BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Department of Electrical and Electronic Engineering

Course No. : EEE 414
Course Title : Electrical Services Design Laboratory

Electrical Services Design Project

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Objectives :

The objective of this project is-

1. Grasping the layout: Understanding the typical floor plan of such buildings and how spaces are organized.

2. Equipping the spaces: Identifying the various electrical fittings and fixtures used in different rooms and their purposes.

3. Charting the electrical flow: Learning to systematically map out the conduit layout that channels electrical wiring throughout the building.

4. Connecting the power: Mastering the design and drawing of switchboard connections, including those for emergency situations.

5. Selecting the right components: Calculating and strategically placing essential elements like circuit breakers, transformers, and generators in the switchboard diagrams, ensuring they meet the specific requirements.

6. Shielding from the elements: Understanding and designing the electrical components of a lightning protection system to safeguard the building.

In essence, this project equips you with the knowledge and skills to navigate the electrical design process for multi-story residential buildings, from understanding the layout to ensuring its safe and efficient operation.

Design Steps :

The project was carried out according to the following design steps:

1. Ground floor and typical floor plan of a three unit-9 storey building
2. Fittings and fixtures for each floor
3. Conduit layout planning for each floor
4. Switchboard and distribution board diagram
5. Lightening protection system (LPS) design

Lighting calculations:

Bedroom

Let,
Room length = L (in meters)
Room width = W (in meters)
N = Number of lights required
E = Luminance level required (lux). This parameter will vary depending on the type of room (e.g. bedroom, kitchen)
F = Average luminous flux from each light source (lumen)
UF = Utilization factor (allowance for light distribution of the luminaire and the room surfaces)
LLF = Light Loss factor (allowance for reduced light output due to deterioration)
Then, following is the equation used to calculate the number of lights required

$$\boxed{\mathbf{N = \frac{E \times Area}{F \times UF \times LLF}}}$$

Fan Requirement: The number of fans required, M is determined by the following formula

$$\boxed{M = \frac{L(in\ ft) * W(in\ ft)}{100}}$$

Bedroom 1
Lights:
Area=6*4.2+1.8*2.1 = 29 m^2
F = 1500 Lumen (for a 20 W bulb)
UF = 0.7
LLF = 0.75
E = 70 lux (bed room)
N= (70*29)/(1500*0.7*0.75) = 2.58.
6 lights have been used in the design
Fans:
Fan required, M= (20*14)/100= 2.8.
3 fans have been considered in bedroom 1. Fans will have 1442 mm sweep

Bedroom 2
Lights:
Area=5.2*4.6+1.8*2.1 =27.7 m^2
F = 1500 Lumen (for a 20 W bulb)
UF = 0.7
LLF = 0.75
E = 70 lux (bed room)

N= (70*27.7)/(1500*0.7*0.75) = 2.46. 5 lights have been used in the design.
Fans:
Fan required, M= (17*15)/100= 2.5.
3 fans have been considered in bedroom 2. Fans will have 1442 mm sweep

Bedroom 3
Lights:
Area=5.3*3.35+3.35*3= 27.8 m^2
F = 1500 Lumen (for a 20 W bulb)
UF = 0.7
LLF = 0.75
E = 70 lux (bed room)
N= (70*27.8)/(1500*0.7*0.75) = 2.47. 5 lights have been used in the design
Fans:
Fan required, M= (20*14)/100= 2.5.
3 fans have been considered in bedroom 3. Fans will have 1442 mm sweep

Dining Rooms
Lights: L = 22' = 6.7 m
W = 17'-5" = 5.3 m
F = 1500 Lumen (for a 20 W bulb)
UF = 0.7
LLF = 0.75
E = 150 lux (dining and living room)
N= (150*5.3*6.7)/(1500*0.7*0.75) = 6.7
8 lights have been used in the design.
<u>2 of them are stick lights and 4 led bulb with capacity 20 watts. 2 of them are ceiling mounted and power requirements will be atleast 40 watts</u>
Fan required, M= (22*17.5)/100= 3.8.
4 fans have been considered. Fans will have 1442 mm sweep

Drawing Rooms
Lights: L = 22' = 6.7 m
W = 17'-5" = 5.3 m
F = 1500 Lumen (for a 20 W bulb)
UF = 0.7
LLF = 0.75
E = 150 lux (dining and living room)
N= (150*5.3*6.7)/(1500*0.7*0.75) = 6.7.
7 lights have been used in the design.
<u>2 of them are stick lights and 4 led bulb with capacity 20 watts. single ceiling mounted decoration light at the middle whose power requirements will be atleast 40 watts.</u>

Fan required, M= (22*17.5)/100= 3.8.
4 fans have been considered
Fans will have 1442 mm sweep

Kitchen

Lights: L = 10’-9” = 3.3 m

W = 10’ = 3 m

F = 1500 Lumen (for a 20 W bulb)

UF = 0.7

LLF = 0.75

E = 200 lux (kitchen)

N= (200*3.3*3)/(1500*0.7*0.75) = 2.51.

3 lights have been used in the design.

Fan required, M= (10.75*10)/100= 1.07

1 fan have been considered in the design. Fans will have 1442 mm sweep

bathrooms

Lights: L = 10’ = 3 m

W = 6’ = 1.8 m

F = 1500 Lumen (for a 20 W bulb)

UF = 0.7

LLF = 0.75

E = 100 lux (bathroom)

N= (100*1.8*3)/(1500*0.7*0.75) = .68.

2 lights have been used in the design.

Balcony

Lights:

L = 17’-5” = 5.3 m

W = 5’ = 1.5 m

F = 1500 Lumen (for a 20 W bulb)

UF = 0.7

LLF = 0.75

E = 100 lux (balcony)

N= (100*1.5*5.3)/(1500*0.7*0.75) = 1. we used 2 lights.

Stairs

Area = 3.2*5.2 = 16.64 m^2

F = 1500 Lumen (for a 20 W bulb)

UF = 0.7

LLF = 0.75

E = 100 lux (stairs)

N= (100*16.64)/(1500*0.7*0.75) = 2.11.

4 lights have been used in the design. All are ceiling mounted

Corridor

Area = 22*5.64 – 16.64 – 4.4 = 103 m^2

F = 1500 Lumen (for a 20 W bulb)

UF = 0.7

LLF = 0.75

E = 100 lux (stairs)

N= (100*103)/(1500*0.7*0.75) = 13.

13 lights have been used in the design. All are ceiling mounted

Garage calculations:
Area = 22*38.4 = 844 m^2
F = 3000 Lumen (garage led)
UF = 0.7
LLF = 0.75
E = 100 lux (garage)
N= (100*844)/(3000*0.7*0.75) = 53.6.
56 lights have been used in the design. All are ceiling mounted
6 exhaust fans have been used for transformer and generator rooms. 3 fans for guard rooms.

