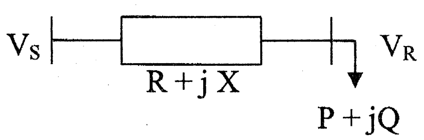
The Open University of Sri Lanka
Diploma in Technology
ECX 3232-Electrical Power
Final Examination-2007
Duration Three Hours
Date: May 2nd 2008 **Time: 0930-1230 hrs.**

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 single phase transformer is rated at 100 kVA, 2300/230 V, 50 HZ. The maximum flux density in the core is 1.2 Wb/m^2 and the net cross-sectional area of the core is 0.04 m^2. Determine:
   - The number of primary and secondary turns needed.
   - If the mean length of the magnetic circuit is 2.5 m and the relative permeability is 1200, determine the magnetizing current. Neglect the current drawn for the core loss. $\mu_0 = 4\pi 10^{-7}\, Hm^{-1}$
   - On short circuit with full load current flowing, the power input is 1200 W and an open-circuit with rated voltage, the power input was 400 W. Determine the efficiency of the transformer at 75% of full-load with 0.8 power factor lagging.

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



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

Where V_s = Sending end voltage and

V_R = Receiving end voltage

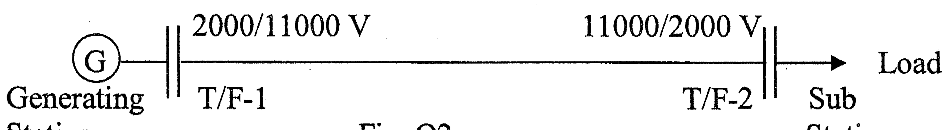


Fig. Q2

A single-phase transmission line, connected with transformers at each end, delivers 250 kVA load at a power factor 0.8 lagging from the low-voltage side of a substation as shown in the figure Q2. The transmission line has a total resistance of 10Ω and an inductive reactance of 30Ω. Each transformer has a voltage ratio of 2000/11000 V, the resistance on the low-and high-voltage sides being 0.04Ω and 1.3Ω, and the reactance 0.125Ω and 4.5Ω respectively. The sending end of the transmission line is connected to a generating station. Calculate the sending end voltage V_S and the power factor at the generating station, if the receiving end voltage V_R is 2000V.

3. An Industrial consumer "ABC" operated at 0.85 p.f. lagging during his daily peaks and 0.95 otherwise is being fed by a certain local electricity supply authority metered at 400V/230V. Variation of his daily load pattern is as described below:

Monday ⟶ Saturday

Midnight	to	1.00 a.m.	15 kW
1.00 a.m.	to	7.00 a.m.	42.5 kW
7.00 a.m.	to	9.00 a.m.	15 kW
9.00 a.m.	to	3.00 p.m.	42.5 kW
3.00 p.m.	to	5.00 p.m.	15 kW
5.00 p.m.	to	11.00 p.m.	42.5 kW
11.00 p.m.	to	midnight	15 kW

During week end ⟶ Sunday

Midnight	to	6.00 a.m.	10 kW
6.00 a.m.	to	6.00 p.m.	5 kW
6.00 p.m.	to	Midnight	10 kW

a) Plot the daily load variation during 24 hours for a week day
b) Plot the daily load variation during 24 hours for week end (i.e. Sunday)
c) What would be the monthly maximum kVA demand and minimum kVA demand
d) What are the Maximum Demand charge, Energy charge and fixed charge under the customer category of "Industrial (Time of Day)"?
e) Compute the energy consumption for a 30 day month (with 4 week ends), and hence prepare the monthly electricity bill for the consumer under the category of "Industrial (Time of Day)"?

(You may use the tariff table attached to this question paper i.e. page [4] of [4] when answering (c), (d), (e), (f) parts of the above question)

4. A pump driven by a 400 V, 3 phase, induction motor delivers 60000 liters of water per minute against a head of 30 meters. At this load the power factor of the motor is 0.85 and the overall motor efficiency of the set is 85%. Calculate:

(a) The kVAr rating of the capacitors required to raise the power factor to 0.95

(b) The power factor of the total installation with these capacitors, when the load has risen to 65000 liters per minute and the motor power factor alone is 0.9. Assume that the efficiency of the motor remains the same. [Assume 1 liter = 1 kg]

5. A complex wave of *r.m.s.* value 240 V has 20%, 3rd harmonic content, 5%, 5th harmonic content and 2%, 7th harmonic content. Find the *r.m.s.* value of the fundamental and each harmonic.
An *e.m.f* represented by the equation $e = 150\sin 314t + 50\sin 942t$ is applied to a capacitor having a capacitance 20 μF. What is the *r.m.s.* value of the charging current.

