EEE 414

Term: 4-2

Electrical Service Design

Prepared by
Saif Ahmed Sunny
Lecturer (PT) – January 2024
Department of EEE, BUET

AutoCAD

AutoCAD

BUET

1. Line drawing at a particular angle
2. Creating a square box **(orthomode)**
3. Deleting a Line (eraser or delete)
4. Deleting an extended portion **(trim)**
5. Drawing a door **(arc)**
6. Drawing parallel Line **(offset)**
7. Units

7. **Layers**
8. Pan, Copy, Cut
9. Move, Rotate, Mirror

10. Osnap
11. Hatch
12. Dimension
13. Text

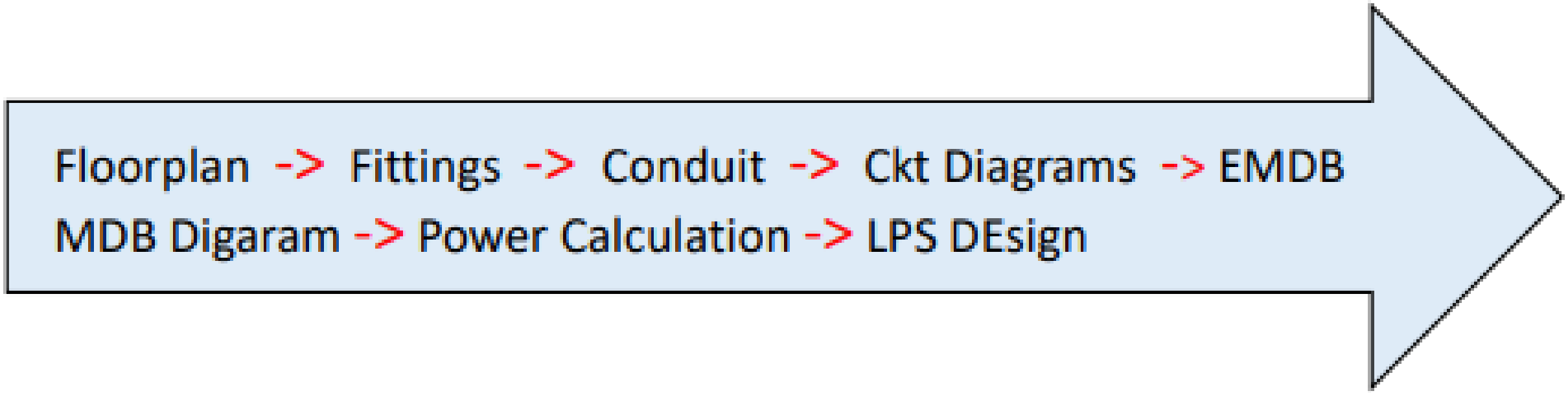
14. Creating Block

Project Proposal

Project Map

BUET

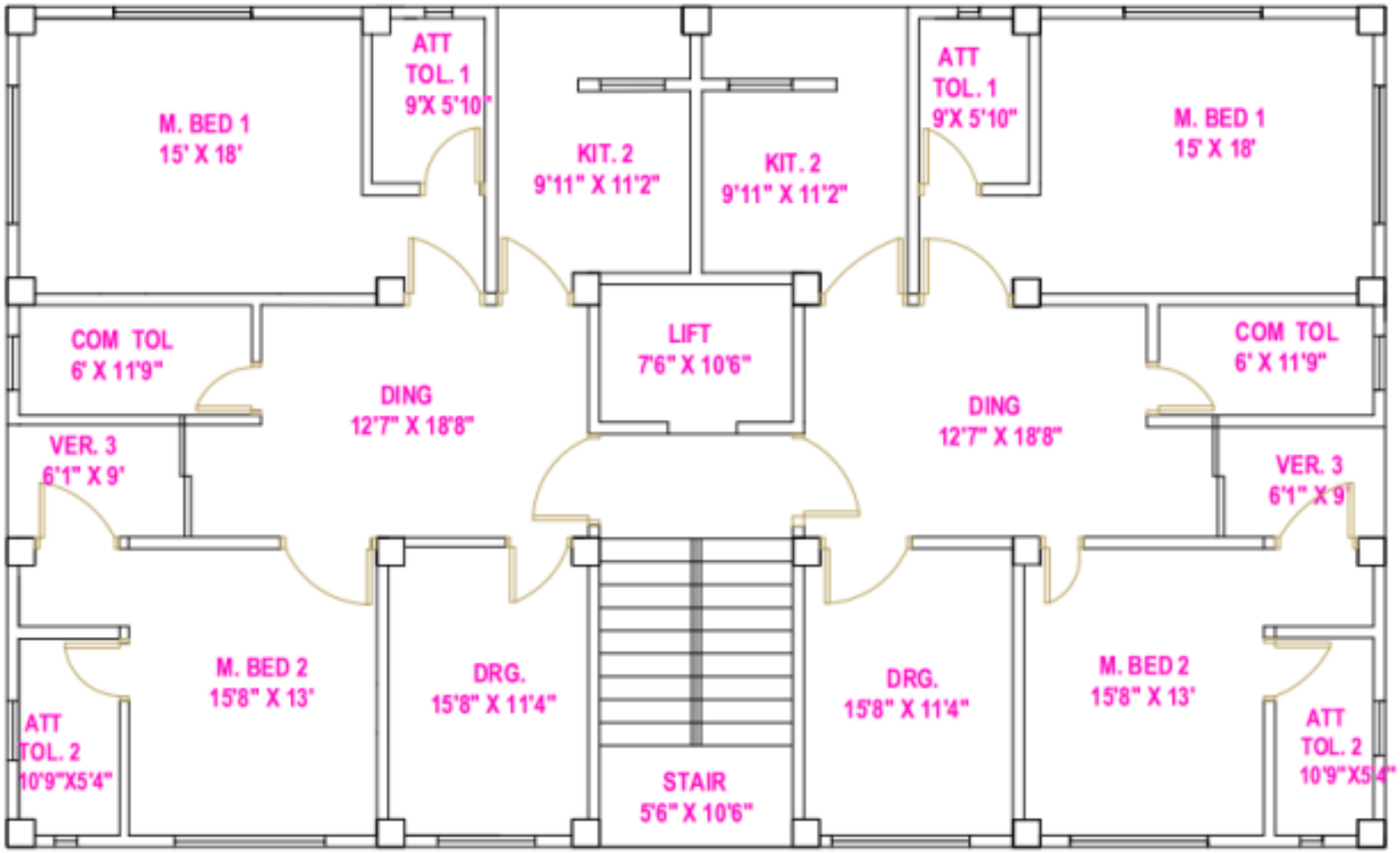
Design Steps



Layers

Layer-1: Main Floorplan
Layer-2: Room Names
Layer-3: Dimensions
Layer-4: Doors
Layer-5: Windows
Layer-6: Light Fan
Layer-7: Power Sockets
Layer-8: Switchboards
Layer-9: Lighting Load Conduit
Layer-10: Power Socket Conduit

Main Floorplan



High Rise (9 Living Floor)

Min 2 units

Each unit min 1200 sq. ft.

Lift

Bedroom (2-3)

Washroom (min 2)