FAN

LIGH

TUBE LIGHT

CEILING LIGHT

EXHAUST FAN

13A FLAT PIN SOCKET

15A ROUND PIN SOCKET

5A SWITCHBOARD SOCKET

EMERGENCY SWITCHBOARD

SWITCHBOARD

STAIR LIGHT

GARAGE LIGHT

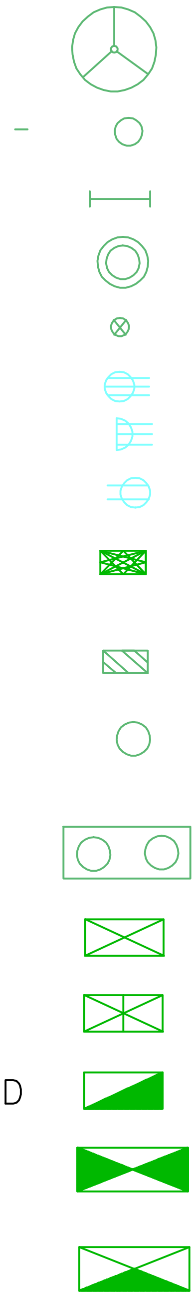
DISTRIBUTION BOARD

SUBDISTRIBUTION BOARD

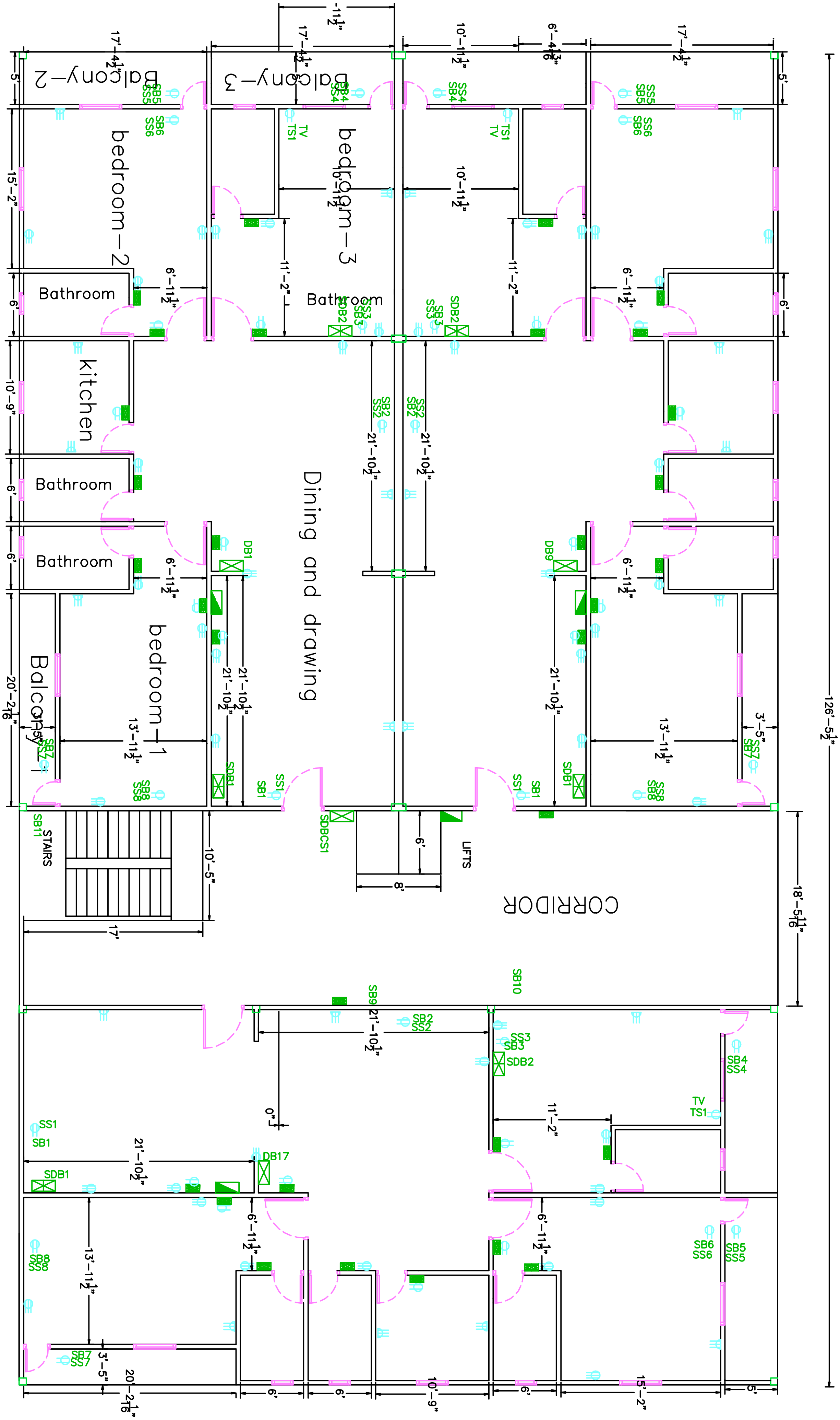
EMERGENCY DISTRIBUTION BOARD

MAIN DISTRIBUTION BOARD

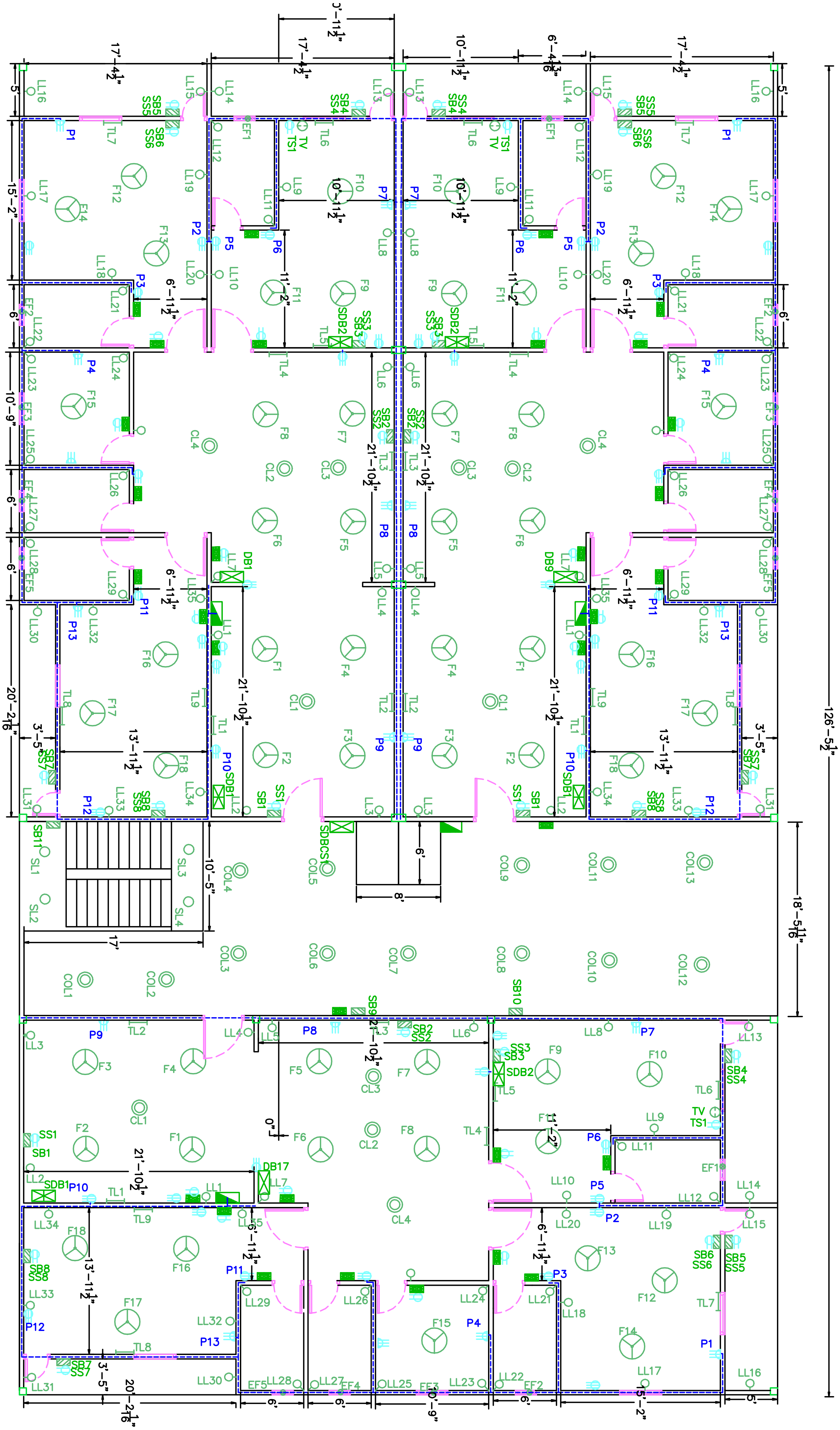
EMERGENCY MDB



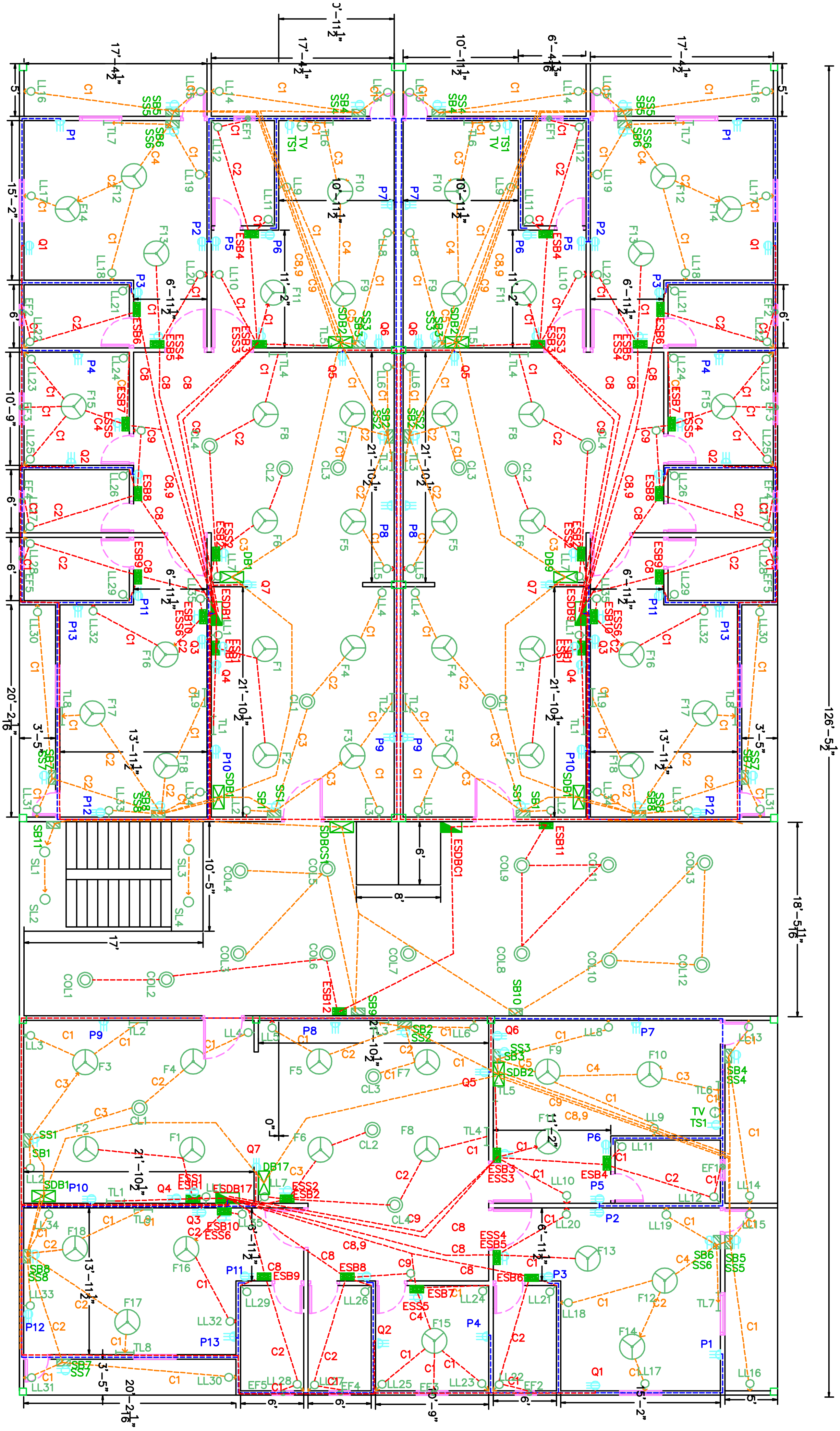
Typical floor basic layout



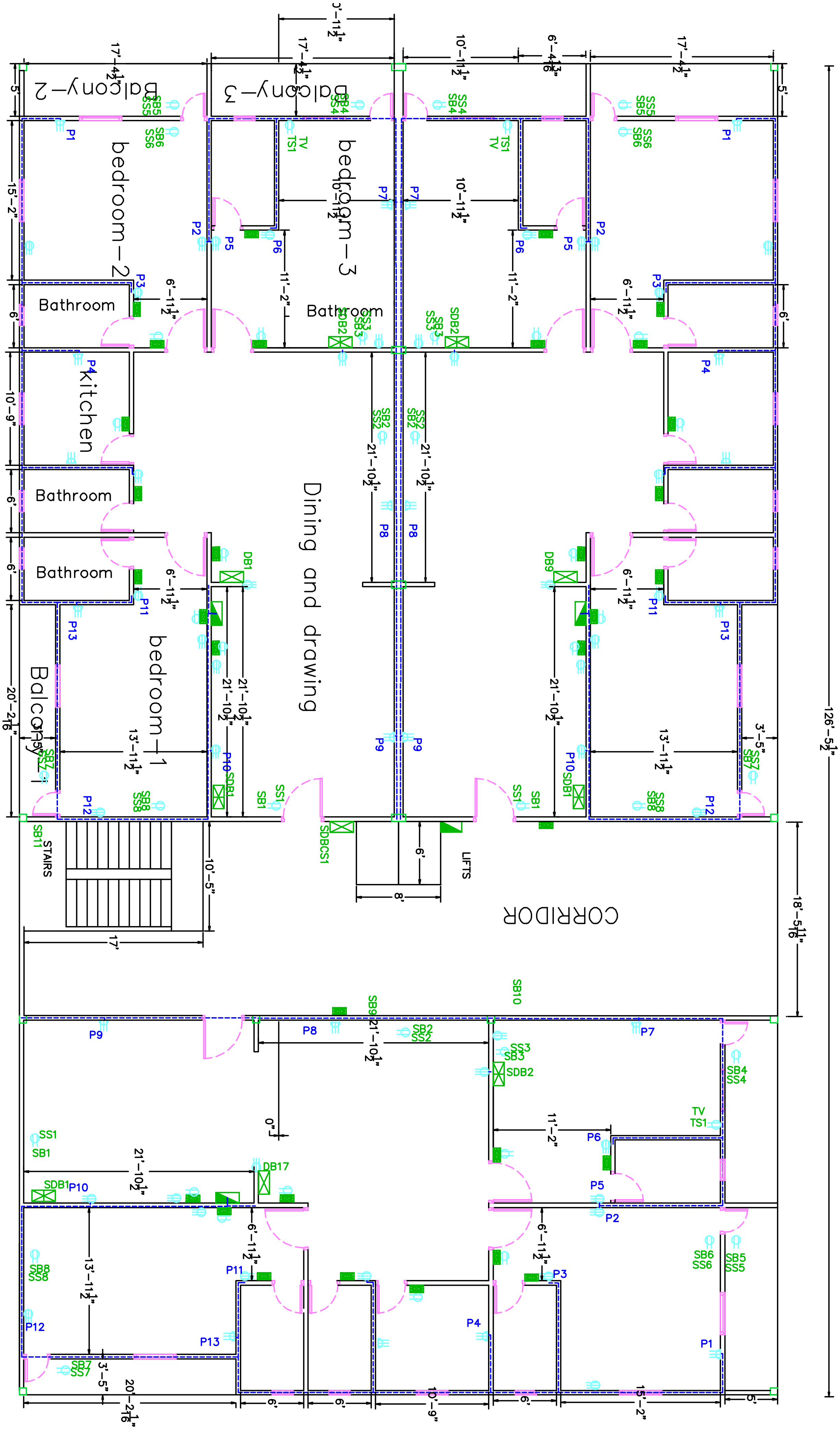
Typical floor with loads



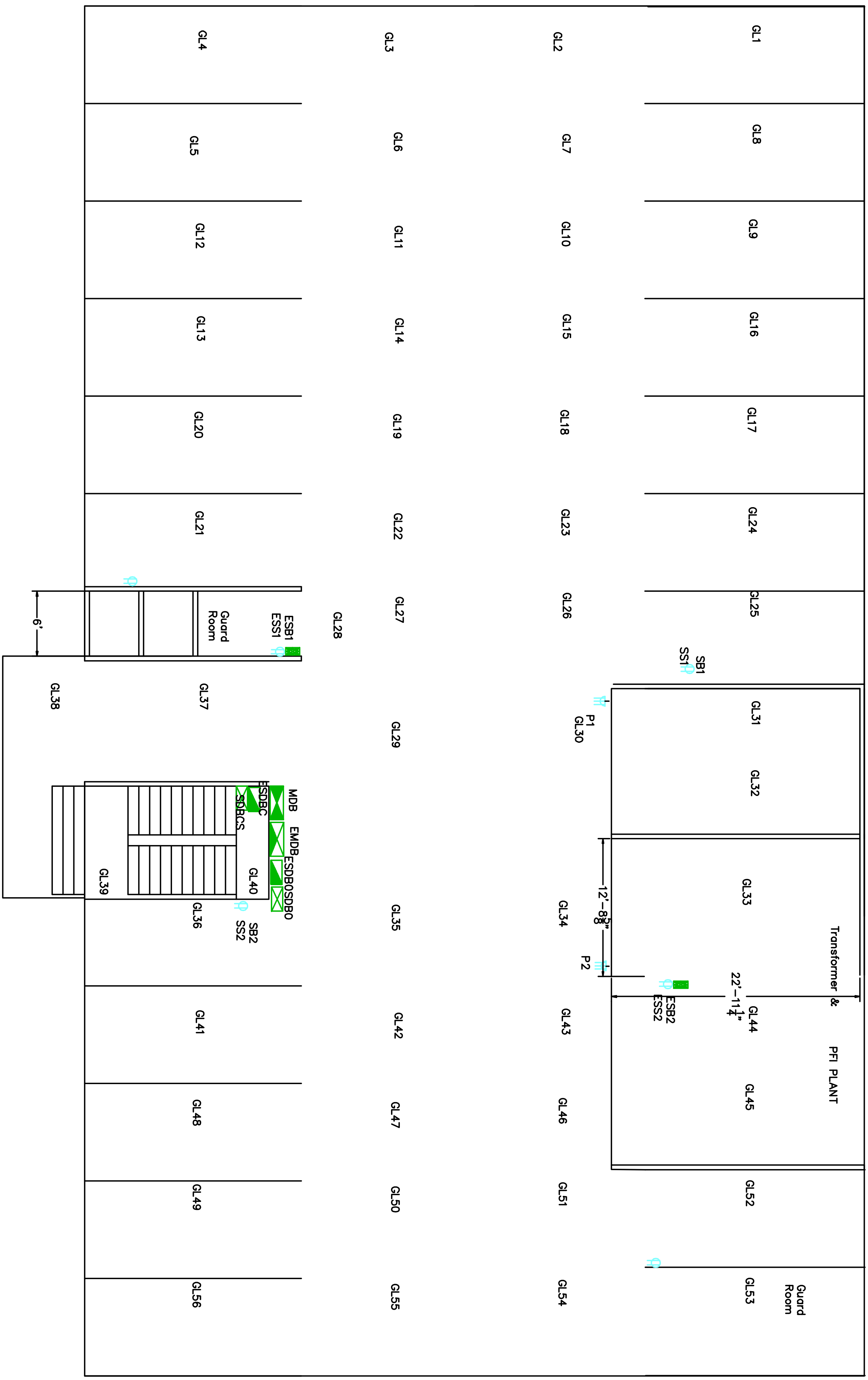
Typical floor with conduits



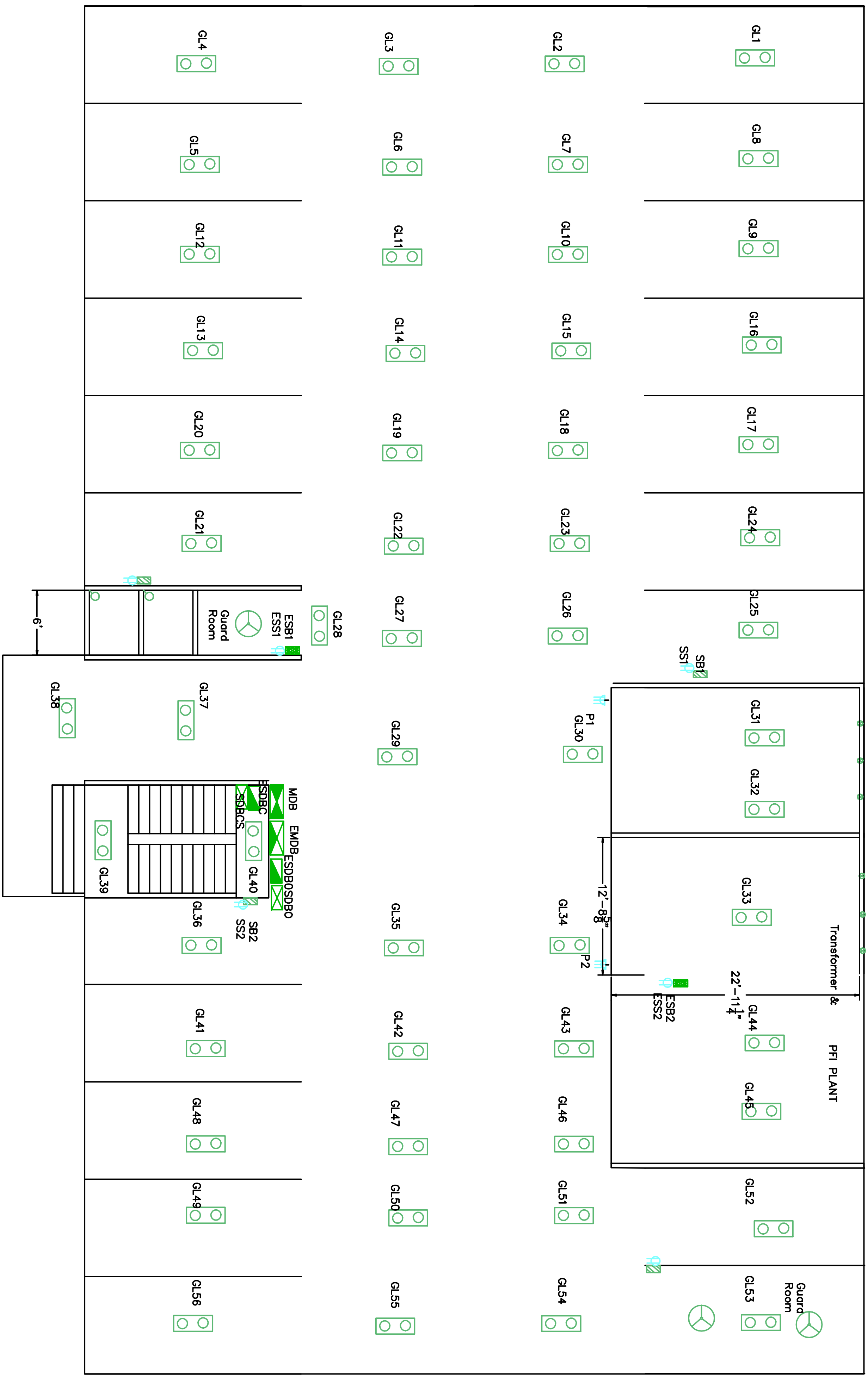
Typical floor power conduit



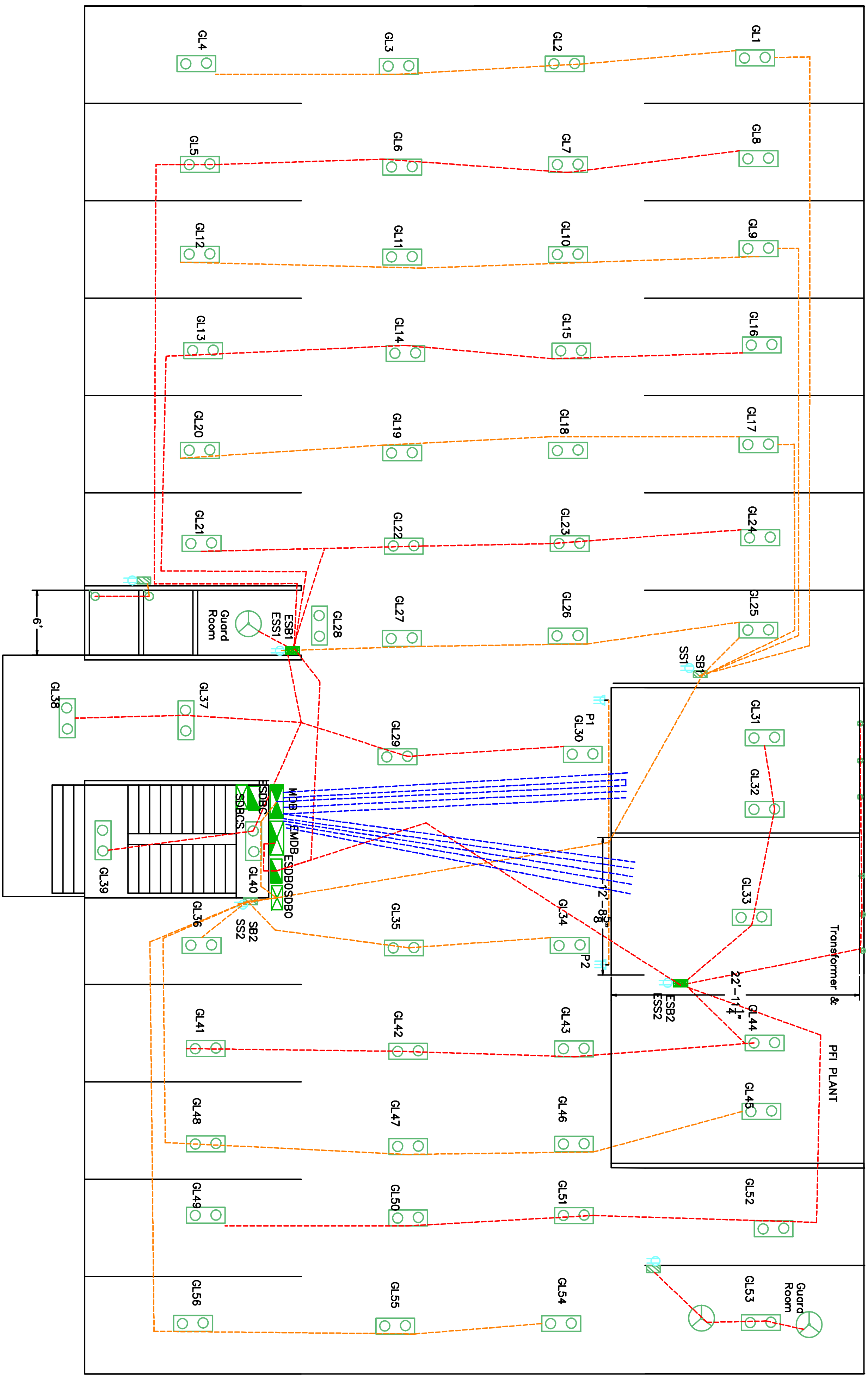
Ground floor basic layout



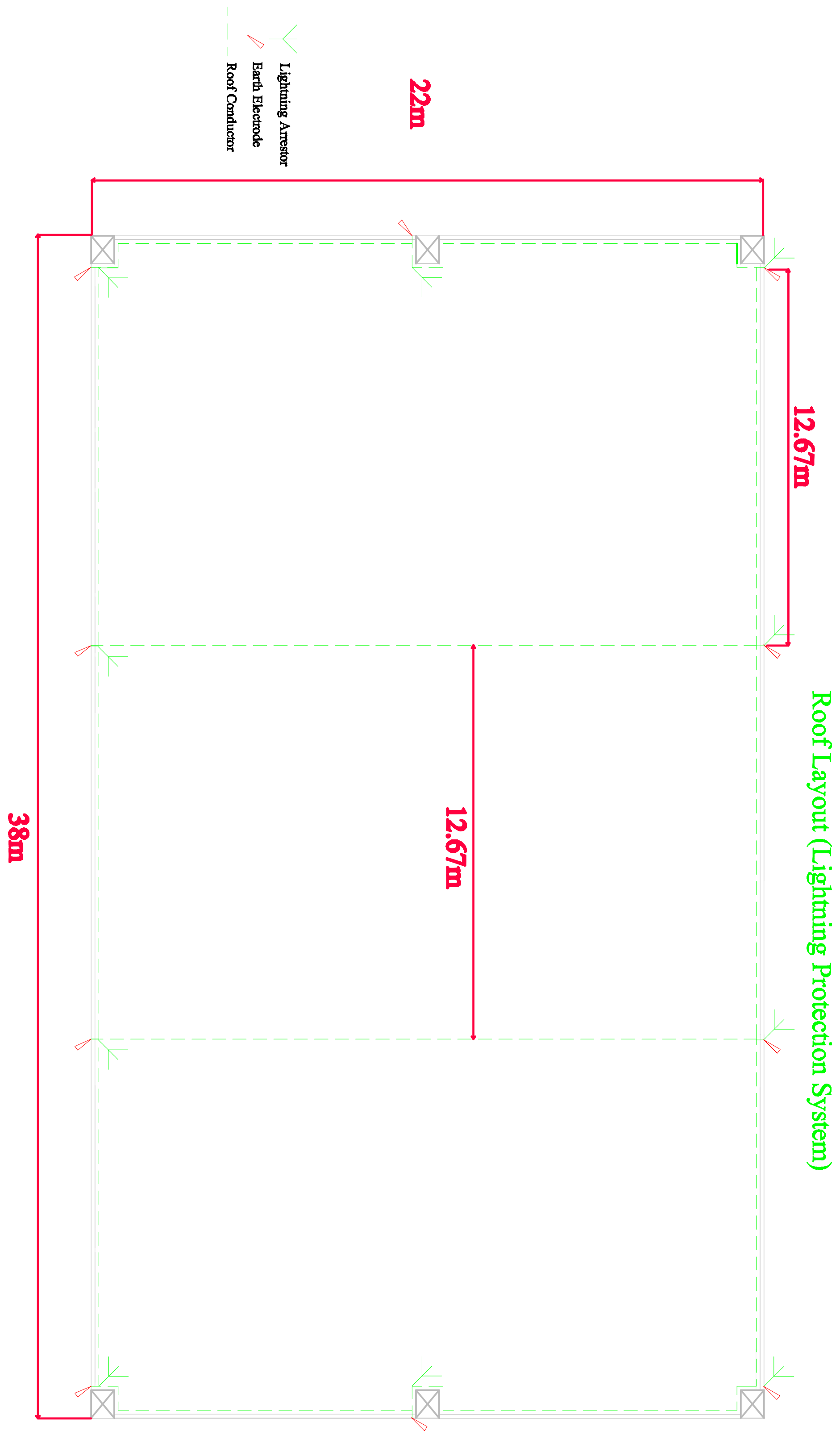
Ground floor with load



Ground floor with conduit



Earth Model



Lightning Arrestor
Earth Electrode
Roof Conductor
22m
12.67m
12.67m
38m
Roof Layout (Lightning Protection System)

Emergency Sub distribution board (SDB) -1 Fixtures							
Room name	Ckt no.	Switchboard	Fixture	Power rating in W	Current rating(A)	Wire rating	Breaker to SDB
Bathroom	Ckt9	ESB9	LL28	20	0.15	2*1.5mm^2 BYM+1.5mm^2 BYA ECC	5A
			LL29	20	0.15		
			EF5	100	0.75		
					1.05		
Bedroom1	Ckt10	ESB10	LL35	20	0.15	2*2.5 mm^2 BYM+ 2.5 mm^2 BYA ECC	5A
			LL32	20	0.15		
			F16	100	0.75		
			ESS6	1100	5		
		Total			**6.05**		
Bedroom-2	Ckt5	ESB5	F13	100	0.75	2*1.5mm^2 BYM+1.5mm^2 BYA ECC	10A
			LL20	100	0.75		
			ESS4		5		
					6.5		
			LL21	20	0.15	2*1.5mm^2 BYM+1.5mm^2 BYA ECC	5A
Bathroom	Ckt6		LL22	20	0.15		
			EF2	100	0.75		
		ESB6			**1.05**		
Bathroom	Ckt4	ESB4	LL11	20	0.15	2*1.5mm^2 BYM+1.5mm^2 BYA ECC	5
			LL12	20	0.15		
			EF1	100	0.75		
	Ckt3	ESB3	LL10	20	0.15	2*2.5 mm^2 BYM+ 2.5 mm^2 BYA ECC	10
			TL5	20	0.15		
			F11	100	.75		
			ESS3		5		
		Total			**7.1**		
Dining & drawing	Ckt2	ESB2	F6	100	0.75	2*2.5 mm^2 BYM+ 2.5 mm^2 BYA ECC	10
			F8	100	0.75		
			CL2	40	0.3		
			CL4	40	0.3		
			TL4	20	0.15		
			ESS2		5		
			LL7	20	0.15		
					7.4		
