UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: May 2023

Module Number: EE7207 **Module Name: Electrical Installations I**

[Three Hours]

[Answer **all questions**]

Q1 a) An electrical design engineer has been assigned for the electrical installation designs in one of the tallest apartment buildings, which is under construction in Sri Lanka "606 The Address" in Colombo. The design engineer states that it is not mandatory to follow the IET wiring regulation in the design and installation phase. Do you agree with the statement of the design engineer? Give reasons to your answer.

[2 Marks]

b) A business premises with 10-story has equipment on each floor as shown in Table Q_1 b).

i) Calculate the power demand (in kVA) for a floor by considering the diversity. Assume the utilization factor for every type of equipment as 1. Annex 01 shows the allowance for diversity.

ii) For the 10-story building, there are 2 elevators, a water pump, and a motor for fire extinguishers whose details are shown in Table Q_1b)ii). The power factor for the water pump and the motor is **0.8** and the power factor for the elevator is 1. Consider 100% current demand for elevators.

Consider the diversity factor for a floor is 0.85. Consider 20% future expansion of the transformer power capacity and limit the transformer maximum loading up to 75%.

Determine the capacity of the transformer at the CEB supply of the building and select the most suitable transformer from the list below.

Three-phase transformer capacity (kVA)	3, 6, 9, 15, 30, 45, 50, 75, 112.5, 150, 225, 300, 500, 750, 1000

[10 Marks]

c) A three-phase 400 V, 15 kW, 0.85 PF induction motor is fed by a 0.1 Ω per phase 400 V three-phase transformer. The induction motor and the transformer are connected through a 10 m long cable having a resistance of 0.01 Ω/m per phase. The induction motor starting current is 5 times of its rated current. Use Table Q1 c) to select a suitable three-pole MCB for this application. Neglect the cable voltage drop.

(Circuit Breaker rated current can be selected from 6A, 10A, 16A, 20A, 30A, 40A, 60A, 80A, 100A, 125A, 160A, 200A, 250A, 300A, 400A, 500A, 600A, 800A, 1000A, 1200A, 1500A)

[5 Marks]

Q2 a) Briefly explain the three types of Electrical Distribution Systems.

[3 Marks]

b) A certain TN-C-S installation have the following details;

- Transformer winding resistance (Reference to secondary side) = 0.001 Ω/phase
- The type of phase and PEN conductors from Transformer to Main Distribution Board is 35 mm^2 Cu/PVC/PVC.
- The type of phase and PEN conductors from Main Distribution Board to Sub Distribution Board is 25 mm^2 Cu/PVC/PVC.
- The type of phase and neutral conductors within installation is 4 mm^2 Cu/PVC/PVC.
- The type of PE conductor within installation is 4 mm^2 Cu/PVC
- Distance from source to MDB and cable installation method is 40 m in Perforated Cable Tray.
- Distance from MDB to SDB is 25 m in Perforated Cable Tray.
- Distance from SDB to Load is 15 m - Enclosed in conduit on a wall

By considering the worst case, answer the following questions i), ii) and iii).
You may refer attached Annex 02-Curent Carrying Capacity of cables and Annex 03-Voltage Drop for calculations.

i) Calculate the earth loop impedance by drawing a suitable circuit diagram.
ii) Calculate the maximum possible earth fault current at the load terminals.
iii) What is the type of protective device that can be used as earth fault protection for this system?

[7 Marks]

Q3 a) i) Explain what is color temperature of a light source.
ii) Suggest methods to improve the utilization factor in lighting designing.

[3 Mark]

b) A building with a bedroom, living room, bathroom, kitchen, lobby, and corridor has the requirement of illumination levels 300 Lux, 275 Lux, 150 Lux, 500 Lux, 200 Lux, and 100 Lux, respectively. It needs to be illuminated for the required lux level using lights of an efficacy of 200 lm/W. The efficiency of the fixture is 55% including utilization and maintenance of the luminaire.
LED light fitting of rating 1*18 W named 'A' and LED E27 1*10.5 W lamps named 'B' are to be used to illuminate the given building.

i) Determine the type and the number of LED lamps out of type A and type B that are needed to obtain the recommended illumination while optimizing the power for only the living room and the kitchen. Consider the light output ratio as 1. Clearly state the assumptions you made. The area of the living room and the kitchen are 33.64 m^2 and 7.41 m^2, respectively.

ii) Create a suitable layout arrangement of the distribution of the LED lights of type A and LED lamps of type B for the living room and the kitchen.

[7 marks]

Q4 a) What are the contents of a Technical Specification?

[2 Marks]

b) Why is the technical specification of a project important? Briefly explain your answer with an example.

[3 Marks]

c) Develop a Single Line Diagram Drawing for the Electrical Distribution System based on the design current calculation shown in Table Q_4.

Hints:

I. Circuit Breaker rated current can be selected from 6A, 10A, 16A, 20A, 32A, 40A and 63A, which are available in the market.

II. You may indicate cable sizes considering only the rated current of the circuit breakers (Refer Annex 02). No need to calculate the voltage drop and the fault current to determine cable sizes.

