ENEL 674 Industrial and Commercial Power Systems

Group 7

Name: Manan Bharatbhai Patel (UCID: 30126849)

Name: Karnav Darshanbhai Joshi (UCID: 30126641)

Name: Prakash Himmatbhai Soliya (UCID: 30176193)

Project Milestone 3

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1. Connected Load vs Load Demand:

Total connected load (continuous and non-continuous loads) in the system is as follows,

Load Type	Connected Load					Demand Factor	Total Load Demand	Remarks
	Distribution Board - 1P	Distribution Board - 2P	Distribution Board - 3P	Distribution Board - U	Total			
	VA	VA	VA	VA	VA		VA	
Lighting	2469.1	0.0	0.0	1137.1	3606.2	0.7	15353.1	1. As per CEC for first 10KVA Diversity factor is 1 & for rest 0.5. 2. However, for emergency lights which run continuously during the emergency, we have considered demand factor 1.
Receptacles	17100.0	0.0	0.0	0.0	17100.0			
Furnace	0.0	0.0	15113.3	0.0	15113.3	0.5	7556.7	1. Non continuous load
Condensing Units	0.0	0.0	38862.7	0.0	38862.7	0.5	19431.4	1. As cooling and heating can not run simultaneously, hence we have considered the demand factor of 0.5
Baseboard Heaters	4123.7	10320.0	0.0	0.0	14443.7	0.5	7221.9	
Exhaust Fan	0.0	0.0	1239.9	206.0	1445.9	1.0	1445.9	1. Non continuous load
Spare	5760.0	960.0	0.0	4320.0	11040.0	0.6	6624.0	1. Non continuous load
EV charger	0.0	0.0	7220.0	0.0	7220.0	0.5	3610.0	1. Non continuous load
Others i.e. dryer, over, CCTV, Fridge, Projector, etc…	20476.2	0.0	0.0	60.6	20536.8	0.4	8214.7	1. Non continuous load
Fire Pump	0.0	0.0	0.0	16531.9	16531.9	1.0	16531.9	1. Continuous load
Total					**145900**	0.6	**85989**	

Key highlights

Total Connected load: - 145,900 VA

Total Demand Factor of the building: - 0.6

Total Load Demand: - 85,989 VA

Further calculation for the distribution panels is as below.

2. Distribution Board – 1P Incomer 3ϕ, 4W, 175A breaker size calculation

As per our calculation mentioned in excel sheet named “Panel Board 1” (Milestone 1/Panel Schedule(s)/Panel Schedule.xlsx). The same calculation is as follows,

	Connected Load (VA)	Spare (VA)
Phase R	14423.59	1920
Phase Y	13578.60	1440
Phase B	12043.18	2400

Table 1

Load Summary (VA)		Diversity	Demand Load
Receptacle	17100	As per CEC for first $10KVA$ Diversity Factor is 1.0 & for rest 0.5	14784.55
Lighting	2469.1		
Other	20476.27	0.5	10238.13
Spare	5760	0.5	2880

Table 2

Without considering demand factor, the total load and maximum current requirements at distribution board 1P breaker I/C is as following:

Connected Load without considering demand factor	
Total Demand (KVA)	45.8053
Total Demand (Amps)	127.146

Table 3

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 127.146 = 158.93\ A$

As per CEC, we decided to go with available breaker size of $175\ A$.

Conductor Sizing

We need $3\phi, 4W, 175A$ bus bar at Distribution board with $3\phi, 4W$ I/C cable that can handle $175A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degrees Celsius
$300\ kcmil$	240

Table 3

We are considering 3ϕ, 4W cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with 300 kcmil conductor size that can carry $240\ A$ (which is greater than $175/0.8\ =\ 218.75\ A$) at 60 degree Celsius.

