The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

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Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX5531/ECX5231 Network theory**
Academic Year	: 2017/18
Date	: 05^{th} February 2019
Time	: 1330-1630hrs
Duration	**: 3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Seven (7)** questions in **Five (5)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Relevant charts/ codes are provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear hand writing.
8. Do not use Red colour pen.

Q1. Figure 1 shows a LTIC system which is having an input u(t) and two outputs $y_1(t)$ and $y_2(t)$.

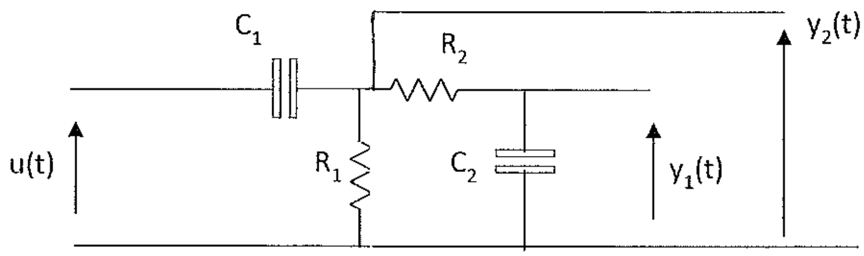

Figure 1

i. By selecting proper state variables, write state equations for the system given in figure 1. *(08 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. *(03 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. *(04 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). Step size should be T/100. *(05 marks)*

Q2. Consider the circuit given in figure 2.

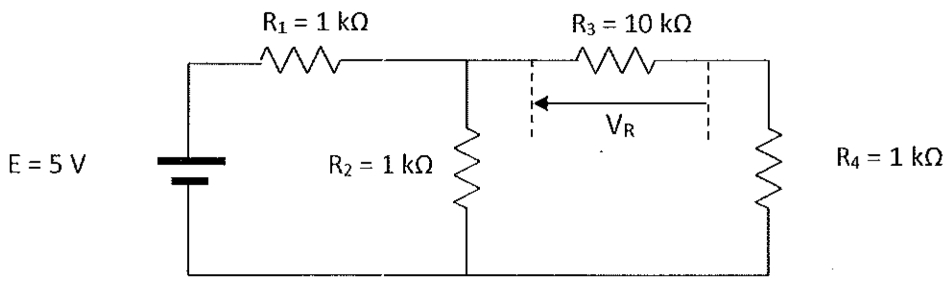

Figure 2

i. Draw the adjoint network for the circuit shown in figure 2. Use standard notation to mark currents and voltages. *(05 marks)*

ii. Using the extended Tellegen's theorem, find the sensitivity of output voltage V_R 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. *(10 marks)*

iii. If R_2 has a tolerance of 20%, calculate the range of variation of V_R. Assume all other components have their designated values. *(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. *(02 marks)*

iii. Using the matrices given below, obtain the transfer function of the system. *(08 marks)*

$$A = \begin{bmatrix} -200 & 200 \\ 1000 & -11000 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 10000 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, D = [0]$$

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. A first order RL circuit has series connected 5 mH inductor and a 10 Ω resistor. The circuit is energized at t = 0 s using a 48 V DC source. Assume the initial current as 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. *(02 marks)*

iii. Calculate the current through the circuit at 1 μs, 2 μs and 5 μs. *(08 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)*

Q5. A JFET amplifier circuit is shown in Figure 3. The high frequency model of the JFET is shown in figure 4. Assume that the circuit is working in steady state.

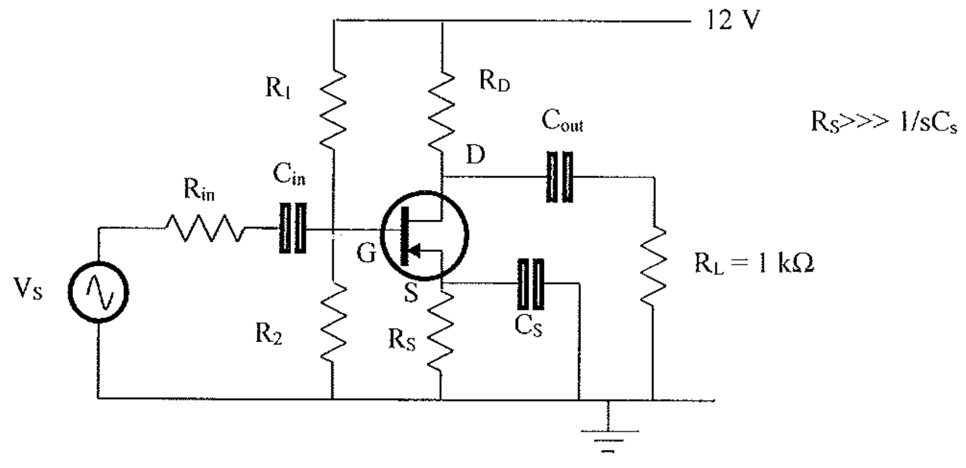

Figure 3: JFET Amplifier circuit

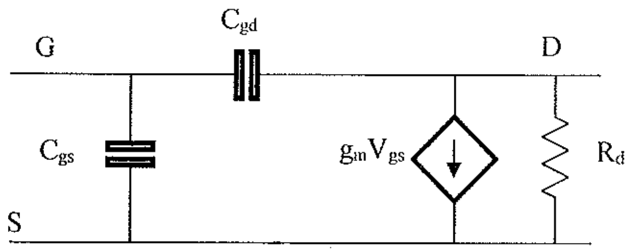

Figure 4: JFET high frequency model

i. Using the high frequency model of the JFET shown in figure 4, draw the high frequency (HF) equivalent circuit of the circuit shown in figure 3. Clearly state the assumptions you made. (You may simplify the circuit appropriately)

