UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER 2008

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 THREE questions.**
2. **Question one carries 40 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 NINE (9) PAGES INCLUDING THIS PAGE

QUESTION ONE (COMPULSORY) ***(40 marks)***

(a) Briefly explain the technical reasoning behind the following statements about electronic hardware:

(i) "Never touch the leads of a large capacitor even if power is switched on, unless …..". *(2 marks)*

(ii) "Connect a 0.1 μF from +Vcc pin and ground as near as possible to the +Vcc pin". *(2 marks)*

(iii) "If the two ends of a roll of wire are available you can use an Ohmeter to estimate the length of the wire". *(2 marks)*

(iv) "An overheated component in a circuit can be a symptom of a problem rather than its cause". *(2 marks)*

(v) "A capacitor voltage can not change instantly, but its current can". *(2 marks)*

(vi) "In the B-H curve of a ferromagnetic material it is not the μ which is important, what you really need to know is that given B what is H". *(2marks)*

(vii) "The flux density in a ferromagnetic material with a coil wound around it depends not only on the current in the coil, but on its past history".*(3 marks)*

(viii) "A thick, non-stranded wire is never suitable for connecting an audio amplifier to a portable speaker". *(2 marks)*

(ix) "When the signal wavelength is much shorter than the cable length it is necessary to match the cable to its terminating impedances". *(3 marks)*

(b) An aluminum wire has a resistance of 20 Ω at room temperature. If this wire is melted down and used to produce a new wire which is 4 times the length of the original wire, what will be the resistance of the new wire at room temperature? Assume that there is no loss of aluminum and its characteristics are not changed by the melting and cooling process. *(5 marks)*

(c) A given material has a resistance of 100 Ω at 23°C and 150 Ω at -25°C.

(i) Does the material have a positive or negative temperature coefficient? Explain. *(1 mark)*

(ii) Determine the value of the temperature coefficient. *(1 mark)*

(iii) What resistance would you expect the material to have at 70°C and what assumption(s) have you made in you estimation? *(3 marks)*

(d) A power amplifier with a source resistance of 100 Ω is adjusted to produce an output signal of 18 V r.m.s signal. The amplifier feeds a low impedance speaker through an audio transformer with a turns ration of 5:1.

(i) Calculate the power that would be delivered to a 4 Ω speaker connected to the secondary of the transformer. *(2 marks)*

(ii) Calculate the power that would be delivered to an 8 Ω speaker. *(2 marks)*

(iii) Why is the power delivered to the 4 Ω speaker greater than the power delivered to the 8 Ω speaker? *(1 mark)*

(e) An amplifier A has an input with infinite resistance and an output which consists of a voltage dependent current source i in parallel with a resistance R_S is shown in Fig. Q.1e. Two such amplifiers are cascaded to form an amplifier B.

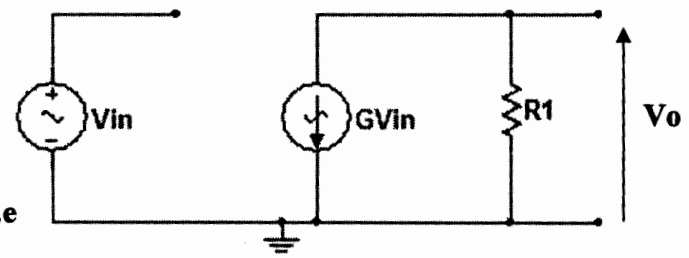


Fig. Q1.e

Assume that

$$i = \begin{cases} 0, & V_{in} < V_T \\ G(V_{in} - V_T), & V_{in} \geq V_T \end{cases} \quad \text{and}$$

$$G > 0 \quad \text{and} \quad V_S > V_T > 0.$$

(i) Obtain an equation for the output voltage V_o as a function of input voltage V_{in} and sketch the output-input characteristic of the amplifier. *(2 marks)*

(ii) Obtain an equation for the input-output characteristic of amplifier B. *(3marks)*

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

(a) An RC circuit is used to delay the turning on of an alarm.

