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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4332 -Electrical Power**
Academic Year	: 2020/21
Date	: 30th January 2022
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 **Five (5)** 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) Briefly explain merits and demerits of coal power plant when compared with LNG power plant. **[04 Marks]**

b) Briefly describe the economic and technical factors which are directly involved in deciding electricity transmission and distribution voltage levels. **[04 Marks]**

c) A load variation throughout a day of a 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)	30	42	45	30
Load Description	Lighting load only	Lighting load +	Lighting load +	Lighting load only
		12 kW induction motor load operating at 0.80 p.f	15 kW induction motor load operating at 0.85 p.f	

i. Draw the daily load curve and determine the load factor of the above consumer.
ii. What is the maximum demand?
iii. What is the applicable tariff structure for this consumer?
iv. Determine the monthly electricity bill of this consumer.
v. Calculate the size of the capacitance/phase needed to be installed between 1300-1800 hrs. to improve the power factor to 0.95. Capacitors are star connected

Note: A month consist of 30 days. Tariff rates offered from the utility is given in page 5

[12 Marks]

Q2

a) What is the purpose of following equipment used in domestic/industrial electrical installations?

- Semi-enclosed Fuse
- Surge arrestor
- MCB
- RCCB

[4 Marks]

b) What are the protective measures stated in direct contact and indirect contact with respect to IET wiring regulations? **[2 Marks]**

c) Figure Q2a shows a simple distribution system composed of main feeder F from a substation, supplying a group of sub-feeders. The sub-feeders deliver power to loads A, B, C, D and E. P denotes the protective devices installed at each point.

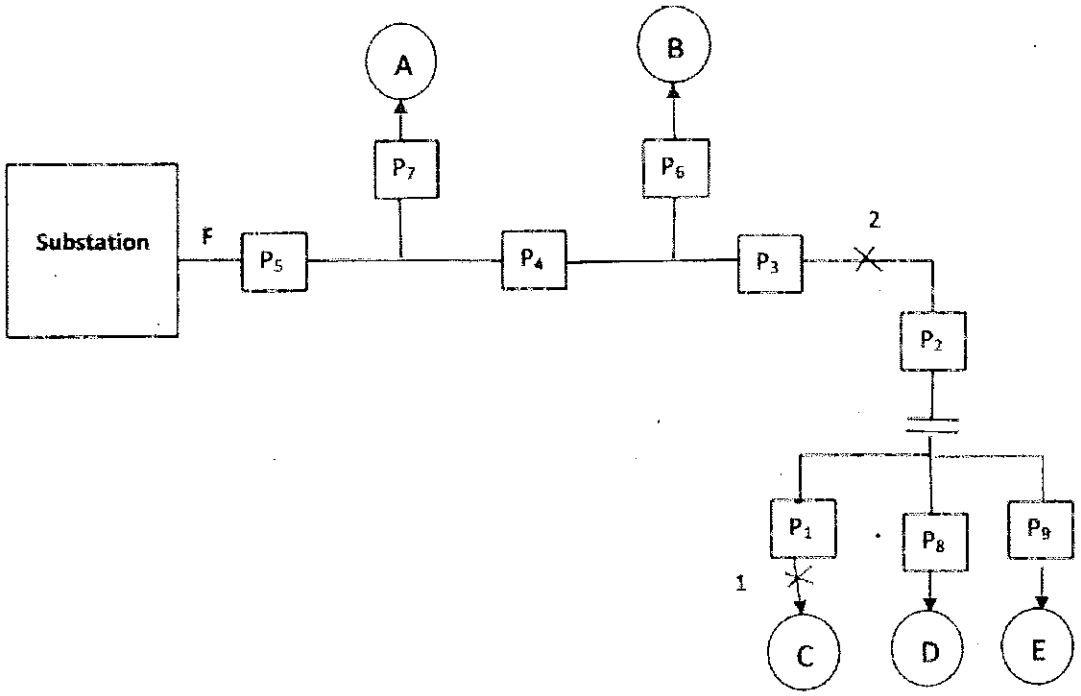


Figure Q2a

i. Briefly explain the importance of coordination of protective devices when fault occurs at point 1 and 2 respectively. **[4 Marks]**

ii. Why it is required to know tripping characteristics of fuses and circuit breakers throughout the system. **[2 Marks]**

iii. Draw tripping characteristics of a fuse and MCCB and compare the characteristics. **[2 Marks]**

d) In household Electrical installations, what is the purpose of grounding electrical equipment? **[2Marks]**

e) Figure Q2b and Figure Q2c shows two different circuit connections of electrical installations. Briefly explain the difference between two circuit connections and discuss which arrangement provides the required protection. **[4 Marks]**

