BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

MODERN BUILDING ESD DESIGN PROJECT

EEE414
Electrical Service Design Sessional

Making home a happy place.

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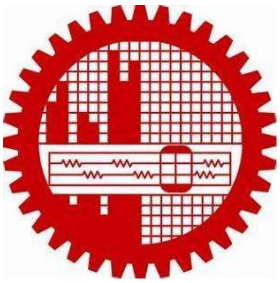
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Department of Electrical and Electronic Engineering



Course No.: EEE 414

Course Title: Electrical Services Design Laboratory

11 December 2024

Electrical Services Design Project

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Contribution Sheet

Topic	Topic Breakdown	Contribution
Layout	Typical Floor Plan	1906070 - Md. Mostaqul Islam, 1906090 - Mir Noushad Hussain
	Rooftop Plan	
	Ground Floor Plan	
	Basement Plan	
Fitting and Fixture Calc	Room Dimensions and Area	1906080 - Md. Liton Ali, 1906070 - Md. Mostaqul Islam
	Room and RI Calculation	
	Room and UF Calculation	
	Room and Light Requirement Calculation	
	Room and Fan and Ac Connections	
	Light Optimisation with Rating Mix	
Conduit Draw	Room to SB Draw	1906090 - Mir Noushad Hussain
	SB to SDB Draw	
	SB to ESDB Draw	
SB Load Calc	SB to Fitting Load Calc	1806052 - Shakil Ahammad
	SDB to SB Load Calc	
	Wire Rating Selection Chart	
	Circuit Breaker Calculation for SDB to CKT	
	Fitting Fixture Rating Summary and Sample Internet Downloaded Picture	
	Conduit Legend	
EMDB	ESDB Load Calculation	1906081 - Anindya Kishore Choudhury
	Generator Rating Calculation	
	Lift Load Calculation	
	Lift Machine Room Inclusion in Rooftop	
	AVR Rating Calculation	
	Generator Room Size Calculation	
	Corresponding circuit breaker calculation EMDB to ESDB	
	EMDB Board Diagram Draw	
MDB	SDB Load Calculation	1906076 - Md. Abu Sayed Chowdhury, 1906077 - Md. Sharif Uddin
	MDB Diagram Draw	
	MDB to SDB Circuit Breaker Calculation	
	MDB to EMDB circuit Breaker Calculation	
	Pump Rating Calculation	
	PFI Plant Calculation	
	Transformer Rating Calculation	
	Transformer Room Calculation	
	LT SwitchGear Room Inclusion	
Rooftop	Lightning Arrestor Calculation	1906076 - Md. Abu Sayed Chowdhury

Project Objectives:

1. Acquaintance with Floor-Planning

- Study the architectural layout of a typical residential building.
- Understand the design elements such as room dimensions, spacing, and compartmentalization.
- Analyze how floor plans influence electrical layout decisions.

2. Familiarization with Fittings and Fixtures

- Identify various electrical and non-electrical fittings used in residential buildings (e.g., light fixtures, fans, sockets, switches).
- Learn about their installation requirements, types, and specifications.

3. Systematic Drawing of Conduit Layout

- Create detailed diagrams showing the routing of electrical conduits.
- Focus on ensuring safety, accessibility, and aesthetics in the layout.
- Adhere to relevant standards and guidelines (e.g., IEC, NEC).

4. Understanding and Drawing Switchboard Connections

- Learn the components of a switchboard and how they interconnect.
- Include emergency connections (e.g., backup power or emergency lighting circuits).
- Emphasize practical considerations like load balancing and safety measures.

5. Calculation and Placement of Switchboard Components

- Calculate ratings for circuit breakers, transformers, and generators based on the building's load requirements.
- Place these components correctly in the switchboard diagram to ensure efficient operation.

6. Electrical Designing for Lightning Protection

- Understand the principles of lightning protection, including grounding, surge protection, and bonding.
- Design a layout that adheres to relevant codes and minimizes risk to the building and its occupants.

Design Steps:

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

Theory & Conventions:

Calculation of required light in a room of a typical building considers different factors of that room.

Light Requirement:

Number of lights can be measured by this formula.

$$N = \frac{E * W * L}{F * UF * MF}$$

N = Number of lights required

F = luminous flux from each light source (lumen)

E = Luminance level required (lux), varies based on room type (e.g., bedroom, kitchen)

L = Room length (meters)

W = Room width (meters)

UF = Utilization factor (accounts for light distribution within the room)

MF = Maintenance factor (accounts for light loss due to deterioration, typically 0.8)

Utilization factor:

To calculate the utilization factor, we first need to calculate the room index. Room index is defined by the following formula:

$$Room\ index = \frac{L * W}{Mounting\ Height * (L + W)}$$

L = Room length (meters)

W = Room width (meters)

Mounting Height = Distance from luminaire height to work plane height.

Mounting height = Luminaire height – Work plane height

= 9 ft – 3 ft

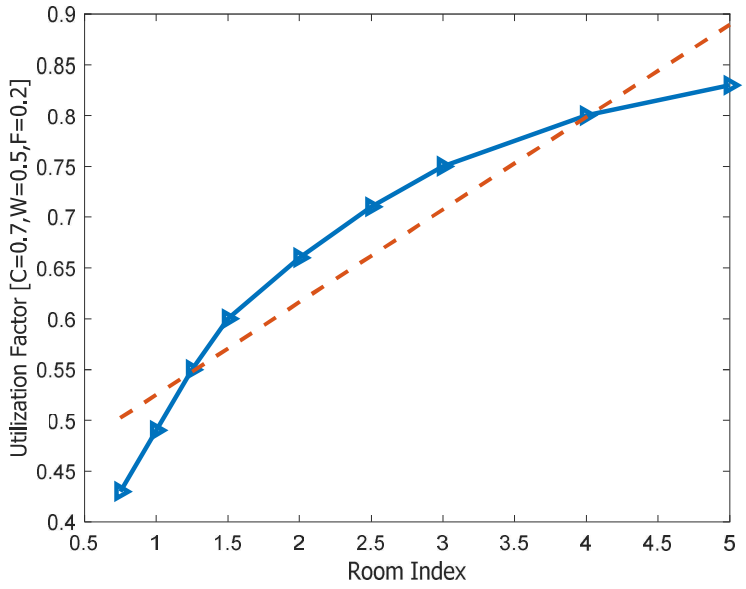
= 6 ft

= 1.828 meter

We also need to know the surface reflectance of ceiling (C), wall (W) and floor(F) of the room. Typically, they are chosen as C = 0.7, W = 0.5 and F = 0.2.

Utilization factor										
Room Reflectance			Room Index							
Ceiling	Wall	Floor	0.75	1	1.25	1.5	2	2.5	3	4	5
0.7	0.5	0.2	0.43	0.49	0.55	0.6	0.66	0.71	0.75	0.8	0.83

From the tabular data shown above, we can readily determine the utilization factor for a particular room index by linear regression for the given C, W and F values.

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c =
    0.0911    0.4340
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Fan Requirement:

For every 100 square feet, one ceiling fan (56”) is needed.

$$Number\ of\ Ceiling\ Fans\ = \frac{A}{100}$$

Here, A is in square feet unit.

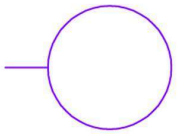
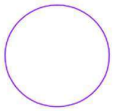
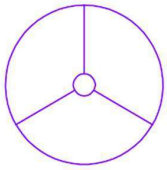
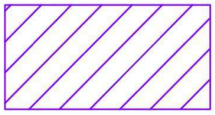
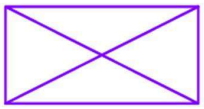
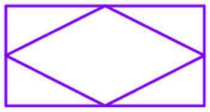
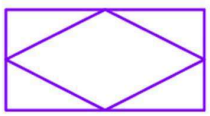
Required Luminescence for Each Room:

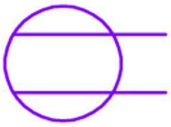
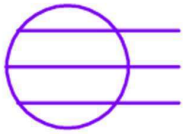
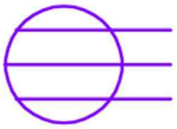
Room Type	Luminous Level (lux)
Dinning Space	100
Living Space-1	100
Living Space-2	100
Kitchen	200
Bedroom-1	100
Bedroom-2	100
Bedroom-3	100
Bedroom-4	100
Balcony-1	70
Balcony-2	70
Balcony-3	70
Storage Room	150
Working Space	300
Toilet	100
Toilet-1	100
Toilet-2	100
Toilet-3	100
Toilet-4	100
Transformer Room	100
LT Switchgear Room	100
Generator Room	100
Guest Room	100
Toilet	100
Guard Room	100
Garage Space	70
Corridor	100
Staircase	100
Lift Room	100
Garage Space	70

Different Bulb and Their Lumen and Watt Rating Table:

Luminous Flux Chart			
Light Type	Symbol	Watt Rating (W)	Lumen Rating (Lumen)
LED Bulb	LB	13	1100
		16	1600
		24	2600
		45	5800
Ceiling Light	CL	6	450
		13	1100
		16	1600
		18	1600
		24	2600
Fluorescent Tube Light	FL	28	1715
		32	1920
		35	2172
		40	2567

Fixture Legend:

Description	Height	Caption	Symbol
Wall Mounted Light	Lintel	LB	
Ceiling Light	Ceiling	CL	
Wall Mounted Tube Light	Lintel	FL	
Fan (56” diameter)	Ceiling	CF	
Switchboard	Mid Wall	SB	
Sub Distribution Board	Mid Wall	SDB	
Main Distribution Board	Mid Wall	MDB	
Emergency Main Distribution Board	Mid Wall	EMDB	

Emergency Sub Distribution Board	Mid Wall	ESDB	
Exhaust Fan (8” diameter)	Lintel	EF	
2 Pin Socket	Mid Wall	SS	
3 Pin Socket 15 A	Mid Wall	P	
3 Pin Socket 20 A	Mid Wall	Q	

Conduit Legend:

Legend	Description	Conduit Size
C1	2 x 1.5 rm BYM	3/4"
C2	4 x 1.5 rm BYM+BYA ECC	3/4"
C3	6 x 1.5 rm BYM + 15 BYA ECC	3/4"
C4	2 x 1.5 rm BYM + 1.5 rm BYA ECC	3/4"
C5	2 x 1.5 rm BYM + 1.5 rm BYA ECC	3/4"
C6	2 x 4 rm BYM + 4 rm BYA ECC	3/4"
C7	2 x 6 rm BYM + 6 rm BYA ECC	1"
C8	4 x 4 rm BYM + 4 rm BYA ECC	1"
C9	4 x 6 rm BYM + 6 rm BYA ECC	1"

Wattage Rating of Light Type, Watt Rating and Used Symbol:

Two types of lighting are used here: LED bulbs and fluorescent-equivalent tube lights. The LED bulb's lumen output serves as the baseline, and the lumens for the tube lights are calculated in comparison. LED bulbs are available in 6W, 13W, 16-18W, 24W, and 45W variants, each chosen based on required lumen levels. Tube lights are used in 28W, 32W, 35W, and 40W options. LED bulbs are labeled as LBxx, tube lights as FLxx, and ceiling-mounted lights are designated as CFxx.

Figure: LED Bulb

Figure: Fluorescent Tube Light

Figure: Ceiling Light

CKT Current Rating:

The circuit current rating is determined based on the total load connected to the circuit. Since the connected loads draw less than 5A, C1 wire has been selected. The C1 wire is rated as 2 x 1.5 rm BYM (3/4") which can carry minimum 5A current.

Power Circuit Introduction, Types, And Ratings Assumed:

A power circuit refers to the 3-pin sockets intended for heavy load connections within the unit. These circuits are divided into two categories: P and Q, with Q circuits designed to support higher loads. Both P and Q circuits connect directly to either the Standard Distribution Board (SDB) or the Emergency Switchboard Distribution Board (ESDB), based on specific requirements. Typically, P circuits are rated for a 3kW load with a 15A current draw, while Q circuits are rated for a 4kW load with a 20A current draw. Each circuit is connected to the SDB with a circuit breaker of suitable current rating to ensure safe operation.

SDB to MDB Current, Breaker Rating & Conduit Rating Calculation:

Add SBD load to P socket and Q socket load multiplying them with their respective distribution factors.

Total SDB Load = SDB Load(without 3 pin) x 0.7 + Total P Socket Load x 0.5 + Total Q Socket Load x 0.3

Divide the Total SDB current by Voltage and PF to find the current drawn by each SDB.

$$SDB\ Current\ = \frac{Total\ SDB\ Load}{Voltage(LN) * pf(0.8)}$$

According to the SDB current, a suitable SP MCCB is used.

Pump Current, Breaker Rating & Conduit Rating Calculation:

The pump is a three phase load. So, the following formula needs to be used for pump current calculation.

$$Pump\ Current\ = \frac{Pump\ \ Load}{\sqrt{3} * Voltage(LL) * pf(0.7)}$$

According to the pump current, a TP MCCB is used as it is a three phase load.

Lift AVR Rating, Current, Breaker Rating & Conduit Rating Calculation:

Lift Current, Breaker Rating & Conduit Rating Calculation:

Assuming the lift to be a 0.7 pf , three phase load, the current drawn by each lift has to calculated using the following formula.

$$Lift\ Current\ = \frac{Lift\ \ Load}{\sqrt{3} * Voltage * pf(0.7)}$$

Then, according to the lift current, a suitable TP MCCB needs to be used.

Lift AVR Rating Calculation:

As the lift is a heavy motor load, fluctuations in its input voltage will cause disruptions while climbing. So, an appropriate Automatic Voltage Regulator needs to be used. The rating of the AVR can be found as follows.

AVR Rating = Lift Load / pf (0.7)

ESDB & Lift to EMDB Current, Breaker Rating & Conduit Rating Calculation:

EMDB consists of all the ESDB loads and all the Lift loads. ESDB and Lift loads have separate power factors. So, their current values are calculated separately and then added to find the total EMDB current. The following formulae are used.

$$EMDB\ Current\ for\ ESDB\ Load\ = \frac{Total\ ESDB\ Load}{\sqrt{3} * Voltage(LL) * pf(0.8)}$$

$$EMDB\ \ Current\ for\ Lift\ Load\ = \frac{Lift\ \ Loadx0.7}{\sqrt{3} * Voltage(LL) * pf(0.7)}$$

Generator to EMDB to MDB Calculation:

ESDB and Lift get its supply from the generator in case of load- shedding or other power crisis. Since all loads will hardly remain active simultaneously, we have calculated their sum with diversity factor for estimating generator rating. The formula is as follows.

Generator Rating(kW) = 0.7 x Lift Load (kW) + ESDB Load (kW)

Here, 0.7 multiplier is the diversity factor for Lift load. To calculate the circuit breaker rating the line to line voltage of the generator is taken 381 V and the power factor is assumed to be 0.7 for Lift load and 0.8 for ESDB load.

SDB to EMDB to MDB calculation of Wire, Breaker and Conduit:

In the MDB , EMDB has additional connections through generators and SDB loads are connected with the main grid only. Diversity factor for Pump load is taken 0.7 as it will not remain active all the time. The formula for MDB load is:

MDB Load (kW) = SDB Load (kW) + EMDB Load (kW) + 0.7 X Pump Load (kW)

Here, 0.7 multiplier is the diversity factor for Pump load. Since a PFI plant was installed. We assume it would improve the power up to 0.95. Hence, the load at MDB is.

$$I\,(A) = \frac{MDB\ Load\ (W)}{\sqrt{3} * 381 * 0.95}$$

PFI Plant Calculation:

Inductive loads such as pump, lifts have high reactive power requirements. This increases the loss in transmission lines. To mitigate this loss, a capacitor bank is installed to make the power factor close to 1.

