UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER MAY 2010

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 SIX (6) PAGES INCLUDING THIS PAGE

QUESTION ONE *(25 marks)*

(a) Figure Q.1a shows a class A emitter follower biased with a constant current source. Assume that $\beta = \infty$, $V_{BE} = 0.7$ V and $V_{CEsat} = 0.3$ V.

(i) Find the value of R that will produce maximum out signal swing. *(7 marks)*

(ii) Find the minimum and maximum values of the emitter current of Q_1. *(2 marks)*

(iii) Calculate the power conversion efficiency of the circuit at maximum output voltage swing. *(6 marks)*

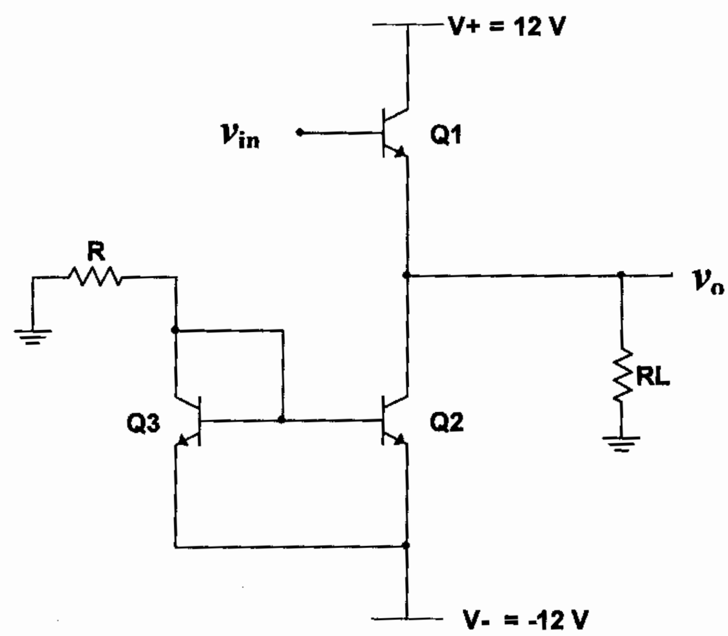

Fig. Q.1a

(b) With the aid of an illustration briefly discuss the Safe Operating Area of a Power BJT. How does this area differ from that of a power MOSFET? *(10 marks)*

QUESTION TWO *(25 marks)*

(a) Consider the class B output stage with complementary MOSFETs shown in Fig. Q.2a. The MOSFET parameters are:

$$V_{tp} = V_{tn} = 0\text{V}, \quad \frac{1}{2}k_n'\frac{W}{L} = \frac{1}{2}k_p'\frac{W}{L} = 0.2 \text{ mA/V}^2$$

$$i_D = \frac{1}{2}k'\frac{W}{L}(V_{GS} - V_t)^2 \text{ in saturation region.}$$

$$i_D = k'\frac{W}{L}\left[(v_{GS} - V_t)v_{DS} - \frac{1}{2}v_{DS}^2\right] \text{ in triode region}$$

(i) At what voltage v_{GS}, does the NMOSFET just enter saturation? *(1 mark)*

(ii) Find the maximum output voltage with Q_n remaining in saturation region. *(9 marks)*

(iii) Find the values of i_L and v_{in} for maximum output voltage. *(2 marks)*

(iv) Find the power conversion efficiency for a sinewave of maximum peak-to-peak value. *(5 marks)*

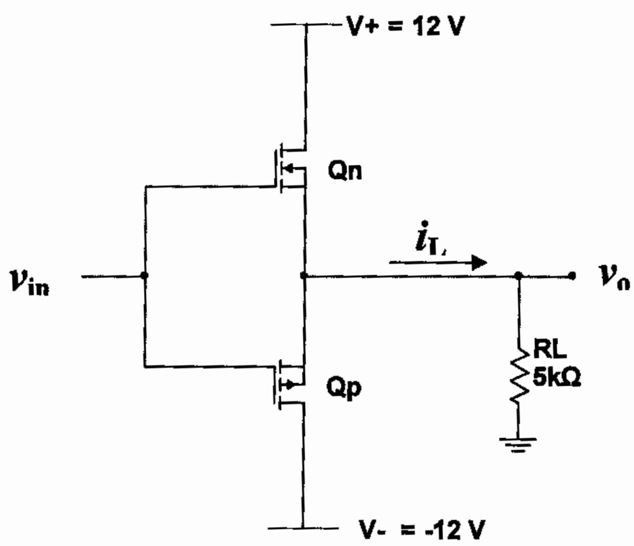

Fig. Q2a

(b) A power MSFET is used at an ambient temperature of 30°C. The specifications of the MOSFET are T_{Jmax} = 175°C, θ_{JC} = 1.8°C/W and θ_{CA} = 50°C/W.

