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 — 9 March 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) The core loss P in a magnetic core, of volume V made of laminations of thickness t, on the application of an alternating flux density of peak value B_m at a frequency f is equally divided between hysteresis and eddy current loss. If the frequency is changed to 1.2f, the volume to 0.6V, thickness of laminations to 0.5t and the peak flux density remains unchanged with peak value B_m, determine the total loss in the core. [2 marks]

(b) A magnetic circuit consists of a toroid of cross section 50 mm^2, magnetic length 80 mm, and relative permeability 5000. Determine the reluctance of the magnetic circuit. If a coil of 100 turns is uniformly wound on the core, determine the inductance of the coil. If a current of 10 mA flows through the coil, determine the magnetic flux density in the core. [2 marks]

(c) A circuit consists of a choke (inductance 10 mH with a Q factor of 20 at 50 Hz), and a practical capacitor (capacitance 10 μF in parallel with a resistance 100Ω) connected in series. Determine the resonance frequency and the equivalent impedance at resonance. [4 marks]

(d) Describe with the aid of suitable diagrams, the principle of operation of a residual current circuit breaker. [2 marks]

2 Figure Q2 shows a mutually coupled circuit supplied from a source of emf E and frequency ω.

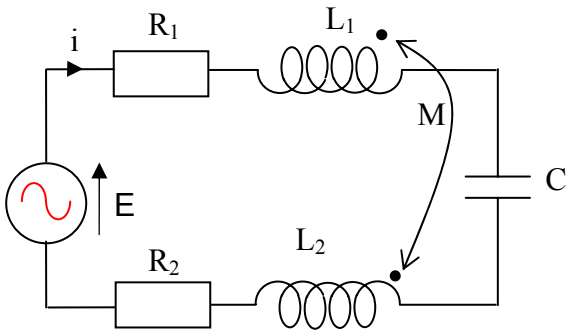

Figure Q2

(a) Apply Kirchoff's voltage law to the circuit shown. [1 marks]

(b) Hence determine an expression for the impedance of the circuit. [1 marks]

(c) If the supply voltage is 230V at 50 Hz, L_1 = 20 mH, R_1 = 15 Ω, R_2 = 10 Ω, C = 50 μF, L_2 = 30 mH, M = 20 mH, express the impedance in both cartesian form and polar form. [2 marks]

(d) Determine the current supplied from the source in magnitude and phase. [1 marks]

(e) Determine the input power factor and the active power supplied to the circuit. [1 marks]

3 An alternating supply of 240 V, 50 Hz is applied across AE in the circuit shown in figure Q3.

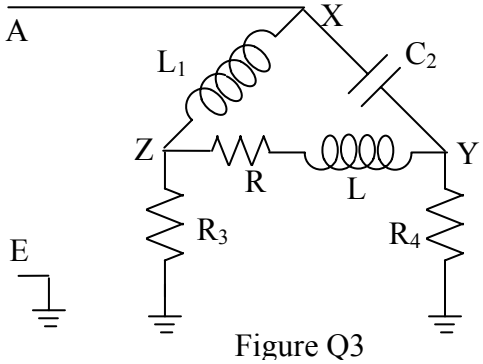

Figure Q3

(a) Convert the delta connected network XYZ, consisting of L_1, C_2, R and L to an equivalent star connection, if L_1 = 100 mH, C_2 = 50 μF, R = 10 Ω, L = 30 mH, $R_3 = R_4$ = 20 Ω. [3 marks]

(b) Hence determine the current supplied from the source [3 marks]

(c) Determine the Thevenin's equivalent across ZY, with ZY disconnected. [3 marks]

4 If $I_s = 2\angle 0^o A$, $E = 100\angle 30^o$ V, $\omega = 250$ rad/s for both supplies, $R_1 = R_3 = R_4 = R_5 = 100\ \Omega$, $R_2 = R_6 = 200\ \Omega$.

