National Exams May 2013

07-Elec-A5, Electronics

3 hours duration

Notes:

1. If any doubt exists as to the interpretation of any question, the candidate Is urged to submit, within their answer, a clear statement of any Assumptions made.

2. This is a CLOSED BOOK EXAM.
One of two calculators is permitted, any Casio or Sharp approved model.

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

4. All questions are worth 20 marks each.

5. Please start each question on a new page and clearly identify the question number and part number, e.g, Q4(a).

6. In schematics, ground and chassis may be assumed to be common, unless specifically stated otherwise.

7. Unless otherwise specified, assume that Op-Amps are ideal and that supply voltages are ±15V.

8. If questions require an answer in essay format, clarity and organization of the answer are important. Provide block diagrams and circuit schematics whenever necessary.

QUESTION (1)

This is an enhancement load NMOS inverter. Given that the transistors are identical,

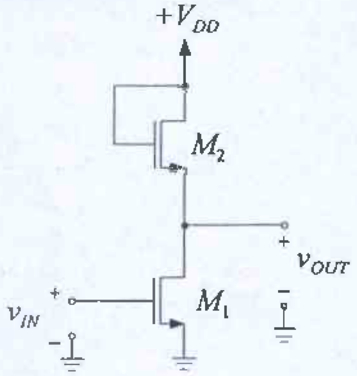
a) Draw the input to output voltage transfer characteristic (VTC) for this inverter. Express and label clearly all voltage levels on the VTC plot. (12 points)

b) Indicate the noise margins NM_L and NM_H on the VTC.

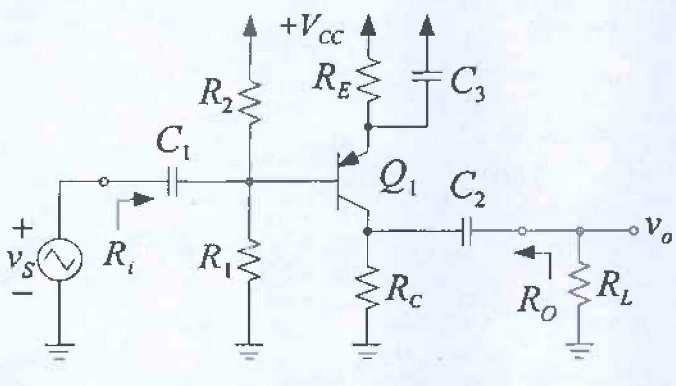
c) Indicate the logic high and low output voltage levels V_{OH}, V_{OL} on the VTC.

d) Indicate the logic high and low input voltage levels V_{IH}, V_{IL} on the VTC.

e) Indicate clearly the mode of operation in each region of the VTC.



QUESTION (2)



Assume that the BJT has the following characteristics:

β = 100
$V_{EB(on)}$ = 0.7V
$V_{EC(sat)}$ = 0.3V
V_A = ∞

Given: V_{CC} = 10V, R_L = 10kΩ, and R_E = 1kΩ,

a) Design this common emitter amplifier circuit to have the following specification:

DC bias current, I_E = 2mA,
A mid-band voltage gain v_{out}/v_S = 100 V/V
Provide values for R_1, R_2, and R_C. (15 points)

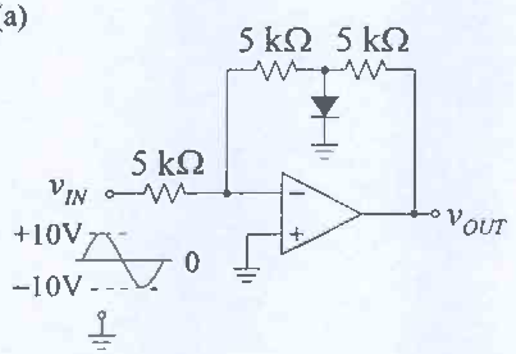
b) What is the equivalent output resistance, R_O? (2 points)

c) What is the maximum undistorted peak to peak output voltage swing at the output? (3 points)

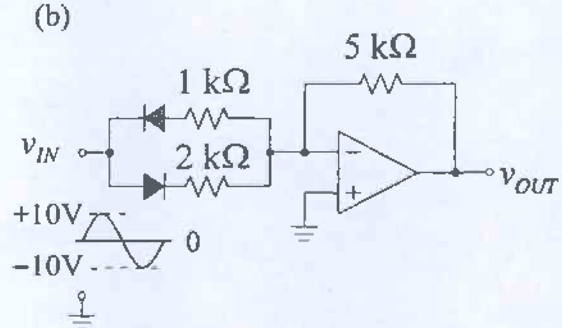
QUESTION (3)

In the following circuits, assume that the diode is ideal and has a forward voltage of 0.7V, and all op amps are ideal and with supply voltages of ±15 V. Sketch the output waveform for one complete sine wave input. (20 points)

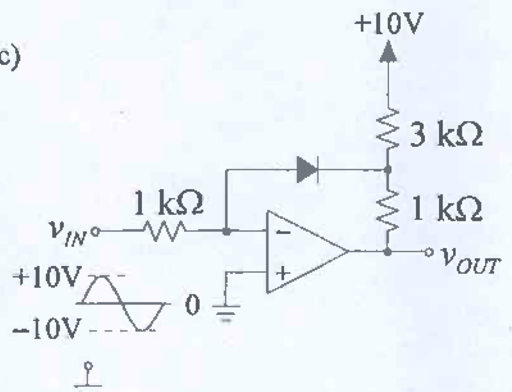
(a)



