(3 Hours) [Total Marks: 80

N.B.

1. **Question No.1 is Compulsory**.
2. Answer any three out of remaining five questions
3. Assume any suitable data wherever required but justified the same
4. Illustrate answer with sketches wherever required

Q 1 a) State whether true or false and justify the same (**Any five)**

1. Variable Speed Drive (VSD) provides significant energy savings in case of variable torque load **(02)**
2. Individual compensation does not change the protection setting in the upstream side. **(02)**
3. Energy Efficient Motor is more compact than standard motor of the same rating. **(02)**
4. Air Circuit Breaker (ACB), Molded Case Circuit Breaker (MCCB) and Miniature Circuit Breaker (MCB) are an examples of an Air Insulated Switchgear (AIS). **(02)**
5. Specific Energy Consumption (SEC) is popularly use to analyze energy efficiency of plant. **(02)**
6. Decision of Correlation Color Temperature (CCT) of lamp depends upon the application for which illumination system is designed. **(02)**

Q,1 b) Illustrate advantages of busbar system in comparison with a cable system **(05)**

Q.1 c) List out energy saving opportunities in fans and blowers. **(05)**

Q 2 a) From the data given below, **(15)**

i. Draw the SLD showing the location of loads metering devices and various protective devices and their ratings.
ii. Calculate the kVA rating of transformer required for the loads.
iii. Specify the ratings of HT and LT (main) circuit breaker
iv. Suggest for which load, power factor improvement required and calculate capacitor bank required to improve power factor to 0.95.

Load No	kW Rating	LF	DF	Efficiency	PF	Phase
1	100	0.8	0.7	0.7	0.7	Three phase
2	350	0.85	0.7	0.8	0.85	Three phase
3	200	0.5	0.5	0.9	0.95	Single phase
4	400	0.55	0.4	0.9	0.80	Single phase

b) Enlist the desirable characteristics of Energy Audit Instruments **(05)**

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Q 3 a) A 50kW heater, 415V, 3ϕ, 50Hz connected to PCC length = 100m. Two other circuit is running in a cable tray. Ambient temperature is 40°C. Fault level is 20kA. Calculate and specify the cable required for the same. **(10)**

Sr. No	Type of Cable	Value of k (Cu)	Value of k (AL)
a)	PVC cable ≤ 300mm^2	115	76
b)	PVC cable > 300mm^2	103	68
c)	XLPE cable	114	92

b) Illustrate the need of UPS. What are the types of UPS? Illustrate the suitability of each with the help of suitable examples. **(10)**

Q 4 a) An 80HP motor is to operate at full load for 800hr/yr, half load 1800hr/yr, and to be switched off the rest of the time. Two motors are available **(10)**

Energy Efficient Motor	Efficiency at full load	0.92
	Efficiency at half load	0.90
Standard Motor	Efficiency at full load	0.90
	Efficiency at half load	0.88

The cost of energy is Rs. 7.5/kWh. Which motor to be selected based on yearly saving in consumption? if the cost of Standard Motor is 200000/- and cost of energy efficient motor is 270000/- then in your opinion which motor to be selected for the installation?

b) List the types of power distribution system. Illustrate anyone in detail **(10)**

Q. 5 a) An office room measuring (43m (L) + 18m (B) + 5m (H) requires an average illumination of 400 lux. **(15)**

a. State the design consideration for above lighting system
b. Calculate the number of luminaires (fixtures) required
c. Draw the lighting layout
d. Calculate the Lighting Power Density (LPD)

b) Define energy monitoring and Targeting. **(05)**

Q 6 Write a short note on **(any four)** **(20)**

i) Preliminary Energy Audit
ii) Single line diagram
iii) CUSUM technique
iv) Building Management System (BMS)
v) Variable Speed Drives as an Energy Efficient Measure

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Data for Illumination Design problems

