The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Diploma in Technology
ECX3232– Electrical Power
Final Examination - 2010/2011
Duration : Three hours.

Date: 1st March 2011 Time: 0930-1230 hrs

The paper contains eight (8) questions. Answer any five (5) questions. All questions carry equal marks. Graph papers will be available on your request.

1) a. Prove that the voltage regulation of a single phase transformer can be approximated as,

$$V_{reg}\% = \frac{I_2 R_2' \cos\phi + I_2 X_2' \sin\phi}{E_2} \times 100\%$$

Where

E_2 - No - load votage of secondary side

I_2 - Load currant

ϕ - Load power factor lagging

R_2' - Equivalent transformer resistance refereed to the secondary side

X_2' - Equivalent transformer leakage reactance referred to the secondary side

b. A 15kVA 2300/230V, 50Hz transformer has voltage drops of 2% and 4% of load voltage, due to winding resistance and leakage reactance respectively, at full load at unity power factor. 230V is maintained at the load terminal. The full load copper loss is equal to the iron loss. All parameters are referred to the secondary side. Find,

i. The primary voltage at full load and unity p.f.

ii. The half load efficiency at 0.8 p.f. lagging.

iii. The load power factor at which the voltage regulation would be zero.

2) An industrial installation comprises the following loads –

   i. 100 nos. fluorescent lamps (230V, 50Hz, 40 W at 0.6 p.f. lag)
   ii. 25 nos. incandescent lamps (230V, 50Hz, 60 W)
   iii. 90 nos. 1-phase machines (230V, 50Hz, 500W at 0.8 p.f. lag)
   iv. 90 nos. 1-phase machines (230V, 50Hz, 250W at 0.8 p.f. lag)

   The loads (i), (iii) & (iv) operate for 8 hrs per working day, from 08.00 hrs – 16.00hrs.(24 working days/month)

   Load (ii) operates for 12hrs each day of the full month. (18.00hrs – 06.00hrs)

   Considering a full month to be of 30 days,

   a. Estimate monthly bill assuming applicable tariff as:
      Rs. 3000/= fixed charge per month
      Rs. 8.50 per kWh
      Rs. 650/= per kVA maximum demand
   b. Estimate the overall power factor assuming that the loads are distributed evenly amongst the three phases.
   c. Determine the value of the capacitance to be connected in Δ on the 400V, 50 Hz, 3-phase supply in order that the power factor is improved to 0.98 lag.
   d. What is the expected saving in the monthly electricity bill after the power factor correction capacitors are installed.

   Indicate any assumptions made.

3) A single phase ring distributor ABC shown in figure Q3 is fed at A. The loads at B and C are 20 A at 0.8 p.f. lagging and 15 A at 0.6 p.f. lagging respectively: both expressed with reference to the voltage at A. The total impedance of the three sections AB, BC & CA are (1+j1), (1+j2) and (1+j3) ohms respectively. Find the total current fed at A and the current in each section.

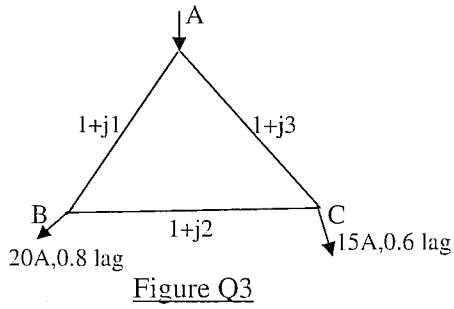

Figure Q3

4) Consider the circuit shown in figure Q4.

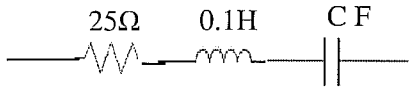

Figure Q4

The instantaneous value of voltage applied across the circuit is given by,

$V = 100\sin(\omega t) + 20\sin(3\omega t + 45) + 5\sin(5\omega t + 30)V \quad Where \quad \omega = 314 rad/s$

a. Determine the value of 'C' which will produce resonance at the 3rd harmonic frequency.

b. With that value of C, Calculate;
   i. An expression for the current flowing through the circuit.
   ii. The r.m.s value of this current
   iii. The total power dissipation of the circuit.
   iv. The total harmonic distortion of the voltage.

5) a. Draw the power flow diagram of a 3-phase induction motor. Briefly explain each term given in the diagram.

b. A 400V, 3 phase, 6pole, 50Hz, induction motor has an efficiency of 90% when delivering an output of 40kW. At this load, the stator copper loss and rotor copper loss each equals the iron loss. And the mechanical losses are 1/3 of the no-load loss. Calculate,
   i. Iron loss.
   ii. Mechanical loss.
   iii. Air gap power at this load.
   iv. Electrical torque.
   v. Slip at this load.

6) a. Sketch per phase equivalent circuit of a three phase induction motor and identify its parameters.

b. A 208V, two-pole, 60Hz, 15kW, Y-connected wound-rotor induction motor has following per phase equivalent circuit parameters (All referred to the stator);

$R_1 = 0.200ohm \quad R_2 = 0.120ohm \quad X_M = 15.0ohm$

$X_1 = 0.410ohm \quad X_2 = 0.410ohm$

Mechanical losses = 250 W

For a slip of 0.05, Calculate,
   i. The line current I_L
   ii. The stator copper loss.
   iii. The air-gap power.

iv. Load torque.

v. The overall machine efficiency.

7) A 10kW, 200V shunt wound DC motor has field and armature resistance of 100Ω and 0.25Ω respectively. Calculate the resistance to be inserted in the armature circuit to reduce the rotor speed by 20% at full load. The motor has an efficiency of 80%. Assume that the torque remains constant and the effect of saturation and armature reaction may be neglected.

8) a. Describe briefly the terms '*core loss*' and '*copper loss*' of a transformer and state the factors affecting each of these losses.

b. Explain, what is meant by the 'time of day tariff' offered by the Ceylon Electricity Board, and the purpose of introducing such a tariff.

c. Why is it not recommended to operate an electrical installation with a low power factor? Explain.

d. Explain the differences of semi enclosed fuses and MCBs with regard to their time current characteristics.