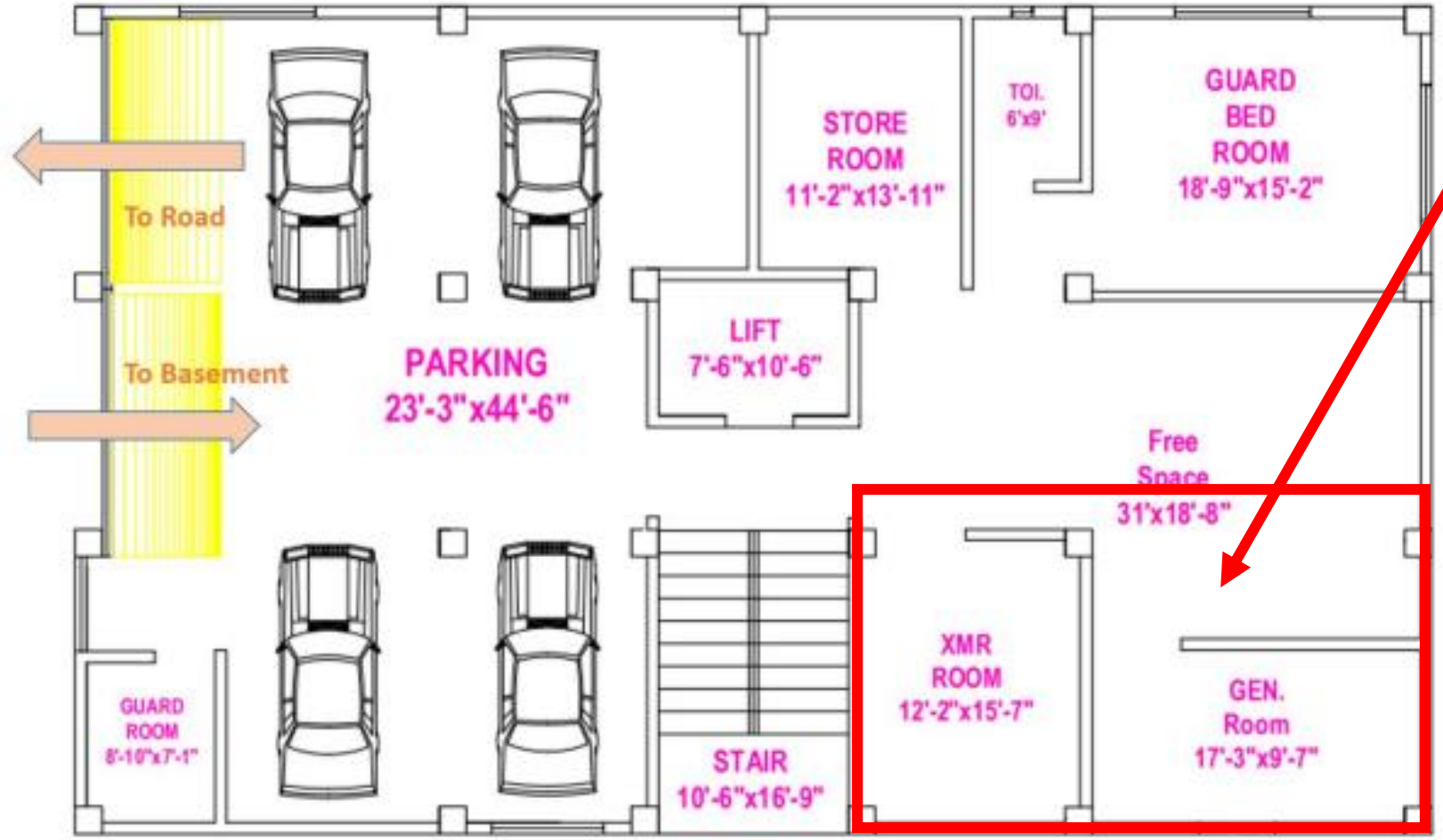
Kitchen

Dining

Drawing

Veranda

Ground Floorplan



Parking Space

Electrical Room

Transformer Room

Generator Room

Guard Room

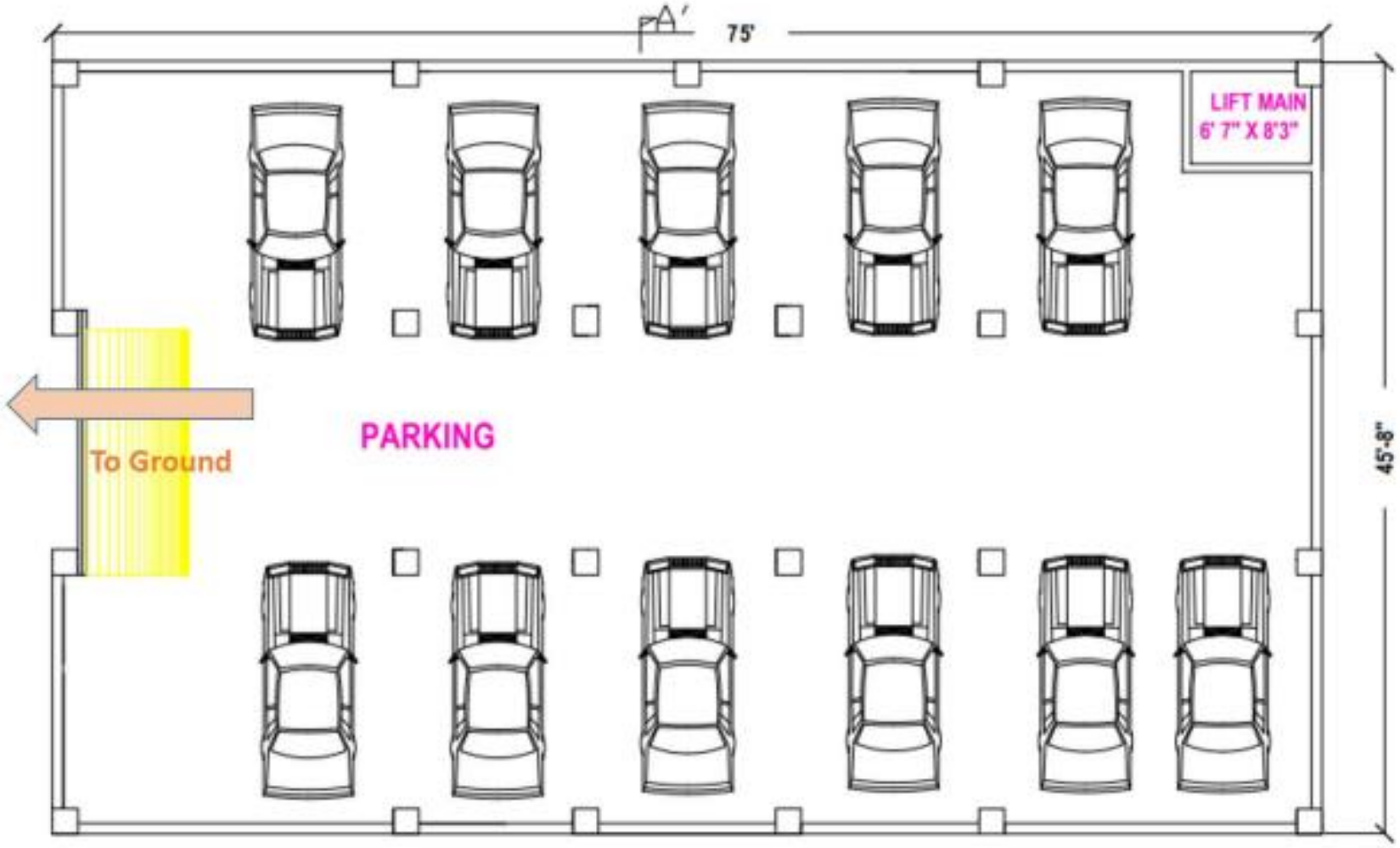
Guard Bedroom

Washroom

Ramp

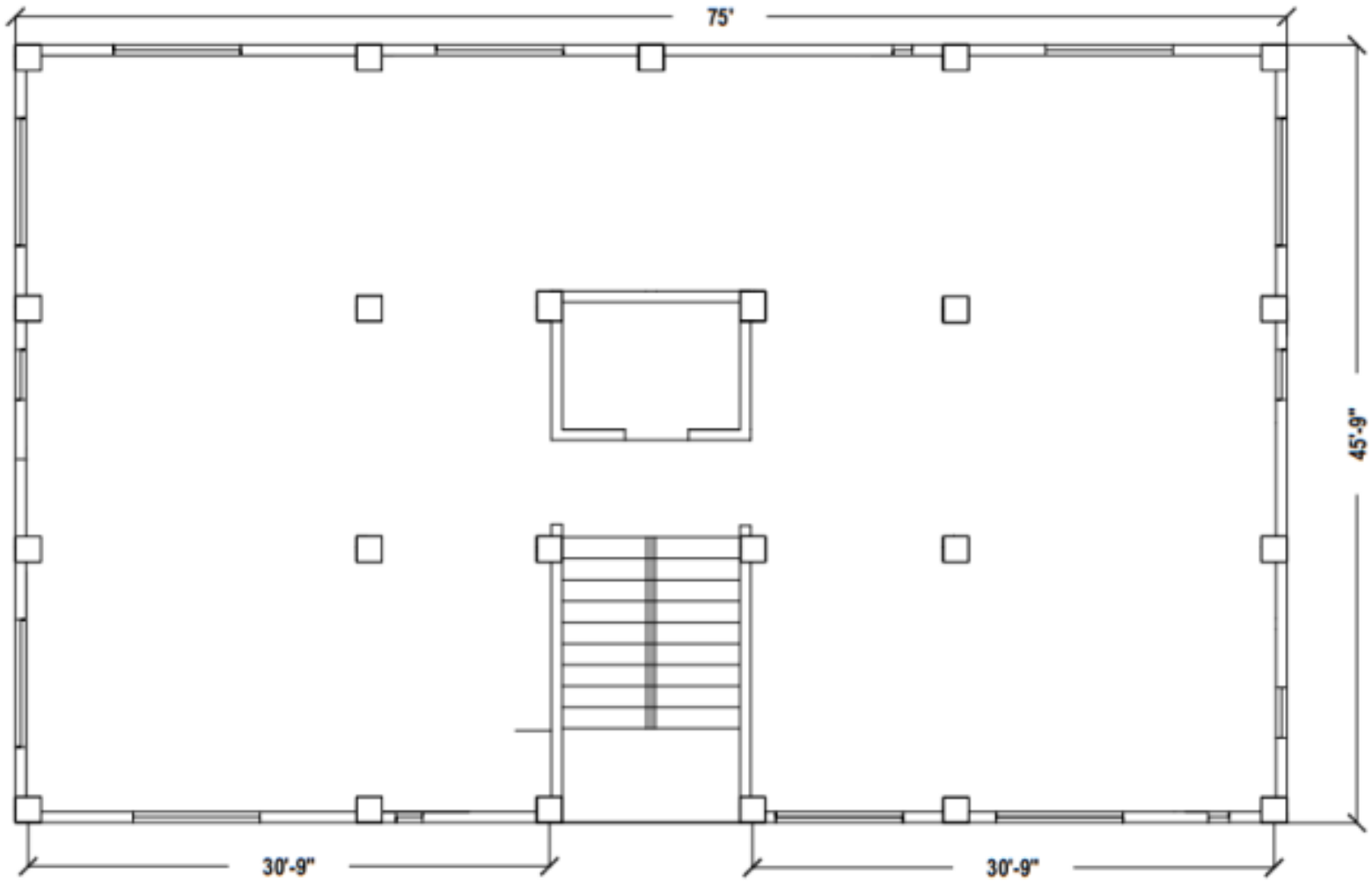
Ground Floor
Basement

Basement/Garage



Parking Space
Store Room
Lift Maintenance Room

Roof



Beams
Lift Machine Room
Stairs

Mainly used for Lightning Protection System **(LPS)** Design

Fittings and Fixtures

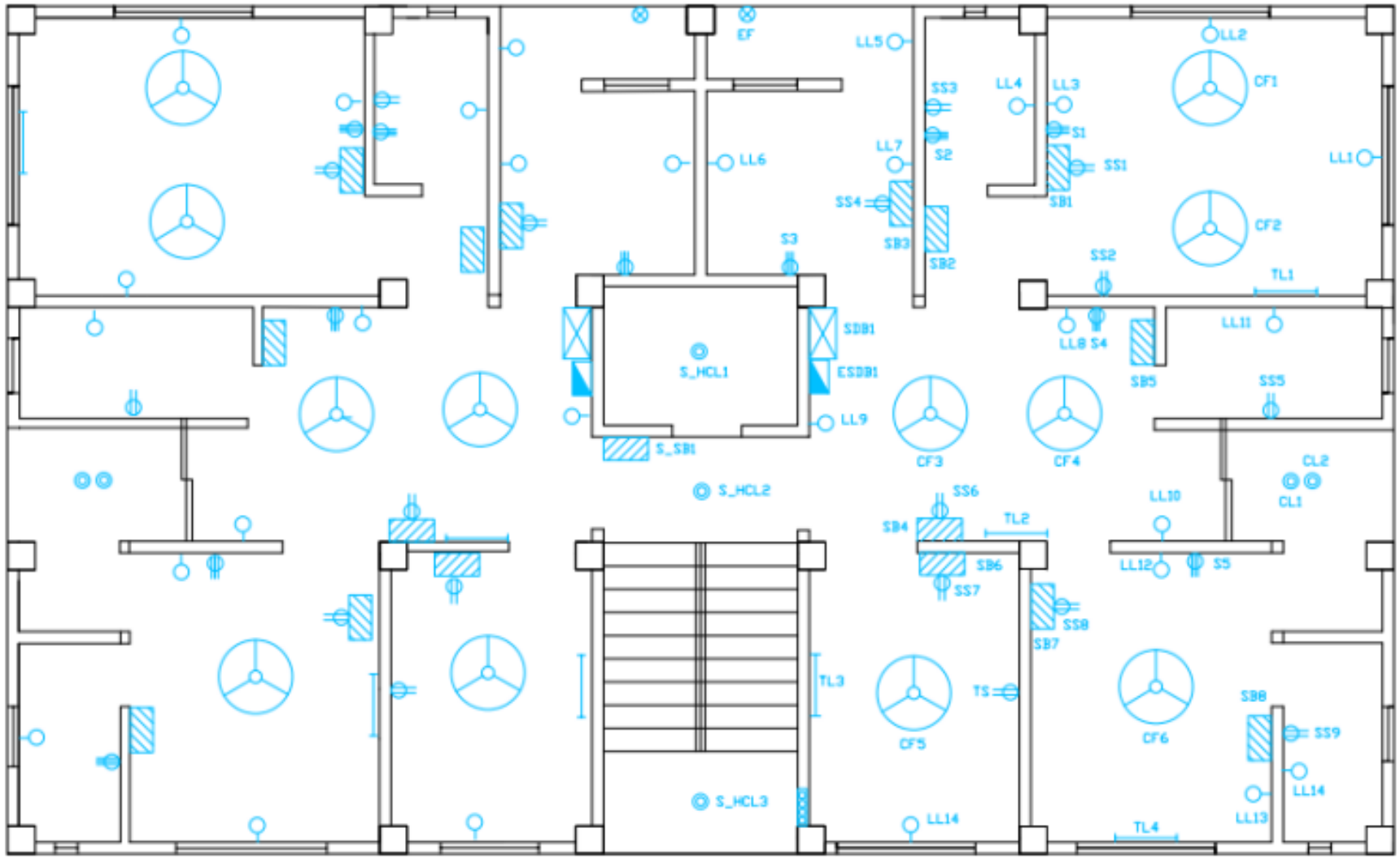
Fittings and Fixtures

Fixture: An electrical fixture is a product that is used for fitting various electrical devices like lights, fans etc. They can be thought of as "fixed" and not easily replaceable. Example: wall brackets, switchboards, power sockets.

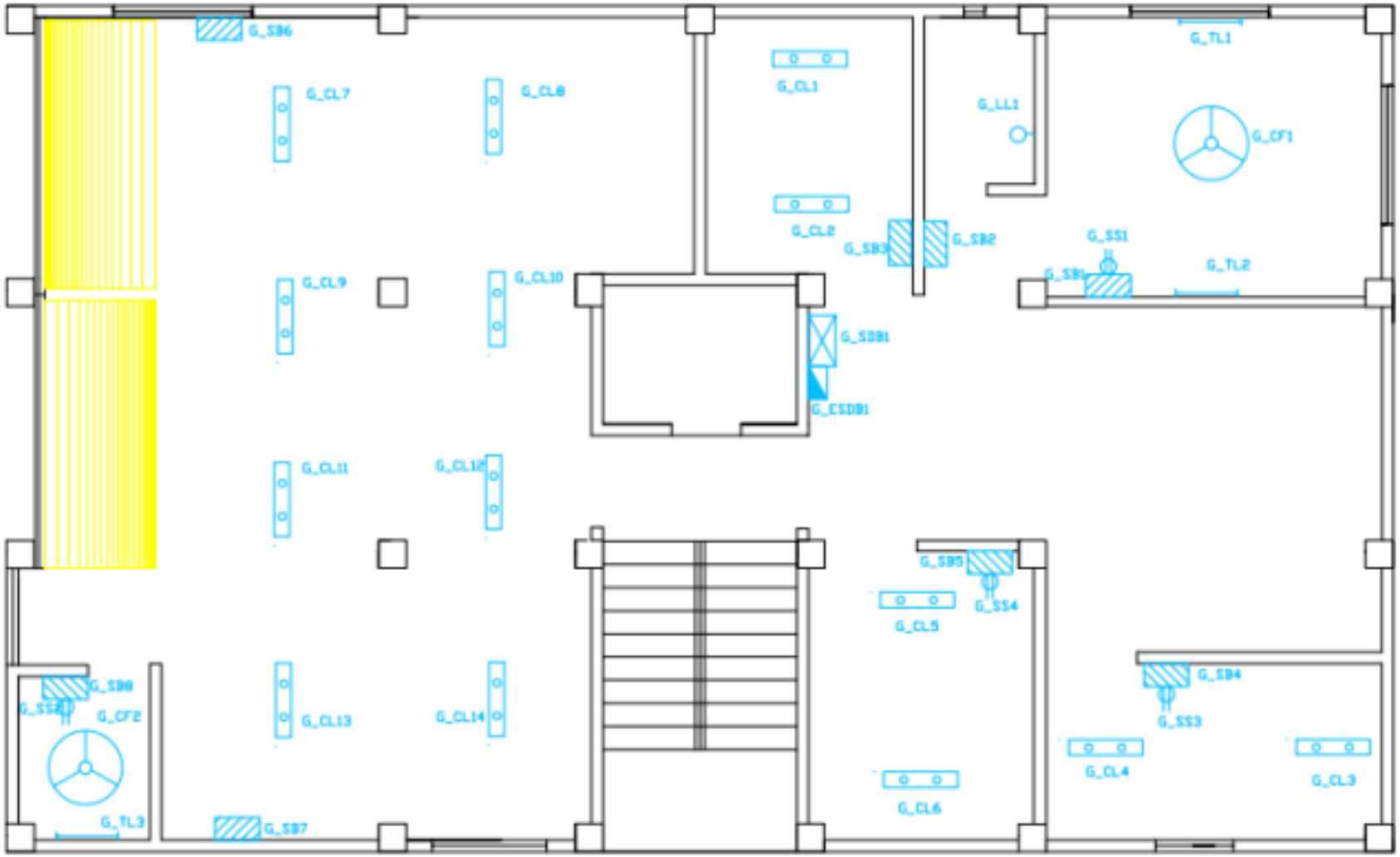
Fittings: An electrical fitting is any electrical appliances that fit in various fixtures. They are usually easily replaceable by users and are more prone to changes compared to fixtures. Example: Tube lights, TV, electric fan etc.

Although fitting and fixtures do not mean the same thing, it can often be difficult to differentiate between them perfectly and there may be different definitions in the law in different countries. Thus, for all intents and purposes, we will mention them together to remove any ambiguity.

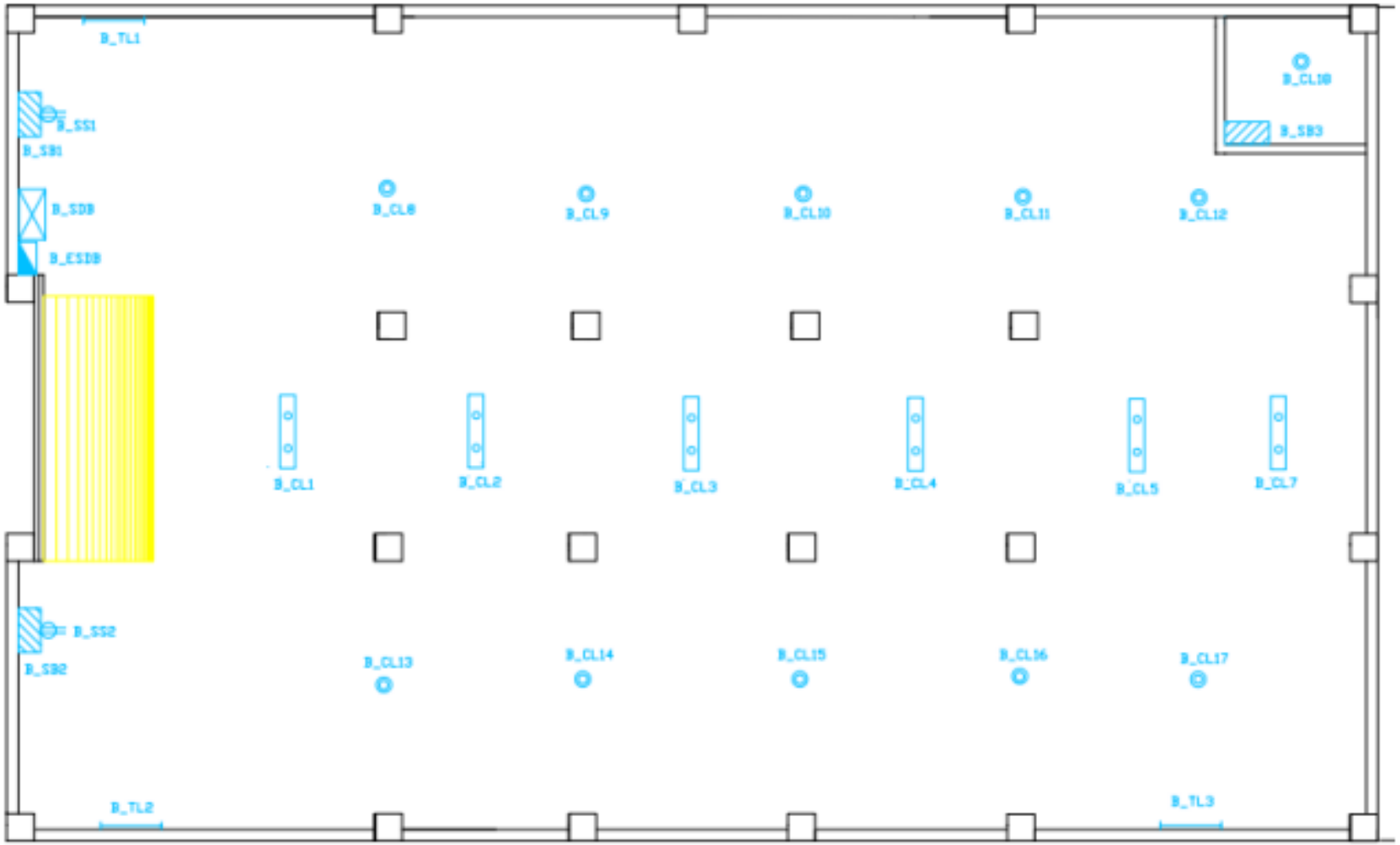
Fittings and Fixtures (Main Floorplan)



Fittings and Fixtures (Ground Floor)



Fittings and Fixtures (Basement)



Fittings and Fixtures

Some things to keep in mind:

a) Place power sockets by thinking about the kind of appliances they might be connected to. For example, for a fridge or an oven a 3-pin 15A power socket might be necessary, while for a bed side lamp a 2-pin 5A socket at Table height might be good enough.
b) Each room should have at least one switchboard, place them in a such a way so that they are easily accessible.
c) There must be a Main Distribution board in your design.
d) Place the lights keeping in mind the purpose of the room and what sort of activity will be happening there. Adjust the amount and type of lighting to fit the room's purpose.

