National Exams December 2015

07-Elec-B5, Advanced Electronics

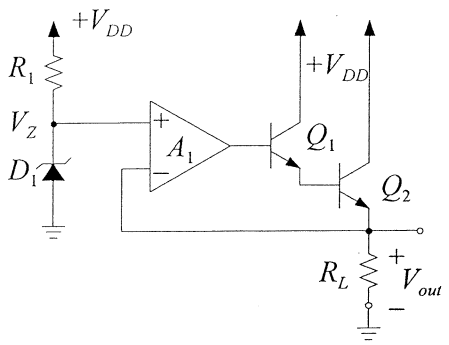
3 hours duration

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.**
   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)

This series voltage regulator has the following component values and device characteristics:



Op amp, A_1 is ideal

β = 100, V_{BE} = 0.7 V, V_T = 25 mV and V_A = 100 V for Q_1

V_Z = 6.7 V at I_Z = 1 mA, R_Z = 10 kΩ for D_1.

R_1 = 3.3 kΩ

R_L = 4 Ω

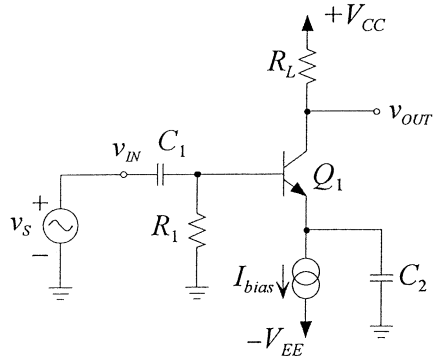
a) Given V_{DD} = 10V, what is the nominal output voltage, V_{OUT}? (4 points)

b) If V_{DD} has a 1V p-p ripple, what will be the ripple voltage at the output? (8 points)

c) Find the power efficiency, η of this voltage regulator. (8 points)

QUESTION (2)

In the following circuit, assume that β = 100, V_{BE} = 0.7 V, $V_{CE(sat)}$ = 0.3 V, V_A = 100 V, C_μ = 2 pF for all transistors. Neglect r_x and r_o in the hybrid-π model.



Given: R_L = 5k Ω
R_1 = 1k Ω
C_1 = 5 μF
C_2 = ∞
$|V_{CC}| = |V_{EE}|$ = 10 V
I_{bias} = 1 mA
V_T = 25 mV

a) Estimate the mid-band gain v_{OUT}/v_S in (V/V). (4 points)

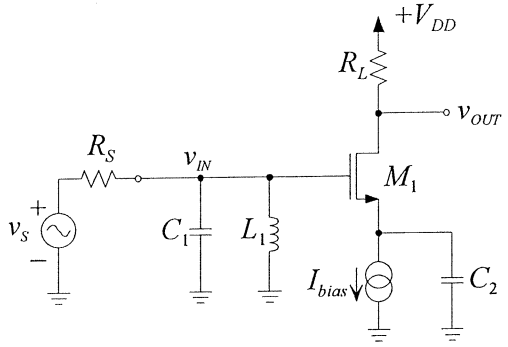
b) Find the lower 3dB frequency f_L in (Hz). (4 points)

c) Find the upper 3dB frequency f_H in (Hz). (6 points)

d) Find the 2nd high frequency dominant pole in (Hz). (6 points)

QUESTION (3)

In the following tuned amplifier circuit, the transistor M_1 is biased such that V_{DD} = 10 V. 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
I_{bias} =2 mA.

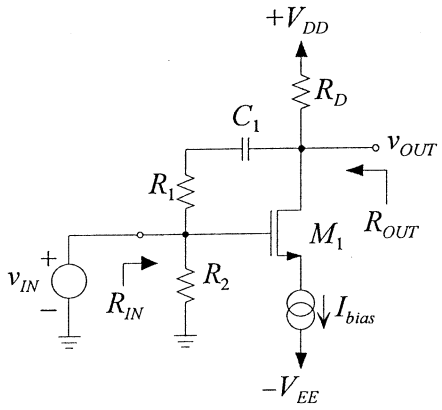
a) What is the center frequency, ω_o of this amplifier? (4 points)

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 (4)

Consider the following amplifier with a feedback circuit.



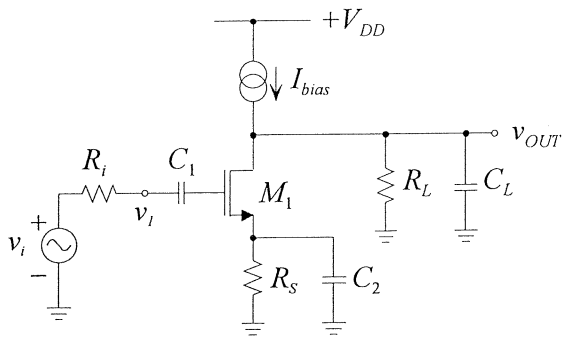
Given: R_D = 3k Ω, $C_1 = \infty$, R_2 = 20 kΩ
$|V_{CC}| = |V_{EE}|$ = 10 V
I_{bias} = 1 mA
K = 1 mA/V^2, V_{TH} = 1 V, and $\lambda = 0$

a) Determine the input and output resistance (R_{IN} and R_{OUT}) if there is no feedback network (i.e. $R_1 = \infty$). (8 points)

b) Determine the input and output resistance (R_{IN} and R_{OUT}) if R_1 = 100 kΩ. (12 points)

QUESTION (5)

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
$R_S = 1$ kΩ	
$C_{gs} = 20$ fF	$C_{gd} = 5$ fF
$C_L = 5$ fF	$C_1 = \infty$
$C_2 = \infty$	

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

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

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