University of Moratuwa, Sri Lanka

B. Sc. Engineering Degree Course

Final Part I Examination 1999/00

UEE 201 - THEORY OF ELECTRICITY

0900 - 1200 hrs 30 May 2001

Answer **FIVE** Questions Only. Question 1 carries 28 marks, and all other Questions carry 18 marks each

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

1 (a) Obtain from first principles an equivalent circuit for the circuit shown in figure Q1ab in terms of non-coupled circuit elements only. [4 marks]

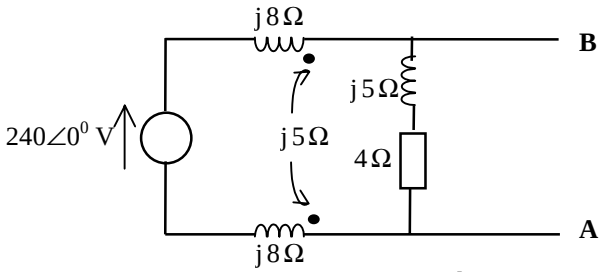

Figure Q1ab

(b) Using the results of (a) or otherwise, obtain the Norton's equivalent circuit across terminals **A** and **B** in figure Q1ab. [3 marks]

(c) For the circuit shown in figure Q1cde, calculate the value of the impedance connected across AC in the delta equivalent. [3 marks]

(d) Obtain the ABCD parameters of the two-port network shown in figure Q1cde. [4 marks]

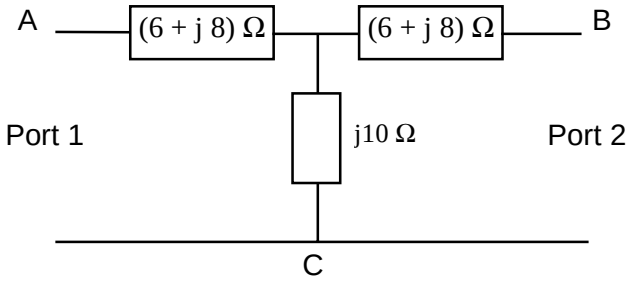

Figure Q1 cde

(e) Port 1 of the circuit shown in figure Q1cde is supplied from an alternating supply of 250 V, with port 2 on open circuit. Calculate and sketch the phasor diagram showing all the voltages and currents in the circuit. [4 marks]

(f) For the circuit shown in figure Q1f, what value of X will give maximum power to the load of 7 + j 3 Ω, and what will be the load voltage and load power under this condition. [4 marks]

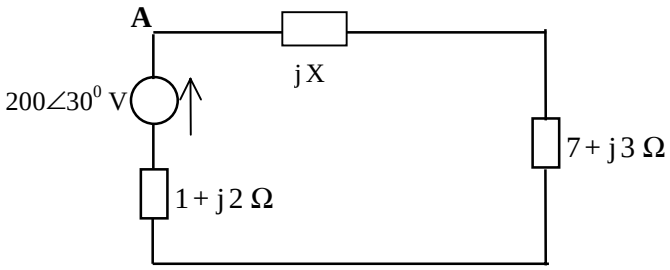

Figure Q1f

(g) A transformer with a magnetic material of relative permeability of 2000, equivalent magnetic length 150 mm and cross section area 75 mm^2 has an effective air gap of 1 mm in its perimeter. Determine the effective reluctance of the magnetic path. If one of the coils wound on a limb has 1000 turns, what would be the inductance of that coil. [3 marks]

(h) A capacitor is made up of two dielectric materials A and B of relative permittivity of 2.5 and 4, and thickness 1 mm and 3 mm respectively. If the cross-section of each dielectric is 500 mm^2 determine the total capacitance. If a potential difference of 200 V is applied across the composite dielectric, what would be voltage across each dielectric. [3 marks]

2 A capacitor of impedance 100 Ω, and two resistors each of value 141.4 Ω are connected in star, with star point S, from a balanced 400 V, 50 Hz, three phase supply ABC.

(a) Taking the A-phase voltage to be the reference, determine the voltage V_{SN} of the star point to the supply neutral N. [4 marks]

(b) Hence determine the voltages across the branches AS, BS and CS. [6 marks]

(c) Determine the power consumed by each of the resistors BS and CS. [2 marks]

(d) Sketch a phasor diagram showing all the voltages in the circuit. [3 marks]

(e) State and explain a practical use of this circuit. [3 marks]

3 (a) Determine the rms value of the periodic current i(t) shown in figure Q3(a), if it is periodic and has the value 5 cos $6\omega_o t$ in the region $-T_1$ to T_1 . [$\omega_o T = 2\pi$] [3 marks]

(b) Determine the first 4 significant terms of the Fourier series of the current i(t).[5 marks]

(c) Determine an expression for the terminal voltage v(t) shown in figure Q3(b).[3 marks]

(d) Determine the average power supplied from the source of figure Q3(b) if the current is same as that shown in figure Q3(a).[2 marks]