(a) Convert the current source shown in figure Q4 to equivalent voltage source. [1 mark]

(b) Write down the branch impedance matrix and mesh-branch incidence matrix and the mesh voltage source. [3 marks]

(c) Hence determine the mesh impedance matrix. [3 marks]

(d) Using matrix mesh analysis, determine the current in the resistor R_4. [3 marks]

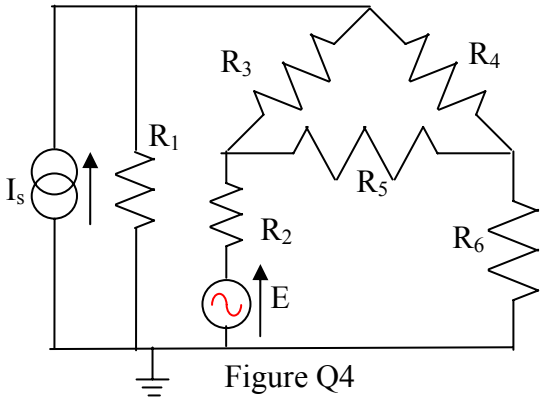

Figure Q4

5 Figure Q5 shows a 3 phase, 400 V, 50 Hz, 3-wire balanced supply ABC feeding a balanced star connected load. If L = 100 mH, R = 50 Ω in each branch of the load,

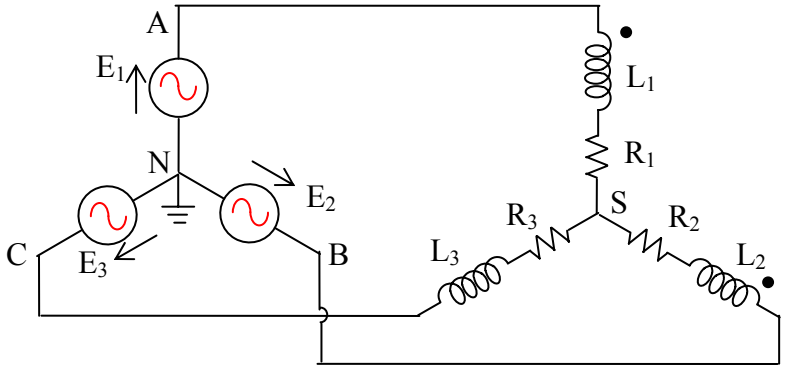

Figure Q5

(a) Taking V_{AN} as reference, determine the current flowing in all three phases of the load in magnitude and phase angle, if no mutual inductance exists in the circuit. [2 marks]

(b) Determine the power factor of the load and the active power supplied. [1 marks]

(c) If a small amount of mutual inductance M = 10 mH exists between inductors L_1 and L_2, but not with the rest, determine and sketch the uncoupled circuit taking the effect of mutual inductance into account. [1 mark]

(d) Hence determine the current in the branch containing L_3 . [5 marks]

(e) Hence determine the potential of S with respect to the supply neutral N. [2 marks]

6 (a) Determine the z-parameter matrix for the two port circuit shown in Figure Q6a [4 marks]

(b) Figure Q6b shows a circuit which has reached steady alternating conditions. If the switch is transferred away from the alternating voltage source side at time t=0, using Laplace transform, determine the transient voltage across the capacitor C_2. [6 marks]

