National Exams May 2010

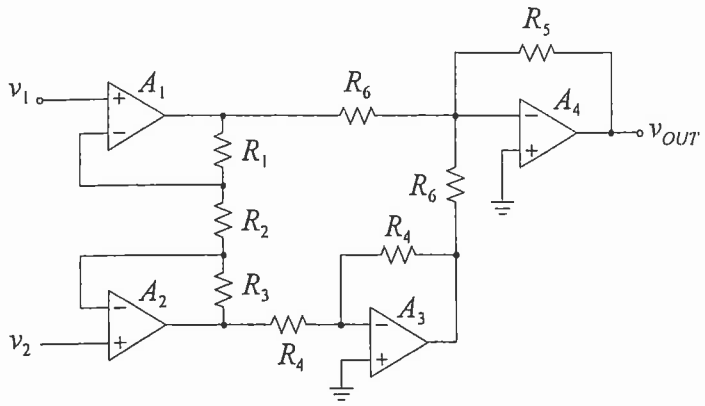
07-Elec-A5, Electronics

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.
   Candidates may use one of two calculators; a Casio or Sharp approved models.
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.

QUESTION (1) a) Derive an expression for the output v_{OUT} as a function of v_1 and v_2 in the following op amp circuit. (12 points)



Given:

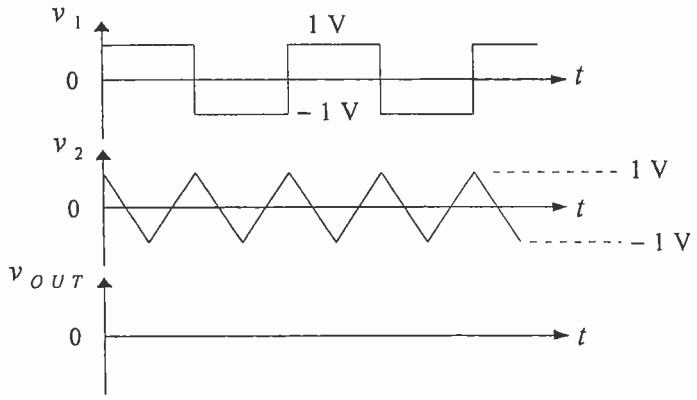
all op amps are ideal,

$R_1, R_2, R_3 = 2\ \text{k}\Omega$

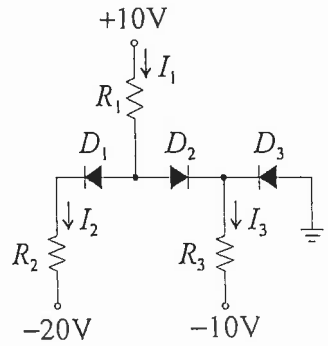
$R_4, R_5, = 1\ \text{k}\Omega$

$R_6 = 3\ \text{k}\Omega$

b) For the input voltages v_1 and v_2 below, sketch accurately the output waveform for v_{OUT}. (8 points)



QUESTION (2) Solve for the currents I_1, I_2, and I_3 in the following diode circuit. (20 points)



Given:

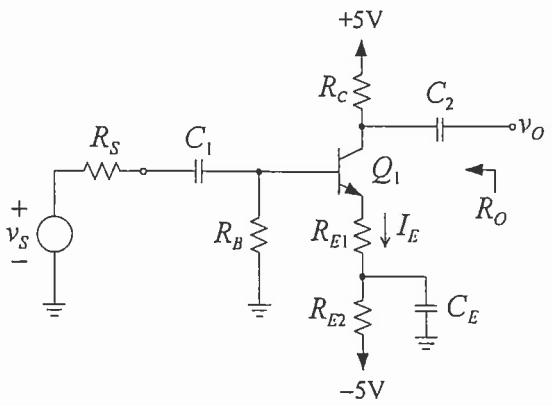
All diodes are ideal with 0.6V forward drop

$R_1 = R_2 = R_3 = 10\ \text{k}\Omega$

QUESTION (3)

The common emitter amplifier circuit on the right is required to amplify a 12 mVp-p sinusoidal signal from a microphone, v_s to produce an output signal of v_O = 0.4Vp-p.

Provide the component values for RC, RE1 and RE2 to meet the required specificantion (20 points)

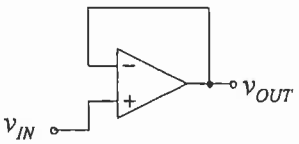


Given:

β = 100
$V_{BE(on)}$ = 0.7V
R_S = 500 Ω
R_B = 100 kΩ
I_E = 0.2mA

QUESTION (4)

An op amp with a slew rate of 1 V/μs and a unity-gain bandwidth, f_t of 1 MHz is connected in the unity-gain follower configuration.



a) What is the largest possible input voltage step for which the output voltage waveform can still produce an exponential raise and fall waveform? (8 points)

b) For this input voltage, find the 10% to 90% rise time. (6 points)

c) If the input step is 10 times larger than the voltage that you have found in part (a), find the 10% to 90% rise time. (6 points)

Given:

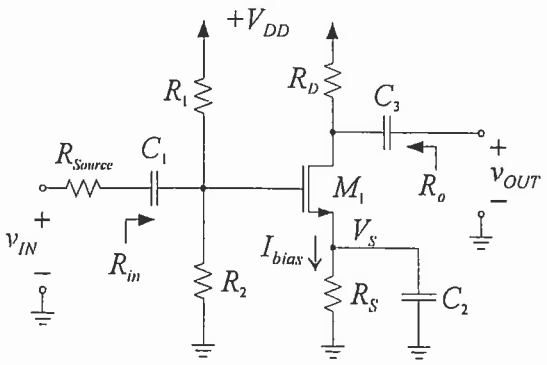
Supply Voltage = ±10 V

Useful Formulae:

$$\frac{V_{OUT}}{V_{IN}} = \frac{1}{1+s/\omega_t}, \quad v_{OUT}(t) = V\left(1-e^{-\omega_t t}\right)$$

QUESTION (5)

Consider the common source amplifier circuit on the right. Determine the voltages at all nodes and the current through all branches. (20 points)



Given:

$R_1 = 100\ \text{k}\Omega$ $R_2 = 100\ \text{k}\Omega$

$R_D = 6\ \text{k}\Omega$ $R_S = 6\ \text{k}\Omega$

$V_{TH} = 1\text{V}$ $\lambda = 0\ \text{V}^{-1}$

$V_{DD} = 10\text{V}$

$K_n'(W/L) = 1\text{mA/V}^2$

Useful formulae: for *n*-channel MOSFET

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

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

QUESTION (6)

Design this inverting amplifier to have a closed-loop voltage gain of $v_{OUT}/v_{IN} = -100$ V/V, and an input resistance of $R_{in} = 50\text{k}\Omega$.

a) Derive and expression for v_{OUT}/v_{IN} (10 points)

b) Provide the resistance values for R_1, R_2, R_3, and R_4. (10 points)