

National Exams December 2014

07-Elec-A5, Electronics

3 hours duration

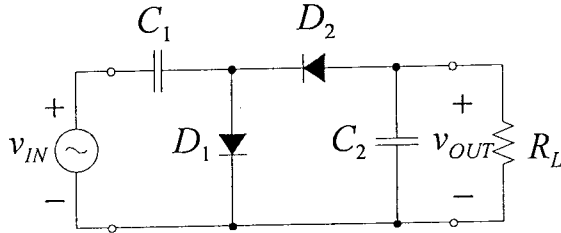
Notes:

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**.
Any non-communicating calculator is permitted.
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 $\pm 15V$.
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)

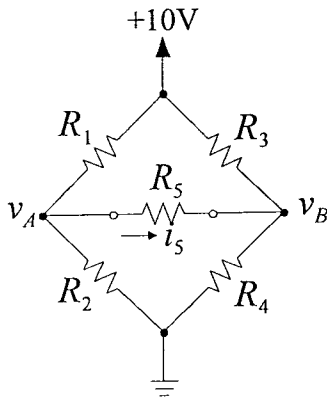
For the following diode circuit, v_{IN} is a 10 V peak to peak 1 kHz sine wave. (20 points)

- a) Sketch the waveform for the output voltage v_{OUT} with no load ($R_L = \infty$)
- b) Sketch accurately the waveform for the output voltage v_{OUT} with $R_L = 100 \Omega$ and $C_1 = C_2 = 100 \mu\text{F}$



QUESTION (2)

In the following circuit, it is required to determine the current and voltage flowing through resistor R_5 . (20 points)

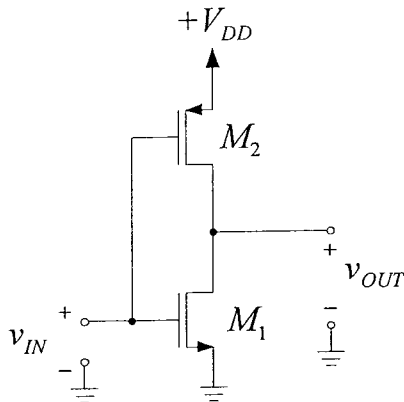


- Given:
- $R_1 = 1 \text{ k}\Omega$
 - $R_2 = 1.2 \text{ k}\Omega$
 - $R_3 = 9.1 \text{ k}\Omega$
 - $R_4 = 11 \text{ k}\Omega$
 - $R_5 = 2 \text{ k}\Omega$

QUESTION (3)

In the following CMOS inverter, the threshold voltages of the *n*- and *p*-channel transistors are V_{Tn} and $-|V_{Tp}|$, respectively:

- c) Draw the input to output voltage transfer characteristic (VTC) for this inverter. Express and label clearly all voltage levels on the VTC plot. (20 points)
- d) Indicate the noise margins NM_L and NM_H on the VTC.
- e) Indicate the logic high and low output voltage levels V_{OH} , V_{OL} on the VTC.
- f) Indicate the logic high and low input voltage levels V_{IH} , V_{IL} on the VTC.
- g) Indicate clearly the mode of operation in each region of the VTC.

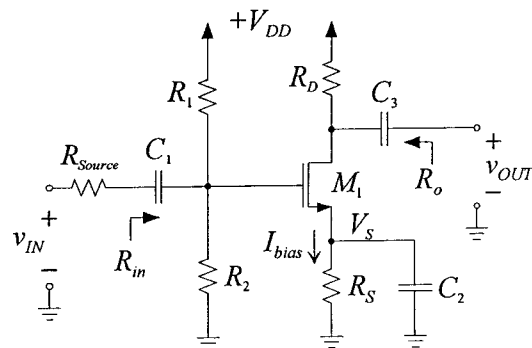


QUESTION (4)

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

Given:

- $R_1 = 100 \text{ k}\Omega$
- $R_2 = 100 \text{ k}\Omega$
- $R_D = 6 \text{ k}\Omega$
- $R_S = 6 \text{ k}\Omega$
- $V_{TH} = 1 \text{ V}$
- $\lambda = 0 \text{ V}^{-1}$
- $V_{DD} = 10 \text{ V}$
- $K'_n (W/L) = 1 \text{ mA/V}^2$

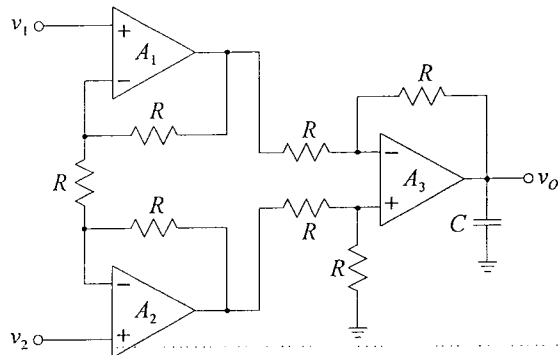


Useful formulae: for *n*-channel MOSFET

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

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

QUESTION (5)



Given that all the op amps are ideal. The op amps' power supply is $\pm 15\text{V}$. 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)

