V_o and indicate the peak voltages.

2.) Continued

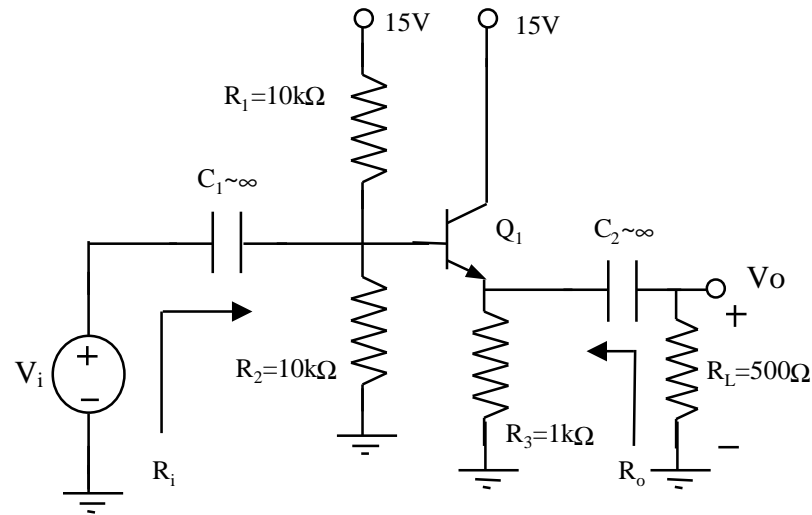


b) In the Zener diode circuit shown above $V_Z = 12V$ for $1mA < I_Z < 600mA$. Determine:

i) the output voltage V_o when $R_L = 500\Omega$,

ii) the maximum power that the diode should be able to dissipate and the value of R_L for which this power occurs,

3.) (14 marks) Bipolar Junction Transistor. Use $\beta=100$.



a) Draw the circuit for DC analysis and find I_C .

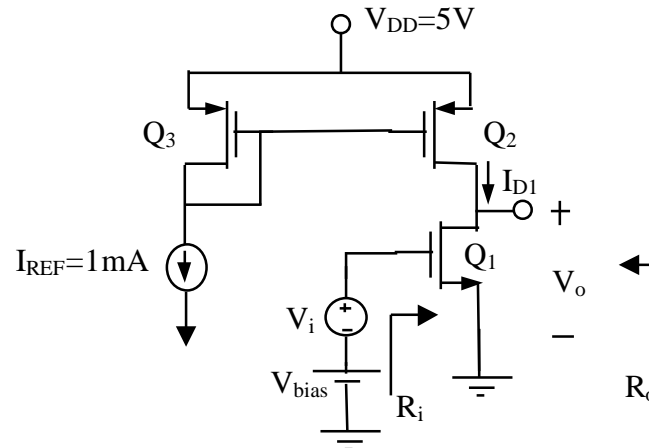
b) Find the values of r_π , g_m , and r_e .

3.) Continued

c) Draw the small signal circuit for AC analysis (with the equivalent model of your choice). Determine R_i and R_o for small signal operation.

d) Determine the small signal AC gain V_o/V_i .

- 4.) (12 marks) MOSFET. All transistors have $V_T=1\text{V}$, $V_A=30\text{V}$, $k_n' = k_p' = 100\mu\text{A}/\text{V}^2$, and $L=1\mu\text{m}$. Q_1 has $W_1=100\mu\text{m}$ and Q_3 has $W_3=50\mu\text{m}$. $V_{\text{bias}} > V_T$.



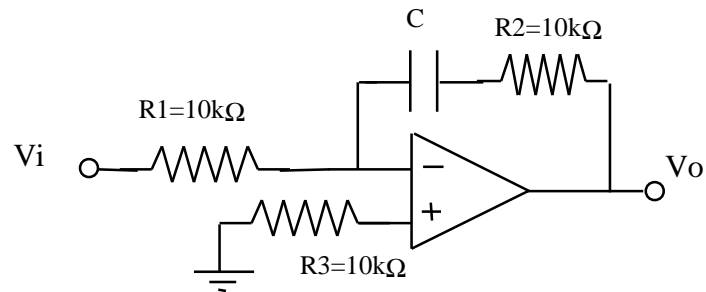
- a) Find the width of Q_2 (W_2) such that $I_{D1}=0.5\text{mA}$. For this calculation neglect the finite output resistance of the transistors. In order to find W_2 what other assumption has been made regarding
- the body contact for each MOSFET
 - the operating mode of each MOSFET.

4.) Continued

b) Draw the small signal equivalent circuit for AC analysis. Determine g_m and r_{o1} for Q_1 and r_{o2} for Q_2 .

c) Calculate the small signal gain V_o/V_i and R_i and R_o .

5.) (12 marks) Operational Amplifier.



a) Find the input impedance and voltage gain expression for the circuit shown, as a function of radial frequency ω , assuming the op-amp is ideal.

b) Sketch the magnitude and phase response of gain of the circuit.

5.) Continued

c) Choose a value of C to give a corner frequency of 20 kHz.

d) Calculate the input impedance and voltage gain as a function of radial frequency ω , if the op-amp has a finite open loop gain of 10,000.