Project Report on

Course Code: ENEL 674 (L01)

Course Name: Industrial and Commercial Power Systems

Submitted By,

Group: 09

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Objective

The objective of this study is to develop the electrical design for a building by analyzing customer requirements. In the first milestone, the focus will be on performing load calculations to determine appropriate cable and panel sizes, designing the lighting layout and schedules based on lumen calculations, and preparing the mechanical schedule. Additionally, a single-line diagram will be created, including preliminary equipment sizing and placement.

Scope of Work

- **Requirement Analysis** – Assess customer needs for the electrical system.
- **Load Schedule** – Prepare a detailed load calculation for each room.
- **Lighting Schedule** – Design lighting based on lumen calculations and submit a lumen schedule.
- **Panel Schedule** – Develop a balanced load distribution across phases.
- **Power Layout** – Plan the placement of equipment, receptacles, and feeding panels.
- **Lighting Layout** – Determine the types and number of luminaires.
- **Single-Line Diagram (SLD)** – Create a diagram showing panel locations, breakers, utility connections, and backup systems.
- **Modification Proposal –** Present recommendations to the customer for any necessary changes.

Project Consideration

- ✓ The Project is based on a 10-acre land with 05 building plans, among which 01 building layout is the primary consideration.
- ✓ The utility supply is 112.5 KVA from 25 KV Delta connected feeder.
- ✓ The secondary voltage of transformer is considered 208 V 3phase Star connection.
- ✓ A generator with 125% of continuous load is considered to recover the power outage condition.
- ✓ The building will be used as a multipurpose hall for renting purpose so adequate receptacles has been considered for external equipment for sound and lighting.
- ✓ Loads are primarily calculated based on room requirement, lighting requirement, and additional receptacles for maintenance and external equipment.
- ✓ Panel has been designed with balanced load between 3 phases (15% max deviation) and load which require schedule maintenance has been taken from separate panels for not hampering daily operation.
- ✓ Security and fire protection has been considered but with bare minimum details as it's out of scope for milestone 1.
- ✓ Conductor and conduit sizing has been considered as per CEC regulation.
- ✓ The minimum conductor size was 12 AWG and minimum conduit size 21 mm.
- ✓ The generator and utility line will be operated through an Automatic transfer switch system.
- ✓ The total secondary cable from Transformer/Generator to electrical room is underground and no overhead cable is considered. From panels to room wiring will be in conduit and all sizing calculation is done based on this.
- ✓ Average ambient temperature in room is considered 30 deg.
- ✓ Additional features considered:
    - PA system
    - Water sprinkler system
    - WIFI at each corner
    - Card reader in sensitive entrance
    - Security camera
    - Barrier free switch
    - Fire exit lighting and Smoke detector
- ✓ All 20A receptacles are T type receptacles.
- ✓ Other receptacles are duplex receptacles.
- ✓ Receptacles close to water source like sinks are weather proof receptacles.
- ✓ A 30 HP motor with mechanical starter has been considered for fire pump.

- ✓ Breakers are rated with 125% of load.
- ✓ Cable sizing considered with 5% future growth and 125% of load current.
- ✓ For lighting, LED light is considered in most of the places considering high efficacy and long-life span. But in different room, different sorts of lighting has been considered based on the requirement.
- ✓ Lights for big room like Cultural activities or common are considered suspended lighting.
- ✓ Equipment like Generator and Transformer will be in a separate room outside the building to ensure fire safety and avoiding sound disturbance.

Process Flow

The following figure illustrates the process flow of this project. By analyzing customer's requirement, we have performed the electrical design of the building. We have done lumen calculation, receptacle calculation, load calculation, panel scheduling of every room in the base plan. After that, we have estimated conduit sizing for both continuous and non-continuous load. Finally based on all the calculations, we have conducted lighting design, power layout, normal and emergency SLD. The below figure displays the process flow:

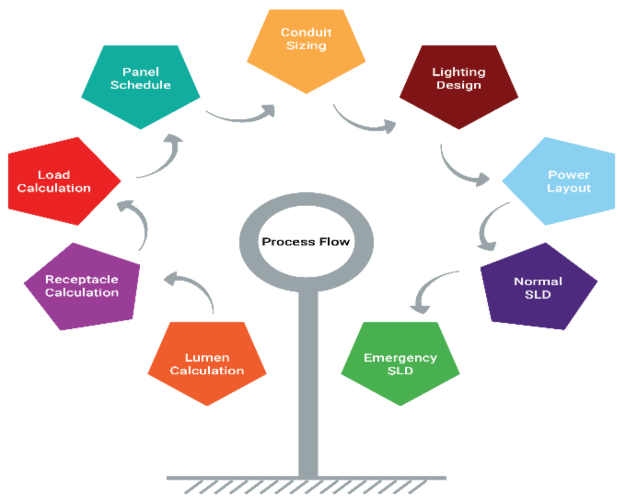


Fig: Process Flow

Technical Specification

Lumen Calculation

For calculation of number of luminaire, we have considered a light loss factor (LLF) of 0.9 and RCR = 10 if RCR is greater than 10 on luminaire cut sheets. We have used the following formula to determine the number of luminaire.

So, Number of luminaire = $\frac{illuminance*L*W}{lumen\ per\ luminiare*Cu*LLF}$

Here, for L & W, we have considered the base plan and we have calculated the Cu from spec sheet based on the RCR.

In this section, we have calculated number of luminaire for all the rooms displayed in the base plan. In the below figure, we have considered Room 101 classroom, Room 102 Closet, Room 103 W. Washroom, Room 104 M. Washroom, Room 105 Washroom Corridor, Room 106 Janitor and Room 107 Water Meter.

Lumeniare Feature	Room 100 Foyer	Room 101 Classroom	Room 102 Closet	Room 103 W. Washroom	Room 104 M. Washroom	Room 105 Washroom Corridor	Room 106 Janitor	Room 107 Water Meter
Illuminace	350	375	150	280	280	250	300	75
number of lumaniare	1	9	4	16	7	2	2	1
lumen per luminiare	4000	4000	300	1200	1200	270	600	1000
Luminaire type (LED)	Ceiling-mounted spot light	Flat Panel LED.	Recessed LED Downlight	LED Recessed Downlight.	LED Recessed Downlight.	LED Recessed Downlight	LED Recessed Downlight.	LED Utility Light
Description (Model No)	Hue White and Color Ambiance Centris 4-Spot Ceiling Light	Lithonia CPX 2X4 4000LM 40K M2	Energizer 4" LED Recessed Ceiling Light	Juno LED 6" Recessed Downlight	Juno LED 6" Recessed Downlight	Cree 4" LED Downlight	Halo RL560 Series LED	KT-WPLED10-840
mounting (Suspended Ceiling)	Ceiling-mounted	Recessed mounting	Recessed	Recessed ceiling installation.	Recessed ceiling installation.	Recessed Ceiling Mount	Recessed ceiling installation.	ceiling-mounted light
wattage(W)	40 W	40	6	12	12	3	9	10
lumens(lm)	4,600 lumens	4000	300	1200	1200	270	600	1000
manufacturer	Philips Hue	Lithonia Lighting	Energizer	Juno Lighting	Juno Lighting	Cree	Halo	Keystone
Remarks	Provides both functional and ambient lighting, with individual spot adjustability			ENERGY STAR certified, dimmable.	ENERGY STAR certified, dimmable	Energy-efficient, low-wattage	ENERGY STAR certified, smooth light distribution	
Driver	Integrated LED driver	constant current LED driver	Internal driver	Integrated driver	Integrated driver	Integrated LED driver	Integrated driver	internal constant-current LED driver.
CCT(K)	Adjustable from 2000K to 6500K	4000	4000	4000	4000	4000	5000	4000
CRI	80	80	>80	>90	>90	> 80	>90	>80
Controls(V)	Philips Hue app, Bluetooth, Alexa, Google Assistant, Hue Bridge integration	0-10	0-10	Compatible with dimmers	Compatible with dimmers	Non-dimmable		Non-dimmable
voltage(V)	24 V	120 - 277	120	120V.	120V.	120	120V.	120-277
Efficacy(lm/W)	115 lumens per watt (lm/W)	100	50-60	100	100	90	66.7	100

In the below figure, we have considered Room 108 Catering Kicthenette, Room 109 Commons, Room 110 Cultural Room, Room 111 Storage, Room 112 Snack, Room 113 Information, Room 114 and Room 115 Yukuta.

Lumeniare Feature	Room 108 Catering Kicthenette	Room 109 Commons	Room 110 Cultural Room	Room 111 Storage	Room 112 Snack	Room 113 Information	Room 114	Room 115 Yukuta
Illuminace	500	450	750	100	350	300	200	200
number of lumaniare	13	12	11	1	3	6	3	6
lumen per luminiare	4000	3600	21,000	2000	4000	4,000 lumens	400 lumens	800 lumens
Luminaire type (LED)	LED Recessed Panel	LED Panel Light	LED High Bay Light	LED Vapor Tight Fixture	LED Vapor Tight Fixture	LED Panel	LED Recessed Downlight	LED Recessed Downlight
Description (Model No)	Lithonia Lighting CPX 2X2	Philips CoreLine LED Panel 600x600	ps Ultra Efficient LED High Bay 1	SHARK2-22N	SHARK2-48N	Philips CorePro LED Panel 40W	Philips CorePro LED Downlight 5W	Philips CorePro LED Downlight 10W
mounting (Suspended Ceiling)	Recessed Ceiling Grid Mount	Surface Mount	Suspended	Ceiling or wall mount	Ceiling or wall mount	Ceiling Surface Mount (Recessed option available)	Recessed (Ceiling Mount)	Recessed (Ceiling Mount)
wattage(W)	40	36	150	24	48	40W	5W	10W
lumens(lm)	4000	3600	21000	2000	4000	4,000 lumens	400 lumens	800 lumens
manufacturer	Lithonia	Philips	Philips	RAB Lighting	RAB Lighting	Philips	Philips	Philips
Remarks	Glare-free design, high efficiency	Slim, energy-efficient	Ideal for high ceilings and large spaces	IP66-rated for dust and water resistance.	-rated for dust and water resista	Ideal for offices and workspaces, energy-efficient, uniform lighting	Suitable for small rooms, energy-efficient, compact	Suitable for minimalistic and serene settings, energy-efficient, long-lasting
Driver	Integrated Driver	LED Driver	high-efficiency driver	0-10V	0-10V	Integrated LED Driver	Integrated LED Driver	Integrated LED Driver
CCT(K)	4000	3600	4000	4000	4000	4000K (Neutral White)	3000K (Warm White)	3000K (Warm White)
CRI	> 90	80+	80+	>80	>80	≥80 (Good color rendering)	≥80 (Good color rendering)	≥80 (Good color rendering)
Controls(V)	0-10	Compatible with dimmers	Compatible with dimmers	Dimmable with compatible switch	immable with compatible switc	Non-dimmable (Dimmable versions available)	Non-dimmable (Dimmable versions available)	Non-dimmable (Dimmable versions available)
voltage(V)	120-277	120-277	120-277	120-277	120-277	120V	120V	120V
Efficacy(lm/W)	105	100	140	83	83	100 lm/W	80 lm/W	80 lm/W

In the below figure, we have considered Room 116 Education, Room 117 Mechanical, Room 118 Staff, Room 119 Administration, Room 120 Vestibule, Room 121 Classroom, Room 122 Exhibit and Room 123 Tea.

Lumeniare Feature	Room 116 Education	Room 117 Mechanical	Room 118 Staff	Room 119 Administration	Room 120 Vestibule	Room 121 Classroom	Room 122 Exhibit	Room 123 Tea
Illuminace	500	200	300	500	300	375	300	150
number of lumaniare	5	6	4	5	5	9	16	4
lumen per luminiare	4,000 lumens	800 lumens	2,000 lumens	4,000 lumens	800 lumens	400	1800 lumens	400
Luminaire type (LED)	LED Panel	LED Recessed Downlight	LED Panel	LED Panel	LED Recessed Downlight	flat panel LED	LED Recessed Downlight	recessed LED panel light
Description (Model No)	Philips CorePro LED Panel 40W	Philips CorePro LED Downlight 10W	Philips CorePro LED Panel 20W	Philips CorePro LED Panel 40W	Philips CorePro LED Downlight 10W	Lithonia CPX 2X4 4000LM 40K M2	Philips CorePro LED Downlight 20W	Philips CoreLine LED Panel 600x600 36W 4000K
mounting (Suspended Celling)	Ceiling Surface Mount (Recessed option available)	Recessed (Ceiling Mount)	Ceiling Surface Mount (Recessed option available)	Ceiling Surface Mount (Recessed option available)	Recessed (Ceiling Mount)	Recessed mounting	Recessed (Ceiling Mount)	Recessed
wattage(W)	40W	10W	20W	40W	10W	40	20W	36
lumens(lm)	4,000 lumens	800 lumens	2,000 lumens	4,000 lumens	800 lumens	4000	1800 lumens	4000
manufacturer	Philips	Philips	Philips	Philips	Philips	Lithonia Lighting	Philips	Philips
Remarks	Ideal for educational spaces, energy-efficient, uniform lighting	Ideal for low to medium height spaces, energy-efficient, long-lasting	Ideal for general spaces, provides even lighting, energy-efficient	Ideal for office spaces, energy-efficient, provides uniform lighting	Suitable for general illumination, energy-efficient, long-lasting		Suitable for general illumination in galleries, energy-efficient, long-lasting	
Driver	Integrated LED Driver	Integrated LED Driver	Integrated LED Driver	Integrated LED Driver	Integrated LED Driver	constant current LED driver	Integrated LED Driver	Integrated LED driver
CCT(K)	4000K (Neutral White)	4000K (Neutral White)	4000K (Neutral White)	4000K (Neutral White)	3000K (Warm White)	4000	4000K (Neutral White)	4000
CRI	≥80 (Good color rendering)	≥80 (Good color rendering)	≥80 (Good color rendering)	≥80 (Good color rendering)	≥80 (Good color rendering)	80	≥80 (Good color rendering)	85
Controls(V)	Non-dimmable (Dimmable versions available)	Non-dimmable (dimmable versions available)	Non-dimmable (Dimmable versions available)	Non-dimmable (Dimmable versions available)	Non-dimmable (Dimmable versions available)	0-10	Non-dimmable (Dimmable versions available)	0-10
voltage(V)	120V	120V	120V	120V	120V	120 - 277	120V	120V - 277V
Efficacy(lm/W)	100 lm/w	80 lm/W	100 lm/W	100 lm/W	80 lm/W	100	90 lm/W	110

In the below figure, we have considered Room 200 Stairewell, Room 202 Electrical, Room 203 Mechanical and Room 204 Telecom.

Lumeniare Feature	Room 200 Stairwell	Room 202 Electrical	Room 203 Mechanical	Room 204 Telecom
Illuminace	150	500	250	750
number of lumaniare	2	27	13	31
lumen per luminiare	800 lumens	7,000 lumens	8,000 lumens	7200 lumens
Luminaire type (LED)	LED Recessed Downlight	LED Linear Strip	Vapor-Tight LED	LED Panel Light (2x4 ft)
Description (Model No)	Philips CorePro LED Downlight 10W	**Philips Ledalite TruGroove 4ft LED Strip**	**Philips Day-Brite Vapor-Tight LED (VT1)**	Philips Ledalite TruGroove
mounting (Suspended Celling)	Recessed (Ceiling Mount)	**Surface-mounted or suspended**	Surface-mounted or suspended	Recessed, surface-mounted, or suspended
wattage(W)	10W	55W	65W	56W
lumens(lm)	800 lumens	7,000 lm	8,000 lm	7200 lm
manufacturer	Philips	**Philips (Ledalite TruGroove Series)**	**Philips (Day-Brite)**	**Philips (Ledalite TruGroove Series)**
Remarks	Suitable for indoor spaces such as stairwells, energy-efficient, long-lasting	**Glare-free, uniform illumination, ideal for electrical rooms**	**IP65-rated**, dust & moisture resistant, ideal for mechanical rooms	Uniform illumination, glare-free, ideal for telecom environments
Driver	Integrated LED Driver	Philips Advance Xitanium	Philips Advance Xitanium	Philips Advance Xitanium
CCT(K)	3000K (Warm White)	4000K (Neutral White)	4000K (Neutral White)	5000K (Cool White)
CRI	≥80 (Good color rendering for residential and commercial areas)	>80	>80	>80
Controls(V)	Non-dimmable (available dimmable versions)	0-10V Dimmable, Motion & Daylight Sensor Compatible	0-10V Dimmable, Motion & Daylight Sensor Compatible	0-10V Dimmable, Motion & Daylight Sensor Compatible
voltage(V)	120V	120-277V AC	120-277V AC	120-277V AC
Efficacy(lm/W)	80 lm/W	~127 lumens per watt	~123 lumens per watt	~128 lumens per watt

Receptacle Calculation

The below table illustrate the number of receptacles we have used in every room in this project:

Room name	Room no.	Equipment	Quantity
Foyer	Room 100	Receptacles (2-15A)	2
Classroom	Room 101	Receptacles (4-15A)	4
Closet	Room 102	Receptacles	2
W. Washrrom	Room 103	Receptacles waterproof (3-15A)	3
M. Washroom	Room 104	Receptacles waterproof (1-15A)	1

Janitor	Room 106	Receptacles (1-20A)	1
Catering Kicthenette	Room 108	Receptacles Waterproof (4-20A/ 1-30A/1-15A)	6
Commons	Room 109	Receptacles (3-15A)	3
Cultural Room	Room 110	Receptacles (5-15A)	5
Storage	Room 111	Receptacles (2-15A)	2
Snack	Room 112	Receptacles (1-15A/ 3-20A)	4
Information	Room 113	Receptacles (3-15A)	3
Room 114	Room 114	Receptacles (2-15A)	2
Yukuta	Room 115	Receptacles (1-15A)	1
Education	Room 116	Receptacles (3-15A/ 1-15A)	4
Mechanical	Room 117	Receptacles (1-20A/1-15A)	2
Staff	Room 118	Receptacles (3-15A)	3
Administration	Room 119	Receptacles (1-20A/2-15A)	3
Vestibule	Room 120	Receptacles (2-15A)	2
Classroom	Room 121	Receptacles (4-15A)	4
Exhibit	Room 122	Receptacles (3-15A)	3
Tea	Room 123	Receptacles (1-15A)	1
Electrical	Room 202	Receptacles (2-15A)	2
Mechanical	Room 203	Receptacles (2-15A)	2
Telecom	Room 204	Receptacles (3-15A)	3

Table: Receptacle Calculation (Room wise)

Equipment List

Equipment	Model
Access Control System	HID VertX V1000
Barrier-Free Access	Openpath OP-ABP
CC Camera	Hikvision DS-2CD2142FWD7
Coffee Machine	Keurig K1500
Commercial Oven	Blodgett DFG-100
Computer	Dell OptiPlex 7070
Digital Display	Samsung QB65R
Dishwasher	Bosch SHX878ZD5N
Emergency Light and Exit Sign	Lithonia ELM2 LED
Espresso Machine	La Marzocco Linea Mini
Fire Alarm System	Honeywell MS-9200UDLS
Firefighter Access Point	Motorola APX 6000XE
Flat Top Grill	Vulcan VCRG36-M
Fridge	LG LTCS20020S
Hand Dryer (Automatic)	Dyson Airblade V
Intercom	Aiphone LEF-3L
Microwave	Panasonic NE-1054F
Microwave	Panasonic NN-SN686S
Printer/Scanner/Copier	HP LaserJet Pro MFP M428

Projector	Epson PowerLite 2250U
Push Switch	Legrand 93151
Receptacles	Leviton 5362-W
Smoke Detector	System Sensor 2W-B0.5
Warming Oven	Nemco 6150-36
Water Purifier	Brita Total 360
Wifi	Cisco Aironet 2802i

Table: Equipment List

Load Calculation

For load calculation, we have considered PF = 0.95. From the data sheet, we have find out the power (KW) and voltage (V). Then we have calculated the current (A) and apparent power S (KVA) based on the below formula:

Current, I (A) = $\frac{P\ (KW)*1000}{PF*V\ (v)}$

Apparent Power, S (KVA) = $\frac{P\ (KW)}{PF}$

Sl.	Room name	Room no.	Total Load (Per Room KW)	Total Load (Building kW)
1	Foyer	Room 100	4.8445	250.63975
2	Classroom	Room 101	8.467	
3	Closet	Room 102	3.624	
4	W. Washroom	Room 103	7.2605	
5	M. Washroom	Room 104	3.0725	
6	Washroom Corridor	Room 105	0.0275	
7	Janitor	Room 106	1.818	
8	Water Meter	Room 107	0.75	
9	Catering Kicthenette	Room 108	22.34775	
10	Commons	Room 109	12.2775	
11	Cultural Room	Room 110	53.4695	
12	Storage	Room 111	3.624	
13	Snack	Room 112	11.556	
14	Information	Room 113	5.9235	
15	Room 114	Room 114	3.615	
16	Yukuta	Room 115	1.91	
17	Education	Room 116	8.447	
18	Mechanical	Room 117	8.624	
19	Staff	Room 118	5.4985	
20	Administration	Room 119	6.647	
21	Vestibule	Room 120	6.317	
22	Classroom	Room 121	9.0525	
23	Exhibit	Room 122	6.9525	
24	Tea	Room 123	1.9675	
25	Stairwell	Room 200	0.0635	
26	Electrical	Room 202	29.0575	
27	Mechanical	Room 203	16.006	
28	Telecom	Room 204	7.4195	

Table: Load Calculation (Room Wise)

Panel Schedule

Here, we have done panel for A, B, C, D, E, F, G and H.

Panel A load distribution:

Here Panel ID is 12A. 1 for 1st floor, 2 for 208V and A for Panel A. In Panel A, we have connected Room 100 Foyer, Room 101 Classroom, Room 102 Closet, Room 103 W. Washroom, Room 104 M. Washroom, Room 106 Janitor, Room 107 Water Meter and Room 200 Stairwell.

Panel Schedule

Date		Panel ID	12A	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit		ISC Rating	
Location		Voltage (V)	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Description	Circuit No	Room No
	1	Receptacles (15A)	1	1.85	1	20	A	40	1	3.789473684	2	Receptacles (20A)	2	
	3	Receptacles (15A)	2	3.7	1	39	B	1	1	0.021052632	1	Sprinkler Flow Switch and Temper Switch1	4	
	5	Receptacles (15A)	5	9.25	1	97	C	8	1	0.757894737	1	FF-4 120V 1phase 6FLA	6	
	7	Light	23	1.44	1	15	A	1	1	0.021052632	1	Access Control	8	101-107, 200
	9	Wifi	6	0.082105263	1	1	B						6	
	11	Intercom	4	0.021052632	1	1	C						8	
	13	Close Circuit Camera	4	0.023157895	1	1	A						10	
	15	Barrier free access	3	0.052631579	1	1	B						12	
	17	Emergency light and exit sign	5	0.018421053	1	1	C						14	
	19	Push switch	6	0.012631579	1	1	A						16	
101-107, 200	21	120V 6FLA FF-1	1	0.757894737	1	8	B						18	
	23	Annunciator Panel used as Fire fighter access point	1	0.421052632	1	5	C						20	
	25	Projector	1	0.421052632	1	5	A						26	
	27	Computer	1	0.273684211	1	3	B						36	
	29	Speaker	1	0.231578947	1	3	C						38	
	31	Receptacles waterproof (15A)	2	3.78	1	40	A							
	33	Light / Sensor light	32	6.4672	1	68	B							
	35	Hand Dryer Automatic	2	0.252631579	1	3	C							
	37	Barrier free Access	1	0.052631579	1	1	A							
	39	Barrier free Access	1	0.052631579	1	1	B							
	41	BBH-8 120V 1phase, 1KW	1	1.052631579	1	11	C							

Load Balance Summary		
Sl	Phase	Total Load (KVA)
1	A	11.38
2	B	11.4
3	C	11.95

Panel B load distribution:

Here Panel ID is 12B. 1 for 1st floor, 2 for 208V and B for Panel B. In Panel B, we have connected Room 108 Catering Kicthenette.

Panel Schedule

Date		Panel ID	12B	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	44	ISC Rating	
Location		Voltage (V)	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	Phase	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Descripti	Circuit No	Room No
	1	Receptacles Waterproof (2-20A)	2	3.7600	1	40.000	A	1	1	0.0053	1	Intercom	2	108
	3	Receptacles Waterproof (1-30A/1-15A)	2	3.7600	1	40.000	B						4	
	5	Receptacles Waterproof (2-20A)	2	3.76	1	40.000	C						6	
	7	Light	13	0.5474	1	6.000	A						8	
	9	Fridge	1	0.7632	1	8.000	B						10	
	11	Dishwasher	1	1.37	1	15.000	C						12	
	13	Espresso Machines	1	1.5789	1	17.000	A						14	
	15	Digital Display	1	0.1158	1	2.000	B						16	
	17	Flat top grill	1	0.94	3	10.000	C						18	
	19	Flat top grill	1	0.9400	3	10.000	A						20	
Room 108	21	Flat top grill	1	0.9400	3	10.000	B						22	
	23	Water Purifier	1	0.06	1	1.000	C						24	
	25	Commercial Oven	1	0.3800	3	4.000	A						26	
	27	Commercial Oven	1	0.3800	3	4.000	B						28	
	29	Commercial Oven	1	0.38	3	4.000	C						30	
	31	Wifi	1	0.0137	1	1.000	A						32	
	33	BBH-1	1	2.6316	1	28.000	B						34	
	35	Close Circuit Camera	2	0.01	1	1.000	C						36	
	37	Emergency light and exit sign	1	0.0037	1	1.000	A						38	
	39	Exhaust Fan	1	0.0003	1	1.000	B						40	
	41	BBH-2	1	1.05	1	11.000	C						42	

Load Balance Summary		
Sl	Phase	Total Load (KVA)
1	A	7.23
2	B	8.59
3	C	7.58

Panel C load distribution:

Here Panel ID is 12C. 1 for 1st floor, 2 for 208V and C for Panel C. In Panel C, we have connected Room 110 Cultural Room.