(i) What maximum power dissipation should be allowed for the MOSFET under this condition? *(2 marks)*

(ii) If the MOSFET is mounted on a heatsink with θ_{CS} = 1.2°C/W and θ_{SA} = 4°C/W, by what factor can the dissipation of the MOSFET be increased? *(3 marks)*

(iii) What will be the temperature of the heatsink in (ii) when the MOSFET is dissipating maximum allowable power? *(3 marks)*

QUESTION THREE *(25 marks)*

(a) Figure Q.3a shows a class AB amplifier stage. For the diodes $I_S = 2\text{x}10^{-14}$ A and for the transistors $I_S = 5\text{x}10^{-14}$ A.

(i) Calculate V_{BB}, i_{e1} and i_{e2} when $v_{in} = 0$. *(9marks)*

(ii) Calculate V_{BB}, i_{e1} and v_o when $v_{in} = +5$ V *(6 marks)*

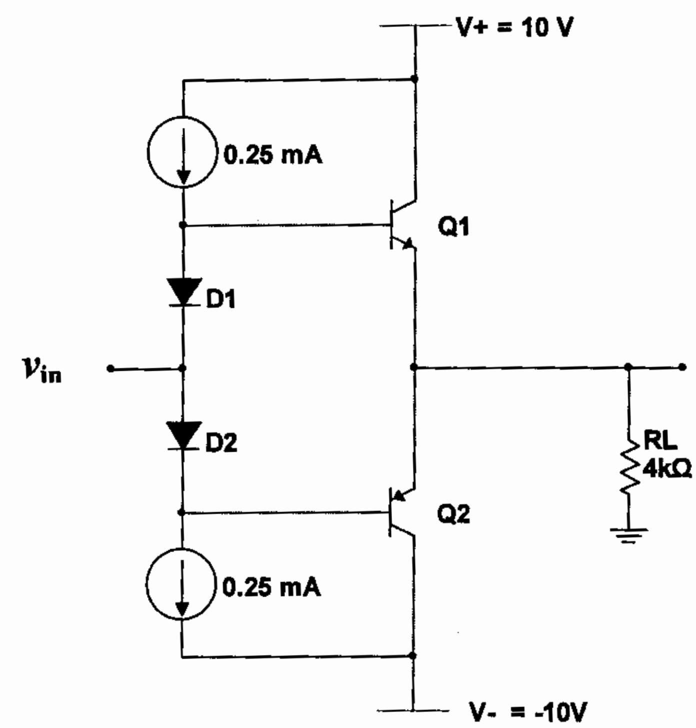

Fig. Q.3a

(b) Design a V_{BE} multiplier to be used in a class AB push-pull output stage to give V_{BB} = 1.157 V. The transistor used has $I_S = 10^{-14}$ A, $\beta = \infty$ and $I_C = 0.9 I_{BIAS}$ where I_{BIAS} is a constant current source of 180 μA supplying the V_{BE} multiplier. *(10 marks)*

QUESTION FOUR *(25 marks)*

A 500-MHz source of 500-Ω source impedance is to be matched to a 10-Ω load using a lossless network.

(a) Using the Q-method design a d.c. blocking L-section matching network. *(10 marks)*

(b) Using a virtual (intermediate) resistance equal to the geometric mean of the source and load impedances, design a double L-section matching network. *(15 marks)*

QUESTION FIVE (25 *marks*)

An RF transistor with proper bias point has the following common emitter S-parameters:

$$S_{11} = 0.6\angle 56^{\circ}$$
$$S_{12} = 0.09\angle 70^{\circ}$$
$$S_{21} = 4.4\angle 75^{\circ}$$
$$S_{22} = 0.11\angle -164^{\circ}$$

(a) Test the device for stability at this operating point. *(8 marks)*

(b) Find the Maximum Available Gain, MAG, expected when narrowband conjugate matching is employed. *(2 marks)*

(c) If the source and load impedances are both 50 Ω, and the reverse transmission coefficient is neglected, give a complete simple design of the RF amplifier for a narrow band match at 1 GHz. A Smith Chart may be used. *(15 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 $B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2$