University of Moratuwa, Sri Lanka

B. Sc. Engineering Degree Course

Level 2 – Semester I Examination 2004/05

EE 201 - THEORY OF ELECTRICITY

Time Allowed: Three Hours — September 2005.

Answer **All** Questions. — Marks allocated for the paper is 70.

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) If the circuit shown in figure Q1 is at resonance, what would be the value of the inductor L, and what would be corresponding current supplied from the supply. [2 mark]

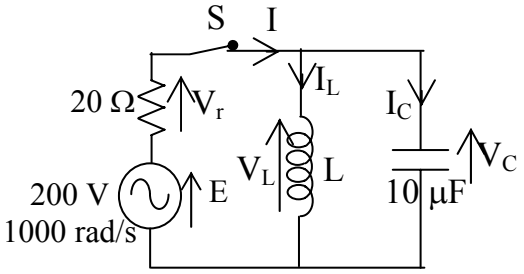

Figure Q1

(b) If L = 50 mH instead, determine all the currents and voltages indicated on figure Q1. [3 marks]

(c) Sketch the phasor diagram showing all the currents and voltages calculated in section (b) relative to the supply voltage E. [2 marks]

(d) If in figure Q1, the supply could be expressed as $e(t) = 282.8 \cos 1000\, t$ V, and the switch S is opened at time t = 1 ms, using calculations already made or otherwise, determine the initial current through the inductor and the initial voltage across the capacitor for the purpose of transient analysis. [2 marks]

(e) Sketch the transformed circuit corresponding to section (d) for analysis using Laplace Transform. [2 mark]

2. (a) Show from first principles how two inductances L_1, L_2 in two branches of a T-junction which have a mutual inductance M can be represented by a T-junction having non-coupled branches. [2 marks]

(b) Draw the non-coupled equivalent circuit of the circuit shown in figure Q2. [2 marks]

(c) Determine and sketch the Thevenin's equivalent circuit across the 30 Ω resistor for the circuit shown in figure Q2. [3 marks]

(d) Hence determine the current through the 30 Ω resistor for figure Q2. [2 marks]

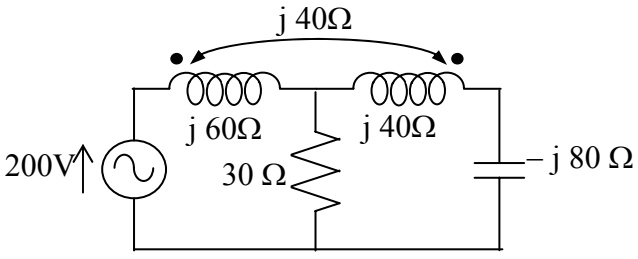

Figure Q2

3. (a) In a single phase circuit, the active power delivered to the load is measured to be 180 W when the load impedance is (125+j16) Ω and the source impedance is (35+j20) Ω. Determine the magnitudes of the supply voltage **E,** the supply current **I** and the supply power factor. [4 marks]

(b) For the star connected circuit shown in figure Q3, determine the impedance of the arm AC of the delta equivalent. [2 marks]

(c) Obtain the y-parameter matrix of the two port circuit shown in figure Q3. [4 marks]

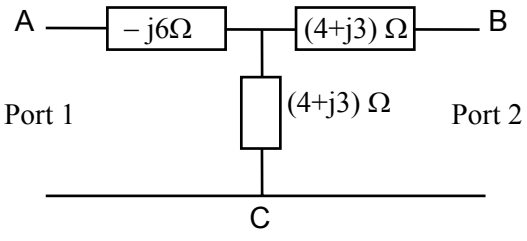

Figure Q3

4. (a) A balanced 400V, 50 Hz, 3 phase supply feeds (i) a star connected load with each arm consisting of a resistance of 40 Ω in series with an inductance of 95.5 mH, and (ii) a 2 kW three-phase motor with a power factor of 0.7. Determine the current supplied from the supply and the supply power factor. [4 marks]

(b) A balanced, three phase, 400 V, 4-wire supply, sequence ABC, supplies an unbalanced star-connected load consisting of $Z_{AS} = 120\angle -30^o\ \Omega$, $Z_{BS} = 100\angle 60^o\ \Omega$, and $Z_{CS} = 80\angle 0^o\ \Omega$. Determine the currents in the three phases. [2 marks]