For 300 kcmil conductor with jacket, conduit size will be 78mm. In addition to that minimum radius to center of conduit is $330mm$. Final design for distribution board – 1P incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size	Conduit bends
$240\ A$	$300\ kcmil$	$78\ mm$	$330\ mm$

Table 4

3. Distribution Board – 2P Incomer 3ϕ, 4W, 40A breaker size calculation

As per our calculation mentioned in excel sheet named “Panel Board 2” (Milestone 1/Panel Schedule(s)/Panel Schedule.xlsx). The same calculation is as follows,

	Connected Load (VA)	Spare (VA)
Phase R-Y-B	10320	960

Table 6

Load Summary (VA)		Diversity	Demand Load
Receptacle	0	As per CEC for first $10KVA$ Diversity Factor is 1.0 & for rest 0.5	0
Lighting	0		
Baseboard Heater	10320	0.5	5160
Spare	960	0.5	480

Table 7

Without considering demand factor, the total load and maximum current requirements at distribution board 2P breaker I/C is as following:

Connected Load without considering demand factor	
Total Demand (KVA)	11.28
Total Demand (Amps)	31.31106769

Table 8

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 31.31 = 39.14\ A$

As per CEC, we decided to go with available breaker size of $40\ A$.

Conductor Sizing

We need $3\phi, 4W, 40A$ bus bar at Distribution board with $3\phi, 4W$ I/C cable that can handle $40A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degree Celsius
AWG#06	55

Table 9

We are considering 3ϕ, 4W cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with AWG#06 conductor size that can carry $55\ A\ (which\ is\ greater\ than\ 40/0.8\ =\ 50\ A)$ at 60 degree Celsius.

For AWG#06 conductor with jacket, conduit size will be $35mm$. In addition to that minimum radius to center of conduit is $184mm$. Final design for distribution board – 2P incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size	Conduit bends
$55\ A$	AWG#06	$35\ mm$	$184\ mm$

Table 10

4. Distribution Board – 3P Incomer 3ϕ, $4W, 225A$ breaker size calculation

As per our calculation mentioned in excel sheet named “Panel Board 3” (Milestone 1/Panel Schedule(s)/Panel Schedule.xlsx). The same calculation is as follows,

	Connected Load (VA)	Spare (VA)
Phase R-Y	62435.889	0

Table 11

Load Summary (VA)		Diversity	Demand Load
Receptacle	0	As per CEC for first $10KVA$ Diversity Factor is 1.0 & for rest 0.5	0
Lighting	0		
Condensing Unit	38862.72	0.5	19431.36
Exhaust Fan	1239.889	1	1239.89
Furnace	15113.28	0.5	7556.64
EV Charger	7220	0.4	2888

Table 12

Without considering demand factor, the total load and maximum current requirements at distribution board 3P breaker I/C is as following:

Connected Load without considering demand factor	
Total Demand (KVA)	62.43
Total Demand (Amps)	173.31

Table 13

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 173.31 = 216.69\ A$

As per CEC, we decided to go with available breaker size of $225\ A$.

Conductor Sizing

We need $3\phi, 4W, 225A$ bus bar at Distribution board with $3\phi, 4W$ I/C cable that can handle $225A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degree Celsius
500 kcmil	320

Table 14

We are considering 3ϕ, $4W$ cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with $500\ kcmil$ conductor size that can carry $320\ A$ (which is greater than $225/0.8\ =\ 281.25\ A$) at 60 degree Celsius.

For $500\ kcmil$ conductor with jacket, conduit size will be $91mm$. In addition to that minimum radius to center of conduit is $381mm$. Final design for distribution board – 3P incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size	Conduit bends
$320\ A$	500 kcmil	$91\ mm$	$381\ mm$

Table 15

5. Distribution Board – U Incomer 3ϕ, $4W$, $125A$ breaker size calculation

As per our calculation mentioned in excel sheet named “Panel Board 4” (Milestone 1/Panel Schedule(s)/Panel Schedule.xlsx). The same calculation is as follows,

