University of Moratuwa, Sri Lanka

B. Sc. Engineering Degree Course

Final Part I Examination 1998/99

UEE 201 - THEORY OF ELECTRICITY

0900 - 1200 hrs 1 September 2000

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 = 8.854×10^{-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 mark]

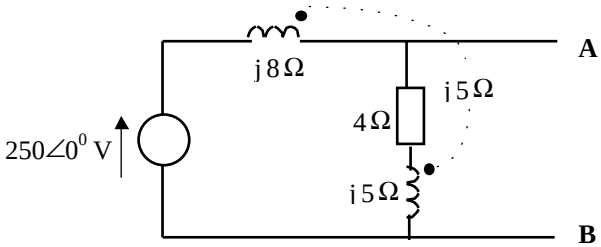

Figure Q1ab

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

(c) For the circuit shown in figure Q1cde, calculate the value of the impedance connected to A in the star equivalent. [3 marks]

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

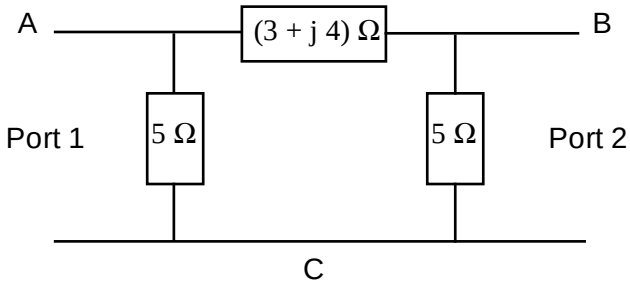

Figure Q1 cde

(e) When supplied from an alternating supply across Port 1 of the circuit shown in figure Q1cde, the voltage across port 2 is 200 V when on open circuit. Sketch a phasor diagram showing all the voltages and currents in the circuit. [4 mark]

(f) Using Millman's theorem, determine the voltage at the star point S in the circuit shown in figure Q1f. [4 marks]

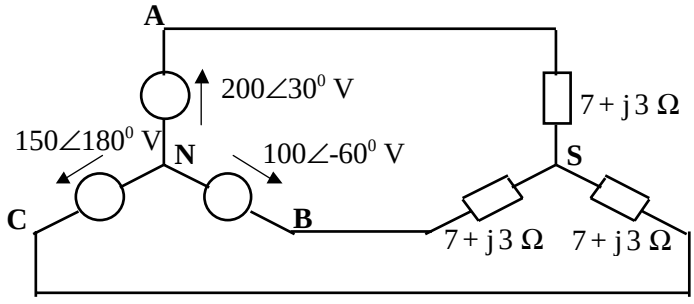

Figure Q1f

(g) In a certain non-linear circuit, the supply voltage and the corresponding current have the waveforms given by

$$v(t) = 350 \sin \omega t + 50 \sin (3\omega t + 7\pi/6) \text{ V} \quad \text{and}$$

$$i(t) = 14 \sin (\omega t - \pi/6) + 5 \sin (3\omega t + 2\pi/3) + 1 \sin (5\omega t - \pi/6) \text{ A}$$

Determine the active power supplied from the source. [3 mark]

Determine also the overall *rms* value, the *rms* value of the fundamental, and the *total-harmonic-distortion* of the current. [3 mark]

2 For the circuit shown in figure Q2, determine using mesh analysis the currents in all the branches. [18 marks]

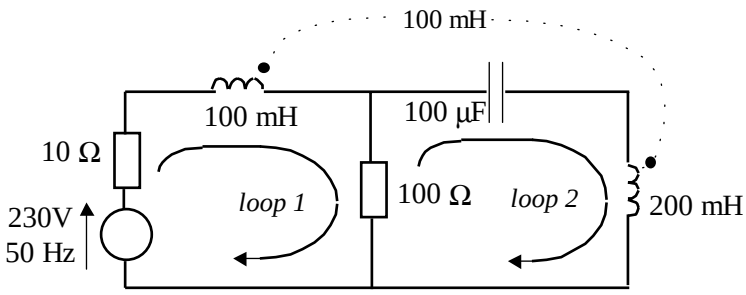

Figure Q2

3 (a) In a certain circuit it is required that the voltage across the load is equal in magnitude to the source emf E. If the internal impedance of the source is an inductive reactance of x and the load may be represented by an impedance of $R + j X$ determine the values of R and X for maximum power transfer and determine the value of this power in terms of E and x. [10 marks]

(b) A certain circuit consists of the following two branches connected in parallel - (i) a resistance of 10 Ω in series with a variable inductance; and (ii) a resistance of 5 Ω in series with a capacitance 100 μF. If resonance occurs at a frequency of 50 Hz, determine the value of the inductance. Determine also the Q-factor of the circuit. [8 marks]

