National Exams December 2008

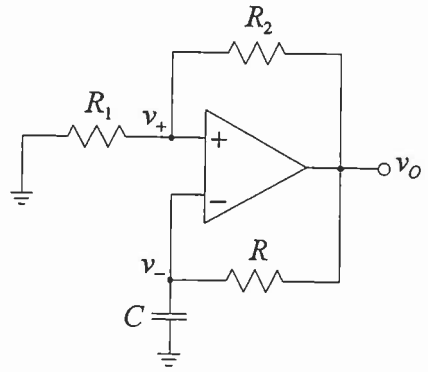
07-Elec-A5, Electronics

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.
   calculator is permitted.
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. Some questions require an answer in essay format. Clarity and organization of the answer are important. Provide block diagrams and circuit schematics whenever necessary.
9. **Candidates are allowed to bring one aid sheet written on both sides.**

QUESTION (1)



The op amp in this circuit is ideal. It is powered by a ±15V supply. Given that

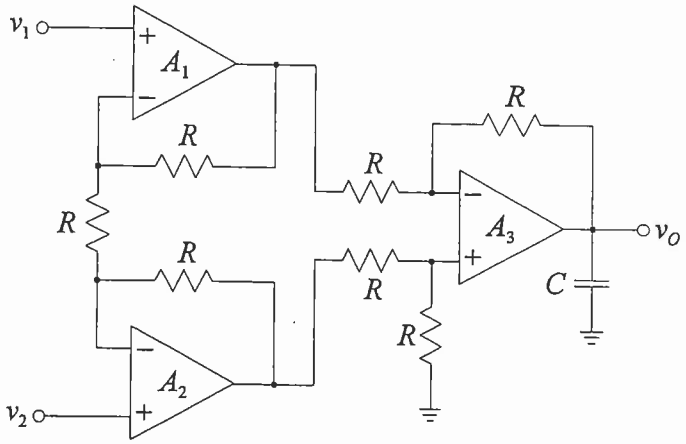
$R_1 = 20\text{k}\Omega$
$R_2 = 20\text{k}\Omega$
$R = 20\text{k}\Omega$
$C = 1\mu\text{F}$

a) Sketch **accurately** in your answer book the voltage waveforms, v_+, v_-, and v_O. (10 points)

b) What are the positive and negative amplitudes of the output voltage, v_O? (5 points)

c) What is the frequency of the output waveform, v_O? (5 points)

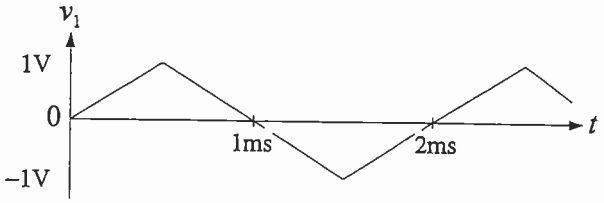
QUESTION (2)

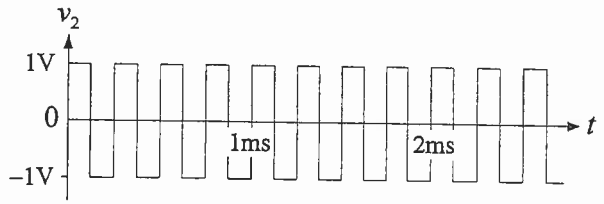


Given that all the op amps are ideal. The op amps' power supply is ±15V. Also, $R = 10\text{k}\Omega$ and $C = 10\mu\text{F}$.

(a) Derive an expression for the output voltage v_O as a function of v_1 and v_2. (10 points)

(b) Sketch the output waveform accurately in your answer book. (10 points)

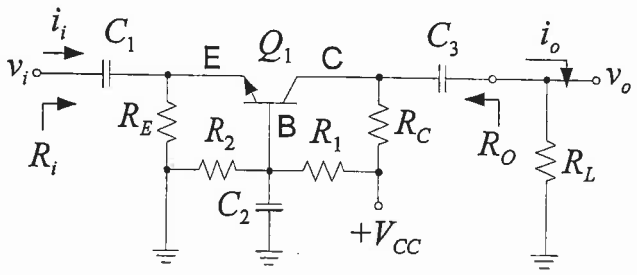




QUESTION (3)