Panel Schedule

Date		Panel ID		Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type		Total Circuit		ISC Rating	
Location		Voltage		BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase		No. Wire			

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	Phase	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Descripti	Circuit No	Room No
Room 110	1	Receptacles (5-15A)	5	9.473684211	1	99	A						2	
	3	Light Proper for spotting	11	1.736842105	1	19	B						4	
	5	Wifi	1	0.013684211	1	1	C						6	
	7	Intercom	1	0.005263158	1	1	A						8	
	9	Close Circuit Camera	4	0.023157895	1	1	B						10	
	11	Emergency light and exit sign	1	0.003684211	1	1	C						12	
	13	Projector	2	0.842105263	1	9	A						14	
	15	Barrier free access	1	0.052631579	1	1	B						16	
	17	Push button	1	0.001052632	1	1	C						18	
	19	Egress Door	1	0.052631579	1	1	A						20	
	21	Microphone	2	0.004210526	1	1	B						22	
	23	Speaker	1	0.231578947	1	3	C						24	
	25	BBH-6 1phase 2.5 KW 208 V	1	2.631578947	1	28	A						26	
	27	BBH-7 1phase 2.5 KW 208 V	1	2.631578947	1	28	B						28	
	29	Condensing unit,208,3ph,14fla	1	5.043157895	3	53	C						30	
	31	Condensing unit,208,3ph,18fla	1	6.484210526	3	68	A						32	
	33	Condensing unit,208,3ph,39fla	1	13.68421053	3	143	B						34	
	35	Condensing unit,208,3ph,37fla	1	13.36842105	3	140	C						36	
	37												38	
	39												40	
	41												42	

Load Balance Summary

Sl	Phase	Total Load (KVA)
1	A	19.33
2	B	18.59
3	C	18.66

Panel D load distribution:

Here Panel ID is 12D. 1 for 1st floor, 2 for 208V and D for Panel D. In Panel D, we have connected Room 109 Commons, Room 111 Storage and Room 112 Snack.

Panel Schedule

Date		Panel ID		Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type		Total Circuit		ISC Rating	
Location		Voltage		BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase		No. Wire			

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Phase	Breaker Size	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	Phase	Circuit No	Room No
109	1	Receptacles (15A)	3	5.6893	1	A	60	Warming Oven	1	1.052631579	1	11	A	2	112
109	3	Light	12	0.454736842	1	B	5	Wifi	1	0.013684211	1	1	B	4	112
109	5	Wifi	1	0.013684211	1	C	1	Intercom	1	0.005263158	1	1	C	6	112
109	7	Intercom	1	0.005263158	1	A	1	Close Circuit Camera	1	0.005789474	1	1	A	8	112
109	9	Close Circuit Camera	4	0.023157895	1	B	1	Emergency light and exit sign	1	0.003684211	1	1	B	10	112
109	11	Emergency light and exit sign	1	0.003684211	1	C	1	Receptacles (15A)	1	1.8974	1	20	C	14	112
109	13	Projector	2	0.842105263	1	A	9							16	
109	15	Barrier free access	1	0.052631579	1	B	1							18	
109	17	Push button	2	0.002105263	1	C	1							20	
109	19	Egress Door	1	0.052631579	1	A	1							22	
109	21	BBH-3 120 V	1	1.052631579	1	B	11							24	
109	23	BBH-4 208 V	1	2.631578947	1	C	28							26	
109	25	BBH-5 120 V	1	1.052631579	1	A	11							28	
109	27	BBH-9 120V	1	1.052631579	1	B	11							30	
111	29	Receptacles (15A)	2	3.789384211	1	C	40							32	
111	31	Light	1	0.025263158	1	A	1							34	
112	33	Receptacles (20A)	3	5.6893	1	B	60							36	
112	35	Light	3	0.151578947	1	C	2							38	
112	37	Microwave	1	1.052631579	1	A	11							40	
112	39	Coffee Machine	1	1.536842105	1	B	17							42	
112	41	Fridge	1	0.763157895	1	C	8							44	

Load Balance Summary

Sl	Phase	Total Load (KVA)
1	A	9.772
2	B	9.812
3	C	9.324

Panel E load distribution:

Here Panel ID is 12E. 1 for 1st floor, 2 for 208V and E for Panel E. In Panel E, we have connected Room 113 Information, Room 114, Room 115 Yukuta, Room 116 Education, Room 118 Staff and Room 119 Administration.

Panel Schedule

Date		Panel ID	12E	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	42	ISC Rating	
Location		Voltage	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Description	Circuit No	Room No
Room - 113	1	Receptacles (3-15A)	3	5.684210526	1	60	A	40	1	3.789473684	2	Receptacles (2-15A)	2	Room - 114
Room - 113	3	Light	6	0.252631579	1	3	B	1	1	0.015789474	3	Light	4	Room - 114
Room - 113	5	Wifi	1	0.013684211	1	1	C	20	1	1.894736842	1	Receptacles (1-15A)	6	Room - 115
Room - 113	7	Intercom	1	0.005263158	1	1	A	1	1	0.063157895	6	Light	8	Room - 115
Room - 113	9	Close Circuit Camera	1	0.005789474	1	1	B	1	1	0.052631579	1	Climate Controlled	10	Room - 115
Room - 113	11	Computer	1	0.273684211	1	3	C	79	1	7.578947368	4	Receptacles (4-15A)	12	Room - 116
Room - 118	13	Light	4	0.084210526	1	1	A	3	1	0.210526316	5	Light	14	Room - 116
Room - 118	15	Receptacles (3-15A)	3	5.684210526	1	60	B	1	1	0.013684211	1	Wifi	16	Room - 116
Room - 118	17	Wifi	1	0.013684211	1	1	C	1	1	0.005263158	1	Intercom	18	Room - 116
Room - 118	19	Close Circuit Camera	1	0.005789474	1	1	A	1	1	0.005789474	1	Close Circuit Camera	20	Room - 116
Room - 119	21	Receptacles (1-20A/2-15A)	3	5.684210526	1	60	B	1	1	0.003684211	1	Emergency light and exit sign	22	Room - 116
Room - 119	23	Light	5	0.210526316	1	3	C	6	1	0.547368421	2	Computer	24	Room - 116
Room - 119	25	Printer, Scanner, Copier	1	0.526315789	1	6	A	6	1	0.526315789	1	Printer, Scanner, Copier	26	Room - 116
Room - 119	27	Intercom	1	0.005263158	1	1	B	1	1	0.005789474	1	Close Circuit Camera	28	Room - 119
Room - 119	29	Wifi	1	0.013684211	1	1	C	1	1	0.003684211	1	Emergency light and exit sign	30	Room - 119
Room - 119	31	Computer	2	0.547368421	1	6	A	0	1				32	
Room - 119	33												34	
Room - 119	35												36	
Room - 119	37												38	
Room - 119	39												40	
Room - 119	41												42	
Room - 119	43												44	

Load Balance Summary

Sl	Phase	Total Load (KVA)
1	A	11.45
2	B	11.72
3	C	10.56

Panel F load distribution:

Here Panel ID is 12F. 1 for 1st floor, 2 for 208V and F for Panel F. In Panel F, we have connected Room 117 Mechanical.

Panel Schedule

Date		Panel ID	12F	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	42	ISC Rating	
Location		Voltage	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Descriptio	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker	Pole	Load (KVA)	Quantity	Equipments Descriptio	Circuit N	Room No
	1	force flow fan,120V,1ph,1.5k	1	1.578947368	1	17	A						2	
	3	Receptacles (1-20A)	1	1.89	1	20	B						4	
	5	Receptacles (1-15A)	1	1.89	1	20	C						6	
	7	force flow fan,120V,1ph,1.5k	1	1.578947368	1	17	A						8	
	9	Light	6	0.063157895	1	1	B						10	
	11	Access Control	1	0.021052632	1	1	C						12	
	13	furnace,208,3ph,10fla F-1, F	1	1.2	3	13	A						14	
	15	furnace,208,3ph,10fla F-1, F	1	1.2	3	13	B						16	
	17	furnace,208,3ph,10fla F-1, F	1	1.2	3	13	C						18	
	19	Wifi	1	0.013684211	1	1	A						20	
117	21	Intercom	1	0.005263158	1	1	B						22	
	23	Emergency light and exit sig	1	0.003684211	1	1	C						24	
	25												26	
	27												28	
	29												30	
	31												32	
	33												34	
	35												36	
	37												38	
	39												40	
	41												42	

Load Balance Summary

Sl	Phase	Total Load (KVA)
1	A	4.37
2	B	3.15
3	C	3.11

Panel G load distribution:

Here Panel ID is 12G. 1 for 1st floor, 2 for 208V and G for Panel G. In Panel G, we have connected Room 120 Vestibule, Room 121 Classroom and Room 122 Exhibit.

Panel Schedule

Date		Panel ID	12G	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	42	ISC Rating	
Location		Voltage	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Description	Circuit N	Room No
Room - 120	1	Light	5	0.052631579	1	1	A	79	1	7.578947368	4	Receptacles (4-15A)	2	Room - 121
Room - 120	3	Receptacles (2-15A)	2	3.789473684	1	40	B	1	1	0.013684211	1	Wifi	4	Room - 121
Room - 120	5	Wifi	1	0.013684211	1	1	C	4	1	0.378947368	9	Light	6	Room - 121
Room - 120	7	Intercom	1	0.005263158	1	1	A	1	1	0.005263158	1	Intercom	8	Room - 121
Room - 120	9	Close Circuit Camera	1	0.005789474	1	1	B	1	1	0.003684211	1	Emergency light and exit sign	10	Room - 121
Room - 120	11	Emergency light and exit sign	1	0.003684211	1	1	C	3	1	0.273684211	1	Computer	12	Room - 121
Room - 120	13	Access Control	1	0.021052632	1	1	A	1	1	0.011578947	2	Close Circuit Camera	14	Room - 121
Room - 120	15	exhaust fan,208,3ph,1.5HP	1	0.393	3	5	B	5	1	0.421052632	1	Projector	16	Room - 121
Room - 120	17	exhaust fan,208,3ph,1.5HP	1	0.393	3	5	C	9	1	0.842105263	1	Sound System	18	Room - 121
Room - 120	19	exhaust fan,208,3ph,1.5HP	1	0.393	3	5	A	2	1	0.126315789	6	Spot Light	20	Room - 122
Room - 120	21	force flow fan,120V,1ph, 1.5KW FF-2	1	1.578947368	1	17	B	4	1	0.336842105	16	Light	22	Room - 122
Room - 123	23	Light Minimal	4	0.151578947	1	2	C	60	1	5.684210526	3	Receptacles (3-15A)	24	Room - 122
Room - 123	25	Wifi	1	0.013684211	1	1	A	1	1	0.013684211	1	Wifi	26	Room - 122
Room - 123	27	Receptacles (1-15A)	1	1.894736842	1	20	B	1	1	0.005263158	1	Intercom	28	Room - 122
Room - 123	29	Sound System	1	0.842105263	1	9	C	1	1	0.011578947	2	Close Circuit Camera	30	Room - 122
Room - 123	31	Close Circuit Camera	1	0.005789474	1	1	A	5	1	0.421052632	1	Projector	32	Room - 122
Room - 122	33	Intercom	1	0.005263158	1	1	B	1	1	0.003684211	1	Emergency light and exit sign	34	Room - 122
	35				1		C						36	
	37				1		A						38	
	39				1		B						40	
	41				1		C						42	

Load Balance Summary

SI	Phase	Total Load (KVA)
1	A	8.65
2	B	8.45
3	C	8.59

Panel H load distribution:

Here Panel ID is M2H. M for Mezzanine floor, 2 for 208V and H for Panel H. In Panel H, we have connected Room 202 Electrical, Room 203 Mechanical and Room 204 Telecom.

Panel Schedule

Date		Panel ID	M2H	Breaker (A)		Main Breaker/MLO	
Project Name		Mountaining Type	Surface	Total Circuit	42	ISC Rating	
Location		Voltage	120/208	BUS Rating (A)		ISCA (Calculated)	
Owner Details		Phase	3	No. Wire	4		

Note

Room No	Circuit No	Equipments Description	Quantity	Load (KVA)	Pole	Breaker Size	BUS	Breaker Size	Pole	Load (KVA)	Quantity	Equipments Description	Circuit N	Room No
Room - 202	1	Close Circuit Camera	2	0.011578947	1	1	A	10	1	0.889473684	13	Light	2	**Room - 203**
Room - 202	3	Light	27	1.563157895	1	17	B	3	1	0.196842105	1	Exhaust Fan,120,1ph,0.25HP	4	**Room - 203**
Room - 202	5	Wifi	1	0.013684211	1	1	C	13	3	1.2	1	Furnace,208,3ph,12FLA	6	**Room - 203**
Room - 202	7	Fire Alarm Control Panel	1	1.010526316	1	11	A	13	3	1.2	1	Furnace,208,3ph,12FLA	8	**Room - 203**
Room - 202	9	Receptacles (2-15A)	2	3.789473684	1	40	B	13	3	1.2	1	Furnace,208,3ph,12FLA	10	**Room - 203**
Room - 202	11	Intercom	1	0.005263158	1	1	C	50	1	4.736842105	1	Domestic hot water tank,120V,1ph 5FLA	12	**Room - 203**
Room - 202	13	Fire Pump (30 HP)	1	7.85	3	82	A	1	1	0.013684211	1	Wifi	14	**Room - 203**
Room - 202	15	Fire Pump (30 HP)	1	7.85	3	82	B	1	1	0.005263158	1	Intercom	16	**Room - 203**
Room - 202	17	Fire Pump (30 HP)	1	7.85	3	82	C	1	1	0.011578947	2	Close Circuit Camera	18	**Room - 203**
Room - 202	19	Fire Alarm Booster panel	1	0.631578947	1	7	A	60	1	5.684210526	3	Receptacles (3-15A)	20	**Room - 204**
Room - 202	21	Emergency light and exit sign	1	0.003684211	1	1	B	20	1	1.827368421	31	Light	22	**Room - 204**
Room - 203	23	Receptacles (2-15A)	2	3.789473684	1	40	C	1	1	0.013684211	1	Wifi	24	**Room - 204**
Room - 203	25	Furnace,208,3ph,10FLA	1	1.2	3	13	A	1	1	0.005263158	1	Intercom	26	**Room - 204**
Room - 203	27	Furnace,208,3ph,10FLA	1	1.2	3	13	B	1	1	0.005789474	1	Close Circuit Camera	28	**Room - 204**
Room - 203	29	Furnace,208,3ph,10FLA	1	1.2	3	13	C	3	1	0.273684211	1	Computer	30	**Room - 204**
	31												32	
	33												34	
	35												36	
	37												38	
	39												40	
	41												42	

Load Balance Summary

SI	Phase	Total Load (KVA)
1	A	18.5
2	B	17.64
3	C	19.1

Power Supply

A Power Factor Improvement (PFI) panel is used to improve the power factor by adding capacitor banks, reducing reactive power (KVAR) and improving system efficiency.

- **Active Power (P)** = 250.74 kW
- **Assumed Existing Power Factor (PF_{old})** = 0.95
- **Desired Power Factor (PF_{new})** = 0.98

The relationship between active power, reactive power, and apparent power is:

$Q_{old} = P * \tan * \cos^{-1} (PF_{old})$
$= 250.74 * \tan * \cos^{-1} (0.95) = 82.41$

$Q_{new} = P * \tan * \cos^{-1} (PF_{new})$
$= 250.74 * \tan * \cos^{-1} (0.98) = 50.91$

The required capacitor bank size $Q_c = Q_{old} – Q_{new}$ = 31.5 KVAR
So, we need 32 KVAR capacitor bank.

Service Sizing

For conductor sizing, we have assumed ambient temperature is 30 deg. We have considered Cu conductor with an insulating temperature 60 deg. For conductor sizing, as per CEC code, any load which run more than 3 hours is continuous load.

For Continuous load $_{\text{rated current}}$ = 1.25 * load current

Total Rated current = Discontinuous load $_{\text{rated current}}$ + Continuous load $_{\text{rated current}}$

Power (KW) Continous	Power (KW) Discontinous	Voltage (V)	Pf	Current (A) Continous	Current (A) Discontinous	Rated Current(A)	Conductor Sizing (Kcmil)
110.49	140.74	208	0.95	404.0172825	411.7034471	815.7207297	800

Table: Service Sizing (Whole Building)

From, Table 2, we have found the conductor size. Here, 800 continuous current (A) 404.0172825, we need conductor of 800 Kcmil size.

The below figure illustrate the conductor size and conduit size of every room in the base plan. From Table 6A, we have measured the conduit size based on the conductor size.

Room Name	Load (KW)	Panel	Current (A) Room	Required Ampacity	Conductor Size	Conduit size (mm)
Room 100 Foyer	4.84	12A	24.54112159	30.67640199	8 AWG	21
Room 101 Classroom	8.46	12A	42.89625799	53.62032248	6 AWG	27
Room 102 Closet	3.624	12A	18.37541831	22.96927289	10 AWG	21
Room 103 W. Washrrom	7.26	12A	36.81168239	46.01460298	6 AWG	27
Room 104 M. Washroom	3.07	12A	15.56637258	19.45796572	12 AWG	21
Room 105 Washroom Corridor	0.0275	12A	0.139438191	0.174297739	12 AWG	21
Room 106 Janitor	1.81	12A	9.177568198	11.47196025	12 AWG	21
Room 200 Stairwell	0.063	12A	0.319440219	0.399300274	12 AWG	21
Room 107 Water Meter	0.75	12A	3.802859751	4.753574688	12 AWG	21
Room 108 Catering Kicthenette	22.34	12B	113.27	141.59	2/0	41
Room 110 Cultural Room	53.46	12C	271.06	338.83	600 kcmil	78
Room 109 Commons	12.27	12D	62.21478552	77.7684819	3 AWG	27
Room 111 Storage	5.42	12D	27.4819998	34.35249975	10 AWG	21
Room 112 Snack	11.55	12D	58.56404016	73.2050502	3 AWG	27

Room 113 Information	5.92	12E	30.01723963	37.52154954	8 AWG	21
Room 114	3.61	12E	18.3044316	22.8805395	10 AWG	21
Room 115 Yukuta	1.91	12E	9.684616165	12.10577021	12 AWG	21
Room 116 Education	8.44	12E	42.79484839	53.49356049	6 AWG	27
Room 118 Staff	5.49	12E	27.83693337	34.79616672	8 AWG	21
Room 119 Administration	6.64	12E	33.66798499	42	6 AWG	27
Room 117 Mechanical	8.64	12F	43.8	54.76	6 AWG	27
Room 120 Vestibule	6.317	12G	32.03022006	40.03777507	6 AWG	27
Room 121 Classroom	9.05	12G	45.88784099	57.35980124	4 AWG	27
Room 122 Exhibit	6.95	12G	35.23983369	44.04979211	6 AWG	27
Room 123 Tea	1.96	12G	9.938140148	12.42267519	12 AWG	21
Room 202 Electrical	29.05	M2H	147.2974343	184.1217929	4/0	53
Room 203 Mechanical	16	M2H	81.12767468	101.4095933	1 AWG	35
Room 204 Telecom	7.41	M2H	37.57225434	46.96531792	6 AWG	27

Table: Service Sizing (Room wise)

Lightening Layout Diagram:

For lightening layout, we have used DIALux software to design it. The below figures illustrate main floor lightening layout, mezzanine floor lightening layout alongside each room's layout individually.

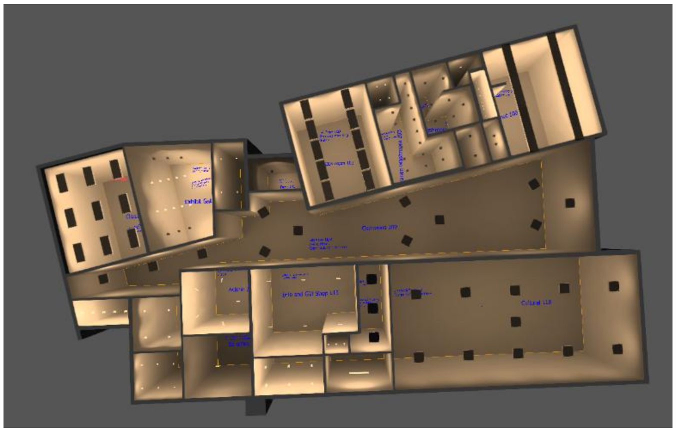


Fig: Main Floor Lightening Layout.

Fig: Mezzanine Floor Lightening Layout.

