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

004

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX5531 Network theory**
Academic Year	: 2021/22
Date	: 14th February 2023
Time	: 1330-1630 hrs
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. No charts/ codes are provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear handwriting.
8. Do not use Red colour pen.

Question 01

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

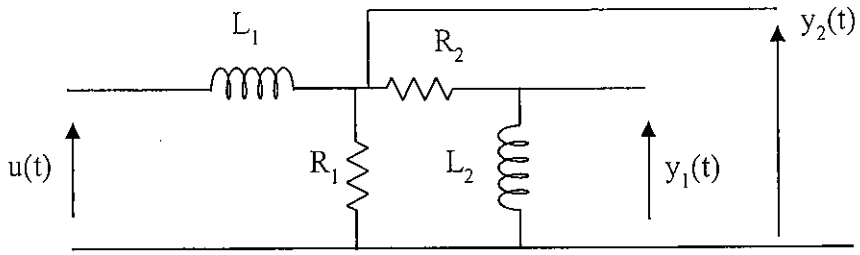


Figure Q1

i. Write state equations for the system given in Figure Q1, by selecting proper state variables. *(05 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 currents of L_1 and L_2 are similar and equal to 0.1 A. 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)*

Question 02

Consider the circuit shown in Figure Q2. All sources that are in the form of $A_m \sin \omega t$, operates in the same phase and the frequency is 106.1 Hz. Assume that the circuit is working at the steady state.

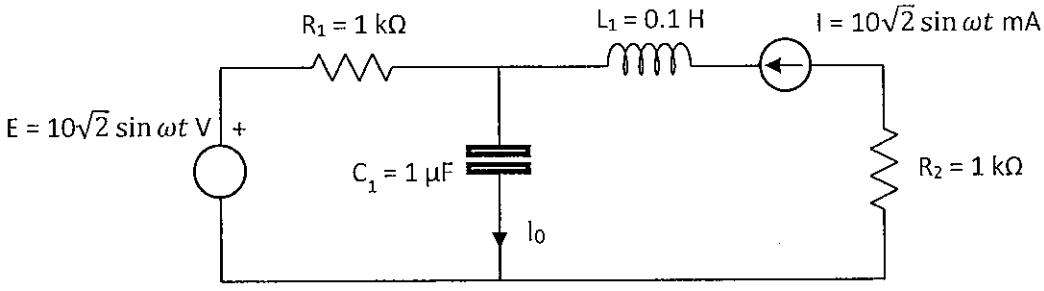


Figure Q2

i. Draw the adjoint network for the circuit shown in Figure Q2. Use standard notation to mark currents and voltages in the adjoint network. *(10 marks)*

ii. Using the extended Tellegen's theorem, find the sensitivity of the current through C_1 (I_0) for changes in each element R_1, R_2, L_1 and C_1 separately. Assume that a change in

only one component at a time. *(10 marks)*

Question 03

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 into 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)*

$$A = \begin{bmatrix} -400 & 200 \\ 1000 & -10000 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 11000 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, D = [0]$$

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. 100 $rads^{-1}$
   b. 10000 $rads^{-1}$

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

Question 04

A first order RL circuit has series connected 20 mH inductor and a 1.5 kΩ resistor. The circuit is energized at t = 0 s using a 15 V DC source. Initially, energy stored in the inductor is zero.

i. Using Backward Euler method of integration, formulate the companion model of energy storing element for nodal analysis. (Time step = 10 µs) *(03 marks)*

ii. Draw the complete equivalent circuit using the companion model. *(02 marks)*

iii. Write the matrix equation of the equivalent circuit to find the current through the circuit. *(05 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)*

v. Solving the matrix equation, calculate the current through the circuit at 10 µs, 20 µs and 50 µs. *(05 marks)*

Question 05

Consider the JFET amplifier circuit shown in Figure Q5.1. The high frequency model of the JFET is shown in Figure Q5.2. Assume that the circuit is operating at the steady state.