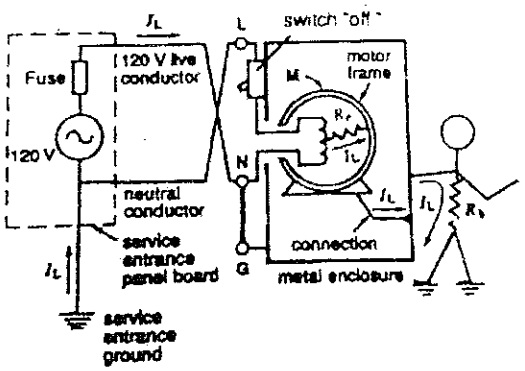


Figure Q2b

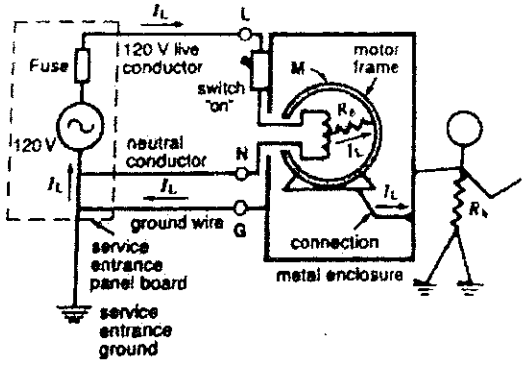


Figure Q2c

Q3

a) Draw and explain the phasor diagram of a real transformer connected to a lagging load. **[3 Marks]**

b) Explain why the secondary voltage of a real transformer decreases with increasing resistive load. **[3 Marks]**

c) An open circuit (OC) test and a short circuit (SC) test are conducted on a single-phase distribution transformer rated at 5 kVA, 200/400 V, 50 Hz. The following results were obtained from the two tests:

OC test: 200V, 1.25 A, 150 W
SC test: 20V, 12.5 A, 175 W

i. Draw the equivalent circuit parameters of the transformer referred to the low voltage side and high voltage side inserting all the parameter values.
ii. Calculate the efficiency of the transformer at 75% loading with 0.7 lagging load power factor.
iii. At what load (or kVA) the transformer is to be operated for maximum efficiency. Also calculate the value of maximum transformer efficiency.
iv. Determine the voltage regulation of the transformer at full load 0.8 power factor lagging. **[14 Marks]**

Q4

a) Briefly describe the merits and demerits of an auto transformer over two winding transformer. **[4 Marks]**

b) Why it is necessary to short-circuit the secondary of a CT when the instrument is to be taken out of circuit? **[4 Marks]**

c) A 10000/2500 V transformer is rated at 100 kVA as a two-winding transformer. It is desired to connect the two windings of the transformer in series to connect a 12500 V primary supply and to operate the same as an auto transformer. Explain the connections for achieving the same. What are the possible voltage ratio and the corresponding maximum output? **[12 Marks]**

Q5

a) Briefly explain the two problems occur in a DC machine owing to "armature reaction" and suggest remedial measures to overcome for those problems. **[2 Marks]**

b) Derive expression for torque-speed relationship for DC series motor and draw the characteristics. **[3 Marks]**

c) The armature of a 6-pole lap wound DC shunt motor takes 400A at a speed of 350 rpm. The flux per pole is 80 mWb, the number of turns is 600, and 3% of the torque is lost in windage, friction and in the form of iron losses. Calculate the output power. **[6 Marks]**

d) A DC series motor connected to a 440 V supply, runs at 600 rpm when taking a current of 50 A from the supply. Calculate the value of resistance required to be inserted in series with the motor which reduces the speed to 400 rpm. The gross torque is half of the previous value. The total resistance of the motor is 0.3 Ω. Assume linear magnetization. **[9 Marks]**

Q6

a) Briefly Explain the two starting methods of single-phase induction motor with the aids of circuit diagrams. **[8 Marks]**

b) The power input to a 400 V, 6 pole, 50 Hz three-phase squirrel cage induction motor running at 975 rpm is 40 kW. The stator losses are 1 kW and the friction and windage losses are 2 kW. Calculate:

i. Slip of the motor
ii. Rotor copper losses
iii. Output power
iv. Motor efficiency **[12 Marks]**

Q7

a) Draw a block diagram of the complete speed control system for a sinusoidal brushless DC motor and briefly explain its operation. **[4 Marks]**

b) List basic differences between the trapezoidal and sinusoidal BLDCMs. For what type of an applications is the sinusoidal motor being better? **[3 Marks]**

c) What is the difference between a variable reluctance stepper motor and a permanent magnet stepper motor? **[2 Marks]**

d) Calculate the basic step angle for the following stepper motor. **[2 marks]**

three-phase variable reluctance stepper motor with 6 stator poles and 16 rotor teeth

e) Give sketches to show the construction of a three-phase variable reluctance (VR) stepper motor with 6 stator poles and 16 rotor teeth. Indicate the switching pattern for normal stepping and half-stepping operations. **[4 Marks]**

f) The stepper motor describe in **e.** is used to drive a lead screw having a pitch of 20 threads per inch. The lead screw, in turn produces a linear motion of a cutting tool. If the motor is pulsed 10 times, by how much does the cutting tool move? **[5 Marks]**

Q8

a) Explain the factors considered when selecting electric motor for an industrial application. **[5 Marks]**

b) Briefly explain the problems associated with harmonics in a power system. **[3 Marks]**

c) A balanced nonlinear load produces line currents containing fundamental and 20% third Harmonic: $I_{an}(t) = I_1 \cos(\omega t - \theta_1) + 0.2 \cos(3\omega t - \theta_3)$.
Find the rms neutral current, and compare its amplitude to the rms line current amplitude. **[6 Marks]**

d) A 600 kW induction furnace connected to an 800 V single-phase line operates at a power factor of 0.6 lagging. It is supplied by a 4 kV line and a step-down transformer.

i. Calculate the current in the 4000V line.
ii. If 500 kVar capacitor is installed on the HV side of the transformer, calculate the new power factor and the new line current. **[6 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 (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.