University of Moratuwa, Sri Lanka

Faculty of Engineering

Department of Electrical Engineering

B. Sc. Engineering Honours Degree Course

Level 2 – Semester 1 Examination

EE201 – THEORY OF ELECTRICITY

Time Allowed: 3 Hours August 2006

Additional Material

Graph Paper will be provided if required.

Instructions to Candidates

This paper contains 7 questions in 4 pages.

This examination accounts for 70% of the module assessment.

Total marks for the paper is 70 marks.

The maximum mark attainable for each part is indicated in square brackets.

Answer **All** Questions.

This is a closed book examination and only authorised Calculators will be permitted.

Technical Information for candidates

Permeability of free space $\mu_0 = 4\,\pi \times 10^{-7}$ H/m

Permittivity of free space $\varepsilon_o = 8.854 \times 10^{-12}$ F/m

Velocity of light in free space = 2.998×10^{8} m/s

Question 1

(a) A certain alternating voltage source has an internal emf of 240 V at 50 Hz, an internal impedance of (10+j10) Ω and supplies a load of (R + jX). If the terminal voltage is to kept at 230 V, write down an equation to relate the magnitudes of the internal emf and the terminal voltage in terms of R and X. *[2 marks]*

(b) Determine the value of the R and X required to transfer maximum power to the load. *[5 marks]*

(c) Determine the values of this maximum power, and the load current under these conditions. *[1 marks]*

(d) Draw the phasor diagram showing the internal emf, the load voltage, voltages across R and X and the current under these conditions. *[2 marks]*

Question 2

(a) Briefly explain three significantly different methods of defining the resonance frequency of an R-L-C circuit. *[2 marks]*

(b) Figure Q2bc shows a circuit which is mutually coupled. Using first principles, convert it to a non-coupled circuit. *[3 marks]*

(c) Using the result of Q2(b) or otherwise, determine the resonance frequency and the current at resonance. *[2 marks]*

(d) Determine the frequencies at the half-power points. *[3 marks]*

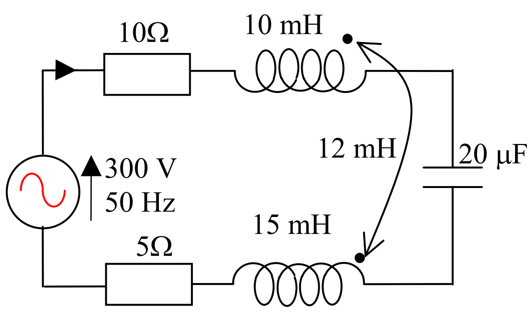

Figure Q2bc

Question 3

(a) For the circuit shown in figure Q3-4, find the Thevenin's equivalent circuit at the broken line ***B*.** *[4 marks]*

(b) Determine the z-parameter two-port matrix for the network shown in figure Q3-4 with the port 1 taken at the broken line at ***A*** and the port 2 taken at the broken line at ***B***. *[4 marks]*

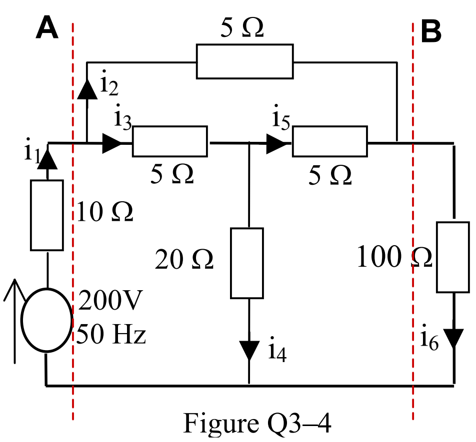

Figure Q3–4

Question 4

(a) For the circuit shown in figure Q3-4, write down the branch-mesh incidence matrix and the branch impedance matrix. *[2 marks]*

(b) Show how the mesh impedance matrix may be obtained from the branch-mesh incidence matrix and the branch impedance matrix. Hence or otherwise write down the mesh impedance matrix. *[2 marks]*

(c) Using matrix mesh analysis, determine the mesh currents. *[3 marks]*

(d) determine the currents in all the branches in figure Q3-4. *[3 marks]*

Question 5

A 3 phase, 50 Hz, 3-wire, balanced supply feeds, with a voltage of 400 V at the load end, (i) a balanced star connected load with each arm consisting of a series combination of an inductor L = 100 mH and a resistor R = 50 Ω, and (ii) a balanced three phase motor of rated at 1 kW running at full load at power factor 0.6 lag.