Fig: Foyer 100 Layout

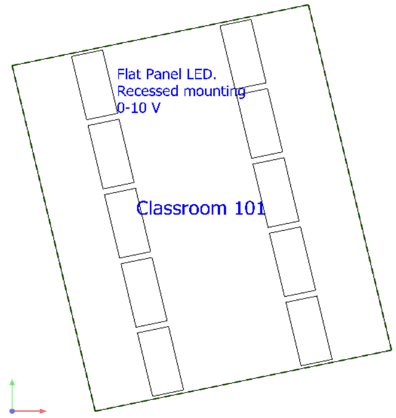


Fig: Classroom 101 Layout

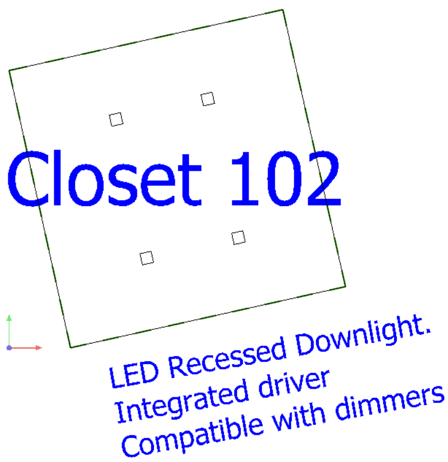


Fig: Closet 102 Layout

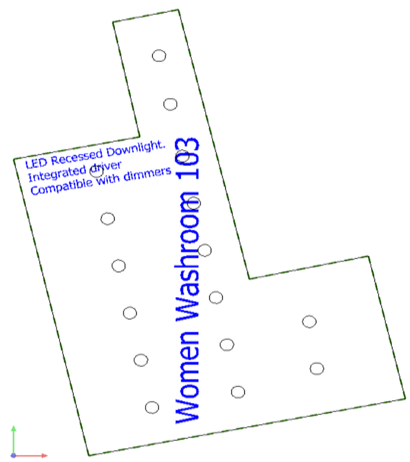


Fig: Women Washroom 103 Layout

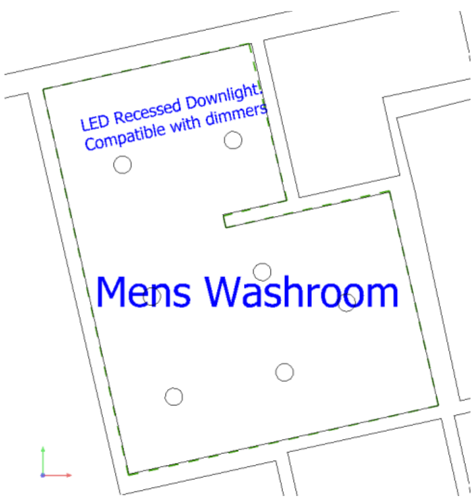


Fig: Men's Washroom Layout

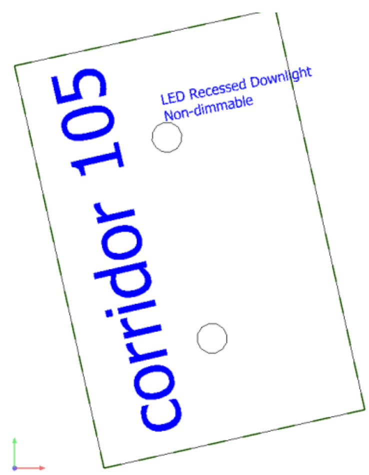


Fig: Corridor 105 Layout

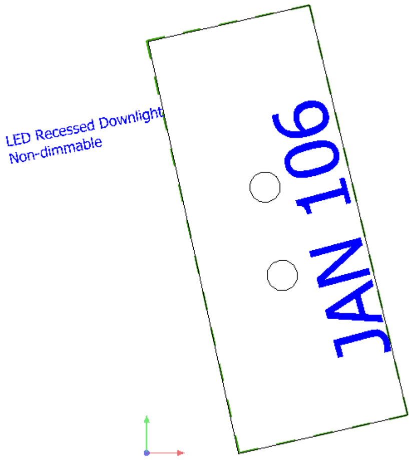


Fig: Room 106 Layout

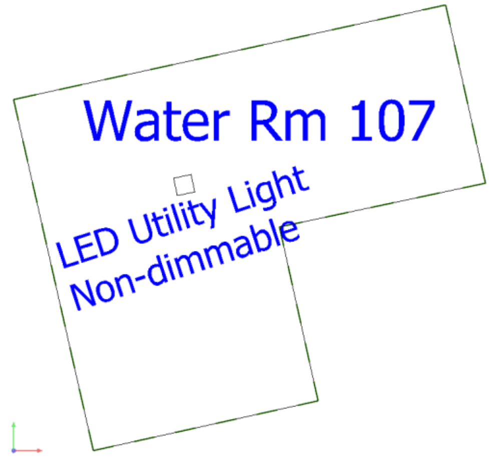


Fig: Room 107 Layout

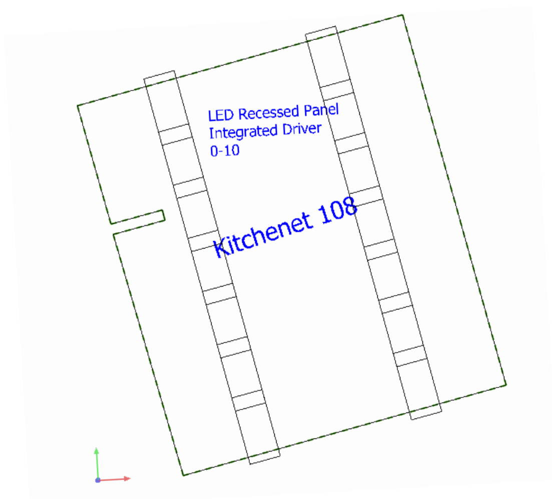


Fig: Kitchenette 108 Layout

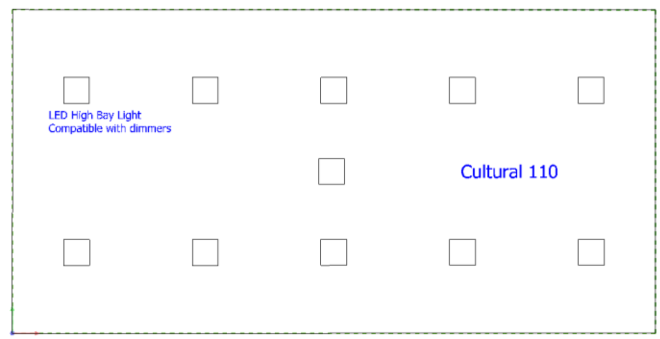


Fig: Cultural 110 Layout

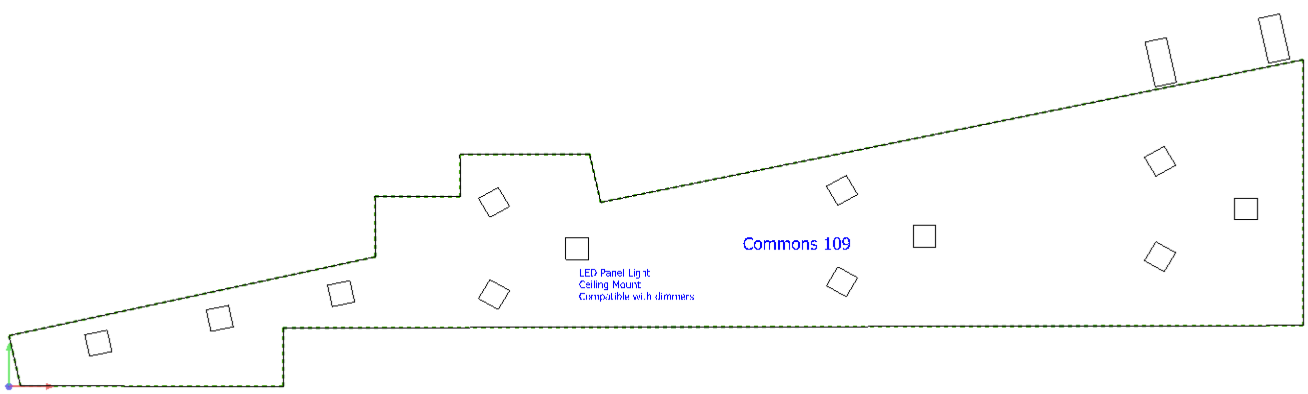


Fig: Common 109 layout

Fig: Storage 111 Layout

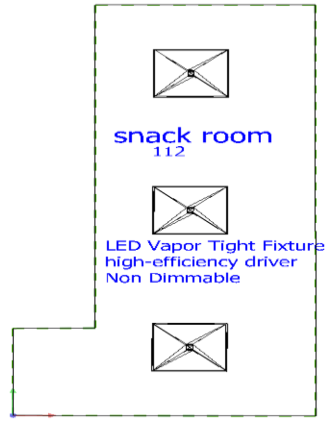


Fig: Snack Room 112 Layout

Fig: Gift Shop 113 Layout

Fig: Storage 114 Layout

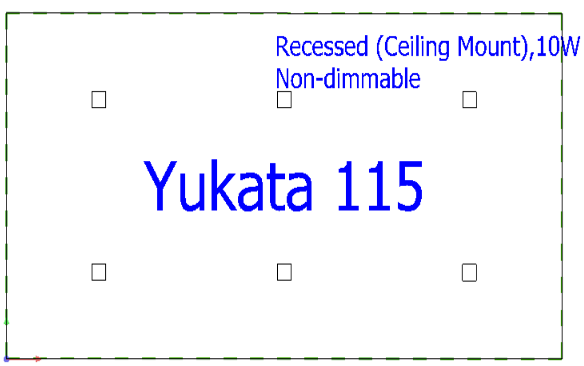


Fig: Yukata 115 Layout

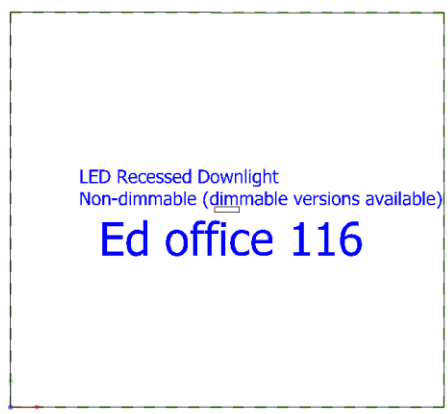


Fig: Ed Office 116 Layout

Fig: Mechanical 117 Layout

Fig: Staff 118 Layout

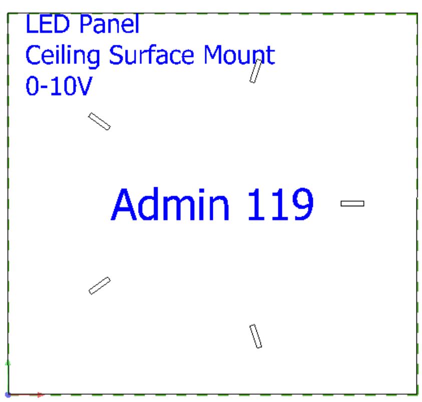


Fig: Admin 119 Layout

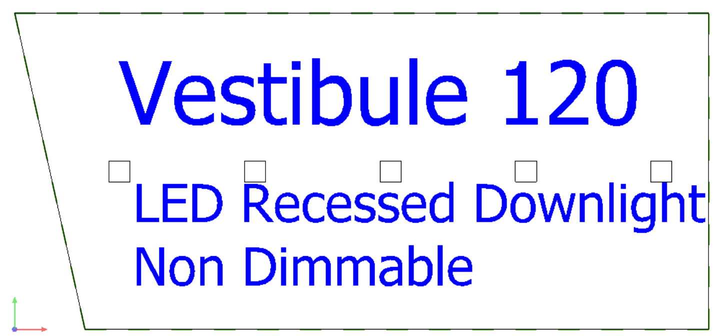


Fig: Vestibule 120 Layout

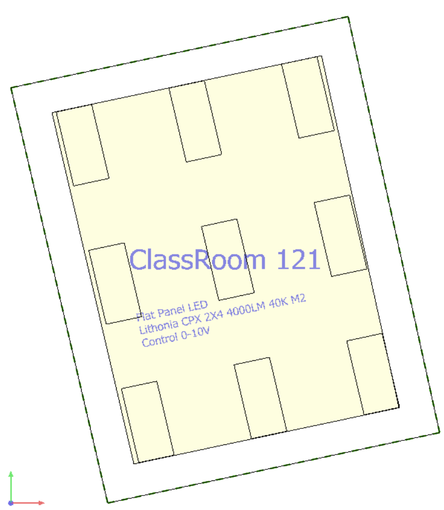


Fig: Classroom 121 Layout

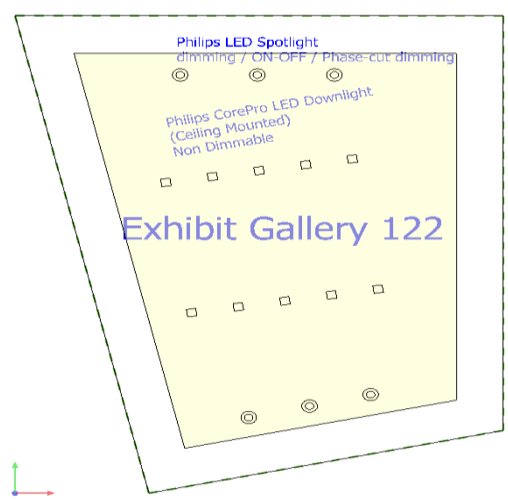


Fig: Exhibit Gallery 122 Layout

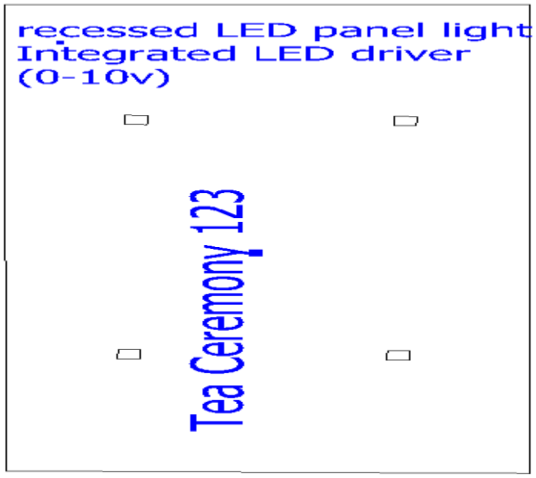


Fig: Tea Ceremony 123 Layout.

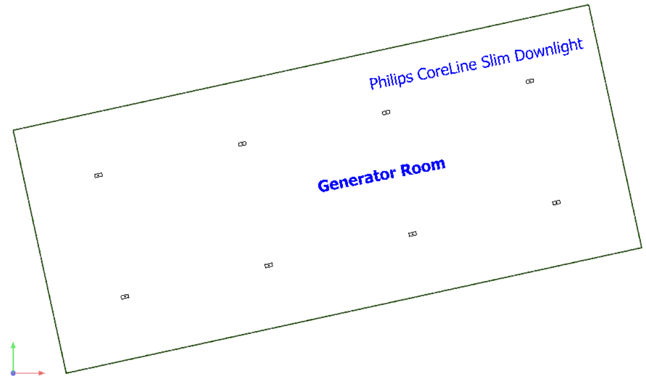


Fig: Generator Room Layout.

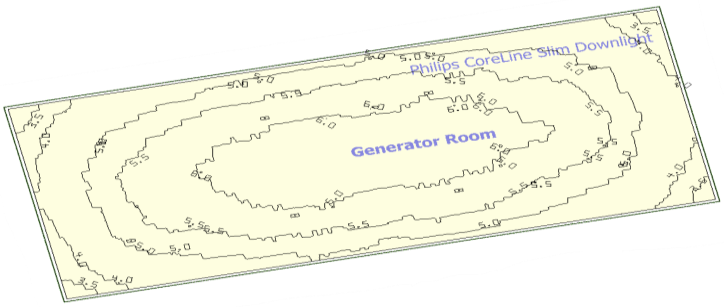


Fig: Generator Room with Luminairies.

Feedback: A good practice to use DIALux software for design. However, switching zones could be marked more clearly. Also, the lighting layout in the single expected PDF report is not clear to be read. Some fixtures and their control types are not well labeled.

Answer: In this milestone-2, we have marked switching zone very clearly this time. Also, we have labeled fixtures and their control types to every room individually. For better understand, we have attached snap from every room in this report.

Milestone-5: We have inserted a generator room layout with luminaires in our lighting layout design based on the recommendation we have given in the milestone-2.

Power Layout Diagram:

Feedback: The drafts are hard to be read (i.e. lines too thin and requiring a lot of zoom in to be analyzed). Make sure to work on it for the next milestone.
Answer: In this milestone-2, we have increased the line width and the size of equipment's. But, when we generate an image from AutoCAD and fit into the document, it still requires zooming. So for better viewing, we have attached .dwg file alongside with our report in D2L. In this milestone-2, we have added generator just beside the kitchenette in our power layout drawing.

The below figure illustrates the updated power layout diagram for the given base plan of this project:

Feedback from Milestone-2: Use different colors in diagrams for fire safety and security elements to improve clarity.

Answer: In this milestone-3, we have used different colors in the diagram for fire safety and security elements. For better view, we have attached .dwg file alongside with our report in D2L.

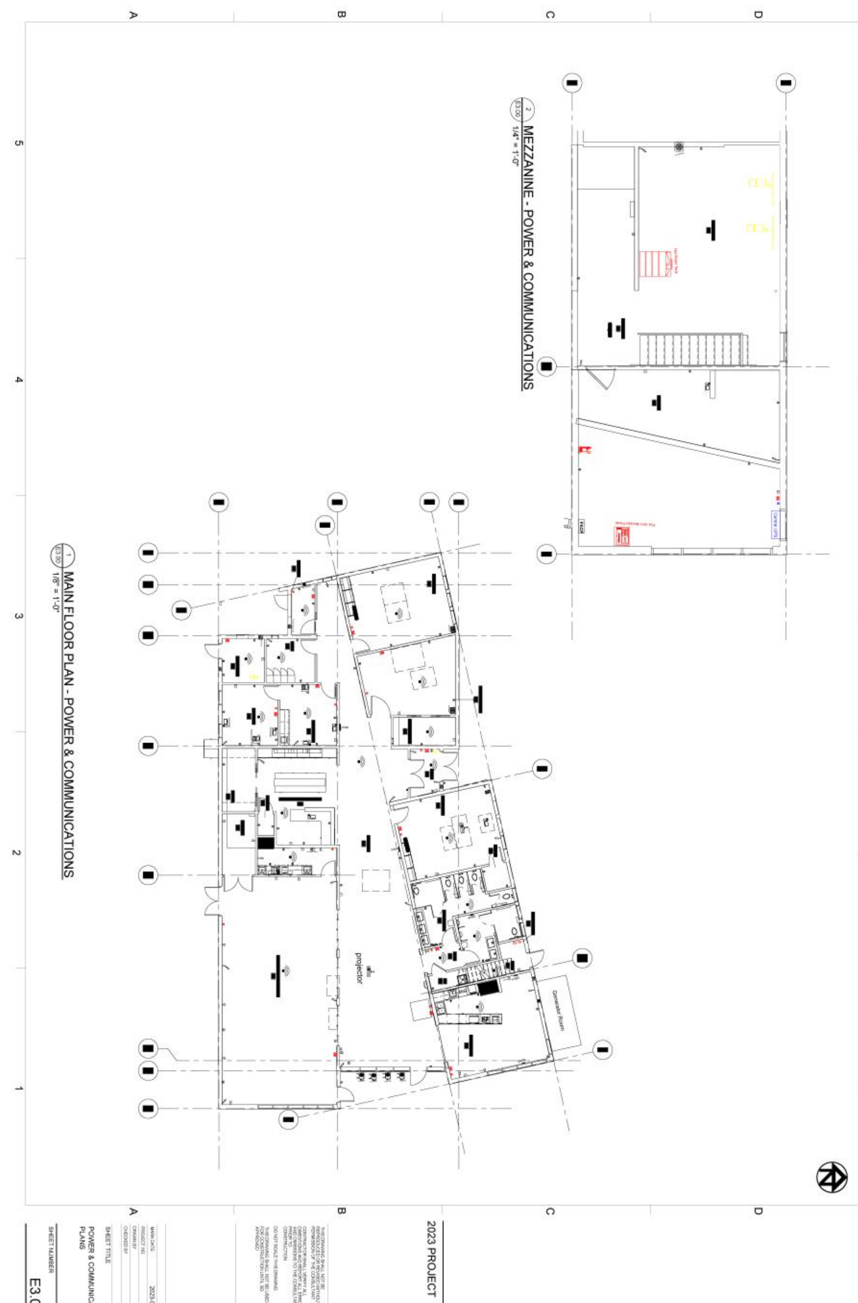


Fig: Power Layout Diagram

Milestone-5: We have already incorporated generator in our power layout diagram based on the recommendation we have given in our milestone-2.

Mechanical Schedule:

The below figure illustrates the mechanical schedule for the given base plan of this project:

MECHANICAL EQUIPMENT SCHEDULE

Printed on Feb 17, 2023 at 1:48 PM

			Nameplate				Overcurrent Protection			Feeder				Disconnect				Starter/VFD					Starter Control							
Unit No.	Description	Location	Voltage (V)	Phase Ø	MCA (A)	Load (HP, FLA, kW)	Type	Rating	Poles	Conductors	Bond	Conduit	Fed From	NEMA Rating	S	I	C	Type	NEMA Size	S	I	C	Type	Remote Type	N/O Contacts	N/C Contacts	S	I	C	Remarks
AIR CONDITIONING EQUIPMENT																														
CU-1	CONDENSING UNIT	EXTERIOR - SOUTH CULTURAL ACTIVITY	208	3		14.0 FLA	MCC	40	3	8 AWG		21	Panel 12C										INT							CONTROLLED BY FURNACE
CU-2	CONDENSING UNIT	EXTERIOR - SOUTH CULTURAL ACTIVITY	208	3		18.0	MCC	40	3	8 AWG		21	Panel 12C										INT							CONTROLLED BY FURNACE
CU-3	CONDENSING UNIT	EXTERIOR - SOUTH CULTURAL ACTIVITY	208	3		39.0	MCC	90	3	2 AWG		35	Panel 12C										INT							CONTROLLED BY FURNACE
CU-4	CONDENSING UNIT	EXTERIOR - SOUTH CULTURAL ACTIVITY	208	3		37.0	MCC	90	3	2 AWG		35	Panel 12C										INT							CONTROLLED BY FURNACE
AIR HANDLING																														
F-1	FURNACE	MECHANICAL ROOM 117	208	3		10.0 FLA	MCC	25	3	10 AWG		21	Panel 12F										LTST							CONTROLLED BY THERMOSTAT
F-2	FURNACE	MECHANICAL ROOM 117	208	3		10.0 FLA	MCC	25	3	10 AWG		21	Panel 12F										LTST							CONTROLLED BY THERMOSTAT
F-3	FURNACE	MECHANICAL ROOM 203	208	3		10.0 FLA	MCC	25	3	10 AWG		21	Panel M2H										LTST							CONTROLLED BY THERMOSTAT
F-4	FURNACE	MECHANICAL ROOM 203	208	3		12.0 FLA	MCC	25	3	10 AWG		21	Panel M2H										LTST							CONTROLLED BY THERMOSTAT
DOMESTIC HOT WATER																														
DHWT-1	DOMESTIC HOT WATER TANK	MECHANICAL ROOM 203	120	1		5.0 FLA		15	1	12 AWG		21	Panel M2H					VFD					INT							
EXHAUST FANS																														
EF-1	EXHAUST FAN	MECHANICAL ROOM 203	120	1		0.25 HP	MCC	15	1	12 AWG		21	Panel M2H					Mag					COM		2	2				INTERLOCK LOCAL LIGHTING
MOTOR	30Hp fire pump motor	Electrical ROOM 202	208	3		30HP	MCC	200	3	2/0		41	Panel M2H					Mag					VFD		2	2				pressure or flow switches
EF-2	EXHUAST FAN	ROOM 120	208	3		1.5 HP	MCC	15	3	12AWG		21	Panel 12G					Mag							2	2				INTERLOCK LOCAL LIGHTING
BASEBOARD HEATERS																														
BB-1	BASEBOARD HEATER	KITCHENETTE 108	208	1		2.5 kW	MCC	20	1	12 AWG		21	Panel 12B										LTST							CONTROLLED BY THERMOSTAT
BB-2	BASEBOARD HEATER	KITCHENETTE 108	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12B										LTST							CONTROLLED BY THERMOSTAT
BB-3	BASEBOARD HEATER	COMMONS 109	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12D										LTST							CONTROLLED BY THERMOSTAT
BB-4	BASEBOARD HEATER	COMMONS 109	208	1		2.5 kW	MCC	20	1	12 AWG		21	Panel 12D										LTST							CONTROLLED BY THERMOSTAT
BB-5	BASEBOARD HEATER	COMMONS 109	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12D										LTST							CONTROLLED BY THERMOSTAT
BB-6	BASEBOARD HEATER	CULTURAL ACTIVITY 110	208	1		2.5 kW	MCC	20	1	12 AWG		21	Panel 12C										LTST							CONTROLLED BY THERMOSTAT
BB-7	BASEBOARD HEATER	CULTURAL ACTIVITY 110	208	1		2.5 kW	MCC	20	1	12 AWG		21	Panel 12C										LTST							CONTROLLED BY THERMOSTAT
BB-8	BASEBOARD HEATER	MENS 104	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12A										LTST							CONTROLLED BY THERMOSTAT
BB-9	BASEBOARD HEATER	COMMONS 109	120	1		1.0 kW	MCC	15	1	12 AWG		21	Panel 12D										LTST							CONTROLLED BY THERMOSTAT
FORCE FLOWS																														
FF-1	FORCE FLOW FAN	FOYER 100	120	1		6.0 FLA	MCC	15	1	12 AWG		21	Panel 12A					Mag					LTST		2	2				CONTROLLED BY THERMOSTAT
FF-2	FORCE FLOW FAN	ROOM 120	120	1		1.5 kW	MCC	20	1	12 AWG		21	Panel 12G					Mag					LTST		2	2				CONTROLLED BY THERMOSTAT
FF-3	FORCE FLOW FAN	MECHANICAL ROOM 117	120	1		1.5 kW	MCC	20	1	12 AWG		21	Panel 12F					Mag					LTST		2	2				CONTROLLED BY THERMOSTAT
FF-4	FORCE FLOW FAN	WATER METER 107	120	1		6.0 FLA	MCC	15	1	12 AWG		21	Panel 12A					Mag					LTST		2	2				CONTROLLED BY THERMOSTAT

COMMON ABBREVIATIONS
E=ELECTRICAL CONTRACTOR M=MECHANICAL CONTRACTOR INT=INTEGRAL TO UNIT (BY MANUFACTURER) S=SUPPLIED BY I=INSTALLED BY C=CONNECTED BY NR=NOT REQUIRED

NAMEPLATE & FEEDER ABBREVIATIONS
FLA=FULL LOAD AMPACITY MCA=MINIMUM CIRCUIT AMPACITY HP=HORSE POWER FU=FUSE(S) P=POLES

STARTER TYPE ABBREVIATIONS
VFD=VARIABLE FREQUENCY DRIVE MAG=MAGNETIC FVNR MAN=MANUAL COM=COMBO BREAKER + MAG FVNR=FULL VOLTAGE NON-REVERSING FVR=FULL VOLTAGE REVERSING SOFT=SOFT STARTER TST=LINE VOLTAGE THERMOSTAT

STARTER CONTROL TYPE ABBREVIATIONS
BMS=BUILDING MANAGEMENT SYSTEM H,O,A=HAND,OFF,AUTO F,O,R=FORWARD,OFF,REVERSE O,O=ON,OFF LTST=LOW VOLTAGE THERMOSTAT R,J=RUN,JOG F,R=FORWARD,REVERSE O,C=OPEN,CLOSE

GENERAL NOTES

a. IN MOST CASES THE FLA'S AND ASSOCIATED BRANCH CIRCUITS ARE BASED ON THE CANADIAN ELECTRICAL CODE. CONFIRM THE ACTUAL FLA'S OF MOTORS WITH THE MECHANICAL CONTRACTOR DISTRIBUTION SHOP DRAWINGS IS BASED ON THE ASSUMPTION THAT FLA'S OF MOTORS HAVE BEEN CONFIRMED. NO ADDITIONAL COSTS WILL BE CONSIDERED FOR FAILURE TO CONFIRM THE FLA'S OF MOTORS PRIOR TO SUBMISSION OF DISTRIBUTION EQUIPMENT

[3] -

b. IF MOTOR FEEDER SIZES ARE NOT SHOWN, REFER TO SINGLE LINE DIAGRAM.

c. ELECTRICAL CONTRACTOR IS TO UPDATE ALL INFORMATION IN THIS SCHEDULE PRIOR TO SUBMITTING AS-BUILT DRAWINGS. THE OVERCURRENT PROTECTION AND MOTOR NAMEPLATE COLUMNS ARE TO BE FILLED IN BY THE CONTRACTOR.

d. WHERE INDICATED, PROVIDE ROOFTOP GFCI RECEPTACLES AS PER CEC RULE 26-704.

e. UNLESS NOTED OTHERWISE, ALL EQUIPMENT TEMPERATURE RATINGS ARE ASSUMED TO BE 75°C (CONDUCTOR TEMPERATURE). FOR EXISTING EQUIPMENT, CONFIRM THAT THE TEMPERATURE RATINGS ARE 75°C. IF THE EQUIPMENT IS UNMARKED AND RATED 100 A OR LESS, ASSUME THE TEMPERATURE RATING IS 60°C AND INCREASE THE CONDUCTOR SIZE APPROPRIATELY (CEC RULE 4- 006).

