National Exams May 2015

07-Elec-A5, Electronics

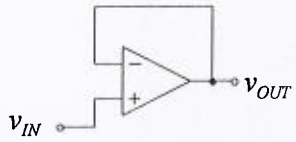
3 hours duration

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 ±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)

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 exponentially rise 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:

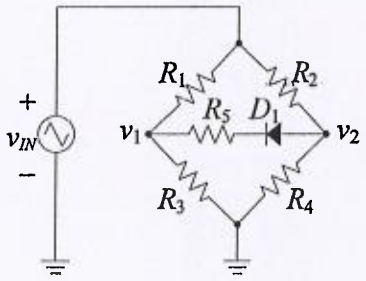
Supply Voltage = ±10 V

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 (2)

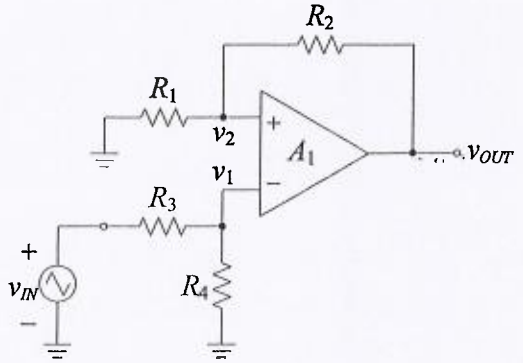
In the following circuit, the input voltage v_{IN} is a 1 kHz, ±10 V triangular source. Provide an accurate sketch of the voltage waveforms v_1 and v_2 as a function of time. The diode D_1 is ideal with a 0.7V forward drop. (20 points)



Given:
R_1 = 1 kΩ
R_2 = 1.2 kΩ
R_3 = 4.7 kΩ
R_4 = 11 kΩ
R_5 = 2 kΩ

QUESTION (3)

The op amp is in this circuit can be considered as ideal. It is power by a ±10 V supply and naturally the output will be limited to these levels. If the input is a ±10 V triangular wave at 1 kHz, provide accurate sketches of the voltage waveforms v_1 and v_2 as a function of time. (20 points)

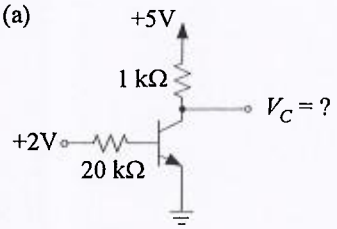


Given:
R_1 = 10 kΩ
R_2 = 100 kΩ
R_3 = 10 kΩ
R_4 = 11 kΩ

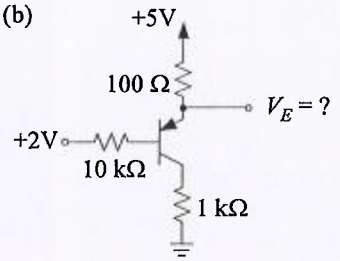
QUESTION (4)

In the following questions, all BJT transistors have $\beta = 50$, $V_{BE,on}$ or $V_{EB,on} = 0.6V$, $V_{CE,sat}$ or $V_{EC,sat} = 0.3V$ and $V_A = \infty$. Solve for the required voltages. (20 points)

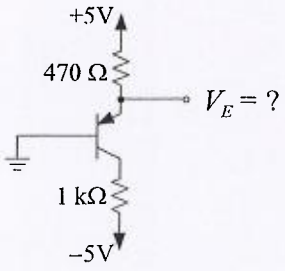
(a) (4 points)



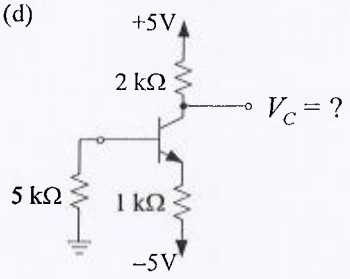
(b) (4 points)



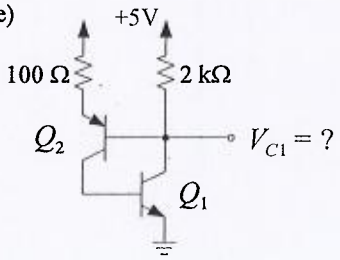
(c) (4 points)



(d) (4 points)

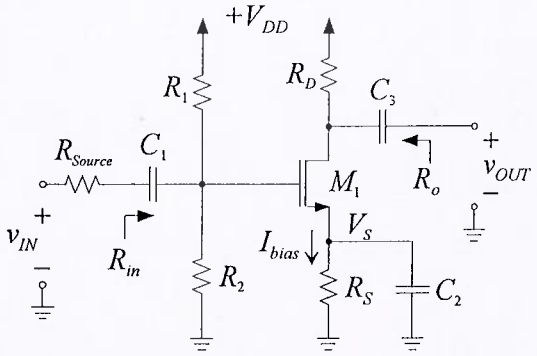


(e) (4 points)



QUESTION (5)

Consider the common source amplifier circuit on the right. Determine the values for all the resistors to provide the following specifications: (20 points)



R_{in} = 50 kΩ
R_{out} = 6 kΩ
I_{bias} = 0.5 mA

Given:
R_{source} = 600 Ω
V_{DD} = 10 V
V_{TH} = 1 V λ = 0 V^{-1}
$\mu_n C_{ox}(W/L) = 1$ mA/V^2

Useful formulae: for *n*-channel MOSFET

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

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