University of Ruhuna - Faculty of Technology

Bachelor of Engineering Technology Honours Degree
Level 3 (Semester I) Examination, June 2023
Academic year 2021/2022

Course Unit: ENT 3142 – Circuit Analysis and Fault Diagnosis (Written)

Duration: 2 hours

- This paper contains **four (04)** questions on **three (03)** pages.
- Answer all the questions.
- Each question carries equal marks.
- This is a **closed book** examination.

- **If you have any problem with the interpretation of a wording of a question you may use your own interpretation clearly mentioning it.**
- **You may make any suitable assumptions and approximations in your calculations, clearly stating and justifying them where necessary.**

Q1. Consider the two-port network shown in Figure Q1a.

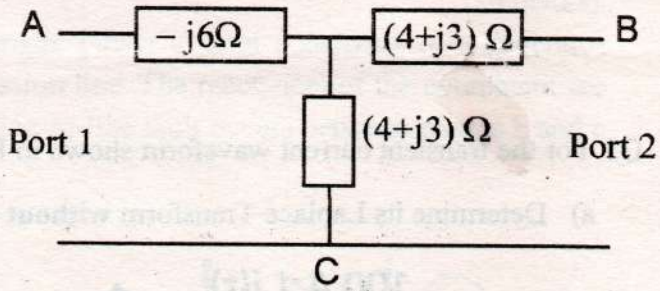


Figure *Q1a*

a)

i. Obtain the **Y-parameter matrix**. (20 marks)

ii. Hence, find its **Z-parameter matrix**. (10 marks)

b) Answer the following questions for the circuit shown in Figure Q1b.

i. Redraw the circuit replacing the voltage source by an **equivalent current source**. (10 marks)

ii. By suitably numbering the nodes, determine the **node branch incidence matrix**. (20 marks)

iii. Using the result in part ii) or from other method, determine the **nodal admittance matrix**. (20 marks)

iv. Using nodal analysis, determine the **branch currents** in all the branches of the original circuit. (20 marks)

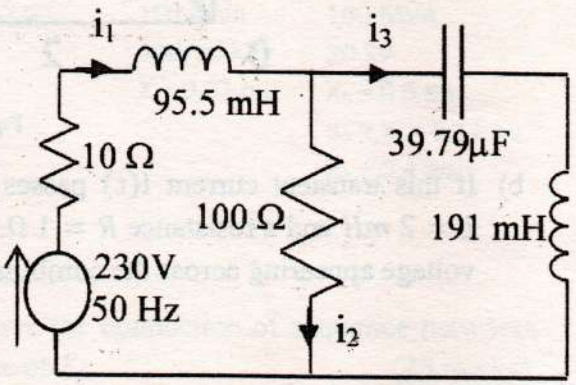


Figure *Q1b*

Q2. The following Figure Q2a shows the current $i(t)$ passing through a certain device.

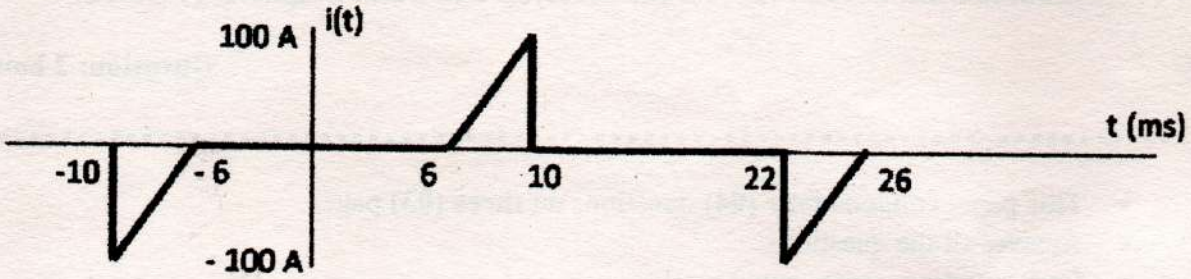


Figure *Q2a*

a) State whether the waveform shows any **symmetrical properties** along with a **mean value.** (15 marks)

b) State the significance of these properties in determining the Fourier series. (30 marks)

c) What is the **period** and the fundamental **angular frequency** of the waveform? (15 marks)

d) Determine the **Fourier series** of this current $i(t)$ to three significant terms. (40 marks)

Q3. For the transient current waveform shown in Figure Q3a,

a) Determine its Laplace Transform **without using first principles.** (30 marks)