REFERRAL NOTES

[1] - PRIOR TO ORDERING EQUIPMENT (BREAKERS, OVERLOADS, ETC.), AND INSTALLATION OF BRANCH CIRCUITS. APPROVAL OF

[2] - SHOP DRAWINGS.

Fig: Mechanical Schedule

Normal SLD

The below figure is the Normal single line diagram for 25 KV voltage (Underground)

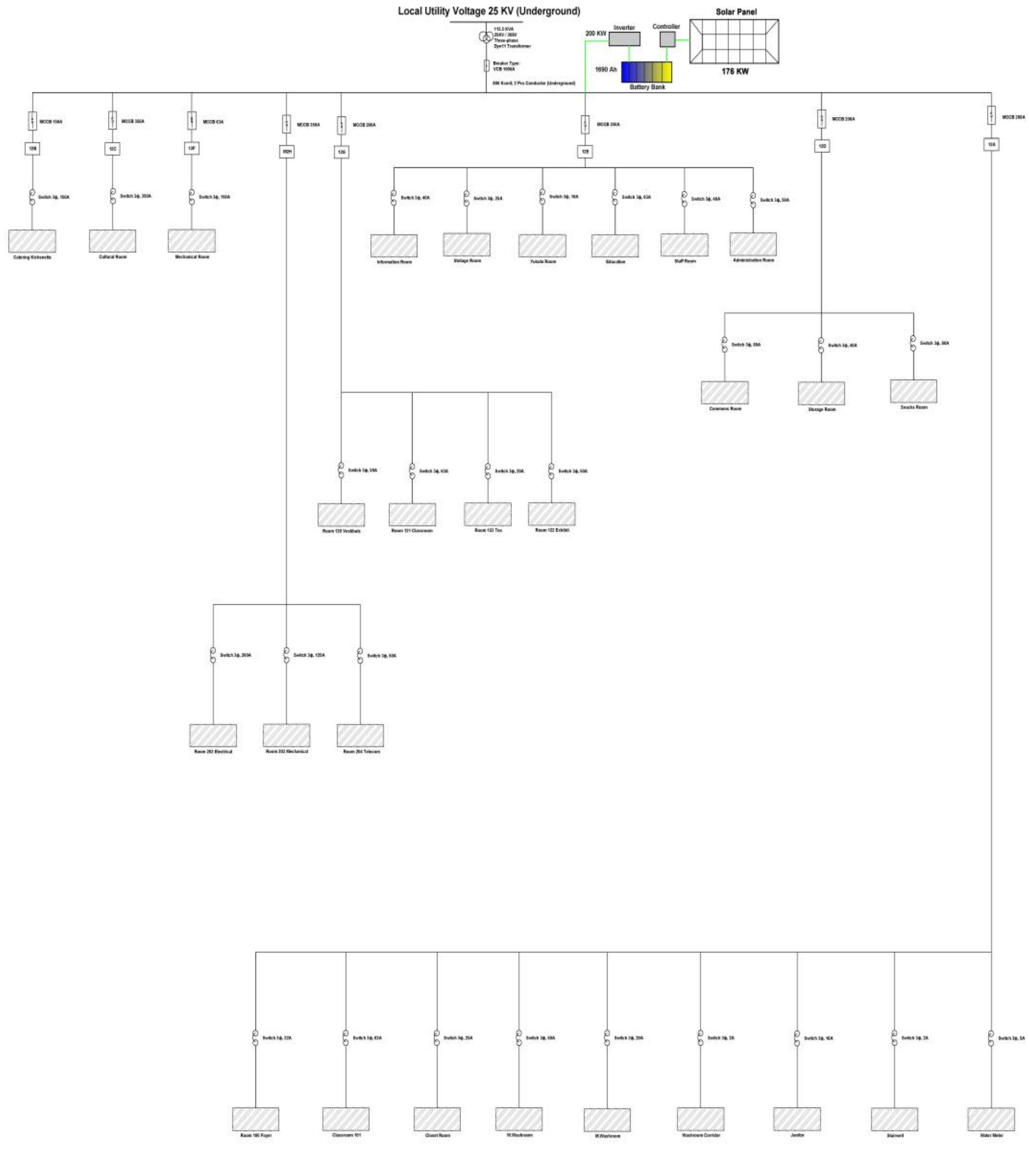


Fig: Normal SLD

Feedback: The drafts are hard to be read (i.e. lines too thin and requiring a lot of zoom in to be analyzed). Make sure to work on it for the next milestone.

Answer: In this milestone-2, we have increased the line width and the size of equipment's. But, when we generate an image from AutoCAD and fit into the document, it still requires zooming. So for better viewing, we have attached .dwg file alongside with our report in D2L.

Milestone-5: We have inserted solar panel & battery bank in our normal power SLD design based on the recommendation we have given in our milestone-2.

Emergency SLD

The below figure is the updated Emergency single line diagram for 25 KV voltage (Underground). Here, in this updated emergency SLD, we have added UPS in our drawing

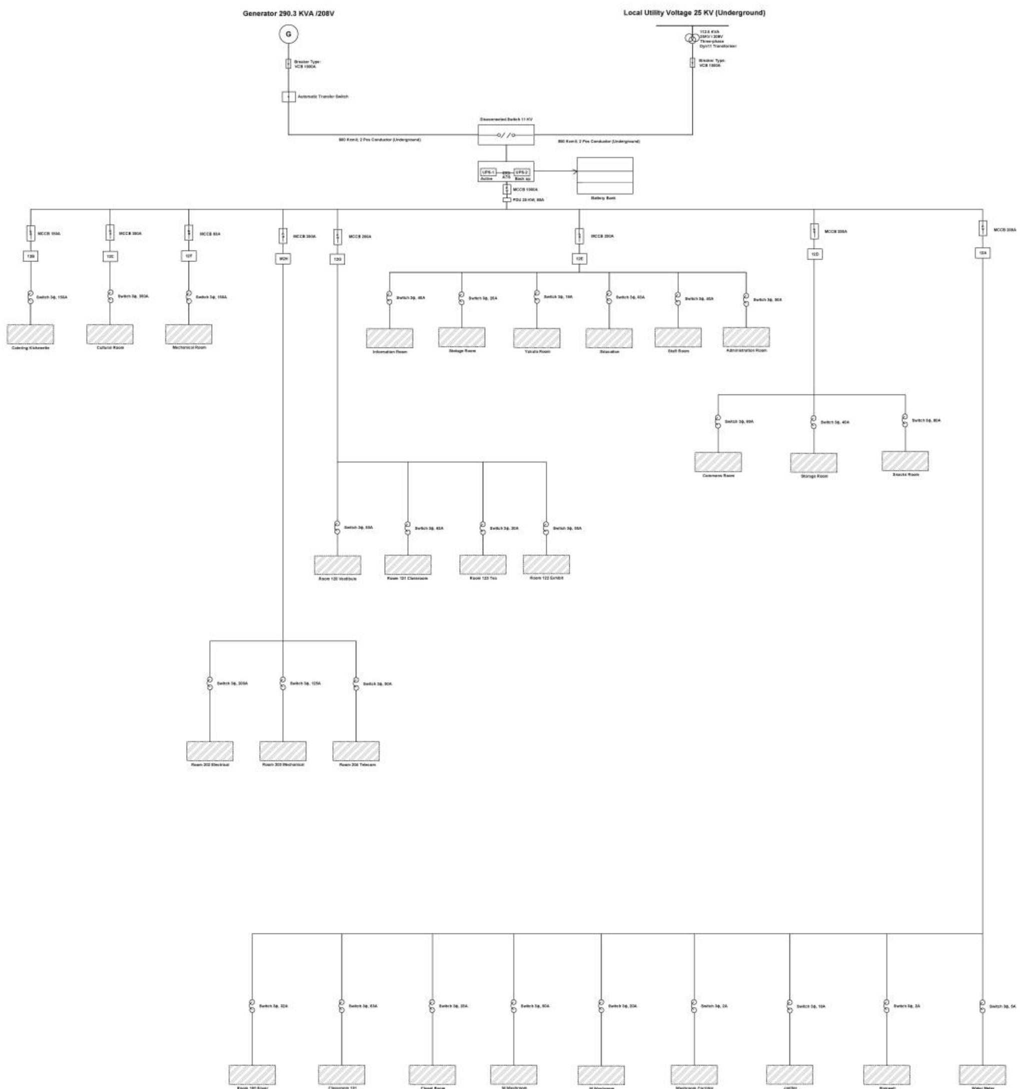


Fig: Emergency SLD

Feedback: The drafts are hard to be read (i.e. lines too thin and requiring a lot of zoom in to be analyzed). Make sure to work on it for the next milestone.

Answer: In this milestone-2, we have increased the line width and the size of equipment's. But, when we generate an image from AutoCAD and fit into the document, it still requires zooming. So for better viewing, we have attached .dwg file alongside with our report in D2L.

Milestone-5: We have previously incorporated generator in our Emergency SLD based on the recommendation we have given in our milestone-2.

Generator Type, Location, Sizing

We are recommending Kohler 250REOZJD Diesel Generator for this project. It is capable to handle our total load. Their type, sizing and other specifications are given below:

Kohler 250 REOZJD Diesel Generator Specifications [1]

Parameter	Specification
Model	Kohler 250REOZJD
Rated Power	250 kW
Voltage	208V, 3-phase
Frequency	60 Hz
Phase	3-Phase
Fuel Type	Diesel
Engine	Kohler KDI 3404-TCR
Alternator	Kohler KTA 250C (brushless, self-excited)
Fuel Tank Capacity	180 gallons (nominal)
Runtime at 75% Load	Approx. 10-12 hours
Cooling System	Air-cooled
Noise Level	69-72 dBA (sound-attenuated)
Enclosure	Soundproof, weatherproof, enclosed
Transfer Switch (ATS)	Automatic Transfer Switch (optional)
Oil Capacity	10.5 gallons
Starting System	12V DC starting system, 24V optional
Dimensions (L x W x H)	118" x 54" x 72"
Weight	Approx. 4,800 lbs
Air Intake	1,900 cfm
Exhaust System	4" exhaust pipe with flexible connection
Lubrication	Full-pressure lubrication system
Rated Current	870 Amps at 208V
Control Panel	Kohler KLCB-2000 or equivalent (with monitoring options)

Coolant Capacity	10 gallons
Service Interval	500 hours (for oil change)
Vibration Isolation	Rubber mountings for vibration reduction
Warranty	1-year or 2,000 hours (whichever comes first)

Inclusion of UPS Equipment

In this project milestone-2, we have used UPS for emergency equipment's. We have calculated total load for all emergency equipment's to measure the UPS rating and Battery sizing.

Emergency Equipment Details for UPS Capacity and Battery Specification Calculation:

Sl	Equipment List (Emergency)	Quantity	Avg.Load Per Quantity (W)	Total Load (KW)	Apparent (KVA	Phase	Power factor
1	Wifi	22	13	0.29	0.30	1	0.95
2	Close Circuit Camera	30	5.5	0.17	0.17	1	0.95
3	Barrier free access	5	50	0.25	0.26	1	0.95
4	Emergency light and exit sign	16	3.5	0.06	0.06	1	0.95
5	Push switch	6	1	0.01	0.01	1	0.95
6	Projector	7	400	2.80	2.95	1	0.95
7	Computer	8	260	2.08	2.19	1	0.95
8	Speaker	2	220	0.44	0.46	1	0.95
9	Sprinkler Flow Switch and Temper	1	20	0.02	0.02	1	0.95
10	Push button	2	1	0.00	0.00	1	0.95
11	Egress Door	2	50	0.10	0.11	1	0.95
12	Access Control	3	20	0.06	0.06	1	0.95
13	Sound System	2	800	1.60	1.68	1	0.95
14	Fire Alarm Control Panel	1	960	0.96	1.01	1	0.95
15	Fire Alarm Booster panel	1	600	0.60	0.63	1	0.95
16	Light	180	28.08	7.13	7.50	1	0.95
	Total	**288**	**3432.08**	**16.55**	**17.43**		

Parameters

- **Real Power (P):** 16.55 kW
- **Apparent Power (S):** 17.43 kVA
- **Power Factor (PF):** 0.95

We have assumed Backup time is around 1 hour.

UPS Sizing:

To ensure reliability and accommodate potential future expansions, we consider a UPS with a capacity **25-30% higher** than the current load.

Recommended UPS Rating:

UPS Rating = (17.43 kVA×1.25) = 21.79 kVA. Rounding up, **25 kVA** UPS.

So, we are recommending **Schneider Electric Galaxy VS 25kVA** for UPS. We are recommending two UPS where one will be active and others will be standby.

Cost:

The price of **Schneider Electric Galaxy VS 25kVA** is \$19,866.99 (Canadian Doller) [2].
So, for 2 UPS, the total cost will be = (\$19,866.99 × 2) = \$39733.98 (Canadian Doller).

Battery Sizing:

Step 1: Calculate Total Energy Requirement
Energy (Wh) = Real Power (kW)×Backup Time (hours) \ {Energy (Wh)}
=16.55 Kw × 1 hour =16,550 Wh

Step 2: UPS Efficiency
Assuming a UPS efficiency of **90%** (0.9):
Adjusted Energy (Wh) = 16,550 Wh / 0.9 = 18,389 Wh

Step 3: Determine Battery Bank Voltage
Larger UPS systems, like the Schneider Electric Galaxy VS (25 kVA), typically operate on a DC bus voltage of 208V.

Step 4: Calculate Required Battery Capacity
Battery Capacity (Ah) = Battery Voltage / DC Power Required
= 18,389 / 208 = 88.04 ≈ 90 Ah
Battery capacity of 90Ah is required.

Step 5: Determine Number of Batteries
Each **battery voltage is 12V**, so the number of batteries needed in series:
Number of Batteries =Battery Bank Voltage / Battery Voltage
=208/12 =17.33 ≈ 18
So, **18 batteries** of **12V, 90Ah** are required in series.
So, we are recommending **Trojan J185H-AC 12V 85Ah Battery** here.

Cost:

As per the latest data, the price of each battery is \$760.97 [3]
So, the cost for 18 batteries: 18 × \$760.97 = \$13,697.46 (Canadian Doller)

We have recommended 2 UPS. So, basically we need 36 batteries of 12V, 90Ah each.
So, the cost for 36 batteries: 36 × \$760.97 = \$27394.92 (Canadian Doller)

Distribution Options for the Site

The following things are the overview of power distribution

- Total Load: 250.63 kW
- Total Number of Rooms: 28
- Number of Distribution Panels: 8 (fed from the grid)
- Backup Systems: Generator and UPS for emergency power
- Renewable Energy Source: Solar PV system

- Transformer: 112.5 kVA, 25/208V
- Breaker Sizes:

  VCB: 1000A

  MCCBs: 200A (3), 250A, 350A, 150A, 63A

  Switches (3ϕ): 150A, 350A, 63A, 200A, 125A, 50A, 40A, 25A, 16A, 80A, 32A, 20A, 2A, 5A

Option 1. Grid-based with Emergency Backup Power Sources and Distribution

Grid Supply

- Primary source supplying all 8 panels.
- Reliable but subject to utility costs and potential outages.

Generator Backup

- Ensures emergency power in case of grid failure.

Uninterruptible Power Supply (UPS)

- Rated at 25 kVA to support 16.55 kW of critical loads.
- Backup time: 1 hour (with a 90 Ah battery bank).

Option 2. Grid with Solar with Emergency Backup Power Sources and Distribution

Grid Supply

- Primary source supplying all 8 panels.
- Reliable but subject to utility costs and potential outages.

Generator Backup

- Ensures emergency power in case of grid failure.

Uninterruptible Power Supply (UPS)

- Rated at 25 kVA to support 16.55 kW of critical loads.
- Backup time: 1 hour (with a 90 Ah battery bank).

Solar PV System

- Installed 176 kW capacity.
- Reduces dependence on grid power and lowers carbon emissions.

Overall, **Pros**

- Reliable power supply.
- No major infrastructure changes required.
- UPS ensures smooth transition during power outages.

Cons: Still dependent on grid electricity, which increases costs.

Cost Benefit Analysis:

- Grid electricity: \$0.10 – \$0.15/kWh (varies based on usage).
- Solar savings: Reduces peak demand charges.

Electricity Cost Saving between option 1 and 2:

1. Annual Energy Consumption

E_{load} = Power ×Operating Hours

- **Power Load** = 110 kW
- **Operating Hours** = **8 hours/day** × 365 days/year = **2,920 hours/year**
- **Annual Energy Demand** = 110 kW × 2,920 hours

$$E_{load} = 321{,}200 \text{ kWh/year}$$

As per recent data of 2025, Alberta's default electricity rate, known as the Rate of Last Resort (RoLR), has been set for \$0.126 per kwh(on average) [9]

2. Cost Without Solar

Cost without solar $= E_{load} \times \text{Rate}$

$$= 321{,}200 \times 0.126 = 40{,}471.2 \text{ CAD/year}$$

3. Cost With Solar

Using the **solar energy generation** formula:

$E_{solar} = P_{solar} \times H_{sun} \times \eta$

- **Solar System Capacity** = **176 kW**
- **Sun Hours per Year** = **1,825 hours/year**
- **System Efficiency** = **20% (0.20)**

$E_{solar} = 176 \times 1{,}825 \times 0.20 = 64{,}240$ kWh/year

Electricity still needed from the grid:

$E_{grid} = E_{load} - E_{solar}$

$= 321{,}200 - 64{,}240 = 256{,}960$ kWh/year

Cost with Solar:

Cost with solar $= E_{grid} \times \text{Rate}$

$$= 256{,}960 \times 0.126 = 32{,}376.96 \text{ CAD/year}$$

So, by using solar during peak hours, the total savings in electricity cost is

(40,471.2 - 32,376.96) = 8,094.24 CAD per year.

Renewable Energy or Alternative sources

For renewable energy source, we are recommending Solar panel. To feed our continuous load, we need to calculate the number of panel we will require.

1. Project Overview:

- **Building Dimensions:** 832 m^2 (Roof Area)
- **Land Dimension:** 10 acre = 40468.6 m^2 (approx.)
- **Total Building Load:** 110 kW (Continuous Load)
- **Location:** Existing land after constructing buildings

2. Solar Panel Selection: We have taken **Canadian Solar HiKu6 Mono PERC 500W** in our solar panel selection. Based on [4] we get the below features:

- **Assumed Panel Efficiency:** 20%
- **Typical Panel Size:** 2.2m × 1.1m (2.42 m^2 per panel)
- **Rated Power Output per Panel:** 500W (0.5 kW)

3. Available Land Space and Panel Capacity: In this project, the owner has 10 acre of land. The owner constructed a building which dimension is 832 m^2. But the owner will develop 4 other buildings of similar sizes.

- **Total Existing Land Area:** 40468.6 m^2 – (4 × 832 m^2) = 36308.6 m^2
- **Total Usable Land Area:** Assume 70% usability due to parking space, walkway, driving path and others. So, usable area = 36308.6 m^2 × 0.70 = 25416.02 m^2
- **Maximum Number of Panels we can accommodate:** = 25416.02 m^2 / 2.42 m^2 per panel = 10502 panels (approx.)

4. Required Solar Capacity to Meet Load:

- **Daily Load:** Assuming 110 kW is the peak demand, estimate daily consumption:

  Daily Energy Demand: 110 kW × 8 hours (avg. working hours) = 880 kWh/day

- **Solar Irradiance:** For Southern Alberta, we assume 5 peak sun hours per day
- **Required Solar Capacity:**

  Required Power = 880 kWh / 5 hours = 176 kW

  Number of Panels needed = 176 kW / 0.5 kW per panel = 352 panels

  Required Land Area = 352 × 2.42 m^2 = 887.04 m^2 (well within the available space)

Cost Analysis:

As of recent data, the average price per watt for monocrystalline panels in Canada ranges from \$2.50 to \$3.50 [5]. We are taking an approximate value of \$3.00 here.

Cost Per Panel: \$3.00/W × 500W = \$1500 per panel
Overall Cost: 352 × \$1500 = \$528000

So, overall cost for 352 panel is around \$528000 (Canadian Doller)

Renewable Zero Carbon Initiatives

By using Solar panel instead of using Grid Electricity, we can save much more Carbon emission. To calculate the **carbon emissions** for a **110 kW load** powered by the Alberta grid, we use the following formula [6]:

Carbon Emissions = $E_{load} \times$ Emission Factor

Step 1: Calculate Annual Energy Consumption

$E_{load} = P_{load} \times H_{operation}$

Where:

- P_{load} = 110 kW (load power)
- $H_{operation}$ = 8 hours/day × 365 days/year = **2920 hours/year**

E_{load} = 110×2920 = 321200 kWh/year

Step 2: Use Grid Emission Factor

- Alberta grid emission factor = **0.52 kg CO_2/kWh**

Step 3: Calculate Carbon Emissions

Carbon Emissions = 321200×0.52 =167024 kg CO_2/year ≈ 167 metric tons CO_2/year

A **110 kW load running for 8 hours per day in Alberta emits approximately 167 metric tons of CO_2 per year** when powered by the grid.

When using solar panels, **carbon emissions are nearly zero** during operation. However, to account for lifecycle emissions (manufacturing, transportation, and installation), we use an estimated **lifecycle emission factor** for solar energy.

The energy generated by the solar system is [8]:

$E_{solar} = P_{solar} \times H_{sun} \times \eta$

- P_{solar} = 176 kW (installed capacity)
- H_{sun} = 1825 hours/year (sunlight hours)
- η =20% (system efficiency = 0.20)

E_{solar} =176 ×1825×0.20 = 64240 kWh/year

Solar panels have a **lifecycle emission factor** of **20-50 g CO_2/kWh** (depending on manufacturing and installation) [7]. Taking an average value of **35 g CO_2/kWh (0.035 kg CO_2/kWh)**:

Solar Carbon Emissions = 64240×0.035 = 2248.4 kg CO_2/year ≈ 2.25 metric tons CO_2/year

If we use solar, we can reduce carbon emission up to = (167 - 2.25) metric tons CO_2/year
= 164.75 metric tons CO_2/year

Safety Measures

In this project, we have considered multiple safety measure in our electrical design. For 24/7 monitoring, we have given CCTV in every room. Furthermore, we have used fire protection & detection system in every room. Also, we have used smoke detector, sprinkler to detect fire detect. Besides that, we have used MCCB (Molded Case Circuit Breaker) to protect the electric circuit from overload and short circuit in every room. In the building main panel, we have used VCB (Vacuum Circuit Breaker) to protect against overload and short circuits. Finally, we have set emergency exit sign in some of the room.

Consideration for Future Technology

These are some future consideration we have considered in this project:

- ✓ Smart Sensors & IoT Integration – Enables real-time monitoring of energy use, lighting, and HVAC (Heating, Ventilation, and Air Conditioning) for efficiency.
- ✓ AI-Driven Building Management Systems (BMS) – Uses machine learning to optimize energy consumption and occupant comfort.
- ✓ Automated Climate Control – Adjusts heating and cooling based on occupancy patterns and external weather conditions.
- ✓ Battery Energy Storage Systems (BESS) – Stores excess renewable energy for use during peak demand or outages.
- ✓ Hydrogen & Fuel Cell Integration – Provides an alternative clean energy source for heating and electricity.

Summarization of the Impact on Following Based on Stage-2 Recommendation

In this section, we have summarized the impact on various technical specifications such as normal power SLD, emergency power SLD, power layout diagram, lighting layout diagram, luminaries schedule, mechanical schedule, panel schedule and service sizing calculation, based on our milestone-2 recommendation. We have conducted short summary in separate Excel file which is also attached in D2L. Detail analysis are given below:

Inclusion of UPS equipment

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: For inclusion of UPS equipment, there will be no changes at Normal Power SLD.

Emergency Power SLD: For inclusion of UPS equipment, there will be an impact at Emergency SLD.
Here, Real Power (P): 16.55 kW, Apparent Power (S): 17.43 kVA and Power Factor (PF): 0.95
We have assumed that, Backup Time: 1 hour
So, UPS Rating = (17.43 kVA×1.25) = 21.79 kVA. Rounding up, 25 kVA UPS.
We have used two UPS here where one is active, another one is standby. We have already drawn 2 UPS in our emergency SLD diagram in our milestone-2.

Lighting layout drawing: For inclusion of UPS equipment, there will be a slight changes at lighting layout drawing. Emergency lighting circuits may be powered by the UPS, requiring changes in the lighting layout to identify UPS-backed lights.

Luminaire schedule: For inclusion of UPS equipment, there will be no changes at luminaire schedule.

Power layout drawing: In our milestone-2, we have already incorporated 2 UPS in our power layout diagram.

Mechanical schedule: For inclusion of UPS equipment, there will be an impact on mechanical schedule. If the UPS requires cooling (for large UPS systems), the mechanical schedule must include the additional heat load and HVAC modifications.

Panel Schedule: As we have used two UPS here where one is active, another one is standby and both are connected via a static bypass switch for the continuous and non-continuous load. Also the UPS are connected with a dedicated MCCB breaker for protection. Considering the scenario of this architecture panel schedule will be impacted.

Service sizing calculation: We have incorporated 2 UPS (Each of 25 KVA) in our design. There will be an impact to the overall service sizing calculation.

Generator type, location, sizing

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: For generator type, location and sizing, there will be no changes at Normal Power SLD.

Emergency Power SLD: In our milestone-2, we have used 290 KVA, 3 phase, 208 V generator as per demand load. This generator has been connected with UPS through vacuum circuit breaker rated at 1000 A. This vacuum circuit breaker has been connected with automated circuit switch and a disconnected circuit switch rated at 11 kV. We have used 2 pc, 800 kcmil underground cable for wiring from disconnected switch to the generator. This has been already incorporated in our Emergency SLD diagram.

