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

00042

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX7231 Advanced Circuit Design and Analysis**
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 **Five (5)** questions in **Four (4)** pages.
3. Answer all **Five (5)** questions.
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 – (30 marks)

Figure Q1 shows a circuit which is having an input u(t) and two outputs $y_1(t)$ and $y_2(t)$. Answer the questions based on the circuit.

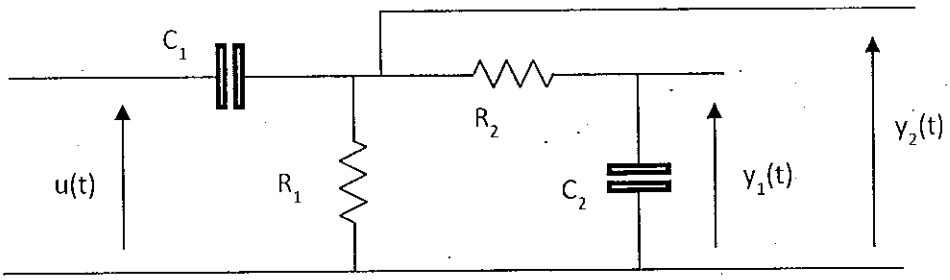

Figure Q1

$R_1 = 1000\ \Omega, R_2 = 1000\ \Omega, C_1 = 0.1\ \mu F, C_2 = 0.1\ \mu F$

i. Write down the most suitable state variables to represent the circuit response in state-space. *(02 marks)*

ii. Derive the state and output equations in standard matrix form and clearly indicate the matrices A, B, C, and D as per the standard notation. *(08 marks)*

iii. Derive an expression for the zero-input response of the given system in terms of component values. Assume that initial voltage of C_1 and C_2 are similar and equal to 50 mV. 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)*

v. Using Laplace transform, convert the state and output equations into s-domain. *(05 marks)*

vi. Derive an expression for the transfer function of the system in matrix form. *(05 marks)*

Question 02 – (15 marks)

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

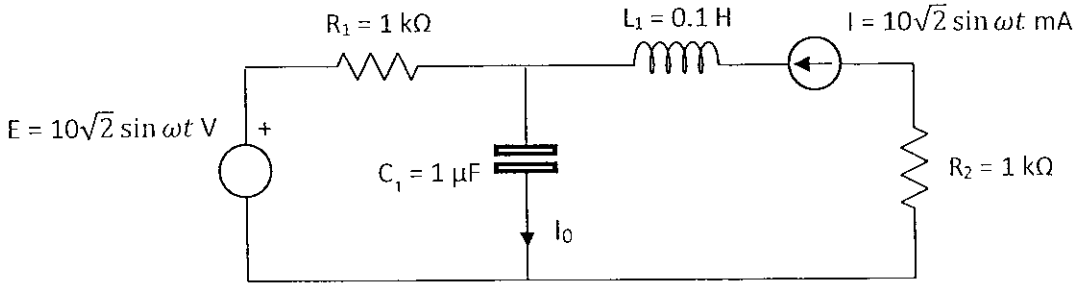

Figure Q2

i. Draw the adjoint network for the circuit shown in Figure 2. Use standard notation to mark currents and voltages in the adjoint network. *(05 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 a change in only one component at a time. *(10 marks)*

Question 03 – (25 marks)

Figure Q3 shows an RC circuit powered by a constant DC voltage source of 10 V. The circuit is energized at t = 0 s using the DC voltage source. Initially, the charge stored in the capacitors are zero.

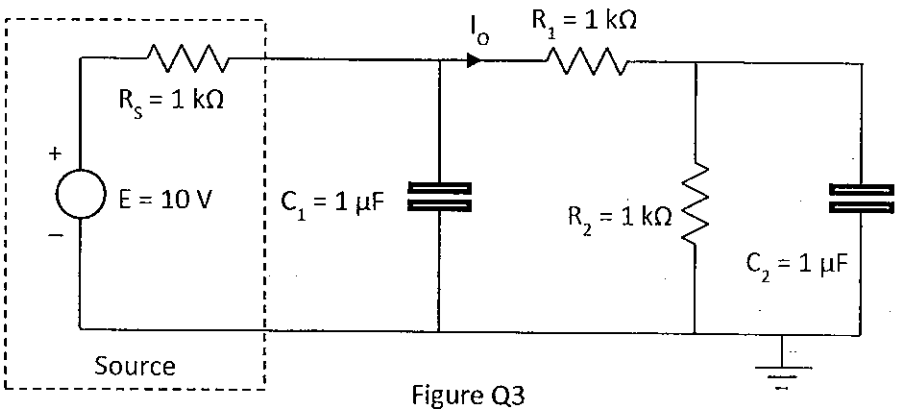

Figure Q3

i. Using Backward Euler method of integration, formulate the companion model of the capacitor for nodal analysis. (Time step = 10 μs) *(05 marks)*

ii. Draw the complete equivalent circuit replacing the capacitors with their companion models. *(05 marks)*

iii. Write the matrix equation of the equivalent circuit to find the current (I_0) through the resistor R_1. *(05 marks)*

iv. Develop an algorithm to generate the transient response of the current I_0 and interpret it using a flow chart. *(05 marks)*

v. Calculate the current I_0 at 20 μs. *(05 marks)*

Question 04 – (15 marks)

