

National Exams December 2010

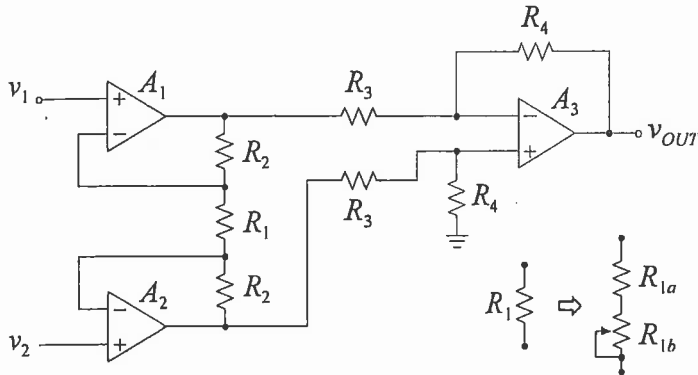
07-Elec-A5, Electronics

3 hours duration

Notes:

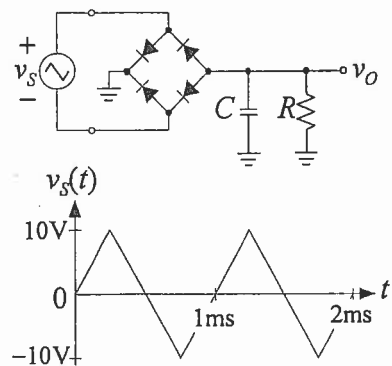
1. If any doubt exists as to the interpretation of any question, the candidate is urged to submit, within their answer, a clear statement of any assumptions made.
2. This is a CLOSED BOOK EXAM.
A Casio or Sharp approved calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.
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 $\pm 15V$.
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 R_1, R_2, R_3, R_4, v_1 and v_2 in the following op amp circuit. (8 points)
- b) If R_1 is comprised of a fixed resistor, R_{1a} in series with a variable resistor, R_{1b} , determine the value of R_{1a}, R_{1b} , and R_2 that can provide a gain that varies from 5 to 500. Assume that $R_4 = 2R_3$. (12 points)



QUESTION (2)

- i) For this full-wave rectifier circuit, 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 $RC \gg T$,
- Sketch accurately in your answer book the output voltage waveform, v_o . (5 points)
 - What is the peak voltage, V_p and the ripple voltage V_r that would appear at the output? (5 points)
 - What is the average output voltage at v_o ? (5 points)
 - Estimate the time interval, t_{on} during which the diodes conduct during each period. (5 points)



QUESTION (3)

For this circuit,

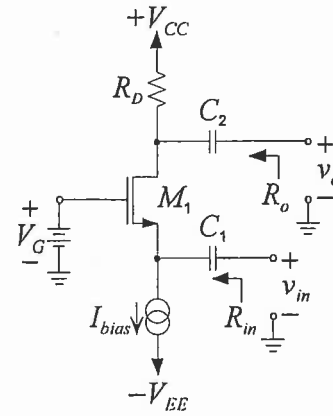
$V_{TH} = 1 \text{ V}$ (for both transistors M_1 and M_2)

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

$V_{CC} = |V_{EE}| = 10 \text{ V}$ $V_G = 1 \text{ V}$

$R_D = 3 \text{ k}\Omega$ $C_1 = C_2 = \infty$

$I_{bias} = 2 \text{ mA}$



- a) Determine the gain v_o/v_i . (10 points)
- b) Determine the input and output resistance, R_{in} and R_o . (5 points)
- c) What is maximum peak to peak input voltage that can be applied while still keeping M_1 operating in the saturation region? (5 points)

Useful formulae: for n-channel MOSFET

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

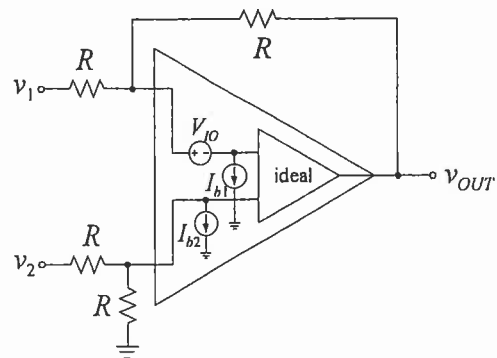
$i_{DS} = K (v_{GS} - V_{TH})^2 (1 + \lambda v_{DS})$ saturation region

QUESTION (4)

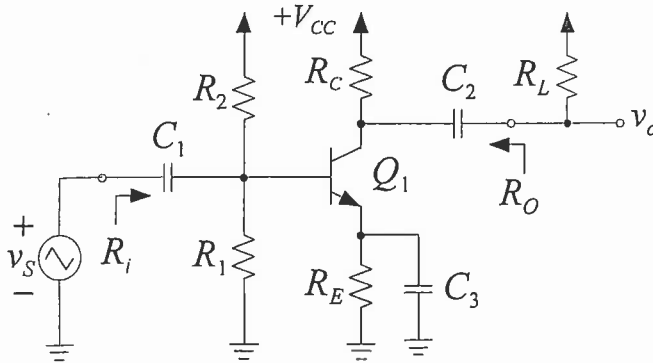
A real op amp is modeled by an ideal op amp, input bias current sources and an input offset voltage source.

Given $V_{IO} = 10 \text{ mV}$, $I_{b1} = I_{b2} = I_b = 100 \text{ nA}$
 $R = 100 \text{ k}\Omega$

- a) Derive an expression for v_{OUT} as a function of v_1 and v_2 . (14 points)
- b) What is the value of the output voltage, v_{OUT} if both v_1 and v_2 are set to zero. (6 points)



QUESTION (5)



Assume that the BJT has the following characteristics:

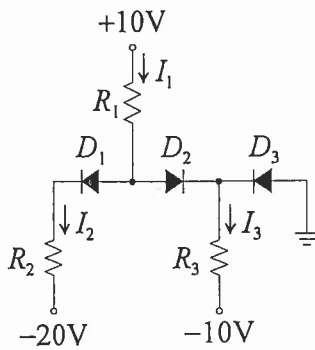
- $\beta = 100$
- $V_{BE(on)} = 0.7V$
- $V_{CE(sat)} = 0.3V$
- $V_A = \infty$

Given:

- $V_{CC} = 10 V$
- $R_L = 10 k\Omega$
- $R_E = 200 \Omega$

- a) Design this common emitter amplifier circuit to have the following specification:
 DC bias current, $I_E = 1mA$,
 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 (6) 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
- $R_1 = R_2 = R_3 = 10 k\Omega$