	Ckt1	ESB1	LL1	20	0.15	2*2.5 mm^2 BYM+ 2.5 mm^2 BYA ECC	10
			ESS1		5		
			TL1	20	0.15		
			F1	100	0.75		
			F2	100	0.75		
					6.8		
Bathroom		ESB8	LL26	20	0.15	2*1.5mm^2 BYM+1.5mm^2 BYA ECC	5
			LL27	20	0,15		
			EF4	100	0.75		
			Total		**1.05**		

Kitchen		ESB7	LL24	20	.15	2*2.5 mm^2 BYM+ 2.5 mm^2 BYA ECC	10
			LL23	20	.15		
			LL25	20	.15		
			EF3	100	.75		
			ESS5		5		
Total					6.2		

CORRIDOR	CKT7	ESB12	COL1	20	0.15	2*1.5 mm^2 BYM+ 1.5 mm^2 BYA ECC	5
			COL2	20	0.15		
			COL6	20	0.15		
			TOTAL		**0.45**		
			COL8	20	0.15	2*1.5 mm^2 BYM+ 1.5 mm^2 BYA ECC	5
			COL9	20	0.15		
			COL11	20	0.15		
			TOTAL		**0.45**		

Room name	Power Socket	Current Rating(A)	Wire Rating
Bedroom-2	Q1	13A	2*4 mm^2 BYM+ 4 mm^2 BYA ECC
Kitchen	Q2	15A	2*4 mm^2 BYM+ 4 mm^2 BYA ECC
Bedroom-1	Q3	13A	2*4 mm^2 BYM+ 4 mm^2 BYA ECC
Bedroom-3	Q6	13A	2*4 mm^2 BYM+ 4 mm^2

			BYA ECC
Dining & Drawing	Q5 Q7 Q4	13A 13A 13A	2*4 mm^2 BYM+ 4 mm^2 BYA ECC

ESDB1-8:
Total rating in fixtures: Ckt1+…..+Ckt10 = 1.05+6.05+6.5+1.05+7.1+7.4+6.8+1.05+6.2 = 43.2 A
Total rating in power circuits:13*6+15= 93 A
Activity factor for fixtures = 0.8
Activity factor for power circuits = 0.4
Total current rating for SDB-2 to DB = (43.2x0.8 + 93x0.4) = 71.76 A
Thus, breaker rating for SDB-2 = 70A SP MCCB
Wire rating for SDB-2 = 50 mm^2 BYM + 25 mm^2 BYA ECC

EMERGENCYSub distribution board(SDB)-ground Fixtures							
Room name	Ckt no.	Switchboard	Fixture	Power rating in W	Current rating(A)	Wire rating	Breaker to SDB
Garage	Ckt1	ESB1	L5	40	0.3	2*2.5 mm^2 BYM+ 2.5 mm^2 BYA ECC	
			L6	40	0.3		
			L7	40	0.3		
			L8	40	0.3		
			L13	40	0.3		
			L14	40	0.3		
			L15	40	0.3		
			L16	40	0.3		
			L21	40	0.3		
			L22	40	0.3		
			L23	40	0.3		
			L24	40	0.3		
			L28	40	0.3		

			L29	40	0.3		
			L30	40	0.3		
			L37	40	0.3		
			L38	40	0.3		
			ESS1		5		
		ESB2	GL32	40	0.3	2*2.5 mm^2 BYM+ 2.5 mm^2 BYA ECC	
			ESS2		5		
			GL34	40	0.3		
			GL35	40	0.3		
			GL39	40	0.3		
			GL41	40	0.3		
			GL42	40	0.3		
			GL43	40	0.3		
			GL44	40	0.3		
			GL49	40	0.3		
			GL50	40	0.3		
			GL51	40	0.3		
