UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, MAY 2007

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING

TITLE OF PAPER: ELECTRONIC SYSTEM DESIGN

COURSE CODE: E330

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1. **There are five questions in this paper. Answer Question ONE and any other TWO questions.**
2. **Question one carries 60 marks while the other questions each carry 20 marks.**
3. **If you think not enough data has been given in any question you may assume any reasonable values.**
4. **E12 Range: 10 12 15 18 22 27 33 39 47 56 68 82**

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THIS PAPER CONTAINS EIGHT (8) PAGES INCLUDING THIS PAGE

QUESTION ONE (COMPULSORY) ***(60 marks)***

(a) (i) Define the following parameters of a practical capacitor:

Resonance frequency

Equivalent Series Resistance *(4 marks)*

(ii) What is the significance of the above parameters in capacitor selection? *(4 marks)*

(b) A resistor is specified as 100 Ω, ±2% at 20 °C with a temperature coefficient of +200 ppm/°C and stability of +1000 ppm/year. After one year the same resistor is measured at 60 °C.

(i) Over what range of values would you expect the measured value to be? *(5 marks)*

(ii) Give one reason why the stability parameter is not zero. *(2 marks)*

(c) For the loaded tapped-secondary transformer with turns for each winding shown in Fig. Q.1c,

(i) Determine the currents in the load resistors. *(3 marks)*

(ii) Determine the resistance looking into the primary. *(4 marks)*

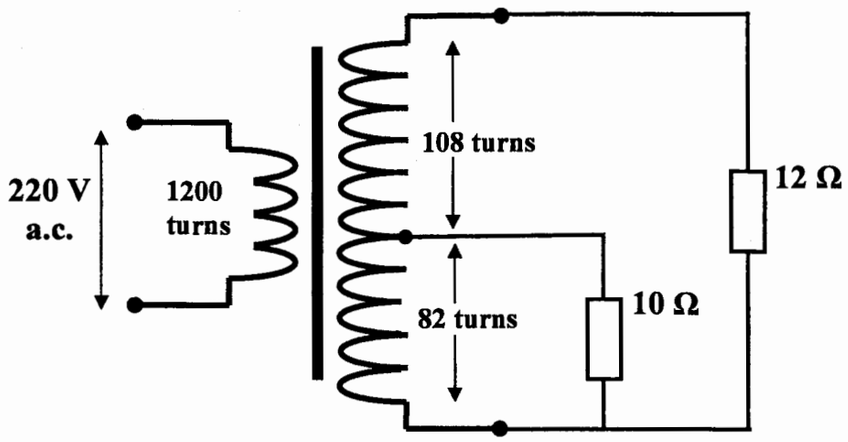

Fig. Q.1c

(d) A control potentiometer has the following ratings:

Nominal resistance = 220 Ω

Power dissipation = 2 W derate (reduce rating) at 25 mW/°C for each degree of ambient temperature over 60 °C

Determine whether it is possible to use this pot with a 15 V supply at an ambient temperature of 110 °C. Assume that the temperature coefficient is negligible.

(5 marks)

(e) A circuit is required to enable a 5-volt signal switch on a 220 V a.c. mains operated appliance of 500 W. Give a design of a suitable circuit for this specifying typical component values to be used. *(5 marks)*

(f) The memory of a portable digital clock-radio is volatile and needs a dc supply of at least 2 V otherwise all stored information about radio station frequencies is lost. Besides this, the clock needs to be powered otherwise it stops working. The supply for the clock-radio is 4.5 V from 3 cells. When the battery voltage reaches down to 3 V through normal use a "low battery" warning is displayed so that the user can change the batteries before the stored data is lost. At this point the current drawn from the almost exhausted cells reduces to 375 μA just to keep the memory and clock powered but not the radio.

(i) Draw a scheme by which a capacitor can be used as short term source of power while the owner changes the batteries. *(2 marks)*

(ii) What value of capacitor would you use to give the owner up to 30 sec to change the batteries? *(5 marks)*

(g) A resonant circuit requires an inductance of 2 mH. A toroidal core with the following specifications is available:

Mean ring radius = 20 mm

Core radius = 5 mm

Relative permeability of core = 2000

(i) How many turns would you wind to get the inductance required? *(4 marks)*

(ii) If the total magnetic flux in the core should not exceed 0.2 mWb, what would be the maximum current rating of your inductor? *(4 marks)*

(i) An application requires a switch. List five main parameters you would use to select the right switch for the application. *(5 marks)*

(j) Two wires in a cable are in parallel proximity to each other resulting in a coupling capacitance of 150 pF/m between them. The wires are used to send signals from two separate sources each of 10 kΩ source impedance to two separate loads of 10 kΩ each.

