The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Bachelor of Technology – Level 5

ECX 5231 – Network Theory
Final Examination 2012/2013

Duration 3 hours

Date: 10.08.2013 Time: 13:30 – 16:30

This paper consists of eight questions. Answer any five questions. All questions carry equal marks.

Q1 The circuit shown in Figure Q1 represents a passive low pass filter. Component values are R_1=1KΩ, R_L= 10KΩ, C_1=C_2=C_3= 0.1μF, L_1= 1mH and V_g= 10sin1000t.

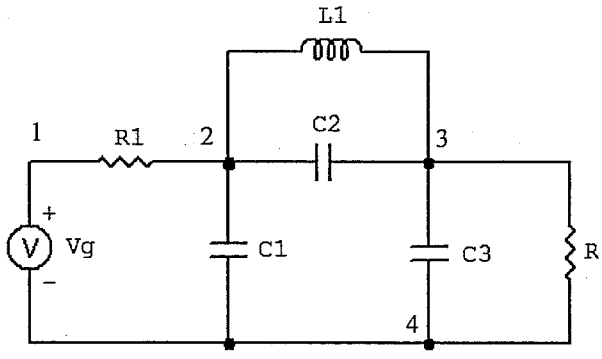

Figure Q1

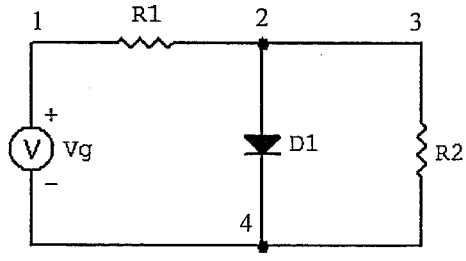

Figure Q2

a. Write stamps for each element of the circuit. *[Marks 4]*
b. The general equation format for the AC analysis is $[G + j\omega C + (j\omega)^{-1} L]\, x = w(t)$. Formulate the given circuit according to this format. *[Marks 6]*
c. It is necessary to obtain the frequency response of the circuit using the result of part (b). Sketch a flow chart to describe the simulation of AC analysis of the circuit. *[Marks 10]*

Q2 The DC behavior of nonlinear circuits is described by a system of nonlinear algebraic equations and Newton's method is used to obtain a DC solution. Consider the circuit shown in Figure Q2. Consider that $I_d = I_s\ [\exp(V_d/V_t) - 1]$ and $Is = 10^{-14}$A. Component vales are R_1 = 3kΩ, R_2 = 2kΩ and Vg = 5V.

a. Obtain a proper initial approximation for the given circuit. *[Marks 4]*
b. When a circuit has one or more nonlinear elements the equation format becomes $Gx + P(x) - w(t) = 0$. Arrange equations of the circuit according to the general format with help of stamps. *[Marks 6]*
c. Setup the Newton's method using above formulation and sketch a flowchart to describe the simulation of DC operating point analysis of the circuit. *[Marks 10]*

Q3 A number of numerical integration algorithms are used to obtain transient simulations. They have their own advantages and disadvantages.

a. List such three integration algorithms used in simulators and briefly explain their advantages and disadvantages in transient simulations. *[Marks 2×3=6]*
b. What is meant by single step and multi step integration algorithms and what type is used in third generation simulators? *[Marks 7]*

c. The general format of the Trapezoidal integration method is $x'_n = \frac{2}{h}(x_n - x_{n-1}) - x'_{n-1}$ by using this develops a companion network model of a Capacitor to be used in nodal equations. *[Marks 7]*

Q4 Sparsity is a key feature of large scale circuits such as VLSI digital circuits or electric power network. Consider the following formulation structure; it represents a simple electrical network.

$$\begin{bmatrix} 11 & 0 & 0 & 0 & 0 \\ 0 & 8 & 0 & 0 & 16 \\ 0 & -2 & 6 & -1 & -3 \\ -4 & 0 & 0 & 5 & 0 \\ 0 & 0 & -5 & 0 & 7 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} = \begin{bmatrix} 1 \\ 3 \\ 5 \\ 2 \\ 4 \end{bmatrix}$$

a. What is the importance of preserving sparsity during the simulation process? *[Marks 3]*
b. Reorder the given system of equations to minimize the filling during solving process. *[Marks 7]*
c. Suggest a proper data storage structure to store above modified matrix and show how you can store non-zero components in the presented data structure. *[Marks 7]*
d. Explain number of operations done by the simulator to accelerate the solution process. *[Marks 3]*

Q5 Consider the circuit shown in Figure Q5, where V_g is a unit step function.