			GL52		0.3		
Total				**18.4**			
Guard room 1	Ckt2	ESB3	GL53 FF1 FF2	40 100 100	0.3 .75 .75	2*1.5 mm^2 BYM+ 1.5 mm^2 BYA ECC	5A
Total					**1.3**		

Ground floor EDB0:
Total load current = 19.7 A
20 A SP MCCB CB
2*6 mm^2 BYM+ 6 mm^2 BYA ECC

CORRIDOR ESDBC1-C8:
Ckt11+Ckt12= .45+.45 = 0.9 A
5A SP MCB circuit breaker should be used.
2*1.5 mm^2 BYM+ 1.5 mm^2 BYA ECC

SDBC:
LOAD = 0.9*8 = 7.2 A
10 A SP MCCB CB
2*2.5 mm^2 BYM+ 2.5 mm^2 BYA ECC

Total Generator load:
Balanced emergency load:
$8*70*400*\sqrt{3}$ = 388 kVA
Garage emergency load= 19.7*220 = 4.4 kVA
Corridor emergency load = .9*8*220 = 1.5 kVA
Pump emergency load 3 phase = 5 kVA

Lift emergency load 3 phase = 10 kVA

Pf for generator= 0.9
Total emergency load = 408 kVA = 367kW
400kW standby diesel generator should be used.

Sub distribution board (SDB) -2 Fixtures							
Room name	Ckt no.	Switchboard	Fixture	Power rating in W	Current rating(A)	Wire rating	Breaker to SDB
Bedroom-2	Ckt5	SB5	LL15	20	0.15	2.5mm^2 BYM+2.5mm^2 BYA (ECC)	10A
			SS5		5		
			LL16	20	0.15		
			Total		**5.3A**		
	Ckt6	SB6	LL17	20	0.15	2.5mm^2 BYM+2.5 mm^2 BYA(ECC)	10A
			SS9		5		
			LL19	20	0.15		
			LL18	20	0.15		
			TL7	20	0.15		
			F12	100	0.75		
			F14	100	0.75		
Total				**7.1A**			
Bedroom-3	Ckt4	SB4	LL13	20	0.15	2.5mm^2 BYM+2.5mm^2 BYA (ECC)	10A
			SS4		5		
			LL14	20	0.15		
			Total		**5.3**		
	Ckt3	SB3	LL8	20	0.15	4mm^2 BYM+4mm^2 BYA (ECC)	15A
			SS3		5		
			LL9	20	0.15		
			TV	150	1.125		
			TS		5		
			F10	100	0.75		
			TL6	20	0.15		
Total				**12.325**			
Dining & drawing	Ckt2	SB2	F7	100	0.75	2.5 mm^2 BYM+2.5 mm^2 BYA(ECC)	10A
			SS2		5		
			F5	100	0.75		
			CL3	40	0.3		
			LL6	20	0.15		
			TL3	20	0.15		

			LL5	20	0.15		
Total				**7.25**			

Room name	Power Socket	Current rating (A)	Wire rating
Dining & Drawing	P8	15A	4mm^2 BYM+4mm^2 BYA (ECC)
Dining & Drawing	P9	15A	4mm^2 BYM+4mm^2 BYA (ECC)
Dining & Drawing	P10	13A	4mm^2 BYM+4mm^2 BYA (ECC)
Bedroom-1	P11	13A	4mm^2 BYM+4mm^2 BYA (ECC)
Bedroom-1	P12	13A	4mm^2 BYM+4mm^2 BYA (ECC)
Bedroom-1	P13	15A	4mm^2 BYM+4mm^2 BYA (ECC)