Fig: Capacitor Bank

For PFI calculation, First the real power requirements of different parts of circuits are calculated. In our system we assumed devices with two different kinds of power factor. Power factor for normal load is 0.8. For heavy loads such as pumps and lift the power factor is 0.7. To calculate the real power, we use notation as follows.

$$P1 = \text{Load with 0.8 pf.}$$

$$P2 = \text{Load with 0.7 pf.}$$

From real power, we calculate the reactive power requirement.

$$Q1 = P1 \times \tan(\cos^{-1}(0.8))$$

$$Q2 = P2 \times \tan(\cos^{-1}(0.7))$$

So, total reactive power required.

$$Q = Q1 + Q2$$

After PFI plant installation, power factor will be 0.95. Then, the required reactive power from capacitor bank.

$$Q_{required} = Q - (P1+P2) * \tan(\cos^{-1}(0.95))$$

Hence, we need to install a capacitor bank that can supply this reactive power.

PFI Plant to MDB Calculation:

Assuming the capacitor bank is purely capacitive, the local power factor of the capacitor bank is 1. Now current rating of PFI plant is.

$$I(A) = \frac{Qrequied\ (VAR)}{\sqrt{3} * 381 * 1}$$

Transformer Rating Calculation:

Transformer Capacity is calculated by multiplying the line to line voltage with line current and square root of three, as it is a three phase element.

The Capacity is found using the following formula,

$$\text{Transformer Capacity} = \text{sqrt}(3) \times \text{Voltage(LL)} \times \text{Line Current}$$

Then according to the capacity an appropriately rated Transformer is selected for service.

Lightning Arrester Theory and Risk Assessment:

A lightning arrester, also known as a surge arrester, is a device used to protect electrical equipment from the high-voltage surges associated with lightning strikes and other transient over-voltages. The primary function of a lightning arrester is to divert

the surge away from sensitive equipment to the ground, thereby preventing potential damage.

For lightning arrester below standards are taken.

Figure : Lightning Arrester

Index	Parameter	Class	Value
A	Use of Structure	Houses and similar buildings	2
B	Type of Construction	Brick, plain concrete or masonry with nonmetal roof	4
C	Contents of Consequential Effects	Ordinary domestic of office building, factories and workshops not containing valuable materials	2
D	Degree of Isolation	Located in a large area having structures of similar or greater height	2
E	Type of Terrain	Flat terrain at any level	2
F	Height of Structure	38-46 m	22
G	Lighting Prevalence	Over 21	21
Total			55

Recommendation for Lightning Arresters:

- Risk assessment factor < 40, lightning protection system is not mandatory and can be used for increased safety.
- There should be at least one air terminal per 80m2 .
- Every comer must have one air terminal
- Roof conductor should be placed 25’ apart.
- If the roof area is greater than 80m2, Formula for number of down conductor.

$$Number\ of\ down\ conductor = \frac{A(sq.meter) - 80}{100} + \mathbf{i}$$

Lightning Arrester Calculation:

Lightning arresters must be placed 25’ or 7.62m apart. Hence the formulas are.

$$Number\ of\ Lightning\ Arrester\ Along\ Length = \frac{Roof\ Length\ (m)}{7.62}$$

$$Number\ of\ Lightning\ Arrester\ Along\ Width = \frac{Roof\ Width\ (m)}{7.62}$$

$$Number\ of\ Down\ Conductor = \frac{A(sq.meter) - 80}{100} + 1$$

Summary Tables and Sample Calculation:

Room Dimensions and Area:

Floor Type	Room Type	Luminous Flux (lm)	E (lux)	Length (ft-inch)	Width (ft-inch)	Length (m)	Width (m)	Area (ft2)	Area (m2)
Typical Floor	Dinning Space	2172	100	10'-7"	7'-9"	3.23	2.36	82.02	7.62
	Living Space-1	2600	100	25'-7"	15'-5"	7.80	4.70	394.41	36.64
	Living Space-2	2600	100	16'-6"	13'-1"	5.03	3.99	215.87	20.06
	Kitchen	2600	200	12'-6"	8'-8"	3.81	2.64	108.33	10.06
	Bedroom-1	1600	100	12'-10"	10'-0"	3.91	3.05	128.33	11.92
	Bedroom-2	2600	100	16'-0"	9'-9"	4.88	2.97	156.00	14.49
	Bedroom-3	2600	100	16'-8"	12'-8"	5.08	3.86	211.11	19.61
	Bedroom-4	1920	100	8'-8"	7'-11"	2.64	2.41	68.61	6.37
	Balcony-1	1600	70	15'-5"	5'-0"	4.70	1.52	77.08	7.16
	Balcony-2	1100	70	9'-1"	5'-2"	2.77	1.57	46.93	4.36
	Balcony-3	1600	70	15'-2"	4'-5"	4.62	1.35	66.99	6.22
	Storage Room	1600	150	7'-5"	4'-6"	2.26	1.37	33.37	3.10
	Working Space	5800	300	12'-2"	9'-9"	3.71	2.97	118.62	11.02
	Toilet-1	1600	100	8'-4"	6'-0"	2.54	1.83	50.00	4.65
	Toilet-2	1100	100	7'-3"	4'-9"	2.21	1.45	34.44	3.20
	Toilet-3	1600	100	7'-5"	6'-2"	2.26	1.88	45.74	4.25
	Toilet-4	450	100	3'-10"	3'-6"	1.17	1.07	13.42	1.25
Ground Floor	Xformer Room	2600	100	16'-8"	14'-0"	5.08	4.27	233.33	21.68
	LT SGear Room	2600	100	11'-2"	7'-5"	3.40	2.26	82.82	7.69
	Generator Room	2600	100	16'-11"	9'-4"	5.16	2.84	157.89	14.67
	Guest Room	1600	100	15'-8"	8'-0"	4.78	2.44	125.33	11.64

	Toilet	1600	100	9'-9"	4'-5"	2.97	1.35	43.06	4.00
	Guard Room	1600	100	5'-9"	5'-6"	1.75	1.68	31.62	2.94
	Garage Space	2600	70	87'-10"	34'-2"	26.77	10.41	3000.97	278.80
Roof Top	Corridor	2600	100	16'-8"	6'-10"	5.08	2.08	113.89	10.58
	Staircase	2600	100	16'-8"	7'-10"	5.08	2.39	130.56	12.13
	Lift Room	1600	100	15'-10"	7'-10"	4.83	2.39	124.03	11.52
Basement	Garage Space	2600	70	112'-2"	34'-2"	34.19	10.41	3832.36	356.04

Conventionally the measurements are in feet-inch. But for some specific calculation feet-inch has been converted to meter (m).

1 feet = 12 inch, 1 inch = 2.54 cm.

Room Index Calculation:

Floor Type	Room Type	Length (m)	Width (m)	Room Index (RI)	Mounting Height
Typical Floor	Dining Space	3.23	2.36	0.75	6 ft
	Living Space-1	7.8	4.7	1.6	
	Living Space-2	5.03	3.99	1.22	
	Kitchen	3.81	2.64	0.85	
	Bedroom-1	3.91	3.05	0.94	
	Bedroom-2	4.88	2.97	1.01	
	Bedroom-3	5.08	3.86	1.2	
	Bedroom-4	2.64	2.41	0.69	
	Balcony-1	4.7	1.52	0.63	
	Balcony-2	2.77	1.57	0.55	
	Balcony-3	4.62	1.35	0.57	
	Storage Room	2.26	1.37	0.47	

	Working Space	3.71	2.97	0.9	
	Toilet-1	2.54	1.83	0.58	
	Toilet-2	2.21	1.45	0.48	
	Toilet-3	2.26	1.88	0.56	
	Toilet-4	1.17	1.07	0.31	
Ground Floor	Xformer Room	5.08	4.27	1.27	
	LT SGear	3.40	2.26	0.74	
	Generator Room	5.16	2.84	1	
	Guest Room	4.78	2.44	0.88	
	Toilet	2.97	1.35	0.51	
	Guard Room	1.75	1.68	0.47	
	Garage Space	26.77	10.41	4.1	
Roof Top	Corridor	5.08	2.08	0.81	
	Staircase	5.08	2.39	0.89	
	Lift Room	4.83	2.39	0.87	
Basement	Garage Space	34.19	10.41	4.37	

The room index has been calculated using formula,

$$RI = \frac{Length * Width}{(length+width) * Mounting\ Height}$$

We have taken mounting height same for all the room that is 6ft. (Room height - table height).

For lift room,

length = 4.83 m

width = 2.39 m

mounting height = 6ft = 1.828 m

RI = 0.87

Utilization Factor Calculation:

Floor Type	Room Type	Room Index (RI)	Utilization Factor (UF)	Reflectance of Floor, Wall and Ceiling
Typical Floor	Dining Space	0.75	0.50	C = 0.7, W = 0.5 and F = 0.2
	Living Space-1	1.6	0.58	
	Living Space-2	1.22	0.54	
	Kitchen	0.85	0.51	
	Bedroom-1	0.94	0.52	
	Bedroom-2	1.01	0.53	
	Bedroom-3	1.2	0.54	
	Bedroom-4	0.69	0.50	
	Balcony-1	0.63	0.49	
	Balcony-2	0.55	0.48	
	Balcony-3	0.57	0.49	
	Storage Room	0.47	0.48	
	Working Space	0.9	0.52	
	Toilet-1	0.58	0.49	
	Toilet-2	0.48	0.48	
	Toilet-3	0.56	0.49	
	Toilet-4	0.31	0.46	
Ground Floor	Xformer Room	1.27	0.55	
	LT SGear Room	0.74	0.50	
	Generator Room	1	0.53	
	Guest Room	0.88	0.51	
	Toilet	0.51	0.48	

	Guard Room	0.47	0.48	
	Garage Space	4.1	0.81	
Roof Top	Corridor	0.81	0.51	
	Staircase	0.89	0.51	
	Lift Room	0.87	0.51	
Basement	Garage Space	4.37	0.83	

C = 0.7, W = 0.5 and F = 0.2 have been taken as the reflectance constant for ceiling, wall and floor. For the reference table, a linear interpolation was adopted. The linear interpolation was,

For the lift room RI = 0.87 and UF = 0.51

Room and Light Requirement Calculation:

Floor Type	Room Type	Utilization Factor (UF)	Luminous Flux (lm)	E (lux)	Maintenance Factor	Number of lights (N)	LED Bulb (Watt)	Tube Light (Watt)
Typical Floor	Dining Space	0.43	2172	100	0.8	0.87	Null	35
	Living Space-1	0.63	2600	100		3.04	24, 24	35
	Living Space-2	0.54	2600	100		1.77	24	35
	Kitchen	0.45	2600	200		1.89	24, 24	Null
	Bedroom-1	0.47	1600	100		1.79	18	28
	Bedroom-2	0.49	2600	100		1.32	24	28
	Bedroom-3	0.54	2600	100		1.74	24	35
	Bedroom-4	0.42	1920	100		0.84	Null	32
	Balcony-1	0.4	1600	70		0.80	18	Null
	Balcony-2	0.38	1100	70		0.72	13	Null
	Balcony-3	0.39	1600	70		0.70	16	Null
	Storage Room	0.36	1600	150		0.76	18	Null

Floor Type	Room Type	Utilization Factor (UF)	Luminous Flux (lm)	E (lux)	Maintenance Factor	Number of lights (N)	LED Bulb (Watt)	Tube Light (Watt)
	Working Space	0.47	5800	300		1.38	45	40
	Toilet-1	0.39	1600	100		0.75	16	Null
	Toilet-2	0.36	1100	100		0.76	13	Null
	Toilet-3	0.38	1600	100		0.68	16	Null
	Toilet-4	0.32	450	100		0.75	6	Null
Ground Floor	Xformer Room	0.55	2600	100		1.90	24, 24	Null
	LT SGear Room	0.43	2600	100		0.74	24	Nu;;
	Generator Room	0.49	2600	100		1.34	24, 16	Null
	Guest Room	0.46	1600	100		1.77	18, 18	Null
	Toilet	0.37	1600	100		0.65	18	Null
	Guard Room	0.36	1600	100		0.48	16	Null
	Garage Space	1.23	2600	70		11.62	24x7,16x2	Null
Roof Top	Corridor	0.44	2600	100		1.00	24	Null
	Staircase	0.46	2600	100		1.13	24	Null
	Lift Room	0.46	1600	100		1.75	18, 18	Null
Basement	Garage Space	1.30	2600	70		14.40	24x10	Null

Number of lights can be measured by this formula.

$$N = \frac{E * W * L}{F * UF * MF}$$

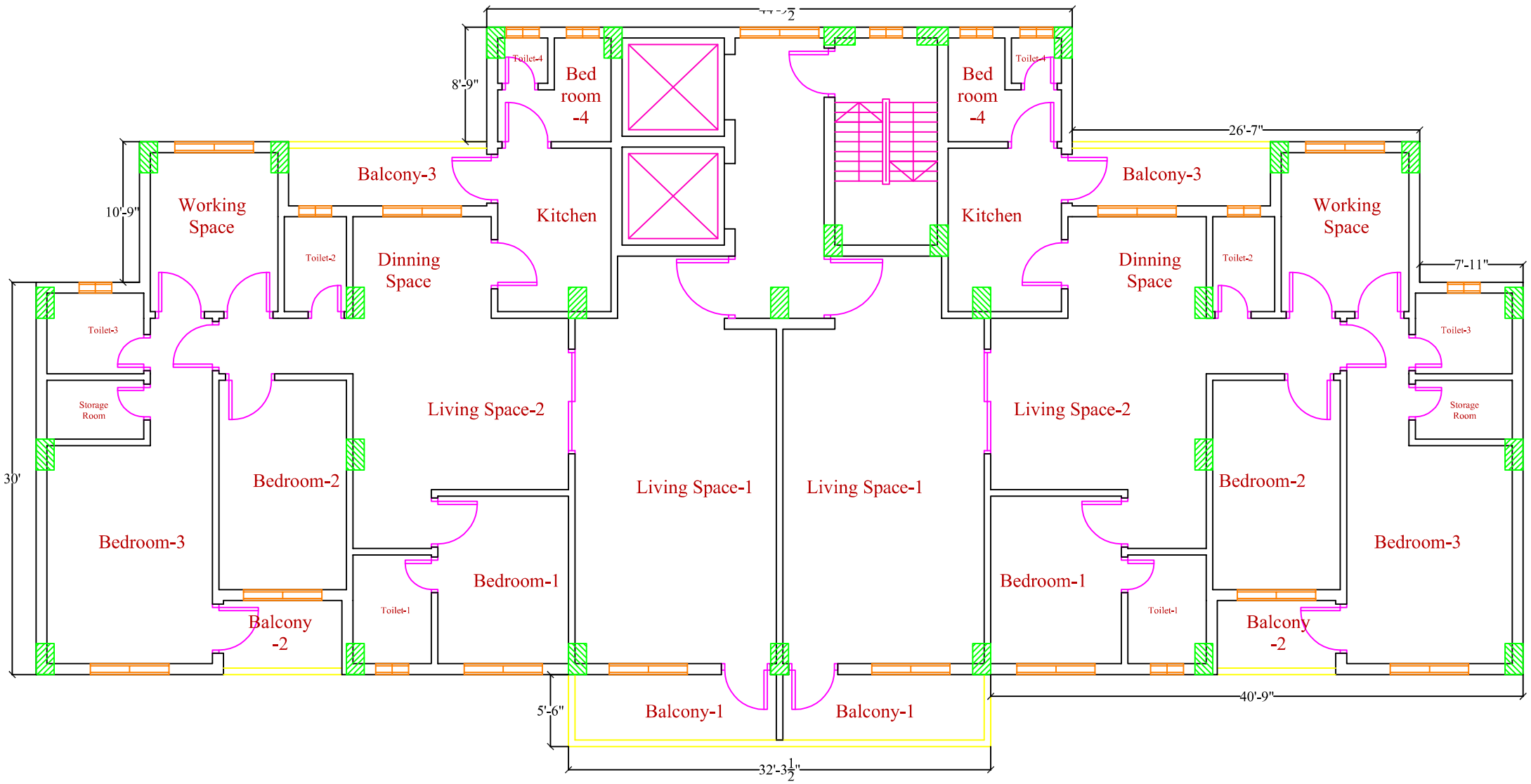
For the living space-1, the calculated required light 2.77 . Taking based luminous flux 2600 lumens, total lumens requirement is 7200 lumens. 2 LED bulbs of 24 W having

luminous flux 2600 lumens and for rest of the lumens, a tube light of 35W 2172 lumens have been used.

