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The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Bachelor of Technology Honors in Engineering – Level 5
ECX 5231 – Network Theory
Academic Year 2015/2016
Final Examination **Closed Book**
Date: 04 - 12 - 2016 **Time: 09:30 – 12:30**

This question paper consists of **six** questions. Answer **any four** questions. All questions carry equal marks.

Q1. Figure 1.1 shows a LTIC system which is having an input u(t) and two outputs $y_1(t)$ and $y_2(t)$.

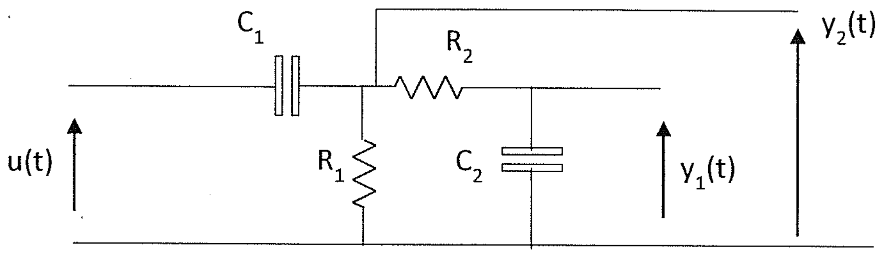

Figure 1.1

i. By selecting proper state variables, write state equations for the system given in figure 1.1. *(10 marks)*
ii. Represent the state equations in standard matrix form and clearly indicate the matrices A, B, C, and D as per the standard notation. *(05 marks)*
iii. Derive an expression for the zero-input response of the given system in terms of component values. Assume that, the initial voltages of C_1 and C_2 are 1 V and 2 V respectively. (Evaluation of state transition matrix is not required) *(05 marks)*
iv. Develop an algorithm to find the zero-input response of the system and interpret it using a flow chart. Period of response is T (0 to T seconds). Calculation step size should be T/100. *(05 marks)*

Q2. A first order RL circuit has series connected 10 mH inductor and a 10 Ω resistor. The circuit is energized at t = 0 s using a 48 V DC source. Initial current through the circuit before energizing is zero.

i. Using Backward Euler method of integration, formulate the companion model of energy storing element for nodal analysis. (Time step = 1 μs) *(05 marks)*
ii. Draw the complete equivalent circuit using the companion model. *(05 marks)*
iii. Calculate the current through the circuit at 1 μs, 2 μs and 5 μs. *(10 marks)*
iv. Develop an algorithm to generate the transient response of the current through the circuit and interpret it using a flow chart. *(05 marks)*

Q3. State equations of a LTI system are given below.

$$[\dot{x}(t)] = [A]x(t) + Bu(t)$$

$$y(t) = [C]x(t) + Du(t)$$

(i) Using Laplace transform, convert the state space equations in to s-domain. *(02 marks)*
(ii) Obtain an expression for the transfer function of the system in matrix form. *(05 marks)*
(iii)Using the matrices given below, obtain the transfer function of the system. *(10 marks)*

$$A = \begin{bmatrix} -10 & 10 \\ 10 & -10100 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 100 \end{bmatrix}, C = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, D = [0]$$

(iv)Using the transfer function obtained in (iii), calculate the magnitude of the given system at following frequencies. You may consider the input to the system is always kept at unity (1 unit) for all the frequencies. *(03 marks)*

a. 10 rads^{-1}
b. 100 rads^{-1}

(v) Develop an algorithm to find the frequency response (magnitude only) of the system and interpret it using a flowchart. *(05 marks)*

Q4. Consider the pure resistive circuit given in figure 4.1.