Sub distribution board (SDB) -1 Fixtures							
Room name	Ckt no.	Switchboard	Fixture	Power rating in W	Current rating(A)	Wire rating	Breaker to SDB
Bedroom-1	Ckt7	SB7	LL30	20	0.15	2.5mm^2 BYM+2.5mm^2 BYA (ECC)	10A
			SS7		5		
			LL31	20	0.15		
			Total		**5.3A**		
	Ckt8	SB8	LL34	20	0.15	2.5mm^2 BYM+2.5mm^2 BYA (ECC)	10A
			SS8		5		
			LL33	20	0.15		
			TL8	20	0.15		
			TL9	20	0.15		
			F17	100	0.75		
			F18	100	0.75		
Total				**7.1**			
Dining & drawing	Ckt1	SB1	F3	100	0.75	2.5 mm^2 BYM+2.5 mm^2 BYA(ECC)	10A
			SS1		5		
			F4	100	0.75		
			CL1	40	0.3		

			LL4	20	0.15		
			TL2	20	0.15		
			LL2	20	0.15		
			LL3	20	0.15		
Total				**7.4**			

Room Name	Power Socket	Current rating (A)	Wire rating
Bedroom-2	P1	13A	4mm^2 BYM+4mm^2 BYA (ECC)
Bedroom-2	P2	13A	4mm^2 BYM+4mm^2 BYA (ECC)
Bedroom-2	P3	13A	4mm^2 BYM+4mm^2 BYA (ECC)
Kitchen	P4	15A	4mm^2 BYM+4mm^2 BYA (ECC)
Bedroom-3	P5	13A	4mm^2 BYM+4mm^2 BYA (ECC)
Bedroom-3	P6	13A	4mm^2 BYM+4mm^2 BYA (ECC)
Bedroom-3	P7	15A	4mm^2 BYM+4mm^2 BYA (ECC)

Sub distribution board (SDB) -3 Fixtures							
Room name	Ckt no.	Switchboard	Fixture	Power rating in W	Current rating(A)	Wire rating	Breaker to SDB
Corridor	Ckt1	SB9	CL3	40	0.3	1.5mm^2 BYM+1.5mm^2 BYA (ECC)	5A
			CL4	40	0.3		
			CL5	40	0.3		
	Ckt2						
			Total		**0.9**		
		SB10	CL7	40	0.3	1.5mm^2 BYM+1.5mm^2 BYA (ECC)	5A
			CL10	40	0.3		
			CL12	40	0.3		
			CL13	40	0.3		
Total				**1.2**			
Stairs	Ckt3	SB11	SL1	20	0.15	1.5 mm^2 BYM+1.5 mm^2 BYA(ECC)	5A
			SL2	20	0.15		
			SL3	20	0.15		
			SL4	20	0.15		
Total				**0.6**			

Sub distribution board (SDB) -0 Fixtures							
Room name	Ckt no.	Switchboard	Fixture	Power rating in W	Current rating(A)	Wire rating	Breaker to SDB
Garage	Ckt1	SB1	GL1	40	0.3		
			GL2	40	0.3		
			GL3	40	0.3		10A
			GL4	40	0.3		
			GL9	40	0.3		
			GL10	40	0.3		
			GL11	40	0.3		
			GL12	40	0.3		
			GL17	40	0.3		
			GL18	40	0.3		
			GL19	40	0.3		
			GL20	40	0.3		
			GL25	40	0.3		
			GL26	40	0.3		
			GL27	40	0.3		
	Ckt2		SS1		5	2.5mm^2 BYM+2.5mm^2 BYA (ECC)	
			Total		**9.5**		
		SB2	GL34	40	0.3		
			GL35	40	0.3		
			GL36	40	0.3		
			GL45	40	0.3		
			GL46	40	0.3		
			GL47	40	0.3		
			GL48	40	0.3		
			GL54	40	0.3		
			GL55	40	0.3	2.5mm^2 BYM+2.5mm^2 BYA (ECC)	10A
			GL56	40	0.3		
			SS2		5		
Total				**8**			
Guard Room	Ckt3	SB3	LL1	20	0.15	2.5mm^2 BYM+2.5 mm^2 BYA(ECC)	10A
			SS3		5		
Total				**5.15**			

Room name	Power Socket	Current rating (A)	Wire rating

Garage	P1	15A	4mm^2 BYM+4mm^2 BYA (ECC)
Garage	P2	15A	4mm^2 BYM+4mm^2 BYA (ECC)

Sub-Distribution Board Calculations

Sub-distribution board 2

Total current rating in fixtures = (CKT2 + CKT3 + CKT4 + CKT5 + CKT6) = (5.3 +7.1+5.3+12.325+7.25) A = 37.275 A
Total current rating in power circuits = (P8 + P9 + P10 + P11 + P12 + P13) = (15+15+13+13+13+13) = 82 A
Activity factor for fixtures = 0.8
Activity factor for power circuits = 0.4
Total current rating for SDB-2 to DB = (37.275x0.8 + 82x0.4) = 62.62 A
Thus, breaker rating for SDB-2 = 70A SP MCCB
Wire rating for SDB-2 = 50 mm^2 BYA + 25 mm^2 BYA ECC

Sub-distribution board 1

Total current rating in fixtures = (CKT1 + CKT7 + CKT8) = (5.3+7.1 +7.4) A = 19.8 A
Total current rating in power circuits = (P1 + P2 + P3 + P4 + P5 + P6) = (15+15+13+13+13+13) = 82 A
Activity factor for fixtures = 0.8
Activity factor for power circuits = 0.4
Total current rating for SDB-1 to DB = (19.8x0.8 + 82x0.4) = 48.64 A
Thus, breaker rating for SDB-1= 50A SP MCCB
Wire rating for SDB-1 = 25 mm^2 BYM + 16 mm^2 BYA ECC

Sub-distribution board 3

Total current rating in fixtures = (CKT1 + CKT2 + CKT3) = (0.9+1.2+0.6) A = 2.7 A
Total current rating for SDB-1 to DB =2.7
Thus, breaker rating for SDB-1= 5A SP MCCB
Wire rating for SDB-1 = 1.5 mm^2 BYM + 1.5 mm^2 BYA ECC

Sub-distribution board 0

Total current rating in fixtures = (CKT1 + CKT2 + CKT3) = (9.5+8+5.15) A = 22.65 A
Total current rating in power circuits=(P1+P2) =30A
Without adding activity factor to SDB0,
Total current rating for SDB-0 to MDB =52.65A
Thus, breaker rating for SDB-0= 60A SP MCCB
Wire rating for SDB-1 = 35 mm^2 BYM + 16 mm^2 BYA ECC

Distribution Board Calculations

Distribution Board-1
Total current rating= (48.64+62.62) A=111.26 A
Thus, breaker rating for DB-1 = 120A SP MCCB
Wire rating for SDB-2 = 95 mm^2 BYM + 50 mm^2 BYA ECC

Ground floor (SDB0):
(9.5+8+5.15)*.8+30*.4=22.65*.8+12 = 30 A
30 A SP MCCB CB should be used
10 mm^2 BYM+ 10 mm^2 BYA ECC

Corridor and stairs(SDBCS):
1.2+0.6 = 1.8 A
AF = 0.8
Total load = 1.8*8*0.8 = 14.4*0.8 = 11.52 A
15 A SP MCB CB should be used
4 mm^2 BYM+ 4 mm^2 BYA ECC

DB and ESDB:
Total current: 120+70 A = 190 A
200A SP MCCB CB
150mm^2 BYM + 70 mm^2 BYA

Transformer:

Total load for Transformer:
Load current per phase = 120*8+70*8= 1520 A
Total balanced load = $\sqrt{3}$*1520*415 VA = 1092.5 kVA
Lift load 3 phase = 2*4kW=8kW = 10kVA
Pump load 3 phase = 6 hp = 4kW= 5kVA
Garage emergency load= 19.7*220 = 4.4 kVA
Corridor emergency load = .9*8*220 = 1.5 kVA
Ground floor SDB load = 30*220 kVA = 6.6 kVA
Corridor and stairs SDB load = 3.3 kVA

Total Required load = 1123 kVA
= 1123*0.95= 1067 kW

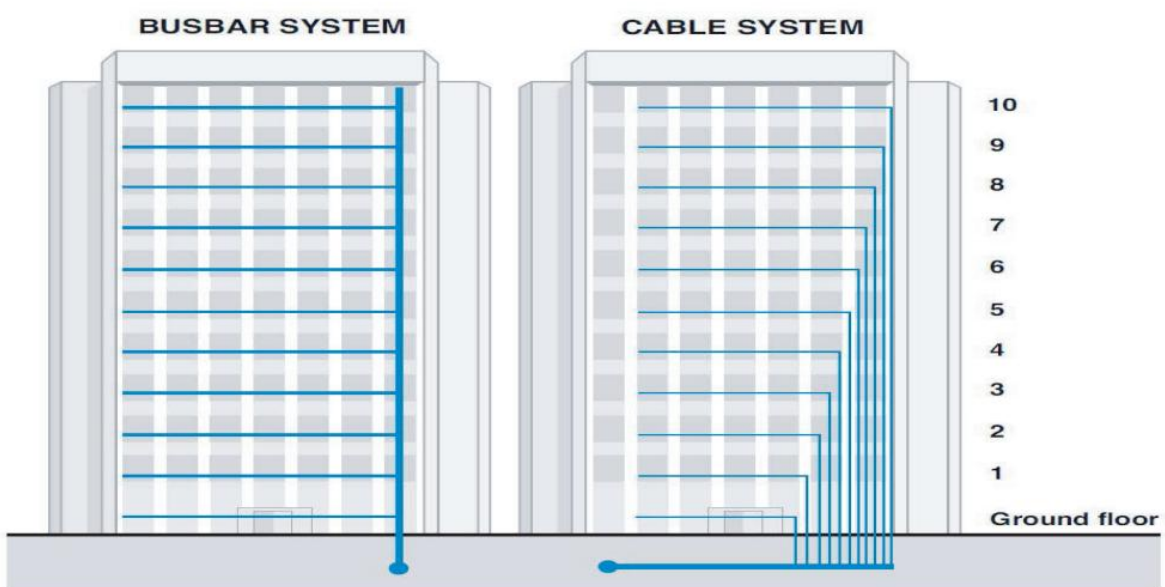
Transformer rating for that= 1067/(0.8*0.8)= 1667 kVA
L= 2.2m, W = 2.2 m
Total space for transformer 4.2*4.2 m^2 (enclosed 4 walls)

PFI plant

Pfi plant size requirement : 960 kVAR rating
Dimension L= 2m, W = 2 m
4*4 = 16 sqmm area is acquired.

