00110

THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DEPARTMENT OF ELECTRICAL & COMPUTOR ENGINEERING

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: EEX4332 -Electrical Power
Academic Year	: 2021/22
Date	: 11th February 2023
Time	: 0930-1230 hrs
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Four (4)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Relevant charts/ codes are provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear hand writing.
8. Do not use red colour pen.

Q1.

a) Write three main functions of a distribution substation? [3 marks]

b) Briefly explain methods can be used to improve the power factor of a circuit? [5 marks]

c) A large industrial plant receives three-phase electric power from a local utility. The following loads are being fed in the plant at 11 kV (line to line)

- 1.4 + j 1.4 MVA,
- 3.5 MW at 0.88 lagging power factor,
- 700 kW of pure heating and lighting (negligible reactive power) load, and
- A number of induction motors: total power output of 2500 kW, with a composite efficiency of 0.85 and power factor of 0.9 (lagging) respectively.

Calculate the power factor, active, reactive and apparent power of the plant. [12 marks]

Q2.

a) State what is meant by the term "electrical installation" [3 marks]

b) Explain what is meant by electric shock? [3 marks]

c) Consider a typical house that connected to a 230 V, 50 Hz supply. In the house, there is a 15 A socket outlet circuit protected by a 20 A Type B MCB (BS EN 60898). The external earth fault loop impedance of the house is 0.7 Ω. The house owner connected a microwave oven to the socket outlet and the circuit experienced an earth fault. The effective resistance across the microwave oven (the load) is 1.65 Ω.
(Time/Current zones of ac effects (15 -100 Hz) on persons and time- current characteristic of MCB are given in the figure A1(a) and figure A1(b) respectively in the appendix A1. You may use any reasonable assumptions).

i. Calculate,
Prospective earth fault current flowing through the microwave oven [2 marks]

Prospective earth fault voltage across the microwave oven [2 marks]

Time taken for the fuse to blow [1 marks]

ii. Assume that the house owner accidently touches the metal part of the microwave oven during the earth fault.

State whether the houseowner is affected due to direct or indirect contact. [2 marks]

Determine the current that is flowing through body of the house owner? [2 marks]

What form of a shock will the house owner would get? [2 marks]

iii. As per the BS 7671 IET Wiring regulation, what is the missing component in this circuit? [2 marks]

Q3.

a) Explain why the cost of supplying electricity to consumers depends, largely, on the method of production of electricity. [5 marks]

b) Daily load variation of a certain consumer metered at 400/230 kV, 50 Hz is shown in Table Q3(a)

Table Q3(a)

Time (hours)	0000-0700	0700-1300	1300-1800	1800-2400
Total Load (kW)	25	42	46	25
Load Description	Lighting Load only	Lighting Load +	Lighting Load +	Lighting Load only
		17 kW induction motor load operating at 0.85 p.f	21 kW induction motor load operating at 0.9 p.f.	

i. Draw the daily load curve-and determine the load factor of the above consumer. [2 marks]
ii. What is the maximum demand? [2 marks]
iii. What is the applicable tariff structure for this consumer? [2 marks]
iv. Determine the monthly electricity bill of this consumer. [7 marks]

Note: A month consist of 30 days

Tariff rates offered from Ceylon Electricity Board is given in appendix A2.

Q4.

a) A stepper motor has 18 stator poles and 10 rotor poles. Find the full step angle? [4 marks]

b) Stator of a three phase, 4 pole slip ring induction motor is connected to 50 Hz supply. At the rotor terminals, a frequency of 30 Hz is required. Find the possible speeds at which the rotor must be driven. What is the ratio of slip ring emfs at these speeds at no load? [8 marks]

c) A 8 pole DC machine has 300 conductors and each conductor is capable of carrying 50 A without excessive temperature rise. The flux per pole is 0.02 Wb and the machine is driven at 3000 rpm. If the armature conductors are wave connected, compute the followings: total current, emf, power developed in the armature and electromagnetic torque.

i. Total current [2 marks]
ii. Emf [2 marks]
iii. Power developed in the armature [2 marks]
iv. Electromagnetic torque [2 marks]

Q5.

a) Compare 5 main characteristics of Brush Less DC (BLDC) motor vs Brushed DC motor? [6 marks]

b) What do you mean by "servomechanism" and how is it useful for small DC motors? [7 marks]

c) The power supplied to a 3- phase induction motor is 30 kW and the corresponding stator losses are 1 kW. Consider the slip is 0.032. Friction and windage losses assumed to be 0.8kW.

i. Calculate the net mechanical power developed. [2 marks]
ii. Calculate the rotor I^2R loss. [2 marks]
iii. If the speed of the above motor is reduced to 30% of the synchronous speed by means of external rotor resistors, what will be the net power developed? Assume the torque and stator losses to remain unaltered. [3 marks]

