National Exams December 2009

07-Elec-B5, Advanced Electronics

3 hours duration

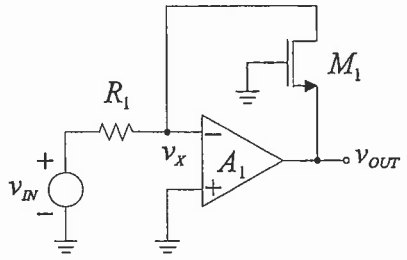
Notes:

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 models.
3. Any 5 (FIVE) questions constitute a complete 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 the expression for voltage gain v_{OUT}/v_{IN}. (15 points)

b) What is the function of this circuit? (5 points)



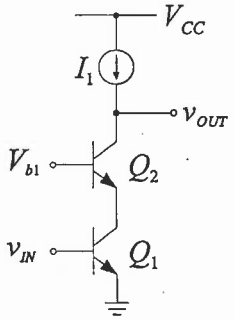
Useful formulae: for n-channel MOSFET

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

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

QUESTION (2)

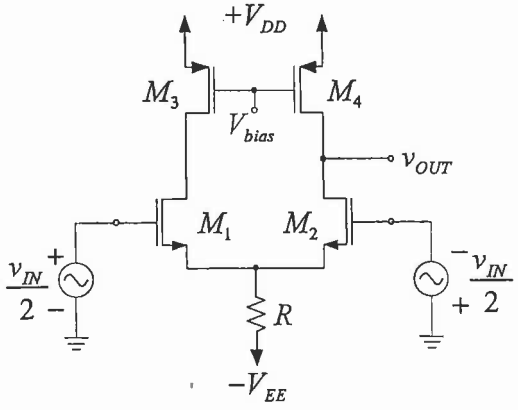
The bipolar circuit is biased with a current of I_1 = 1mA. Determine the voltage gain v_{OUT}/v_{IN}. (20 points)



Given:

$\beta = 100$
$V_A = 5$ V

QUESTION (3)



In the following circuits, assume all transistors have the following parameters:

$K = 0.5$ mA/V^2, $|V_{TH}| = 1$ V and $\lambda = 0.02$.

Given:

$V_{bias} = 8$ V
$V_{DD} = 10$ V
$R = 2$ kΩ

a) Estimate the differential gain v_{OUT}/v_{IN} in (V/V). (6 points)

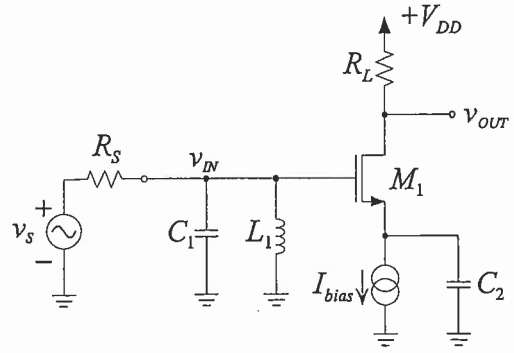
b) Find the common mode input resistance R_{icm}. (4 points)

c) Find the common mode input range. (4 points)

d) Estimate the common mode rejection ratio, CMRR. Express your result in dB. (6 points)

QUESTION (4)

In the following tuned amplifier circuit, the transistor M_1 is biased such that VDD = 10 V, I_{bias} =2 mA. The transistor parameters are given as K = 1 mA/V^2, V_{TH} = 1 V, C_{gs} = 10 pF, C_{gd} = 1 pF, and $\lambda = 0$.



For: $L_1 = 1$ µH
$C_1 = 200$ pF, $C_2 = \infty$
$R_S = 1$ kΩ, $R_L = 2$ kΩ

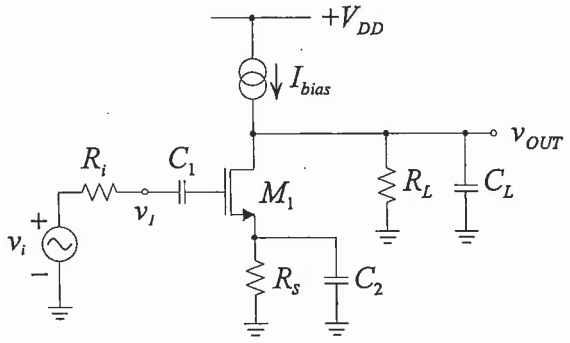
a) What is the center frequency, ω_o of this amplifier? (4 points)

b) What is the gain v_{OUT}/v_S at $\omega = \omega_o$? (8 points)

c) What is the 3dB bandwidth of this tuned amplifier? (8 points)

QUESTION (5)

The following common source amplifier is already biased properly.



Given:

$g_m = 2$ mA/V $\quad r_o = 20$ kΩ

$R_i = 20$ kΩ $\quad R_L = 20$ kΩ

$R_S = 3$ kΩ

$C_{gs} = 20$ fF $\quad C_{gd} = 5$ fF

$C_L = 5$ fF $\quad C_1 = \infty$

$C_2 = \infty$

a) Find the mid-band voltage gain v_{OUT}/v_i. (6 points)

b) What is the new mid-band voltage gain, v_{OUT}/v_i if capacitor C_2 is removed? (6 points)

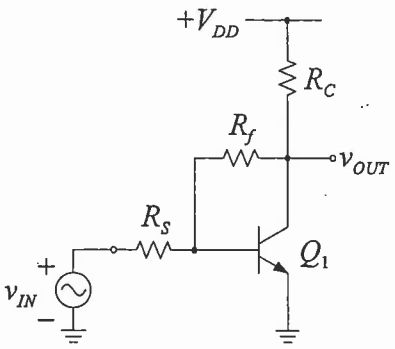
c) What is the new 3dB frequency f_H if capacitor C_2 is removed? (8 points)

QUESTION (6)

In the following amplifier can be considered as a feedback circuit.

a) Determine the input and output resistance (R_{IN} and R_{OUT}) if $R_f = \infty$ (8 points)

b) Determine the input and output resistance (R_{IN} and R_{OUT}) if $R_f = 47\ \text{k}\Omega$. (12 points)



Given:

$R_C = 4.7\ \text{k}\Omega$ $R_S = 10\ \text{k}\Omega$

$\beta_1 = 100$ $V_A = \infty$