Lighting layout drawing: In our milestone-2, we have fit the generator in separate room beside electrical room. We have already drawn the room layout in our power layout diagram. As it is a separate room, there will be an impact in our lighting layout drawing.

Luminaire schedule: In our milestone-2, we have selected Kohler 250REOZJD as our generator where the size is 118” x 54” x 72”. To fit this generator, we need the room size at least 190" (L) x 126" (W) x 108" (H) which is equivalent to 15.83 feet long, 10.5 feet wide, and 9 feet high. But in our drawing, we have drawn 16 feet long, 10.5 feet wide and 10.5 feet high. As it is a separate room, there will be an impact in our luminaire schedule.

We know,

# of luminaries = $\frac{illuminance \times L \times W}{(lumen\ per\ luminaires) \times Cu \times LLF}$

Here, we have assumed that,
LLF = 0.9, Cu = 0.4, illuminance = 375, lumen per luminaries = 2000

Based on the room’s length and width, we get that,

# of luminaries = $\frac{375 \times 4.826 \ \times 3.2}{2000 \times 0.4 \times 0.9}$ = 8.041

So, we need 9 luminaries in that generator room.

Power layout drawing: In our milestone-2, we have fit the generator in separate room beside electrical room. We have already drawn the room layout sizing at 16 feet long, 10.5 feet wide and 10.5 feet high in our power layout diagram.

Mechanical schedule: For generator type, location and sizing, there will be an impact at Mechanical schedule. Generators produce significant heat during operation. Proper ventilation is required to prevent overheating. The mechanical schedule must include air intake and exhaust fans, louvers, or an HVAC system to maintain proper airflow in the generator room. Diesel or gas-powered generators require a fuel storage and supply system, which affects mechanical planning. The mechanical schedule should include fuel tank capacity, fuel piping layout, and ventilation requirements for fuel storage areas.

Panel Schedule: As we have fit the generator in a separate room, there will be an impact on panel schedule.

The generator is acted here at an emergency device. Generator will be connected with the bus bar with an automated circuit switch. Whenever, the grid doesn't provide electricity, the generator will do. So, we don't need to consider generator for panel schedule. But as it lies in a separate room, we have to consider the light designed here for scheduling the panel.
Based on lumen calculation, we have found that 9 luminaries need in the generator room.
Here,
We have assumed the load of light = 0.547 KVA
Quantity = 9
Total load = $(0.547 \times 1000 \times 9)$ W = 4923 W
So, breaker needed = $(4923 \times 1.25)/120 = 51.28$ A => 60A breaker is needed.

Service sizing calculation: As we have fit the generator in a separate room, there will be an impact on service sizing calculation. As the load is tiny (0.547 KVA), there will be a minimal changes in the service sizing.

Distribution options for the site

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: For distribution option for the site, there will be an impact in the Normal Power SLD diagram. In normal SLD, it need to depict the distribution network, including feeders, subpanels, and connection points. It need to show how loads are balanced across the distribution system. Also, it should indicate how renewable energy sources (solar, BESS, fuel cells) connect to the distribution network.

Emergency Power SLD: For distribution option for the site, there will be an impact in the Emergency Power SLD diagram. It need to highlight how critical loads are powered during outages (e.g., via BESS, fuel cells, or micro grids). It need to show how the system can isolate and power critical loads independently.

Lighting layout drawing: For distribution option for the site, there will be no impact in our existing Lighting layout drawing.

Luminaire schedule: For distribution option for the site, there will be no impact in our existing Luminaire schedule.

Power layout drawing: For distribution option for the site, there will be an impact for our existing power layout drawing. The layout must reflect the chosen distribution method (centralized feeders, decentralized micro grids, or hybrid systems) and the locations of transformers, switchgear, and distribution panels. It need to show how power is distributed from sources to loads.

Mechanical schedule: For distribution option for the site, there will be an impact for mechanical schedule. We need to allocate space for distribution equipment (e.g., transformers, switchgear, distribution panels). Also, we need to include pathways for power cables and conduits.

Panel schedule: The distribution option for the site impacts the panel schedule by determining the number of panels, breaker sizes, and load distribution. With a decentralized distribution option, the panel schedule will include multiple subpanels, each with its own schedule for local loads, reducing individual breaker sizes and ensuring balanced load distribution across the site.

Service sizing calculation: In the milestone-2, we have proposed decentralized distribution option. There will be a slight impact in the service sizing calculation. Since power is distributed among multiple panels, we need to ensure the transformer can handle peak loads while considering diversity factors. Feeder cables must be sized appropriately for each distribution panel, considering voltage drop and fault current levels. A decentralized system requires selective coordination among breakers to ensure faults are isolated at the right levels.

Renewable Energy or alternative sources

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: In our milestone-2, we have considered solar panel as a renewable energy. In normal power SLD, there will be an impact for installing solar panel. The SLD must show solar inverter (DC to AC conversion) and solar panel connecting to the main panel.

Emergency Power SLD: The emergency power Single-Line Diagram (SLD) will need to incorporate the solar system and its components. The SLD must show how the solar system powers critical loads during a grid outage.

Lighting layout drawing: In our project, we proposed to install solar panel outside the building in an open existing land. So, there will be no impact in our Lighting layout drawing.

Luminaire schedule: As we have planned to install solar panel outside the building in an open existing land, there will be no impact in the luminaire schedule.

Power layout drawing: Integrating solar panels into the electrical system will significantly impact the power layout drawing. The solar panel array must be shown on the layout, indicating its physical location (ground-mounted). The solar inverter location should be included, typically near the main panel or electrical room.

Mechanical schedule: For inclusion of Solar panel, there will be an impact at Mechanical schedule. The mechanical schedule must include cooling fans or HVAC requirements for the inverter. The mechanical schedule should include structural support for ground-mount racking systems.

Panel schedule: Integrating solar panels in an open area typically does not impact the panel schedule, as solar systems are connected upstream of the distribution panels and do not directly affect the individual circuit loads or breaker assignments within the panel.

Service sizing calculation: Installing solar panels outside can impact the service sizing calculation for your electrical system. When we install solar panels, they generate electricity that offsets the power we need from the grid. This reduces the load on your electrical service. As a result, your service size (e.g., the main breaker or service panel capacity) may not need to be as large as it would without solar. As we know,

$$\text{Net Load} = \text{Total Electrical Load} - \text{Solar Generation}$$

Zero carbon initiatives

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: In our milestone-2, for reducing carbon, we have considered Solar panel instead of using Grid Electricity. In normal power SLD, there will be an impact for installing solar panel. The SLD must show solar inverter (DC to AC conversion) and solar panel connecting to the main panel.

Emergency Power SLD: In our project, we haven’t considered solar as an emergency source when it is fully integrated in place of grid electricity. Hence, there will be no changes at Emergency Power SLD.

Lighting layout drawing: The lighting layout may be impacted by solar integration due to power limitations, requiring optimized fixture placement to reduce energy consumption. Emergency and critical lighting zones must be prioritized based on battery backup capacity. Additionally, smart lighting controls (dimmers, motion sensors) may be needed to improve energy efficiency.

Luminaire schedule: Integrating fully solar panels instead of grid electricity will have an impact on luminaire schedule. Energy-efficient lighting (e.g., LED) is often paired with solar systems to reduce power consumption, and daylight harvesting strategies may be incorporated.

Power layout drawing: Integrating solar panels instead of grid electricity, will significantly impact the power layout drawing. The utility power source will be removed from the power layout. The main distribution panel (MDP) will now receive power only from the solar inverter & battery storage. Solar panels and their array layout must be added to the drawing. A solar inverter and a DC combiner box must be included. Solar panel to inverter wiring (DC cables) must be shown. Inverter to main panel wiring (AC cables) must be sized properly.

Mechanical schedule: Integrating solar panels instead of grid electricity, will significantly impact the mechanical schedule. The mechanical schedule must include cooling fans or HVAC requirements for the inverter. The mechanical schedule should include structural support for ground-mount racking systems.

Panel schedule: Replacing grid electricity with solar power does not directly impact the panel schedule, as the solar system connects upstream of the distribution panels and does not alter the individual circuit loads or breaker assignments within the panel.

Service sizing calculation: For service sizing calculation, there will be a significant impact if we use solar panel instead of grid electricity. Grid service sizing calculations will be eliminated, and all calculations will be based on solar power availability and battery storage capacity. The total service size is:

$$\text{Total Load Demand} = \text{Building Load} - \text{Solar Generation}$$

Consideration of future technologies

Recommendation from Milestone 2: No recommendation is given

Normal Power SLD: Based on my consideration of future technologies, there will be an impact of Normal Power SLD. Normal SLD should show connections for solar, BESS, and hydrogen/fuel cells. It must include AI-driven BMS and IoT-controlled loads. It should indicate how the system interacts with the grid (e.g., net metering, peak shaving).

Emergency Power SLD: Based on my consideration of future technologies, there will be an impact of Emergency Power SLD. It should highlight how BESS and fuel cells provide backup power during outages. It should show how critical loads are powered during emergencies. It include automatic transfer switches for seamless transition to backup power.

Lighting layout drawing: Based on my consideration of future technologies, there will be an impact of lighting layout drawing. In the drawing, IoT-enabled lighting controls, occupancy sensors, and daylight harvesting systems should be added. We need to optimize lighting layouts to reduce energy consumption and align with renewable energy availability. Zoning and dimming controls must be included for better power management.

Luminaire schedule: Based on my consideration of future technologies, there will be a slightly impact of luminaire schedule. The lumen schedules need to be aligned with AI-driven energy management strategies.

Power Layout drawing: Based on my consideration of future technologies, there will be an impact of power layout drawing. The drawing must include IoT devices, smart sensors, BESS, hydrogen/fuel cell systems, and their connections. It must add wiring for IoT and sensor networks and show how renewable energy sources (solar, BESS, fuel cells) integrate with the main power distribution system.

Mechanical schedule: Based on my consideration of future technologies, there will be an impact of mechanical schedule. Battery energy storage (BESS) may require cooling which requires HVAC modifications. Apart from this, structural reinforcements is needed for ground-mounted racks. Also, smart climate control systems integrated to optimize power consumption. These all impacts the mechanical schedule.

Panel schedule: Based on my consideration of future technologies, there will be an impact of panel schedule. The panel schedule will need to account for IoT devices, smart sensors, and AI-driven BMS by including dedicated circuits for these systems. Additionally, it must integrate BESS and hydrogen/fuel cell connections, ensuring proper breaker sizing and load distribution for optimized energy management.

Service sizing calculation: Based on my consideration of future technologies, there will be an impact of service sizing calculation. Here, account for renewable energy generation and storage, will reduce the required grid service size. Also, we need AI-driven load optimization and BESS for peak shaving. In the service sizing calculation, hydrogen/fuel cell output in the total power capacity should be included.

Equipment Data Sheets

In this project, we have used 33 equipment's so far. Here, we are attaching the datasheet of 4 equipment's. Rest of the equipment's datasheet have been attached in the separate pdf file. For better viewing, please refer to alternative pdf where we have attached the datasheet.

Product data sheet

Tmax molded case circuit-breakers

Tmax T7

Compliance with Standards
UL489
CSA C22.2 No. 5.1
IEC 60947-2 EC Directive: - "Low voltage directives" (LVD) no. 73/23 EEC - "Electromagnetic compatibility directive" (EMC) no. 89/336 EEC

Type of circuit-breaker				Tmax T7		
Frame				1000/1200		
Rated ultimate short-circuit breaking capacity, Icu				S	H	L
	(AC) 50-60 Hz 240 V		[kA]	65	100	150
	(AC) 50-60 Hz 277 V		[kA]	–	–	–
	(AC) 50-60 Hz 347 V		[kA]	–	–	–
	(AC) 50-60 Hz 480 V		[kA]	50	65	100
	(AC) 50-60 Hz 600Y/347 V		[kA]	–	–	–
	(AC) 50-60 Hz 600 V		[kA]	25	50	65
	(DC) 250 V-2 poles in series		[kA]	–	–	–
	(DC) 500 V-2 poles in series		[kA]	–	–	–
	(DC) 500 V-3 poles in series		[kA]	–	–	–
	(DC) 600 V-3 poles in series		[kA]	–	–	–
Trip units:						
Thermomagnetic	T fixed, M fixed (10xIn) TMF			–		
	T adj., M fixed (10xIn) TMD			–		
	T adj., M adj. (5...10xIn) TMA			–		
	T adj., M fixed (3xIn) TMG			–		
	T adj., M adj. (2.5...5xIn) TMG			–		
Magnetic only	M adjustable (6...12xIn) MA			–		
Electronic	PR231/P			•		
	PR232/P			•		
	PR331/P			•		
	PR332/P			•		
Versions				F-W		
Terminals	Fixed (F)			F FC CuAl HR/VR		
	Plug-in (P)			–		
	Withdrawable (W)			HR/VR		
Fixing on DIN rail				–		
Mechanical life		[No. operations /hourly oper.]		10000/60		
Electrical life		[No. operations /hourly oper.]		2000/60		
Basic fixed dimensions	3/4 pole	W	[mm]	210/280		
		D	[mm]	154/154 Manual 178/178 Motorized		
		H	[mm]	268/268		
Weights	fixed	3/4 pole	[kg]	9.7/12.5 Manual 11/14 Motorized		
	plug-in	3/4 pole	[kg]	–		
	Withdrawable	3/4 pole	[kg]	29.7/39.6 Manual 32/42 Motorized		

Power and productivity for a better world™ ABB

Fig: MCCB datasheet of ABB

KOHLER POWER SYSTEMS

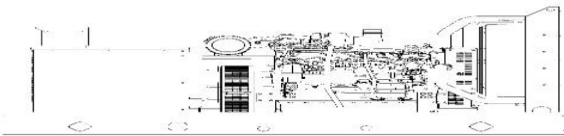
Model: 250REOZJD

208–600 V | Diesel

ISO 9001 KOHLER POWER SYSTEMS NATIONALLY REGISTERED

Ratings Range

		60 Hz
Standby:	kW	250–255
	kVA	313–319
Prime:	kW	225–230
	kVA	281–288



Generator Set Ratings

Alternator	Voltage	Ph	Hz	130°C Rise Standby Rating kW/kVA	130°C Rise Standby Rating Amps	105°C Rise Prime Rating kW/kVA	105°C Rise Prime Rating Amps
4UA10	120/208	3	60	250/313	867	225/281	781
	127/220	3	60	250/313	820	225/281	738
	120/240	3	60	250/313	752	225/281	677
	139/240	3	60	250/313	752	225/281	677
	220/380	3	60	250/313	475	225/281	427
	240/416	3	60	250/313	434	225/281	390
	277/480	3	60	250/313	376	225/281	338
	347/600	3	60	250/313	301	225/281	271
4UA13	120/208	3	60	255/319	885	230/288	798
	127/220	3	60	255/319	837	230/288	754
	120/240	3	60	255/319	767	230/288	692
	139/240	3	60	255/319	767	230/288	692
	220/380	3	60	255/319	484	230/288	437
	240/416	3	60	255/319	442	230/288	399
	277/480	3	60	255/319	383	230/288	346
	347/600	3	60	255/319	307	230/288	277

Standard Features

- Kohler Co. provides one-source responsibility for the generating system and accessories.
- The generator set and its components are prototype-tested, factory-built, and production-tested.
- The 60 Hz generator set offers a UL 2200 listing.
- The generator set accepts rated load in one step.
- The 60 Hz generator set meets NFPA 110, Level 1, when equipped with the necessary accessories and installed per NFPA standards.
- The generator set complies with ISO 8528-5, Class G2, requirements for transient performance in all generator set configurations. Select the Decision-Maker® 550 controller for improved voltage regulation and ISO 8528-5, Class G3, compliance.
- The 60 Hz generator set engine is certified by the Environmental Protection Agency (EPA) to conform to Tier 3 nonroad emissions regulations.
- A one-year limited warranty covers all systems and components. Two-, five-, and ten-year extended warranties are also available.
- Alternator features:
  - The unique Fast-Response™ II excitation system delivers excellent voltage response and short-circuit capability using a permanent magnet (PM)-excited alternator.
  - The brushless, rotating-field alternator has broadrange reconnectability.
- Other features:
  - Controllers are available for all applications. See controller features inside.
  - The low coolant level shutdown prevents overheating (standard on radiator models only).
  - Integral vibration isolation eliminates the need for under-unit vibration spring isolators.

RATINGS: All three-phase units are rated at 0.8 power factor. All single-phase units are rated at 1.0 power factor. *Standby Ratings:* Standby ratings apply to installations served by a reliable utility source. The standby rating is applicable to varying loads for the duration of a power outage. There is no overload capability for this rating. Ratings are in accordance with ISO-3046/1, BS 5514, AS 2789, and DIN 6271. *Prime Power Ratings:* Prime power ratings apply to installations where utility power is unavailable or unreliable. At varying load, the number of generator set operating hours is unlimited. A 10% overload capacity is available for one hour in twelve. Ratings are in accordance with ISO-8528/1, overload power in accordance with ISO-3046/1, BS 5514, AS 2789, and DIN 6271. For limited running time and base load ratings, consult the factory. Obtain the technical information bulletin (TIB-101) on ratings guidelines for the complete ratings definitions. The generator set manufacturer reserves the right to change the design or specifications without notice and without any obligation or liability whatsoever. GENERAL GUIDELINES FOR DERATION: *Altitude:* Derate 0.5% per 100 m (328 ft.) elevation above 1000 m (3300 ft.). *Temperature:* Derate 1.0% per 10°C (18°F) temperature above 25°C (77°F).

G5-291 (250REOZJD) 3/10g

Fig: Generator datasheet of KOHLER power systems.

Product data sheet

Specifications

Galaxy VS UPS 25kW 208V with N+1 power module for external batteries, Start-up 5x8

GVSUPS25KRFS

Overview

Presentation	Highly efficient, easy-to-deploy 25kW, 208V 3-phase UPS that brings best-in-class power protection and low total cost of ownership to edge, small and medium data centers, as well as to critical infrastructure in commercial and industrial applications. Includes 5x8 start-up service and one additional power module for N+1 redundancy.
Lead time	Usually Ships within 2 Weeks

Main

Main Input Voltage	208 V 3 phase
Other Input Voltage	200 V 220 V
Main Output Voltage	208 V 3 phase
Kw Rating	25 kW
Rated power in VA	25 kVA
Battery Type	External battery system Li-Ion (Lithium Ion) VRLA
Provided equipment	Dust filter EcoStruxure IT ready (UPS) Installation guide Integrated network management Power modules ship installed Start-Up Service
Range of Product	Galaxy VS
Range Compatibility	Galaxy VS

Batteries & Runtime

Battery Voltage	384-480VDC
End of Discharge Battery Voltage	307 V DC
End of Discharge Maximum Battery Current	85 A

General

Bypass Voltage Tolerance	+/- 10 %
Redundant	Yes
Product or Component Type	Uninterruptible power supply (UPS)

Physical

color	White

Price is "List Price" and may be subject to a trade discount – check with your local distributor or retailer for actual price.

Mar 29, 2025 Life Is On | Schneider Electric 1

Fig: UPS Datasheet of Galaxy VS UPS.

Circuit-breakers
IEC 947-2



				SACE Isomax S1		SACE Isomax S2			SACE Isomax S3		
Rated uninterrupted current, **Iu**			[A]	125		160			160 - 250		
Number of poles			N°.	3-4		3-4			3-4		
Rated service voltage, **Ue**		(a.c.) 50-60 Hz	[V~]	500		690			690		
		(d.c.)	[V–]	250		500			750		
Rated impulse withstand voltage, **Uimp**			[kV]	6		6			8		
Rated insulation voltage, **Ui**			[V]	500		690			800		
Test voltage at industrial frequency for 1 minute			[V]	3000		3000			3000		
Rated limit short-circuit breaking capacity, **Icu**				B	N	B	N	S	N	H	L
	(a.c.) 50-60 Hz	220/230 V~	[kA]	25	40	25	50	65	65	100	170
	(a.c.) 50-60 Hz	**380/415 V~**	[kA]	**16**	**25**	**16**	**35 (1)**	**50**	**35 (1)**	**65**	**85**
	(a.c.) 50-60 Hz	440 V~	[kA]	10	16	10	20	25	30	50	65
	(a.c.) 50-60 Hz	500 V~	[kA]	8	12	8	12	15	25	40	50
	(a.c.) 50-60 Hz	690 V~	[kA]	—	—	6	8	10	14	18	20 (5)
	(d.c.)	250 V – (2 poles in series)	[kA]	16	25	16	35	50	35	65	85
	(d.c.)	500 V – (2 poles in series)	[kA]	—	—	—	—	—	35	50	65
	(d.c.)	500 V – (3 poles in series)	[kA]	—	—	16	35	50	—	—	—
	(d.c.)	750 V – (3 poles in series)	[kA]	—	—	—	—	—	20	35	50
Rated duty short-circuit breaking capacity, **Ics** (2)			[%Icu]	50%	50%	100%	75%	75%	100%	75%	75%
Rated short-circuit making capacity (415 V~), **Icm**			[kA]	32	52,5	32	74	105	74	143	187
Tripping time (415 V~)			[ms]	8	6	8	7	6	8	7	6
Rated short time withstand current (1 s), **Icw**			[kA]								
Use category (EN 60947-2)				A		A			A		
Isolation behaviour				■		■			■		
IEC 947-2, EN 60947-2				■		■			■		
Releases	thermomagnetic	T fixed, M fixed 5Ith		■	■						
		T fixed, M fixed 10Ith		■	■						
		T adjustable, M fixed 3Ith							■	■	
		T adjustable, M fixed 5Ith				■	■		■	■	■
		T adjustable, M fixed 10Ith				■	■	■	■	■	■
		T adjustable, M adjustable									
	magnetic only	M fixed			■	■	■	■	■	■	■
	microprocessor-based	PR211/P (I - LI)									
		PR212/P (LSI - LSIG)									
	Interchangeability										
Versions											
Terminals (5)	fixed			FC - R		EF - FC - FC CuAl - R			F - EF - ES - FC - FC CuAl - RC - R		
	plug-in			FC - R		FC - R			EF - FC - R		
	withdrawable (3)			—		—			EF - FC - R		
Fixing on DIN rail				DIN EN 50022		DIN EN 50022			DIN EN 50023		
Mechanical life	[No. operations / Operations per hour]			25000 / 240		25000 / 240			25000 / 120		
Electrical life (a 415 V~)	[No. operations / Operations per hour]			8000 / 120		8000 / 120			10000 (160A) - 8000 (250A) / 120		
Basic dimensions	fixed	3 / 4 poles	W[mm]	78 / 103		90 / 120			105 / 140		
			D [mm]	70		70			103,5		
			H [mm]	120		120			170		
Weights	fixed	3 / 4 poles	[kg]	0,9 / 1,2		1,1 / 1,5			2,6 / 3.5		
	plug-in	3 / 4 poles	[kg]	1 / 1,4		1,3 / 1,7			3,1 / 4.1		
	withdrawable	3 / 4 poles	[kg]	—		—			3,5 / 4,5		

Notes
1) All versions with Icu = 35 kA are certified to 36 kA.
2) The percentage Ics performance of S3 N/H/L, S4 N/H/L, S5 N/H and S6 N/S/H circuit-breakers is 25% lower at 690 V.
3) Withdrawable circuit breakers must be fitted with the front flange for the lever operating mechanism or the accessories which are an alternative to it such as the rotary handle or motor operator.
4) The plug-in version of circuit-breaker S5 is only available for rated current. 400 A.
5) The SACE S3 circuit breaker with breaking capacity L at 690

Fig: Low Voltage Circuit Breaker Datasheet.

Report Assumption Details

1. Running a **Load Flow Analysis** before conducting **Short Circuit Analysis** and selecting **Protective Equipment** is a standard approach in power system studies. So we draw the circuit diagram in ETAP and run the power.
2. Based on the **ETAP Load Flow Analysis**, assuming approximate cable lengths
3. As per demand put the primary voltage of transformer 25 KV and Secondary is 208V. According to ETAP consider FLS 2.58 for Primary side and 310.9 for secondary.
4. We consider a relay-controlled breaker rated of 36KV and 630A.
5. Current transformer of 400/5 A connected with over current relay.
6. Consider Relay of SIEMENS (Model: 7SR11). Pick up time: 0.07 Sec.
7. During ARC Flash consider FCT: 0.5 sec.

Power Flow Summary Report:

Following figure is the load flow diagram with grid to load.

