# National Exams May 2012

## 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.
   A Casio or Sharp approved calculator is permitted.

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).

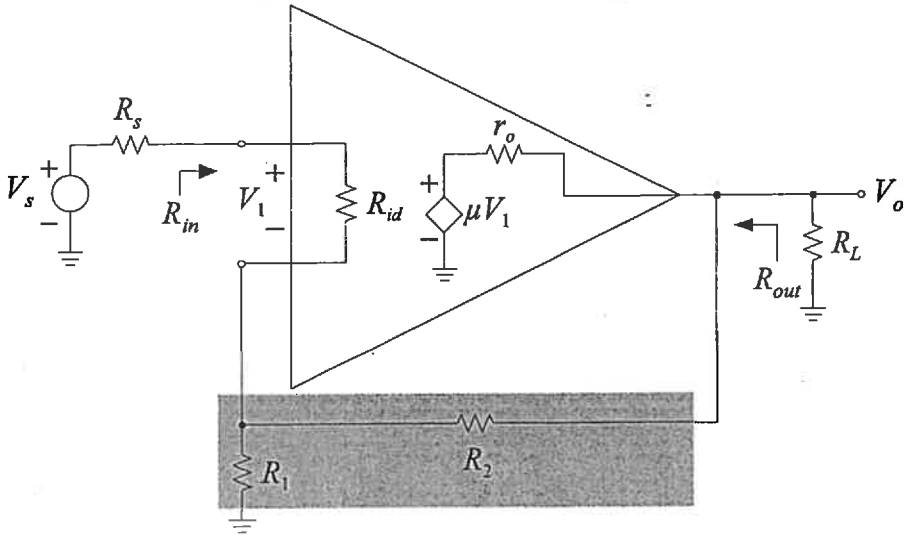
6. In schematics, ground and chassis may be assumed to be common, unless specifically stated otherwise.

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)

The following op amp has a finite gain, finite input resistance and non-zero output resistance.




$\mu = 104$ V/V

$R_{id} = 100$ kΩ

$r_o = 1$ kΩ

Given:

$R_L = 2$ kΩ

$R_s = 10$ kΩ

$R_1 = 1$ kΩ

$R_2 = 1$ MΩ

Using feedback theory, determine the following parameters:

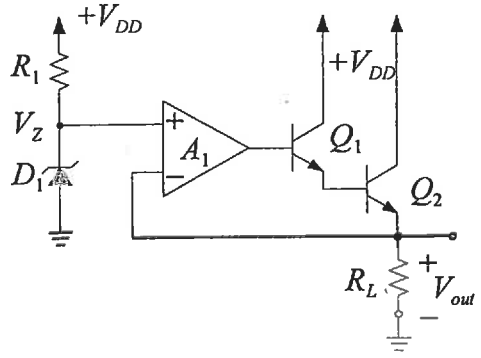
a) voltage gain, $V_O/V_S$ (8 points)

b) input resistance, $R_{in}$ (6 points)

c) output resistance, $R_{out}$ (6 points)

## QUESTION (2)

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




Op amp, $A_1$ is ideal

$\beta = 100$, $V_{BE} = 0.7$ 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

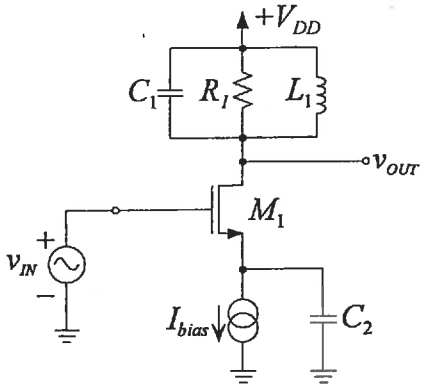
a) Given $V_{DD} = 10$V, what is the nominal output voltage, $V_{OUT}$? (4 points)

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, $\eta$ of this voltage regulator. (8 points)

## QUESTION (3)

In the following tuned amplifier circuit, $V_{DD} = 10$ 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, $C_2 = \infty$
$R_1 = 2$ kΩ

a) What is the center frequency, $\omega_o$ of this amplifier? (4 points)