Q6.

a) What is the rotor speed of four pole 50 Hz synchronous generator? [4 marks]

b) Discuss in your own word what are "Open circuit test" and short circuit test" of a power transformer? How these two tests are performed at the laboratory? [10 marks]

c) A three-phase star/delta connected 11 kV/400 V, 50 Hz transformer takes a line current of 4 A, when it is connected to 0.95 power factor lagging load. Determine primary and secondary side currents and output power of the transformer. Assume that the transformer is ideal. [6 marks]

Q7.

a) What restrictions are there for prevent raising the transmission voltage to very high values? [4 marks]

b) A 3300 V, 1200 kVA alternator is feeding a load of 0.85 power factor. What is the maximum output power of the alternator? [4 marks]

c) Mark weather the following statements are correct or wrong by putting "√ " mark for correct answers and " × " mark for the wrong answers. [5 marks]

i. When the rotor speed of a three-phase induction motor reaches the synchronous speed, the rotor induced emf will be zero.
ii. The safe limits of the voltage and current through human body are 50 V and 16 mA respectively.
iii. The type of the armature winding of a DC machine, weather it is lap wound or wave wound, can increase the output power of that machine.
iv. Long distance transmission cannot be done at generator voltage levels because of the huge material requirement and the associated high copper loss.

v. Indirect contact is a contact of persons or livestock with live parts which may result electric shock.

vi. The auto transformer is a unit which employing two windings in order to provide the appropriate voltage.

vii. Single phase induction motor is a self-starting motor.

viii. By studying the speed-torque characteristic of a DC series motor, we can see that the speed rapidly drops as the torque increases.

ix. Mechanical angle ($\theta_{mechanical}$) of a 4-pole induction motor is 180°.

x. Ring main distribution systems are mostly used in rural areas and radial systems are used in in areas where the higher reliability for the consumers is a requirement.

d) If a stepper motor has following given data calculate torque generated by the stepper motor. L= 5.25 $\times 10^{-3}$ m, g= 5.25 $\times 10^{-5}$ m, r=0.78 $\times 10^{-2}$ m, F= 600 At, t= 12 [7 marks]

Q8.

a) Explain the significance of bar chart in electrical installation work. [5 marks]

b) State the starting methods of a single-phase induction motor and explain one of the method with suitable diagrams. [10 marks]

c) An 8- pole, 3 phase, 50 Hz induction motor is operating at a speed of 720 rpm. Calculate the frequency of the rotor current of the motor. [5 marks]