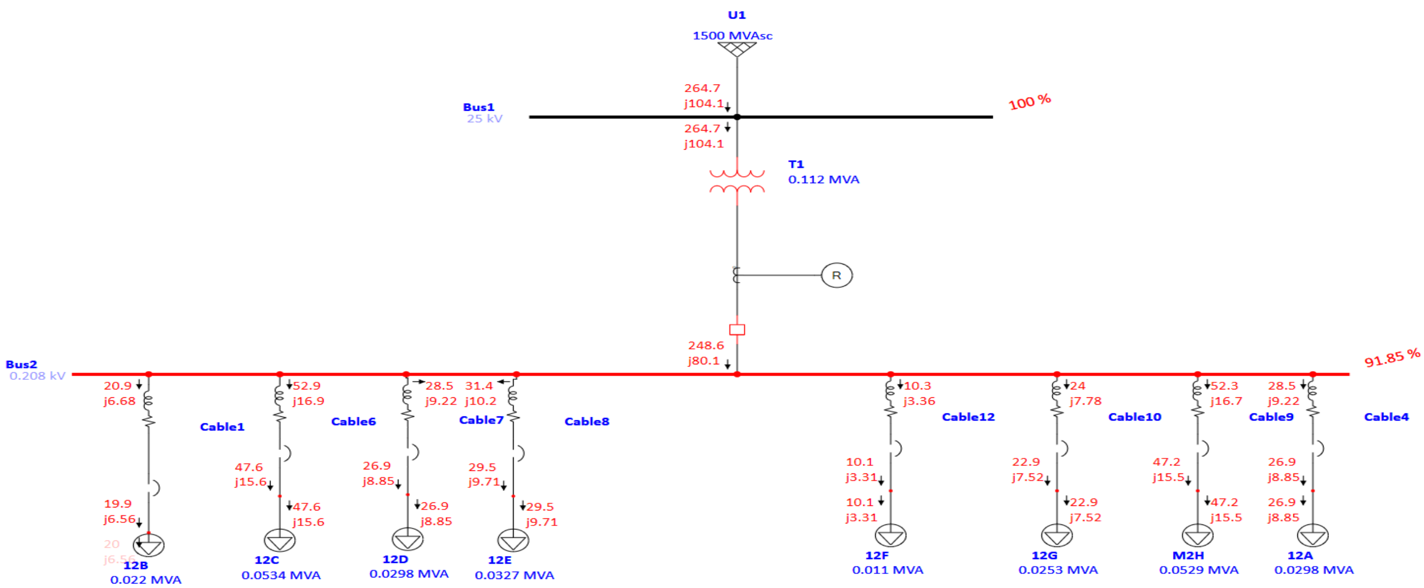


Fig: Load flow Diagram without Generator (Grid to Load)

1. System Overview

- Primary Voltage: 25 kV
- Secondary Voltage: 0.208 kV
- Transformer Rating: 0.112 MVA
- Total Load: ~0.25 MVA (approximate)
- System Efficiency: 91.85%

2. Bus Data

- Bus1 (25 kV): 100% voltage level
- Bus2 (0.208 kV): 91.85% voltage level

3. Transformer Details

- T1 (0.112 MVA, 25 kV / 0.208 kV)
- Power Flow: ~248.6 kVA, j80.1 reactive component

4. Load Distribution

- Connected Loads: 7
- Largest Load: 0.0529 MVA (M2H)

- Smallest Load: 0.011 MVA (12F)

5. Cable / Line Performance

- Highest Impedance: Cable6 (52.9 + j16.9)
- Voltage Drop Observed: ~8.15%
- Power Factor Considerations: Some loads may require reactive power compensation

Here, following figure is the load flow diagram with Generator to Load

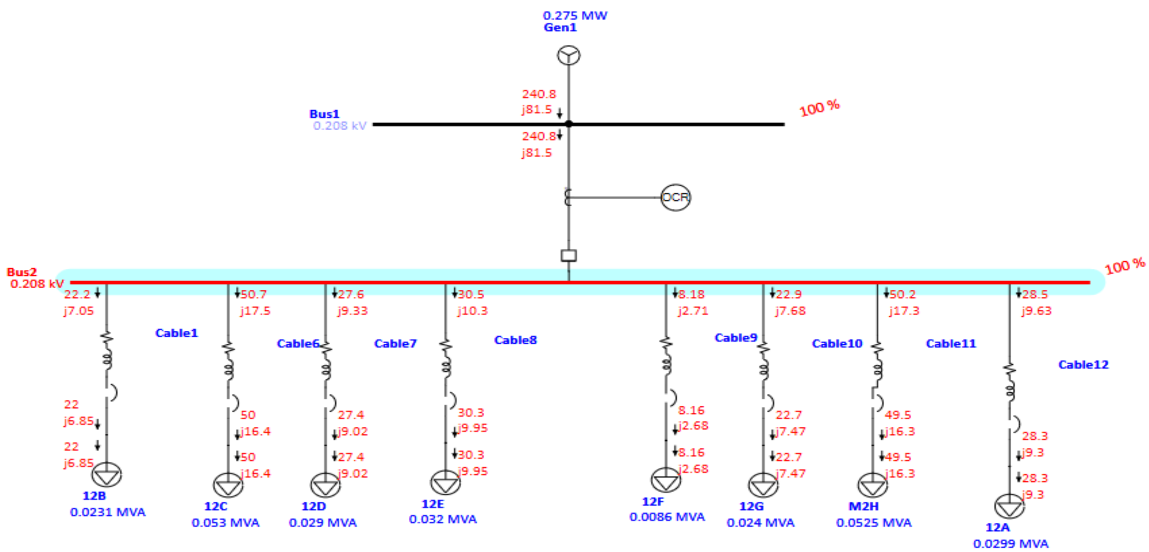


Fig: Load flow Diagram with Generator to Load

1. System Overview

- Main Power Source: Generator (Gen1)
- Primary Bus (Bus1) Voltage: 25 KV
- Secondary Bus (Bus2) Voltage: 0.208 KV
- Fault Current Contribution: ~4.916 kA (short circuit)
- Arc Flash Boundary (AFB): 3.5 feet
- Incident Energy (IE): 4.569 cal/cm² at 18 inches

2. Short Circuit Analysis

- Fault Location: Bus2
- Highest Fault Current: 4.916 kA
- Breaker Clearing Time: Not specified (affects arc flash risk)
- Protection Coordination: Evaluated through relay (Relay1) and circuit breakers (CB1–CB26)

3. Bus Voltage & Current Flow

- Bus1: 3.639 kA (short circuit current contribution)
- Bus2: Multiple load connections with varying impedance
- Connected Loads: 7 motors or transformers (12B, 12C, 12D, 12E, 12F, 12G, M2H, 12A)
- Current in Cables: No active load (0 kA currently)

4. Protection System Overview

- Circuit Breakers (CB1 – CB26): Positioned for isolation and fault clearing
- Relay (Relay1): Monitors system and trips upon fault detection
- Cable Impedance Values: Varying from 0.046 to 0.264 ohms

Short Circuit Analysis

Here is the short circuit analysis of Grid to Load is given below:

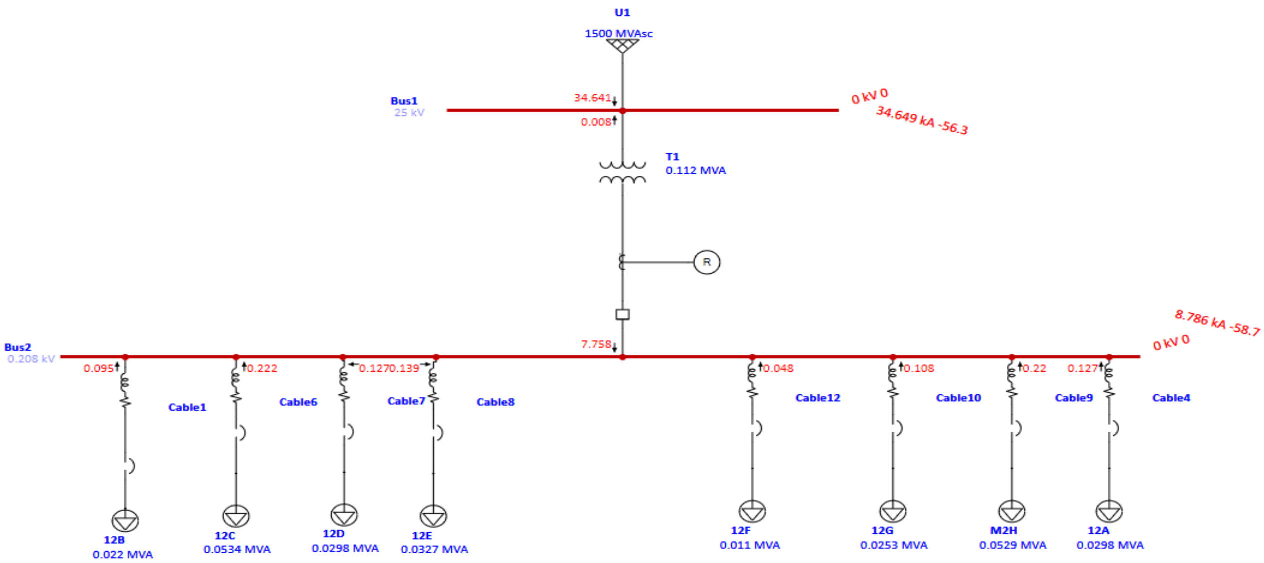


Fig: Short-Circuit Analysis (Grid to load)

ETAP simulation results (Grid to load):

Bus	Voltage Level (V)	RMS Symmetrical Short Circuit Current (kA)
Bus 1	25,000	34.649
Bus 2	208	8.786

System Overview:

Parameter	Value
Source Short-Circuit MVA	1500 MVA_{sc} at Bus 1 (25 kV)
Transformer	T1 (0.112 MVA) stepping down voltage
Bus 2 Voltage	0.208 kV

To perform short-circuit calculations, we need to follow a structured approach using the per-unit system and fault current equations. Now, we will calculate the short-circuit current at Bus 2 and Bus 1 step by step.

1. Given Data

- **Source Short-Circuit Level:**
  S_{sc} = 1500 MVA at Bus 1 (25 kV)
- **Transformer:**
  T1= 0.112T1 = 0.112T1= 0.112 MVA, stepping down to **0.208 kV**
- **Bus Voltages:**

  V_1 = 25 kV (Primary side), V_2 = 0.208 kV (Secondary side)
- **Fault Current from Diagram:**

  Bus 1: 34.649 kA, **Bus 2:** 8.786 kA
- Impedance values are not explicitly given, so we assume a typical percent impedance (Z %) for the transformer.

2. Short-Circuit Current at Bus 1

The short-circuit current at Bus 1 is calculated using:

$I_{sc} = S_{sc} / \sqrt{3}V$

Substituting values:

I_{sc1}= (1500×10^6/ √3 ×25×10^ 3)

I_{sc1} = 34.64 Ka

3. Transformer Impedance and Short-Circuit Current at Bus 2

The transformer impedance is typically given as percent impedance Z_{pu}**.** Let's assume:

Z_T = 5% = 0.05 (per-unit)

Using the impedance voltage formula:

$I_{sc2} = I_{sc1} \times Z_T$

I_{sc2} =34.64/0.0534.64
=8.786 kA

Here, the below figure is the short circuit analysis from Generator to Load.

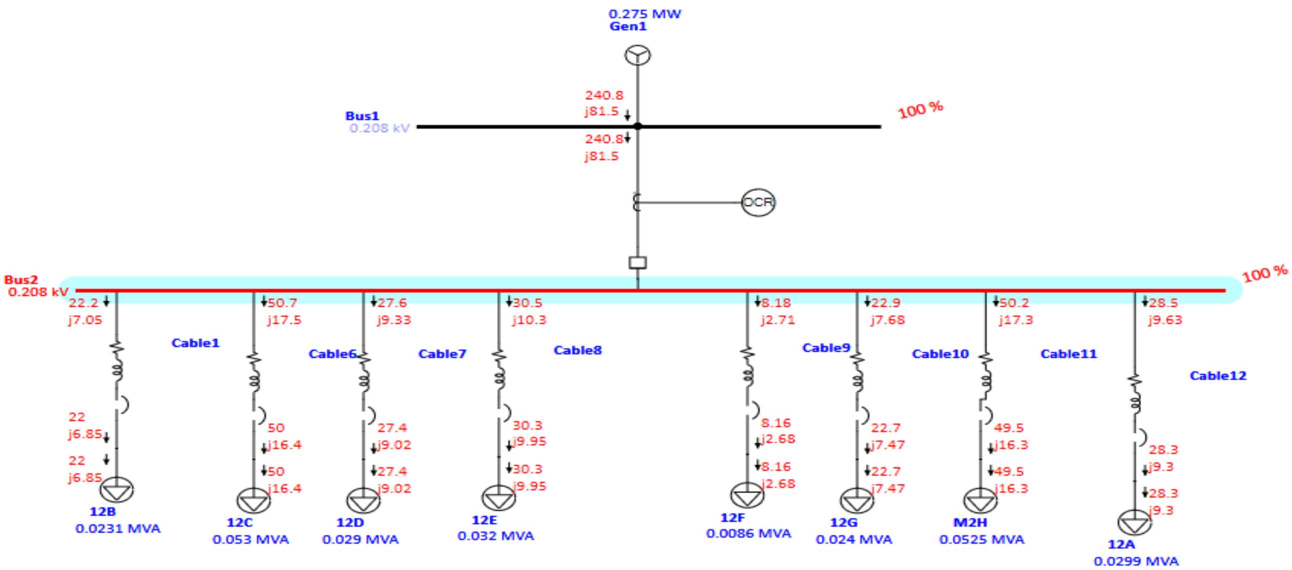


Fig: Short-Circuit Analysis with Generator to load.

ETAP simulation results (Generator to load):

Bus	Voltage level, V	RMS Symmetrical short circuit current, kA
Bus 1	**208**	**469.9 A**
Bus 2	**208**	**5.2 kA**

System Overview:

Parameter	Value
Generation Source	0.275 MW Generator (Gen1) at Bus 1 (0.208 kV)
Bus 1 Voltage	0.208 kV
Bus 2 Voltage	0.208 kV

Connected Loads and Cables:

Load	Cable	Power (MVA)	Short-Circuit Contribution (A)
12B	Cable1	0.0231	22 + j6.85 A
12C	Cable6	0.053	50 + j16.4 A
12D	Cable6	0.029	27.4 + j9.02 A
12E	Cable7	0.032	30.3 + j9.95 A
12F	Cable8	0.0086	8.16 + j2.68 A
12G	Cable9	0.024	22.7 + j7.47 A
M2H	Cable10	0.0525	49.5 + j16.3 A
12A	Cable11	0.0299	28.3 + j9.3 A

<u>Hand Calculation:</u>

1. Short-Circuit Current at Bus 1:

The short-circuit current at a bus can be calculated using the following formula:

$I_{sc} = V / Z_{eq}$

where:

- V is the bus voltage (0.208 kV)
- Z_{eq} is the equivalent impedance seen at the fault location

From the diagram:

- The impedance at Bus 1 is approximately:

Z_{bus1} =240.8+j81.5 mΩ = (0.2408+j0.0815) Ω

Using the short-circuit current formula:

I_{sc1} = (208)/ √3× (0.2408+j0.0815)

Calculating the magnitude:

$|Z_{bus1}|$= √ {(0.2408) ^2 + (0.0815) ^2} =0.2558Ω

I_{sc1} =208/ √3×0.2558208 =469.9 A

2. Short-Circuit Current at Bus 2:

From the diagram, the equivalent impedance at Bus 2 can be approximated using the impedance contributions of cables and loads.

The total impedance seen at Bus 2 is the combination of branch impedances:

Z_{bus2} = (22+j7.05) mΩ = (0.022+j0.00705) Ω

Using the same formula:

I_{sc2} =208/ √3× (0.022+j0.00705)

Calculating magnitude:

$|Z_{bus2}|$= √ {(0.022) ^2 + (0.00705) ^2 =0.0231Ω

I_{sc2} =208/ √3×0.0231 =5.2 kA

Observations:

Observation	Value
Bus 1 Short-Circuit Current	469.9 A
Bus 2 Short-Circuit Current	5.2 kA (significantly higher due to lower impedance).

Protection & Co-ordination

The primary goal of overcurrent coordination is to establish the optimal characteristics, ratings, and settings for overcurrent protective devices to minimize equipment damage while ensuring the rapid interruption of short circuits. Proper coordination ensures that the closest protective device to the fault operates first, limiting disruptions to the electrical system.

The term pickup refers to the minimum current required to activate a protective device. In the case of relays, pickup is defined as the minimum current that causes the relay to close its contacts. For overcurrent protective relays, the pickup current corresponds to the relay’s current (or tap) setting.

Time-Current Characteristic (TCC) Curve Interpretation

From the ETAP-generated TCC curve, we can observe the following:

- Relay 02 (LV Side Relay): The pickup setting is calculated as:

$$Pickup\ Current = \frac{\text{Transformer Rated Current} \times 1.2}{\text{CT Ratio in LV Side}}$$

With a considered factor of 4, Relay 02 is expected to trip first for a fault near the feeder.

- Relay 01 (HV Side Relay): The pickup value is 3.10, ensuring that it provides backup protection by operating only after Relay 02 has had sufficient time to clear the fault.

From the TCC plot, starting at 0.01s and for a given fault current, the first intersected curve belongs to Relay 02, meaning it will operate first. As we move further along the plot, the next intersected curve is Relay 01, confirming that it acts as a backup. This ensures selective coordination and minimizes unnecessary service interruptions.

MCCB Considerations:

Molded-case circuit breakers (MCCBs) with thermal trip elements generally sustain 100% of their rated current at 25°C in open air. However, they should be applied at 80% of their continuous-current rating unless otherwise labeled. To ensure proper ventilation and prevent overheating, MCCBs must be installed according to Underwriters Laboratories (UL) specifications when placed within a panel board.

The ETAP TCC Curve validates that:

1. Relay 02 (LV side) is the first to trip for feeder faults, ensuring localized protection.
2. Relay 01 (HV side) acts as a backup, tripping after a coordination interval of 0.3s.
3. MCCBs are applied with correct continuous-current ratings to maintain system reliability.

This coordination ensures a selective and reliable protection scheme, reducing the risk of widespread outages while maintaining system integrity.

TCC Curve Analysis:

Below figure is the TCC curve implementation using ETAP. The image contains multiple protective devices (relays and transformer withstand curves), each with a distinct TCC profile:

1. Relay 1 (P-51 OC1)

- The curve for Relay 1 (P-51 OC1) is plotted in the lower left region.
- It starts at approximately 1A (0.1 × 10) and extends to around 100A (0.1 × 1000).
- The trip time varies from about 0.1s at high current (100A) to more than 100s at lower current (1A).
- The relay follows an inverse time characteristic, meaning higher fault currents lead to faster tripping.

2. Relay 2 (P-51 OC1)

- Similar in nature to Relay 1 but is positioned slightly lower.
- Starts at about 1A and reaches 100A.
- The trip time is slightly faster than Relay 1, indicating better selectivity in downstream protection.

3. Transformer Withstand (T1 Withstand)

- This curve represents the thermal and mechanical withstand limits of the T1 transformer.
- The maximum withstand limit is around 100A for 10 seconds.
- Protective relays must operate before reaching this limit to prevent transformer damage.

4. Transformer Full Load Amperes (FLA) and Overload Capability

- T1 FLA (Full Load Amperes) is marked around $0.1 \times 10 = 1A$.
- The curve shows the continuous operation region, meaning the transformer can handle this current indefinitely.
- Beyond this limit, operation moves into the overload region, where protection coordination becomes critical.

5. Coordination between Protection Devices

- The graph is structured so that Relay 2 trips before Relay 1.
- This ensures that faults closer to the load are cleared locally without affecting upstream devices.
- If Relay 2 fails, then Relay 1 acts as a backup, operating at a slightly delayed time.
- The coordination ensures minimum disruption and prevents cascading outages.

6. Instantaneous Trip and Time-Delayed Response

- The instantaneous trip region (bottom-left of the curves) occurs for very high fault currents (~100A).
- This means that faults above this threshold will trip the relay almost immediately (~0.01s).
- The inverse-time characteristic (gradual slope) ensures that lower fault currents are cleared with a delay, allowing for selective coordination.

This TCC curve ensures:

1. Selectivity: Relay 2 clears local faults before Relay 1.
2. Equipment Protection: Tripping happens before the transformer reaches it's withstand limit.
3. Proper Coordination: Ensuring the correct relay operates at the right time based on the fault current.

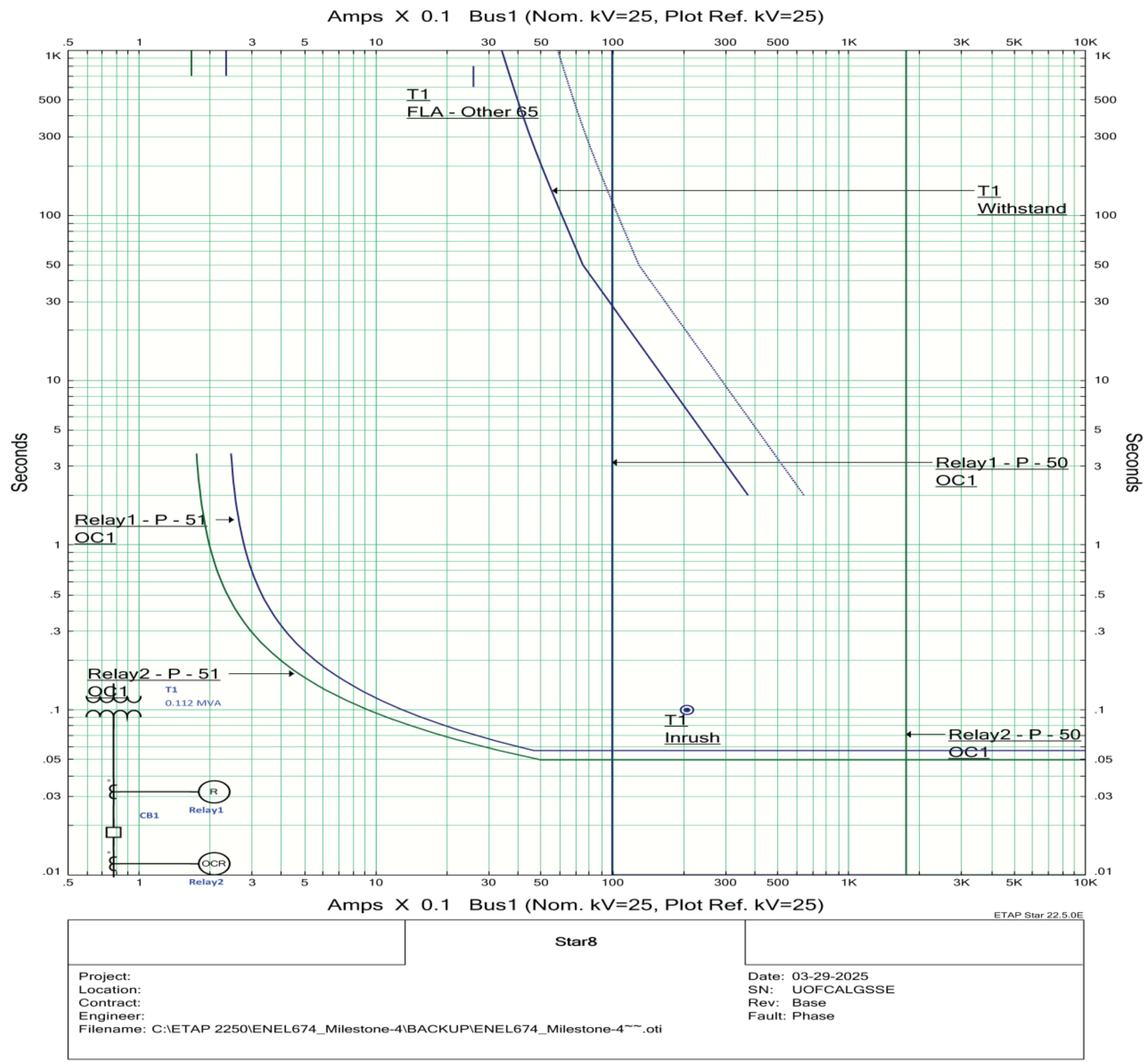


Fig: TCC Curve Analysis

IEEE 242 Recommendations:

IEEE 242, also known as the IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (commonly called the Buff Book), provides guidelines for the protection, coordination, and reliability of power systems in industrial and commercial facilities. The recommendations cover various aspects of electrical system design and operation to ensure safety, reliability, and efficiency.

Key Recommendations in IEEE 242

1. **Protection Coordination**

- ✓ Proper selection and setting of protective devices (circuit breakers, relays, fuses) to ensure coordinated operation.
- ✓ Ensuring selective tripping, so only the faulty section is isolated without affecting the rest of the system.

2. **Overcurrent Protection**

- ✓ Use of inverse-time and instantaneous overcurrent relays for effective system protection.
- ✓ Coordination of protective devices based on time-current characteristics.

3. **Short-Circuit Analysis**

- ✓ Guidelines on calculating short-circuit currents and selecting appropriate protective devices.
- ✓ Ensuring switchgear and breakers have adequate interrupting ratings.

4. **Ground Fault Protection**

- ✓ Recommendations for detecting and mitigating ground faults.
- ✓ Use of ground fault relays and grounding methods to improve system safety.

5. **Arc Flash and Personnel Safety**

- ✓ Guidelines for arc flash analysis and proper labeling of equipment.
- ✓ Personal protective equipment (PPE) selection based on incident energy calculations.
- ✓ Coordination of motor protection relays with upstream devices.

6. **Transformer Protection**

- ✓ Recommendations for protecting transformers against overcurrent, over temperature, and internal faults.
- ✓ Use of differential protection and sudden pressure relays.

7. **Power System Reliability and Redundancy**

- ✓ Designing for system reliability using redundant paths, automatic transfer switches (ATS), and uninterruptible power supply (UPS) systems.

8. **Fuse and Breaker Selection**

- ✓ Selection criteria for fuses and circuit breakers to prevent nuisance tripping and ensure system protection.

In our Project:

The maximum inrush current of the transformer is assumed to occur at 0.1 seconds and can reach up to 12 times the transformer's self-cooled rated current. To ensure the stability of the protection scheme, this inrush current must be plotted to verify that the protective relays do not trip erroneously due to magnetizing inrush conditions.