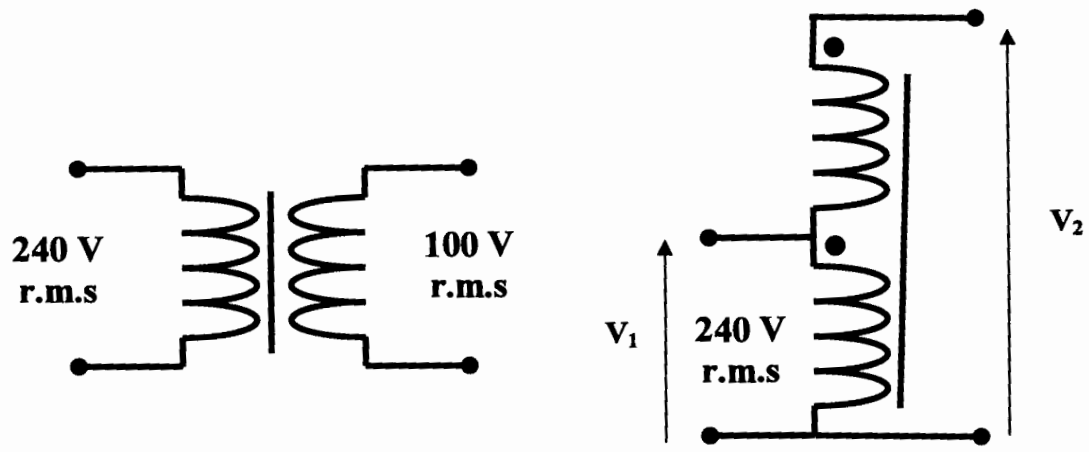
(i) Sketch a block diagram of the main elements that would be required to implement such a delay and by means of waveform diagrams show how the delay is obtained. *(3 marks)*

(ii) Such a system is used to delay the sounding of an alarm after a door to a building is opened on entry. The system is powered by a 6 V battery and a delay of at least 25 s is required. Calculate the resistive components necessary to implement such a system. You may assume that a good quality 33 μF capacitor and any required ICs are available. *(10 marks)*

(b) Two voltage levels, 0 V and 5 V, are used to send current through a d.c. motor in either of two directions. The motor operates from a 12 V battery. Design a suitable circuit for operating the motor. You may assume that you have a 12 V DPDT relay switch, transistors, diodes and various resistors available for use in your circuit. *(7 marks)*

QUESTION THREE ***(20 marks)***

(a) Fig Q.3a shows a 240V/100V step down transformer rated at 2 kVA which may be reconnected as an autotransformer.



Step down transformer

Step down transformer connected as autotransformer

Fig. Q 3a

(i) Determine the rated maximum primary and secondary currents of the transformer in the two configurations. *(5 marks)*

(ii) Determine the maximum rated load in kVA which can be connected to the autotransformer. *(3 marks)*

(iii) Determine the supply current at maximum load. *(2 marks)*

(b) A signal generator is made up of components whose types, failure rates and quantities are given in Table Q.3b.

(i) By carrying out appropriate calculations determine the type of component you would expect to contribute most to the failure of the signal generator and the type contributes the least? *(7 marks)*

(ii) Estimate the time the generator is expected to work before a fault occurs. *(2 marks)*

(ii) What is the probability that a new signal generator will still be operating after 10,000 hours of operation? *(1 marks)*

Table Q.3b

TYPE OF COMPONENT	FAILURE RATE (x 10^{-6} per hr)	NUMBER USED
Transistors	0.04	25
Capacitors	0.1	44
Resistors	0.03	83
Diodes	0.01	22
Linear I.Cs	0.15	5
Digital I.Cs	0.1	3
Potentiometers	3	5
Switches	0.1(per contact)	35 contacts
Transformer	0.4 (per winding)	4 windings
Soldered joints	0.005	752

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

(a) A battery is made up of cells, each of which has 600 mA-h capacity and nominal voltage of 1.5 V. The cells are arranged as shown in Fig. Q.4a. The battery is used to power a portable radio which takes an average current of 200 mA

(i) How much current will be supplied by each cell? *(2 marks)*

(ii) How long would you expect the battery to last? *(2 marks)*

(iii) How much power is supplied to the radio? *(2 marks)*

(iv) What is the total capacity of the battery? *(2 marks)*

(iv) Briefly explain why it is not advisable to build such a battery using cells of different types even though their nominal voltages might be the same. *(4 marks)*