	Connected Load (VA)	Spare (VA)
Phase R-Y-B	17935.60	4320

Table 16

Load Summary (VA)		Diversity	Demand Load
Receptacle	0	As per CEC for first $10KVA$ Diversity Factor is 1.0 & for rest 0.5 (As this is emergency panel, it might required to turn on simultaneously in case of emergency. Thus demand factor is considered 1.0)	1137.10
Lighting	1137.10		
Fire Pump	16531.86	In case of emergency, it must be turn on regardless of other loading on the panel. Thus, diversity factor is considered 1.0	16531.86
Others	266.64	1	266.64
Spare	4320	Future load that will connect to emergency bus must remain turn on during the emergency. Thus, demand factor considered on higher side compared to other. (0.75)	3240

Table 17

Without considering demand factor, the total load and maximum current requirements at distribution board U breaker I/C is as following:

Connected Load without considering demand factor	
Total Demand (KVA)	22.25
Total Demand (Amps)	61.77

Table 18

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 61.77 = 77.25\ A$

As per CEC, we decided to go with available breaker size of $80\ A$.

However, one of the circuits from the busbar fed to 20 hp fire pump, thus the breaker requirement for that load is 110 A. Thus, income breaker of the busbar should be kept as same rating or higher than that.

Final breaker selection for the I/C breaker is 125 A.

Conductor Sizing

We need $3\phi, 4W, 125A$ bus bar at Distribution board with $3\phi, 4W$ I/C cable that can handle $125A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degree Celsius
3/0	165

Table 19

We are considering 3ϕ, $4W$ cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with $3/0$ conductor size that can carry $165\ A$ (which is greater than $125/0.8\ =\ 156.25\ A$) at 60 degree Celsius.

For $3/0$ conductor with jacket, conduit size will be $53mm$. In addition to that minimum radius to center of conduit is $241mm$. Final design for distribution board – UPS incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size	Conduit bends
$165\ A$	$3/0$	$53\ mm$	$241\ mm$

Table 20

6. TR outgoing L.T. bkr to BUS-BAR Chamber 3ϕ, $4W, 300\ A$ breaker size calculation

As per our calculation mentioned above in section 1. To 4. The total demand in Amps is as follows,

Distribution board - 1P load demand in Amps	Distribution board - 2P load demand in Amps	Distribution board - 3P load demand in Amps	Distribution board - UPS load demand in Amps	Total load demand in Amps
77.45	15.67	86.47	58.8	238.39

Table 21

As per CEC, breaker size should be considered 125% of continuous load current.

The minimum breaker requirement $= 1.25 * 238.39 = \ 297.98\ A$

As per CEC, we decided to go with available breaker size of $300\ A$.

Conductor Sizing

We need $3\phi, 4W, 300A$ bus bar at BUS-BAR Chamber with $3\phi, 4W$ I/C cable that can handle $300A$ line current. According to CEC standard, we did the following calculations.

Number of Conductor	Ampacity correction factor
$4-6$	0.8

Size of conductor	Allowable ampere at temperature
AWG or kcmil	60 degree Celsius
700 kcmil	385

Table 22

We are considering $3\phi, 4W$ cable that needs ampacity correction factor of 0.8 as per above table.

As per standards, we are going with 700 kcmil conductor size that can carry $385\ A$ (which is greater than $300/0.8\ = \ 375\ A$) at 60 degree Celsius.

For 700 kcmil conductor with jacket, conduit size will be $116mm$. Final design for distribution board – UPS incomer cable is as follows,

Maximum allowable ampacity	Cable size	Conduit size
$385\ A$	700 kcmil	$116\ mm$

Table 23

7. 24.9kV/208V (delta/star) transformer sizing for given building

As per our calculations in section 5., we have considered transformer outgoing L.T. breaker size 300A, 208V.

For above mentioned load requirement, transformer loading can be calculated as follows,

$$\begin{aligned}\text{Tranformer rating} &= \sqrt{3} * line\ voltage * line\ current \\ &= \sqrt{3} * 208 * 300 \\ &= 107.952\ \text{kVA}\end{aligned}$$

Considering the nearby value, given transformer by utility having $112.5\ \text{kVA}$ rating is ideal.