Riser Design:

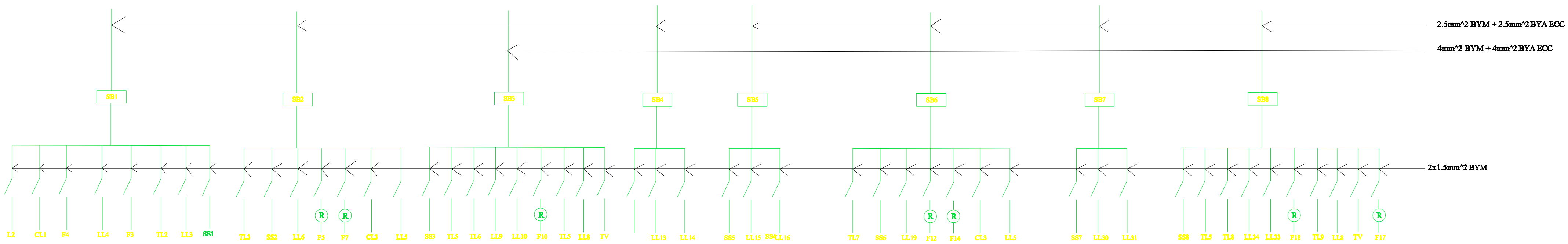
Sandwich BBT



Earth probe design:

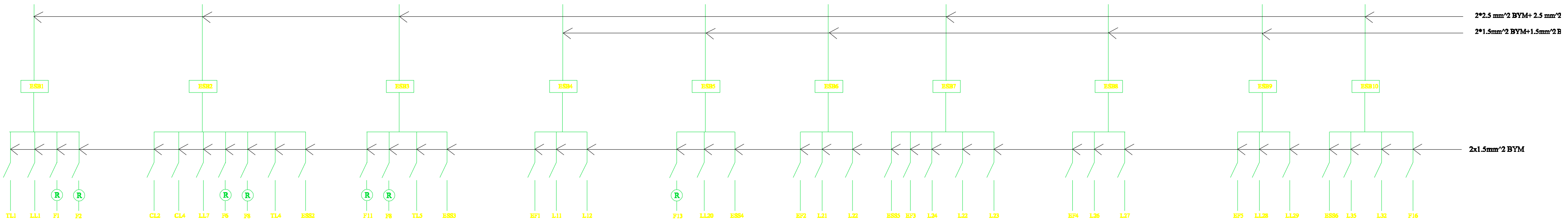
Earth lead and Main Earth conductor will be 70 mm^2 BYA.

Earth electrode should be bored 120 feet/ to the water level

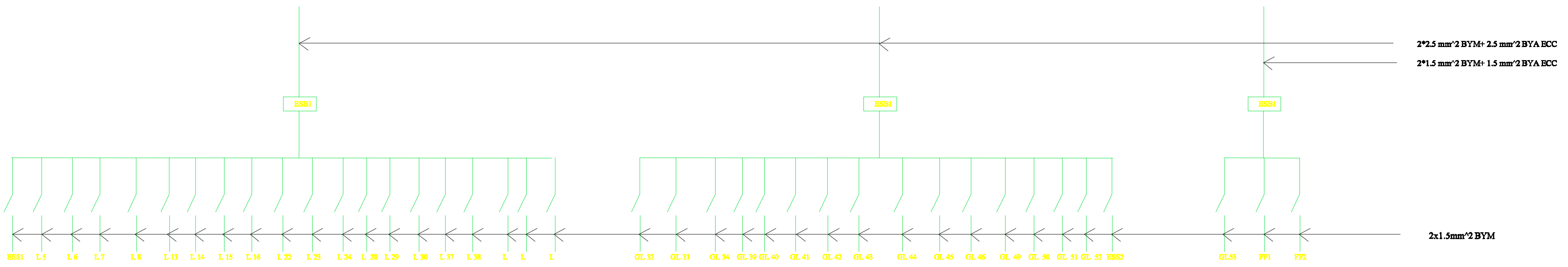


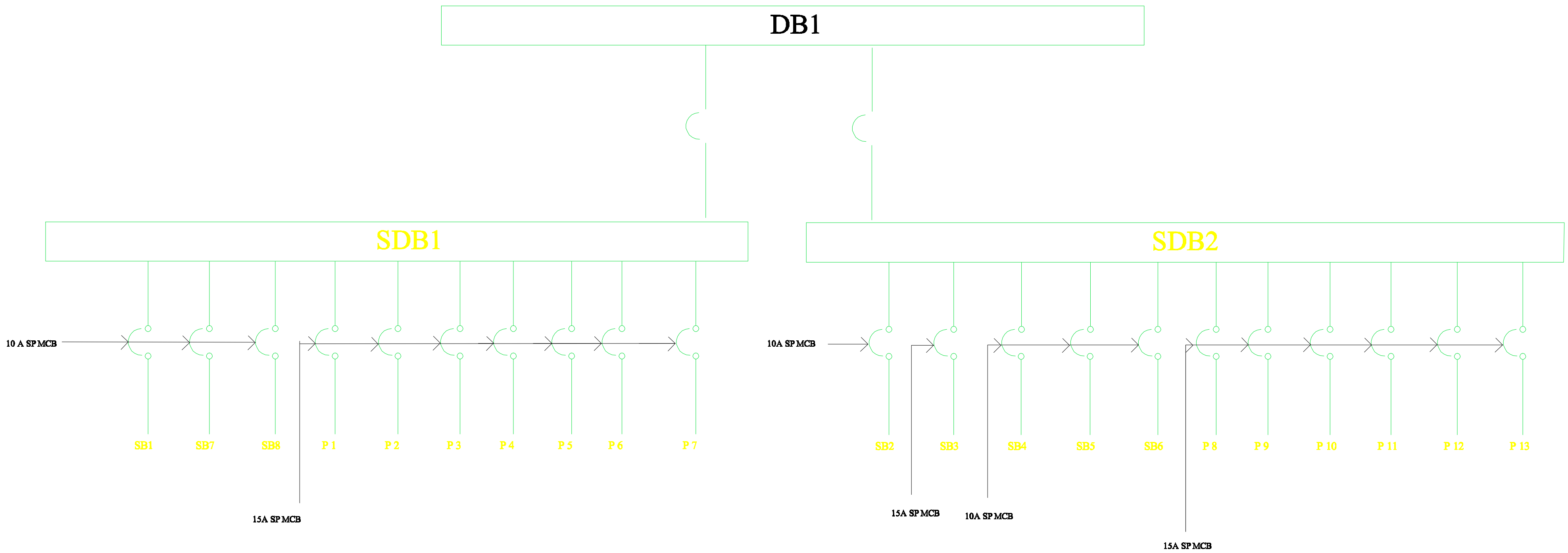
2.5mm^2 BYM + 2.5mm^2 BYA ECC
4mm^2 BYM + 4mm^2 BYA ECC
SB1
SB2
SB3
SB4
SB5
SB6
SB7
SB8
2x1.5mm^2 BYM
L2
CL1
F4
LL4
F3
TL2
LL3
SS1
TL3
SS2
LL6
F5
F7
CL3
LL5
SS3
TL5
TL6
LL9
LL10
F10
TL5
LL8
TV
LL13
LL14
SS5
LL15
SS4
LL16
TL7
SS6
LL19
F12
F14
CL3
LL5
SS7
LL30
LL31
SS8
TL5
TL8
LL34
LL33
F18
TL9
LL8
TV
F17

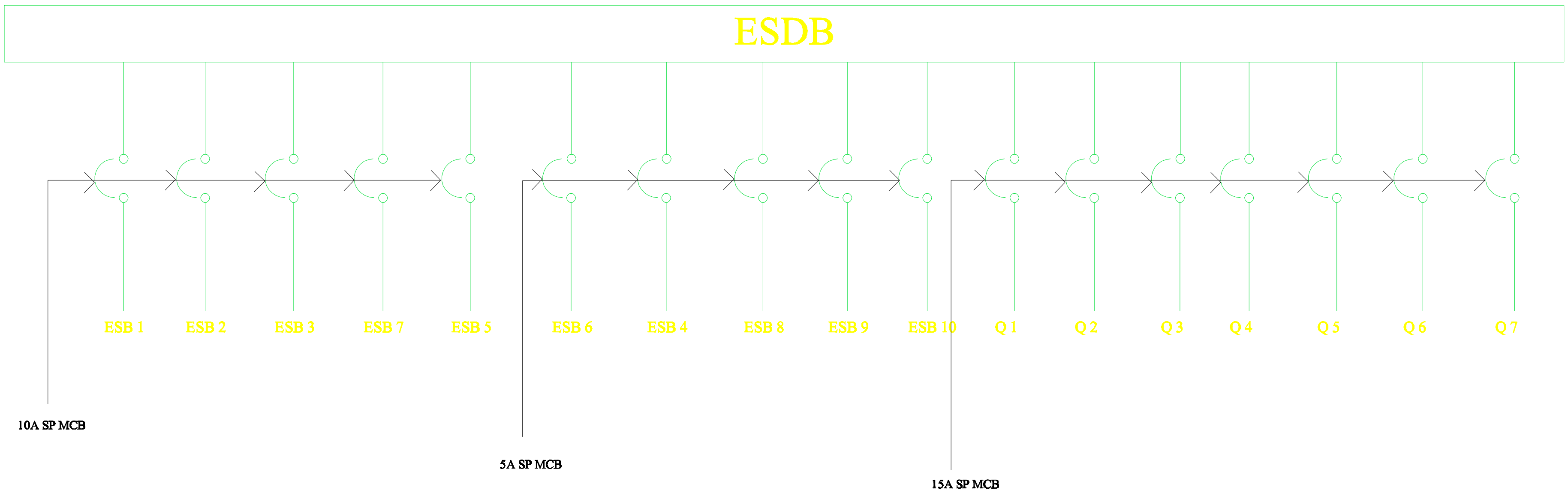
Emergency Sub distribution board (SDB) -1 Fixtures

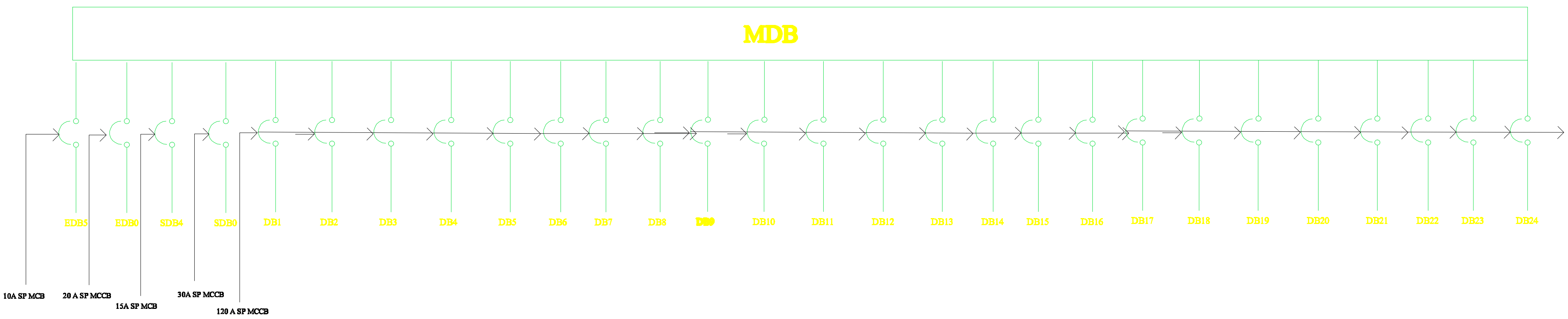


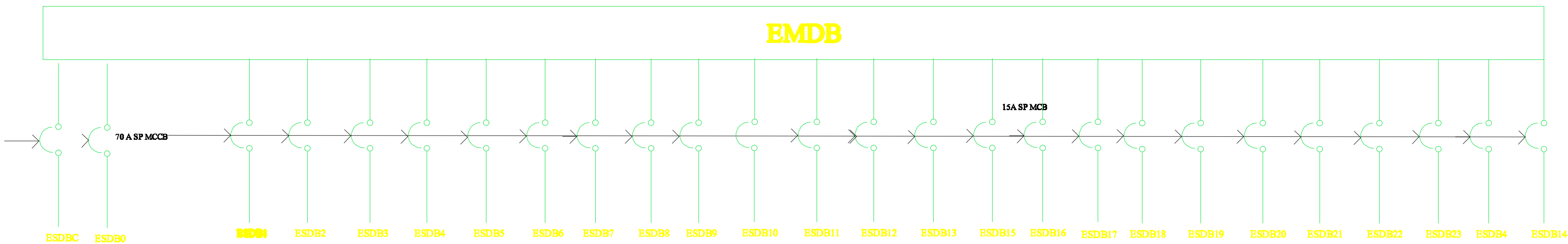
EMERGENCYSub distribution board(ESDB)-ground Fixtures