Determine

(a) the total line current supplied from the source *[3 marks]*

(b) the total reactive power supplied. *[1 marks]*

If each of the lines supplying the load has an impedance (l = 10 mH, r = 5 Ω), determine

(c) the voltage at the supply end of the line, *[2 marks]*

(d) the overall power factor at the source, and *[1 marks]*

(e) the capacitances that must be connected across the combined load to improve the power factor to 0.9 lag when the load voltage is 400 V. *[3 marks]*

Question 6

(a) Write down the matrix equation relating the phase voltages with the corresponding sequence components. *[1 marks]*

(b) Determine the phase components corresponding to the sequence components. *[3 marks]*

Positive sequence voltage = $200\angle 0^{o}$ V

Negative sequence voltage = $100\angle -30^{o}$ V

Zero sequence voltage = $50\angle 90^{o}$ V

(c) Using the results obtained in 6(b), show graphically, how the positive sequence component may be determined. *[2 marks]*

Question 7

(a) Very briefly explain the link between the Fourier Series, Fourier Transform and the Laplace Transform. *[2 marks]*

(b) Determine the Fourier Series of the periodic waveform i(t) shown in figure Q7b to 3 significant terms. *[6 marks]*

$i(t) = 100 \cos 314\, t$ for $0 < t \leq 0.005$

$i(t) = 100 - 20000.t$ for $0.005 < t \leq 0.01$

$i(t) = 300 - 20000.t/$ for $0.01 < t \leq 0.015$

$i(t) = -\,100 \cos 314\, t$ for $0.015 < t \leq 0.02$

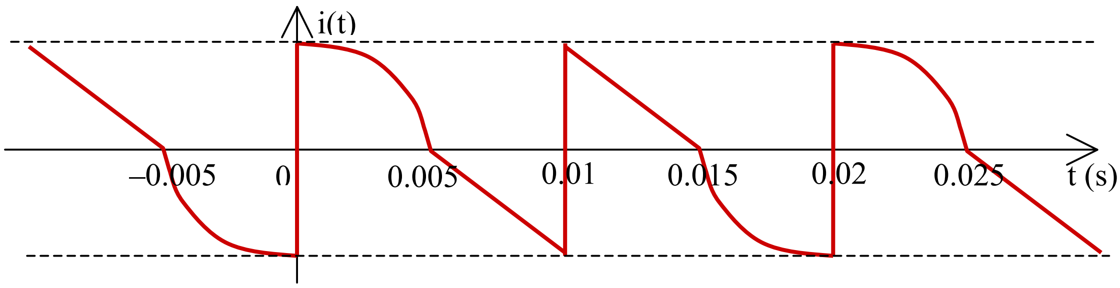

Figure Q7b

(c) If a current ***i(t) = 10 sin 314 t + 75 sin 628 t – 15 sin 942 t*** is supplied to a series RL circuit (R=10 Ω, L = 10 mH), determine an expression for the corresponding voltage across the circuit. *[1 marks]*

(d) Determine the Laplace Transform of the following:

a. causal ramp waveform ***t*** *[1 marks]*

b. causal step waveform ***h(t)*** *[1 marks]*

c. causal sine waveform ***sin ω t*** *[1 marks]*

d. causal waveform ***v(t)*** shown in figure Q7d. *[3 marks]*

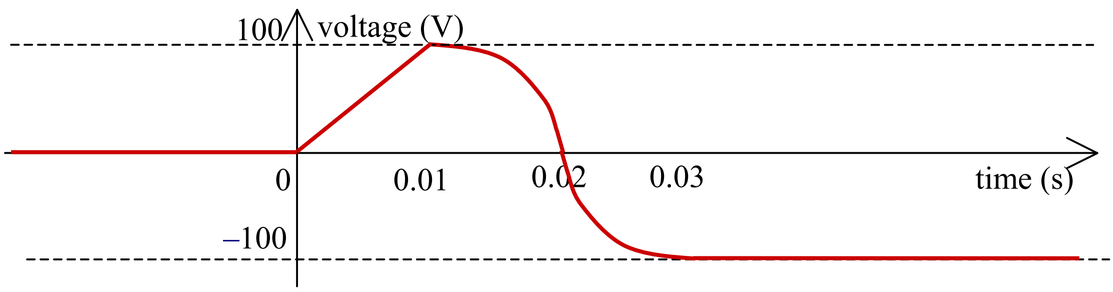

Figure Q7d

$v(t) = 10000\, t$ for $0 < t \leq 0.01$,

$v(t) = 100 \sin 50\pi\, t$ for $0.01 < t \leq 0.03$

(e) If the voltage waveform v(t) shown in figure Q7d is applied across a series RC circuit (R=10 Ω, C = 10 μF), show how an expression for the Laplace transform of the corresponding current in the circuit is determined. *[1 mark]*

[END OF QUESTION PAPER]