(i) Estimate the cross talk in dB when the total length of the cable is 2 m. *(4 marks)*

(ii) What measures would you take to reduce the cross-talk to an acceptable level? *(4 marks)*

QUESTION TWO ***(20 marks)***

Sending a voltage signal using a long wire causes unacceptable voltage drops at the load end. However, if the signal is sent as a loop current then the current received at the load is the same as the sent current. A circuit to change the voltage signal into a current is required. The voltage-to-current converter is based on the circuit in Fig. Q2. The circuit is required to give an output current of 2 mA with input voltage (e_{in}) of 0 V and 30 mA with an input voltage of 2 V. But most opamps including the one used here cannot give an output a current of 30 mA so modifications are required in this basic circuit. Also a zero and span adjustment is required. The opamp used needs power supplies of ±15 V and saturation occurs at output voltages of ±13 V.

(i) Give a complete design of this voltage-to-current converter specifying values of all the components required within the E12 range of values. *(15 marks)*

(ii) If a maximum current of 30 mA is drawn from the power supplies, specify the maximum load resistance that can be used. *(5 marks)*

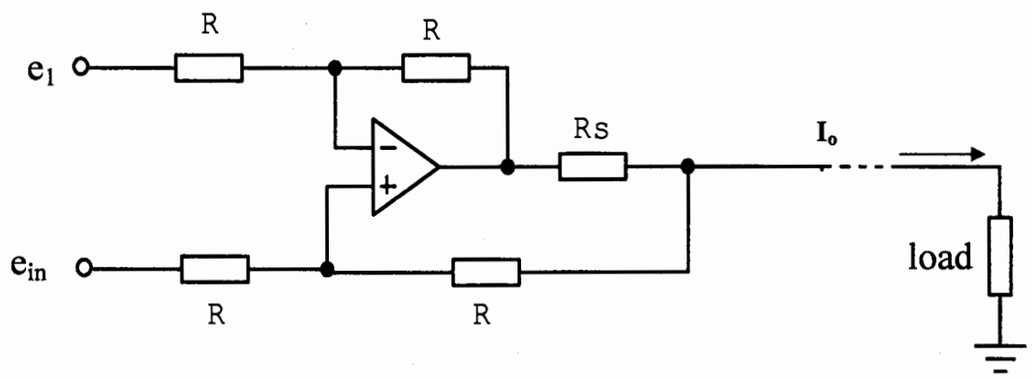

Fig. Q2

QUESTION TRHEE ***(20 marks)***

An active sensor A, an amplifier B and an output load C when tested individually have the terminal characteristics shown in Fig. Q.3.1. The characteristics are basically linear with the intercepts and key points shown. The sensor, amplifier and load are connected in cascade as in Fig. Q.3.2

(a) From the terminal characteristics derive the equivalent circuit models of the three components. *(10 marks)*

(b) Find the load voltage. *(4 marks)*

(c) The circuit is to be modified to reduce low frequency hum and high frequency noise. Determine the connections and values of capacitors you would use to make lower cut-off frequency of 500 Hz and the upper cut-off frequency of 22 kHz. *(6 marks)*