The pickup current of the protective relay is determined based on the maximum full-load amperes (FLA) of the transformer and appropriately adjusted using the current transformer (CT) ratio to ensure accurate sensing and coordination.

The time-inverse relay characteristics are maintained using the default settings in ETAP (or adjusted as required) to achieve proper time-delay coordination. This ensures that fault clearance is both selective and optimized to minimize disruption to the system.

All protective equipment, including circuit breakers, fuses, and relays, are selected based on the short-circuit current level to ensure adequate interrupting capacity and coordination within the system.

For proper coordination, the relay closest to the fault on the feeder side is set to trip first, thereby clearing the fault locally. If the feeder relay fails to clear the fault, the upstream relay is configured to operate next, ensuring backup protection while maintaining selectivity in the system.

Arc Flash

We have analyzed arc for both with grid source and with generator source in the SLD of our project. Below is the ETAP drawing snap for SLD with grid and SLD with generator.

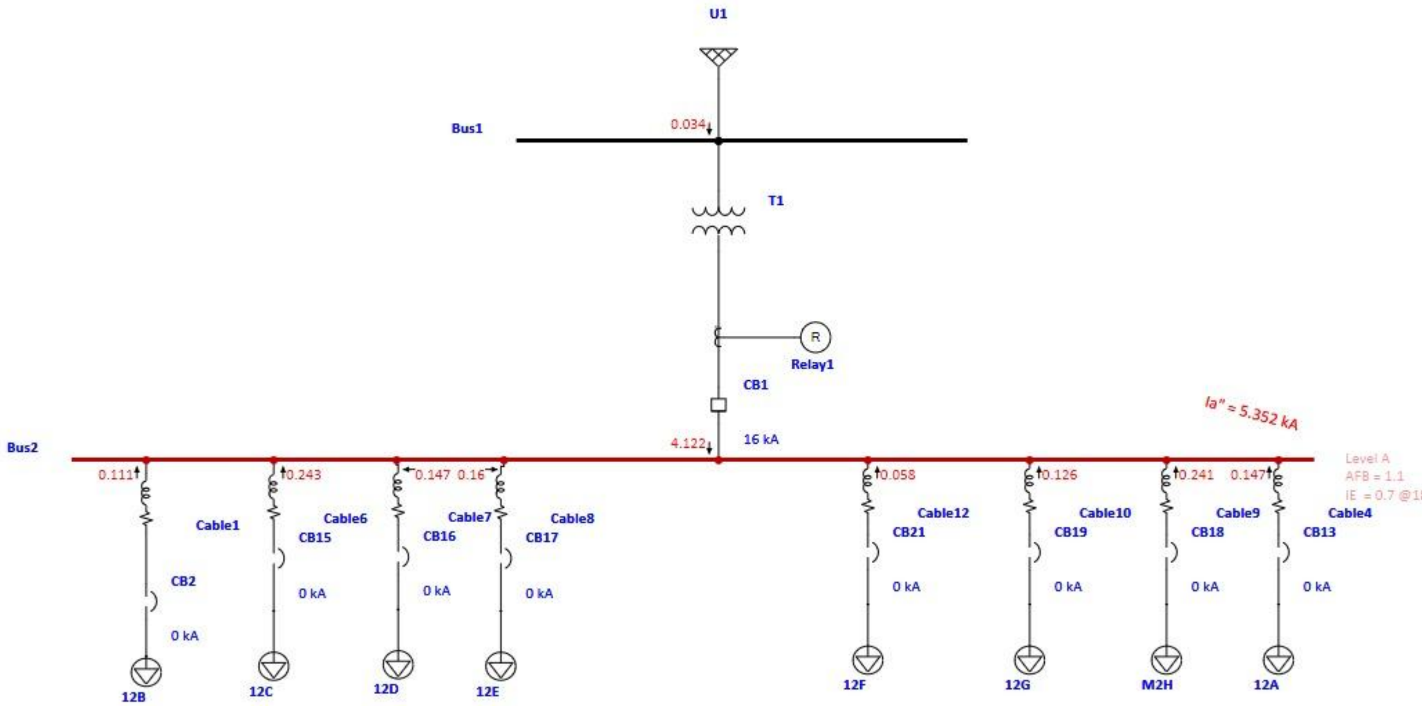


Fig: Arc Analysis with Grid Source

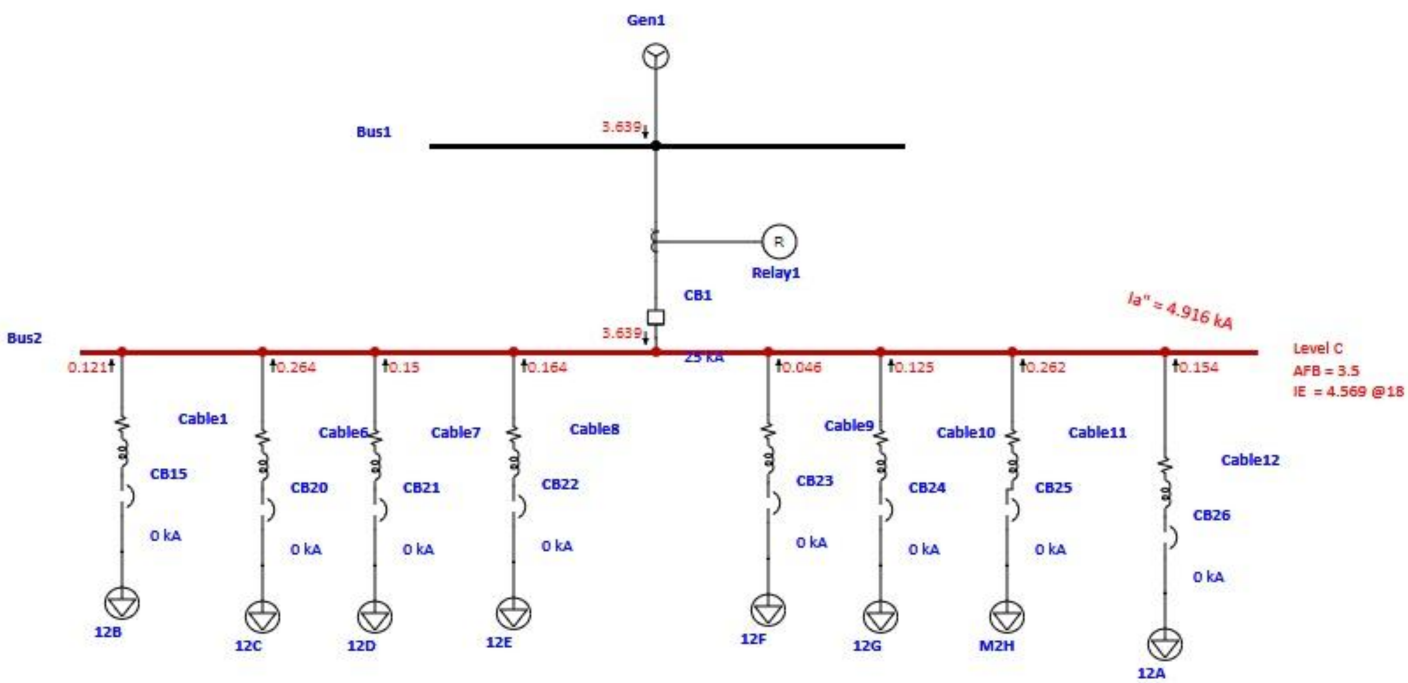


Fig: Arc Analysis with Generator Source

An arc flash is a hazardous electrical event caused by an unintended current discharge through the air between two energized conductors or a conductor and an earthed surface. These incidents can occur due to equipment failure, accidental contact, insulation breakdown, or conductive dust. The rapid release of energy during an arc flash can result in high temperatures, pressure waves, and intense light, posing serious risks to personnel and equipment.

In our project we have used the global parameter for calculating arc flash as per IEEE 1584. The IEEE 1584 standard, developed by the Institute of Electrical and Electronics Engineers (IEEE), provides methodologies for estimating arc flash incident energy levels, which are essential for determining the necessary personal protective equipment (PPE), safety boundaries, and mitigation strategies.

This report analyzes the arc flash hazards for two different scenarios, evaluating key parameters such as arcing current, incident energy, and arc flash protection boundaries.

The arc flash study is performed using IEEE 1584-based calculations. The global parameter settings in the analysis software were used to determine the arc flash incident energy, protection boundaries, and hazard levels. The results provide critical insights into the potential risks at different points in the electrical system.

Scenario 1: Arc Flash with Grid Source

The system consists of a transformer (T1) feeding Bus2, with multiple outgoing feeders. The arc flash calculations were performed at Bus2, considering a fault occurring at this location.

Key Arc Flash Parameters:

- Maximum Arcing Current (Ia'): 5.352 kA
- Bus Location: Bus2
- Incident Energy (IE): 0.7 cal/cm² at 18 inches
- Arc Flash Protection Boundary (AFB): 1.1 ft
- Arc Flash Hazard Category: Level A

Scenario 2: Arc Flash with Generator Source

The second scenario involves a generator (Gen1) feeding Bus1, which in turn supplies Bus2. This configuration affects the fault current levels and subsequently alters the arc flash hazard parameters.

Key Arc Flash Parameters:

- Maximum Arcing Current (Ia'): 4.916 kA
- Bus Location: Bus2
- Incident Energy (IE): 4.569 cal/cm² at 18 inches
- Arc Flash Protection Boundary (AFB): 3.5 ft
- Arc Flash Hazard Category: Level C

Analysis:

In the first scenario, the arc flash energy is relatively low, suggesting minimal PPE requirements. The protection boundary is small, indicating that the risk is localized. On the other hand, in the second scenario, the arc flash hazard is significantly higher in this scenario due to the increased available fault current from the generator. The incident energy level of 4.569

cal/cm² falls into Category C, requiring a higher level of PPE. The protection boundary is extended to 3.5 feet, necessitating additional safety precautions.

Bus	Voltage Level, V	Arcing Current (kA)	Arc Flash Boundary (ft)	Incident Energy (cal/cm2)
2 (Scenario 1)	208	5.352 kA	1.1 ft	0.7 cal/cm²
2 (Scenario 2)	208	4.916 kA	3.5 ft	4.569 cal/cm²

PPE Recommendation & Requirements:

Technicians must never enter an arc flash hazard zone without the appropriate Personal Protective Equipment (PPE). The level of PPE required depends on the incident energy levels at each location. Using IEEE 1584 calculations and NFPA 70E guidelines, the required PPE Category (CAT) is determined based on the incident energy (cal/cm²) at the specific bus locations in each scenario.

Recommended PPE for Scenario 1 (Grid Source):

Since the **incident energy is below 1.2 cal/cm²**, arc-rated PPE is **not mandatory**. However, technicians must still follow basic electrical safety protocols:

1. **Standard flame-resistant (FR) work clothing**
2. **Safety goggles or face shield**
3. **Leather safety shoes** (electrically rated)
4. **Hard hat** (if required for worksite safety)
5. **Hearing protection** (optional, recommended for electrical work)
6. **Rubber insulating gloves** (if working near live conductors)

Key Consideration: Workers can operate within the arc flash boundary **without a full arc-rated PPE suit**, but precautions should still be taken.

Recommended PPE for Scenario 2 (Bus2 - Generator Source):

Since the incident energy is **above 4 cal/cm²**, **Category 2 arc-rated PPE** is required for safety:

1. **Arc-rated long-sleeve uniform (minimum 8 cal/cm² rating)**
2. **Arc-rated face shield with balaclava** (or arc-rated hood)
3. **Rubber insulating gloves with leather protectors**
4. **Leather safety shoes** (EH-rated, non-conductive)
5. **Hard hat** (insulated and arc-rated)
6. **Hearing protection** (earplugs or earmuffs for arc blast noise protection)

Key Consideration: Technicians must wear **full CAT 2 PPE** when working within **3.5 feet** of the energized equipment.

Summary of PPE Requirements for Both Scenarios:

Scenario	Arcing Current (kA)	Incident Energy (cal/cm²)	Arc Flash Boundary (ft)	PPE Category	Required PPE
Scenario 1 (Transformer Source, Bus2)	5.352 kA	**0.7 cal/cm²**	**1.1 ft**	Below CAT 1	Standard workwear, leather gloves, safety goggles
Scenario 2 (Generator Source, Bus2)	4.916 kA	**4.569 cal/cm²**	**3.5 ft**	**CAT 2**	Arc-rated clothing (8 cal/cm²), face shield/balaclava, gloves, hearing protection

Appendices

Appendices A - SLD of Short Circuit with Grid

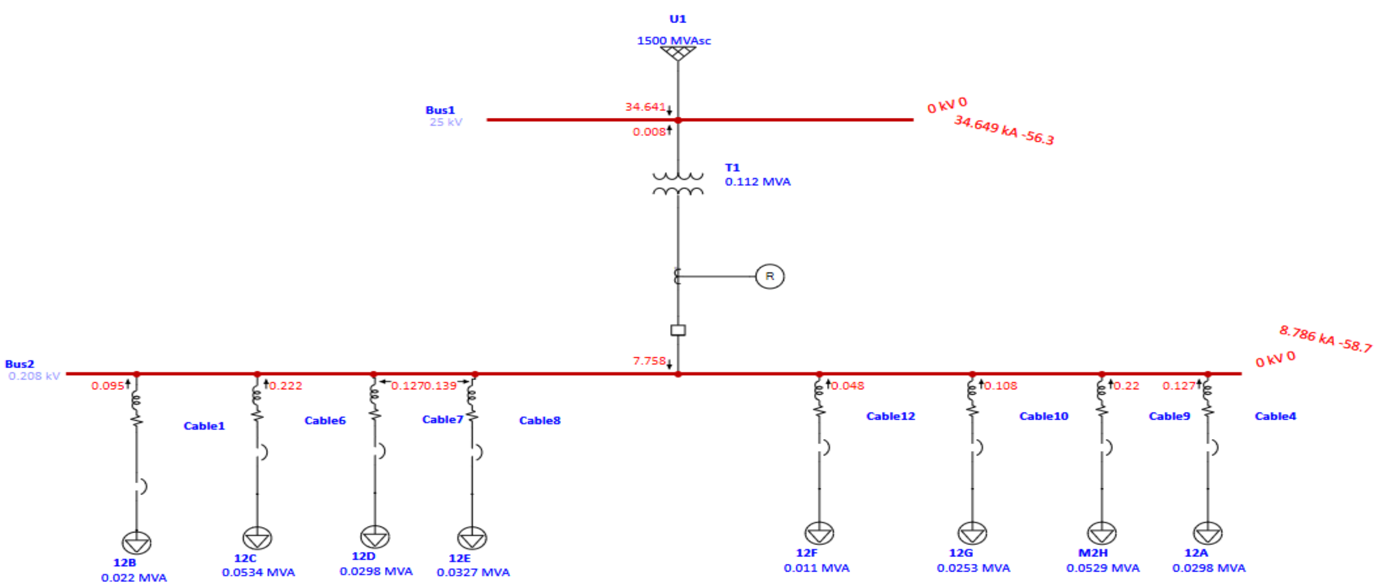


Fig: SLD of Short Circuit with Grid

Appendices B - SLD of Short Circuit with Generator

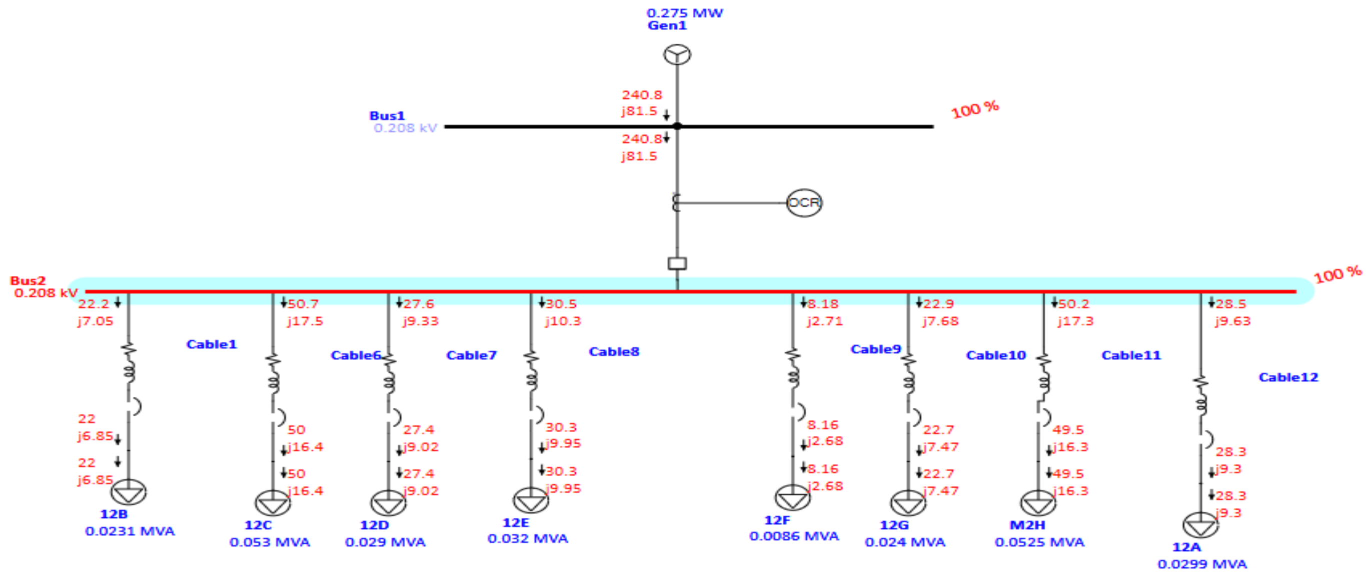


Fig: SLD of Short Circuit with Generator

Appendices C – Arc Flash Analysis with Grid

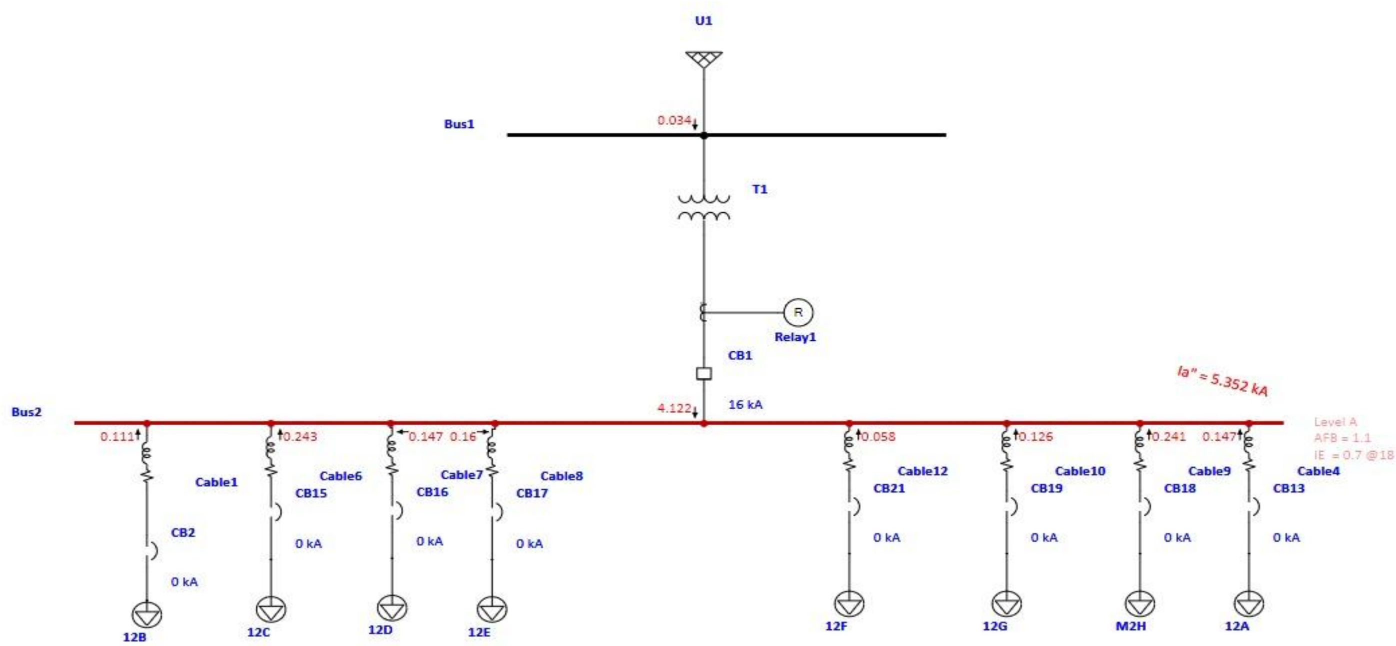


Fig: SLD of Arc Flash Analysis with Grid

Appendices D – Arc Flash Analysis with Generator

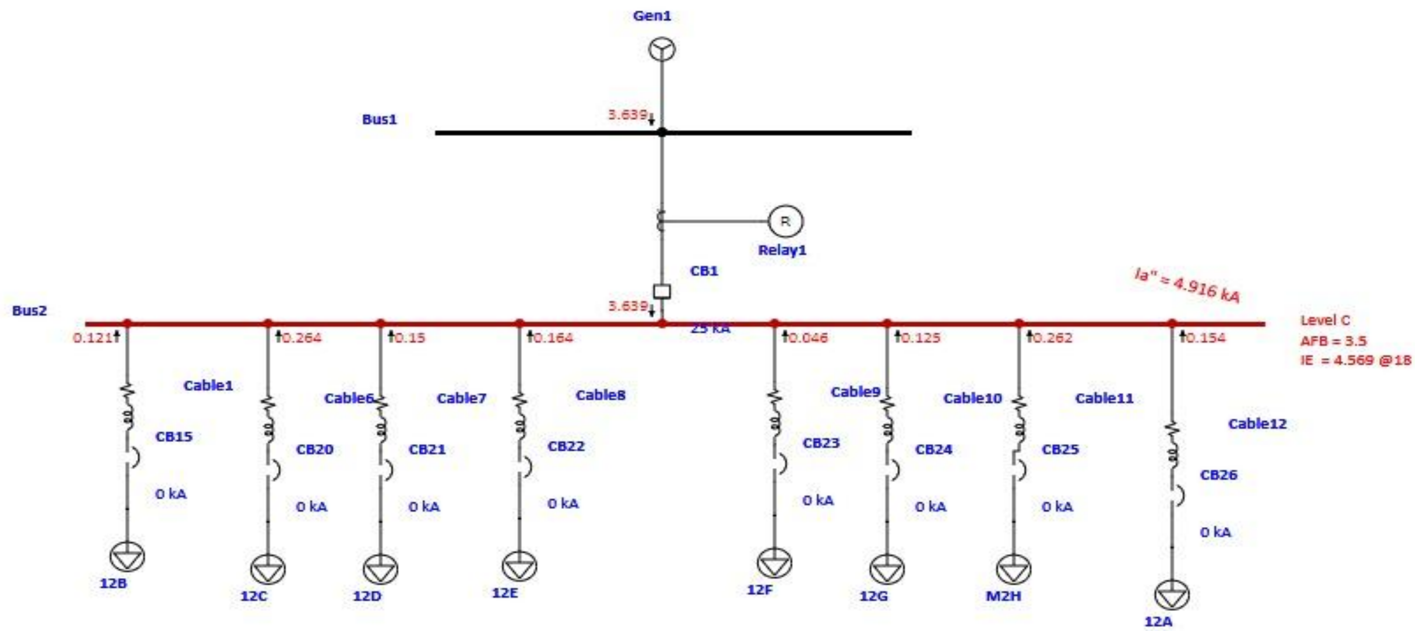


Fig: SLD of Arc Flash Analysis with Generator.

Appendices E – Device Settings Report

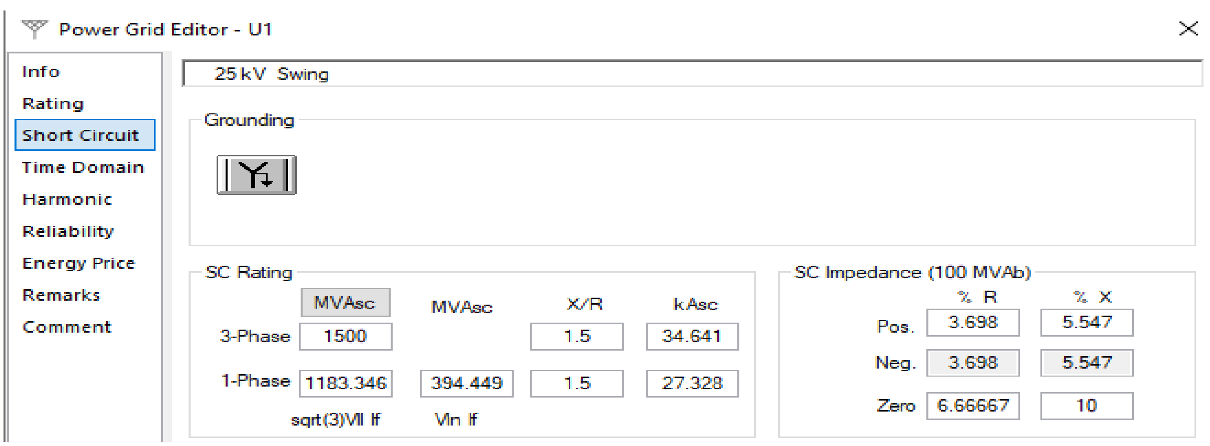


Fig: Parameter Settings for Short Circuit at Grid.