Fittings and Fixtures

Lights- 3” radius
Tube light – 3’ length
Ceiling fan – diameter 48” or 56” outer and 6” inner

Symbol Description	Fittings and Fixture
Wall Bracket Light at Lintel Level	
2-Pin 5A Socket at SB Level	
3-Pin 5A/15A Socket	
2-Pin 5A Socket at Table Height	
2-Pin 5A Socket at Skirting Level for TV	
2-pin TV Antenna Socket	

Switch Board	
Fluorescent Wall Light Fitting	
Ceiling Light Fitting Type k	
Meter Board	
Main Distribution Board	
Exhaust Fan	
Ceiling Fan	

Light Calculation

$$E = \frac{n * N * F * LLF * UF}{A}$$

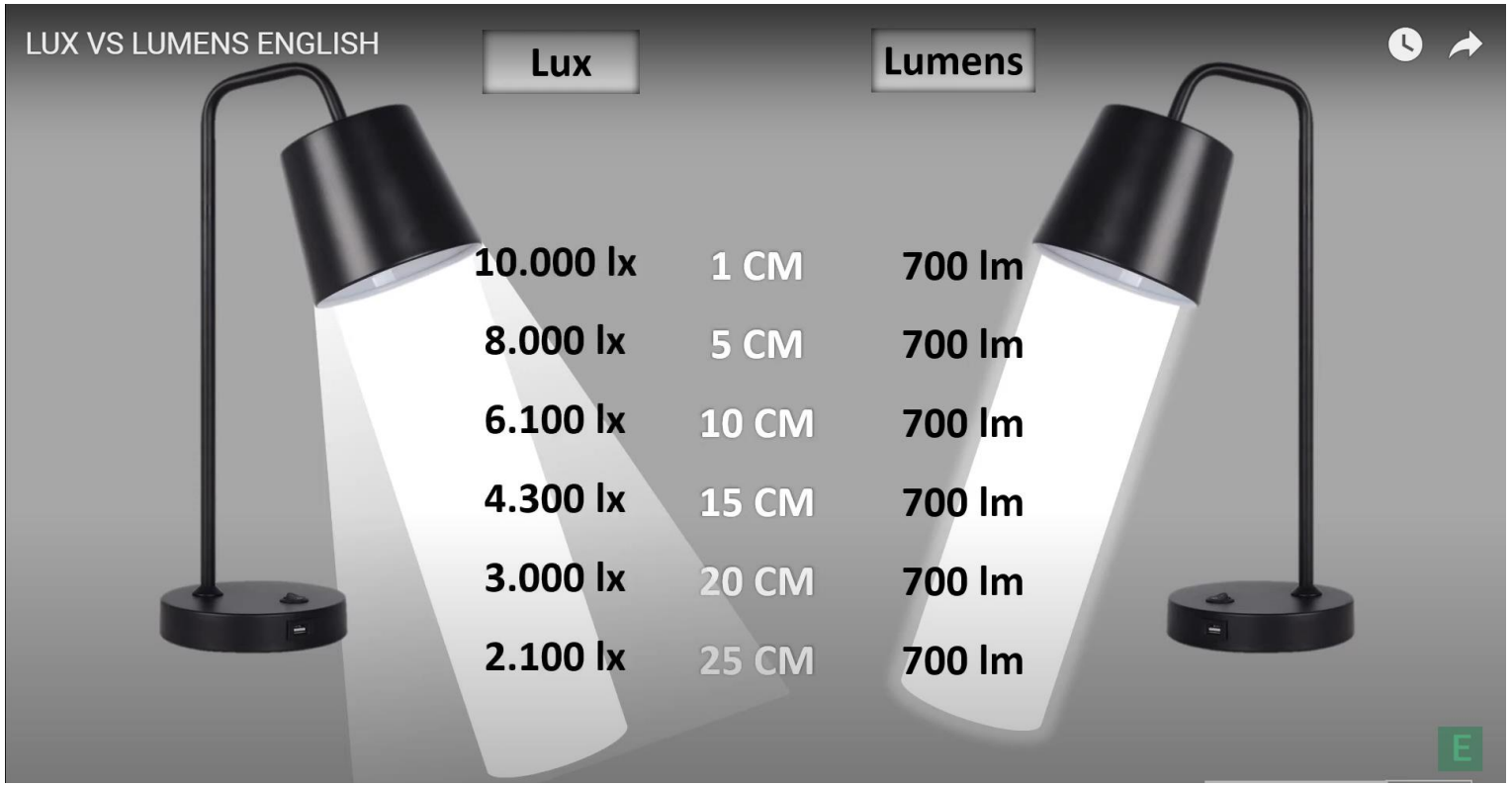
$$N = \frac{E * A}{n * F * LLF * UF}$$

N = Number of Lights
E = Illumination (lux = lm/m2) - Table
A = Area of the Room (sq. meter)
n = lights per illuminaire
F = Lumen of Light
UF = Utilization Factor
LLF = Light Loss Factor

Lux vs Lumen

Lumen – Amount of Light a Bulb emits in all directions

Lux - Light per unit surface (Lumen/m2)



https://www.youtube.com/watch?v=rtPA9UeRANY

E – Illumination Table

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

F- Lumen of Light (Watt vs Lumen Chart)

Incandescent Bulb

TABLE 10

Incandescent Flood Light Lamps (Luminous Flux lm)

Type	Wattage (220-230 V)	Luminous Flux (lm)
120 E	100 W	1050
123 E	250 W	3250
126 G	500 W	8000
6036 G	1000 W	19000
7083 U	100 W	2250
162 G	500 W	12600

Fluorescent Bulb

TABLE 12

Flourscent lamps(220 V), Standard (Construction)

Wattage (W)	Lenth of lamps (mm)	Lumimous flux (lm)
8	288	350
16	720	950
20	590	1250
40	1200	3200

F- Lumen of Light (Watt vs Lumen Chart)

LED Bulb

Sale!

Philips Essential 15W LED Bulb 1450 lumen

~~৳ 300~~ **৳ 250**

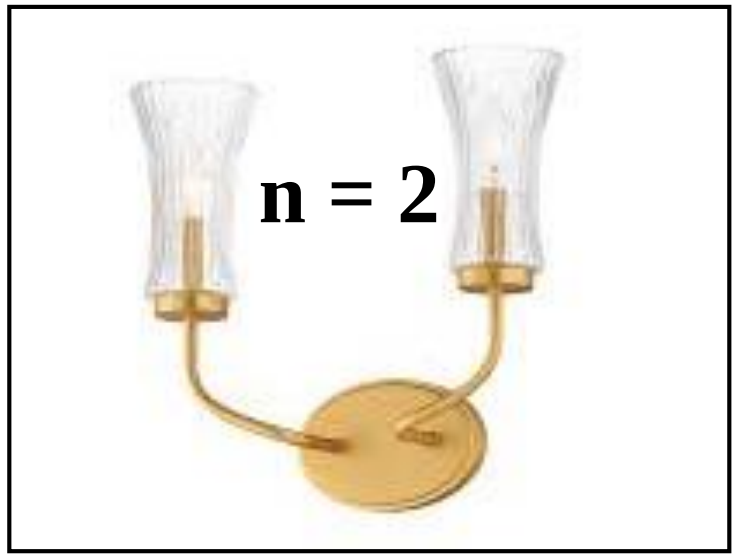
- Power: 15W
- Bulb Shape: B50
- Lumens: 1450 lm
- Color Temperature: Cool Daylight (6500K)
- Lifetime: 15,000 hours
- Base: B22 / E27
- Input voltage: 100-260VAC
- CRI: 80 Ra
- Dimmable: No
- Warranty: 1 Year.

TYPES

Light Calculation

$$E = \frac{n * N * F * LLF * UF}{A}$$

$$N = \frac{E * A}{n * F * LLF * UF}$$



N = Number of Lights
E = Illumination (lux = lm/m2) - Table
A = Area of the Room (sq. meter)
n = lights per illuminaire
F = Lumen of Light
UF = Utilization Factor
LLF = Light Loss Factor

n = 1

UF*LLF = 0.75

Fan Calculation

$$N = \frac{A}{100}$$

A = Area of the Room (sq. feet)

Sample Calculation

Example:

A Bedroom
Dimension A = L x W = 15 x 13 ft2 = 18.118 m2
Illuminance E = 100
Light Loss Factor and Utilization Factor LLF x UF = 0.75
Flux F = 1450 Lumen
Lights per illuminaire n = 1

Light N = 1.66
So, 2 LED Bulbs

Fan N = 1.95
So, 2 Fans

Fittings and Fixtures (Another Method)

Mounting height MH = Luminaire Height – Working Plane Height = 9ft – 3ft = 6ft = 1.828m
Maintenance Factor MF = 0.8

Example:

A Dining Room
Dimension L x W : 21’6” x 21”6” or 6.55m x 6.55m

(1) Room Index

$$RI = \frac{L * W}{(L+W)*MH}$$ Here, L W MH in meter.

$$RI = \frac{6.55 * 6.55}{(6.55+6.55)*1.828} = 1.79$$

Fittings and Fixtures (Another Method)

(2) Utilization Factor

By linear interpolation

$$\frac{x - x1}{x2 - x1} = \frac{y - y1}{y2 - y1}$$

$$\frac{1.79 - 1.5}{2 - 1.5} = \frac{UF - 0.6}{0.66 - 0.6}$$

UF = 0.6348

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

Fittings and Fixtures (Another Method)

(3) Light Calculation

Same Lumen Rating

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

$$N = \frac{150*6.55*6.55}{3200*0.6348*0.8}$$

N = 3.95

So, 4 light bulbs.

N = Number of Lights
E = Lux of the Room = 150 lux
L = Length in meter = 6.55m
W = Width in meter = 6.55m
F = Lumen of Light = 3200 lm
UF = Utilization Factor = 0.6348
MF = Maintenance Factor = 0.8

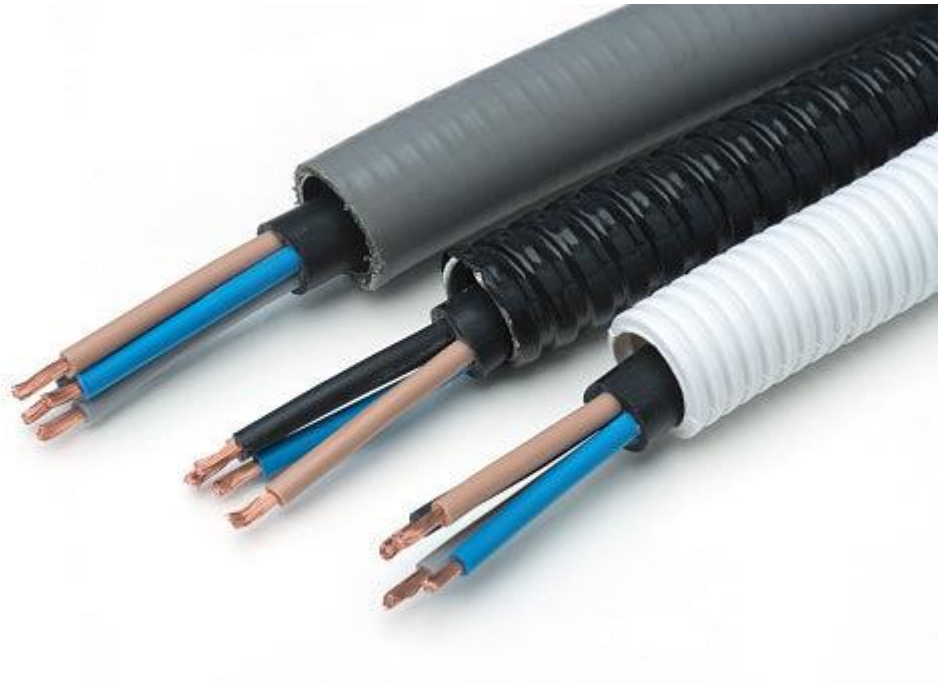
Fittings and Fixtures (Another Method)

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
0.7	0.3	0.2	0.35	0.41	0.47	0.52	0.59	0.65	0.69	0.75	0.78
0.7	0.1	0.2	0.29	0.35	0.41	0.46	0.53	0.59	0.63	0.7	0.74
0.5	0.5	0.2	0.38	0.44	0.49	0.53	0.59	0.63	0.66	0.7	0.73
0.5	0.3	0.2	0.31	0.37	0.42	0.46	0.53	0.58	0.61	0.66	0.7
0.5	0.1	0.2	0.27	0.32	0.37	0.41	0.48	0.53	0.57	0.62	0.66
0.3	0.5	0.2	0.3	0.37	0.41	0.45	0.52	0.57	0.6	0.65	0.69
0.3	0.3	0.2	0.28	0.33	0.38	0.41	0.47	0.51	0.54	0.59	0.62
0.3	0.1	0.2	0.24	0.29	0.34	0.37	0.43	0.48	0.51	0.56	0.59
0	0	0	0.19	0.23	0.27	0.3	0.35	0.39	0.42	0.46	0.48

Conduit

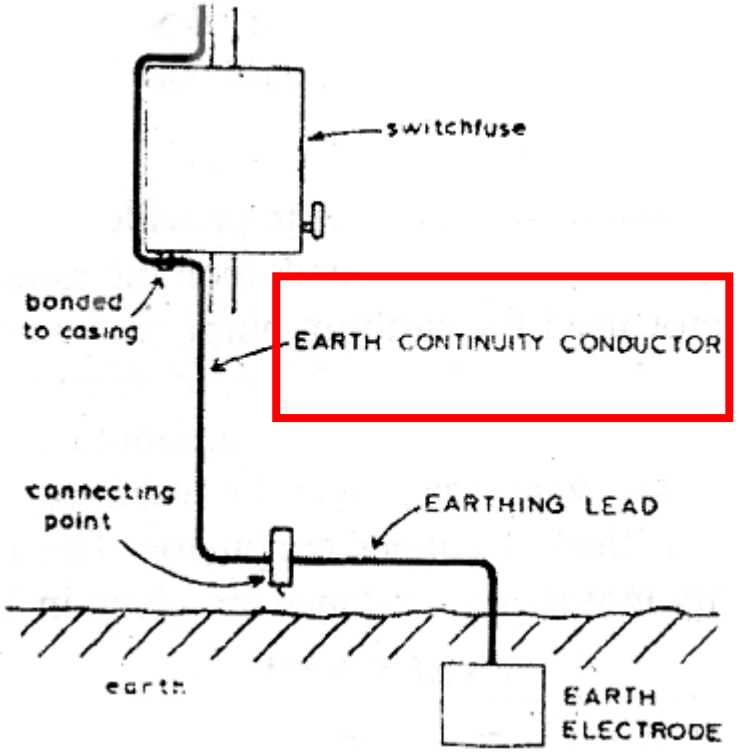
Conduit

Conduit: Conduit means channel. An electrical conduit is a tube used to protect and route electrical wiring in a building. They can be made of metal, wood or plastic (PVC). They can be primarily classified into two classes: 1) Surface/exposed conduits, 2) Concealed conduits



Conduit

Symbol	Wire Rating (single core)-mm^2	Current Rating (ampere)	GI Pipe Diameter (inch)
C1	2x1.5	5A	¾
C2	4x1.5	5A	¾
C3	6x1.5	5A	¾
C4	8x1.5	5A	¾
C5	10x1.5	5A	1
C6	12x1.5	5A	1
C7	14x1.5	5A	1
C8	2x4+4 ECC	15A	1
C9	2x6+6 ECC	20A	1



ECC- Earth Continuity Conductor

ECC is not needed for the conduits from SB to Light, Fan and 2pin Sockets (C1 – C7)

