

**GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY**

Faculty of Engineering

Department of Electrical, Electronic and Telecommunication Engineering

BSc Engineering Degree

Semester 2 Examination – November 2022

(Intake 39,38,37,36,35 - EE/ET/BM/MC/ME)

EE 1203 – THEORY OF ELECTRICITY

Time allowed: 3 hours

23 November 2022

ADDITIONAL MATERIAL PROVIDED

Table of Laplace Transforms

Graph Paper, if requested.

INSTRUCTIONS TO CANDIDATES

This paper contains 5 questions on 5 pages

Answer All questions.

This is a closed book examination

This examination accounts for 70% of the module assessment. A total maximum mark obtainable is 100. The marks assigned for each question and parts thereof are indicated in square brackets. The relevant learning outcomes are also indicated with the question number.

If you have any doubt as to the interpretation of the wordings of a question, make your own decision, but clearly state it on the script

Assume reasonable values for any data not given in or provided with the question paper, clearly make such assumptions made in the script

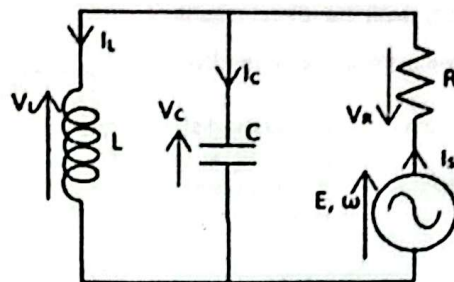
All examinations are conducted under the rules and regulations of the KDU

Table of Laplace Transforms of common causal functions $f(t)$

Causal $f(t)$	$F(s) = \mathcal{L}[f(t)]$
Unit Impulse $\delta(t)$	1
Unit Step $H(t)$	$\frac{1}{s}$
Unit Ramp t	$\frac{1}{s^2}$
e^{-at}	$\frac{1}{(s+a)}$
$t \cdot e^{-at}$	$\frac{1}{(s+a)^2}$
$\sin(\omega t)$	$\frac{\omega}{(s^2 + \omega^2)}$
$\cos(\omega t)$	$\frac{s}{(s^2 + \omega^2)}$
$e^{-at} \cdot f(t)$	$F(s+a)$
$f(t-T)$	$e^{-as} \cdot F(s)$

$$\frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ \alpha & \alpha^2 & \alpha^3 \\ \alpha^2 & \alpha^3 & \alpha^4 \end{bmatrix}$$

Question 1 [LO1]

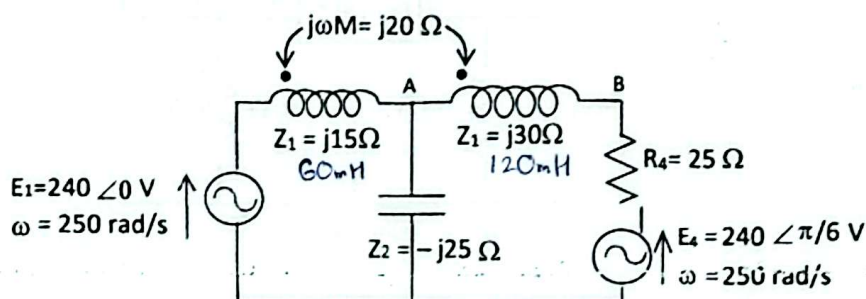


$$\begin{aligned} E &= 250V \\ \omega &= \omega \text{ rad/s} \\ L &= 160\text{mH} \\ C &= 200\mu\text{F} \\ R &= 25\Omega \end{aligned}$$

Figure 1abcd

For the circuit shown in figure Q1abcd,

- Obtain an expression for the parallel impedance of inductor L and capacitor C in terms of ω . [4 marks]
- Determine an expression for the total impedance seen by the source. [2 marks]
- Determine the numerical value of ω required for parallel resonance to occur. [2 marks]
- Under this condition of resonance, determine the current supplied by the source and the voltage across the inductor. [2 marks]
- For the circuit shown in figure Q1efg, convert the circuit with mutual coupling to an equivalent circuit with no mutual coupling and redraw the circuit



[4 marks]

Figure Q1efg

- Mark the relevant mesh currents on the non-coupled diagram and write down the Kirchhoff's voltage law equation for these meshes. [3 marks]
- Determine the loop currents. [3 marks]

Question 2 [LO2]

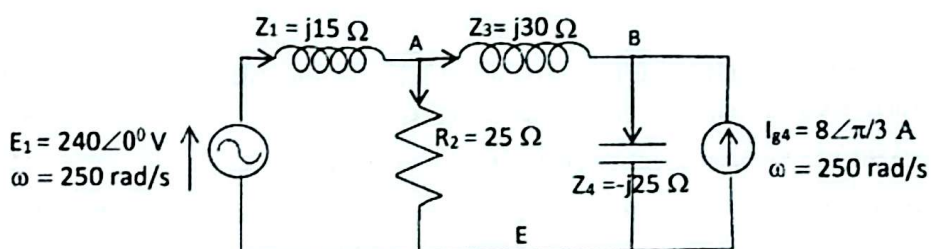


Figure Q2abc

For the circuit shown in Figure Q2abc,

- Convert the current source to a voltage source and redraw the circuit for mesh analysis, including marking the relevant independent loops. [2 marks]
- Write down the branch-mesh incidence matrix and the branch voltage vector. [4 marks]
- Determine the mesh impedance matrix and the mesh voltage vector. [4 marks]

d) For the circuit shown in figure Q2d,

- convert the dependent current source, with no direct shunt admittance, to equivalent dependent voltage sources. [4 marks]
- write down the Kirchhoff's circuit equations [2 marks]
- determine the currents in all the branches [4 marks]