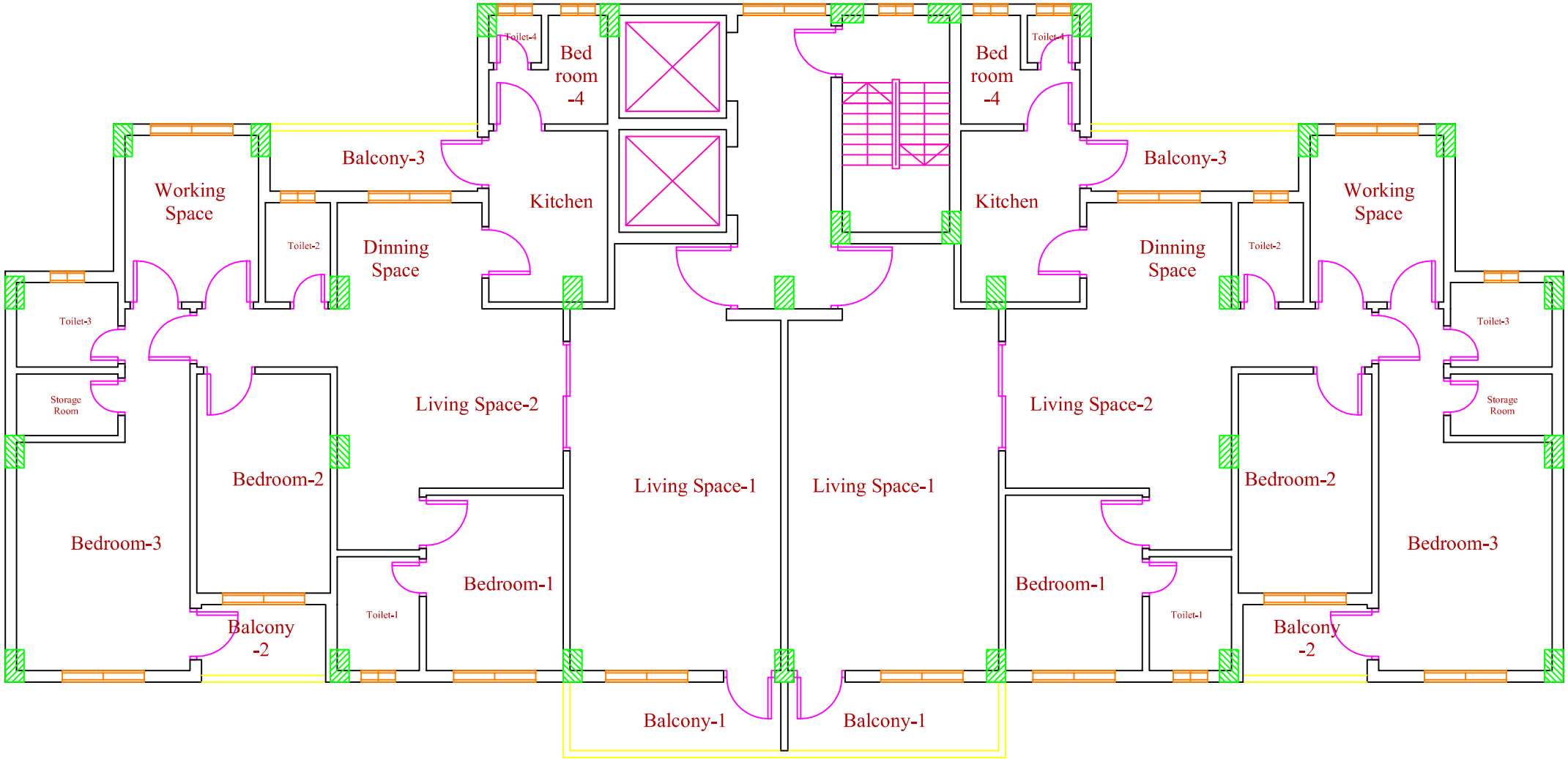
Room and Fan and AC Connections:

Floor Type	Room Type	Area (m2)	Fans	AC
Typical Floor	Dining Space	7.62	1	N
	Living Space-1	36.64	3	Y
	Living Space-2	20.06	1	N
	Kitchen	10.06	0	N
	Bedroom-1	11.92	1	Y
	Bedroom-2	14.49	1	Y
	Bedroom-3	19.61	1	Y
	Bedroom-4	6.37	1	N
	Balcony-1	7.16	0	N
	Balcony-2	4.36	0	N
	Balcony-3	6.22	0	N
	Storage Room	3.1	0	N
	Working Space	11.02	1	Y
	Toilet-1	4.65	0	N
	Toilet-2	3.2	0	N
	Toilet-3	4.25	0	N
	Toilet-4	1.25	0	N
Ground Floor	Xformer Room	21.68	0	N
	LT SGear Room	7.69	0	N
	Generator Room	14.67	0	N
	Guest Room	11.64	1	N
	Toilet	4	0	N
	Guard Room	2.94	1	N

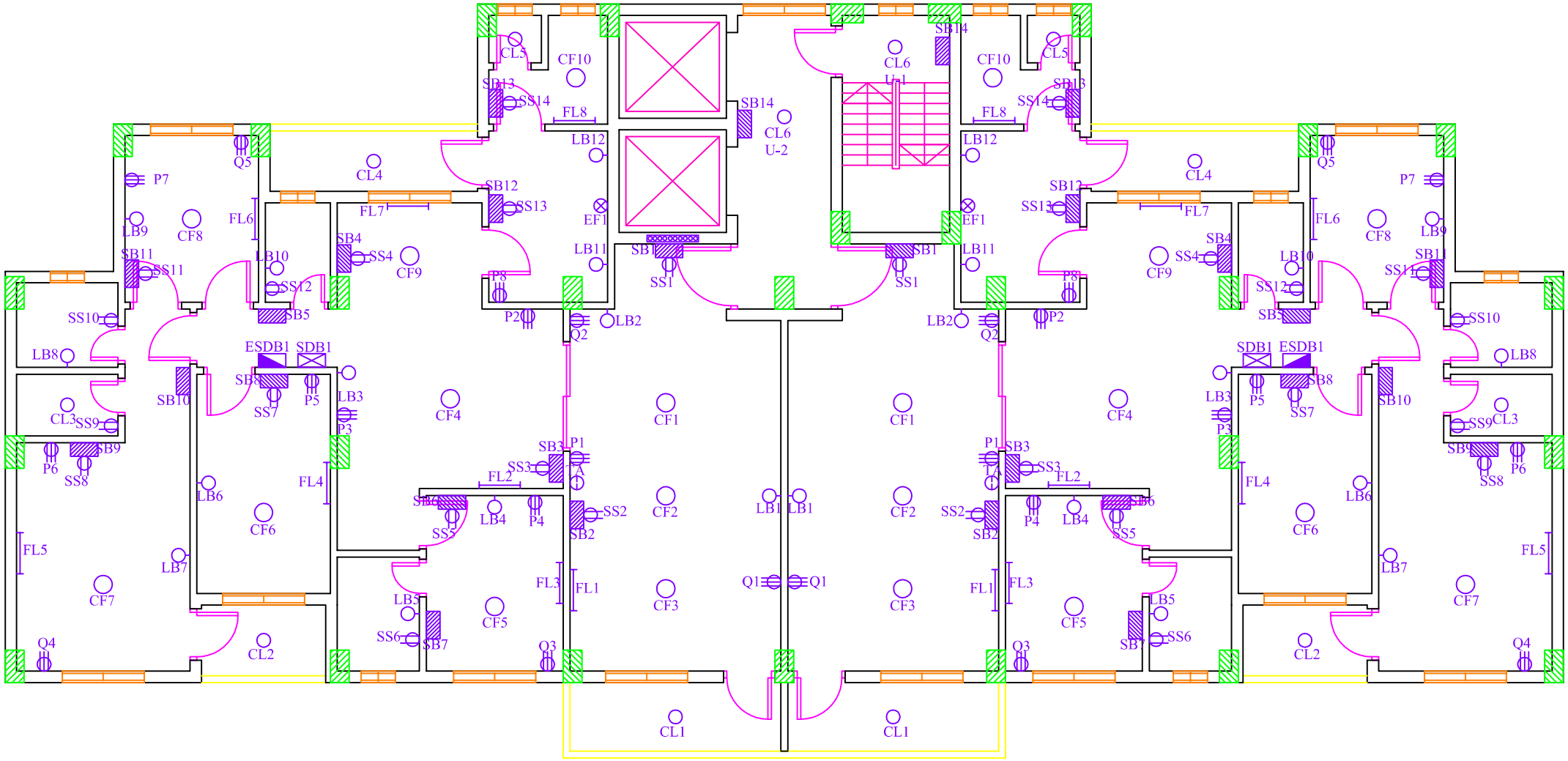
Typical Floor Plan with Dimensions



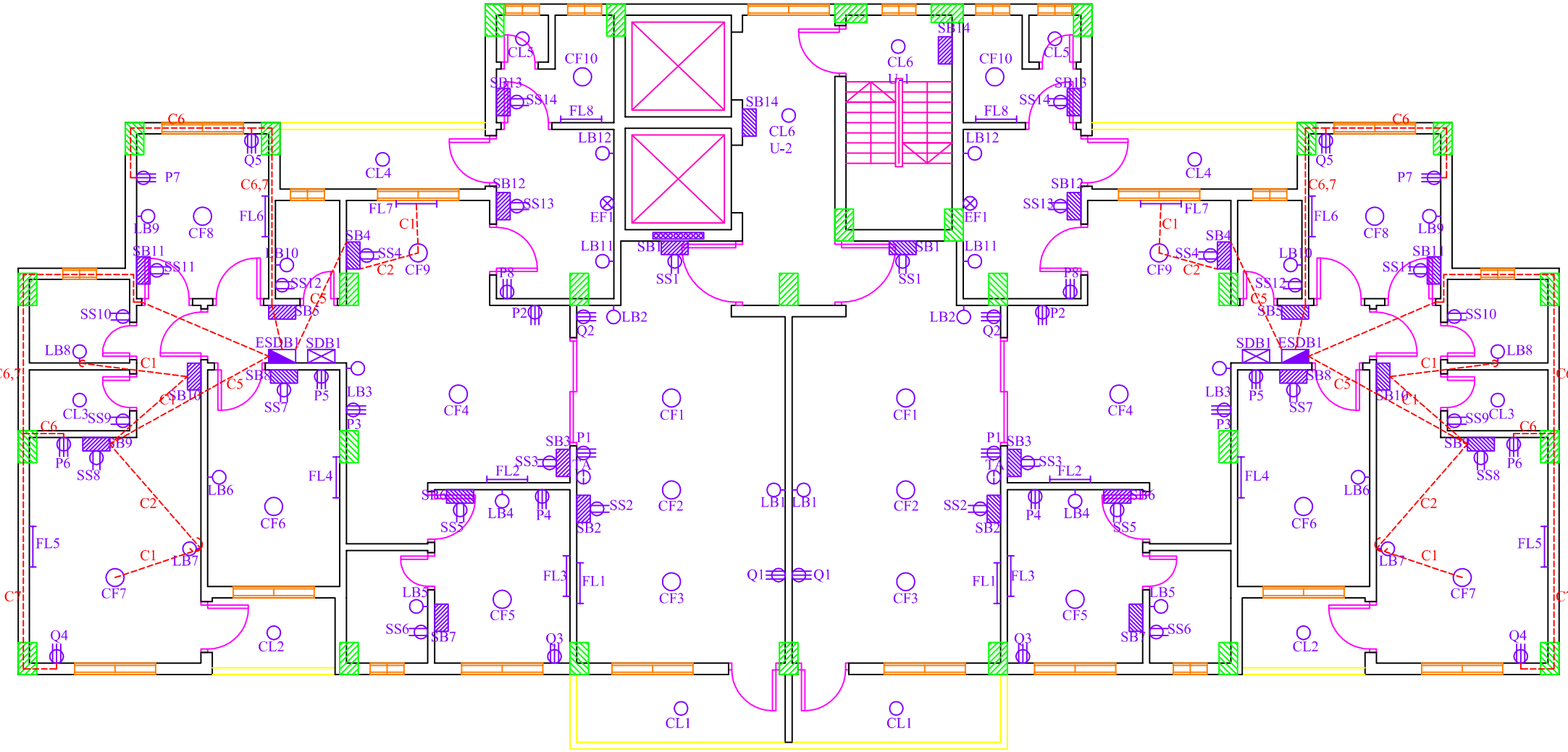
Typical Floor Layout (Just Layout)



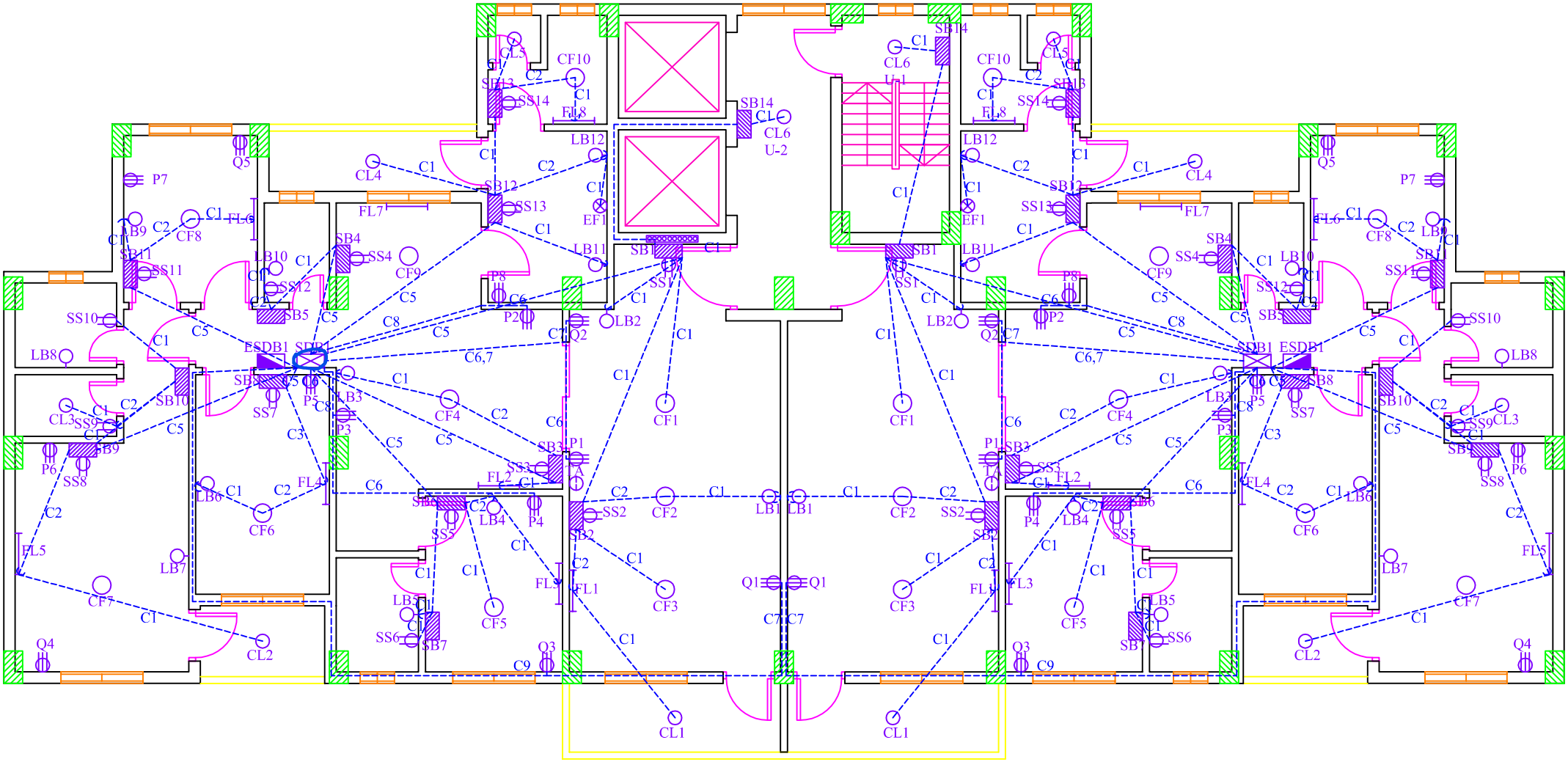
Typical Floor Fixtures and Fittings (No Wire)