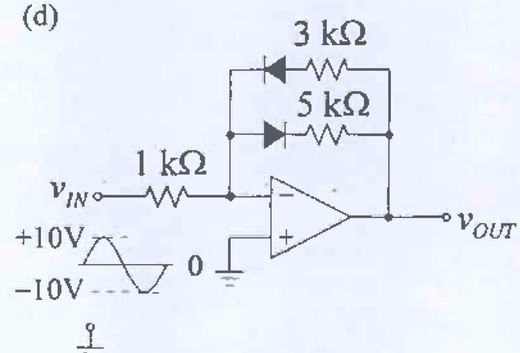
(b)



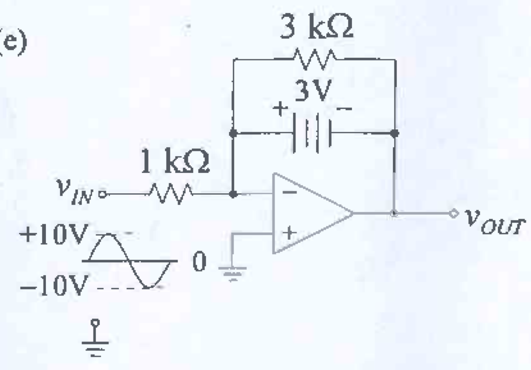
(c)



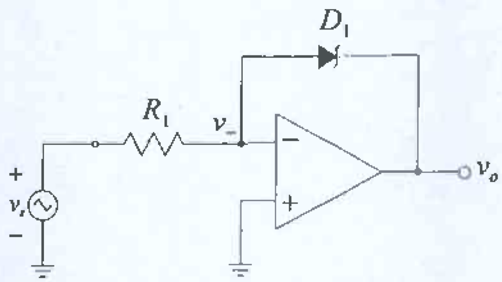
(d)

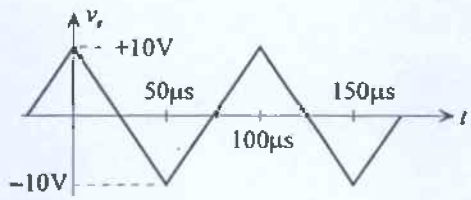


(e)



QUESTION (4)



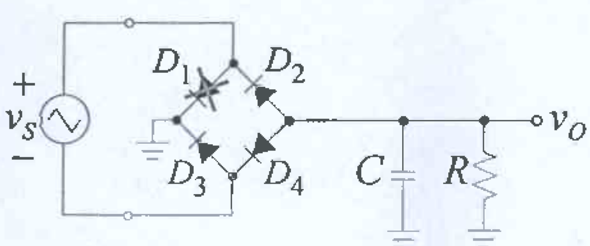


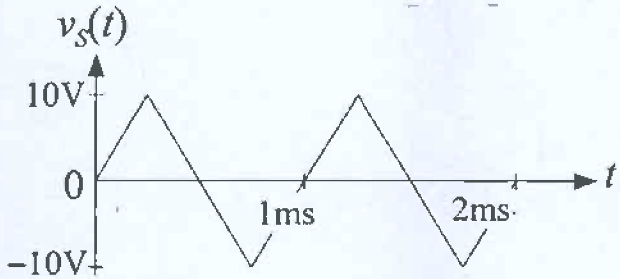
The op amp in this circuit is ideal except for a slew rate limit of 0.5V/μs. It is powered by ±15V supplies. Given that

$R_1 = 10\text{k}\Omega$
For D_1, $V_Z = 5\text{V}$, forward voltage drop = 0.7V

Sketch **accurately** in your answer book the voltage waveform for v_O. You must indicate the breakpoints, including the accurate timing and voltage levels. (20 points)

QUESTION (5)





Due to an abnormal operating condition, Diode D_1 in this full-wave rectifier circuit was suddenly destroyed, and stopped conducting in both forward and reverse directions (i.e. open circuit).

Assume that all other diodes are ideal with zero forward voltage drop and that the time constant $RC = 5$ ms. For a 1 kHz triangular input waveform with a peak amplitude of 10V,

a) Sketch accurately in your answer book the output voltage waveform, v_O. (5 points)

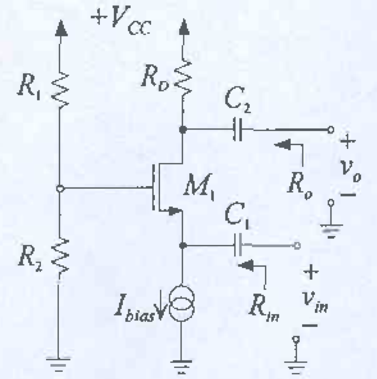
b) What is the peak voltage, V_p and the ripple voltage V_r that would appear at the output? (5 points)

c) What is the average output voltage at v_o? (5 points)

d) Estimate the time interval, t_{on} during which the diodes conduct during each period. (5 points)

QUESTION (6)

Transistor M_1 in this common gate amplifier circuit has the following characteristics:



$V_{TH} = 1$ V

$K = 1$ mA/V^2 $\lambda = 0.1$

Given: $V_{DD} = 10$ V, $I_{bias} = 2$ mA,
$C_1 = C_2 = \infty$,
$R_1 = 10$ kΩ, $R_2 = 5$ kΩ, $R_D = 2$ kΩ

a) Determine the small signal gain, v_o/v_{in}. (12 points)

b) Determine the input resistance, R_{in}. (4 points)

c) Determine the output resistance, R_o. (4 points)

Useful formulae: for n-channel MOSFET

$$i_{DS} = K\left[(v_{GS} - V_{TH})v_{DS} - \frac{1}{2}v_{DS}^2\right] \quad \text{triode region}$$

$$i_{DS} = \frac{1}{2}K(v_{GS} - V_{TH})^2(1 + \lambda v_{DS}) \quad \text{saturation region}$$