UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER MAY 2012

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	ANALOGUE ELECTRONICS IV
COURSE CODE:	E512
TIME ALLOWED:	THREE HOURS

INSTRUCTIONS:

1. **There are five questions in this paper. Answer any FOUR questions. Each question carries 25 marks.**
2. **If you think not enough data has been given in any question you may assume any reasonable values.**

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THIS PAPER CONTAINS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION ONE *(25 marks)*

(a) A power output stage is shown in Figure-Q1. Assume $I_R = 100mA$, $V_{CE(sat)} = 0.2V$ and $V_{CC} = 12V$.

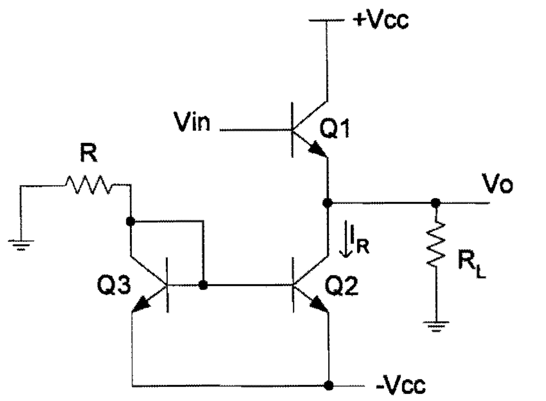

Figure-Q1

(i) If $R_L = 100\Omega$, find the maximum input signal that can be applied while having an undistorted output signal. Calculate the power conversion efficiency under this condition. Do not neglect the dissipation in R and Q_3.

(8 marks)

(ii) Find the value of R_L for maximum efficiency and evaluate the value of efficiency.

(5 marks)

(b) The following data is found for a BJT from a datasheet.

$T_{j\max} = 150^0 C$ $\quad$ $P_{D\max} = 2W \quad (at\ T_A = 25^0 C)$

$P_{D\max} = 50W \quad (at\ T_C = 25^0 C)$

If the device is to dissipate $25W$ when operating in an ambient temperature of $50^0 C$, find the specifications of the required heatsink. Assume $\theta_{CS} = 0.5\frac{^0 C}{W}$. Also find the temperature of the heatsink.

(12 marks)

QUESTION TWO *(25 marks)*

A class-AB amplifier is shown in Figure-Q2. The transistors Q_1 and Q_2 have $I_S = 3\times10^{-13} A$. For the diodes D_1 and D_2, $I_S = 10^{-13} A.$. The amplifier is supposed to deliver $2W$ of power to the load under the maximum signal swing.

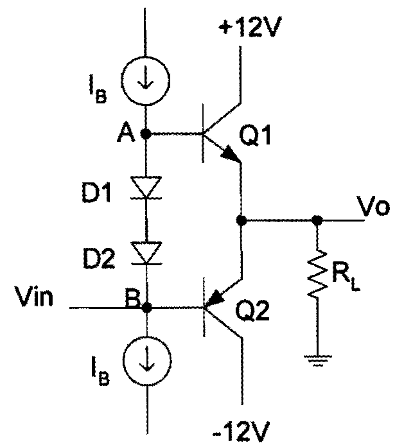

Figure-Q2

(a) Find a value for I_B and determine the quiescent collector currents in the transistors. You may assume $\beta = 50$ and $V_{CE(sat)} = 0.3V$.

(8 marks)

(b) Find the quiescent power dissipation in the transistors and calculate the power conversion efficiency.

(5 marks)

(c) Design a V_{BE} multiplier for this circuit using a high gain transistor having $I_S = 10^{-14} A$. State clearly your assumptions.

(12 marks)

QUESTION THREE *(25 marks)*

(a) The op-amp used in the circuit shown in Figure-Q3(A) has an open loop gain-bandwidth product of $10^6\,Hz$ with a single dominant pole at $10Hz$. Determine the overall bandwidth of the circuit assuming, $R_{id} = \infty$, and $R_o = 0$ for the op-amp.

(7 marks)

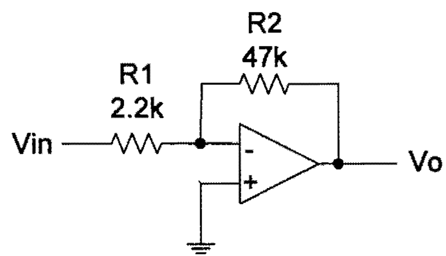

Figure-Q3(A)

(b) Analyze the amplifier shown in Figure-Q3(B), using the method of feedback to determine the closed loop voltage gain $\frac{V_o}{V_s}$, the input impedance R_{in} and the output impedance R_o. Assume that the $\beta = 100$ for all transistors and the biasing arrangements are not shown for simplicity.

(18 marks)

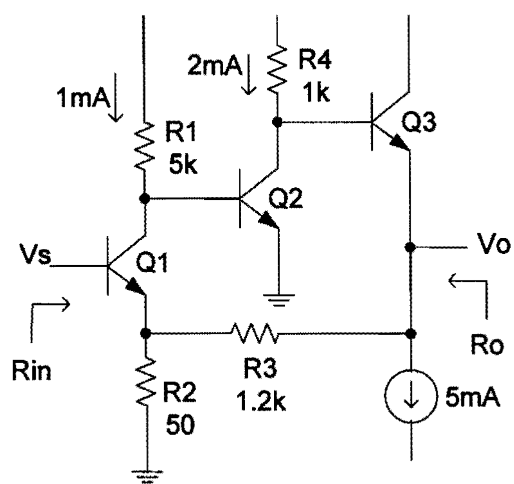

Figure-Q3(B)

QUESTION FOUR (*25 marks*)

A $300MHz$ source having an impedance of 600Ω is to be matched to a 50Ω load using a lossless network.

(i) Using the Q method, design a dc blocking L-section matching network.

(10 marks)

(ii) Design a suitable dc passing π - network for this matching requirement. You may assume a virtual center impedance of 10Ω.

(15 marks)

QUESTION FIVE (25 *marks*)

The s-parameters of a RF transistor in a common emitter amplifier at $1GHz$ with a bias point $V_{CE} = 12V$ and $I_C = 5mA$ are given below.

$s_{11} = 0.7\angle 60^0$ $\quad$ $s_{21} = 5.2\angle 70^0$

$s_{12} = 0.08\angle 70^0$ $\quad$ $s_{22} = 0.09\angle -150^0$

(a) Investigate the stability of the device at the given operating conditions.

(10 marks)

(b) Find the maximum available gain when conjugate matching is employed.

(7 marks)

(c) Assume that the load and the source impedances are each of 50Ω and the reverse transmission can be neglected. Give the schematic diagram of a maximum gain amplifier indicating the component types. You need not to give the component values.

(8 marks)

SOME SELECTED USEFUL RF DESIGN FORMULAE

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|^2}$$

where $|\Delta| = |S_{11}S_{22} - S_{12}S_{21}|$

$$\text{MAG} = 10\log\left|\frac{S_{21}}{S_{12}}\right| + 10\log\left|K - \text{sgn}(B_1)\sqrt{K^2 - 1}\right| \quad \text{dB}$$

where $B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2$