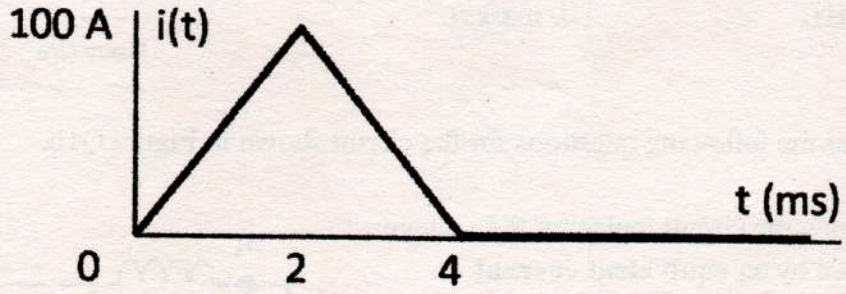


Figure *Q3a*

b) If this transient current $i(t)$ passes through a series combination of an inductance $L = 2\,mH$ and a resistance $R = 1\,\Omega$, determine an expression for the transform of the voltage appearing across the combination. (30 marks)

c) Figure Q3b shows a circuit in which the capacitor C is charged to a voltage of $V_0 = 40\,V$ when the switch S is closed at $t = 0$. If $E_m = 100\,V$, $\omega = 250\,rad/s$, $L = 50\,mH$, $r = 10\,\Omega$, $R = 100\,\Omega$, $C = 40\,\mu F$, draw the equivalent circuit in the Laplace domain, indicating all significant values. (40 marks)

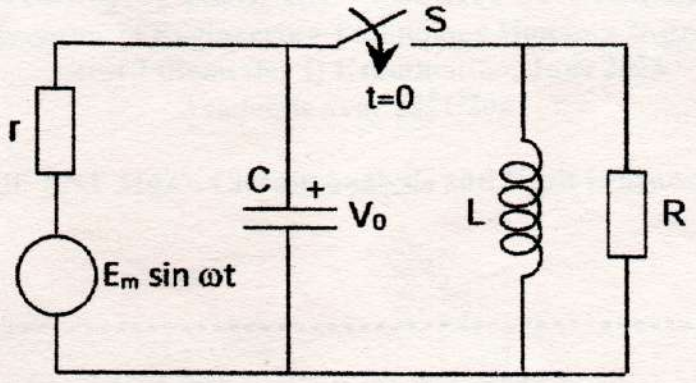


Figure *Q3b*

Q4.

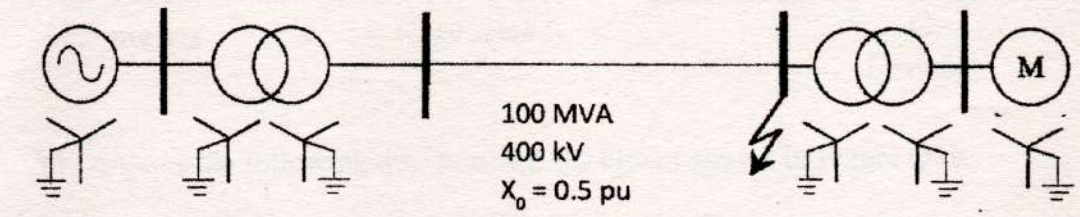
a) State the basic two (02) types of **power system faults**. (10 marks)

b) Show that when the **three unbalanced phasors** a, b and c are represented by positive, negative and zero sequences, the unbalanced phasors and the **sequence networks** are related through the matrix,

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix}$$

where $\alpha = 1\angle 120^0$. (20 marks)

c) The following Figure Q4a shows a simple power system consisting of a generator feeding a motor load through a transmission line. The reactances of the equipment are mentioned underneath them. A bolted line-to-line fault occurs between phases b and c at the location shown.



100 MVA
20 kV
$X_0 = 0.5$ pu
$X_1 = X_2 = 0.12$ pu
$X_n = 0.4$ pu

100 MVA
20/400 kV
$X = 0.07$ pu

100 MVA
400/20 kV
$X = 0.07$ pu

100 MVA
20 kV
$X_0 = 0.5$ pu
$X_1 = X_2 = 0.12$ pu
$X_n = 0.4$ pu

Figure *Q4a*

i. Using symmetrical component analysis, derive the connection of sequence networks for a **line-to-line fault** with a fault impedance of Z_f. (25 marks)

ii. For a bolted line-to-line fault at the shown location, obtain the **positive**, **negative** and **zero** sequence networks considering $S_{base} = 100\ MVA$. (30 marks)

iii. Determine the magnitudes of currents in each phase during the fault. (15 marks)

---------- **End of the paper** ----------