ECC is needed for power sockets (C8, C9) and all the wires after SB

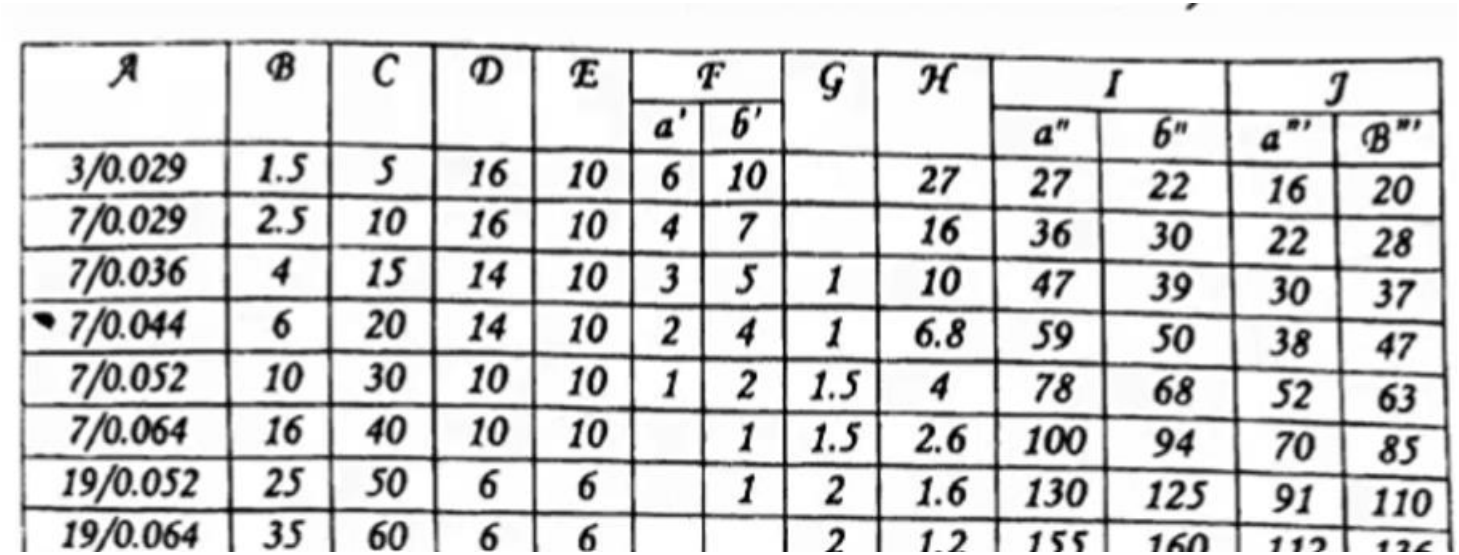
Conduit

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



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

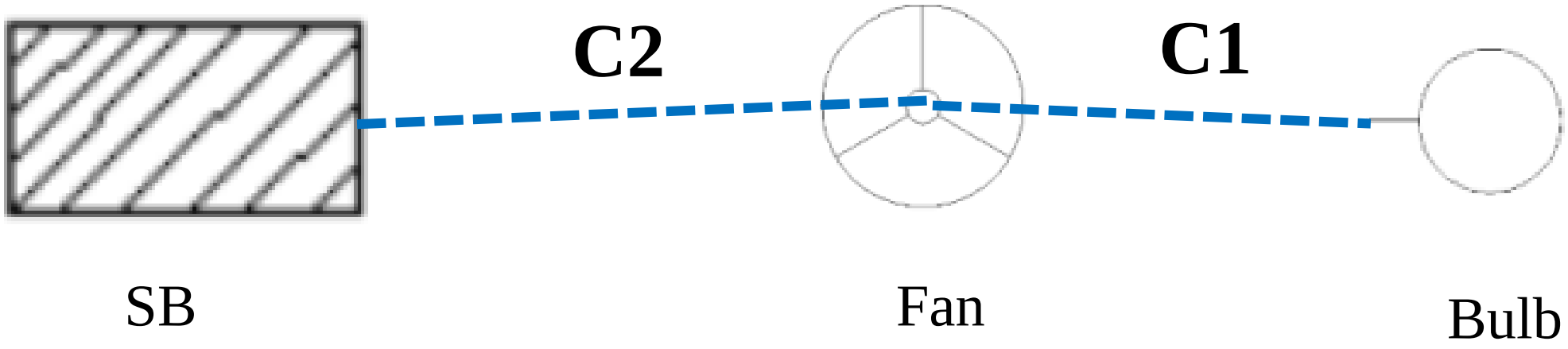
B – Single core cable construction area (mm2)
C – Current Rating (A)
F – number of cables
(a) 3/4“ diameter conduit
(b) 1” diameter conduit

Light, Fan, 2pin Socket – 5A rating
Power (3 pin) Socket – 15A or 20A rating

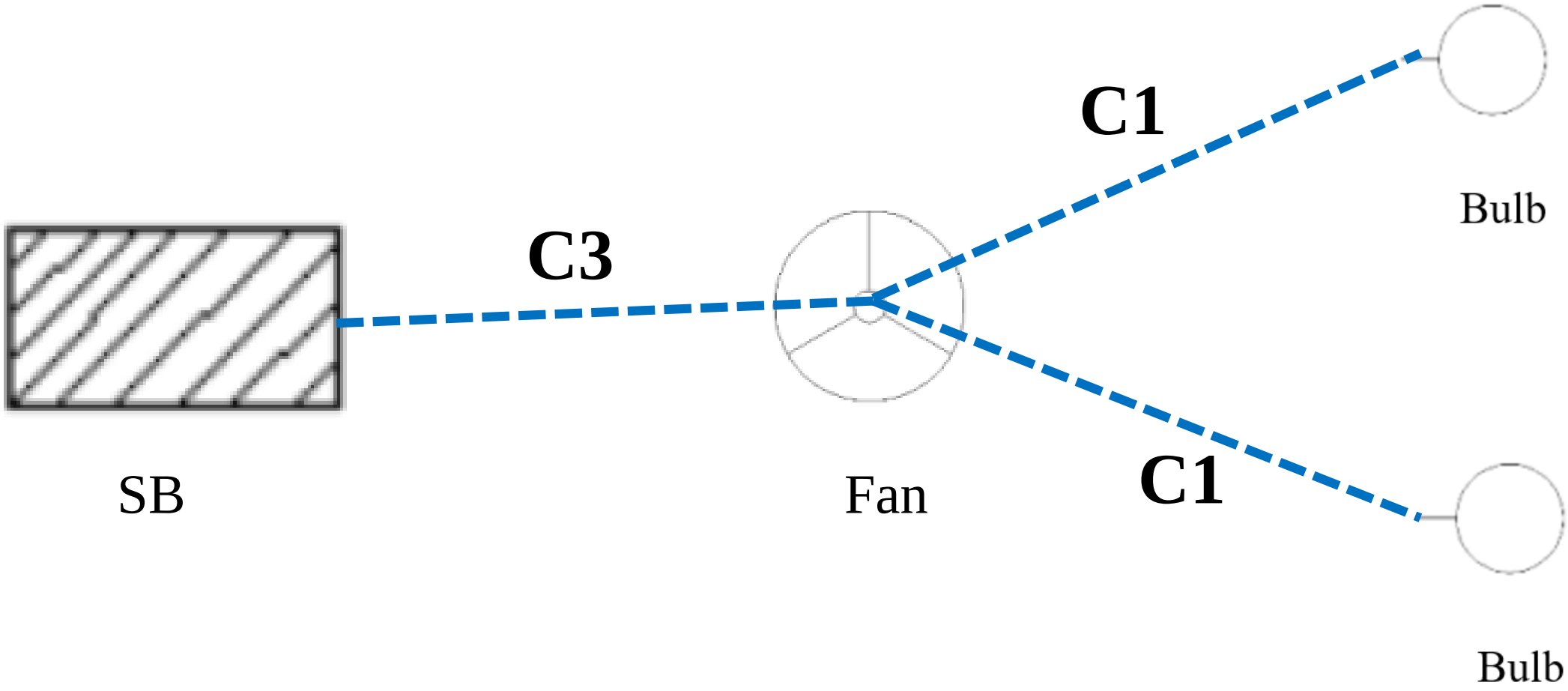
Conduit

Light, Fan, 2pin – Connected to SB – Connected to SDB – Connected to MDB
Power Socket – Connected to SDB – Connected to MDB (ECC Needed)

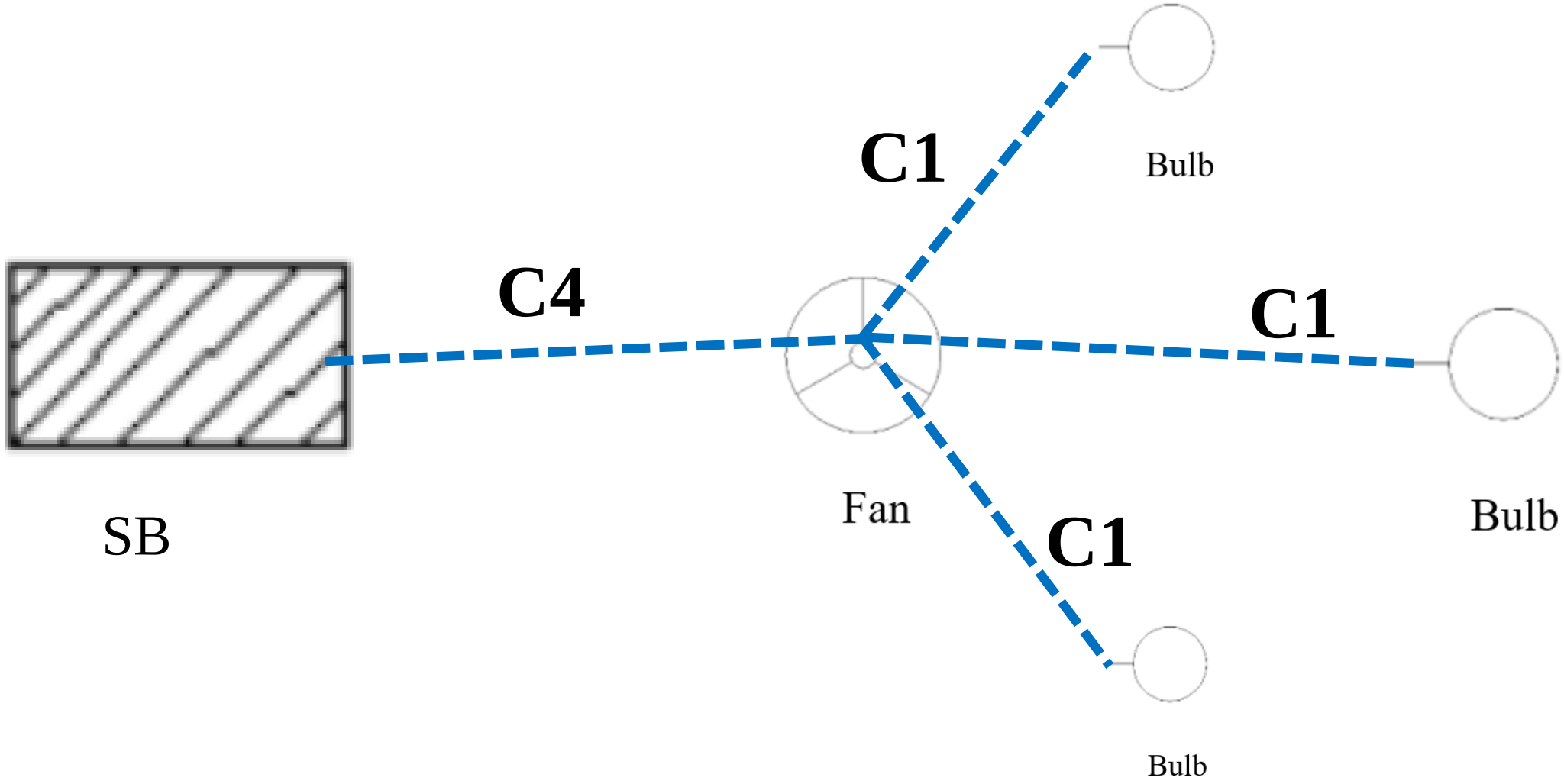
Conduit



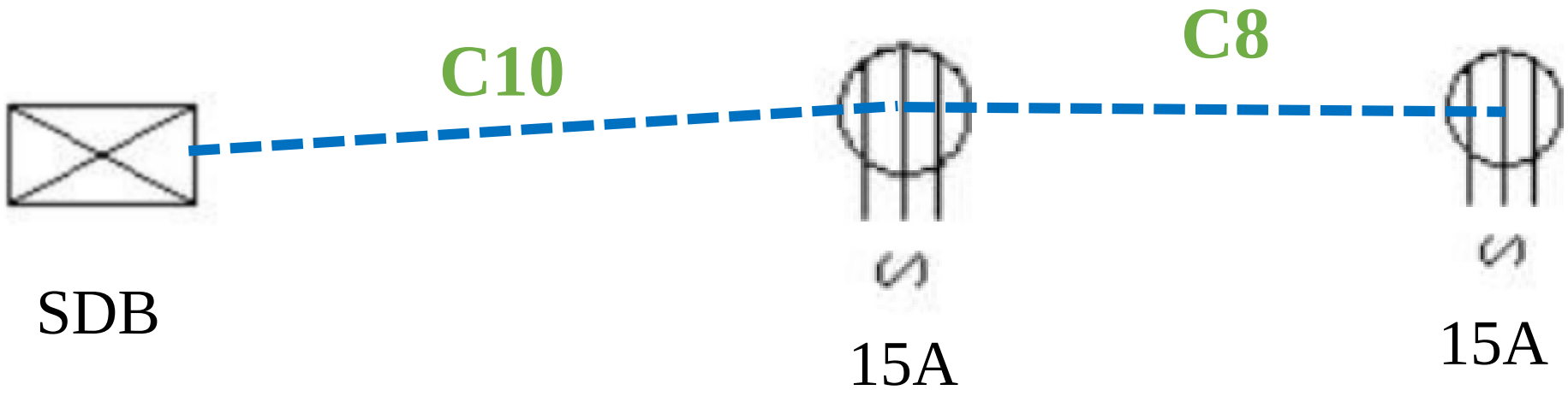
Conduit



Conduit

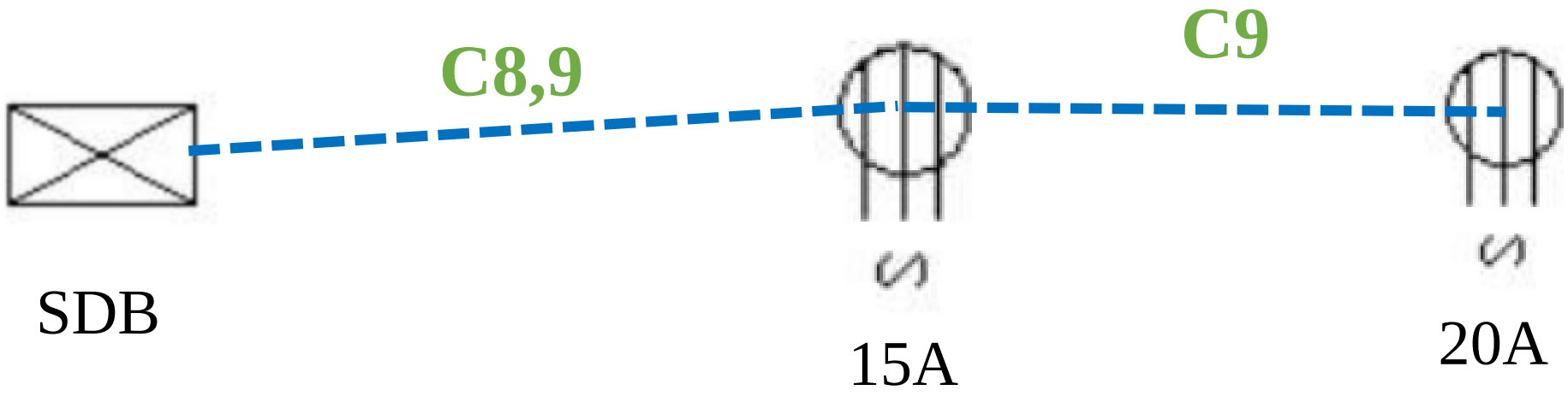


Conduit (Power Socket)



