UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER MAY 2009

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 SEVEN questions in this paper. Answer any FIVE questions. Each question carries 20 marks.
2. If you think not enough data has been given in any question you may assume any reasonable values.
3. E12 range of values: 10 12 15 18 22 27 33 39 47 56 68 82
4. A list of some useful formulae is given at the end of the paper

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THIS PAPER CONTAINS NINE (9) PAGES INCLUDING THIS PAGE

QUESTION ONE ***(20 marks)***

(a) A copper cable is 1.2 km long and has a cross-sectional area of 5 mm^2. On a day when the temperature is 20°C its resistance is found to be 4.08 Ω and on a hot day when the temperature was 50°C its resistance was measured to be 4.57 Ω. Ignore the effect of temperature changes on the dimensions of the wire. Use the above data to find :

(i) the resistivity of the copper. *(5 marks)*

(ii) temperature coefficient of resistance of copper at 20°C. *(5 marks)*

(b) A fuse consists of a non-linear resistive element whose resistance R is dependent on current passing through it and is given by

$$R = R_o\left[1+\alpha(T-T_o\right] \quad \text{and} \quad T-T_o = kP,$$

where P is the power dissipated in the element, $T_o = 25°C$, $R_o = 0.11\ \Omega$, $\alpha = 0.7/°C$ and $k = 0.35°C/W$.

(i) Obtain an expression for R in terms of the current flowing through the fuse. *(5 marks)*

(ii) Find the rated current at which the fuse element will melt and open (blow). Note that the fuse blows when R becomes infinite. *(5 marks)*

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

It is well known that electronic components do not behave as intended under all conditions. Consider a real or practical inductor.

(a) Draw an equivalent circuit which can be used to represent its imperfections at all frequencies. Define any symbols used. *(3 marks)*

(b) Under what condition is the inductor considered lossless? *(1 mark)*

(c) If the inductor is lossy, obtain an expression which can be used to find the impedance of the inductor at all frequencies. *(4 marks)*

(d) Find the condition under which the impedance of a lossless inductor is to be considered infinite. *(4 marks)*

(e) Using reasonable approximations for your expression in (c) obtain an approximate expression for the impedance of a lossy inductor at resonance and show that it is finite. *(4 marks)*

(f) Explain the effect of losses on the Q of the inductor. *(1 mark)*

(g) What techniques can you employ to improve the Q of an inductor? *(3 marks)*

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

(a) Draw symbols of each of the following configuration types of switches and illustrate how you would use each type in connections of a mono/stereo amplifier to a speaker or sets of of speakers. Note that a mono speaker has one amplifier while a stereo amplifier has two separate amplifiers (left and right).

(i) SPST switch to connect a speaker to a mono amplifier. *(1 mark)*

(ii) SPDT switch to connect mono amplifier to either one of two speakers. *(1 mark)*

(iii) DPST switch to connect a stereo amplifier to a set of two speakers. *(2 marks)*

(iv) DPDT switch to connect a stereo amplifier to either one of two sets of speakers. *(2 marks)*

(b) A coaxial cable has a characteristic impedance of 75 Ω and a dielectric of $\varepsilon_r = 2.3$.

(i) 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. *(5 marks)*

(ii) A 60-MHz signal is sent with zero phase from one end of the cable. With what phase will it arrive at the other end? *(5 marks)*

(iii) The cable is fed from a source of 50-Ω impedance which generates a narrow 1 V amplitude isolated pulse, and the other end is short ciruited. Calculate the amplitude level of the pulse after two reflections. Assume that the cable is lossless. *(4 marks)*

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

A coil of 300 turns is wound around a magnetic core of relative permeability 2500. The mean length of the magnetic path in the core is 40 cm and the core has a uniform cross-section of 1 cm^2.

(a) Calculate the magnetic flux density and magnetic flux intensity in the core when a current of 150 mA is passed through the coil. *(10 marks)*

(b) If an air gap of length 1 mm is made in the core at right angles to the magnetic flux lines, find the flux density in the air gap. Neglect fringing effects. *(10 marks)*

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

(a) An amplifier consists of two amplifying stages in cascade. The first stage has input resistance, output resistance and voltage gain of 20 kΩ, 5 kΩ and 20 respectively. The same parameters for the second stage are 10 kΩ, 10 kΩ and 30 respectively. The amplifier supplies a load of 4 kΩ with stray parallel capacitance of 82 pF across it. The applied signal is from a source of 500 Ω internal resistance connected to the input via a series capacitor of 33 nF.