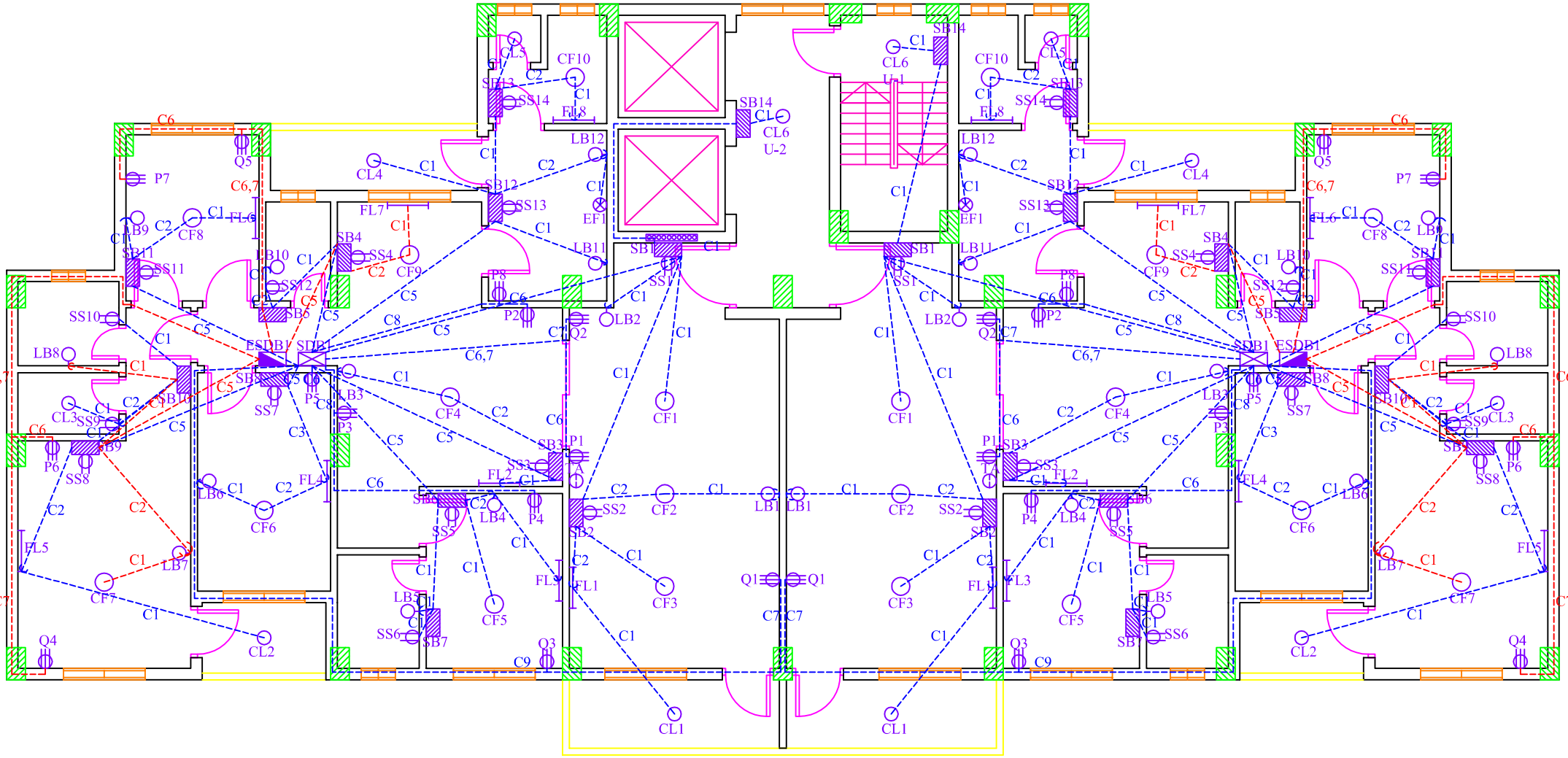
Typical Floor Only Emergency Conduit



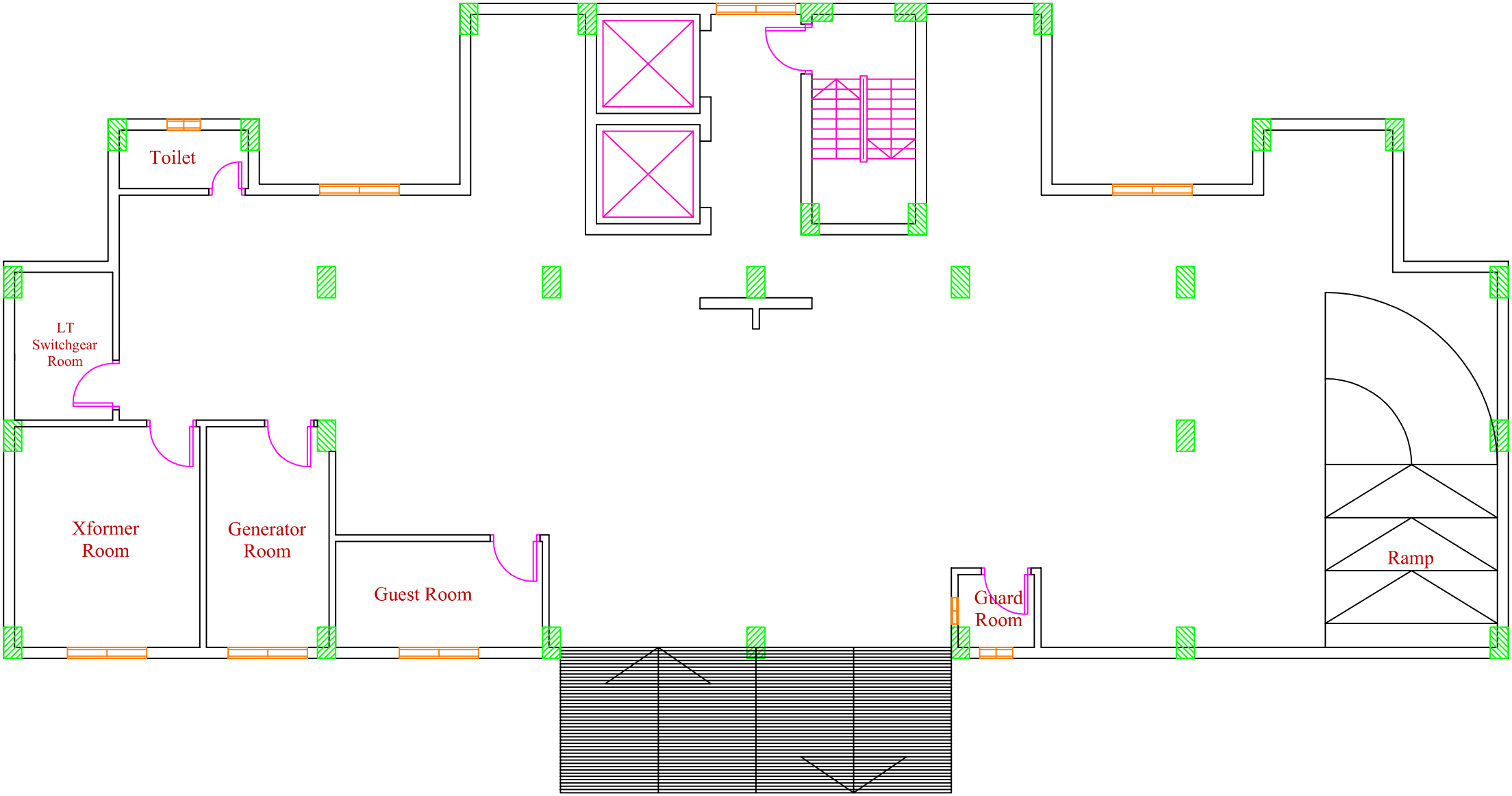
Typical Floor Conduit (without emergency)