C10 = 2C8 = 4x4mm2 BYM + 2x4 BYA ECC

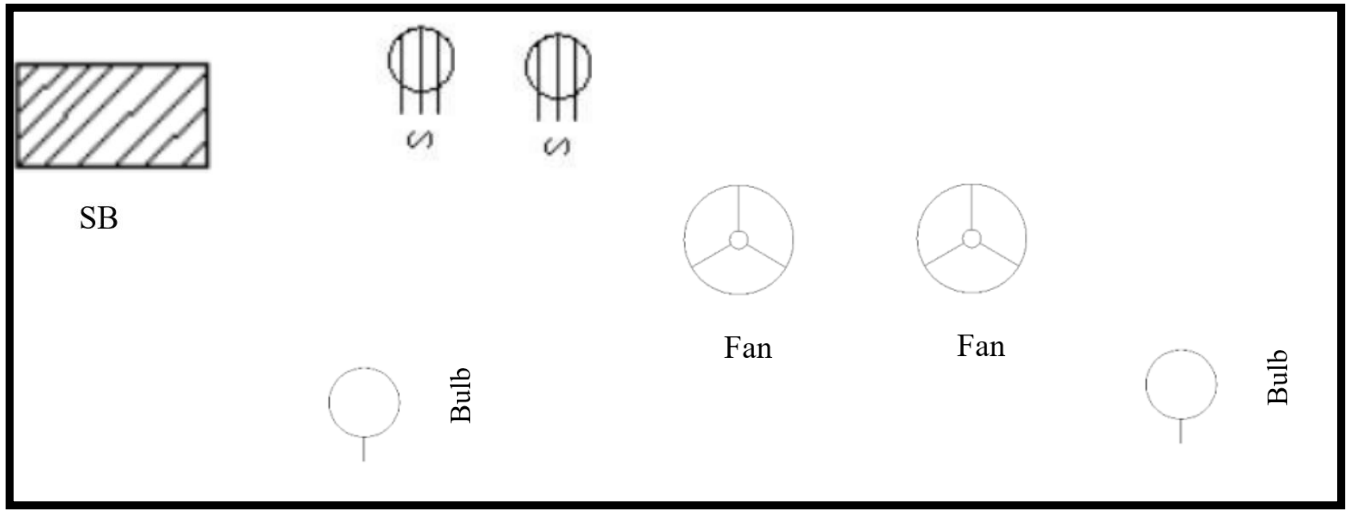
Conduit (Power Socket)

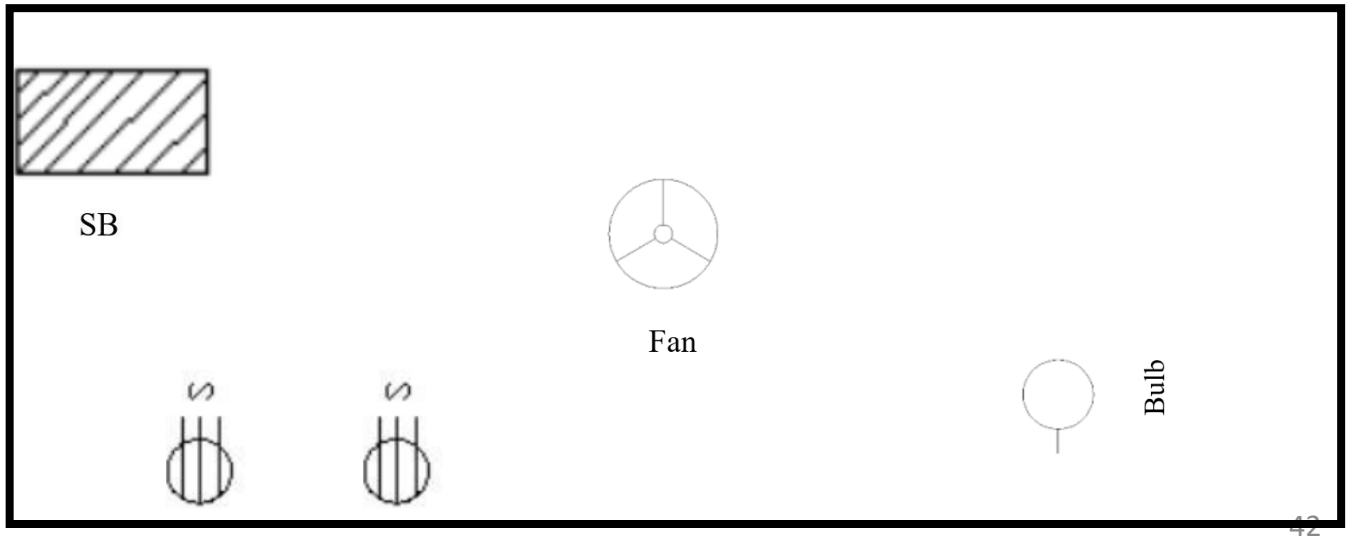


C8,9 = C8 + C9

Conduit (Power Socket)

SDB





Conduit

Symbol	Wire Rating (single core)-mm^2	Current Rating (ampere)	GI Pipe Diameter (inch)
C1	2x1.5	5A	¾
C2	4x1.5	5A	¾
C3	6x1.5	5A	¾
C4	8x1.5	5A	¾
C5	10x1.5	5A	1
C6	12x1.5	5A	1
C7	14x1.5	5A	1
C8	2x4+4 ECC	15A	1
C9	2x6+6 ECC	20A	1

C8,9 = C8 + C9

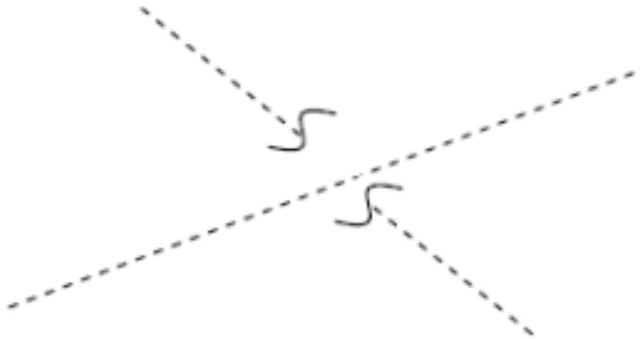
C10 = 2C8 = 4x4 + 2x4 ECC

Conduit

Some things to keep in mind:

a) Conduits should be straight lines. In a room, they will always terminate at the Switch board of that room unless needed for other purposes.

b) Avoid crossing conduits as much as possible. If it is unavoidable use the below symbol:

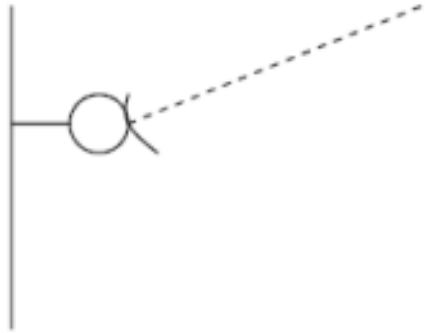


c) Wire should be drawn from distribution board to each switchboard. It is not necessary to draw wires to every switchboard from distribution board, if there are several interconnected switchboards then only one needs to be connected to the distribution board. In this way several groups of switchboards are made, and each group is connected to the distribution board.

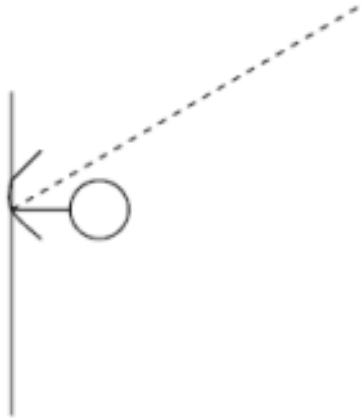
Conduit

d) Prime target of conduit layout is to use least length of conduit not least number of them. Try to take several wire pairs through each conduit as wires are cheaper than conduits.

e) When a conduit has to be connected to something not on the ceiling level, indicate it by using the 'conduit going down' mark.

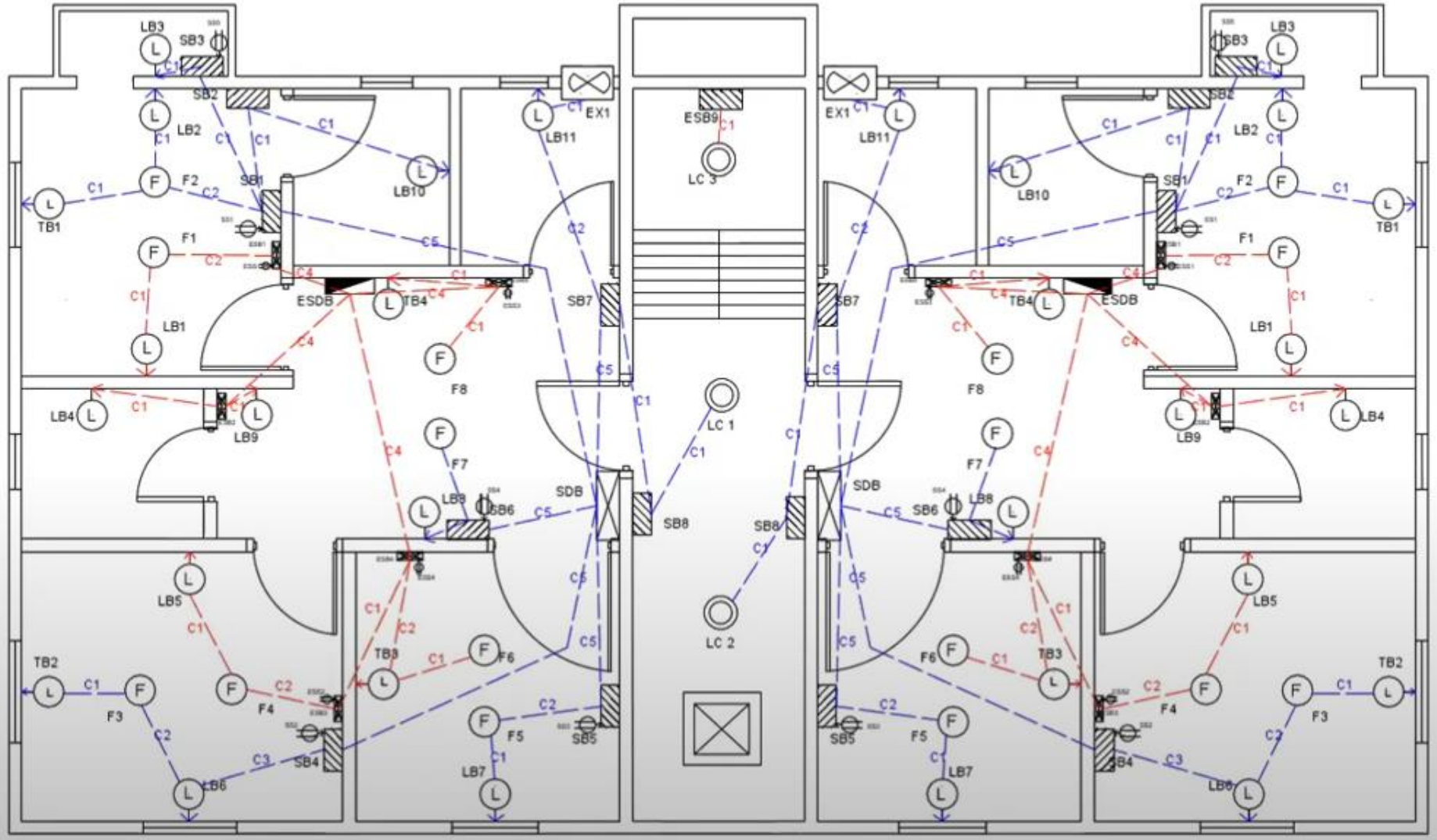


Wrong



Right

Conduit (Lighting Loads)



Normal Conduit

Emergency Conduit

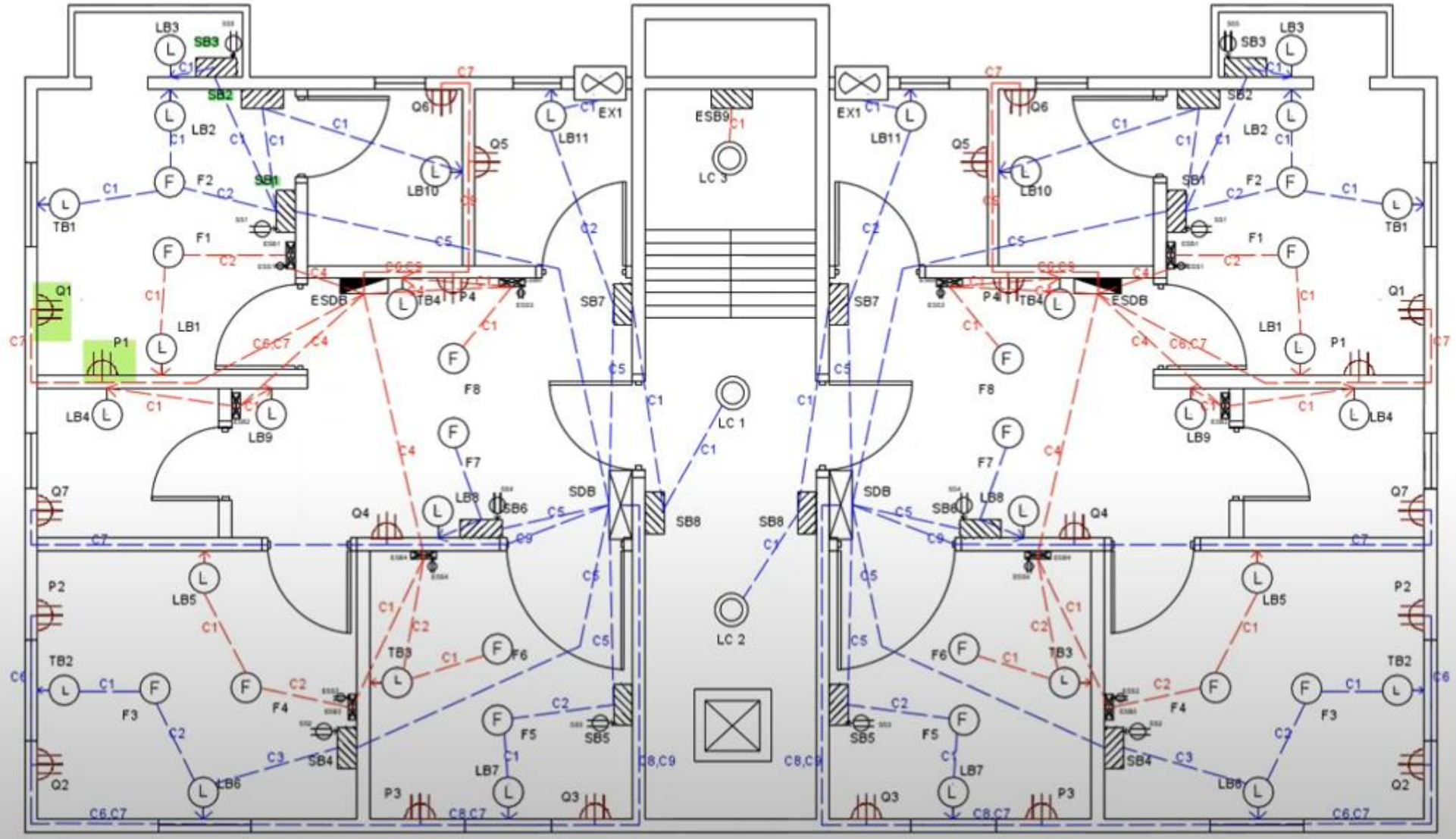
SB

ESB

SDB

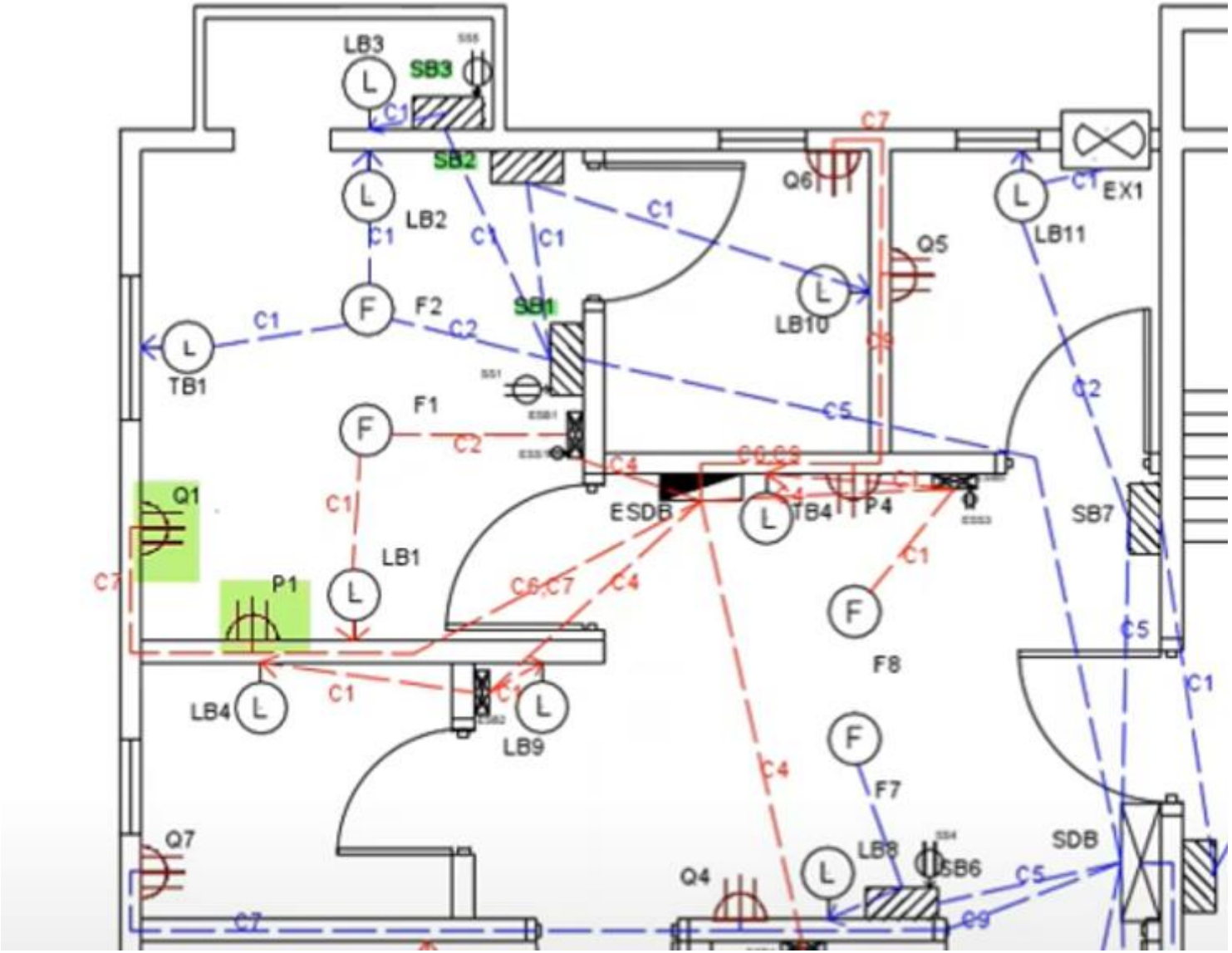
ESDB

Conduit (Power Socket)



