NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

APPLIED PHYSICS DEPARTMENT

SPH 1202 – ANALOGUE ELECTRONICS

EXAMINATION

BSC HONOURS PART I: JANUARY 2003 DURATION : 3 HOURS

ANSWER **ALL** PARTS OF QUESTION 1 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) (i) Define intrinsic material, drift mobility, drift and diffusion currents in semiconductor. [4]

(ii) Calculate the conductivity and resistivity of the bar of intrinsic silicon given the electron density, $n_i = 1.4\times10^{16}$ electrons/m^3, drift mobilities for electrons and holes are $0.12m^2/(V.s)$ and $0.4m^2/(V.s)$ respectively, charge = $1.6\times10^{-19}C$. [5]

(b) Determine the current and the output voltage of the following circuit given in *Figure* 1 assuming that *0.7 V* drop across each silicon diode.

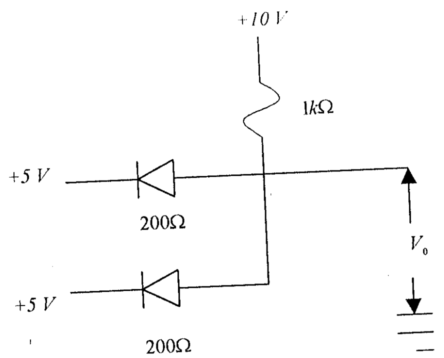

Fig.1. [5]

(c) What is a MOSFET? Write down an expression for drain resistance and show graphically the $I_D - V_{DS}$ circuit characteristics for *n*-channel MOSFET in depletion mode. [4]

(d) Show with graphical illustration how the firing operation of a silicon controlled rectifier such as thyristor is achieved. [4]

(e) Determine charging angle for full-wave rectifier with capacitor filter given the following: $R_L = 1000\ \Omega$, supply voltage is 100 V at 50 mA and the frequency of 50 Hz with a ripple factor of 1% given alternating voltage $V_{ac} = V_r/(2\sqrt{3})$, where V_r = ripple voltage. [5]

(f) For a band-pass filter, define Q-factor and show graphically Chebysev low-pass frequency response. [5]

(g) Design a circuit using an operational amplifier that will produce an output voltage equal to $-(V_1 + 2V_2 + 0.5V_3)$. [5]

(h) Define slew rate. If the slew rate is 10 V/(μs) at a signal frequency of 1 MHz, find the maximum sine wave input voltage. [3]

SECTION B

2. (a) What is peak inverse voltage? Analyse an L-section filter and deduce the ripple factor

$$r = 0.47/(4\omega^2 LC),$$

where L = inductance, C = capacitance and ω = angular frequency. [10]

(b) A load $R_L = 2000\ \Omega$ is to be supplied with 200 V at 50 mA for a full-wave rectifier having an L-section filter with $L = 20H$ and $C = 5\mu F$. Design a rectifier-filter combination to meet these specification given that $f = 50\ Hz$. [10]

3. (a) (i) Derive an expression for the collector current of the bias emitter follower:

$$I_C = [(V_{BB} - V_{BE})h_{FE}]/\{R_B[1 + (R_E/R_B)h_{FE}]\},$$

where V_{BB} = base supply voltage, V_{BE} = base-emitter voltage, R_B = Base resistance, R_E = emitter resistance, h_{FE} = forward current gain. [10]

(b) Draw the circuit diagram of the Wien-bridge oscillator and explain its operation. Design a Wien-bridge oscillator which oscillates at 25 kHz frequency. [10]

4. (a) Derive an expression for the high-frequency response voltage gain A_{vH} and midrange-frequency current gain A_{iM} for a CE cascade. [16]

(b) Given that $g_m = 0.020$ *mho*, $R_L = 1500\ \Omega$, $C_{be} = 40\ pF$, $C_{bC} = 4\ pF$, determine the single capacitance connected across the transistor input C_d. [4]

5. (a) The input voltage to an operational amplifier drawn in *Figure 2* is 4 mV. At point 1 in the amplifier, the voltage gain with respect to the input is $-5.0\ dB$ and at point 2 the voltage gain with respect to point 1 is $20.0\ dB$. Determine

(i) the voltage at point 1, [4]

(ii) the voltage at point 2 and [3]

(iii) the voltage gain in dB at point 2 with respect to input. [3]

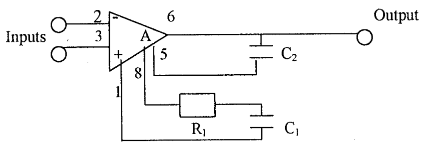

Fig. 2.

(b) A push-pull amplifier has the supply voltage $V_{cc} = 10V$ and the load resistance $R_L = 5\Omega$. The total number of turns on the primary winding is 50 and the secondary winding has 25 turns. Find:

(i) the maximum power that can be delivered to the load and [7]

(ii) the power dissipated in each transistor when maximum power is delivered to the load. [3]

6. (a) Using the data in *Table* 1 design a second-order, voltage controlled voltage source *(VCVS)*, low-pass Butterworth filter with cut-off frequency $2.5\ kHz$, given that the gain in the pass-band is 2.

Table 1: Second-order low-pass filter Butterworth filter design.

Circuit elements values with resistances in $k\Omega$.

Gain	1	2
R_1	1.42	1.13
R_2	5.40	2.25
R_3	Open	6.75
R_4	0	6.75
C_1	0.33 C	C

[10]

(b) The amplifier in *Figure 3* has mid-band gain $|v_L|/|v_s| = 140$. Determine

(i) the approximate lower cut-off frequency; [4]
(ii) the gain $|v_0|/|v_{in}|$ and [4]
(iii) the lower cut-off frequency when C_2 is changed to $20\mu F$. [2]

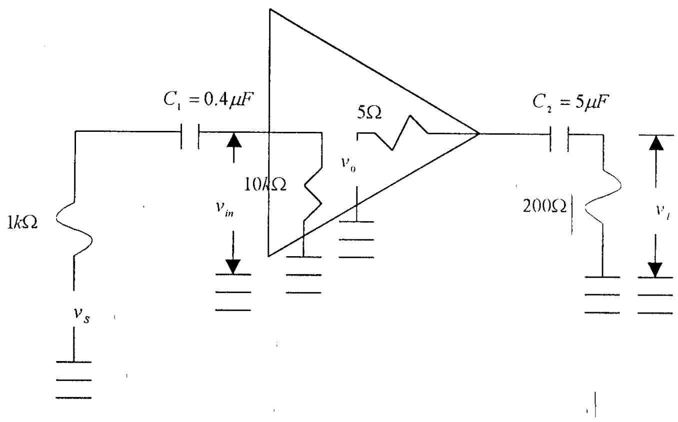

Fig. 3.

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