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The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Advanced Diploma in Technology
ECX3232– Electrical Power
Final Examination -2015/2016
Duration: Three hours

Closed book

Date: 07th December 2016 Time: 09.30-12.30hrs

This paper contains eight (8) questions. Answer any 5 questions. All questions carry equal marks.

(1)

a) Briefly explain the importance of developing renewable energy sources for electricity generation in Sri Lanka **[4 Marks]**

b) What is the reason behind the demand charge (kVA) for industrial consumers? **[3 Marks]**

c) A load variation throughout a day of a certain consumer metered at 400/230 V nominal, 50 Hz, ac system is shown in Table Q1.

Table Q1

Time (hrs)	**0000-0700**	**0700-1300**	**1300-1800**	**1800-2400**
Total Load (kW)	10	15	17	10
Load Description	Lighting load only	Lighting load +	Lighting load +	Lighting load only
		5kW induction motor load operating at 0.85 p.f	7kW induction motor load operating at 0.9 p.f	

1. Draw the daily load curve for this consumer and determine the load factor. **[3 Marks]**
2. What is the maximum demand? **[2 Marks]**
3. What is the applicable tariff rate of this consumer? **[1 Marks]**
4. Calculate the monthly electricity bill of this consumer. **[4 Marks]**
5. Determine the size of the capacitance/phase needed to be installed between 0700-1300 hrs to improve the power factor to unity. Assume that capacitors are star connected. **[3 Marks]**

Note: A month consists of 30 days. Tariff rates offered from the utility is given in page 4.

(2)

a) State the transformer losses obtained from the open circuit test and short circuit test respectively. Also explain variations of these losses with respect to load current. **[4 Marks]**

b) Draw and explain the phasor diagram of an ideal power transformer on load **[3 Marks]**

c) Consider a 4 kVA, 200/400 V, 50 Hz single-phase distribution transformer supplying full-load current at 0.8 power factor lagging. The open circuit (O/C) and short circuit (S/C) test results are as follows:

O/C Test: 200V, 0.8 A, 70 W

S/C Test: 20V, 10 A, 60 W

1. Calculate the efficiency of the transformer, secondary terminal voltage and current into primary at the above load **[10 Marks]**
2. Calculate the load at unity power factor corresponding to maximum efficiency **[3 Marks]**

(3)

a) A DC shunt motor is running at 1200 rpm at rated load torque. What would happen to the motor operation if the following changes are made:
   1. Field winding terminals are reversed
   2. Armature winding terminals are reversed
   3. Supply terminals are reversed
   4. Both field winding and armature winding terminals are reversed.

[4 Marks]

b) A 6 pole, 400 V wave-connected DC shunt motor has 1200 armature conductors and useful flux/pole of 20 mWb. The armature and field resistances are 0.5 Ω and 200 Ω respectively. What will be the speed and torque developed by the motor when it draws 20 A from the supply mains? If core and mechanical losses amount to be 900 W and armature reaction is neglected, find the followings at this load.
   1. Useful torque
   2. Output in kW
   3. Efficiency of the motor

[8 Marks]

c) A 230 V, DC shunt motor has R_f=120 Ω and R_a=0.6 Ω .The motor operates on no load with a full field flux at its base speed of 1000 rpm with I_a=5 A. If the machine drives a load requiring a torque of 100 Nm, calculate armature current and speed of the motor. If the motor is required to develop 10 kW at 1200 rpm, what is the required value of the external series resistance in the field circuit? Neglect saturation and armature reaction. **[8 Marks]**

(4)

a. Identify suitable DC motors for the following applications
   1. Electric traction
   2. Vacuum cleaners
   3. Paper making
   4. Shearing and punching

[4 Marks]

b. Explain the speed-current, torque-current and speed-torque characteristics of a DC series motor. **[3 Marks]**

c. A DC series motor operates at 800 rpm with a line current of 100 A from 230 V main supply. Its armature and field resistances are 0.15 Ω and 0.1 Ω respectively. Find the speed at which the motor runs at a line current of 25 A, assuming that the flux at this current is 45% of the flux at 100A **[13 Marks]**

(5)

a) Compare the merits and demerits of squirrel cage induction motor with wound rotor induction motor. **[4 Marks]**

b) A 400 V, 4 pole, 50 Hz, 15kW star connected wound rotor induction motor has the following equivalent circuit parameters, in ohms per phase referred to the stator;