Power Sockets are directly connected to SDB

Conduit


LB3
SB3
C1
SB2
LB2
C1
C1
C1
C1
C7
Q6
EX1
LB11
Q5
LB10
C1
F2
SB1
C2
TB1
F1
C2
C5
C4
C6,C7
ESDB
TB4
P4
SB7
Q1
C1
LB1
C7
P1
C6,C7
C4
C1
F8
C5
C1
LB4
C1
LB9
F7
C4
Q7
LB8
SB6
SDB
Q4
C5
C7
C9

Conduit (AutoCAD)

Create a New Layer

Line type – HIDDEN in AutoCAD

Specify LTS value

SB Diagram
ESB Diagram

Switch Board Diagram

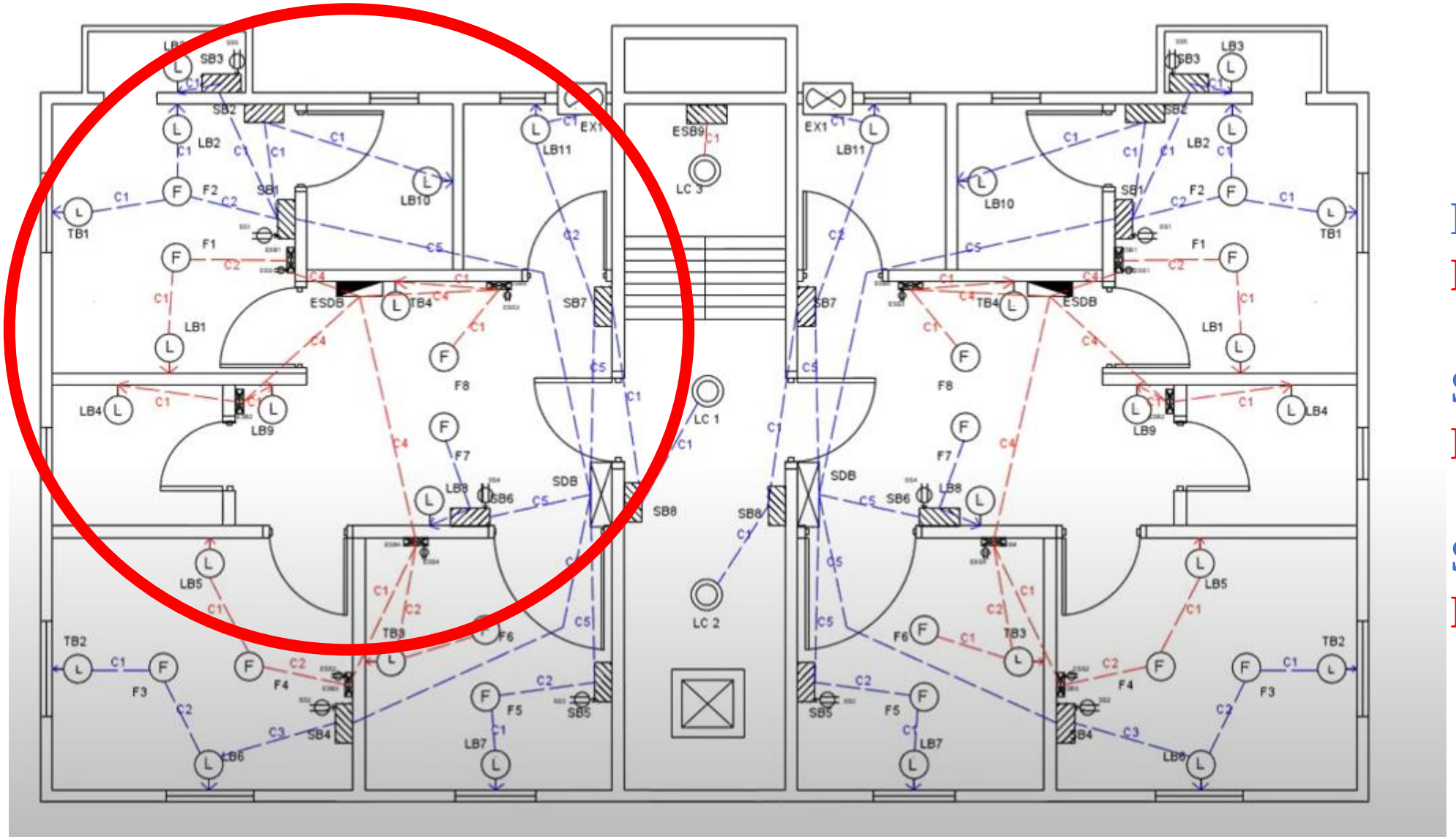
Switch Board (SB) diagram

1. One SB for each room
2. Shows the connections from **normal** Light, Fan, 2pin sockets to SB
3. One SB can be connected to SDB via another SB
4. One Ckt for one SB

Emergecny Switch Board (ESB) diagram

1. One ESB for each room
2. Shows the connections from **emergency** Light, Fan, 2pin sockets to ESB
3. One ESB can be connected to ESDB via another ESB
4. One Ckt for one ESB

Switch Board Diagram (Non-Emergency)



Normal Conduit

Emergency Conduit

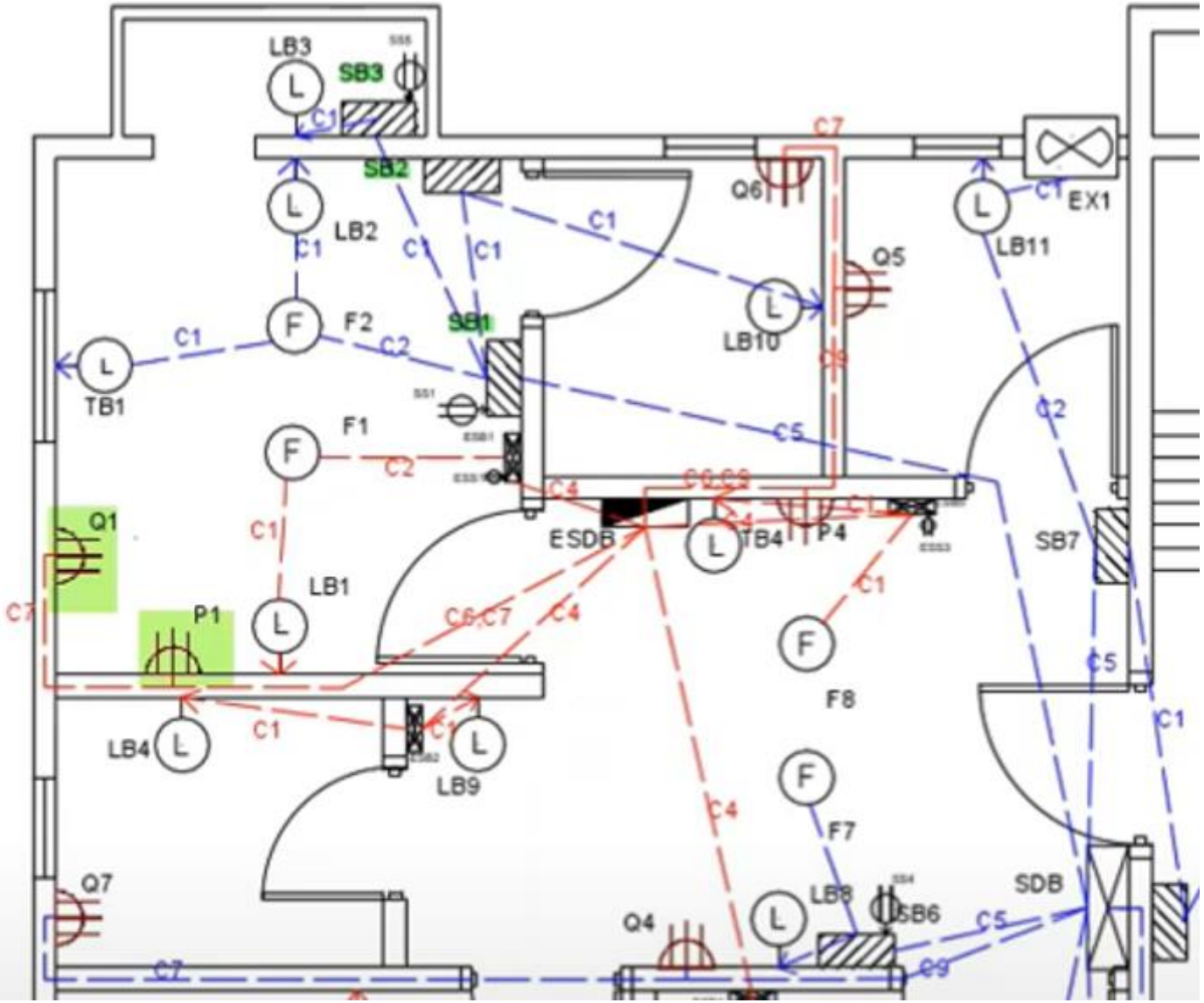
SB

ESB

SDB

ESDB

Switch Board Diagram (Non-Emergency)