4 A balanced 400V, 50 Hz, 3 phase supply feeds a load consisting of (i) a star connected load with each arm consisting of a resistance of 30 Ω in series with an inductance of 100 mH; and (ii) a balanced three-phase heating load (purely resistive) of 2.4 kW. Determine

(a) the current supplied by the source and the supply power factor, and [10 marks]

(b) value of the delta connected capacitor bank required to improve the overall power factor to 0.95 lagging. [8 marks]

5

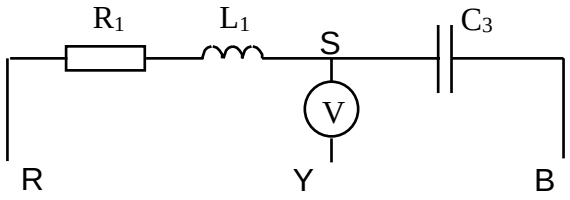

Figure Q5

A 400V, 50 Hz, 3 phase source 'RYB' supplies an un-balanced load as shown in figure Q5. R_1 = 100 Ω in series with L_1 = 183.8 mH is connected across RS; C_3 = 27.57 μF is connected across BS; and an ideal voltmeter is connected across YS.

Determine the reading of the voltmeter, if the supply is (a) positive sequence only, (b) negative sequence only and (c) zero sequence only. [18 marks]

6 Figure Q6 shows the waveform of a current passing through a certain device. Determine the Fourier series of this current to 4 significant terms. [18 marks]

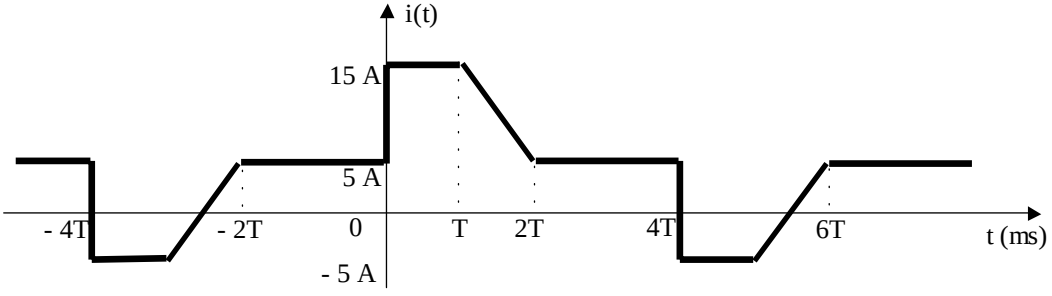

Figure Q6

7 (a) Show that the symmetrical component impedance matrix $[Z_s]$ can be expressed in terms of the phase component impedance matrix $[Z_p]$ and the symmetrical component matrix $[\Lambda]$ as

$$[Z_s] = \alpha\, [\Lambda^*]\ [Z_p]\ [\Lambda] \qquad \text{[4 marks]}$$

Hence show that a full matrix $\begin{bmatrix} \boldsymbol{a} & \boldsymbol{b} & \boldsymbol{b} \\ \boldsymbol{b} & \boldsymbol{a} & \boldsymbol{b} \\ \boldsymbol{b} & \boldsymbol{b} & \boldsymbol{a} \end{bmatrix}$ becomes the diagonal matrix $\begin{bmatrix} \boldsymbol{a}+\boldsymbol{2b} & 0 & 0 \\ 0 & \boldsymbol{a}-\boldsymbol{b} & 0 \\ 0 & 0 & \boldsymbol{a}-\boldsymbol{b} \end{bmatrix}$.

[4 marks]

(b) Figure Q7 shows a circuit which has reached steady state with switch closed. If the switch S is opened at time t=0, obtain an expression for the ensuing current through the inductor. [10 marks]

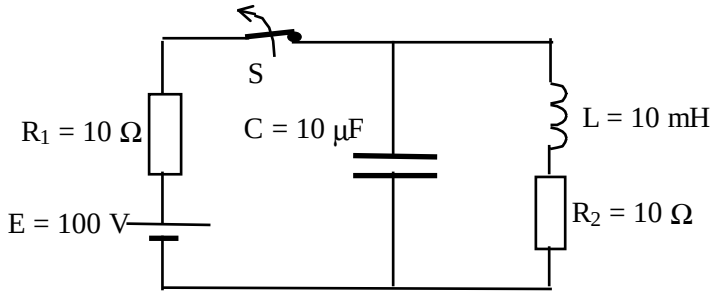

Figure Q7