$R_1 = 0.2$ $R_2^1 = 0.12$

$X_1 = 0.41$ $X_2^1 = 0.41$ $X_m = 15$

Mechanical losses = 300 W

For a given slip of 0.05, calculate

1. Stator line current and its power factor **[4 Marks]**
2. Stator copper loss **[2 Marks]**
3. Air gap power **[4 Marks]**
4. Load torque **[3 Marks]**
5. The overall machine efficiency **[3 Marks]**

a) Briefly explain electricity distribution system in Sri Lanka by providing comparison of its network topologies. **[4 Marks]**

b) A 50 Hz, single phase transmission line has several loads 4 km away from the substation as shown in figure Q6. The transmission line has impedance of 1+ j 5 Ω per km. In order to maintain 230 V at the load end ,Calculate

i. Current flowing in the transmission line **[4 Marks]**

ii. Substation voltage **[4 Marks]**

iii. Active and reactive power dissipated in the line **[4 Marks]**

iv. Active and reactive power delivered by substation **[4 Marks]**

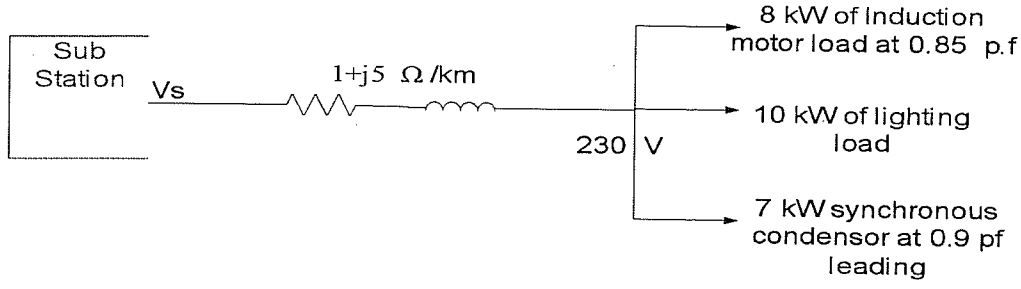

Figure Q6

(7)

a) In Sri Lanka what types of generating stations are dispatched at base loads? Explain your answer. **[5 Marks]**

b) Discuss the merits and demerits of introducing LNG (Liquified Natural Gas) as a generation source instead of coal power. **[5 Marks]**

c) What are the protective devices used in your domestic wiring system. Discuss the advantage of having each item you mentioned. **[5 Marks]**

d) Briefly explain why different level of voltages used for generation, transmission and distribution of electrical energy **[5 Marks]**

(8)

a) What are the benefits of power factor correction? **[4 Marks]**

b) Suppose a plant has 2000 kVA demand, which requires 1600 kW and is billed at a rate of Rs 320/kVA demand.

1. Determine the power factor of the plant.
2. Calculate the kVAr needed to raise the overall power factor to 0.95
3. Compute monthly savings
4. If this facility wants to increase its active load by 25% by installing a capacitor system, how big it would be to avoid an installing of a new transformer? **[8 Marks]**

c) An r.m.s current of 5 A which has a third-harmonic content, is passed through a coil having a resistance of 3 Ω and an inductance of 12 mH. The r.m.s voltage across the coil is 20 V. Calculate the magnitudes of the fundamental and harmonic components of current if the fundamental frequency is $300/2\pi$ Hz. Also find the active power dissipated. **[8 Marks]**

Tariff rates offered from the utility for Q#1

Customer Category I- 1

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand is less than or equal to 42 kVA.

Customer Category I- 2

This rate shall apply to supplies at each individual point of supply delivered and metered at 400/230 Volt nominal and where the contract demand exceeds 42 kVA.

Customer Category I-3

This rate shall apply to supplies at each individual point of supply delivered and metered at 11,000 Volt nominal and above

Customer Category	Energy charge (Rs/kWh)			Fixed Charge (Rs/ month)	Maximum Demand Charge per month (Rs/kVA)	Fuel adjustment charge (% of Energy Charge)
	Peak 1830-2230 hrs	Off-Peak 2230-0530 hrs	Day 0530-1830 hrs			
Industry						
I-1	Consumption per month (kWh) <301 - 10.80 Consumption per month (kWh) >301 - 12.20			600		15
I-2	20.50	6.85	11.00	3,000	1,100	15
I-2	23.50	5.90	10.25	3,000	1,100	15

Note: Fuel adjustments charge is applied only on monthly energy charge. It is not applied on monthly fixed charge and monthly demand charge