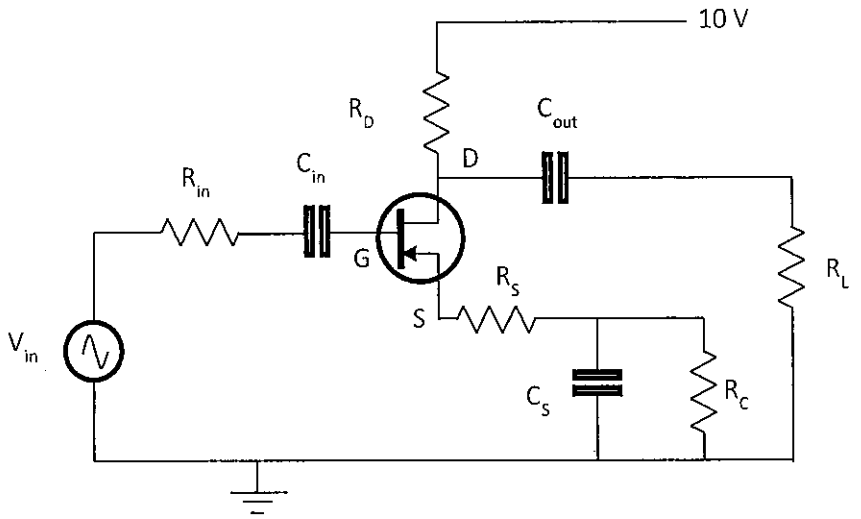


Figure Q5.1

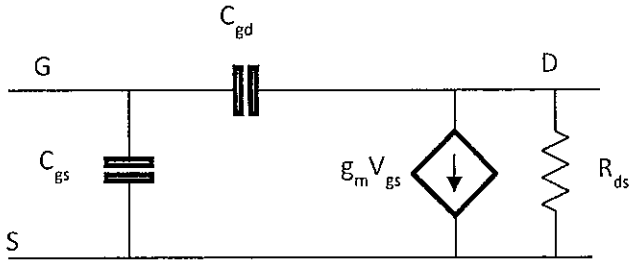


Figure Q5.2

i. Draw the high frequency equivalent circuit of the JFET circuit shown in Figure Q5.1, using the high frequency model of the JFET shown in Figure Q5.2. Clearly indicate the assumptions you make. *(05 marks)*

ii. Write the stamps for each element using modified nodal analysis. *(08 marks)*

iii. Write the matrix equation of the circuit to find the voltages at all nodes and current I_L from Gate to Source, using the stamps you have set in (ii). Solving the equation is not required. *(07 marks)*

Question 06

Figure Q6 shows an electric circuit consisting passive elements and three AC sources.

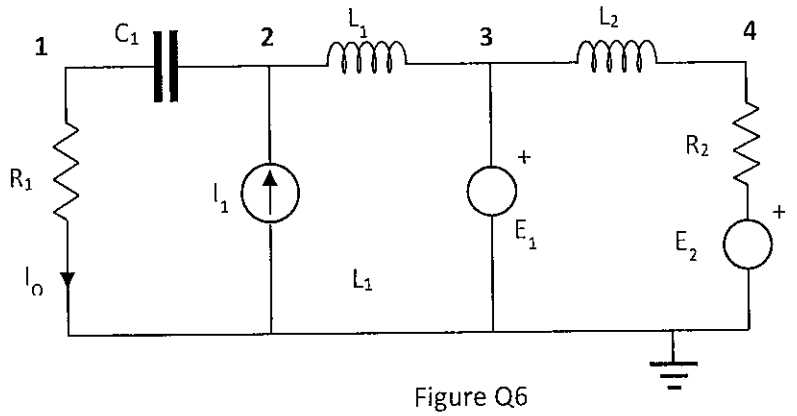


Figure Q6

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

ii. Write the matrix equation to find the voltages at nodes 1, 2, 3, 4 with respect to ground, and output current I_O using the stamps you have obtained in (i). Solving the equation is not required. *(10 marks)*

Question 07

a) Consider the circuit shown in figure Q7.1.

i. Show how the circuit shown in figure Q7.1 is solved using graphical method. You may draw graphs and qualitatively indicate necessary details. *(05 marks)*

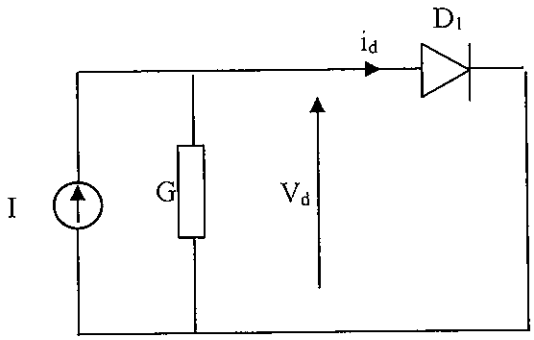


Figure Q7.1

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 Q7.2. 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 $\lambda = 1/0.026\ V^{-1}$.

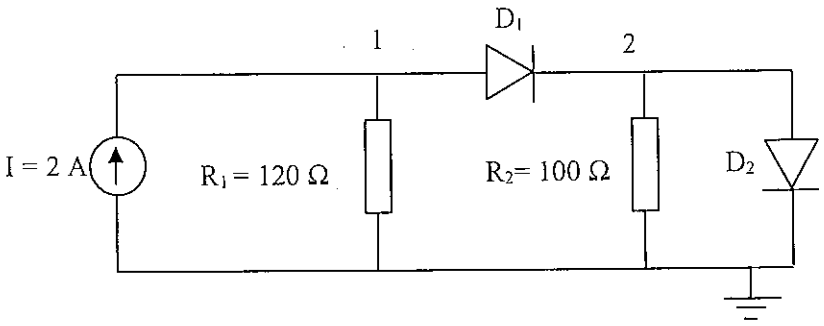


Figure Q7.2

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. With the help of the matrix equation obtained in part i, 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)*