Consider the JFET amplifier circuit shown in Figure Q4.1. The high frequency model of the JFET is shown in Figure Q4.2. Assume that the circuit is operating at steady state.

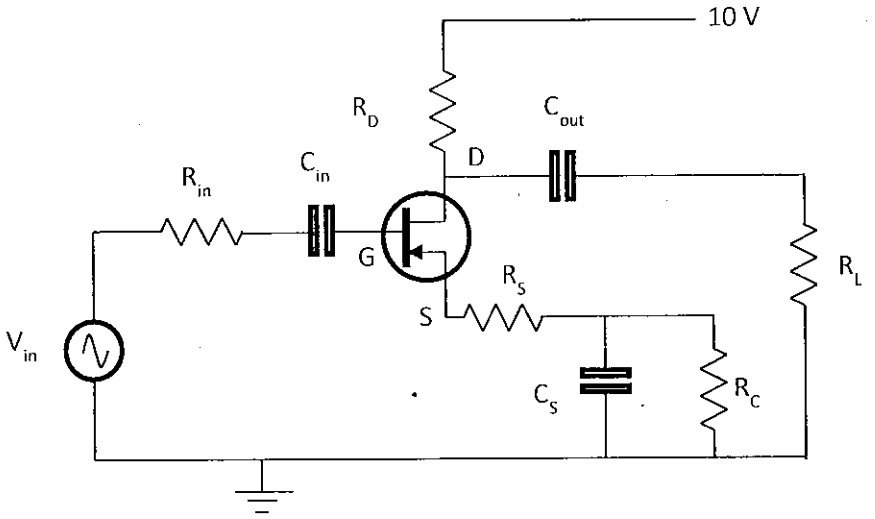

Figure Q4.1

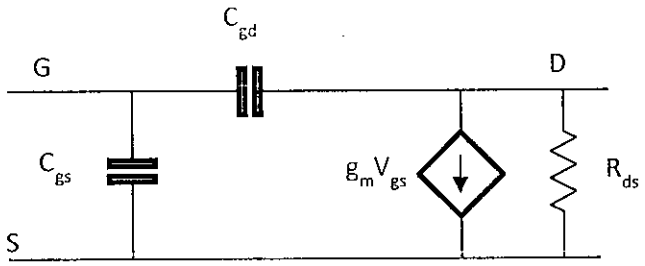

Figure Q4.2

i. Draw the high frequency equivalent circuit of the JFET circuit shown in Figure Q4.1, using the high frequency model of the JFET shown in Figure Q4.2. Clearly indicate the assumptions you make. *(04 marks)*

ii. Write the stamps for each element using modified nodal analysis. *(06 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. *(05 marks)*

Question 05 – (15 marks)

Figure Q5 shows an electric circuit consisting passive elements and three AC sources.

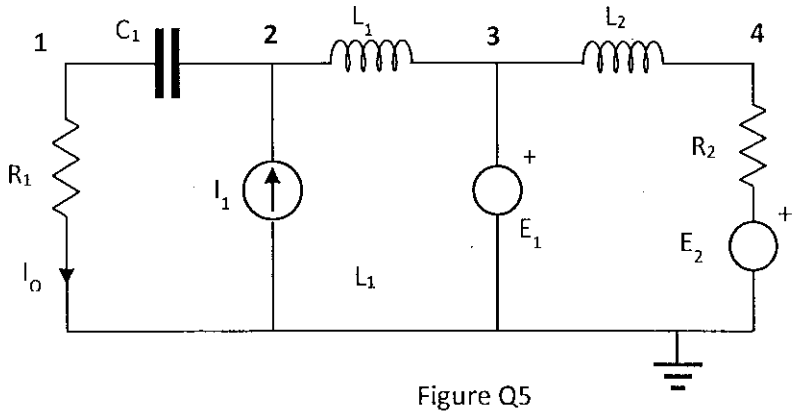

Figure Q5

i. Write the stamps for each element of the circuit using modified nodal analysis *(09 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. *(06 marks)*