K	R_C = 0.7			R_C = 0.5			R_C = 0.3		
	R_W = 0.5	R_W = 0.3	R_W = 0.1	R_W = 0.5	R_W = 0.3	R_W = 0.1	R_W = 0.5	R_W = 0.3	R_W = 0.1
0	0	0	0	0	0	0	0	0	0
0.6	0.43	0.39	0.36	0.42	0.38	0.36	0.41	0.38	0.36
0.8	0.45	0.41	0.38	0.44	0.40	0.38	0.43	0.40	0.38
1.00	0.51	0.47	0.44	0.55	0.47	0.44	0.49	0.46	0.40
1.25	0.55	0.51	0.49	0.53	0.50	0.48	0.52	0.50	0.48
1.50	0.57	0.54	0.52	0.56	0.53	0.51	0.54	0.52	0.50
2.00	0.61	0.58	0.56	0.59	0.57	0.55	0.57	0.56	0.54
2.50	0.63	0.61	0.59	0.61	0.59	0.57	0.59	0.58	0.56
3.00	0.65	0.63	0.61	0.63	0.61	0.59	0.61	0.59	0.58
4.00	0.67	0.65	0.63	0.64	0.63	0.62	0.62	0.61	0.59
5.00	0.68	0.67	0.65	0.65	0.64	0.63	0.63	0.62	0.61

Lamp Data			
Sr. No.	**Type of Lamp**	**Wattage**	**Lumen output**
1.	**Fluorescent (T8/T5)**	**18 (Halo phosphate)**	**1015**
		36 (Halo phosphate)	**2450**
		18 (82/84/86)	**1300**
		36 (82/84/86)	**3250**
		28 (T5)	**2800**
2.	**CFL**	**9**	**600**
		11	**760**
		13	**920**
		18	**1200**

TABLE-36

Correction factors for groups of more than three single-core cables or more than one multicore cables or more than one multicore cables

Multicore cables: (Factors to be applied to the values for one cable)	Number of cables								
	2	3	4	5	6	7	8	9	10
	0.80	0.70	0.65	0.60	0.57	0.52	0.48	0.45	0.43

NOTES:
1. These factors are applicable to groups of cables all of one size equally loaded, including groups bunched in more than one plane
2. Where, spacing between adjacent cables exceeds twice their overall diameter, no reduction factor need be applied

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TABLE 14
IEE-Table 9D2
Current-carrying capacities and associated voltage drops for twin and multicore p.v.c. -insulated cables, non-armoured (copper conductors)

Conductor operating temperature : 70°C

Conductor Cross sectional area	Installation methods A to C †of Fig. 1 ('Enclosed')				Installation methods E to H of Fig. 1 ('Clipped direct')				Installation method K of Fig. 1 ('Defined conditions')			
	One twin cable With or without protective conductor single-phase a.c. or d.c.		One three-core cable with or without protective conductor or one four-core cable, three phase		One Twin cable With or without protective conductor single-phase a.c. or d.c.		One three-core cable with or without protective conductor or one four-core cable, three phase		One Twin cable With or without protective conductor single-phase a.c. or d.c.		One three-core cable with or without protective conductor or one four-core cable, three phase	
	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre
1	2	3	4	5	6	7	8	9	10	11	12	13
mm²	A	mV	A	mV	A	mV	A	mV	A	mV	A	mV
1.0	14	42	12	37	16	42	13	37	-	-	-	-
1.5	18	28	16	24	20	28	17	24	-	-	-	-
2.5	24	17	21	15	28	17	24	15	-	-	-	- FLAT
4	32	11	29	9.2	36	11	32	9.2	-	-	-	- CABLES
6	40	7.1	36	6.2	46	7.1	40	6.2	-	-	-	- ONLY
10	53	4.2	49	3.7	64	4.2	54	3.7	-	-	-	-
16	70	2.7	62	2.3	85	2.7	71	2.3	-	-	-	-
25	79	1.8	70	1.6	108	1.8	90	1.6	114	1.8	95	1.6
35	98	1.3	86	1.1	132	1.3	115	1.1	139	1.3	122	1.1
50	-	-	-	-	163	0.92	140	0.81	172	0.92	148	0.81
70	-	-	-	-	207	0.65 0.64	176	0.57	218	0.65 0.64	186	0.57
95	-	-	-	-	251	0.48 0.46	215	0.42	265	0.48 0.46	227	0.42
120	-	-	-	-	290	0.40 0.36	251	0.34	306	0.40 0.36	265	0.34
150	-	-	-	-	330	0.32 0.25	287	0.29	348	0.32 0.25	302	0.29
185	-	-	-	-	380	0.29 0.23	330	0.24	400	0.29 0.23	348	0.24
240	-	-	-	-	450	0.25 0.18	392	0.20	474	0.25 0.18	413	0.20
300	-	-	-	-	520	0.23 0.14	450	0.18	548	0.23 0.14	474	0.18
400	-	-	-	-	600	0.22 0.11	520	0.17	632	0.22 0.11	548	0.17

