National Exams December 2017

16-Elec-B5, Advanced Electronics

3 hours duration

Notes:

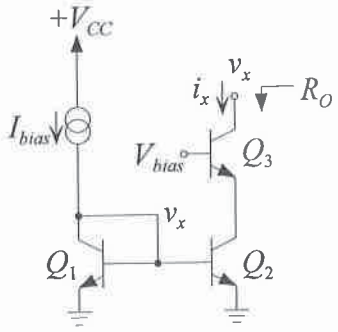
1. If any doubt exists as to the interpretation of any question, the candidate is urged to submit, within their answer, a clear statement of any assumptions made.
2. This is a **CLOSED BOOK EXAM**.
   Any approved Casio or Sharp calculator is permitted.
3. Answer all **FIVE** (5) questions.
4. All questions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

For all the BJTs, assume

β	= 100	$V_{BE(on)}$	= 0.7 V
V_A	= 100 V	$V_{CE(sat)}$	= 0.3 V
V_T	= 25 mV		

Given V_{CC} = 10V, V_{bias} = 3 V and I_{bias} = 10mA



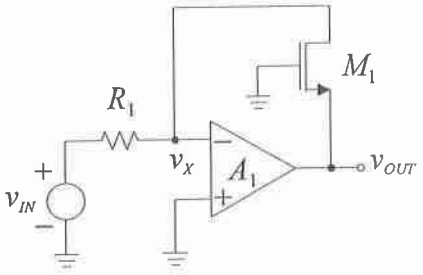
a) Determine the output resistance, R_O. (14 points)

b) Determine the minimum voltage that can be applied to v_x that would still allow this circuit to operate properly. (6 points)

QUESTION (2)

a) Derive the expression for voltage gain v_{OUT}/v_{IN}. (15 points)

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



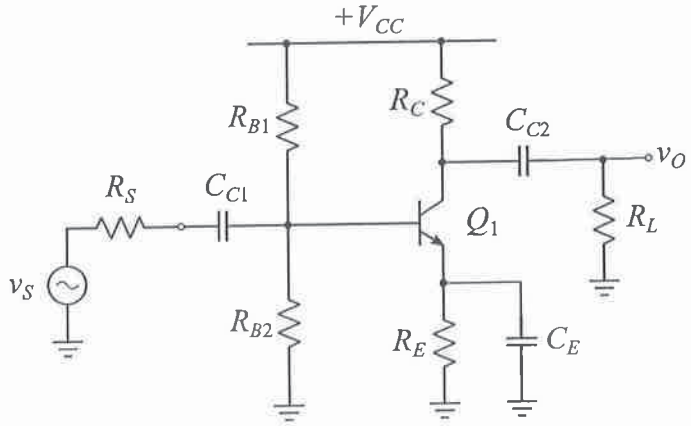
Useful formulae: for n-channel MOSFET

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

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

QUESTION (3)

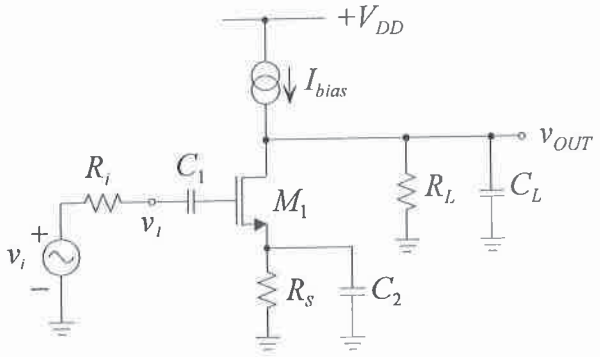
The following common emitter amplifier is already biased properly. Determine the appropriate values for C_{C1}, C_{C2}, C_E to provide a lower cutoff frequency of f_L = 100 Hz. Which capacitor dominates this corner frequency? (20 points)



Given: V_{CC} = 15 V
R_{B1} = 180 kΩ,
R_{B2} = 270 kΩ,
R_S = 5 kΩ,
R_C = 8 kΩ,
R_E = 2 kΩ,
R_L = 5 kΩ,
β = 100,
g_m = 40 mA/V, and
r_π = 2.5 5 kΩ.

QUESTION (4)

The following common source amplifier is already biased properly.



Given:

$g_m = 2$ mA/V	$r_o = 20$ kΩ
$R_i = 20$ kΩ	$R_L = 20$ kΩ
$R_S = 3$ kΩ	
$C_{gs} = 20$ fF	$C_{gd} = 5$ fF
$C_L = 5$ fF	$C_1 = \infty$
$C_2 = \infty$	

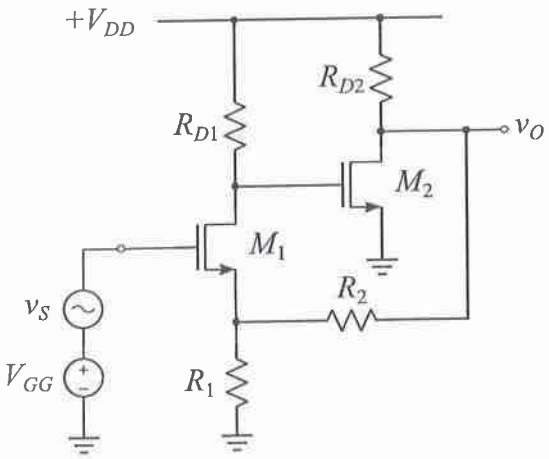
a) Find the mid-band voltage gain v_{OUT}/v_i. (6 points)

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 (5)

The following series–shunt feedback amplifier is already biased properly.



a) Identify the feedback network (β circuit) and provide an expression for β. Also give an expression for the ideal or upper-bound value of the closed-loop gain A_f. You can neglect the output resistance r_o for M_1 and M_2. (6 points)

b) Determine the ratio R_2/R_1 that will provide an ideal closed-loop gain of 10 V/V. If $R_1 = 1$ kΩ, what should be the value for R_2? (4 points)

c) Provide an expression for the open-loop gain $A\beta$ (6 points)

d) For $g_{m1} = g_{m2} = 4$ mA/V, and $R_{D1} = R_{D2} = 10$ kΩ, determine the values of $A\beta$, A, and A_f. (4 points)