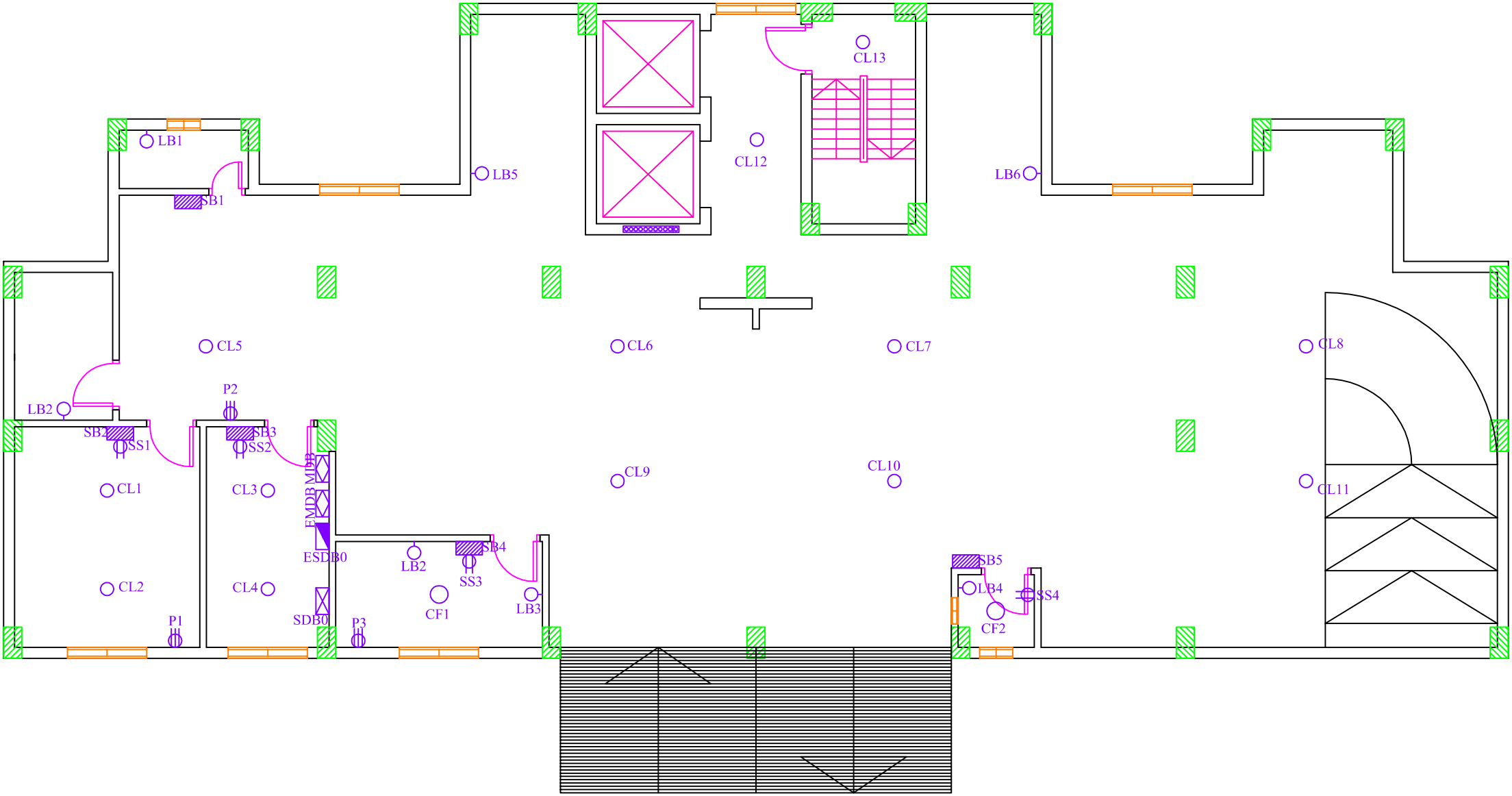
Typical Floor Total Conduit



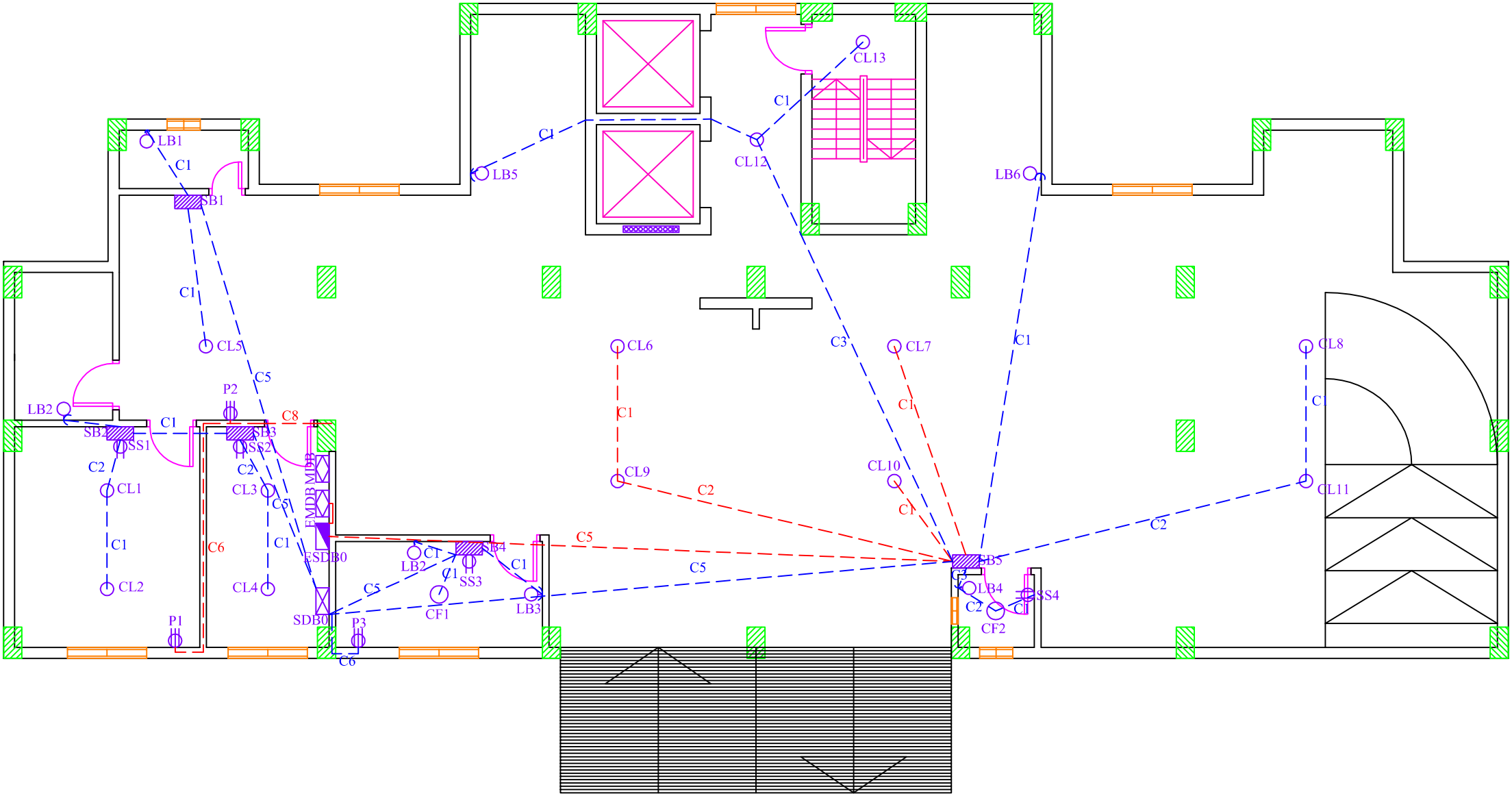
Ground Floor Layout



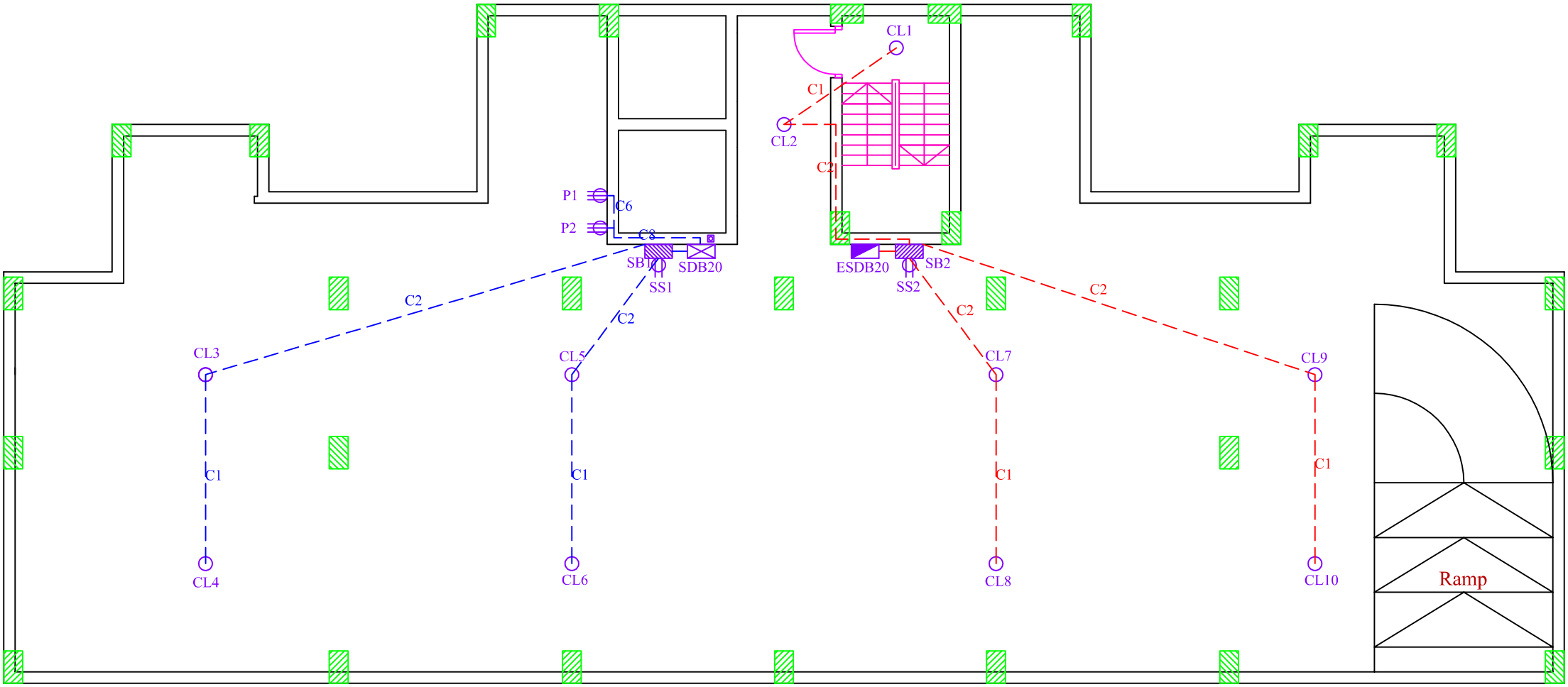
Ground Floor Fixtures and Fittings (No Wire)



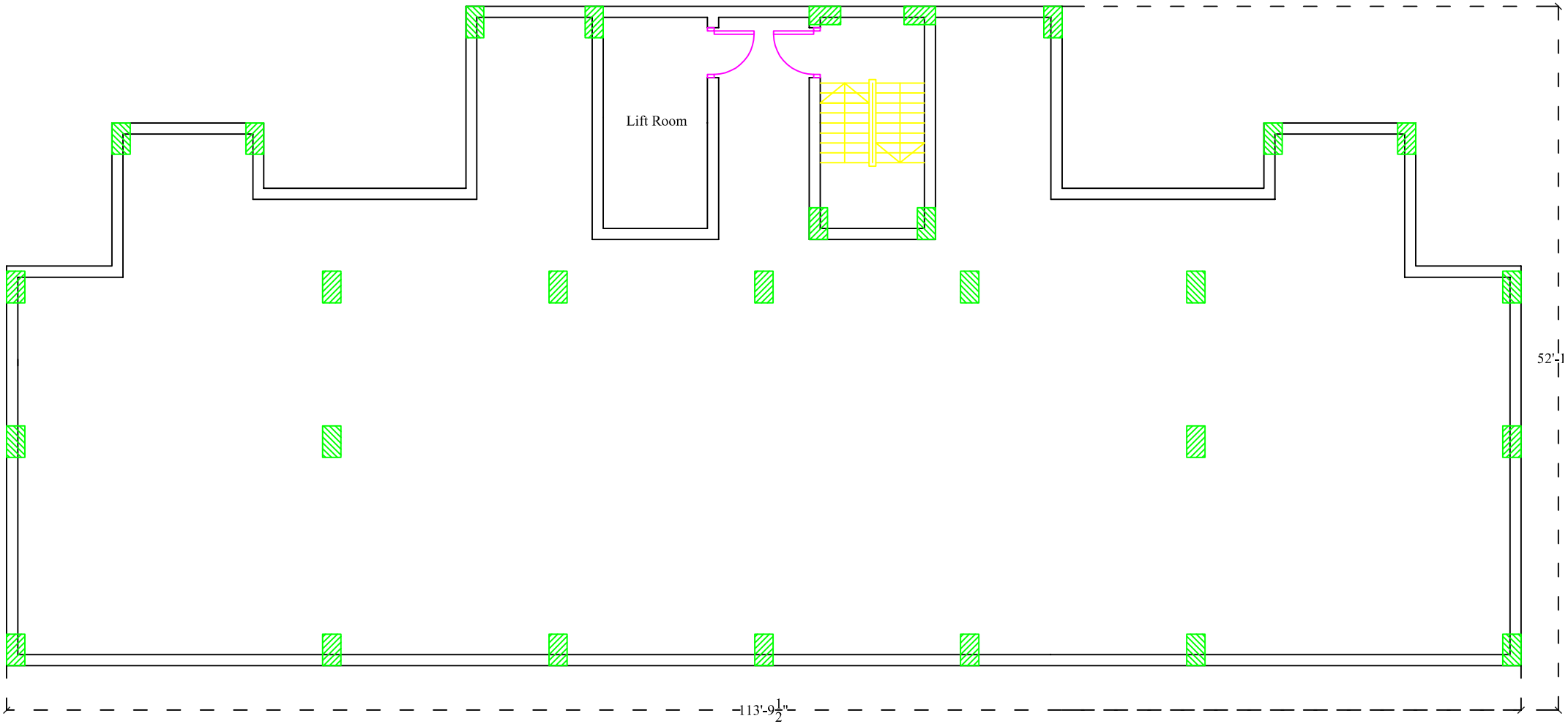
Ground Floor Conduit



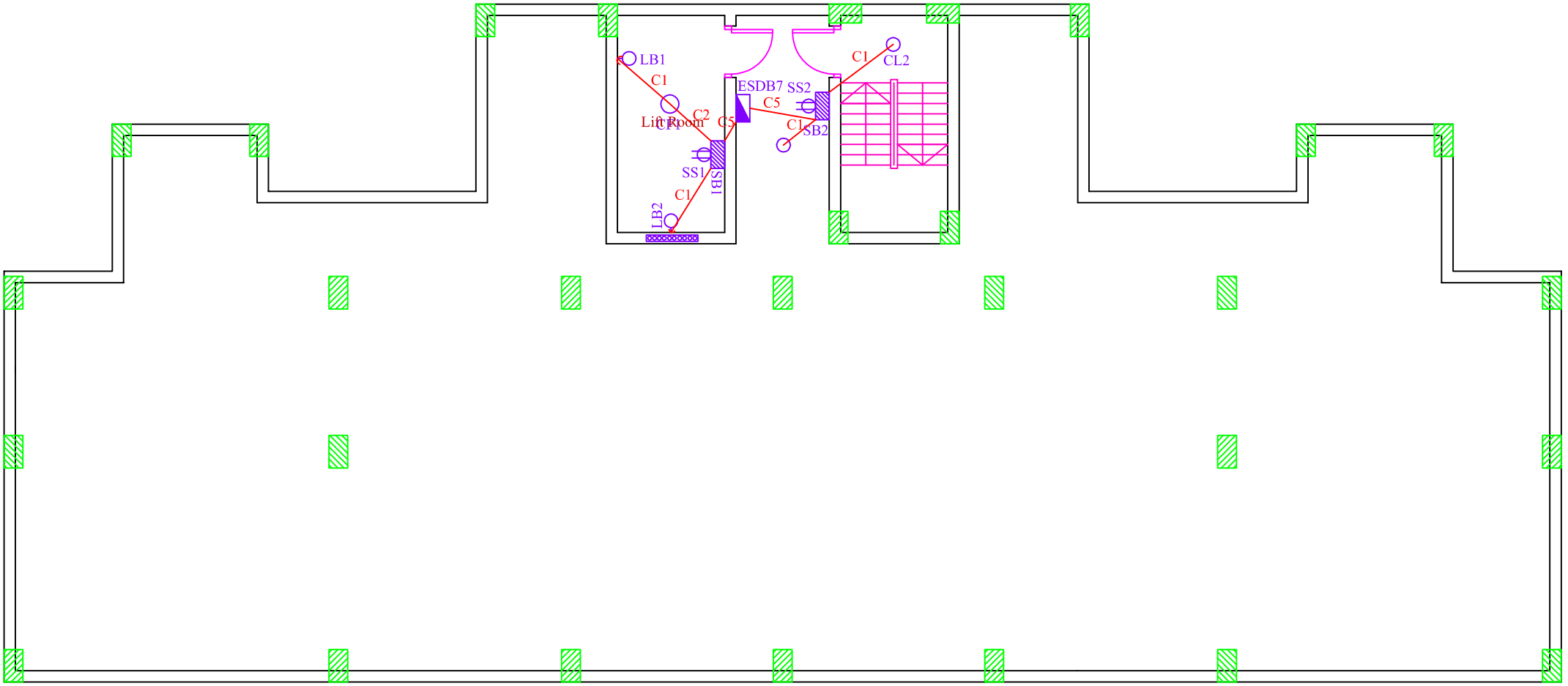
Basement Conduit



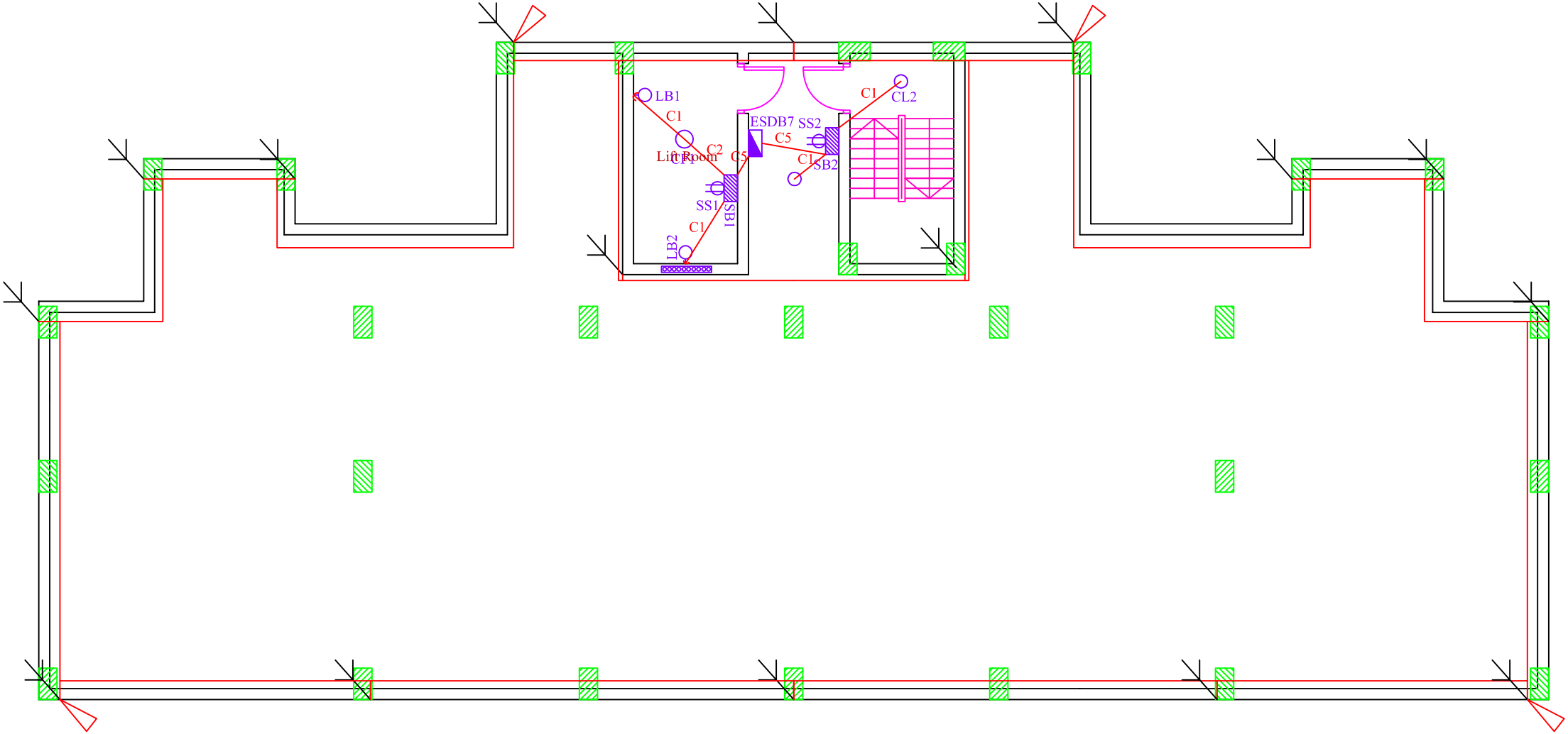
Roof Layout



Roof Conduit



Lightning Arrester



	Garage Space	278.8	0	N
Roof Top	Corridor	10.58	0	N
	Staircase	12.13	0	N
	Lift Room	11.52	0	N
Basement	Garage Space	356.04	0	N

For every 100 square feet, one ceiling fan (56”) is needed.

$$Number\ of\ Ceiling\ Fans\ = \frac{A}{100}$$

Here, A is in square feet unit. For a larger room and bedroom an AC has also been recommended.

