UU046

The Open University of Sri Lanka
Department of Electrical and Computer Engineering

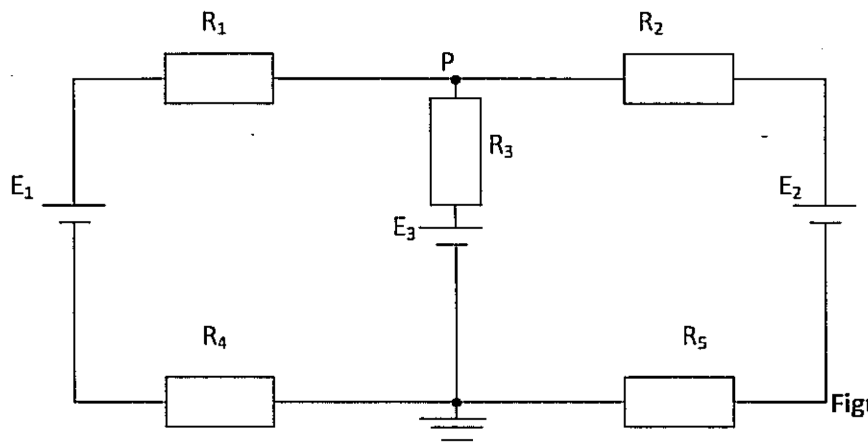
ECX3210 – Electrotechniques

Final Examination 2011/2012 **Closed Book Test**

Date: 11th March 2012 Time: 14.00-17.00

Answer any 5 questions. All questions carry equal marks. Show all relevant steps of calculation.

1) a. Describe the two Kirchhoff's Laws. Indicate the two underlying principles these are based upon.



$R_1 = 16\ \Omega$; $R_2 = 26\ \Omega$; $R_3 = 36\ \Omega$; $R_4 = 20\ \Omega$; $R_5 = 46\ \Omega$;

$E_1 = 12$ V; $E_2 = 48$ V; $E_3 = 6$ V

Figure Q1

b. For the circuit in Figure 1 given above
   i. Calculate the currents flowing through all the resistors.
   ii. What is the power output of each source?
   iii. Calculate the potential at point P.

The initial electrical energy stored in source E_2 is given as 10 kJ. The other sources have 100 kJ each.

   iv. How long will E_2 be able to supply energy to the circuit?

2) a. Describe briefly the main parts and the functioning of a simple ac generator.
   b. How could you simply convert this to a simple dc generator?

   Indicate the output waveform in each case.

   c. The rectangular loop of wire, of dimensions 6 cm × 8 cm shown in Figure Q2 is pivoted about the shorter side on a frictionless axis xy within a vertical magnetic field {(a) – front view, (b) – side view}. It has a mass of 0.15 g per centimetre of length. A current of 8.2 A circulates in the wire in the direction shown.
      i. Find the magnitude and direction of the magnetic field that will cause the loop to swing up to equilibrium when its plane makes an angle of 30° with the vertical plane.

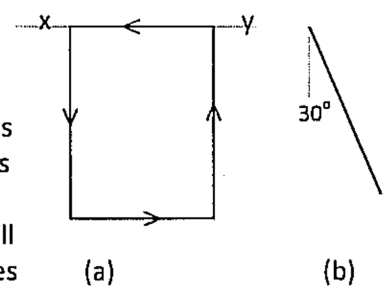


Figure Q2

      ii. What happens when the direction of the field is reversed, while its magnitude remains unchanged?

3) a. Describe Lenz's Law of induction.