The BJT is ideal and with the following parameters,

β = 100
$V_{BE(on)}$ = 0.7 V
$V_{CE(sat)}$ = 0.3 V
V_A = 100 V
V_T = 25 mV



Given

V_{CC} = 10V
R_E = 100Ω
R_C = 1kΩ
R_L = 10kΩ
R_1 = 22kΩ
R_2 = 470kΩ

C_1 = 10μF
C_2 = 10μF
C_3 = 10μF

a) Determine the mid-band voltage gain, $A_v = v_o/v_i$ of this common base amplifier. (5 points)

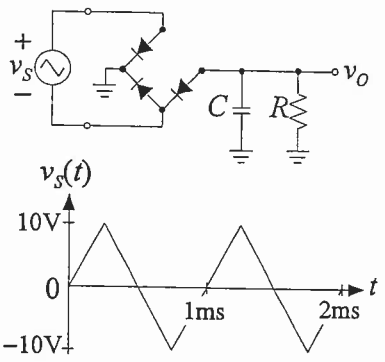
b) Determine the mid-band current gain $A_i = i_o/i_i$ of this common base amplifier. (5 points)

c) Determine the mid-band power gain $A_p = P_o/P_i$ of this common base amplifier. (5 points)

d) Determine the input and output resistance (R_i and R_o). (5 points)

QUESTION (4)

i) For this full-wave rectifier circuit, one of the diode is damaged. As a result, only three diodes are working. Assume that the diodes are ideal with zero forward voltage drop and that the time constant RC = 100 ms. For a 1 kHz triangular input waveform with a peak amplitude of 10V, and using the assumption that $RC >> T$,



a) Sketch accurately in your answer book the output voltage waveform, v_O. (4 points)

b) What is the peak voltage, V_p and the ripple voltage V_r that would appear at the output? (8 points)

c) What is the average output voltage at v_o? (4 points)

d) Estimate the time interval, t_{on} during which the diodes conduct during each period. (4 points)

QUESTION (5)

For this circuit,

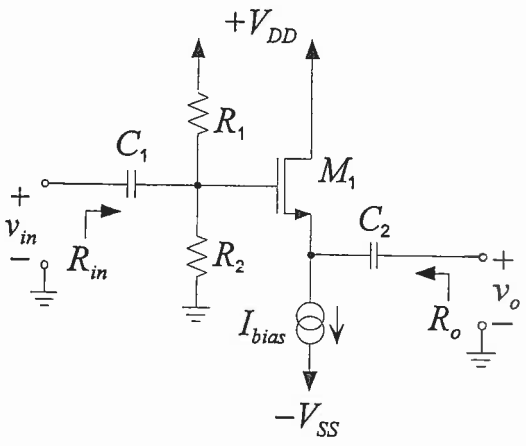
$V_{TH} = 1$ V

$K = 2$ mA/V^2 $\quad \lambda = 0.01$ V^{-1}

$V_{DD} = |V_{SS}| = 10$ V $\quad C_1 = C_2 = \infty$

$R_1 = 20$ kΩ $\quad R_2 = 20$ kΩ

$I_{bias} = 2$ mA



a) Determine the gain v_O/v_{in}. (10 points)

b) Determine the input and output resistance, R_{in} and R_o. (5 points)

c) What is maximum undistorted peak to peak output voltage? (5 points)

Useful formulae: for n-channel MOSFET

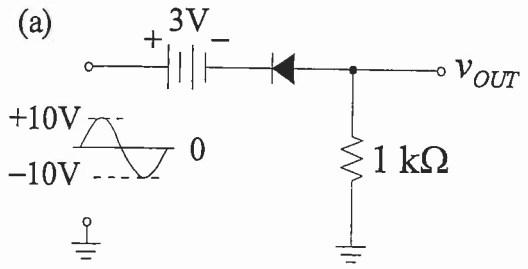
$$i_{DS} = K\left[2(v_{GS} - V_{TH})v_{DS} - v_{DS}^2\right] \quad \text{triode region}$$