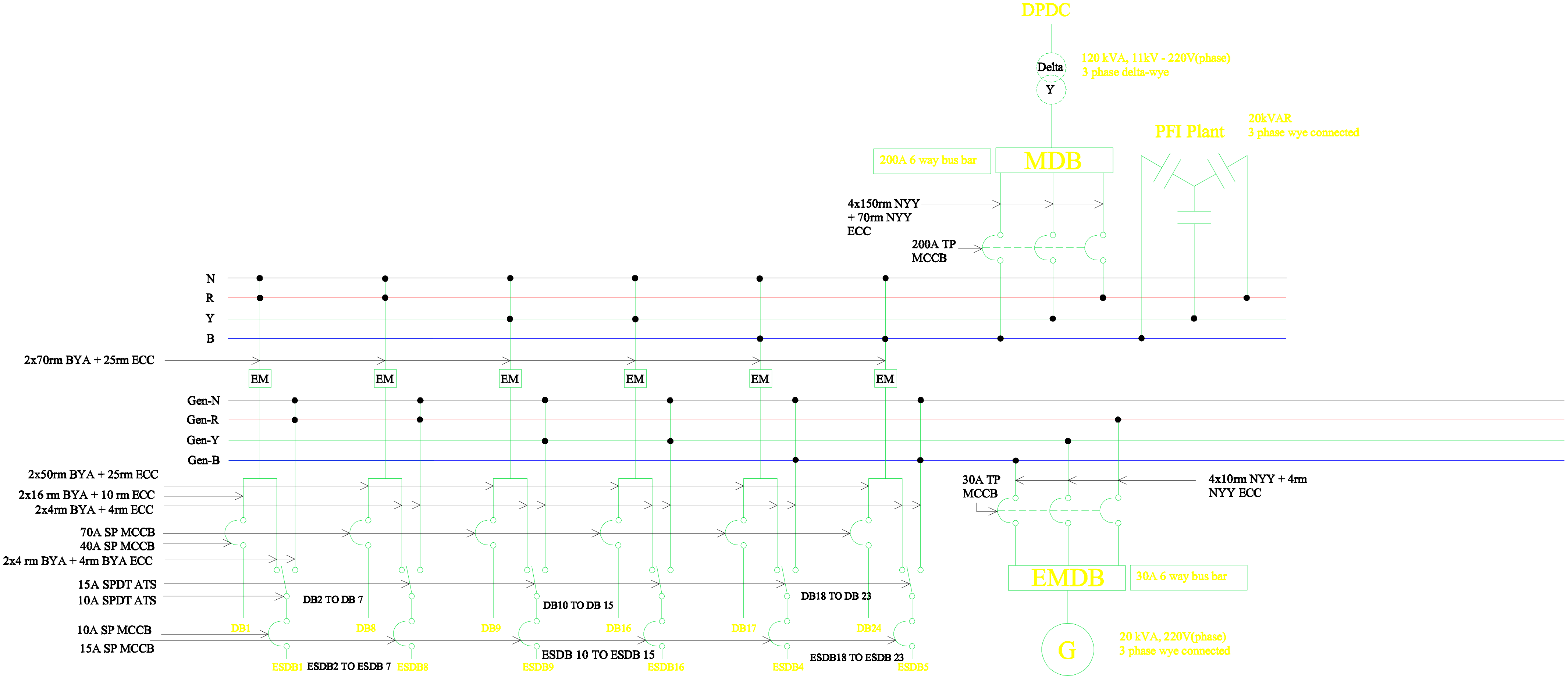

DB1
SDB1
SDB2
10 A SP MCB
SB1
SB7
SB8
P 1
P 2
P 3
P 4
P 5
P 6
P 7
15A SP MCB
10A SP MCB
SB2
SB3
SB4
SB5
SB6
P 8
P 9
P 10
P 11
P 12
P 13
15A SP MCB
10A SP MCB
15A SP MCB


ESDB
ESB 1
ESB 2
ESB 3
ESB 7
ESB 5
ESB 6
ESB 4
ESB 8
ESB 9
ESB 10
Q 1
Q 2
Q 3
Q 4
Q 5
Q 6
Q 7
10A SP MCB
5A SP MCB
15A SP MCB


MDB
EDB5
EDB0
SDB4
SDB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
DB8
DB9
DB10
DB11
DB12
DB13
DB14
DB15
DB16
DB17
DB18
DB19
DB20
DB21
DB22
DB23
DB24
10A SP MCB
20 A SP MCCB
15A SP MCB
30A SP MCCB
120 A SP MCCB


EMDB
70 A SP MCCB
15A SP MCB
ESDBC
ESDB0
ESDB1
ESDB2
ESDB3
ESDB4
ESDB5
ESDB6
ESDB7
ESDB8
ESDB9
ESDB10
ESDB11
ESDB12
ESDB13
ESDB15
ESDB16
ESDB17
ESDB18
ESDB19
ESDB20
ESDB21
ESDB22
ESDB23
ESDB4
ESDB14

Main and Emergency Distribution Board Diagram



Assignment title: Lightning Protection System Design for a 20-residential building with roof dimension 50m × 30m.

Introduction:

The purpose of a lightning protection system (LPS) is to shield occupants and buildings from the destructive consequences of lightning strikes.

Essential parts of LPS:

Index Figures for the assigned Building and Risk Assessment

Index Figure	Point Range
A: Use of Structure	2-10
B: Type of Construction	1-10
C: Contents or Consequential Effects	2-10
D: Degree of Isolation	2-10
E: Type of Terrain	2-8
F: Height of Structure	2-30
G: Lightning Prevalence	2-21

If the total summed up index is over 40, it indicates that Lightning Protection is essential for the structure.

Calculation of total index for our assigned building:

Index Figure	Description	Index
A: Use of Structure	House and similar buildings with outside aerial	4
B: Type of Construction	Reinforced concrete with nonmetal roof	2
C: Contents or Consequential Effects	Ordinary domestic building	2
D: Degree of Isolation	Structures located in a large area having structures or trees of similar height	2
E: Type of Terrain	Flat Terrain	2
F: Height of Structure	31.5m(<53m)	16
G: Lightning Prevalence	15 thunderstorm days/year in Dhaka*	21
	Total Index	**49**

So, for our proposed building the total index is 49 which is greater than 40 and so a Lightning Protection system is mandatory. (The data for thunderstorm days are not found exactly. It has been found that the country suffers 12 days thunderstorm in May month on average each year. So, we took 21 days per year on assumption [1])

Lightning Protection Zone and Air Terminal Placement

A Lightning Protection Zone (LPZ) is a designated segment within a building or structure where specific measures are implemented to safeguard occupants and equipment from potential damage caused by lightning strikes. This concept revolves around subdividing a structure into different zones, each receiving distinct levels of lightning protection, and implementing tailored measures to mitigate the risks associated with lightning.

The strategic placement of air terminals is a pivotal element in devising an effective lightning protection system for a building or structure. This placement hinges on factors such as the structure's size, shape, and the desired level of protection. Air terminals, commonly positioned along the highest points of the structure like the roof or building corners, need to be evenly distributed at regular intervals. Larger structures or those with intricate shapes may necessitate multiple air terminals to ensure comprehensive protection. Crucially, the placement must establish an unbroken path for electrical current, redirecting it away from the structure and safely into the ground.

Moreover, adherence to local codes and regulations is imperative. These guidelines often outline specific criteria for the placement and installation of lightning protection systems, emphasizing the need to comply with regional standards to enhance overall safety and effectiveness.

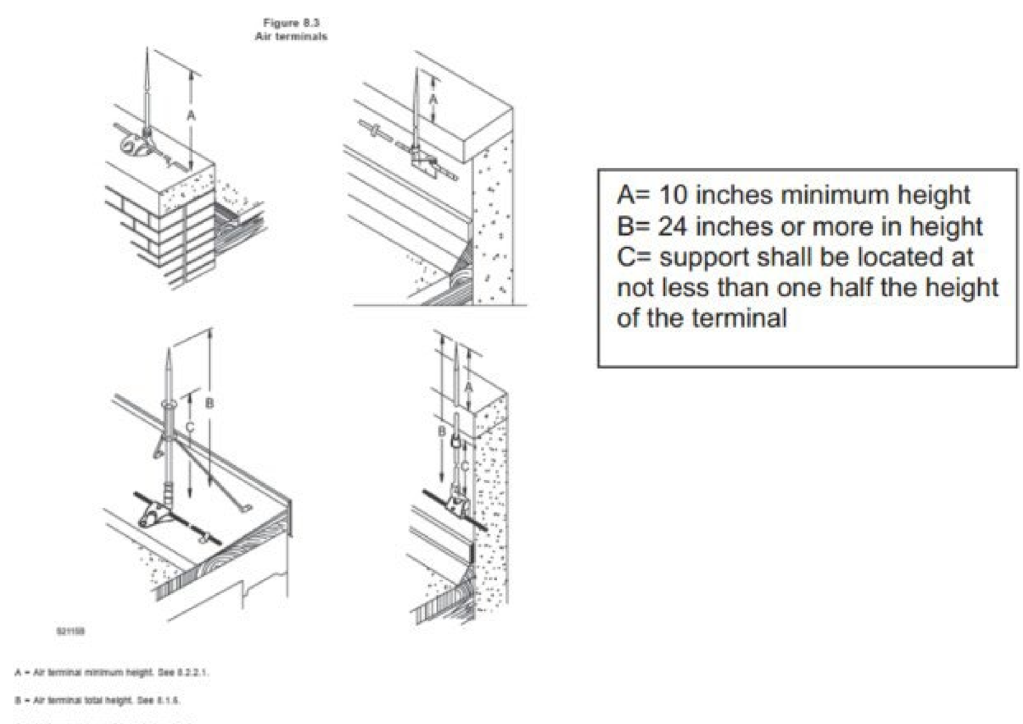


Figure: Air terminal placement using standard grid placement scheme

Calculation of Down conductor:

For a larger building, there shall be one down conductor for the first 80 m^2 plus a further one for every 100 m^2 or part there of more than the first 80 m^2.

Here, roof area= 38 x 22 m^2= 836 m^2
Number of down conductors= 1 conductor for first 80 m^2 + (836-80) m^2/100m^2
= 8.56 ≈ 9 conductors

For the sake of symmetry 10 conductors were used in the design, placing one in each corner and Other 6 in the sides.

Calculation of roof conductor:

The recommended spacing between roof conductors depends on the protection level required, the type of conductor used, and the height of the building. Typically, for a lower medium-rise building, the recommended spacing between conductors is below 18 meters. We will place roof conductors only along the width. The total length of the roof is 22 m. We will place 2 roof conductors 12.67 m far from the parapet wall of two sides. The distance between the roof conductors is also 12.6\m which suits the requirement of below 18m. Also, a roof conductor will go through the parapet walls and connect the air terminal to the down conductor and earth electrode.

Rolling Sphere Design:

Creating a rolling sphere model for lightning protection entails determining the necessary protection area for a specific building or structure. The rolling sphere model serves as the framework for defining the protection scope within a lightning protection system. The following steps outline the process:

1. **Assess Structure Height and Dimensions:**
   - Measure both the height and overall size of the structure requiring lightning protection. These measurements inform the determination of the rolling sphere size incorporated in the design.
2. **Define Required Protection Level:**
   - Evaluate the requisite protection level based on factors such as the structure type, contents, and location. Structures situated in regions with heightened lightning activity necessitate a higher level of protection compared to those in areas with lower lightning frequency.
3. **Establish Air Termination System:**
   - Design an air termination system aimed at intercepting lightning strikes and guiding electrical current along a secure path. Place the air termination system strategically along the rolling sphere's path, determined by the structure's height and size.
4. **Configure Down-Conductor System:**
   - Develop a down-conductor system to create a low-resistance route for electrical current, redirecting it away from the structure and into the ground. Position the down-conductor system where it facilitates the safe discharge of electrical current,

accommodating the expected current load.