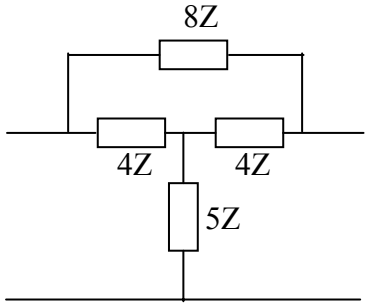

Figure Q6a

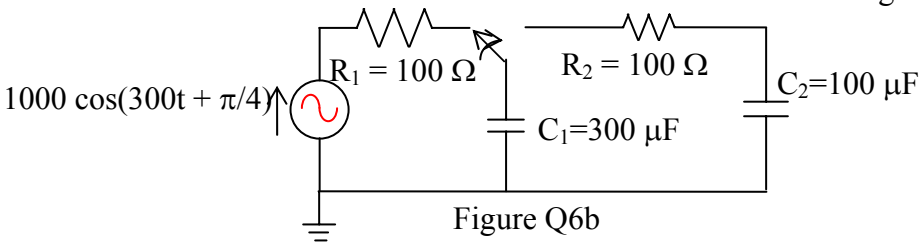

Figure Q6b

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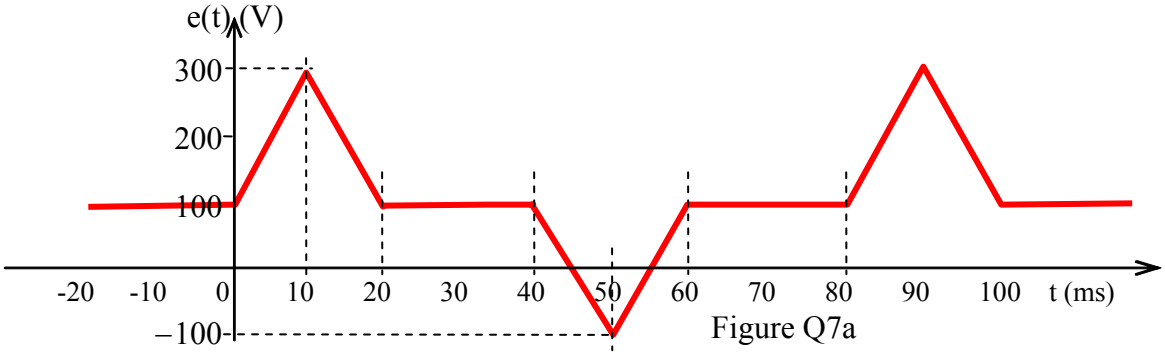

Figure Q7a

(a) Determine the first 3 significant terms of the Fourier Series of the waveform e(t) shown in figure Q7a. [5 marks]

(b) Determine the mean value, average value, approximate rms value and the form factor of the periodic waveform e(t) shown in figure Q7a. [2 marks]

(c) If the waveform e(t) is applied across the series L C circuit shown in figure Q7b, determine the Fourier Series of the resulting current i(t) in the circuit. [3 marks]

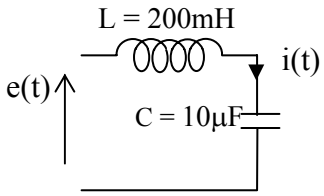

Figure Q7b

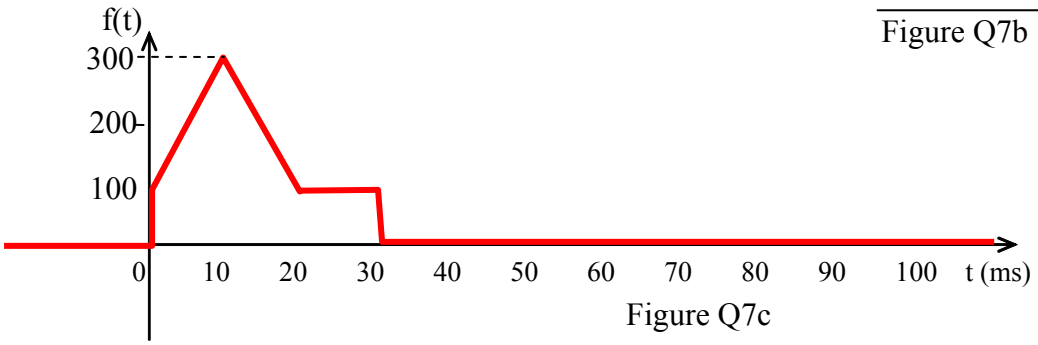

Figure Q7c

(d) Determine from first principles the Laplace Transform of the unit step h(t) = 1 and the unit ramp r(t) = t, for $t \geq 0$. [1 marks]

(e) Determine the Laplace transform of the causal waveform f(t) shown in figure Q7c. [3 marks]