The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Bachelor of Technology - Level 05

103

ECX5231/ECU 3104 – Network Theory
Final Examination 2006/2007

Duration: 3 hours

Date: 30.03.2007 Time: 14.00-17.00

Answer ***five*** questions selecting **at least two** questions from each section. All questions carry equal marks.

SECTION –A

1 It is required to obtain the steady state DC voltages of the transistor amplifier circuit shown in figure A.

(a) Draw the companion network model for the given circuit using Ebers-Moll model of the transistor.

(b) Formulate the given circuit to find the nodal voltages using companion network models.

(c) List all tasks performed by a computer simulation package while obtaining the DC steady state solution for the given circuit.

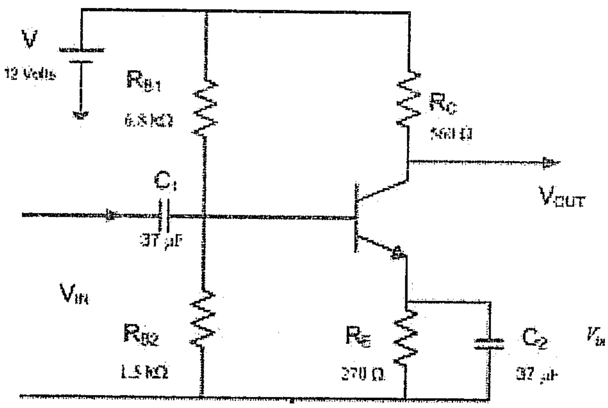

Figure A

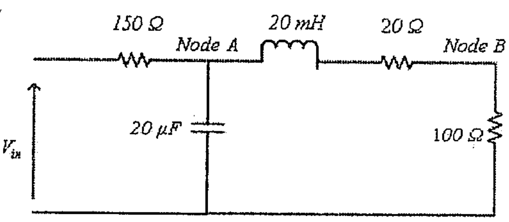

Figure B

2 A power filter circuit is shown in the figure B. It is required to obtain the step response when a 12 V step is applied to the circuit at zero initial condition.

(a) Redraw the circuit by replacing companion network models of the energy storing elements using backward Euler algorithm.

(b) Find nodal voltages for the time instances 0.2 ms, 0.4 ms, and 0.6 ms using a formulation on voltages at node A and node B.

(c) Briefly discuss the effect of step size T on the numerical stability, accuracy, and computational effort in transient analysis.

(d) Suggest a method to detect numerical instability while simulating the transient behavior of circuits.

3 Circuit shown in figure B has to be modeled with state space modeling. Also, it is needed to analyze the transfer characteristics between input and voltage across 100 Ω resistor.

(a) Represent the given network with state space model by selecting appropriate voltage(s) and/or current(s) as state variables.

(b) Obtain the transfer function using state space representation of the circuit.

(c) Briefly explain types of analysis that can be performed on the state space representation of an electrical network.

(d) Compare advantages and disadvantage of using state space representation when compared with companion network model representation.

4 For the circuit shown in figure A, it is required to determine the sensitivity of DC collector voltage against the variation of component values.

(a) Draw the simplified equivalent circuit representation of the given circuit by using Ebers-Moll model of the transistor.

(b) For the controlled source present in the simplified circuit

   i. Obtain the adjoin network model using the Tellegen's theorem.
   ii. Derive an expression to evaluate DC sensitivity with the variation of strength of the controlled source.

(c) Hence, draw the adjoin network model of the circuit shown in figure A.

(d) Calculate sensitivity of the collector voltage to the collector resistor. Assume DC solution to the base and collector currents of the original circuit are 15 μA and 1.4 mA respectively.

(e) Briefly discuss the advantages of using adjoin network method for sensitivity analysis.

SECTION –B

Electric network simulation using computers

Basically, electrical network simulation can be viewed as a two step process.

First, it is required to formulate the network to obtain steady state (DC/sinusoidal) or transient solution, the network may be linear or non linear. Before formulation, some transformations may be required for making it possible to use some common tools. For example Newton-Rapson algorithm can be used to linearize a non linear circuit and treat the resulted circuit as linear circuit. Numerical differentiation algorithms like backward Euler, trapezoidal rule, etc. play a similar role in transient analysis of dynamic circuits. Selection of appropriate step size in numerical differentiation, detection of numerical instability, calculation of gradient at each operating point, etc. are new issues that have to be addressed during simulation. Hence, the use of above mathematical tools causes complications to arise during the simulation process. Each developer of circuit simulators may adopt different techniques to handle above issues. Characteristics of complex devices can be represented using set of standard components. More accurate modeling of these devices causes more complexity of the model, hence more effort is needed to obtain the solution. Hence, the device library of a simulator affects to the performances of a circuit simulator. A number of alternative techniques are used to formulate electrical networks, and each may be more appropriate for one or a set of analysis. In addition to the ability to be implemented on computers, the popularity of a specific formulation technique depends on the ability to use it for more classes of networks and the ability to use it for many types of analysis directly or with some sort of transformations.

Second step of the simulation is the solution process. This process consumes more time and resources, hence tools used to solve the formulation significantly determine the utilization of computer resources. Because processing speed of the early era computers was low, it was the bottleneck at that era. Fortunately, it was a challenge to many engineering and scientific disciplines. Hence a rich set of solutions is presented to solve this problem, literatures that addressing the issue are also not uncommon. It is why electrical engineers have to be more aware on the first stage of simulation than the second. Also separation of above two processes offers the opportunity to develop them independently.

Formulation of a circuit may be a set of coupled linear equations or non linear/linear differential equations. Even though formulation of the dynamical network should be a set of differential equations, use of companion network modeling facilitates to the use of tools that solve ordinary linear equations. It is possible to exploit specific features of formulated electrical circuits to gain advantage while solving the equations. Even though techniques used to formulate electric network may be specific to electrical engineering, tools used to solve the formulations are not exclusive to electrical engineering.

Ability to represent the interconnection of the circuit in different ways, availability of more electrical/electronic device models and types are the front end features that makes a simulator colorful. But, successfulness in sharing powerful tools among the number of processes makes it more powerful. So, availability of the powerful circuit simulators having almost no restriction on the size of the circuit, types of the analysis, types of devices, etc. is not only due to the high computing power of modern computers.

5

(a) List the standard components used to represents the characteristics complex electronic devices during simulation of circuits.

(b) List types of analysis facilitated by modern simulators.

(c) Briefly explain what is meant by the parser of simulator.

6 Explain the dominance of Modified Nodal Analysis (MNA) using stamps with reference to the above scenario.

7

(a) Briefly describe one method of solving linear network equations in terms of resources utilization, applicability to solve formulations for various types analysis directly or with some sort of transformation, and other advantages.

(b) State one specific feature of electrical network equations that is exploited during the solution process.

(c) Briefly explain why there is net gain on the effort of exploitation of the above mentioned feature.

8 Draw the functional block diagram of a simulator used to perform transient and steady state (both DC/sinusoidal) behavior of linear and non linear circuits. Indicate all functional stages used up to the final stage that producing output.

9 Briefly discuss the necessity of followings and how they are carried/used in simulating electrical networks.

(a) Device model library.

(b) Setting initial conditions and step size in transient analysis of circuits.

(c) Testing convergence while solving non linear DC circuits.