The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Diploma in Technology/Bachelor of Technology - Level 03

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ECX3231 - Electrical Circuits & Measurements
Final Examination 2006/2007

Duration: 3 hours

Date: 08.04.2007 Time: 13.30-16.30

This question paper consist of three sections over four pages. Answer ***five*** questions selecting **at least one** question from each section. All questions carry equal marks.

SECTION -A

Q1 (a) State which class of circuits obeys the superposition theorem.

(b) Use superposition theorem to determine the current through each branch of the circuit shown in figure Q1.

(c) Determine the amount of power delivered to the load through terminals A-B.

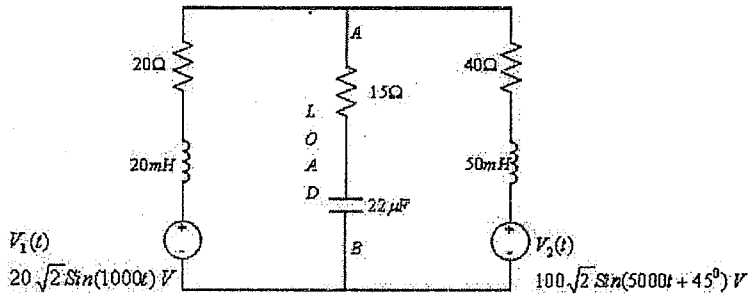


Figure Q1

Q2 Capacitor C shown in the figure Q2.a is charging with input voltage V via the resistor R.

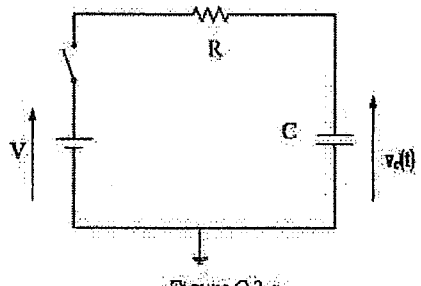


Figure Q2.a

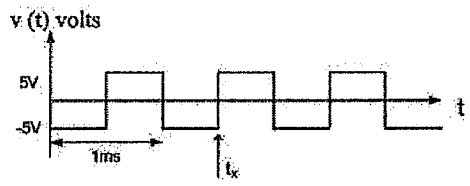


Figure Q2.b

(a) Formulate the transient behaviour of the capacitor voltage using a differential equation.

(b) If the initial capacitor voltage is V_o, show that capacitor voltage $v_c(t)$ can be represented by the following expression.

$$v_c(t) = V\left(1 - e^{-t/RC}\right) - V_o\, e^{-t/RC}$$

(c) The square wave shown in figure Q2.b is applied to the circuit with zero initial condition at t=0. RC time constant of the circuit is 0.5 ms and frequency of the square wave is 1 kHz. Use above expression to find the capacitor voltage at time instant t_x (i.e. Capacitor voltage at the second rising edge of the square wave). **Hint**: Determine the capacitor voltage at each transition of the input until t_x with proper initial conditions using the given expression.

(d) Sketch variation of the capacitor voltage until it reaching to the steady state condition.

Q3

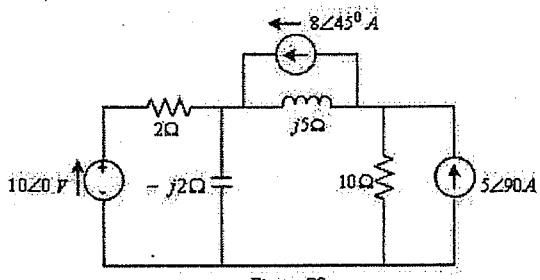


Figure Q3

(a) Write nodal equations for the circuit shown in figure Q3.

(b) Determine the nodal voltages using the nodal equations.

(c) Write equations for each branch current in terms of the nodal voltages.

(d) Rewrite the nodal equation when j5Ω inductor replaced by 6 Ω resistor.

(e) Giving reasons state whether the Nodal or Mesh formulation is more suitable to formulate the given circuit.

Q4 The operational amplifier shown in figure Q4 is an ideal one and circuit is operating at the sinusoidal steady state condition.

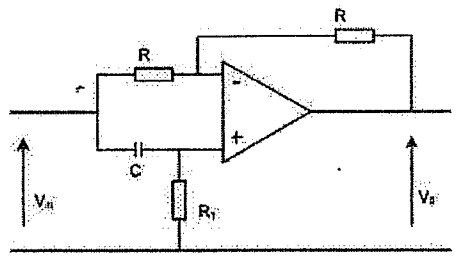


Figure Q4

(a) Show the output of the circuit at can be expressed as follows. $V_o = -V_{in}\left(\frac{1-j\omega CR_1}{1+j\omega CR_1}\right)$