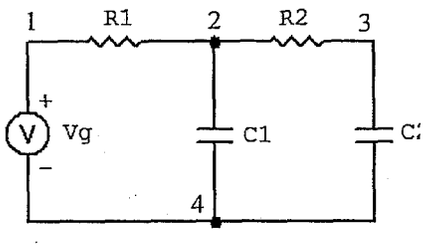

Figure Q5

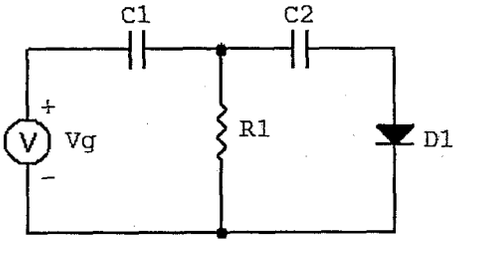

Figure Q6

a. State the Euler method and explain the importance of adaptive time step controlling in transient simulations. *[Marks 4]*
b. In transiant analysis the circuit is described by Differential equations, the general format of these equations are $\boldsymbol{Ex' + Gx - w(t) = 0}$. Formulate the given circuit according to this format using stamps. *[Marks 6]*
c. Setup the Euler method for above formulation and sketch a flow chart to describe the simulation of transient analysis of the circuit. *[Marks 10]*

Q6 Consider the circuit shown in Figure Q6. This circuit has Capacitors and a nonlinear component. It is needed to perform a transient analysis of this circuit.

a. What is the importance of selecting proper initial conditions for the Newton's method? *[Marks 4]*
b. In such a situation circuit equations become the format of $\boldsymbol{Ex' + Gx + p(x) - w(t) = 0}$. Obtain formulation according to this format using stamps. *[Marks 6]*

c. It is necessary to combine both Eular method and Newton's method to solve such an equation format. Develop an algorithm by combining both methods to solve such a system of equations. *[Marks 10]*

Q7 A two bit R-2R binary ladder Digital to Analog Convertor (DAC) is shown in Figure Q7. Assume that the Operational Amplifier is ideal.

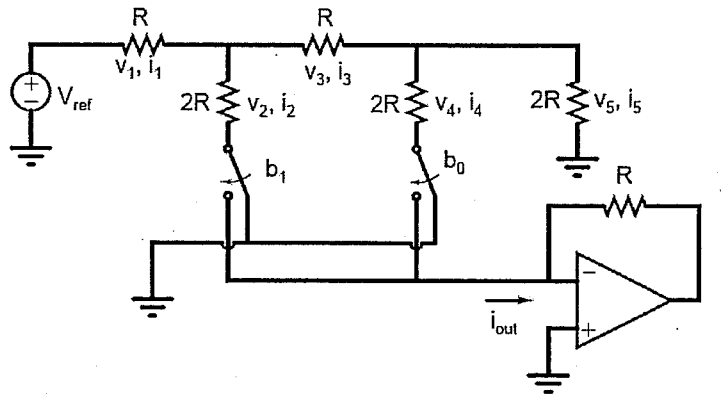

Figure Q7

a. Derive the adjoint network model for the network shown in Figure Q7. *[Marks 3]*
b. Obtain the nodal equations for adjoint network. *[Marks 3]*
c. Obtain the expression for the sensitivity of the output current i_{out} with respect to all elements. *[Marks 10]*
d. Explain the advantages of using adjoint network method for sensitivity analysis. *[Marks 4]*

Q8 A linear circuit containing two energy storage elements is shown in Figure Q8.

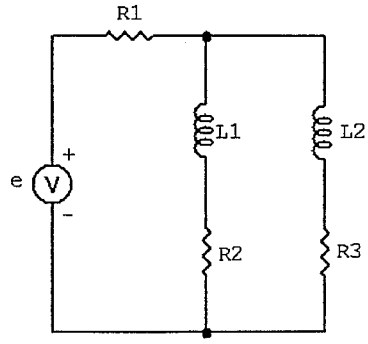

Figure Q8

a. Obtain the State Space equations for the circuit. *[Marks 4]*
b. Express this equations in the standard state equation form $\dot{x} = Ax + Bu$. *[Marks 6]*
c. Develop an algorithm to obtain the transient solution of the circuit shown in Figure Q8. (Hint – Use state equations and a numerical method) *[Marks 10]*

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