NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 1202 – ANALOGUE ELECTRONICS

BSC HONOURS PART II: JUNE 2004 DURATION: 3 HOURS

ANSWER **ALL** QUESTIONS IN SECTION A AND ANY **THREE** QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

SECTION A

1 (a) Explain physical properties of a p-n junction diode which enables it to act as a rectifier. [4]

(b) Write the voltage-ampere equation for a p-n junction diode and explain the meaning of each symbol. [4]

(c) Write down the operative functions of a zener diode and explain these functions graphical. [5]

(d) What is a MOSFET? Write down an expression for drain resistance and show graphically the $I_D - V_{DS}$ circuit characteristics for n – channels in the depletion mode. [5]

(e) What is Peak Inverse Voltage (PIV)? Determine the output voltage for the bridge rectifier in Figure 1 below. What minimum PIV rating is required for the silicon diodes? [6]

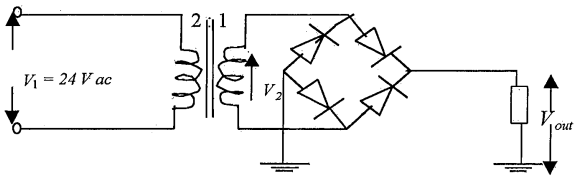

Figure 1

(f) Determine whether the transistor shown in Figure 2 below is in saturation or not. Assume $V_{CE(sat)}$ is small enough to be neglected. [4]

(ii) ac load line
Illustrate your answers with the help of a diagram. [4]

(c) With reference to your answer in (b), explain the term 'Quiescent Point' and its significance on linear and non-linear circuit operations. [4]

(d) Hence with reference to your answer in Question (c), explain the terms
(i) cut – off region

(ii) saturation region

(iii) linear region [4]

(e) Provide the defining equation for V_1 and V_{out} to highlight some aspects of the circuit operation. Give a brief explanation in each case. [4]

4 (a) Give five important characteristics of an operational amplifier and explain virtual ground [7]

(b) Define common mode rejection ratio and slew rate. If the slew rate is 5 V/μs at a signal frequency of 0.2 MHz, find the maximum sine wave input voltage. [7]

(c) Design a circuit using an operational amplifier that will produce an output voltage equal to $-(V_1 + 2V_2 + 0.5V_3)$, where V_1, V_2 and V_3 are input voltages. [6]

5 (a) Draw a block diagram of an oscillator and state the condition necessary for oscillation to take place. [4]

(b) Draw the circuit diagram of an RC phase shift oscillator and explain its operation. Hence design an RC phase shift oscillator that will oscillate at 100 Hz. [8]

(d) Draw the circuit diagram of a Wein Bridge oscillator and explain its operation. Hence design a Wein Bridge Oscillator that will oscillate at 25 kHz. [8]

6 (a) For a band – pass filter, define

(i) bandwidth

(ii) Q – factor

(iii) Frequency response (sketch) [6]

(b) On the same diagram, show the Chebyshev, Butterworth and Bessel filter responses. [6]

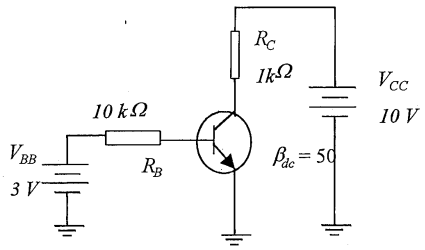

Figure 2

(g) What is thermal runaway? [4]

(h) The operational amplifier shown in Figure 3 has an open loop gain equal to 25 000 and an open output resistance of 100 Ω. Find

(i) The magnitude of the loop gain
(ii) The closed loop gain
(iii) The input resistance seen by V_{in}
(iv) The closed loop output resistance [8]

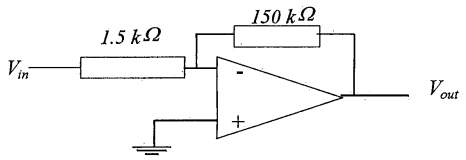

Figure 3

SECTION B

2 (a) Determine the ripple factor for the filtered bridge rectifier shown in Figure 4 below. [8]

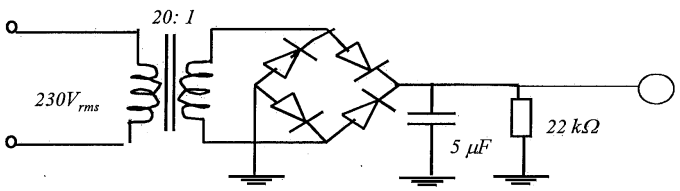

Figure 4

(b) A 120 Hz full wave rectified voltage with a peak value of 162.6 V is applied to the LC filter in Figure 5 below. Determine the filter output in terms of its dc value and the rms ripple voltage. What is the ripple factor? [8]

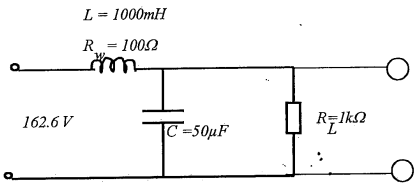

Figure 5

(c) Comment on the two ripple factors you obtained in (a) and (b). [4]

3 Using Figure 6, below:

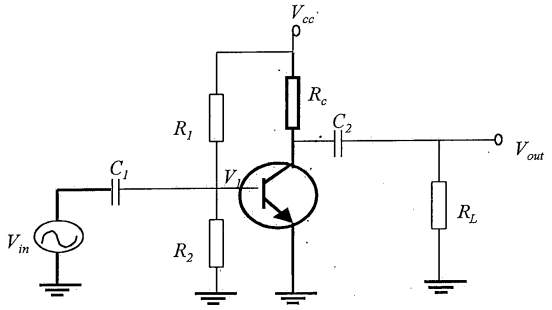

Figure 6

(a) Explain the functions of C_1 and C_2. [4]

(b) Explain the terms

(i) dc load line

(c) Design a second order, voltage controlled voltage source(VCVS), low pass Butterworth filter with cut off frequency 2.5 kHz, given the gain in the pass band is 2. [8]

Table 1: Second order low pass filter Butterworth filter design

Circuit element values with resistance in kΩ

Gain	1	2
R_1	1.32	1.20
R_2	4.40	2.00
R_3	Open	5.50
R_4	0	5.50
C_1	0.41 C	C