6. A 6 pole, DC generator develops an e.m.f of 220 V at 1500 r.p.m. The armature has a lap-connected winding. The average flux density over a pole-pitch is 0.9 Tesla. The length and the diameter of the armature are 0.25m and 0.2 m respectively. Calculate:
a) The flux per pole
b) The total number of active conductors in the armature
c) The torque required by the generator when the armature supplies a current of 50 A

7. A 37.3 kW, 4-Pole, 50 Hz induction motor has friction and windage losses of 3320 Watts. The stator losses equal to the rotor losses. If the motor is delivering full-load power output at a speed of 1440 rpm, calculate:

- The synchronous speed (N_s)
- The motor slip (s)
- Mechanical power developed by the motor (P_m)
- Rotor copper loss/phase ($P_{rotor\ loss}$/phase)
- Total power transferred from stator to rotor, i.e. Air gap power (P_{airgap})
- Stator power input (P_{in})
- The efficiency of the motor (η)

8. a) Briefly explain why low voltages are not used in electrical power transmission.

b) Why the ring main system is better when compared with a radial system in electrical power distribution?

c) Semi enclosed ceramic fuses and MCBs (miniature circuit breaker) are protective devices used in domestic electrical installation, however their Time-Current characteristics are different. Explain?

d) Explain the meaning "Time of day" in electricity tariff offered by Ceylon Electricity Board.

Tariff table for Q3

Customer Category	Conditions	Maximum demand charge Rs./kVA per month	Energy Charge Rs./kwh	Fixed Charge Rs./month
Domestic	Metered at 400V/230V	-	1-30 Units @ 3.00 31-60 Units @ 4.70 61-90 Units @ 5.10 91-180 Units @ 12.10 Above 180 Units @ 17.30	60.00 90.00 120.00 180.00 240.00
Religious	Metered at 400V/230V	-	1-30 Units @ 2.50 31-90 Units @ 3.70 91-180 Units @ 5.50 Above 180 Units @ 8.70	60.00 90.00 180.00 240.00
General Purpose All buildings except industries & some hotels	Metered at 400V/230V contract demand < 42 kVA Demand up to 10 kVA Demand above 10 kVA	-	11.90 11.90	240.00 500.00
	contract demand > or = 42 kVA Metered at 400V/230V Metered at 11/33/132 kV	480.00 460.00	11.80 11.70	3000.00 3000.00
Industrial	Metered at 400V/230V contract demand < 42 kVA Demand up to 10 kVA Demand above 10 kVA	-	8.50 8.50	240.00 500.00
	contract demand > or = 42 kVA Metered at 400V/230V Metered at 11/33/132 kV	400.00 380.00	8.10 8.00	3000.00 3000.00
Industrial **(Time Of Day)** Includes some hotels	Metered at 400V/230V contract demand < 42 kVA Demand up to 10 kVA Demand above 10 kVA	-	16.00 bet 7-10 p.m. 7.90 at other times	240.00 500.00
	Metered at 400V/230V contract demand > or = 42 kVA	380.00	22.00 bet 7-10 p.m. 7.50 at other times	3000.00
	Metered at 11/33/132 kV contract demand > or = 42 kVA	360.00	20.00 bet 7-10 p.m. 7.10 at other times	3000.00
Hotels(GP)	Metered at 400V/230V contract demand > or = 42 kVA	480.00	11.80	3000.00
Hotels(Industry)	contract demand > or = 42 kVA Metered at 400V/230V Metered at 11/33/132 kV	480.00 380.00	8.10 8.00	3000.00 3000.00
Hotels **(Time of day)**	contract demand > or = 42 kVA Metered at 400V/230V	380.00	22.00 bet 7-10 p.m. 7.50 at other times	3000.00
	Metered at 11/33/132 kV	360.00	20.00 bet 7-10 p.m. 7.10 at other times	3000.00
Supplies to licensees LECO/LA	Supply at 400/230 V Supply at 11k V & above	240.00 220.00	8.80 6.90	