Normal Condition

Bedroom-1

1 Fan
2 Light
1 Two pin socket

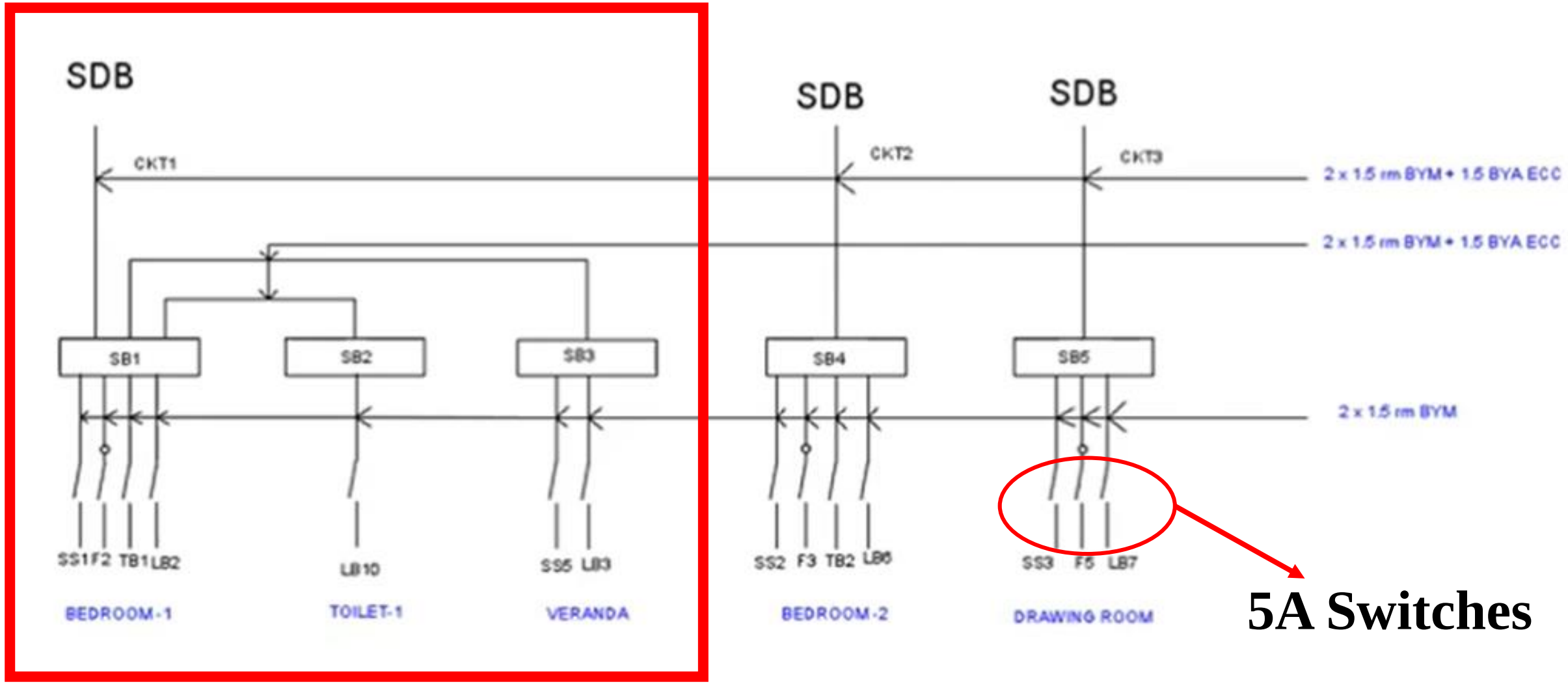
Toilet-1

1 Light

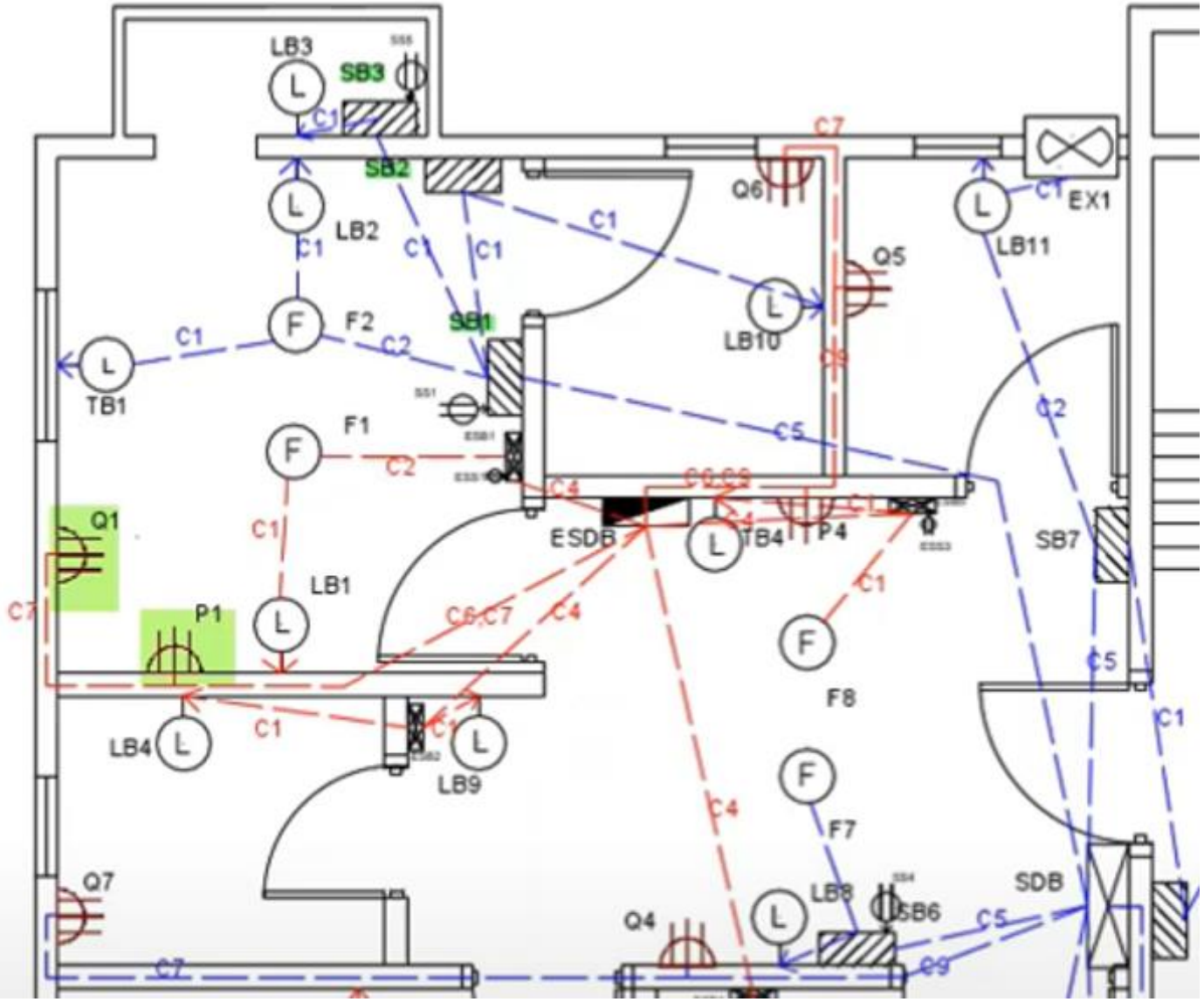
Veranda

1 Light
1 Two pin socket

Switch Board Diagram (Non-Emergency)



Switch Board Diagram (Emergency)



Emergency Condition

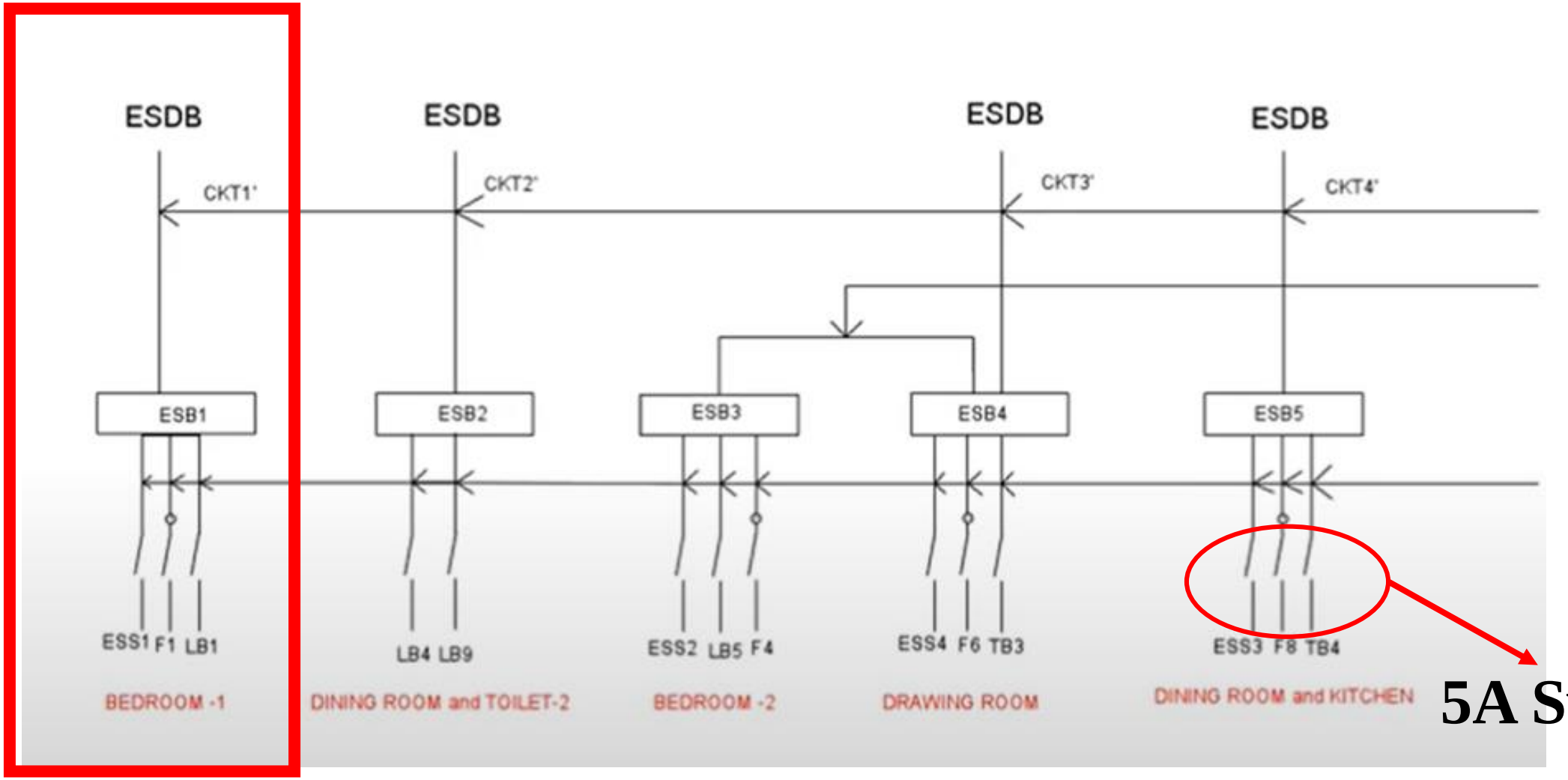
Bedroom-1

1 Fan

2 Light

1 Two pin socket

Switch Board Diagram (Emergency)



5A Switches

SB ESB Diagram

Total SB diagram

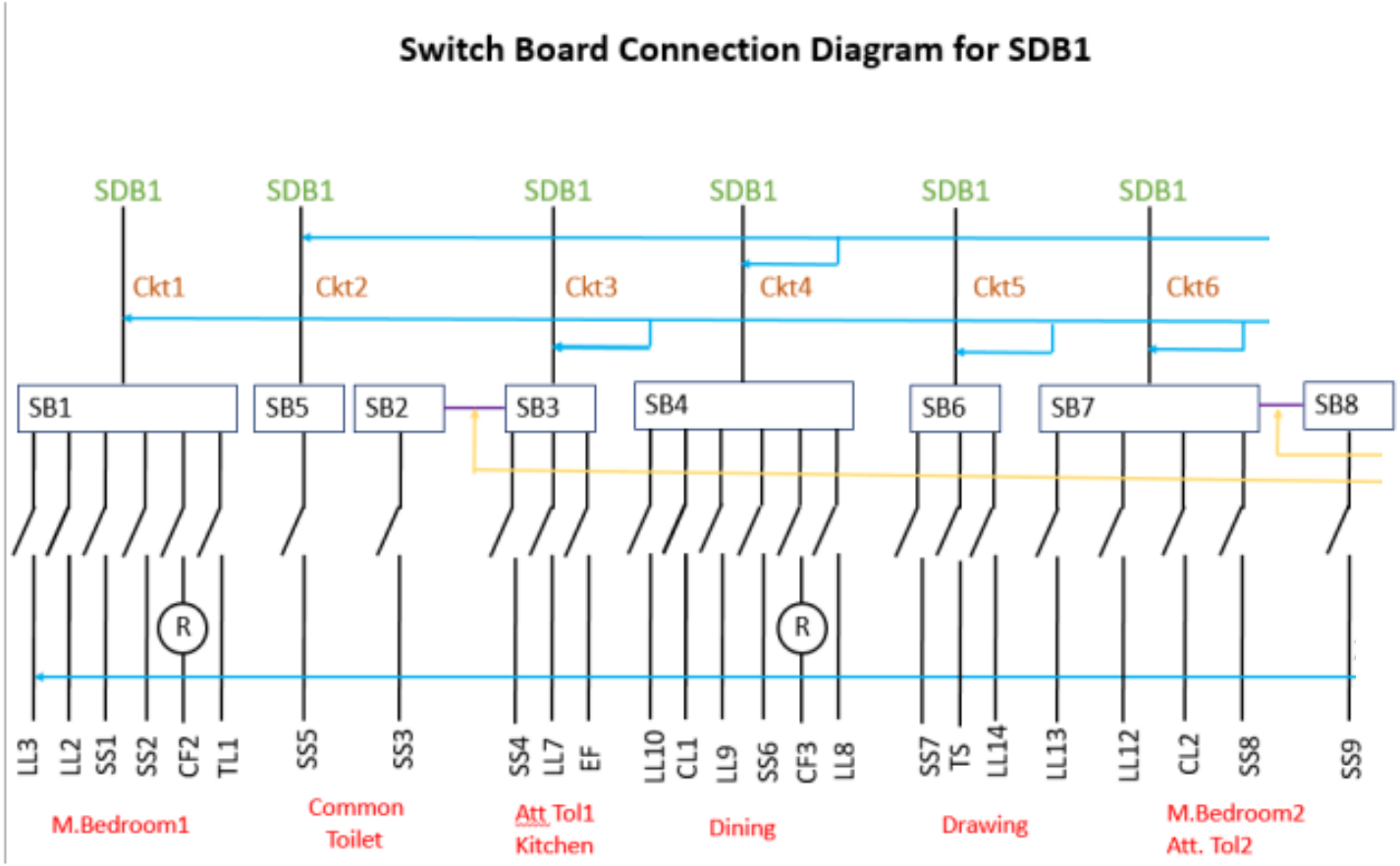
1. Unit-1
2. Unit-2
3. Ground Floor
4. Basement
5. Roof

Total ESB diagram

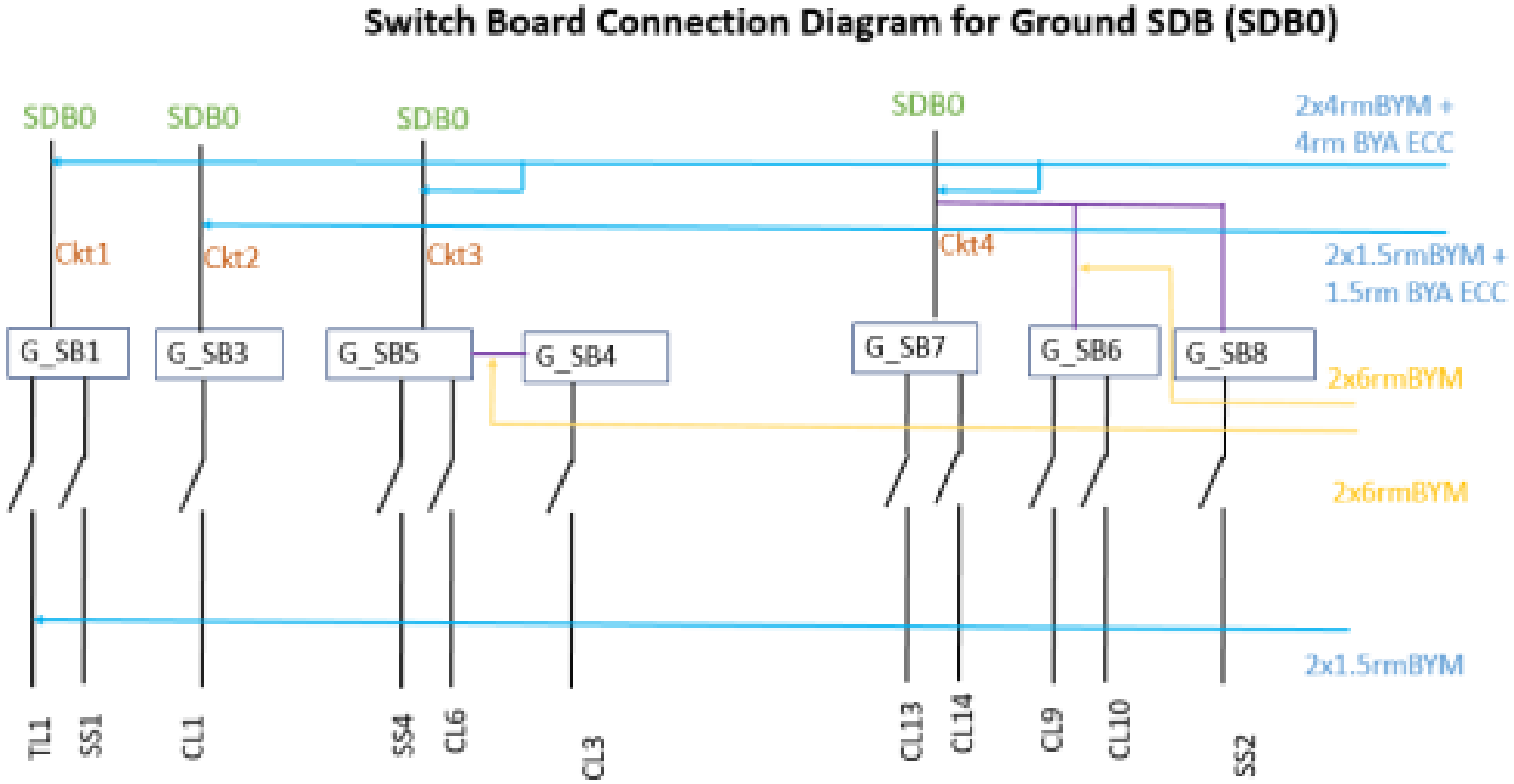
1. Unit-1
2. Unit-2
3. Ground Floor
4. Basement
5. Roof

Some Example Diagrams are presented in the next few slides

SB Diagram (Unit-1 and Unit-2)

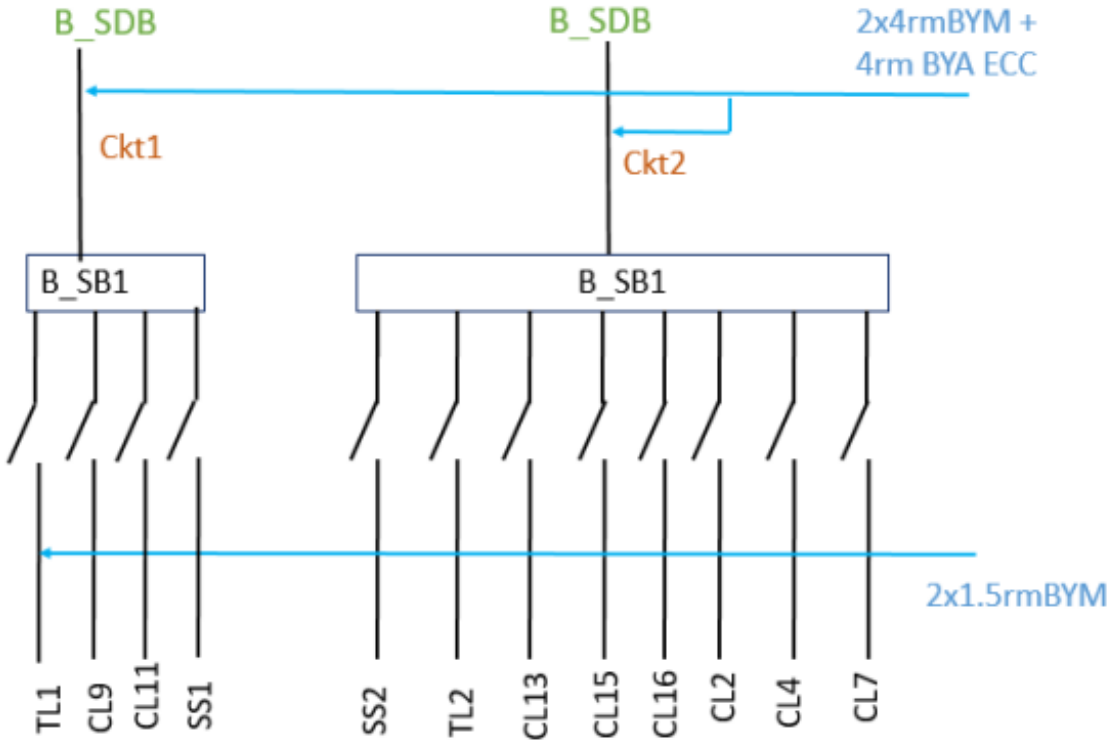


SB Diagram (Ground Floor)

