UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER MAY 2010

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER: ELECTRONIC SYSTEM DESIGN

COURSE CODE: E330

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1. **There are six 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. **A sheet containing some useful formulae is attached at the end of the paper**

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER CONTAINS SIX (6) PAGES INCLUDING THIS PAGE

QUESTION ONE (COMPULSORY) *(40 marks)*

(a) i. Explain why voltage spikes are produced when a current in a magnetic coil is interrupted. *(2 marks)*

ii. With the aid of an illustration show how would you protect electronic devices from this problem? *(3 marks)*

(b) Explain the behaviour of a resistor at high frequencies. Support your answer with an impedance versus frequency sketch. *(4 marks)*

(c) A high stability resistor is specified as having a temperature coefficient of +5 ppm/C and tolerance of ±0.01%. The nominal value of the resistor is 1000 Ω at 20°C. What range of values can this resistor have at a temperature of 60°C? *(4 marks)*

(d) i. Define reliability of an electronic system. *(2 marks)*

ii. Categorize the different types of failures that can occur in an electronic system. *(3 marks)*

(e) A transformer is used to match a 5 Ω speaker to an amplifier of output impedance 1000 Ω.

i. What is the current ratio of this transformer? *(3 marks)*

ii. Is this transformer a power amplifier? Explain your answer *(2 marks)*

(f) Explain the purpose of a ferrite magnetic core in an inductor. *(3 marks)*

(g) In some applications,

i. Why would a slider potentiometer be preferable to a rotary one? *(2 marks)*

ii. Why would a vertically adjusted potentiometer be preferable to a horizontally adjusted one? *(2 marks)*

iii. Why would a potentiometer with an integral on off switch be preferable to using a separate potentiometer and a separate switch? *(2 marks)*

(h) Explain how losses in a capacitor are specified. *(4 marks)*

(i) Explain the difference between series resonance and parallel resonance. *(4 marks)*

QUESTION TWO *(20 marks)*

(a) A resistor is represented as a 1000 Ω ideal resistor in series with an inductor of 10 nH. We wish to use this resistor up to a frequency at which its impedance departs from its low frequency value by more than 10%. Find this frequency. *(12 marks)*

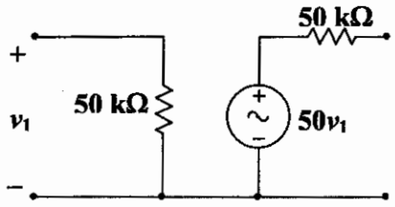
(b) A 600-Ω amplifier is to be matched to an 8-Ω speaker. You are given a toroidal ferrite core and winding wire which allows you to wind a maximum total of 150 turns on the core.

i. Determine the number of turns you would use in each winding *(6 marks)*

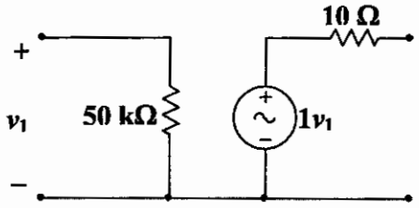
ii. Give a sketch showing how you would connect the transformer. *(2 marks)*

QUESTION THREE *(20 marks)*

Two amplifiers are available, Type A and Type B, shown in the figure below. A cascade of up to three such amplifiers in any mix or order is used to deliver 10 W to a 10-Ω speaker.



TYPE A



TYPE B

(a) Which arrangement of the three amplifiers delivers the 10 W with the minimum possible input signal? Justify your answer. *(5 marks)*

(b) What input signal voltage level is required to deliver the 10 W. *(6 marks)*

(c) If the output signal to the speaker is to be restricted to an upper cut-off frequency of 15 kHz. Show how this may be implemented and calculate the value(s) of any component(s) used. *(5 marks)*

(d) If the input signal is from a 600-Ω microphone and it is to be restricted to a lower cut-off frequency of 200 Hz . Show how this may be implemented and calculate the value(s) of any component(s) used. *(4 marks)*

QUESTION FOUR *(20 marks)*

(a) i) Explain the shape of the B-H (Hyteresis) curve of a magnetic material. *(7 marks)*

ii) Using the B-H curve explain the difference between hard and soft magnetic materials. *(3 marks)*

(b) A 120 VA transformer is supplied from 230 V, 50 Hz mains. The transformer core has a cross-section of 680 mm^2. The secondary voltage is 18 V r.m.s.

i) If the flux density in the core is not to exceed 1.2 Tesla, determine the number of turns of the transformer windings. *(6 marks)*

ii) Calculate the maximum primary and secondary current of the transformer. *(2 marks)*

iii) Explain why the core of such a transformer is made from steel laminations instead of a solid steel block. *(2 marks)*

QUESTION FIVE *(20 marks)*

(a) What role does insulation play in a cable? Why should a circuit designer care to know the limitations caused by cable insulation? *(8 marks)*

(b) A coaxial cable has a characteristic impedance of 50Ω and a dielectric of $\varepsilon_r = 2.2$.

i) Calculate the velocity of signal in the cable. *(2 marks)*

ii) A narrow pulse sent through the cable with the other end open circuited, returns back after 0.3 μs. Calculate the length of the cable. *(4 marks)*

(c) A 30-MHz signal is sent with zero phase from one end of the cable. With what phase will it arrive at the other end? Hint: First calculate the length of the cable in number of wavelengths. *(6 marks)*

QUESTION SIX *(20 marks)*

(a) List and briefly discuss any four strategies you as a product developer would employ to ensure that an electronic system has a very high reliability. *(8 marks)*

(b) Describe the meaning of the terms $R(t)$ and λ in the reliability equation $R(t) = e^{-\lambda t}$ *(3 marks)*

(c) The failure rate of a base station is 0.2%/1000h. Three such base stations are operated in parallel. At least one needs to be operational for normal communication.

(i) What is the improvement in reliability (over using a single base station) obtained after 10,000 hrs of operation. *(5 marks)*

(ii) What is the probability of loss of communication in a 1 week period? *(4 marks)*

SOME SELECTED USEFUL FORMULAE

$$L = \frac{\mu_r \mu_o N^2 A}{l}$$

$$\mu_o = 4\pi \times 10^{-7} \quad \text{H/m}$$

$$\varepsilon_o = 8.854 \times 10^{-12} \quad \text{F/m}$$

$$c = \lambda f = \frac{1}{\sqrt{\mu_o \varepsilon_o}} = v_d \sqrt{\varepsilon_r} = \lambda_d f \sqrt{\varepsilon_r}$$

$$\frac{V_r}{V_i} = \frac{Z_L - Z_o}{Z_L + Z_o}$$

$$Z_o = \frac{1}{\sqrt{LC}}$$

$$V_{rms} = 4.44 f N \Phi_m$$

$$\frac{N_2}{N_1} = \frac{V_2}{V_1} = \frac{I_1}{I_2} = \sqrt{\frac{R_2}{R_1}}$$