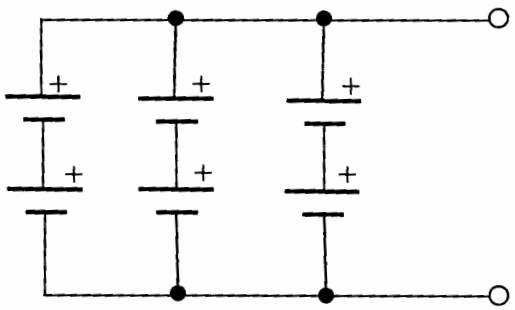
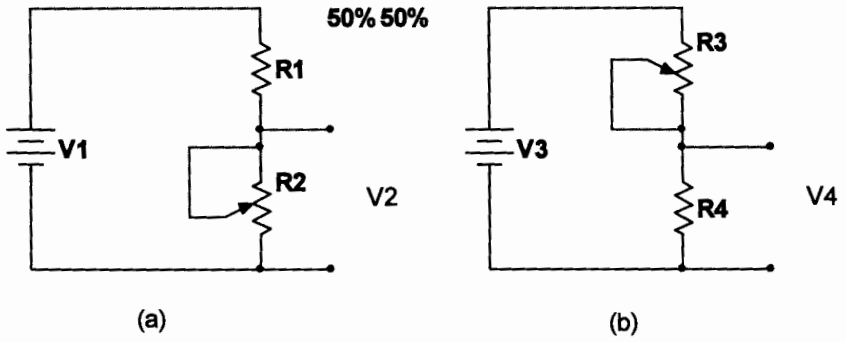


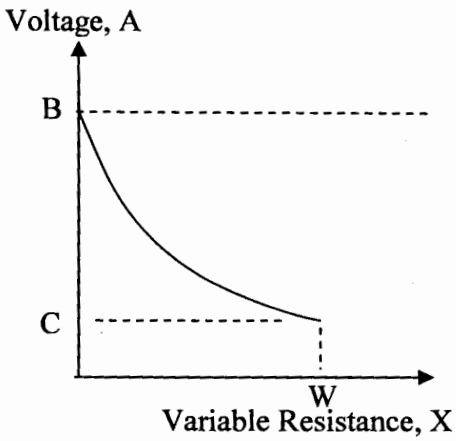
Fig. Q.4a

(b) An experimenter building the voltage divider circuits shown in Fig. Q.4b predicted that varying the resistances should give the results shown on the graphs shown below the circuits.

(i) Pair, giving your reasons, each voltage divider circuit with its corresponding graph. *(3 marks)*

(ii) Complete the labeling of the graphs by working out, from the circuit variables, expressions for the voltages labeled A, B, C, D and E. Determine also what the resistors X and Y should be. *(5 marks)*


50% 50%
R1
V1
R2
V2
(a)
R3
V3
R4
V4
(b)


Voltage, A
B
C
W
Variable Resistance, X
(c)

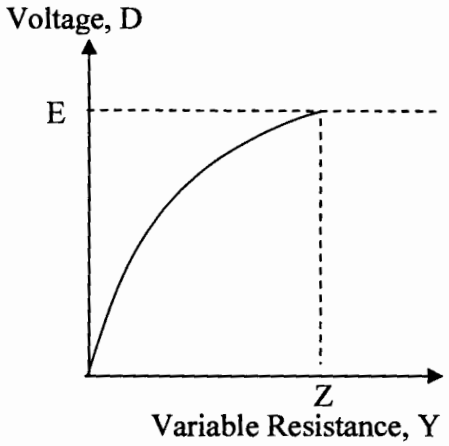

Voltage, D
E
Z
Variable Resistance, Y
(d)

Fig. Q.4b

QUESTION FIVE ***(20 marks)***

An amplifier comprises two voltage amplifying stages in cascade. The first stage has input resistance, output resistance and voltage gain of 50 kΩ, 10 kΩ and +40 V/V respectively. The same parameters for the second stage are 100 kΩ, 100 Ω and–60 V/V respectively. The amplifier supplies power to a load 10 kΩ with a small stray capacitance C_2 across it. The applied signal is from a 2 mV generator with an internal resistance of 20 kΩ.

a) Calculate the voltage appearing at the load when capacitive effects are negligible. *(8 marks)*

b) Calculate the maximum permitted value of C_2 for the bandwidth of the amplifier to extend up to 5 MHz. *(6 marks)*

c) How would you modify the circuit so that low frequency signals of frequencies less than 200 Hz do not enter the amplifier with more than half their signal strength? Calculate values of any new component(s) used. *(6 marks)*