CORRECTION FACTORS

FOR AMBIENT TEMPERATURE	25°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C
Ambient temperature								
Correction factor	1.06	0.94	0.87	0.79	0.71	0.61	0.50	0.35

TABLE 15
IEE-Table 9D3
Current-carrying capacities and associated voltage drops for twin and multicore armoured p.v.c. -insulated cables (copper conductors).

Conductor operating temperature : 70°C

Conductor cross sectional area	Installation method E, F and G † of Table 11 ('Clipped direct')				Installation method K of Table 11 ('Defined conditions")				
	One twin cable single phase a.c. or d.c.		One three - or- four core cable three-phase		One twin cable single phase a.c. or d.c.			One three - or- four core cable three-phase	
	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre		Current carrying capacity	Volt drop per ampere per metre
1	2	3	4	5	6	7		8	9
mm²	A	mV	A	mV	A	mV		A	mV
1.5	20	29	18	25	-	-		-	-
2.5	29	18	24	16	-	-		-	-
4	37	12	31	9.6	-	-		-	-
6	48	7.4	41	6.3	50	7.3		42	6.3
10	66	4.3	56	3.8	69	4.3		58	3.8
16	86	2.7	73	2.3	90	2.7		77	2.3
25	115	1.8	97	1.6	121	1.8		102	1.6
35	142	1.3	119	1.1	149	1.3		125	1.1
50	168	0.92	147	0.81	180	0.92		155	0.81
		a.c d.c.				a.c.	d.c.		
70	209	0.65 0.64	180	0.57	220	0.65	0.64	190	0.57
95	257	0.48 0.46	219	0.42	270	0.48	0.46	230	0.42
120	295	0.40 0.36	257	0.34	310	0.40	0.36	270	0.34
150	337	0.32 0.25	295	0.29	355	0.32	0.25	310	0.29
185	390	0.29 0.23	333	0.24	410	0.29	0.23	350	0.24
240	461	0.25 0.18	399	0.20	485	0.25	0.18	420	0.20
300	523	0.23 0.14	451	0.18	550	0.23	0.14	475	0.18
400	589	0.22 0.11	523	0.17	620	0.22	0.11	550	0.17

CORRECTION FACTORS

FOR AMBIENT TEMPERATURE	25°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C
Ambient temperature								
Correction factor	1.06	0.94	0.87	0.79	0.71	0.61	0.50	0.35

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TABLE 20
IEE-Table 9K1

Current-carrying capacities and associated voltage drops for single-core p.v.c. -insulated cables, non-armoured, with sheath (Aluminium conductors)