Circuit Wise SDB Connection and Calculation for Typical Floor Plan:

Sub Distribution Board 1 (SDB1) Fixtures									
Room Name	Circuit No.	Switchboard	Connected To	Fixture	Power (W)	Power Per CKT (W)	Current Rating (A)	Conduit Rating	Breaker to SDB (A)
Staircase/Corridor, Living Space-1 & Balcony-1	CKT1	SB1	SDB1	CF1	100	625	3.55	C5	5
				LB2	24				
				SS1	100				
		SB14	SB1	CL6	24				
		SB2	SB1	LB1	24				
				CF2	100				
				SS2	100				
				CF3	100				
				FL1	35				
				CL1	18				
Living Space-2	CKT2	SB3	SDB1	CF4	100	259	1.47	C5	5
				LB3	24				
				FL2	35				
				SS3	100				

Dinning Space	CKT3	SB4	SDB1	----	0	113	0.64	C5	5
		SB5	SB4	SS12	100				
				LB10	13				
Bedroom-1 & Toilet-1	CKT4	SB6	SDB1	CF5	100	375	2.13	C5	5
				LB4	24				
				SS5	100				
				FL3	35				
		SB7	SB6	LB5	16				
				SS6	100				
Bedroom-2	CKT5	SB8	SDB1	FL4	28	252	1.43	C5	5
				SS7	100				
				CF6	100				
				LB6	24				
Bedroom-3, Toilet-3, Storage Space & Balcony-2	CKT6	SB9	SDB1	SS8	100	366	2.08	C5	5
				FL5	35				
				CL2	13				
		SB10	SB9	CL3	18				
				SS9	100				
				SS10	100				
Working Space	CKT7	SB11	SDB1	SS11	100	285	1.62	C5	5
				LB9	45				
				CF8	100				
				FL6	40				
Kitchen, Bedroom-4, Toilet-4, Balcony-3	CKT8	SB12	SDB1	SS13	100	442	2.51	C5	5
				LB11	24				
				CL4	16				
				LB12	24				
				EF1	40				
		SB13	SB12	SS14	100				
				CL5	6				
				CF10	100				

				FL8	32				
Total					2717				

Circuit Wise SDB Connection and Calculation for Ground Floor Plan:

Sub Distribution Board 0 (SDB0) Fixtures									
Room Name	Circuit No.	Switchboard	Connected To	Fixture	Power (W)	Power Per CKT (W)	Current Rating (A)	Conduit Rating	Breaker to SDB (A)
Toilet	CKT1	SB1	SDB0	LB1	18	42	0.24	C5	5
				CL5	24				
Generator Room, Xformer Room & LT Switchgear Room	CKT2	SB2	SB3	SS1	100	312	1.77	C5	5
				CL1	24				
				CL2	24				
				LB5	24				
		SB3	SDB0	SS2	100				
				CL3	24				
				CL4	16				
Guest Room	CKT3	SB4	SDB0	SS3	100	236	1.34	C5	5
				LB2	18				
				LB3	18				
				CF1	100				
Garage Space, Guard Room, Corridor & Staircase	CKT4	SB5	SDB0	LB5	16	344	1.95	C5	5
				LB6	16				
				CL8	24				
				CL11	24				
				CL12	24				
				CL13	24				
				LB4	16				
				CF2	100				
				SS4	100				
Total						934			

Circuit Wise ESDB Connection and Calculation for Typical Floor Plan:

Emergency Sub Distribution Board 1 (ESDB1) Fixtures									
Room Name	Circuit No.	Switchboard	Connected To	Fixture	Power (W)	Power Per CKT (W)	Current Rating (A)	Wire Rating	Breaker to ESDB (A)
Dining Space	CKT9	SB4	ESDB1	CF9	100	135	0.77	C5	5
				FL7	35				
Bedroom-3 & Toilet-3	CKT10	SB9	ESDB1	LB7	24	140	0.80	C5	5
				CF7	100				
		SB10	SB9	LB8	16				
Total					275				

Circuit Wise ESDB Connection and Calculation for Ground Floor Plan:

Emergency Sub Distribution Board 0 (ESDB0) Fixtures									
Room Name	Circuit No.	Switchboard	Connected To	Fixture	Power (W)	Power Per CKT (W)	Current Rating (A)	Wire Rating	Breaker to ESDB (A)
Garage Space	CKT5	SB5	ESDB0	CL6	24	96	0.55	C5	5
				CL7	24				
				CL9	24				
				CL10	24				
Total					96				

Circuit Wise ESDB Connection and Calculation for Rooftop Floor Plan:

Emergency Sub Distribution Board 19 (ESDB19) Fixtures									
Room Name	Circuit No.	Switchboard	Connected To	Fixture	Power (W)	Power Per CKT (W)	Current Rating (A)	Wire Rating	Breaker to ESDB (A)
	CKT1	SB1	ESDB19	LB1	18	236	1.340909091	C5	5

Roof Top, Corridor & Staircase				LB2	18				
				CF1	100				
				SS1	100				
	CKT2	SB2	ESDB19	CL1	24	148	0.8409090909	C5	5
				CL2	24				
				SS2	100				
Total						384			

Circuit Wise SDB Connection and Calculation for Basement:

Sub Distribution Board 20 (SDB20) Fixtures									
Room Name	Circuit No.	Switchboard	Connected To	Fixture	Power (W)	Power Per CKT (W)	Current Rating (A)	Conduit Rating	Breaker to SDB (A)
Garage Space	CKT1	SB1	SDB20	CL3	24	196	1.11	C5	5
				CL4	24				
				CL5	24				
				CL6	24				
				SS1	100				
Total						196			

Circuit Wise ESDB Connection and Calculation for Basement:

Emergency Sub Distribution Board 20 (ESDB20) Fixtures									
Room Name	Circuit No.	Switchboard	Connected To	Fixture	Power (W)	Power Per CKT (W)	Current Rating (A)	Conduit Rating	Breaker to SDB (A)
Garage Space (Basement)	CKT2	SB2	ESDB20	CL1	24	244	1.39	C5	5
				CL2	24				
				CL7	24				
				CL8	24				
				CL9	24				

				CL10	24				
				SS2	100				
Total					244				

Power Circuits:

Typical Floor							
SDB1				ESDB1			
P Sockets	Breaker (A)	Q Sockets	Breaker (A)	P Sockets	Breaker (A)	Q Sockets	Breaker (A)
P1	15	Q1	20	P6	15	Q4	20
P2	15	Q2	20	P7	15	Q5	20
P3	15	Q3	20				
P4	15						
P5	15						
P8	15						
Ground Floor							
SDB0				ESDB0			
P Sockets	Breaker (A)	Q Sockets	Breaker (A)	P Sockets	Breaker (A)	Q Sockets	Breaker (A)
P3	15	---	---	P1	15	---	---
				P2	15		
Basement							
SDB20				ESDB20			
P Sockets	Breaker (A)	Q Sockets	Breaker (A)	P Sockets	Breaker (A)	Q Sockets	Breaker (A)
P1	15	---	---	---	---	---	---
P2	15	---	---				

SDB to MDB Current, Breaker Rating & Conduit Rating Calculation:

SDB	SDB Load w/o P & Q Sockets	no of P sockets	no of Q sockets	Total Load DF	P Socket DF	Q Socket DF	Total SDB Load	Total SDB Current	SP MCCB (A)	Conduit Rating	Total SDB Load Multiplied
To MDB											
SDB0	934.00	1.00	0.00	0.70	0.50	0.3	2153.80	12.24	15.00	2 x 4 rm BYM + 4 rm BYA ECC	2153.80
SDB1	2717.00	6.00	3.00	0.70	0.50	0.3	14501.90	82.40	100.00	2 x 70 rm BYM + 70 rm BYA ECC	261034.20
SDB20	196.00	2.00	0.00	0.70	0.50	0.3	3137.20	17.83	20.00	2 x 6 rm BYM + 6 rm BYA ECC	3137.20

Total SDB Load = SDB Load(without 3 pin)x0.7+Total P Socket Loadx0.5+Total Q Socket Loadx0.3

= 2717.00x0.7 + 6x3000x0.5 + 3x4000x0.5

= 14501.90 W

pf = 0.8(assumed for typical loads)

Voltage = 220V(Line-Neutral)

$$SDB\ Current = \frac{Total\ SDB\ Load}{Voltage(LN) * pf(0.8)}$$

$$= \frac{14501.90}{220 * 0.8}$$

$$= 82.40\ A$$

So, a 100 A SP MCCB is necessary.

Pump Current, Breaker Rating & Conduit Rating Calculation:

Element	Load	Current	TP MCCB (A)	Conduit Rating	Load
Pump	5000.00	10.82	15.00	4 x 4 rm BYM + 4 rm BYA ECC	5000.00

$$Pump\ Current = \frac{Pump\ Load}{\sqrt{3} * Voltage(LL) * pf(0.7)}$$

$$= \frac{5000}{\sqrt{3} * 381 * 0.7}$$

$$= 10.82\ A$$

So, a 15 A SP MCCB is necessary.

Lift AVR Rating, Current, Breaker Rating & Conduit Rating Calculation:

Lift Current, Breaker Rating & Conduit Rating Calculation:

Element	**Load**	**Current**	**TP MCCB (A)**	**Conduit Rating**	**Load**
Lift1	18500.00	40.05	50.00	4 x 25 rm NYY + 25 rm BYA ECC	18500.00
Lift2	18500.00	40.05	50.00	4 x 25 rm NYY + 25 rm BYA ECC	18500.00

Lift load = 18500 W

Voltage = 381 V (Line-Line)

Pf = 0.7 (as it is a motor load)

$$Lift\ Current = \frac{Lift\ Load}{\sqrt{3} * Voltage * pf(0.7)}$$

$$= \frac{18500}{\sqrt{3} * 381 * 0.7}$$

$$= 40.05\ A$$

So, a 50 A TP MCCB is necessary for each lift.

Lift AVR Rating Calculation:

AVR1 for Lift1			AVR2 for Lift2		
P (W)	pf	S (VA)	P (W)	pf	S (VA)
18500.00	0.70	26428.57	18500.00	0.70	26428.57

AVR Rating = Lift Load / pf (for lift)

= 18500 / 0.70

= 26428.57 VA

ESDB & Lift to EMDB Current, Breaker Rating & Conduit Rating Calculation:

ESDB	ESDB Load w/o P & Q Sockets	no of P sockets	no of Q sockets	Total Load DF	P Socket DF	Q Socket DF	Total ESDB Load	Total ESDB Current	SP MCCB (A)	Conduit Rating	Total ESDB Load Multiplied
To EMDB											
ESDB0	96.00	2.00	0.00	0.70	0.50	0.3	3067.20	17.43	20.00	2 x 6 rm BYM + 6 rm BYA ECC	3067.20
ESDB1	275.00	2.00	2.00	0.70	0.50	0.3	5592.50	31.78	40.00	2 x 16 rm BYM + 16 rm BYA ECC	100665.00
ESDB19	384.00	0.00	0.00	0.70	0.50	0.3	268.80	1.53	5.00	2 x 1.5 rm BYM + 1.5 rm BYA ECC	268.80
ESDB20	196.00	0.00	0.00	0.70	0.50	0.3	137.20	0.78	5.00	2 x 1.5 rm BYM + 1.5 rm BYA ECC	137.20

Total ESDB Load Summed = ESDB20(Basement)+ESD0(Ground)+18xUnit ESDB+ESDB19(Roof)

= 104138.20 W

Calculation for EMDB & Generator Rating Calculation:

Calculation for EMDB (to MDB)									
Total ESDB Load(W)	Lift Load (W)	Lift Diversity Factor	Total EMDB Load (W)	EMDB Current for ESDB Load (W)	EMDB Current for Lift Load (W)	Total EMDB Current (A)	TP MCCB to MDB (A)	Conduit Rating	Generator Rating (kW)
104138.20	37000.00	0.70	130038.20	197.26	56.07	253.33	300.00	4 x 240 rm NYY + 120 rm BYA ECC	135.00

Generator Rating(kW) = 0.7 x 37kW + 104.138 kW

= 130.038 kW ≈ 135 kW

SDB+EMDB to MDB calculation of Wire, Breaker and Conduit:

Calculation for MDB								
Total SDB Load (W)	EMDB Load (W)	Pump Load (W)	D. Factor	MDB Load (W)	pf (due to PFI plant)	MDB Current (A)	TP MCCB (A) to Busbar	Conduit Rating
266325.20	130038.20	5000.00	0.70	399863.40	0.95	637.83	685.00	4 x 500 rm NYY + 300 rm BYA ECC

MDB Load (kW) = 266.325 kW + 130.028kW + 0.7 X 5 kW = 399.863 kW

$$I\,(A) = \frac{399863}{\sqrt{3} * 381 * 0.95} = 637.83\,A$$

Minimum TP Circuit breaker available for 637.83A is 685A TP MCCB and the appropriate conduit rating is 4 x 500 rm NYY + 300 rm BYA ECC.

PFI Plant Calculation:

PFI Plant									
P 0.8 pf	P 0.7 pf	Q 0.8 pf	Q 0.7 pf	Q available (inductive Q)	Q required (inductive Q)	Q pfi (capacitive Q)	PFI Current (self)	TP MCCB (A)	Conduit Rating
370463.40	29400.00	277847.55	29994.00	307841.55	131428.74	176412.81	267.33	300.00	4 x 240 rm NYY + 120 rm BYA ECC

Real Power calculation:

P1(kW) = Load with 0.8 pF = 370.463 kW

P2(kW) = Load with 0.7 pF =29.4kW

Reactive Power Calculation:

Q1(kVAR) =P1 x $\tan(\cos^{-1}(0.8))$ = 277.847 kVAR

Q2(kVAR) =P2 x $\tan(\cos^{-1}(0.7))$ = 29.994 kVAR

Total Reactive Power:

Q(kVAR) = Q1+Q2 =277.847+29.994 = 307.841 kVAR

Reactive power supplied by capacitor bank

Qrequired = 307.841- (370.463+29.4)* $\tan(\cos^{-1}(0.95))$ = 176.412 kVAR

PFI to MDB Calculation:

Current rating of the PFI plant,

$$I(A) = \frac{Qrequied\ (VAR)}{\sqrt{3}* 381 * 1} = \frac{176412}{\sqrt{3}* 381 * 1} = 267.33A$$

So, 300 A three phase circuit breaker is required. Minimum TP Circuit breaker available for 267.33A is 300A TP MCCB and the appropriate conduit rating is 4 x 240 rm NYY + 120rm BYA ECC.

Transformer Calculation:

Transformer Rating Calculation

MDB Current	S (VA)	Transformer (kVA)
637.83	420908.84	450.00

Total MDB Current = 637.83 A

Minimum Transformer Capacity = 1.73 * Voltage(LL) * Line Current

= 1.73 * 381 * 637.83 VA

Transformer Rating = 450 kVA

Minimum Space Require (with Clearance) = 15 m2 + 4.5 m2 = 19.5 m2

Transformer Room Space = 21.68 m2

A separate LT switchgear room is used for LT panels.