(i) Calculate the voltage gain of the amplifier. *(6 marks)*

(ii) Determine its lower and upper cut off frequencies. *(4 marks)*

(b) The momentary push button switch S in the circuit shown in Fig. Q5b closes when pressed and opens when released. The circuit is used to generate a delay of 20 s from the time switch S is released up to the time the LED lights up. The output of the opamp may be assumed to saturate at the power supply voltages and the LED has a forward voltage drop of 2.2 V at its normal operating current of 15 mA. Complete the design of the circuit by specifying suitable values for all the resistors and the capacitor. *(10 marks)*

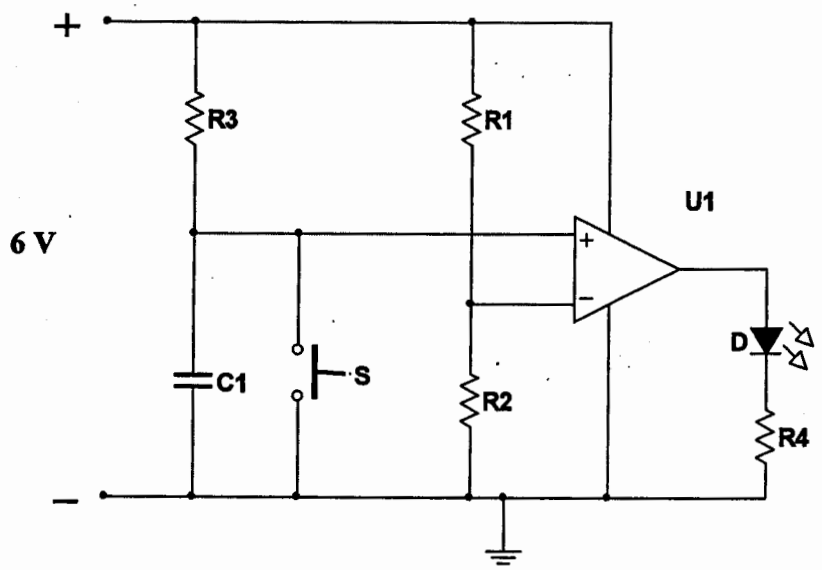

Fig. Q5b

QUESTION SIX ***(20 marks)***

A linear mode power supply uses a step down transformer, a bridge rectifier and a 7805 3-pin regulator. The specifications of the supply and its components are as follows:

Power supply:

Output voltage	=	5V ± 3%
Full load current	=	1.2 A

7805 3-pin regulator:

Tolerance of output	=	± 4%
Drop out voltage	=	2V
Maximum input voltage	=	35 V

Bridge rectifier:

Peak ripple voltage at peak load current	=	1 V
Diode forward voltage drop	=	0.7 V

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

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

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

QUESTION SEVEN ***(20 marks)***

(a) Explain the meaning of each of the following terms as used in the operation of electronic equipment:

(i) Maintainability *(1 mark)*

(ii) Failure *(1 mark)*

(iii) Mean time to failure (MTTF) *(2 marks)*

(iv) Mean time to repair (MTTR) *(1 mark)*

(v) Reliability *(2 marks)*

(b) An instrument has a mean time before failure of 12000 hours. What is its failure rate? What is the probability that this instrument will be operating well after 5000 hours of operation? *(4 marks)*

(c) A radio broadcasting station has three similar transmitters each with a MTBF of 15,000 hours. The transmitters are connected so as to serve different geographical areas. The station is considered "off air" when two or more transmitters fail at the same time. What is the probability that the station is on air during a 24-hour period. *(9 marks)*

END OF EXAMINATION PAPER

SOME USEFUL FORMULAE

$$Z_o = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

$$\rho = \frac{Z_L - Z_o}{Z_L + Z_o}$$

$$R = \frac{l}{\mu_o \mu_r A} = \frac{NI}{\Phi}$$

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

$$B = \mu_o \mu_r H$$

$$v = \frac{1}{\sqrt{LC}} = \frac{c}{\sqrt{\varepsilon_r}}$$

$$V_{tr} = \frac{\left(V_{in,d.c.} + V_{ripple} + V_D\right)}{0.92} \frac{V_{ac(nom)}}{V_{ac(\min)}} \frac{1}{\sqrt{2}}$$