National Exams May 2017

16-Elec-A5, Electronics

3 hours duration

Notes:

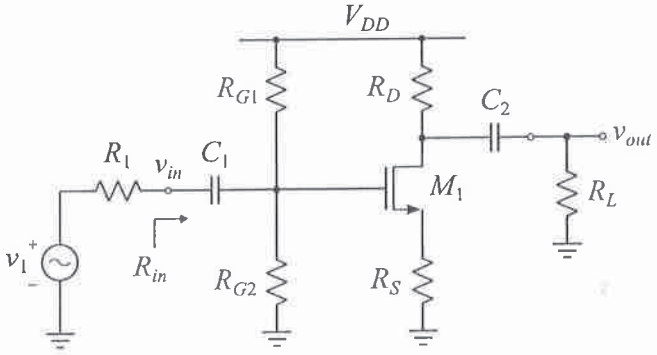
1. If any doubt exists as to the interpretation of any question, the candidate is urged to submit, within their answer, a clear statement of any assumptions made.
2. This is a **CLOSED BOOK EXAM**.
   One of two calculators is permitted; any Casio or Sharp approved model.
3. Answer all **FIVE** (5) questions.
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)

The following is a single stage common source amplifier circuit.
Given: $V_{TH} = 1\text{V}$, $K = 4\ \text{mA/V}^2$, and $\lambda = 0$

a) For a supply voltage $V_{DD} = 15$ V, design the bias circuit such that $I_D = 0.5$ mA, $V_S = 3.5$ V, and $V_D = 6$ V. Please specify the values for R_{G1}, R_{G2}, R_S and R_D. (10 points)

b) Assuming that the equivalent input resistance $R_{in} = 1.67\ \text{M}\Omega$, $R_1 = 100\ \text{k}\Omega$, $R_L = 200\ \text{k}\Omega$, determine the overall small signal voltage gain v_1/v_{out}. (10 points)



Useful formulae: for n-channel MOSFET

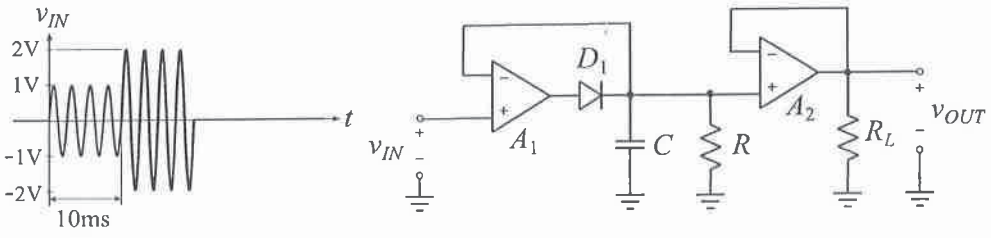
$$i_{DS} = K\left[(v_{GS} - V_{TH})v_{DS} - \frac{1}{2}v_{DS}^2\right] \qquad \text{triode region}$$

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

QUESTION (2)

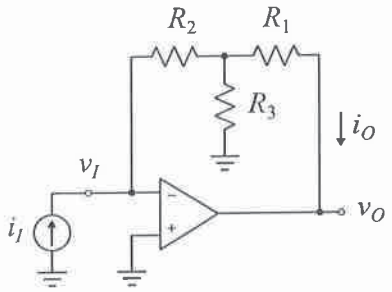
a) For the op amp circuit below, sketch accurately the output voltage waveform (as a function of time). Given: $R = R_L = 1\ \text{k}\Omega$, $C = 2\ \mu\text{F}$ (16 points)

b) What is the function of this circuit? (4 points)



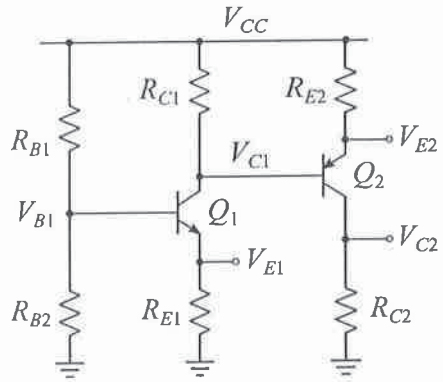
QUESTION (3)

Derive the current gain i_O/i_I as a function of R_1, R_2, and R_3 for the following circuit. (20 points)



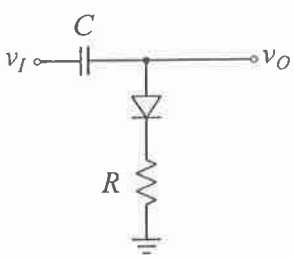
QUESTION (4)

For the transistor circuit below, determine V_{B1}, V_{E1}, V_{C1}, V_{B2}, V_{E2}, V_{C2}, I_{C1}, I_{B1}, I_{C2}, and I_{B2}.
Given: $R_{B1} = 100$ kΩ, $R_{B2} = 50$ kΩ, $R_{C1} = 5$ kΩ, $R_{E1} = 3$ kΩ, $R_{C2} = 2.7$ kΩ, $R_{E2} = 2$ kΩ.
You can assume that the current gain for both transistors is $\beta = 100$. (20 points)

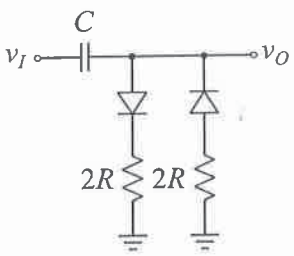


QUESTION (5)

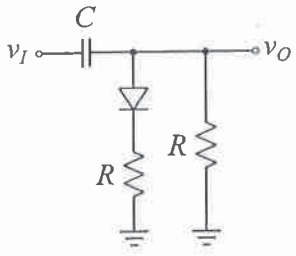
In the following circuits, assume that all the diodes are ideal and has a forward voltage of 0.7 V. Given $RC >> T$, sketch accurately the output waveforms for each circuit. (20 points)



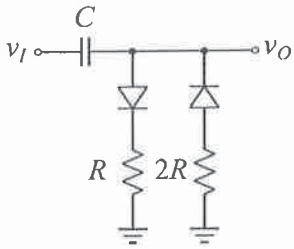
(a)



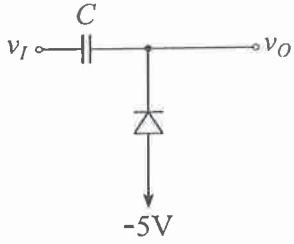
(b)



(c)



(d)



(e)