(c) Determine the sequence components of the unbalanced currents in section (b) [3 marks]

(d) Determine the total power associated with each of the sequence components in section (c). [1 marks]

(e) Show graphically how the positive sequence component of the phase voltages $V_A = 100\angle 0^o$ V, $V_B = 100\angle 90^o$ V, $V_C = 100\angle -90^o$ V is determined. [2 marks]

5. For the circuit shown in figure Q5, replace the voltage source by an equivalent current source and redraw the circuit. [2 mark]

By suitably numbering the nodes, determine the node-branch incidence matrix. [2 marks]

Hence or otherwise determine the nodal admittance matrix. [2 marks]

Using nodal analysis determine the currents in all the branches of the original circuit. [4 marks]

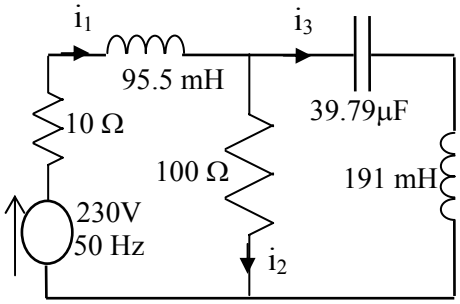

Figure Q5

6. For the periodic current waveform ***i(t)*** shown in figure Q6, determine (a) the mean value, (b) the average value, (c) the rms value and (d) the form factor. [2 marks]

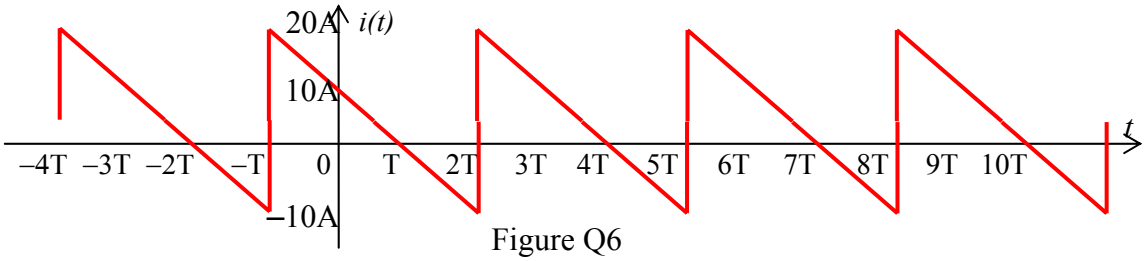

Figure Q6

(e) Write down the Fourier Series of the current waveform ***i(t)*** shown to 4 significant terms. [6 marks]

(f) If T = 10 ms, and this current ***i(t)*** is passed through a series combination of a resistor of 20 Ω and an inductor of 10 mH, determine the Fourier series of the resulting voltage. [2 marks]

7. Determine from first principles, the Laplace transform of (a) the unit step waveform h(t), and (b) the causal unit ramp waveform r(t) = t. [2 marks]

(c) Determine the Laplace transform $\boldsymbol{F_a(s)}$ of the causal waveform ***f(t-a)***, in terms of the Laplace transform ***F(s)*** of the causal waveform f(t). [1 mark]

(d) Using the properties derived in (a), (b) and (c), or otherwise determine the Laplace Transform of the waveform shown in figure Q7. [5 marks]

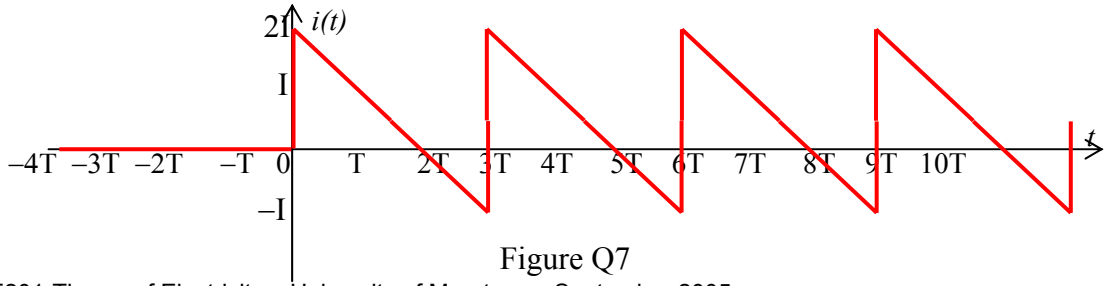

Figure Q7