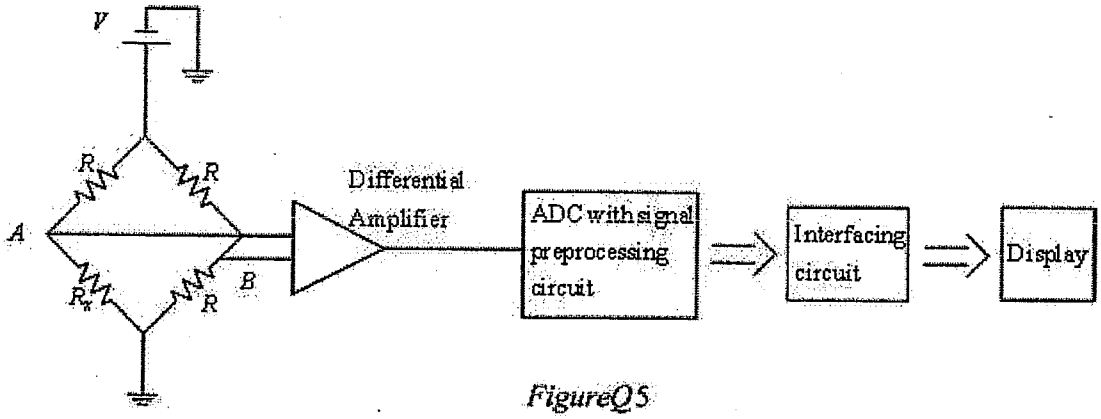
(b) State the function of the circuit by inspecting the transfer function.

(c) If values of R_1 and C are 1 kΩ and 2.2 μF respectively, use above expression to evaluate the output of the circuit when an input of 200mV at 2×10^3 rad/s is applied to the circuit.

(d) Determine the capacitor value C which causes a 45 degree phase difference between input and output, if the resistor R_1 is 100 Ω and angular frequency of the input is 500 rad/sec.

SECTION -B

Q5 A simple temperature measurement system is shown in figure Q5.



FigureQ5

(a) Show differential voltage V_{AB} is linearly varying with the temperature, in a temperature range where the co-efficient of the temperature sensitivity resistor R_x remains constant and $(R_x + R) \gg \Delta R_x$.

(b) If this system is used to measure temperature within $20°C$ to $60°C$ in steps of one centigrade, determine the resolution of the required ADC.

(c) Sketch the block diagram of a suitable ADC for this application.

(d) List error sources that might occur in this measuring system.

Q6 An experimental setup is required to measure B-H characteristics of a ring magnetic specimen. A simple experimental setup is described below. A coil is to be wound to excite a magnetic field on the specimen and another coil should be used to sample the flux produce by that excited field. Two voltages corresponding to the excitation and response can be derived by inserting passive electrical components to the excitation and response sides of the circuit. Therefore above voltages can be connected to a dual trace oscilloscope to visualize the B-H characteristics of the specimen.

(a) Sketch the complete experimental setup with connections to the oscilloscope.

(b) Derive an expression for followings in term of physical quantities of the setup (State any electromagnetic laws if used for the derivation)

i. Magnetic field intensity H that excites the specimen
ii. Induced emf of the search coil

(c) State how a voltage proportional to the excitation can be produced, stating any additional condition(s) required.

(d) State how a voltage proportional to the response can be produced, stating any additional condition(s) required.

SECTION -C

Q7 A passive electrical network N is inserted to suppress the flow of two undesirable signal components from system A to system B as shown in figure Q6. Network N should offer high admittance to the undesirable signal components having frequencies of $2/2\pi$ *kHz* and $50/2\pi$ *kHz*, but an open circuit for the DC voltage and desired signal frequency of $10/2\pi$ *kHz*.

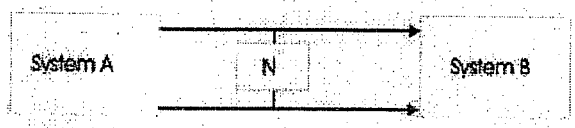


Figure Q7

(a) Determine the values of constants a_1, a_2, and b_1 that satisfying the above requirements, if admittance of the network N is represented by the following function.

$$Y(s)=\frac{s\left(s^2+a_1\right)}{\left(s^2+b_1\right)\left(s^2+b_2\right)}$$

(b) Design the network N having desired characteristics with appropriate passive components.

(c) Determine the driving point impedance of N at 20 kHz for the sinusoidal steady state.

Q8 Two port network model used to represent an amplifier should facilitate to estimate the output voltage and input current at a given input voltage and output current. For the concerned amplifier, the change in input current with the output current is insignificant, but output voltage significantly drops with the output current.

(a) Briefly explain the advantage of using two port network model of the amplifier for the analysis instead of carrying out analysis with basic circuital laws.

(b) Proposed a two port network parameter model suitable for above amplifier.

i. Write two equations representing the proposed two port network model.
ii. Define each parameter of the proposed model and state the dimensions of each parameter with physical significance.
iii. Draw the equivalent circuit representation of the two port network model.

(c) The input impedance of the amplifier is 1 kΩ at open output and measured output impedances at short circuited input is 10 Ω. If the voltage gain is 30 at open output, determine the output voltage of the amplifier when input and output currents are 0.2 mA and 54.5 mA respectively.

Q9 (a) State four MATLAB functions that helps to analyse an electrical circuits.

(b) Briefly explain four types of PSIPCE analysis applicable to an electrical circuit.

(c) With aid of a simple sketch, briefly explain how V-I characteristics of a non linear resistor can be visualized with help of a dual trace oscilloscope.