5. **Design Grounding System:**
   - Formulate a grounding system to safely disperse electrical current into the ground. Design the grounding system to handle the anticipated current load and install it in a location offering a low-resistance pathway to the earth.
6. **Compute Protection Area:**
   - Employ the rolling sphere model to calculate the required protection area for the structure. This calculation informs decisions regarding the quantity and placement

     of air terminations, down-conductors, and grounding points.
7. **Implement Lightning Protection System:**
   - Install the lightning protection system in accordance with the design specifications once the planning is complete. Regularly inspect and maintain the system to ensure its continued effectiveness and operational integrity.

Overall, designing a rolling sphere in lightning protection involves calculating the area of protection required for a particular structure, and designing and installing the appropriate air termination, down-conductor, and grounding systems to provide effective protection against lightning strikes.
10 inch is the minimum height of the air terminal according to NFPA 780. We would use 24 inches for which we would use a 12-inch support because the support should not be less than 0.5 times the length of the air terminals.(NFPA 780)

Below are the choices for R where we will choose 30 meters as the building is a usual Residential building :

R	20 m (I)	30 m(II)	40 m(III)	60 m (IV)

If we choose R = 30m and height h = 24 inch, according to the calculation-

$r = \sqrt{2Rh - h^2}$ = 6.02m
So, the spacing between the air terminal should be less then $d = 2r$ = 12.04 m
We will place 16 air terminals each 10m apart which doesn't violate the rolling sphere.

Calculation of earthing conductors:

As our building is a 20 storied on (above 10 story), the earthing resistance should be around 2 ohms. We could use various types of earth electrode like GI (Galvanized Iron) pipe, copper plate earth electrode and copper rod earth electrode. But regardless of which one we use we must connect multiple electrodes in parallel or drive the GI pipe or Copper rod deep into the ground to reduce the resistance to our requirement. But measures shall be taken so that the parallel electrodes are not less than 1.8 m apart.[3]

(a) Copper rod earth electrode: shall have a minimum diameter of 12.5 mm of minimum length of 3.33 m. Multiple copper rod earth electrodes may have to be installed to achieve an acceptable value of earthing resistance of around 1 ohm.

(b) Copper plate earth electrodes: shall be 600 mm x 600 mm x 6 mm minimum in size. The copper plate shall be buried at least 2 m below the ground level. Multiple Copper plate earth electrodes may have to be installed to achieve an acceptable value of earthing resistance of around 1 ohm.

(c) Galvanized Iron (GI) pipes: GI pipe earthing shall have a minimum diameter of 38 mm and of minimum length of 6.5m. Multiple GI pipes Earth Electrode may have to be installed to achieve an acceptable value of earthing resistance of around 1 ohm.

[3]

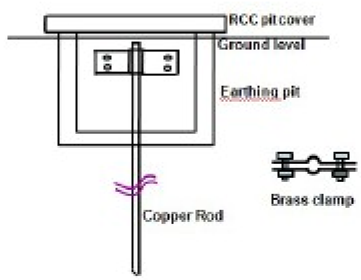


Figure 8.1.2 Copper Rod Earthing

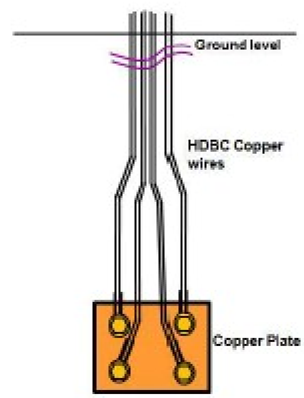
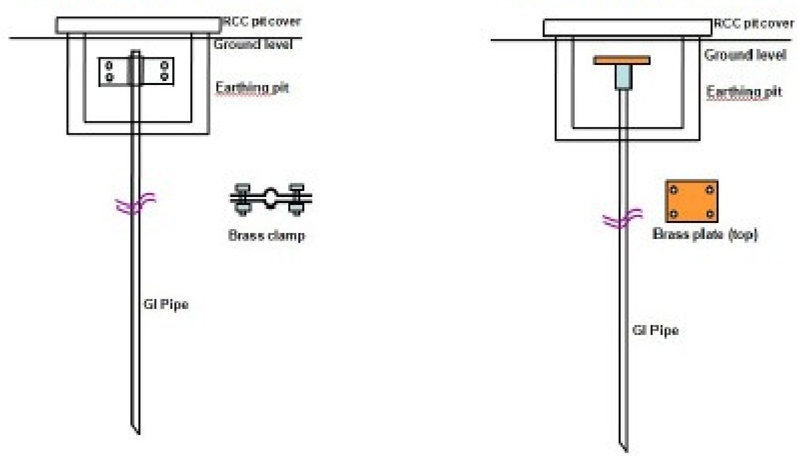


Figure 8.1.3 Copper Plate Earthing

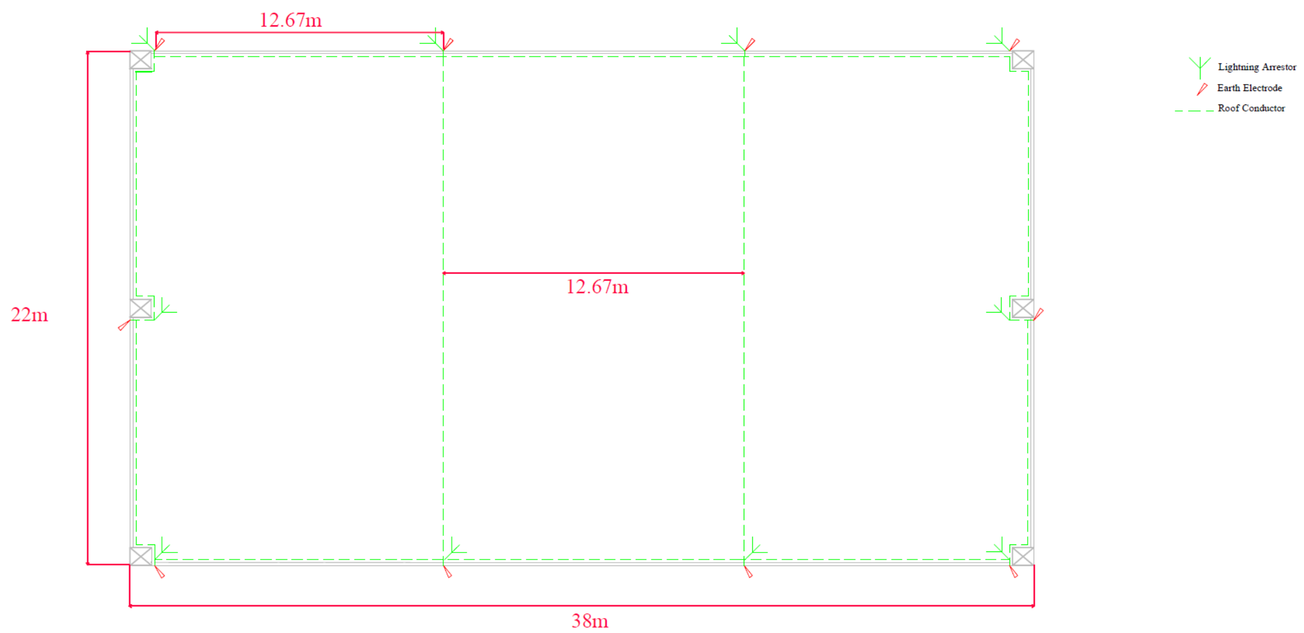


(a) (b)

Figure 8.1.4 Pipe Earthing; (a) Type 1; (b) Type 2

[3]

Proposed Design:



Conclusion:

Safeguarding a building and its occupants from the detrimental impacts of lightning strikes necessitates the implementation of a lightning protection system. This crucial system serves to diminish the potential for structural damage, electrical harm, and the risk of injury or fatality to those within the building. Furthermore, it ensures adherence to building codes and regulations, emphasizing the importance of a comprehensive approach to lightning safety and mitigation measures.

References:

1. Thunderstorms and Lightning in Bangladesh (bmrcbd.org)
2. BNBC Table 8.1.27 (Index Figures Associated with Lightning Protection Design)
3. BNBC 1.3.32 (Earthing)

Conclusion:

In this project, we have performed the designing of a eight-storey with ground floor building plan along with the electrical fixtures and conduit layout. Then, we have designed the switchboard connection diagram showing how the incoming electric power is distributed throughout the residential building. Along with the general connectivity, different wire schedules and protection equipment such as circuit breakers have been shown in the single line diagrams. To protect the building from electrical surges caused by lightning strike, we have planned the necessary lightning protection system. Thus, we have gained a hands-on experience on the electrical service design of a residential building

References:

[1] BNBC Table 8.1.5 (Recommended Values of Illumination for Residential Buildings

[2] Table for Cables, Conduits, ECC, EL, Voltage drop and Current ratings of different specifications as per Manual of Eastern Cables, BICC cables and Tables, Electrical Conductors (International Standard Sizes etc)

[3] BNBC Table 8.1.27 (Index Figures Associated with Lightning Protection Design)

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Table for Cables, Conduits, ECC, EL, Voltage drop and Current ratings of different specifications as per Manual of Eastern Cables, BICC cables and Tables, Electrical Conductors (International Standard Sizes) etc. :

A	B	C	D	E	F		G	H	I		J	
					a'	b'			a"	b"	a"'	b"'
3/0.029	1.5	5	16	10	6	10		27	27	22	16	20
7/0.029	2.5	10	16	10	4	7		16	36	30	22	28
7/0.036	4	15	14	10	3	5	1	10	47	39	30	37
7/0.044	6	20	14	10	2	4	1	6.8	59	50	38	47
7/0.052	10	30	10	10	1	2	1.5	4	78	68	52	63
7/0.064	16	40	10	10		1	1.5	2.6	100	94	70	85
19/0.052	25	50	6	6		1	2	1.6	130	125	91	110
19/0.064	35	60	6	6			2	1.2	155	160	112	136
19/0.072	50	70	6	6			2	0.93	185	195	136	164
19/0.083	70	100	1/0	1/0			2	0.65	225	245	173	207
37/0.072	95	120	1/0	1/0			2.5	0.48	270	300	216	253
37/0.083	120	150	1/0	1/0			2.5	0.4	310	350	244	291
37/0.093	150	200	1/0	1/0			3	0.34	350	405		333
37/0.130	185	250	3/0	3/0			3.5	0.29	390	460		381
61/0.093	240	300	3/0	3/0			4	0.24	450	555		452
61/0.103	300	425	3/0	3/0			4	0.22	515	640		526
91/0.093	400	585	3/0	3/0			6	0.2	586	770		639
91/0.103	500	685	3/0	3/0			6	0.18	680	900		752
127/0.103	630	800	3/0	3/0			6	0.17	800	1030		855

A : *Single core cable construction diameter, inch .... as per Imperial Standard Size : B.S.S (old).*
B : *Single core cable construction area, mm^2 .... as per Metric Standard Size : VDE.*
C : *CB designed current rating amps.*
D : *ECC (Earth Continuity Conductor), SWG.*
E : *EL (Earthing Lead), SWG*
F : *No. of cables in*
  a') 3/4" diameter conduit
  b') 1" diameter conduit
G : *GI pipe diameter (for 4 – core cable), inch.*
H : *Volt drop /amp/meter, Vd in mV (For PVC insulated, non-armoured single core cable 600/1000 volts as per BICC Metric Supplement, page 20-22, September 1969).*
I : *Maximum Current rating (For Type : NYY to VDE 0271/3, 69)*
  a") 30^0 C ambient temperature, underground, amps
  b") 35^0 C ambient temperature in air, amps
J : *Maximum current carrying capacity (For Type : BYA to B.S. 6004 : 1975)*
  a"') Bunched & Enclosed in conduit, two cables single phase at 35^0 C, amps
  b"') Clipped to a surface or on a cable tray bunched and un-enclosed two cables single phase at 35^0 C, amps
NYY : *PVC insulated and PVC sheathed cable, rated voltage 600/1000 volts.*
BYA : *PVC insulated non-sheathed single core cable, rated voltage 450/750 volts.*