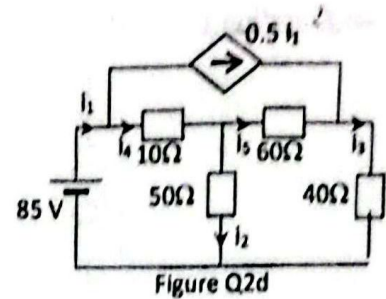


Figure Q2d

e) Write down the two port parameter matrices for the 2 diagrams shown in figure Q2e. [4 marks]

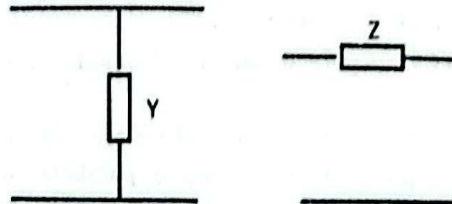


Figure Q2e

f) Determine the ABDC matrix of the two-port network shown in figure Q2f. [6 marks]

$$\begin{bmatrix} 1 & 0 \\ y & 1 \end{bmatrix}$$

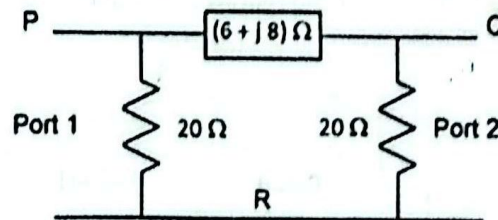


Figure Q2f

Question 3 [LO3]

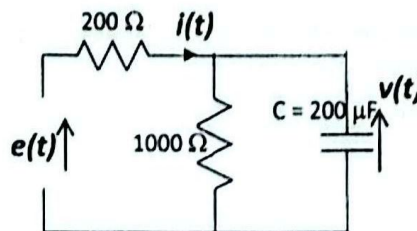


Figure Q3abc

- Laplace transform the circuit shown in figure Q3abc and obtain an expression for the transform of the current $I(s)$ in terms of the transform of the input voltage $E(s)$. [4 marks]
- Hence obtain the transfer function relating $I(s)$ with input voltage $E(s)$. [1 mark]
- If a 400V step is applied as $e(t)$, determine expression for the transient current $i(t)$. [5 marks]

Question 4 [LO4]

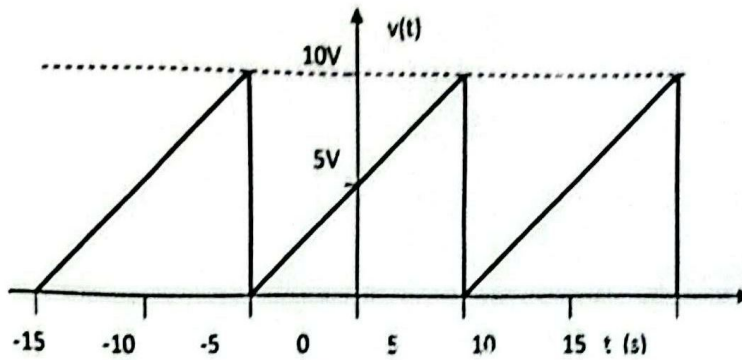


Figure Q4a

- a) For the voltage waveform $v(t)$ shown in figure Q4a, determine three significant terms of the Fourier series. [11 marks]
- Determine also the form factor and the peak factor of the voltage waveform. [4 marks]
- b) If a current $i(t) = 60 \sin 200t - 40 \sin 600t + 10 \sin 1000t$ is passed through a series combination of $R = 10 \Omega$ and $L = 50 \text{ mH}$, determine the Fourier series of the voltage across the combination. [3 marks]
- Determine also the active power dissipation in the circuit. [2 marks]

Question 5 [LO5]

A 415 V, 50 Hz, balanced 3 phase source supplies two 3-phase loads (i) a balanced star-connected load with each arm consisting of a series connection of a resistance $R = 20 \Omega$ and an inductance of $L = 40 \text{ mH}$, and (ii) a three-phase ac motor of 5 kW at a power factor of 0.65 lag.

- (a) Sketch the equivalent three-phase diagram for the system. [1 mark]
- Determine the line current supplied, the active and reactive power consumed by load 1. [4 marks]
- (b) Determine the line current supplied and the reactive power consumed by load 2. [2 marks]
- (c) Determine the total line current, the overall load power factor, the total active power and the total reactive power consumed. [4 marks]
- (d) Determine the rating of each of the 3 capacitors required to improve the load power factor to 0.98 by the use of a 3-phase, delta connected capacitor bank. [3 marks]
- (e) An unbalanced system with phase sequence A-B-C has the phase components of the current given as $I_A = 3.0 \angle 30^\circ \text{ A}$, $I_B = 4.8 \angle 0^\circ \text{ A}$ and $I_C = 2.0 \angle -30^\circ \text{ A}$. Determine the sequence components of the currents. [4 marks]
- (f) Determine the total active power in the unbalanced system if the sequence components of the voltage are given as $V_{A0} = 10 \angle 0^\circ \text{ V}$, $V_{A1} = 230 \angle 120^\circ \text{ V}$ and $V_{A2} = 50 \angle -60^\circ \text{ V}$. [2 marks]

End of answer script