III. You may place the RCCBs at Consumer Units (CUs) level for human protection.

IV. Final circuits can be divided to three phases balancing the electrical loads.

[8 Marks]

Table Q1 b): Details of the equipment in a floor

Equipment (Single Phase)	Number of equipment	Power (kW)
Microwave cooking appliance	1	1
Microwave cooking appliance	1	0.8
Lighting	Total load	0.5
Air Conditioner	1	2.4
Air Conditioner	1	3.2
Air Conditioner	1	1.5
Other facilities after considering the utilization and diversity factors		0.25

Table Q1 b) ii): Details of the equipment in the building

Equipment (Three Phase)	Number of equipment	Power (kW)
Water pump	1	3
Motor	1	3.5
Elevator	2	5

Table Q1 c) : MCB characteristics

Type of MCB	I_m range
Type 1	2.7 I_n- 4 I_n
Type 2	4 I_n -7 I_n
Type 3	7 I_n -10 I_n
Type A	3 I_n -5 I_n
Type B	5 I_n -10 I_n
Type C	10 I_n -50 I_n

Table Q4 : Design current calculation

Panel ID	Circuit No	Design Current (Single Phase)	Panel ID	Circuit No	Design Current (3 Phase)	Design Current Total (3 Phase)
CU-01	1	2.5	MDB	1	22.4	57.6
	2	3.6				
	3	8.2				
	4	7.6				
	5	6.5				
	6	11.6				
	7	13.2				
	8	12.8				
CU-02	1	2.4		2	26.5	
	2	3.9				
	3	4.1				
	4	7.2				
	5	6.8				
	6	6.2				
	7	10.5				
	8	11.3				
	9	13.2				
	10	12.4				
CU-03	1	2.3		3	23.1	
	2	3.8				
	3	8.8				
	4	7				
	5	6.3				
	6	11.8				
	7	13.4				
	8	12.6				

Annex 01: Diversity application

This table is applicable to installations having a current demand not exceeding 400A in each phase.

Purpose of Conductors or Switchgear to which Diversity Applies	Type of Premises		
	Individual Household Installations, Individual Dwellings of a Block	Small Shops, Stores, Offices and Business Premises	Small Hotels, Boarding Houses, Guest Houses, etc.
1. Lighting	66% of total current demand	90% of total current demand	75% of total current demand
2. Heating and Power (Also see 3 to 10 below)	100% of total current demand up to 10 amperes+50% of any current demand in excess of 10 amperes	100% f.l. of largest appliance+75% f.l. of remaining appliances	100% f.l. of largest appliance+80% f.l. of 2nd largest appliance+60% f.l. of remaining appliances
3. Cooking Appliances	10 amperes+30% f.l. of connected cooking appliances in excess of 10 amperes+5 amperes if socket outlet incorporated in unit	100% f.l. of largest appliance+80% f.l. of 2nd largest appliance+60% f.l. of remaining appliances	100% f.l. of largest appliance+80% f.l. of 2nd largest appliance+60% f.l. of remaining appliances

Purpose of Conductors or Switchgear to which Diversity Applies	Type of Premises		
	Individual Household Installations, Individual Dwellings of a Block	Small Shops, Stores, Offices and Business Premises	Small Hotels, Boarding Houses, Guest Houses, etc.
4. Motors (other than lift motors, see 8)	—	100% f.l. of largest motor+80% f.l. of 2nd largest motor+ 60% f.l. of remaining motors	100% f.l. of largest motor+50% f.l. of remaining motors
5. Water-Heaters (instantaneous type)	100% f.l. of largest appliance+100% f.l. of 2nd largest appliance+25% f.l. of remaining appliances	100% f.l. of largest appliance+100% f.l. of 2nd largest appliance+25% f.l. of remaining appliances	100% f.l. of largest appliance+100% f.l. of 2nd largest appliance+25% f.l. of remaining appliances
6. Water Heaters (thermostatically controlled)	No diversity allowable Note: It is important to ensure that the distribution board is of sufficient rating to take the total load connected to it without the application of any diversity.		
7. Thermal Storage Space Heating Installations			
8. Lift motors	Note: Subject to requirements specified by the lift engineer registered under Cap. 618, Lifts & Escalators Ordinance.		
9. Water Pumps	100% f.l. of the largest pump motor and 25% of the remaining motors		
10. Air conditioners	100% f.l. of the largest air-conditioner in the premises and 40% f.l. of the remaining air-conditioner(s)	100% of current demand of largest point of utilisation+ 75% of current demand of every other point of utilisation	100% of current demand of largest point of utilisation+ 75% of current demand of every other point of utilisation

Purpose of Conductors or Switchgear to which Diversity Applies	Type of Premises		
	Individual Household Installations, Individual Dwellings of a Block	Small Shops, Stores, Offices and Business Premises	Small Hotels, Boarding Houses, Guest Houses, etc.
11. Arrangements of Final Circuits in accordance with code 6D	100% of current demand of largest circuit+30% of current demand of every other circuit	100% of current demand of largest circuit+ 40% of current demand of every other circuit	
12. Arrangements of Final Circuits in accordance with code 6E	100% of current demand of largest circuit+40% of current demand of every other circuit	100% of current demand of largest circuit+ 50% of current demand of every other circuit	
13. Fixed Equipment of the same type e.g. Refrigerators and freezers other than those listed above	100% of current demand of largest point of utilisation+ 40% of current demand of every other point of utilisation	100% of current demand of largest point of utilisation+ 75% of current demand of every other point of utilisation	100% of current demand of largest point of utilisation+ 75% of current demand of every point in main rooms (dining rooms, etc.) + 40% of every other point of utilisation

