The Open University of Sri Lanka
Diploma in Technology
ECX 3232-Electrical Power
Final Examination-2008/2009
Duration Three Hours

Date: March 8th 2009 **Time: 0930-1230 hrs.**

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

1. (a) Show that the voltage regulation of a power transformer can be approximated as:

$$V_{reg}\ \% \approx \left\{\left[\frac{IR}{V_{OC}}\right] Cos\phi \pm \left[\frac{IX}{V_{OC}}\right] Sin\phi\right\} \times 100$$

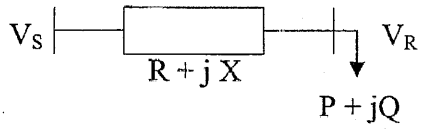
Where R & X are the resistance and reactance of the transformer referred to the secondary side and ϕ is the load power factor. V_{OC} is the Open circuit voltage of the secondary terminals of the transformer.

Explain the significance of $\pm$ sign. State any assumptions made.

(b) Use above formula to show that the maximum voltage regulation of a power transformer occurs when $Tan\phi = \frac{X}{R}$

(c) In a single-phase transformer, zero voltage regulation occurs at power factor 0.9 leading, whereas its maximum possible voltage regulation is observed to be 4%. What would be the voltage regulation of the transformer when operated at 0.8 power factor lagging.

2. (a) Show that the sending end voltage of a distribution network supplying P+jQ load at the receiving end is given by:



$$V_S = \sqrt{\left(V_R + \frac{PR+QX}{V_R}\right)^2 + \left(\frac{PX-QR}{V_R}\right)^2}$$

Where V_S = Sending end voltage and V_R = Receiving end voltage
R, X – resistance and the reactance of the distribution line.

(b) An overhead three-phase transmission line delivers 8 kW at 33 kV at 0.8 p.f. lagging. The total per-phase resistance and reactance of the line are 5 Ω and 15 Ω respectively.
Determine:

- Sending end voltage
- Sending end power factor
- Transmission efficiency of the line.

3. The daily load pattern of an Industrial consumer "XYZ" operated at 0.85 p.f. lagging, during daily peak hours and 0.9 p.f. lagging at other times fed by an electricity supply authority metered at 400V/230V is as given below:

Midnight	To	8.00 a.m.	9 kW
8.00 a.m.	To	5.00 p.m.	42.5 kW
5.00 p.m.	To	Midnight	9 kW

a) Plot the daily load variation
b) What would be the monthly maximum kVA demand and minimum kVA demand?
c) What are the Maximum Demand charge, Energy charge and fixed charge under the customer category of just "Industrial"?
d) Compute the energy consumption for a 30 day month, and hence prepare the monthly electricity bill for the consumer under the above category?
e) If the above customer has decided to install his own 75 kVA, 11000/400 V transformer and request the supply authority to meter him at 11 kV level what would be his new electricity bill under the same category? You may assume that the transformer full load copper loss is 3 kW and the iron loss is 1.5 kW.
f) Based on your answer (e) what would you recommend to the above customer?

(You may use the tariff table attached to this question paper)

4. A three phase 35 kW, 400 V, 60 Hz induction motor operates on full load with efficiency of 90% and at a power factor of 0.8 lagging. Calculate the total kVAr rating of the loss free capacitors required to raise the full-load power factor to 0.95 lagging. What will be the value of capacitance per phase to be installed if the capacitors are:

a) Delta-connected?
b) Star-connected?

Draw the one-line diagram of the motor-capacitor connection for above two configurations.

5. A DC series motor is driving a particular load where the load torque is proportional to the cube of the speed (N^3). The resistance of the armature and the field coil is 1 Ω. The motor takes 10 A and runs at 1000 rpm when operating from a 200 V supply. Calculate the value of the resistance to be inserted in series with the armature to reduce the operating speed to 800 r.p.m.

6. A series circuit consists of a coil of inductance 0.1 H and resistance 25 Ω and a variable capacitor. The instantaneous value of the voltage applied across the circuit is given by:

$v(t) = 100\,Sin\,\varpi t + 20\,Sin(3\varpi t - 45^0) + 5\,Sin(5\varpi t - 30^0)$ where ω=314 rad/sec

Determine the value of C which will produce resonance at 3rd harmonic frequency and with this value of C, find an expression for the current in the circuit, the r.m.s value of this current and the total power absorbed.

7. a) Give the standard symbols for 5 electrical components used in domestic electrical installation work

b) Draw a wiring diagram for a fluorescent circuit, showing the connection of all the associated equipments. Why do we have a choke coil and a starter in such circuit?

c) What is the new colour code for three phase four wire system and single phase two wire system in an electrical installation work as per the IEE regulation? What colour code is used for earth wire?

d With the aid of suitable diagrams explain the operation of a miniature circuit breaker (MCB) and its characteristics.

8. A 400 V, 3 phase, 6 pole 50 Hz, induction motor draws a power of 2 kW at no load and at rated voltage and frequency. At a full-load slip of 3%, the power input to motor is 50 kW and the stator copper loss is 1.5 kW. Neglect I^2R loss at no load. If the stator core loss and mechanical losses are assumed equal, then at a slip of 3% calculate:

- Stator core loss
- Air gap power $P_{air\ gap}$
- The rotor copper loss/phase ($P_{rotor\ loss}$/phase)
- Electrical power available on the shaft (P_e)
- Electrical torque (T_e)
- Mechanical power available on the shaft (P_m)
- Mechanical torque (T_m)
- The efficiency of the motor (η)

Ceylon Electricity Board (CEB) Tariff Effective from 15th March 2008

Customer category	Conditions	Maximum Demand Charge (Rs/kVA) per month	Energy charge (Rs/kWh)	Fixed charge (Rs/month)
INDUSTRIAL	metered at 400V/230V, contract demand less than 42 kVA	none	13.00	240.00
	metered at 400V/230V, contract demand more than 42 kVA	675.00	10.53	3000.00
	metered at 11kV or above	650.00	10.40	3000.00
INDUSTRIAL TIME-OF-DAY OPTION *(Two Part)*	metered at 400V/230V, contract demand more than 42 kVA	650.00	28.60 between 6.30 pm-9.30 pm 9.75 at other times	3000.00
	metered at 11kV or above	650.00	26.00 between 6.30 pm-9.30 pm 9.23 at other times	3000.00
INDUSTRIAL TIME-OF-DAY OPTION *(Three Part)*	metered at 400V/230V, contract demand more than 42 kVA	650.00	29.90 between 6.30 pm-10.30 pm 9.49 between 4.30 pm-6.30 pm 6.89 at other times	3000.00
	metered at 11kV or above	650.00	27.30 between 6.30 pm-10.30 pm 8.97 between 4.30 pm-6.30 pm 6.50 at other times	3000.00
INDUSTRIAL STANDBY OPTION	metered at 400V/230V, contract demand more than 42 kVA	675.00 Per kVA of contract demand	10.53	3000.00
	metered at 11kV or above	650.00 Per kVA of contract demand	10.40	3000.00