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

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

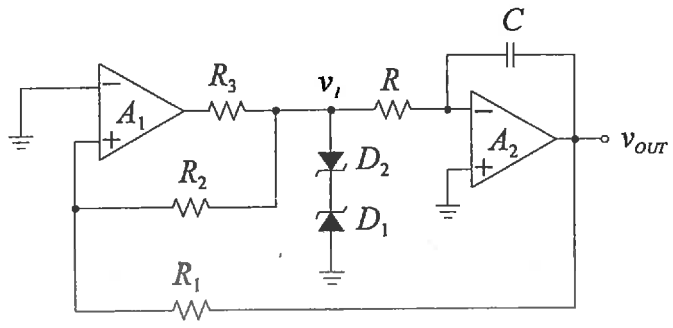
Useful formulae: for n-channel MOSFET

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

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

## QUESTION (4)

The op amps in the following circuit are ideal and are supplied by ±15V. The zener diodes, $D_1$ and $D_2$ have a zener voltage of $V_Z = 10$V and forward voltage of 0V. Sketch **accurately** in your answer book the voltage waveform for $v_{OUT}$ as a function of time. Provide accurate voltage leveling and timing information. (20 points)




Given:

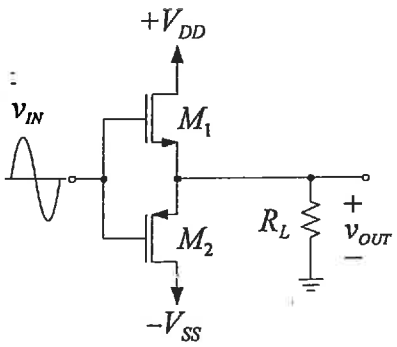
$R_1 = 10$ kΩ $\qquad R = 10$ kΩ

$R_2 = 10$ kΩ

$R_3 = 10$ kΩ $\qquad C = 100$ pF

## QUESTION (5)

The following is a class B power amplifier output stage.




Given: $K = 500$ mA/V$^2$, $V_{TH} = 1.0$ V,
$R_L = 8\ \Omega$ and $|V_{DD}| = |V_{SS}| = 10$ V.

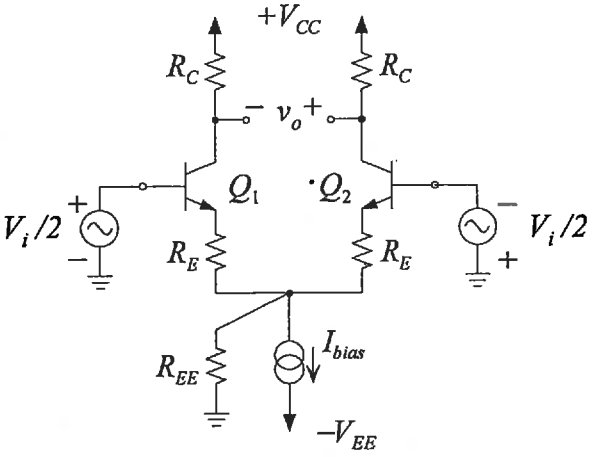
a) What is the maximum RMS output power? (4 points)

b) What is the RMS power dissipated by $M_1$ when the output stage is delivering maximum output power? (8 points)

c) What is the power efficiency, $\eta$ of this output stage when delivering maximum output power? (8 points)

## QUESTION (6)

In the following differential amplifier circuit, $V_{CC} = 15$ V, $-V_{EE} = -15$ V, $I_{bias} = 1$ mA. The transistor parameters are given as $\beta = 100$, $V_{BE} = 0.7$ V, $V_T = 25$ mV, $V_A = 100$ V.




For: $R_C = 10$ kΩ
$R_E = 150\ \Omega$
$R_{EE} = 200$ kΩ

a) What is the input differential resistance, $R_{id}$ that appear across the two input terminals? (4 points)

b) What is the overall voltage gain $v_o/V_i$? You can ignore the effect of $r_o$. (4 points)

c) What is input common mode resistance, $R_{icm}$? (4 points)

d) What is the worst case common mode gain if the two collector resistors, $R_C$ have a mismatch of ±1%? (4 points)

e) What is the CMRR, in dB? (4 points)