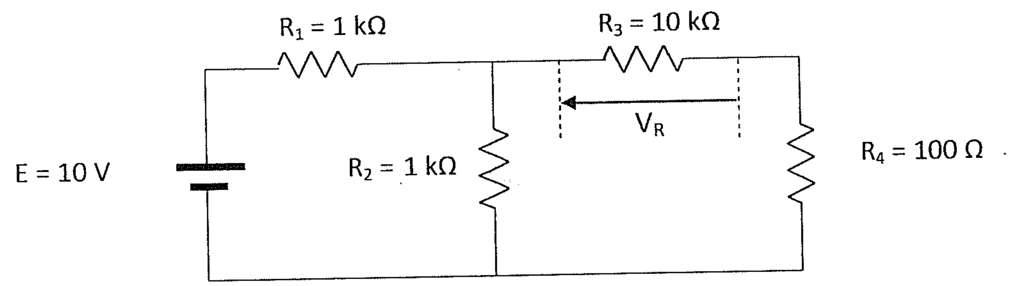

Figure 4.1

i. Draw the adjoint network for the circuit shown in figure 4.1. Use standard notation to mark currents and voltages. *(05 marks)*
ii. Using the extended Tellegen's theorem find the sensitivity of output voltage V_{out} for changes in each element R_1, R_2, R_3 and R_4 separately. Assume a change in only one component at a time. *(15 marks)*
iii. If R_2 has a tolerance of 10%, calculate the range of variation of V_R. Assume all other components have their designated values. *(05 marks)*

Q5. A JFET amplifier circuit is shown in Figure 5.1. The high frequency model of the JFET is shown in figure 5.2. Assume that the circuit is working in steady state.

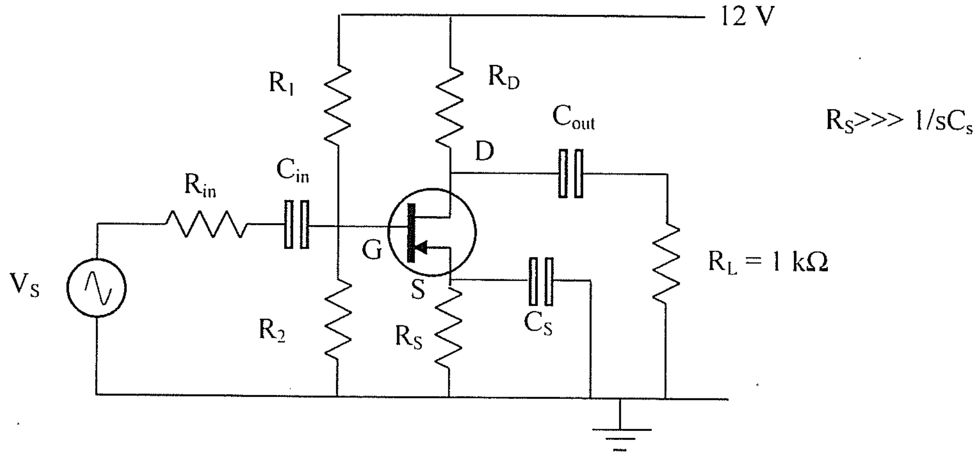

Figure 5.1: JFET Amplifier circuit

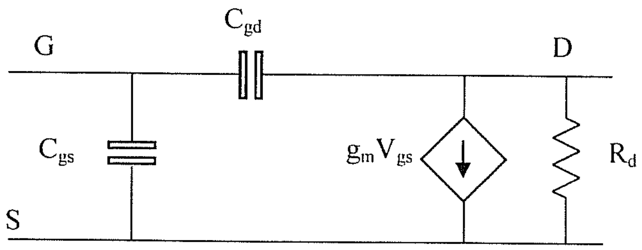

Figure 5.2: JFET high frequency model

i. Using the high frequency model of the JFET shown in figure 5.2, draw the high frequency (HF) equivalent circuit of the circuit shown in figure 5.1. Clearly state the assumptions you made. (You may simplify the circuit appropriately) *(10 marks)*

ii. Use Nodal analysis to set the stamps for each element in the equivalent circuit. *(10 marks)*

iii. Write the matrix equation for the circuit, with the help of stamps you have set in (ii). *(05 marks)*

Q6.

i. Explain the benefits of using state space modeling of a higher order system. *(05 marks)*

ii. Describe the advantage of use of companion models in transient analysis. *(05 marks)*

iii. Explain why LU factorization is advantageous in nodal analysis. *(05 marks)*

iv. Matrices obtained by applying nodal analysis to a system are given below. Use LU factorization method to find the nodal voltages of the system. *(10 marks)*

$$Y = \begin{bmatrix} 1 & 0 & 2 \\ 2 & -1 & 3 \\ 4 & 1 & 8 \end{bmatrix}, I = \begin{bmatrix} -4 \\ -6 \\ -15 \end{bmatrix}, V = \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$