Lightning Arrester Calculation:

Specification	Value (in feet)	Value (in m)
Rod Height	6’-6”	2
Roof Length	113'-10"	34.1884
Roof Width	49'-6"	14.7828
Roof Circumference	340'-9"	103.8606
Roof Conductor Separation	2’-1”	0.635

$$Number\ of\ lightning\ arrester\ along\ length = \frac{34.1884}{7.62} + 1 = 5.48$$

So, we should have at least 5 lightning arresters along length. Eight lightning arresters are used to cover the edges. In the length along which there is more non uniformity a total of 9 LAs have been used. Again, 2 extra LAs have been used for room edges.

$$Number\ of\ lightning\ arrester\ along\ width = \frac{14.7828}{7.62} + 1 = 2.94$$

Fitting to Switchboard (Switchboard Diagram):

For ground floor, we've used SDB0 and ESDB0

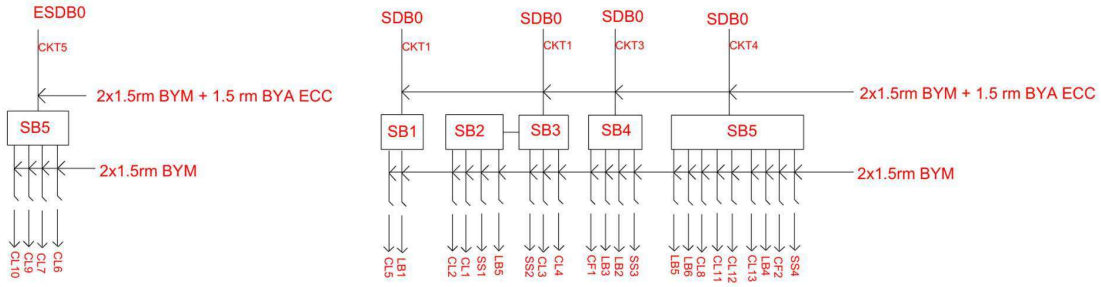


Figure 1: Ground floor SDB and ESDB

For residential floors (common unit), we've used SDB1 to SDB18 and ESDB1 to ESDB18

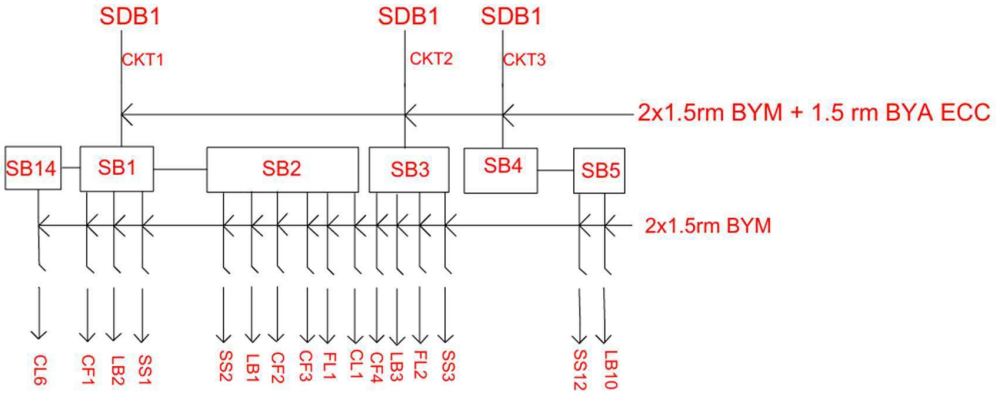


Figure 2: Residential floor SDB (CKT1, CKT2, CKT3)

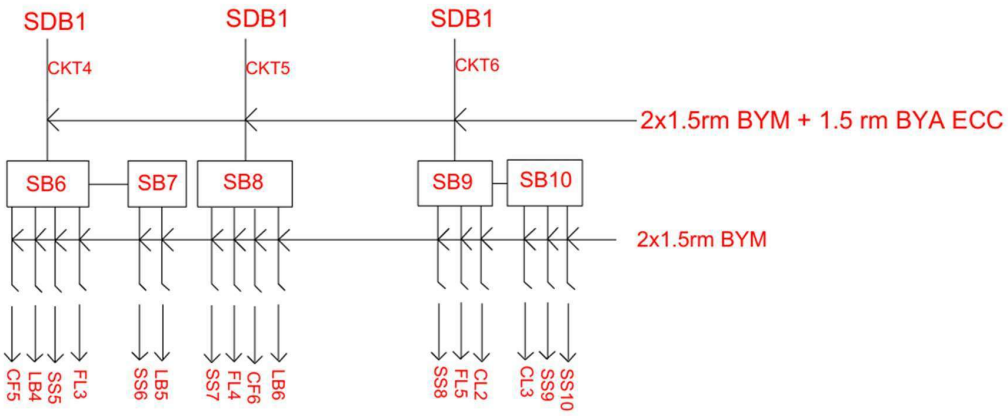


Figure 3: Residential floor SDB (CKT4, CKT5, CKT6)

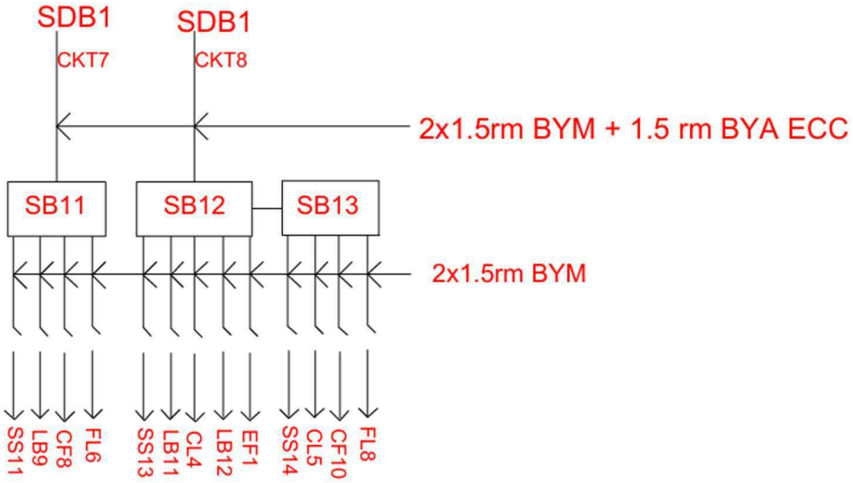


Figure 4: Residential floor SDB (CKT7, CKT8)

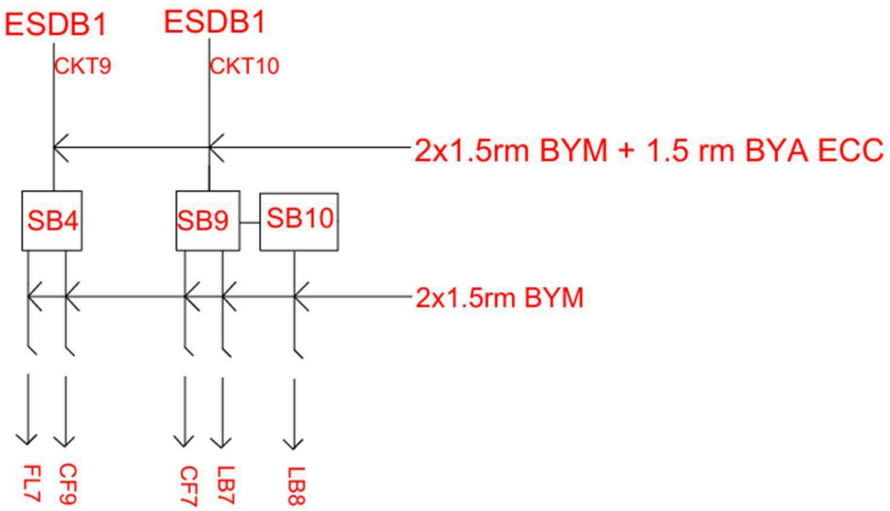


Figure 5: Residential floor ESDB (CKT9, CKT10)

For rooftop, corridor and staircase, we've used no SDB and ESDB19

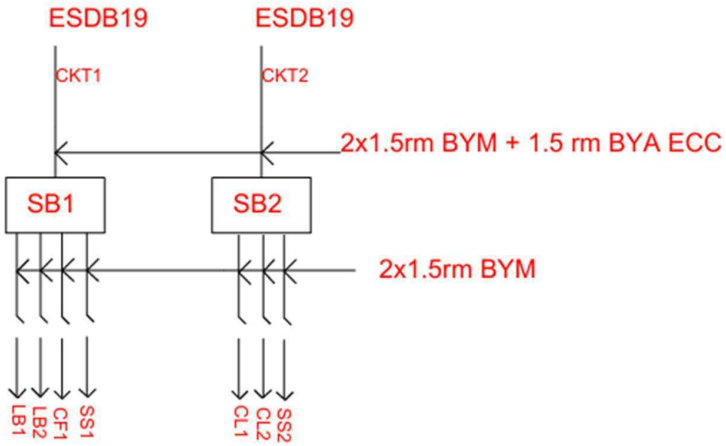


Figure 6: Rooftop ESDB

For basement, we've used SDB20 and ESDB20

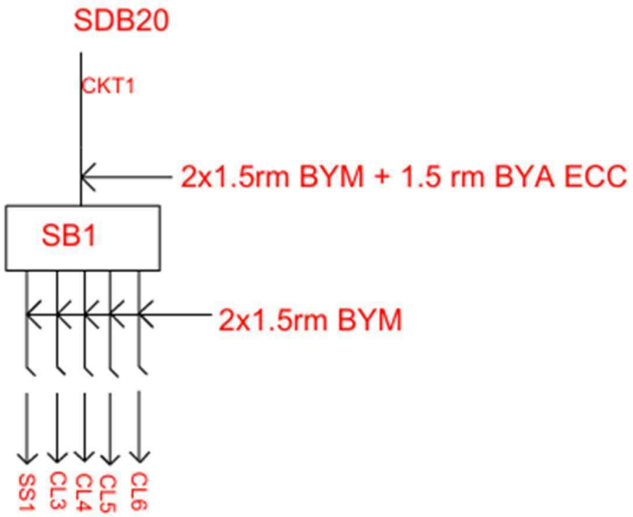


Figure 7: Basement SDB

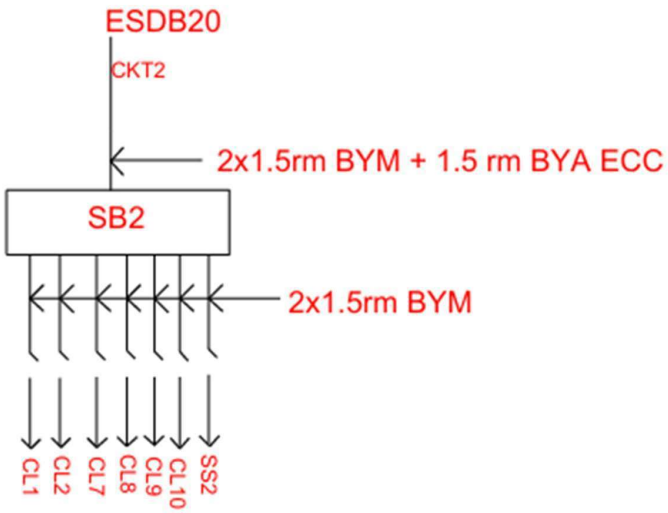


Figure 8: Basement ESDB

SB and Power Ckt to SDB (SDB Diagram):

For ground floor,

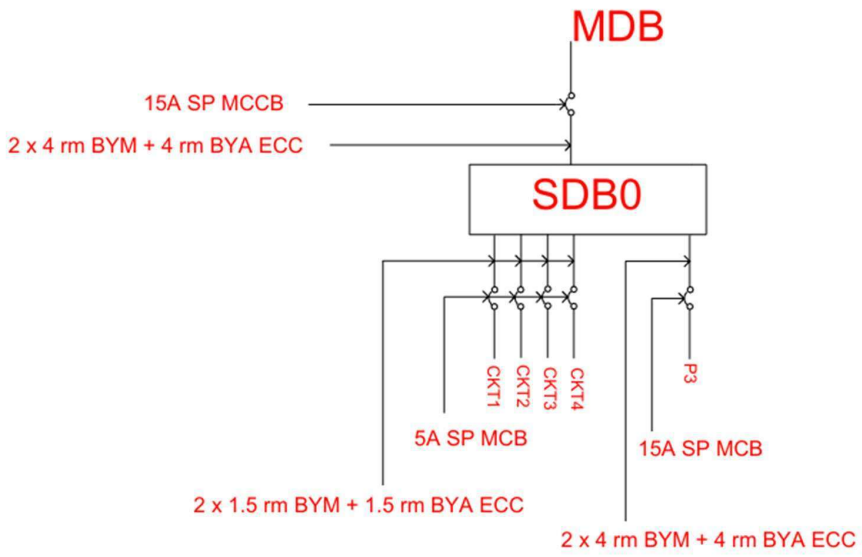


Figure 9: Ground Floor SDB Diagram

For common unit,

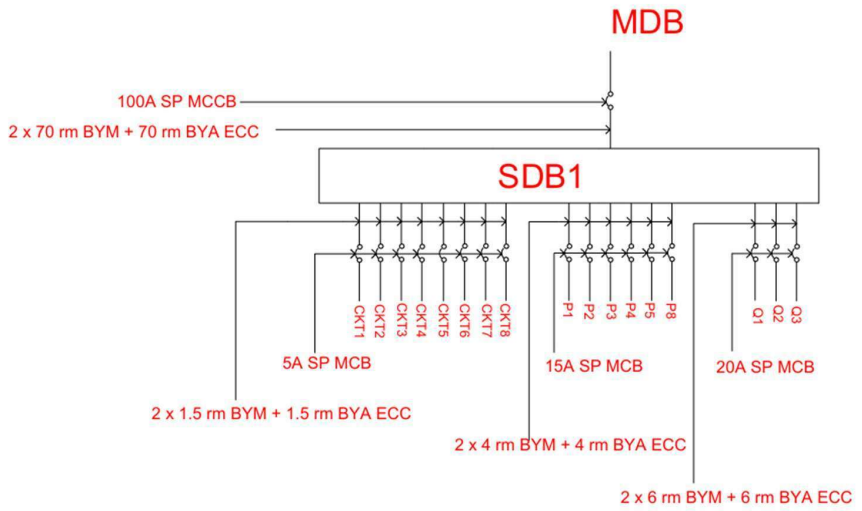


Figure 10: Common Unit SDB Diagram

For basement,

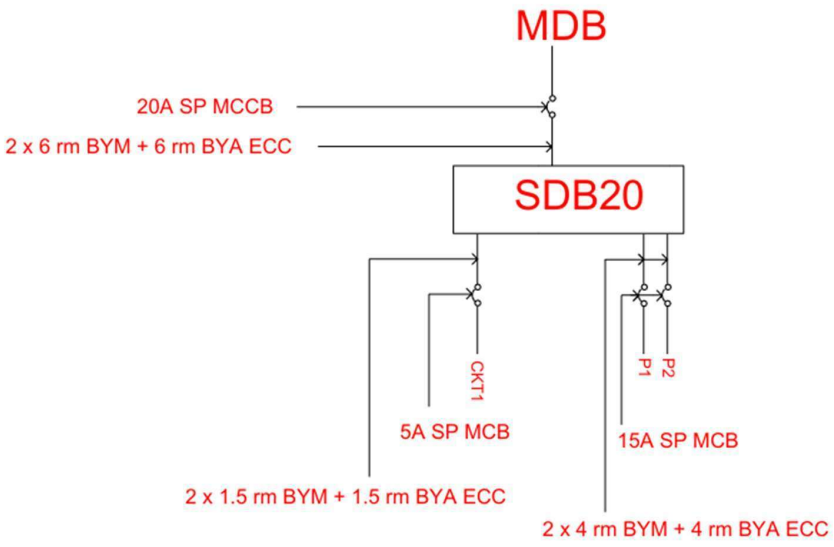


Figure 11: Basement SDB Diagram

SB and Power Ckt to ESDB (ESDB Diagram):