Annex 02

COPPER CONDUCTORS

TABLE 4G1A – Mineral insulated cables thermoplastic covered or bare and exposed to touch (COPPER CONDUCTORS AND SHEATH)

CURRENT-CARRYING CAPACITY (amperes):

Ambient temperature: 30 °C
Sheath operating temperature: 70 °C

Conductor cross-sectional area	Reference Method C (clipped direct)			Reference Methods E, F and G (in free air or on a perforated cable tray etc, horizontal or vertical)				
	Single-phase AC or DC	Three-phase AC		Single-phase AC or DC	Three-phase AC			
	2 single-core cables touching or 1 two-core cable	3 single-core cables in trefoil or 1 three-core or four-core cable	3 single-core cables flat and touching, horizontal or vertical	2 single-core cables touching or 1 two-core cable	3 single-core cables in trefoil or 1 three-core or four-core cable	3 single-core cables flat and touching	3 single-core cables flat and spaced by one cable diameter	
							vertical	horizontal
1	2	3	4	5	6	7	8	9
(mm^2)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
Light duty 500 V								
1	18.5	15	17	19.5	16.5	18	20	23
1.5	23	19	21	25	21	23	26	29
2.5	31	26	29	33	28	31	34	39
4	40	35	38	44	37	41	45	51
Heavy duty 750 V								
1	19.5	16	18	21	17.5	20	22	25
1.5	25	21	23	26	22	26	28	32
2.5	34	28	31	36	30	34	37	43
4	45	37	41	47	40	45	49	56
6	57	48	52	60	51	57	62	71
10	77	65	70	82	69	77	84	95
16	102	86	92	109	92	102	110	125
25	133	112	120	142	120	132	142	162
35	163	137	147	174	147	161	173	197
50	202	169	181	215	182	198	213	242
70	247	207	221	264	223	241	259	294
95	296	249	264	317	267	289	309	351
120	340	286	303	364	308	331	353	402
150	388	327	346	416	352	377	400	454
185	440	371	392	472	399	426	446	507
240	514	434	457	552	466	496	497	565

NOTES:

1. For single-core cables, the sheaths of the circuit are assumed to be connected together at both ends.
2. For bare cables exposed to touch, the tabulated values should be multiplied by 0.9.

TABLE 4G1B

VOLTAGE DROP (per ampere per metre): Sheath operating temperature 70 °C

Conductor cross-sectional area	Single-phase AC or DC						Three-phase AC											
	2 single-core cables touching			1 two-core cable			1 three- or four-core cable			3 single-core cables in trefoil formation			3 single-core cables flat and touching			3 single-core cables flat and spaced by one cable diameter*		
1	2			3			4			5			6			7		
(mm^2)	(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)			(mV/A/m)		
1	42			42			36			36			36			36		
1.5	28			28			24			24			24			24		
2.5	17			17			14			14			14			14		
4	10			10			9.1			9.1			9.1			9.1		
6	7			7			6.0			6.0			6.0			6.0		
10	4.2			4.2			3.6			3.6			3.6			3.6		
16	2.6			2.6			2.3			2.3			2.3			2.3		
	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z
25	1.65	0.200	1.65	1.65	0.145	1.65	1.45	0.125	1.45	1.45	0.170	1.45	1.45	0.25	1.45	1.45	0.32	1.50
35	1.20	0.195	1.20	-	-	-	-	-	-	1.05	0.165	1.05	1.05	0.24	1.10	1.05	0.31	1.10
50	0.89	0.185	0.91	-	-	-	-	-	-	0.78	0.160	0.80	0.79	0.24	0.83	0.82	0.31	0.87
70	0.62	0.180	0.64	-	-	-	-	-	-	0.54	0.155	0.56	0.55	0.23	0.60	0.58	0.30	0.65
95	0.46	0.175	0.49	-	-	-	-	-	-	0.40	0.150	0.43	0.41	0.22	0.47	0.44	0.29	0.53
120	0.37	0.170	0.41	-	-	-	-	-	-	0.32	0.150	0.36	0.33	0.22	0.40	0.36	0.28	0.46
150	0.30	0.170	0.34	-	-	-	-	-	-	0.26	0.145	0.30	0.29	0.21	0.36	0.32	0.27	0.42
185	0.25	0.165	0.29	-	-	-	-	-	-	0.21	0.140	0.26	0.25	0.21	0.32	0.28	0.26	0.39
240	0.190	0.160	0.25	-	-	-	-	-	-	0.165	0.140	0.22	0.21	0.20	0.29	0.26	0.25	0.36

NOTE: * Spacings larger than one cable diameter will result in a larger voltage drop.