Appendix A1

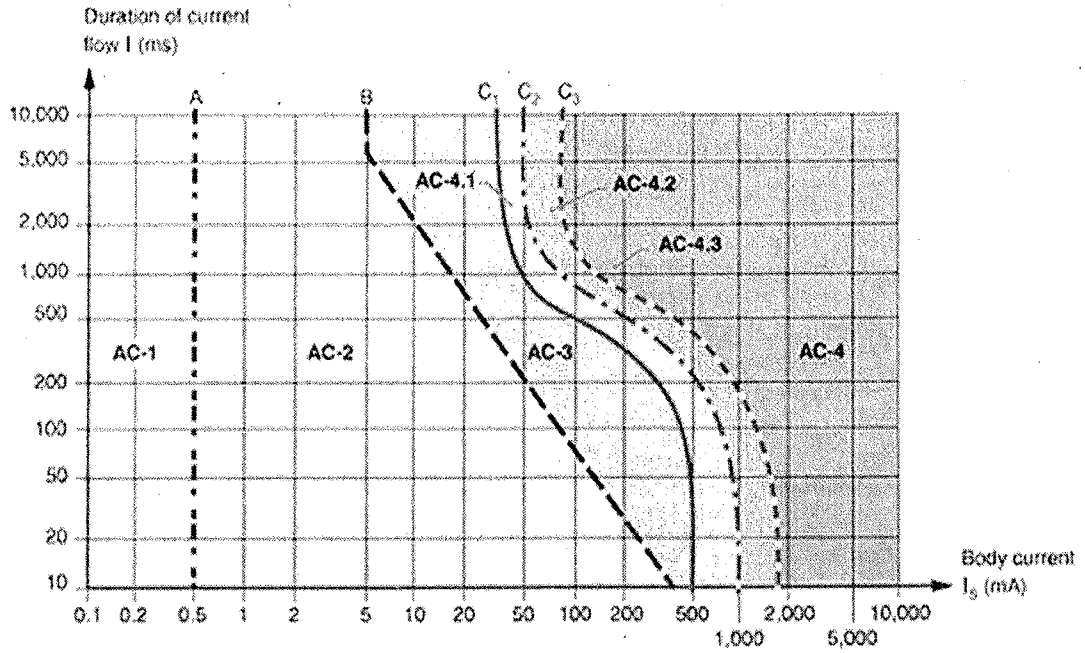


Figure A1(a): Time/ current zones of ac effects (15- 100 Hz) on person

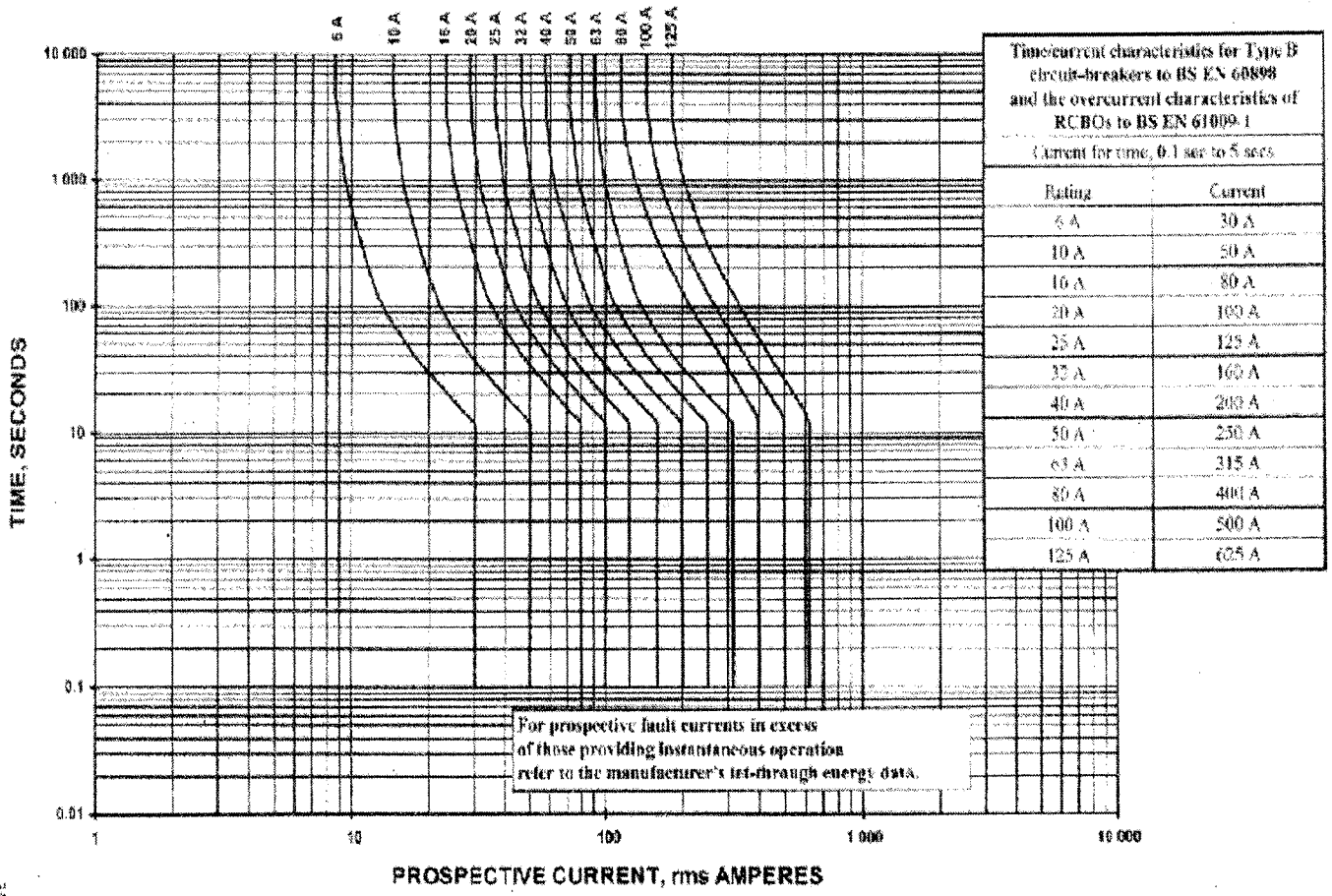


Figure A1(b): Time- current characteristics of MCB

Appendix A2

Tariff rates offered from the utility

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 (LKR/kWh)			Fixed Charge (LKR/ month)	Maximum Demand Charge per month (LKR /kVA)	Fuel adjustment charge (% of Energy Charge)
	Peak (1830hr-2230hr)	Off-Peak (2230hr-0530hr)	Day (0530hr-1830hr)			
Industry						
I-1	12.50			600		15
I-2	21.00	7.00	11.30	3,000	1,100	15
I-3	24.00	6.00	10.50	3,000	1,000	15
Street Lighting	17.00			None	None	0

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