For ground floor,

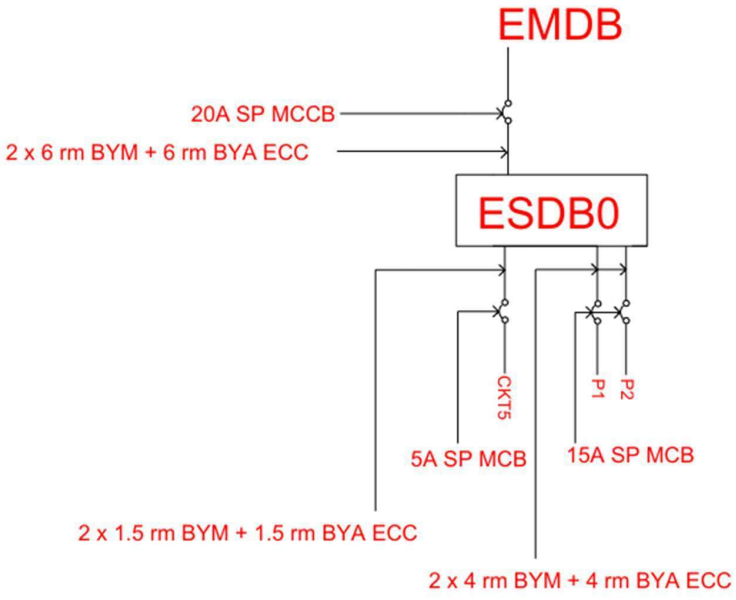


Figure 12: Ground Floor ESDB Diagram

For common unit,

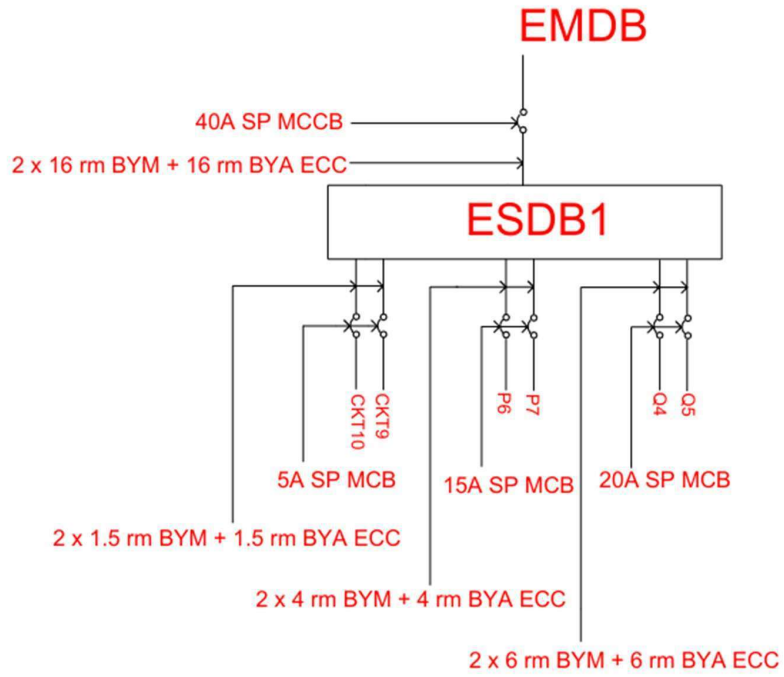


Figure 13: Common Unit ESDB Diagram

For rooftop,

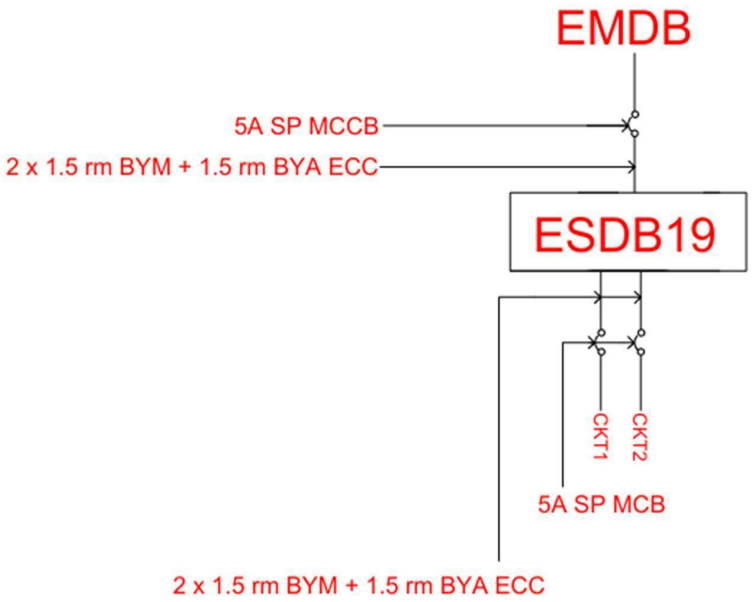


Figure 14: Rooftop ESDB Diagram

For basement,

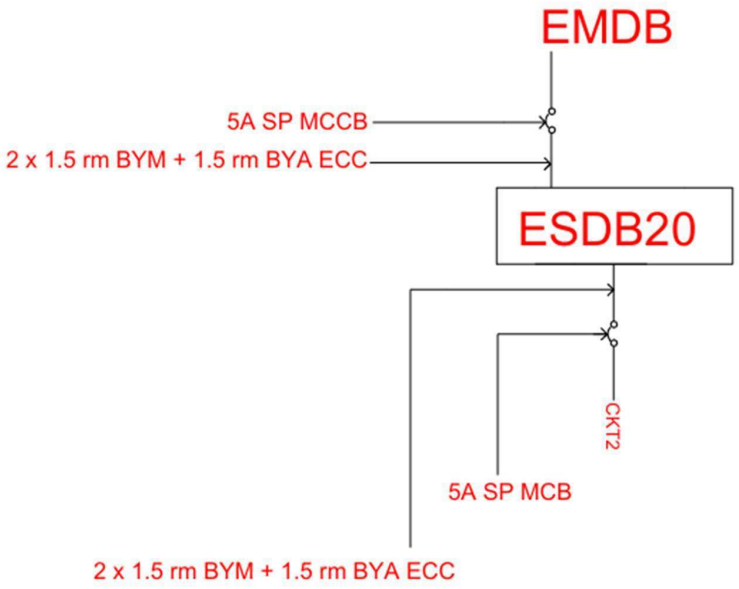


Figure 15: Basement ESDB Diagram

MDB Diagram:

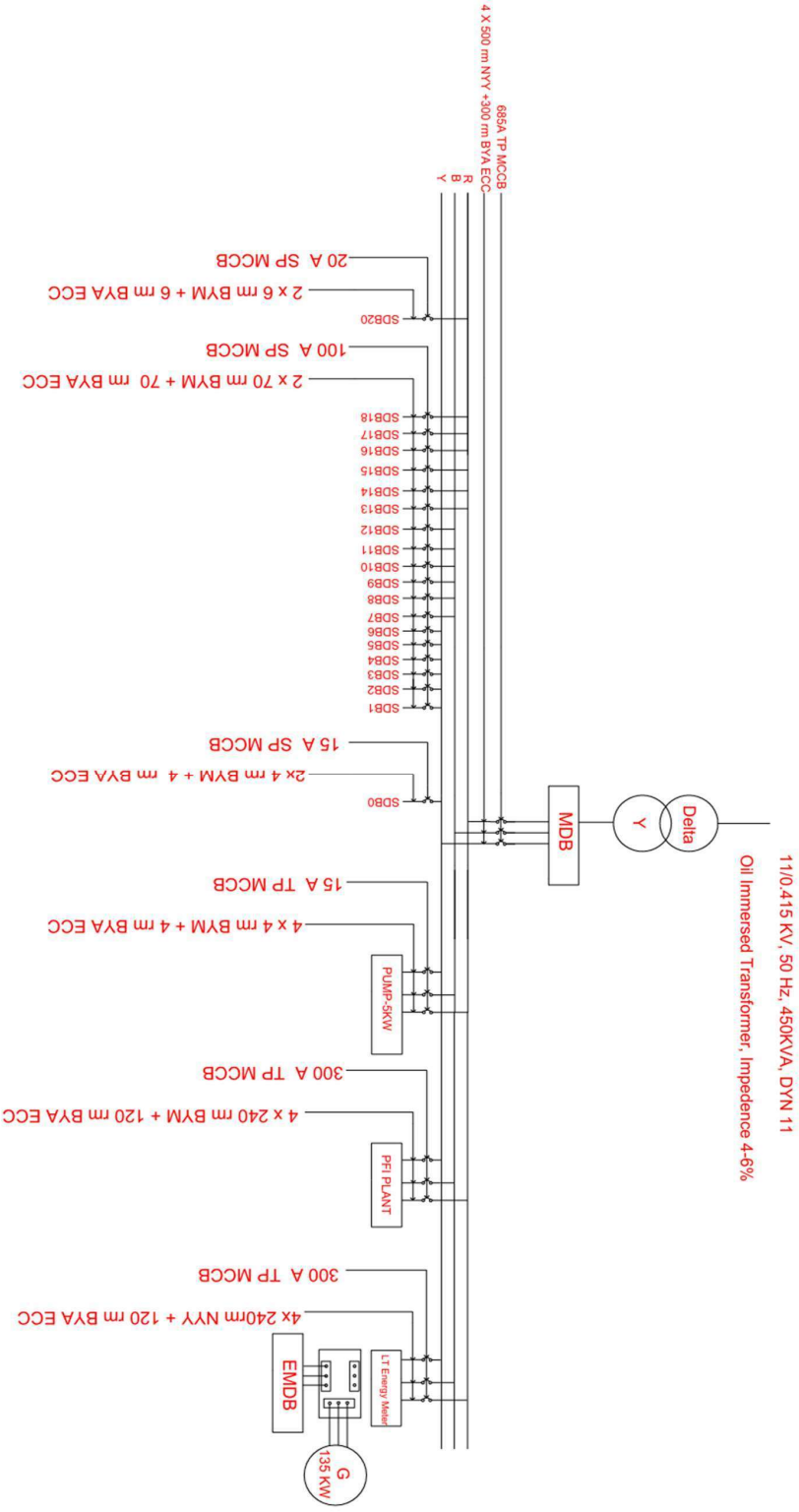


Figure 16: MDB Diagram

EMDB Diagram:

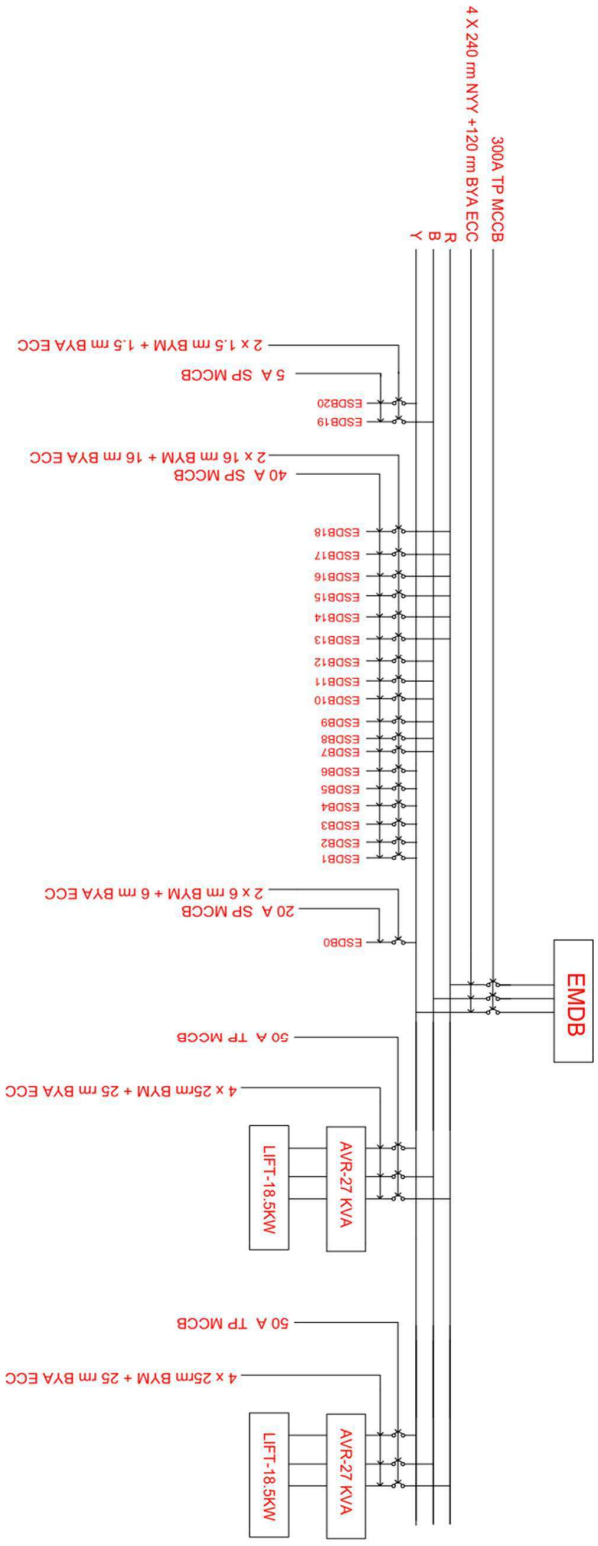


Figure 17: EMDB Diagram

So, we should have at least 2 lightning arresters along the width.

$$Number\ of\ down\ conductor = \frac{A(sq.meter)-80}{100} + 1$$

$$= \frac{34.1884*17.7828-80}{100} + 1$$

$$= 4.6 \approx 4$$

So, we need 1 conductor for the first 80 m^2 and 3 extra down conductor for the rest of the area.

Conclusion:

In conclusion, the culmination of this project report for the Electrical Services Design course represents a significant milestone in our academic journey. Through the application of AutoCAD software, we systematically designed the electrical layout for a 10-story residential building, addressing key components such as lighting, fan placement, and conduit calculations. This project provided invaluable hands-on experience, reinforcing theoretical concepts learned in class and enhancing our understanding of the practical implications of electrical engineering in building design. As we conclude this endeavor, we reflect on the importance of rigorous analysis, attention to detail, and collaborative effort in achieving successful project outcomes. These lessons will undoubtedly inform our future academic pursuits and professional endeavors in the field of engineering.

References:

Table 8.1.5: Recommended Values of Illumination for Residential Buildings

Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
Dwelling Houses		**Hotels**	
Bedrooms		Entrance halls	150
General	70	Reception and accounts	300
Bed-head, Dressing table	250	Dining rooms (tables)	150
Kitchens	200	Lounges	150
Dining rooms (tables)	150	Bedrooms	
Bathrooms		General	100
General	100	Dressing tables, bed heads, etc.	250
Shaving, make-up	300	Writing rooms (tables)	300
Stairs	100	Corridors	70
Lounges	100	Stairs	100
Garages & Porches	100	Laundries	200

Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
Basement Car Park	100	Kitchens	
Porches, Entrances	70	Food stores	100
Sewing and darning	600	Working areas	250
Reading (casual)	150	Goods and passenger lifts	70
Home work and sustained reading	300	Cloak-rooms and toilets	100
		Bathrooms	100
		Above mirror in bathrooms	300

BANGLADESH UNIVERSITY OF ENGINEERING &TECHNOLOGY

Course No. EEE-230

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, mm² .... 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° C ambient temperature, underground, amps
- b") 35° 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° C, amps
- b"') Clipped to a surface or on a cable tray bunched and un-enclosed two cables single phase at 35° 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.

1.3.33 Lightning Protection of Buildings

Whether a building needs protection against lightning depends on the probability of a stroke and acceptable risk levels. Assessment of the risk and of the magnitude of the consequences needs to be made. As an aid to making a judgment, a set of indices is given in Table 8.1.27 below for the various factors involved.

Table 8.1.27 (a): Index Figures Associated with Lightning Protection Design

Index A: Use of Structure	Index	Index B: Type of Construction	Index
Houses and similar buildings	2	Steel framed encased with nonmetal roof[a]	1
Houses and similar buildings with outside aerial	4	Reinforced concrete with nonmetal roof	2
Small and medium size factories, workshops and laboratories	6	Brick, plain concrete, or masonry with nonmetal roof	4
Big industrial plants, telephone exchanges, office blocks, hotels, blocks of flats	7	Steel framed encased or reinforced concrete with metal roof	5
Places of assembly, for example, places of workshop, halls, theatres, museums, exhibitions, department stores, post offices, stations, airports, stadiums	8	Timber formed or clad with any roof other than metal or thatch	7
Schools, hospitals, children's homes and other such structures	10	Any building with a thatched roof	10

[a] A structure of exposed metal which is continuous down to ground level is excluded from the table as it requires no lightning protection beyond adequate earthing arrangements.

Table 8.1.27 (b): Index Figures Associated with Lightning Protection Design

Index C : Contents or Consequential Effects	Index	Index D : Degree of Isolation	Index
Ordinary domestic or office building, factories and workshops not containing valuable materials	2	Structure located in a large area having structures or trees of similar or greater height, e.g. a large town or forest	2
Industrial and agricultural buildings with specially susceptible [b] contents	5	Structure located in an area with a few other structures or trees of similar height	5
Power stations, gas works, telephone exchanges, radio stations	6	Structure completely isolated or exceeding at least twice the height of surrounding structures or trees	10
Industrial key plants, ancient monuments, historic buildings, museums, art galleries	8	**Index E : Type of Terrain**	**Index**
Schools, hospitals, children's and other homes, places of assembly	10	Flat terrain at any level	2
[b] This means specially valuable plant or materials vulnerable to fire or the results of fire.		Hilly terrain	6
		Mountainous terrain 300 m and above	8

Table 8.1.27 (c) : Index Figures Associated with Lightning Protection Design

Index F : Height of Structure	Index	Index G : Lightning Prevalence	Index
Up to 9 m	2	Number of thunderstorm days per year:	
9-15 m	4	Up to 3	2
15-18 m	5	4-6	5
18-24 m	8	7-9	8
24-30 m	11	10-12	11
30-38 m	16	13-15	14
38-46 m	22	16-18	17
46-53 m[c]	30	19-21	20
[c] Structures higher than 53 m require protection in all cases		Over 21	21