(05 marks)

ii. Set the stamps for each element in the equivalent circuit using nodal analysis.

(10 marks)

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

(05 marks)

Q6. Figure 5 shows an electric circuit consisting passive elements and two AC voltage sources.

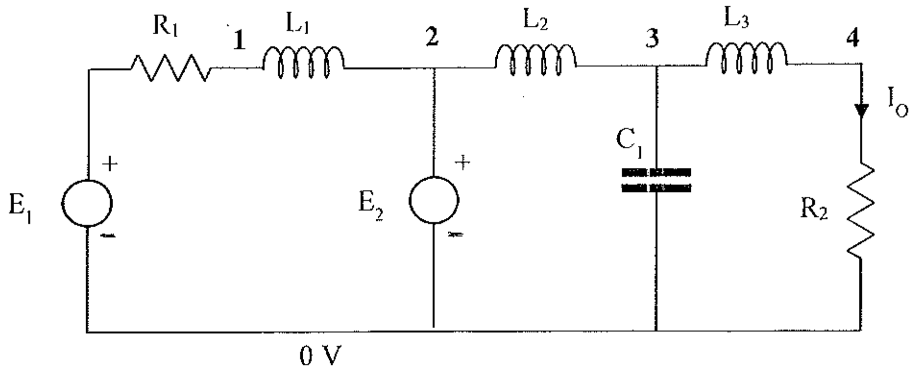

Figure 5

i. Set the stamps for each element of the circuit using nodal analysis. *(10 marks)*

ii. Write the matrix equation to find the voltages at points 1, 2, 3, 4 and output current I_O using the stamps you have obtained in (i). *(10 marks)*

Q7.

a) Consider the circuit shown in figure 6.

i. Show how the circuit shown in figure 6 is solved using graphical method. You may draw graphs and qualitatively indicate necessary details. *(05 marks)*

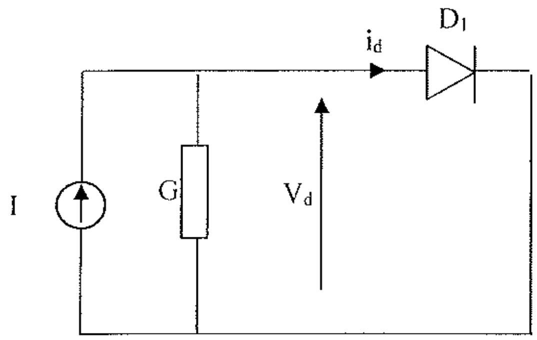

Figure 6

ii. Develop the companion model of the diode. *(05 marks)*

b) A circuit with two diodes D_1 and D_2 is shown in figure 7. Characteristic equation of any of the diodes is given by $i_d = I_s\left(e^{\lambda V_d} - 1\right)$. Assume $I_s = 1 \times 10^{-13}$ A and $\lambda = 1/0.026\ V^{-1}$.

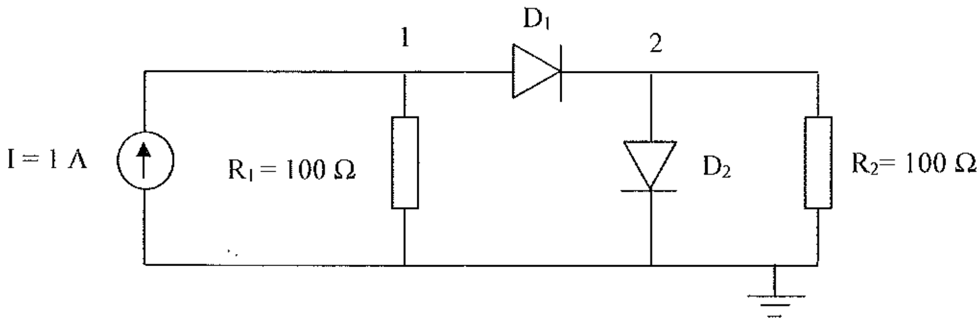

Figure 7

i. Formulate the matrix equation using non-linear analysis for modified nodal analysis. You may use the companion model of the diode you have developed in (a) ii of this question. *(03 marks)*

ii. Write the steps of the algorithm to calculate the nodal voltages of the circuit. *(04 marks)*

iii. Draw a flow chart to represent the algorithm you have used in (ii). *(03 marks)*