Conductor operating temperature : 70°C

Cross sectional area of conductor	Installation methods A to C of Table 11 ('Enclosed')					Installation methods E to H of Table 11 ('Clipped direct')					Installation method J of Table 11 ('Defined conditions')					
	2 Cables, single-phase a.c., or d.c.			3 or 4 cables three-phase a.c.		2 Cables, single-phase a.c., or d.c.			3 or 4 cables three-phase a.c.		Flat or vertical (2 cables, single-phase a.c., or d.c. or 3 or 4 cables three-phase)				Trefoil (3 cables three-phase)	
	Current carrying capacity	Volt drop per ampere per metre		Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre		Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre			Current carrying capacity	Volt drop per ampere per metre
		a.c.	d.c.				a.c.	d.c.				1 ph	d.c.	3 ph.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
mm²	A	mV	mV	A	mV	A	mV	mV	A	mV	A	mV	mV	mV	A	mV
16	60	4.5	4.5	52	3.9	72	4.5	4.5	65	3.9	-	-	-	-	-	-
25	78	2.9	2.8	67	2.5	94	2.8	2.8	85	2.5	-	-	-	-	-	-
35	96	2.1	2.0	83	1.8	115	2.1	2.0	105	1.8	-	-	-	-	-	-
50	120	1.6	1.5	100	1.4	143	1.5	1.5	123	1.3	155	1.5	1.5	1.34	140	1.3
70	150	1.2	1.0	125	1.0	181	1.1	1.0	156	0.93	190	1.1	1.0	0.95	170	0.90
95	175	0.93	0.75	150	0.80	223	0.77	0.75	193	0.69	235	0.80	0.75	0.72	205	0.67
120	205	0.80	0.60	175	0.70	261	0.62	0.60	225	0.56	275	0.65	0.60	0.60	235	0.54
150	235	0.73	0.49	200	0.64	298	0.51	0.49	259	0.48	320	0.55	0.49	0.51	270	0.45
185	-	-	-	-	-	345	0.42	0.39	290	0.40	376	0.46	0.39	0.45	310	0.37
240	-	-	-	-	-	411	0.34	0.29	361	0.34	440	0.43	0.29	0.43	370	0.30
300	-	-	-	-	-	476	0.29	0.23	418	0.30	510	0.38	0.23	0.39	435	0.25
380	-	-	-	-	-	554	0.26	0.19	465	0.28	584	0.35	0.19	0.37	490	0.22
480	-	-	-	-	-	643	0.23	0.15	541	0.26	677	0.32	0.15	0.34	570	0.20
600	-	-	-	-	-	737	0.21	0.12	616	0.24	776	0.30	0.12	0.33	648	0.18

CORRECTION FACTORS

FOR AMBIENT TEMPERATURE	25°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C
Ambient temperature								
Correction factor	1.06	0.94	0.87	0.79	0.71	0.61	0.50	0.35

TABLE 21
IEE-Table 9K2

Current-carrying capacities and associated voltage drops for twin and multicore armoured p.v.c. -insulated cables, non-armoured (Aluminium conductors)

Conductor operating temperature : 70°C

Conductor cross sectional area	Installation method E, to H † of Table 11 (Clipped direct)				Installation method K of Table 11 ('Defined conditions')			
	One twin cable single phase a.c. or d.c.		One three - or- four core cable, three-phase		One twin cable, single phase a.c. or d.c.		One three - or- four core cable, three-phase	
	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre	Current carrying capacity	Volt drop per ampere per metre
1	2	3	4	5	6	7	8	9
mm²	A	mV	A	mV	A	mV	A	mV
16	62	4.5	53	3.9	65	4.5	55	3.9
25	82	2.9	70	2.5	86	2.9	74	2.5
35	102	2.1	86	1.8	107	2.1	91	1.8
50	120	1.5	106	1.3	125	1.5	110	1.3
70	150	1.1	133	0.93	158	1.1	139	0.93
95	185	0.79	163	0.68	195	0.79	172	0.68
120	-	-	190	0.54	-	-	200	0.54
150	-	-	217	0.45	-	-	227	0.45
185	-	-	247	0.37	-	-	260	0.37
240	-	-	296	0.29	-	-	311	0.29
300	-	-	340	0.25	-	-	358	0.25

CORRECTION FACTORS

FOR AMBIENT TEMPERATURE	25°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C
Ambient temperature								
Correction factor	1.06	0.94	0.87	0.79	0.71	0.61	0.50	0.35

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