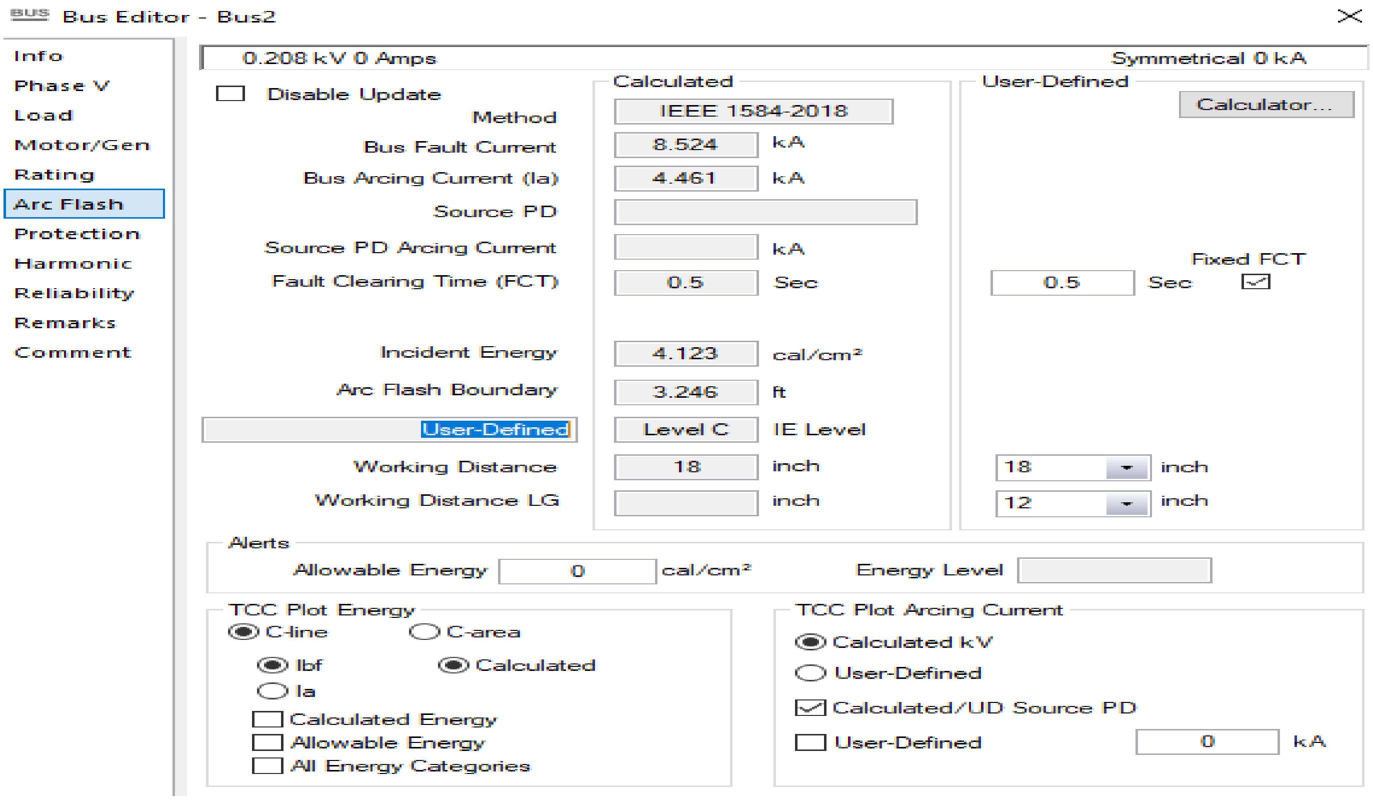


Fig: Parameter Settings for Arc Flash at Bus-2

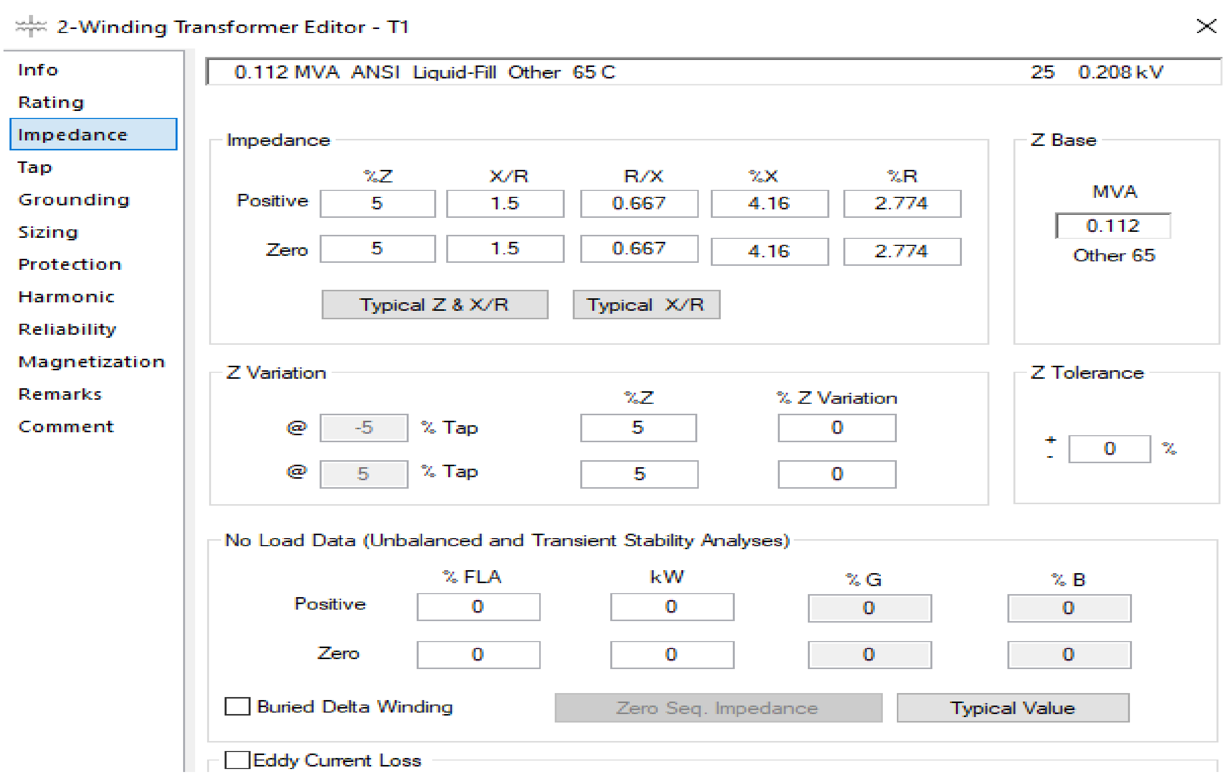


Fig: Parameter Settings for Impedance at Transformer.

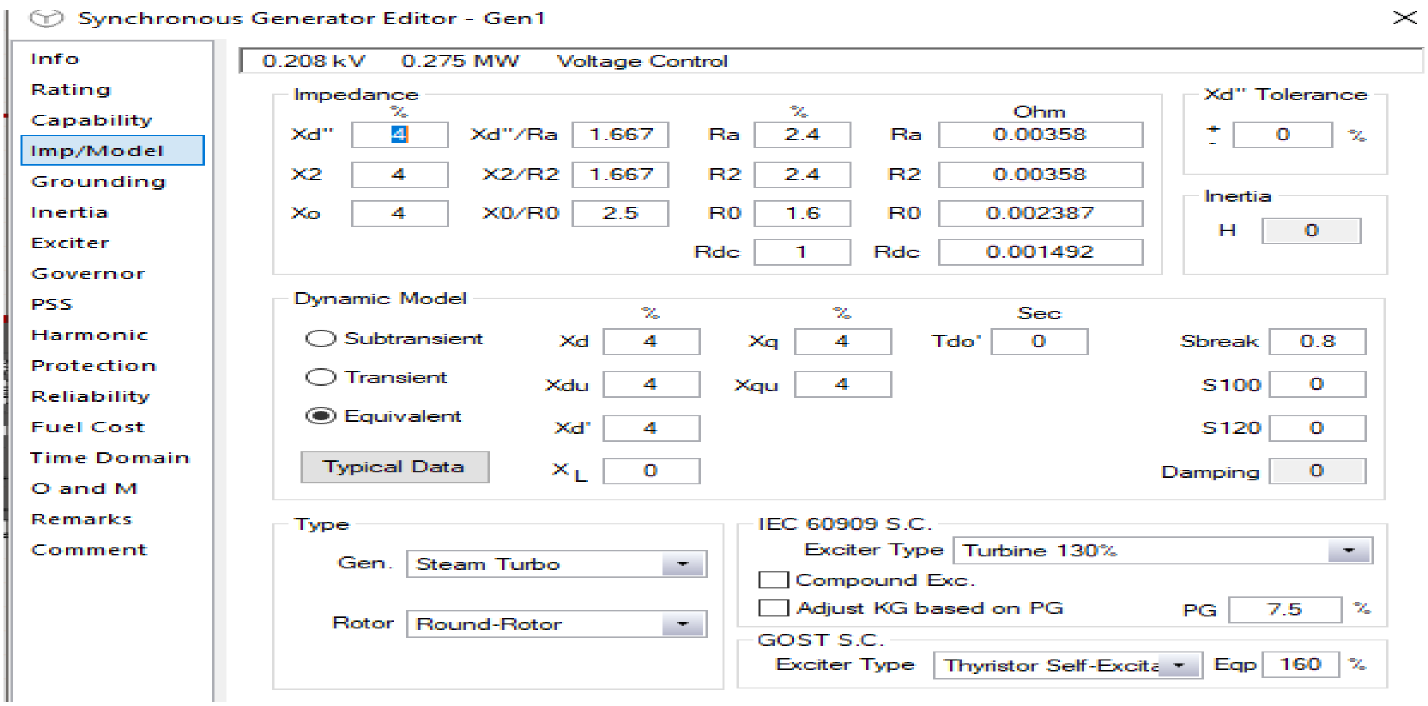


Fig: Parameter Settings for Impedance at Generator.

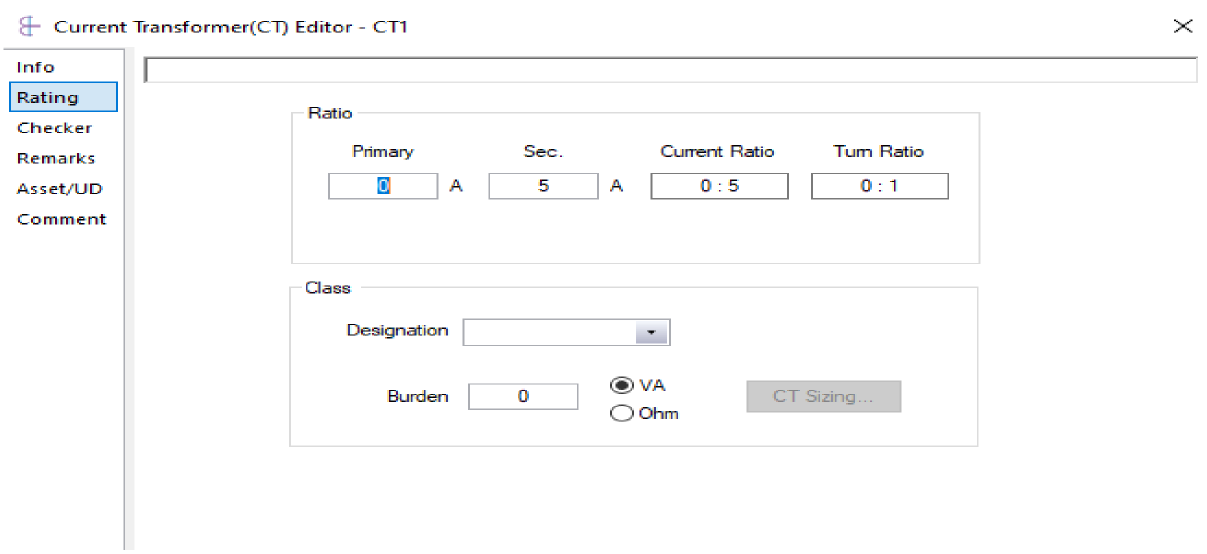


Fig: Transformer Rating

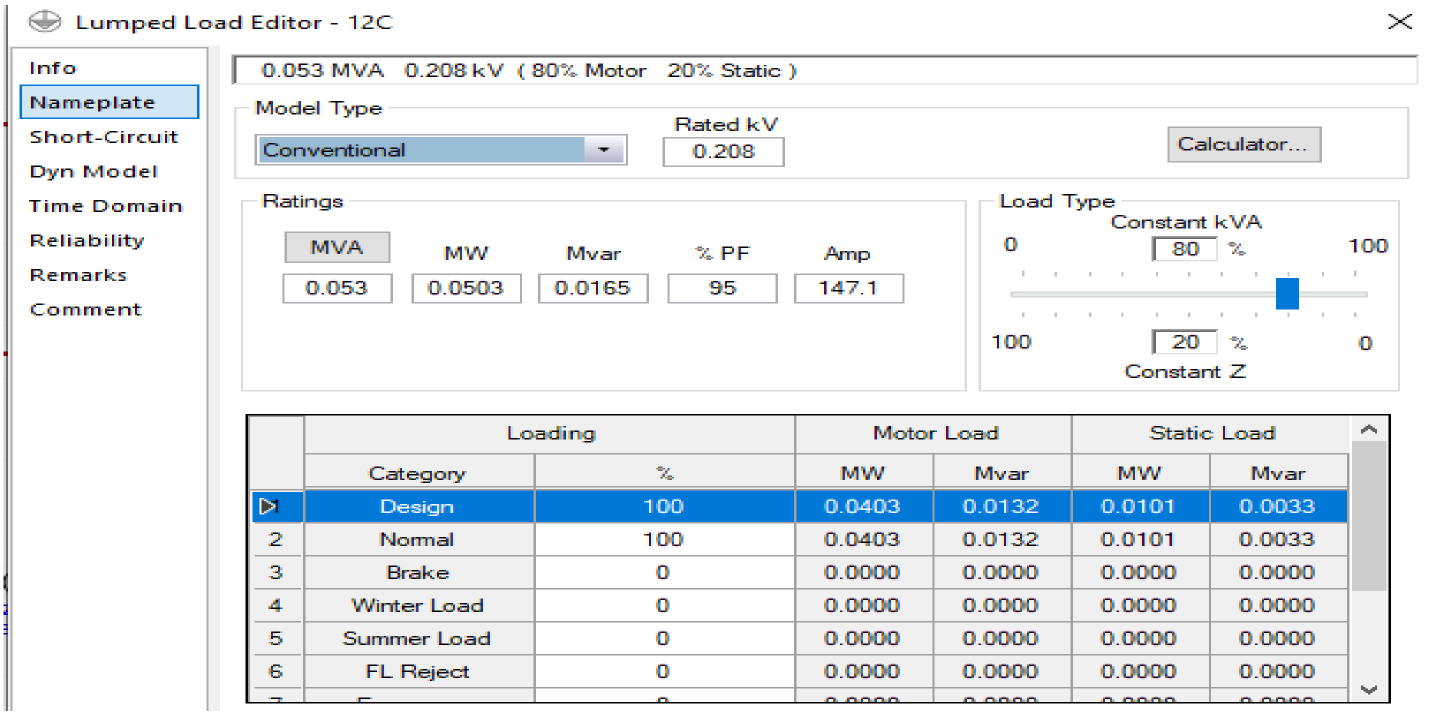


Fig: Parameter Settings for Lumped Load.

Final Summary report - limiting restrictions

This report outlines the key constraints and limitations encountered during the electrical design of the multipurpose building project.

Utility Supply Limitations

- **Voltage Constraints**: Primary supply: **25 kV delta feeder** (fixed utility voltage). Secondary distribution: **208V star (wye)**, limiting high-power equipment compatibility (e.g., motors >50 HP may require 480V).
- **Transformer Capacity**: **112.5 kVA transformer** restricts total load expansion beyond **250.64 kW** without upgrades. Future load growth (>5%) may necessitate a larger transformer or additional units which will increase cost.

Load and Panel Limitations

- **Continuous vs. Non-Continuous Loads**: Conductors sized at **125% of continuous load** (CEC requirement), increasing material costs. **800 kcmil conductors** required for main feeders, complicating conduit routing.

Backup Power Constraints

- **Generator Sizing**: **250 kW diesel generator** covers **125% of continuous load** but lacks redundancy. No provision for parallel generators; failure risks total backup loss.
- **UPS Limitations**: **25 kVA UPS** supports only critical loads (16.55 kW) for **1 hour**. Extended outages require generator activation; no solar-UPS integration.

Renewable Energy Integration Challenges

- **Solar PV System**: Proposed **176 kW system** offsets only **~20% of grid demand** (64,240 kWh/year). **No battery storage** for off-grid operation; solar cannot power loads during outages.

Protection and Safety Restrictions

- **Arc Flash Hazards**: **Bus 2 (208V)**: Incident energy up to **4.57 cal/cm²** (Category 2 PPE required). **No arc-resistant switchgear** specified; relies on PPE and procedural controls.

Final Summary report - lessons learned

The design process provided a comprehensive learning experience, highlighting both technical and collaborative insights. Key lessons learned are summarized below:

Planning & Requirement Analysis
Early engagement with stakeholders is critical to avoid late-stage design changes (e.g., initially missing a male washroom). Future expansion needs (e.g., additional buildings on the 10-acre site) should be considered upfront to avoid costly retrofits.

Load Calculation
We learned how to accurately assess electrical demands across various systems and ensure proper distribution. Understanding diversified loads and demand factors helped in designing a reliable and balanced power system.

Lumen Calculation
Applying lighting design principles, we calculated required illumination levels for different rooms. This improved our ability to select appropriate lighting fixtures and design layouts that meet both functional and aesthetic requirements.

Panel Scheduling
Developing panel schedules taught us how to organize circuit distribution efficiently while considering load balancing, labeling, and panel board capacity. It also emphasized the importance of clear documentation for future maintenance and operation.

Mechanical Schedule
Integrating mechanical equipment into the electrical design deepened our understanding of coordination between HVAC loads, power requirements, and space allocation. This also highlighted the need for clear collaboration between disciplines.

Receptacle Calculation
We have learned to calculate general-purpose and dedicated receptacle loads based on NEC guidelines, for each & every room in this building. This ensured compliance and safe distribution of loads across circuits.

Service Sizing
We learned how to calculate service entrance sizing based on peak demand, continuous loads, and future expansion needs. This is crucial for ensuring that the system is neither under-designed nor unnecessarily oversized.

Standards and Compliance
Familiarity with CEC codes including Spec-Sheet and different sort of Tables for RCR calculations and conductor sizing.

UPS Sizing
Understanding UPS (Uninterruptible Power Supply) sizing taught us how to ensure power continuity during outages. We calculated UPS capacity based on critical loads, runtime requirements, and battery autonomy, ensuring seamless operation of essential systems.

Battery Sizing
We learned how to size batteries for both UPS and renewable energy storage by considering load profiles, discharge rates, voltage levels, and backup duration. This experience highlighted the importance of battery selection in reliability and system longevity.

Solar Panel Selection
In this project, we have learned how to calculate the required number of panel based on required power. We have learned to calculate the carbon emission for both case with grid power and with solar power.

Short Circuit Analysis
Conducting short circuit analysis helped us evaluate the withstand capability of equipment and select proper interrupting ratings. It highlighted the importance of system protection and equipment safety.

Arc-Flash Analysis
Using standards such as IEEE 1584, we conducted arc-flash hazard assessments to determine incident energy levels and required PPE. This emphasized the importance of workplace safety and regulatory compliance.

Documentation and Communication
Maintaining up-to-date and accurate documentation throughout the process supported clear communication, facilitated reviews, and ensured a smoother handover to stakeholders.

Final Summary report - future planning

To ensure the long-term success and sustainability of the system, the following forward-thinking technologies and strategies are recommended. These measures aim to improve energy efficiency, reliability, and adaptability of building infrastructure:

1. Smart Sensors & IoT Integration

Explanation: Integrating smart sensors and Internet of Things (IoT) technologies will enable real-time data collection and monitoring of various building systems. This includes energy consumption, lighting levels, and HVAC performance.

Issue Mitigation: This system can help mitigate issues related to energy waste, inefficient resource allocation, and reactive maintenance. By providing precise data, it allows for proactive adjustments and optimization. For instance, if a particular area consumes excessive energy, the system can alert facility managers, who can then investigate and resolve the issue promptly.

2. AI-Driven Building Management Systems (BMS)

Explanation: Implementing an AI-driven BMS will leverage machine learning algorithms to analyze building data and optimize system performance.

Issue Mitigation: This can mitigate issues related to suboptimal energy usage, inefficient climate control, and difficulty in predicting maintenance needs. The AI can learn from historical data and real-time conditions to make intelligent adjustments, ensuring the building operates at peak efficiency.

3. Automated Climate Control

Explanation: This system will automatically adjust heating and cooling settings based on real-time occupancy patterns and external weather conditions.

Issue Mitigation: This approach can mitigate issues of over- or under-conditioning of spaces, leading to energy waste and occupant discomfort. By dynamically adjusting the climate, the system ensures that energy is used only when and where it's needed.

4. Battery Energy Storage Systems (BESS)

Explanation: Integrating BESS will allow the building to store excess energy, particularly from renewable sources like solar panels.

Issue Mitigation: This can mitigate issues related to reliance on the grid during peak demand periods and vulnerability to power outages. The stored energy can be used to supplement or replace grid power during these times, reducing costs and increasing resilience.

4. Hydrogen & Fuel Cell Integration

Explanation: Exploring the integration of hydrogen and fuel cell technology can provide a clean and sustainable alternative energy source for both heating and electricity.

Issue Mitigation: This can mitigate issues related to reliance on fossil fuels, carbon emissions, and the environmental impact of traditional energy sources. Hydrogen fuel cells produce electricity with minimal emissions, offering a pathway to a carbon-neutral building.

5. Renewable Energy Integration

Explanation: Integrating renewable energy sources, such as solar photovoltaic (PV) systems, wind turbines, or geothermal energy, directly into the building's design and operation.

Issue Mitigation: This will mitigate issues related to reliance on fossil fuels, fluctuating energy costs, and carbon emissions associated with traditional grid power.

6. Integration with Smart Grid Technology

Explanation: Future integration with smart grid technology can further optimize energy management. This involves two-way communication between the building and the power grid, allowing for more efficient energy distribution and consumption.

Issue Mitigation: This can help mitigate issues related to grid instability, peak demand charges, and reliance on traditional power sources. The building can respond to grid signals, such as reducing energy consumption during peak times or providing excess energy back to the grid.

Revision Management Table

Below is the revision management table, based on the feedback we have received till milestone-3.

Project Milestone	Description	Reason for revision	Our Feedback
1	Normal Power SLD	The drafts are hard to be read (i.e. lines too thin and requiring a lot of zoom in to be analyzed). Make sure to work on it for the next milestone.	We have increased the line width and the size of equipment's. But, when we generate an image from AutoCAD and fit into the document, it still requires zooming. So for better viewing, we have attached .dwg file
	Emergency Power SLD	The drafts are hard to be read (i.e. lines too thin and requiring a lot of zoom in to be analyzed). Make sure to work on it for the next milestone.	We have increased the line width and the size of equipment's. But, when we generate an image from AutoCAD and fit into the document, it still requires zooming. So for better viewing, we have attached .dwg file

	Lighting layout drawing	A good practice to use DIALux software for design. However, switching zones could be marked more clearly. Also, the lighting layout in the single expected PDF report is not clear to be read. Some fixtures and their control types are not well labeled.	We have marked switching zone very clearly this time. Also, we have labeled fixtures and their control types to every room individually. For better understand, we have attached snap from every room in this report.
	Power layout drawing	The drafts are hard to be read (i.e. lines too thin and requiring a lot of zoom in to be analyzed). Make sure to work on it for the next milestone.	We have increased the line width and the size of equipment's. But, when we generate an image from AutoCAD and fit into the document, it still requires zooming. So for better viewing, we have attached .dwg file alongside with our report in D2L. In this milestone-2, we have added generator just beside the kitchenette in our power layout drawing.
2	Power layout drawing	Use different colors in diagrams for fire safety and security elements to improve clarity.	We have used different colors in the diagram for fire safety and security elements. For better view, we have attached .dwg file alongside with our report in D2L.
3	No correction given	No correction given	No correction given. So, we don't have any feedback.

Recommendations

The project electrical calculation is done at preliminary stage considering client's requirement. Firstly, in the design, there is no male washroom. So, we have designed a male washroom and calculated all the technical aspects. Secondly, after considering only the continuous current, we need 800 Kcmil conductor. But, if we consider both the continuous and discontinuous current, then we will need 2 conductor of 800 Kcmil size.

Conclusion

In this project, we have developed the electrical layout for a building situated on a 10-acre site. As part of Milestone 1, we performed lumen calculations, receptacle placement analysis, load assessment, and panel scheduling for each room based on the base plan. Following these calculations, we determined the appropriate conduit sizing for both continuous and non-continuous loads. Using these data points, we proceeded with the lighting design, power distribution layout, and single-line diagrams (SLD) for both normal and emergency systems. As part of Milestone 2, we rectify the mistake we have done. Also, as a part of this milestone, we have done summary report with the inclusion of UPS, the inclusion of generator and their type & size, summary report for renewable energy and zero carbon initiative. Finally, we implemented safety measures and provided recommendations for this project.

Scientific Reference

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