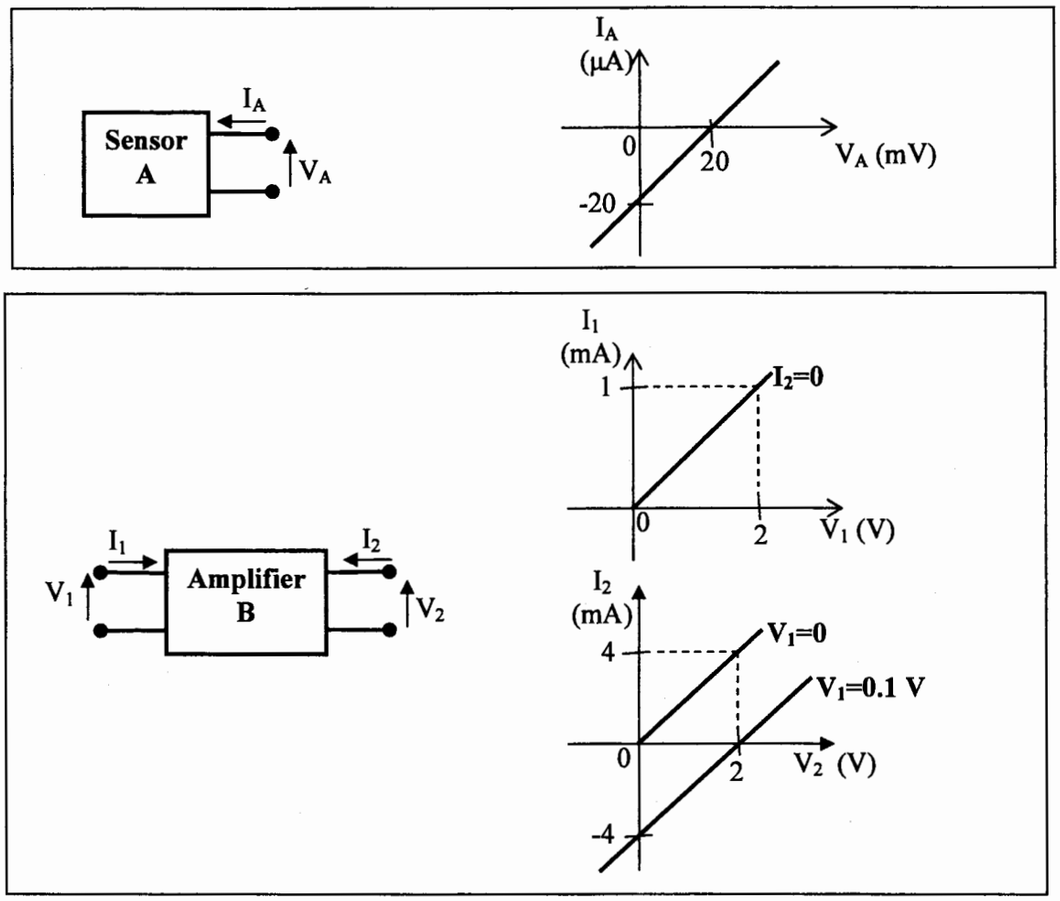

Fig.Q3.1 (continued on next page)

Fig.Q 3.1 (continued)

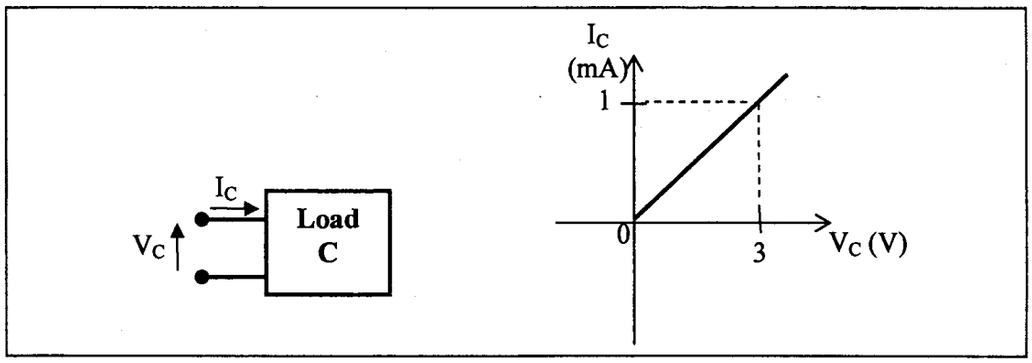

Fig. 3.1

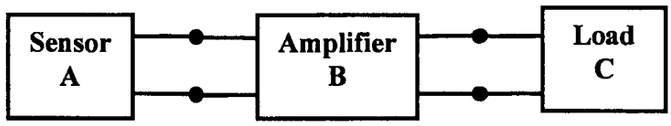

Fig. Q3.2

QUESTION FOUR ***(20 marks)***

A 9 V linear regulator supply uses a step-down transformer, a bridge rectifier and a 7809 3-pin voltage regulator. The specifications of the supply and the components are:

Power Supply:

Output voltage	=	9 V ± 5%
Full load current	=	1.2 A

7809 3-pin regulator:

Tolerance of output	=	±4%
Min dropout voltage	=	2 V
Max input voltage	=	35 V

Rectifier:

Peak ripple voltage	=	2 V
Diode voltage drop	=	0.8 V

Mains supply voltage = 230 V ±10%, 50 Hz

(a) Determine the secondary voltage of a suitable transformer for the power supply. *(11 marks)*

(b) Determine the voltage rating and value of a suitable capacitor for smoothing the rectified voltage. *(9 marks)*