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

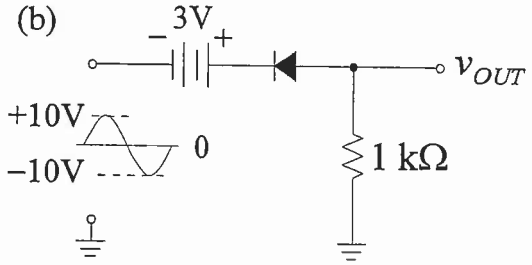
QUESTION (6)

In the following circuits, assume that the diode is ideal and has a forward voltage of 0.7V. Sketch the output waveform for one complete sine wave input. (20 points)

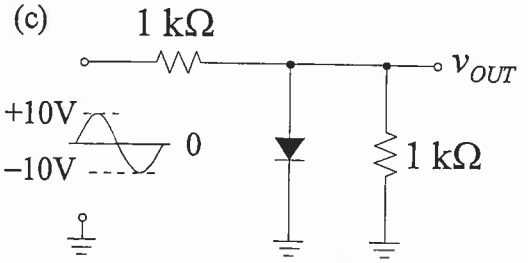
(a)



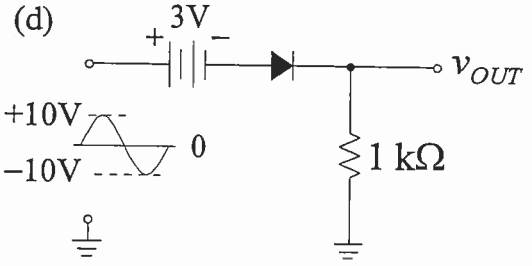
(b)



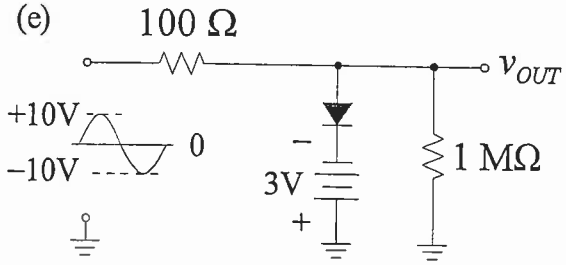
(c)



(d)

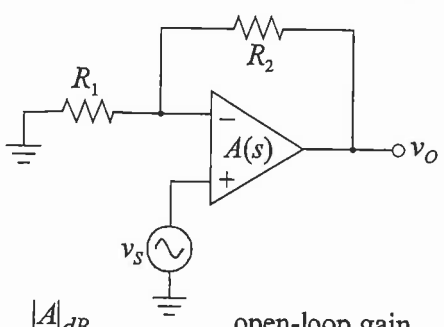


(e)



QUESTION (7)

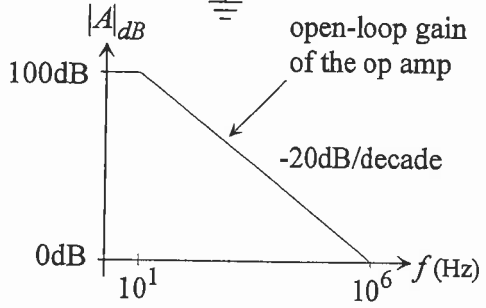
The op amp in the following non-inverting configuration is internally compensated with an open-loop gain as shown. It has a slew rate of 0.5V/μs. Given that R_1 = 1 kΩ, and R_2 = 100 kΩ.



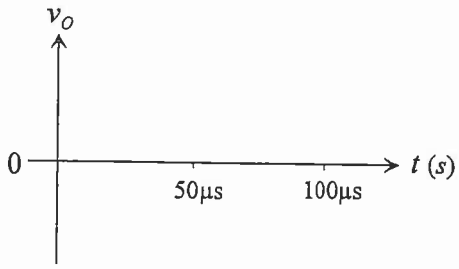
a) What is the f_{3dB} of this non-inverting amplifier? Sketch **accurately** the resulting frequency response. (6 points)

b) If the input is a sinusoidal wave at 10 kHz with an amplitude of 20mV peak to peak, sketch accurately the output waveform v_O. What is the resulting peak to peak output amplitude? (8 points)

c) If the input is a sinusoidal wave at 100kHz with an amplitude of 5V peak to peak, sketch accurately the output waveform v_O. Provide an estimate for the resulting peak to peak output amplitude. (8 points)



(b)



(c)