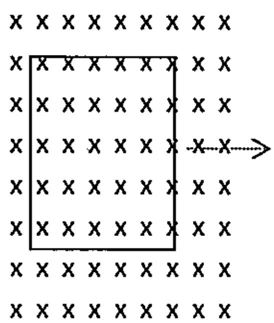


Figure Q3

b. A rectangular coil measuring 30 cm by 40 cm is located inside a region of a spatially uniform magnetic field of 1.25 T, with the field perpendicular to the plane of the coil. The coil is pulled out at a steady rate of 2 cm/s travelling perpendicular to the field lines. The region of the field ends abruptly as shown in Figure Q3. Find the emf induced in this coil when it is

i. all inside the field;

ii. partly inside the field;

iii. all outside the field.

c. A satellite, orbiting the earth at the equator at an altitude of 400 km, has an antenna that can be modelled as a 2-m-long rod. The antenna is oriented perpendicular to the earth's surface. Consider that at 400 km above the equator the earth's magnetic field is essentially horizontal and has a value of 8×10^{-5} T.

iv. Assuming the orbit is circular; determine the induced emf between the tips of the antenna.

(Earth radius $R_E = 6.38 \times 10^6$ m)

4) a. State the formula for the capacitance of a parallel-plate capacitor, and discuss briefly how a change in each parameter value affects the capacitance.

b. Several 0.25 μF capacitors are available. The voltage across each is not to exceed 600 V. You need to make a capacitor with capacitance 0.25 μF to be connected across a potential difference of 900 V.

i. Show in a diagram how an equivalent capacitor with the desired properties can be obtained.

c. A 12.5 μF capacitor is connected to a power supply that keeps a constant potential difference of 24 V across the plates. A piece of material having a relative dielectric constant of 3.75 is placed between the plates, completely filling the space between them.

ii. By how much did the energy change during the insertion? Did it increase or decrease?

5) a. A student using an ammeter comments that two AC branch currents, of 3 A and 5 A respectively, combine together at a point to give a total current of 6.6 A. She states that this is a violation of Kirchhoff's current law. What is your opinion? Explain.

b. For circuit in Fig. Q5, given L = 150 mH, C = 1 μF, and R = 400 Ω. It is found that voltage across the inductor L, $v_L(t) = 17 \sin 2000t$ V.

i. Sketch the phasor diagram for the circuit using minimum calculations. (qualitative only)

ii. Based on the phasor diagram, or otherwise, calculate the currents through all the components.

iii. Construct the expression for e(t).

iv. What is the power factor of the circuit?

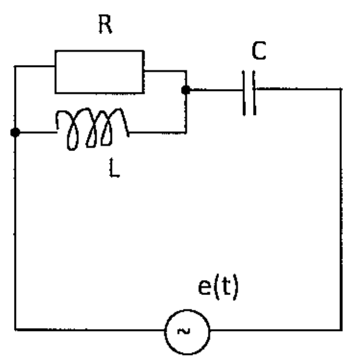


Figure Q5

6) a. i. What is the characteristic of a circuit at resonance?

ii. Describe a practical application of electrical resonance.

b. The circuit in figure Q5 is brought to resonance with all components remaining unchanged. The amplitude of the input voltage is fixed at 34 V.

iii. Calculate currents through all the components in this situation.

7) a. Describe the *dot convention* applied to inductor circuit diagrams.

b. A solenoid 25 cm long and with a cross-sectional area of 0.5 cm^2 contains 400 turns of wire and carries a current of 80 A. Calculate:

i the magnetic field in the solenoid;

ii. the energy density in the magnetic field if the solenoid is filled with air;

iii. the total energy contained in the coil's magnetic field (assume the field is uniform);

iv. the inductance of the solenoid.

($\mu_o = 4\pi\times10^{-7}$ Tm/A)

8) a. Sketch the characteristic curve and describe briefly the main characteristics of a semiconductor diode, based on its internal structure.

b. Describe how the zener stabiliser circuit reacts when :

i. there is a fluctuation of the source (input) voltage.

ii. there is a fluctuation of the output resistance (load).

c. Given e(t) = 12 sin 1000t V, E_1 = 6 V, and E_2 = 4 V, sketch the output wave form across the resistor $V_R(t)$. Mark the values on the axes clearly.

You may consider the diodes to be ideal.

Figure Q8