(e) Determine the average power loss in R of figure Q3(b). [2 marks]

(f) Determine an expression for the current $i_c(t)$ through a capacitor of value 4 μF if the voltage v(t) above is applied across it at an angular frequency ω_o = 250 rad/s [3 marks]

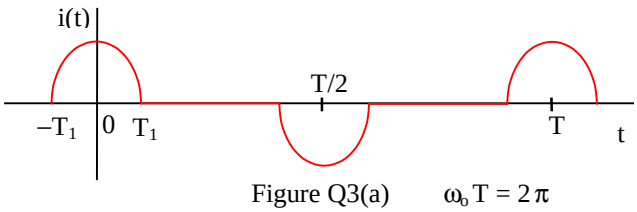

Figure Q3(a) $\omega_o T = 2\pi$

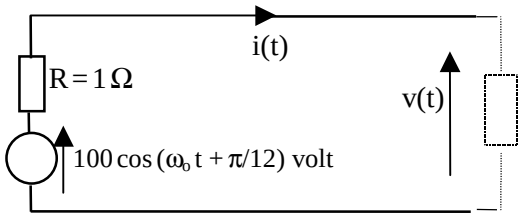

Figure Q3(b)

4 For the circuit shown in figure Q4, replace the mutually coupled branches by equivalent self inductances and redraw the circuit. *[proof not required]* [2 marks]

By suitably numbering a minimum number of branches, determine the branch-mesh incidence matrix. [2 marks]

Hence obtain the mesh impedance matrix. *[proof not required]* [6 marks]

Using mesh analysis determine the current supplied from the source. [8 marks]

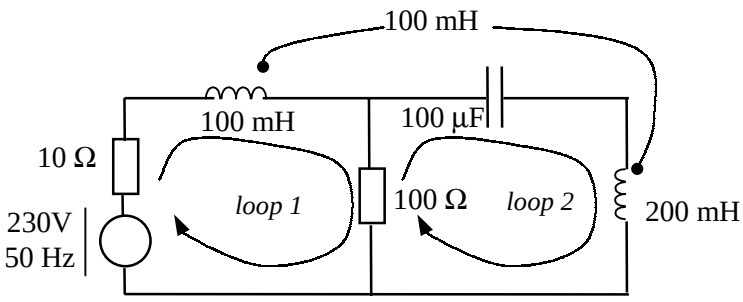

Figure Q4

5 Determine the phase 'A' current supplied by a balanced 400V, 3 phase, 50 Hz supply 'ABC'to each of the following loads.

(a) a star connected load with each arm consisting of a resistance of 100 Ω in series with an inductance of 75 mH [3 marks]

(b) a balanced three-phase fluorescent lighting load of 500 W at a power factor of 0.65 lag. [3 marks]

(c) a composite load comprised of (a) and (b) above. [3 marks]

(d) the overall power factor, the active power and the reactive power when supplying (a) and (b) above. [3 marks]

(e) value of the delta connected capacitor bank required to improve the overall power factor to 0.95 lagging when supplying (a) and (b) above and the terminal voltage remaining unchanged. [6 marks]

6 A balanced, 400V, 50 Hz, 3 phase source supplies from a 4-wire line 'RYBN' an unbalanced load as shown in figure Q6.

(a) Determine the currents in all three phases of the load. [3 marks]

(b) Determine the symmetrical components of the three phase currents. [9 marks]

(c) Determine the power supplied to the load using symmetrical components. [4 marks]

(d) Verify the value using the expression for power loss in resistors. [2 marks]

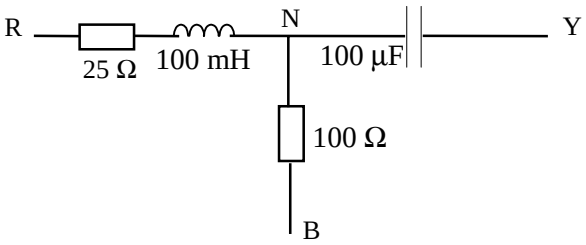

Figure Q6

7 (a) Determine the resonant frequency of the circuit shown in figure Q7. [4 marks]

(b) Determine the voltage across the capacitor at resonant frequency. [4 marks]

(c) Determine from first principles the Laplace transform of the causal function **sin ωt.**

[4 marks]

(d) Derive the transformed circuits for an inductor and a capacitor which have initial stored energy. [6 marks]

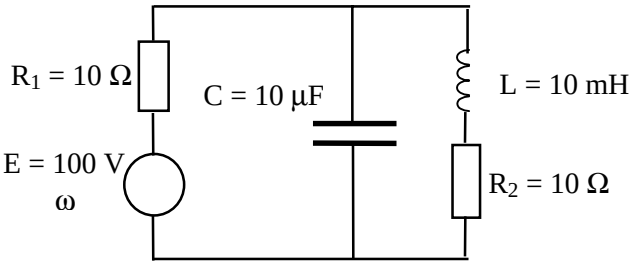

Figure Q7