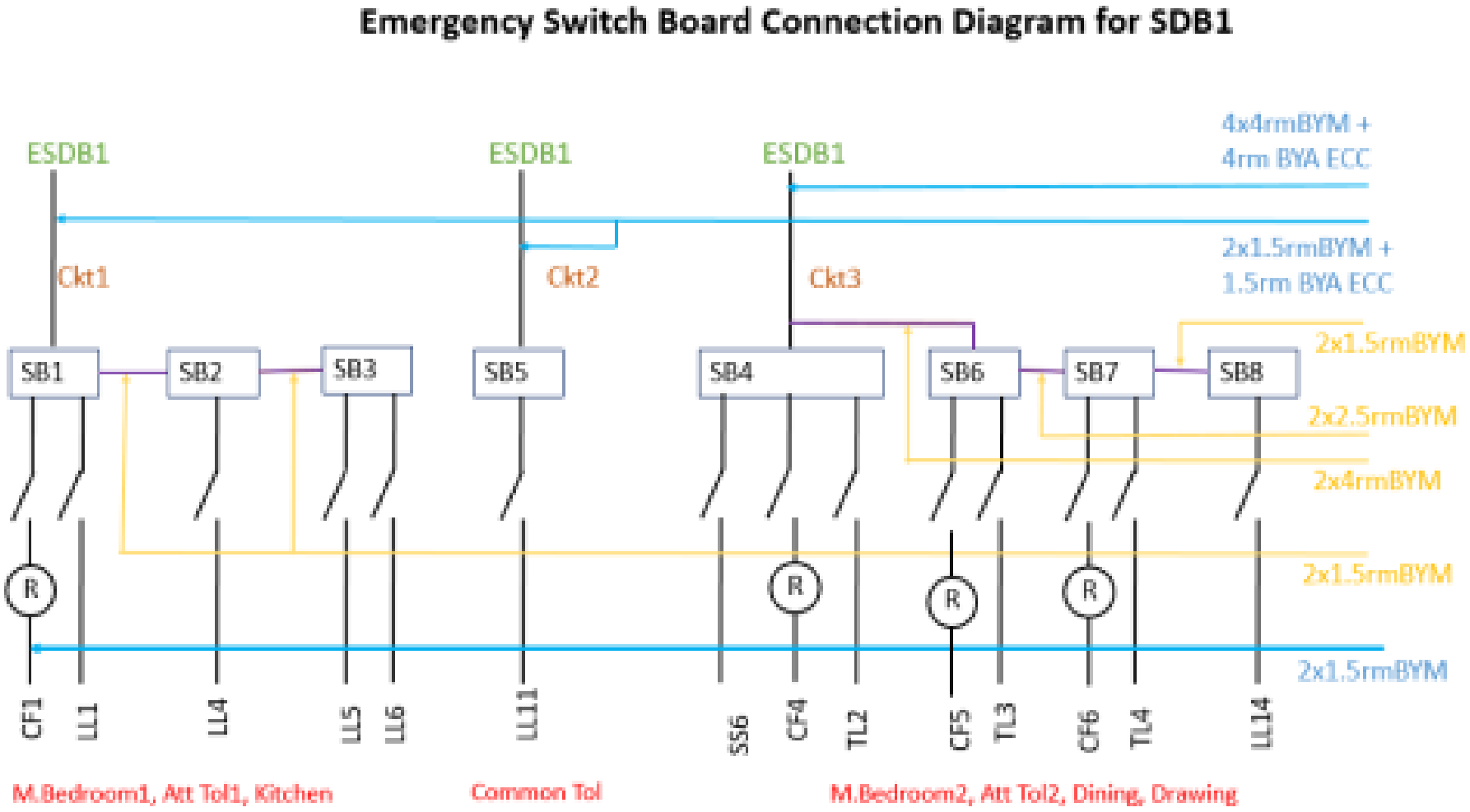


SB Diagram (Basement)

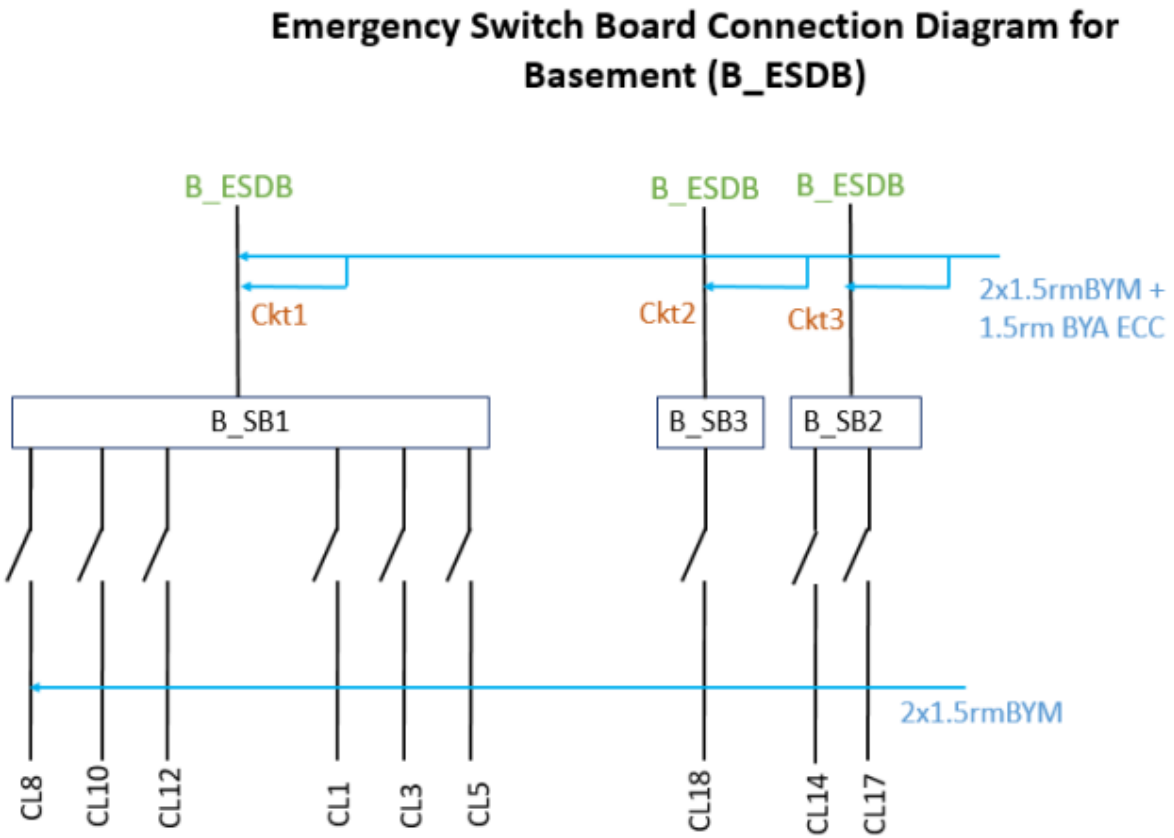
Switch Board Connection Diagram for Basement SDB (B_SDB)



ESB Diagram (Unit-1 and Unit-2)



ESB Diagram (Basement)



SDB Diagram
ESDB Diagram

SDB and ESDB Diagram

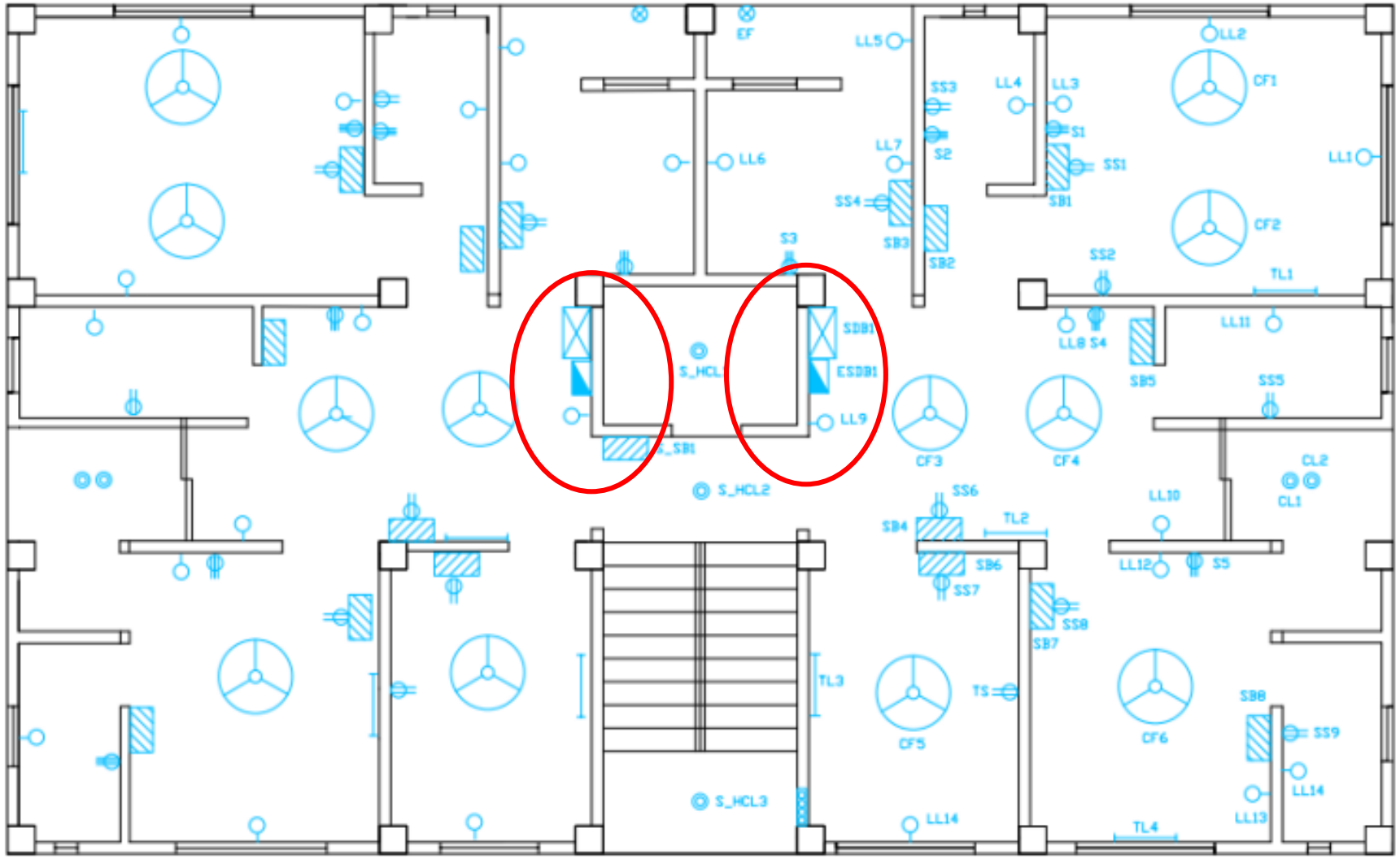
Sub-Distribution Board (SDB) diagram

1. One SDB for each Unit, Ground, Basement and Roof
2. Shows the connections from **SB to SDB**
3. **Power Sockets are Directly Connected to SDB**

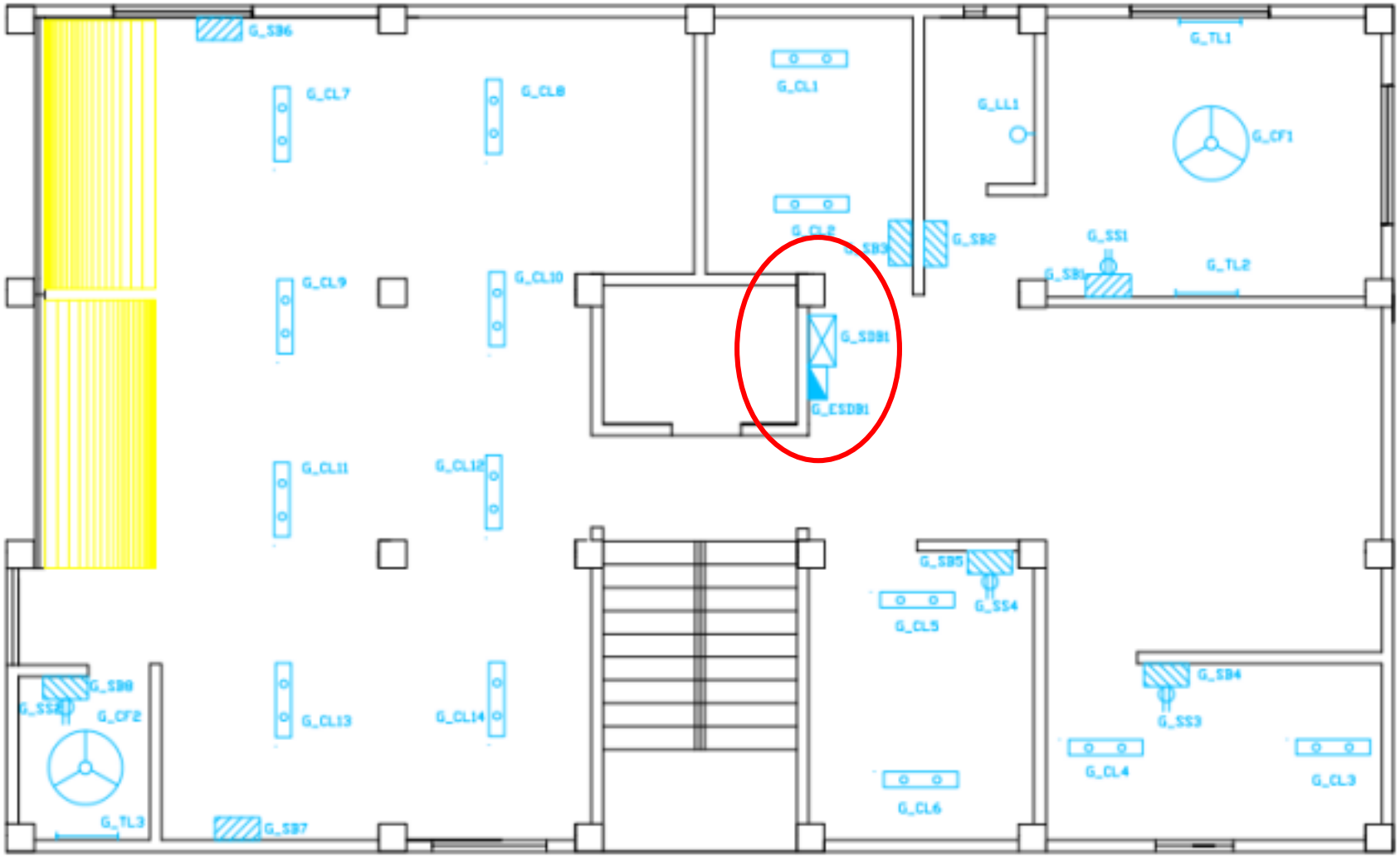
Emergency Sub-Distribution Board (ESDB) diagram

1. One ESDB for each Unit, Ground, Basement and Roof
2. Shows the connections from **ESB to ESDB**
3. **Emergency Power Sockets are Directly Connected to ESDB**

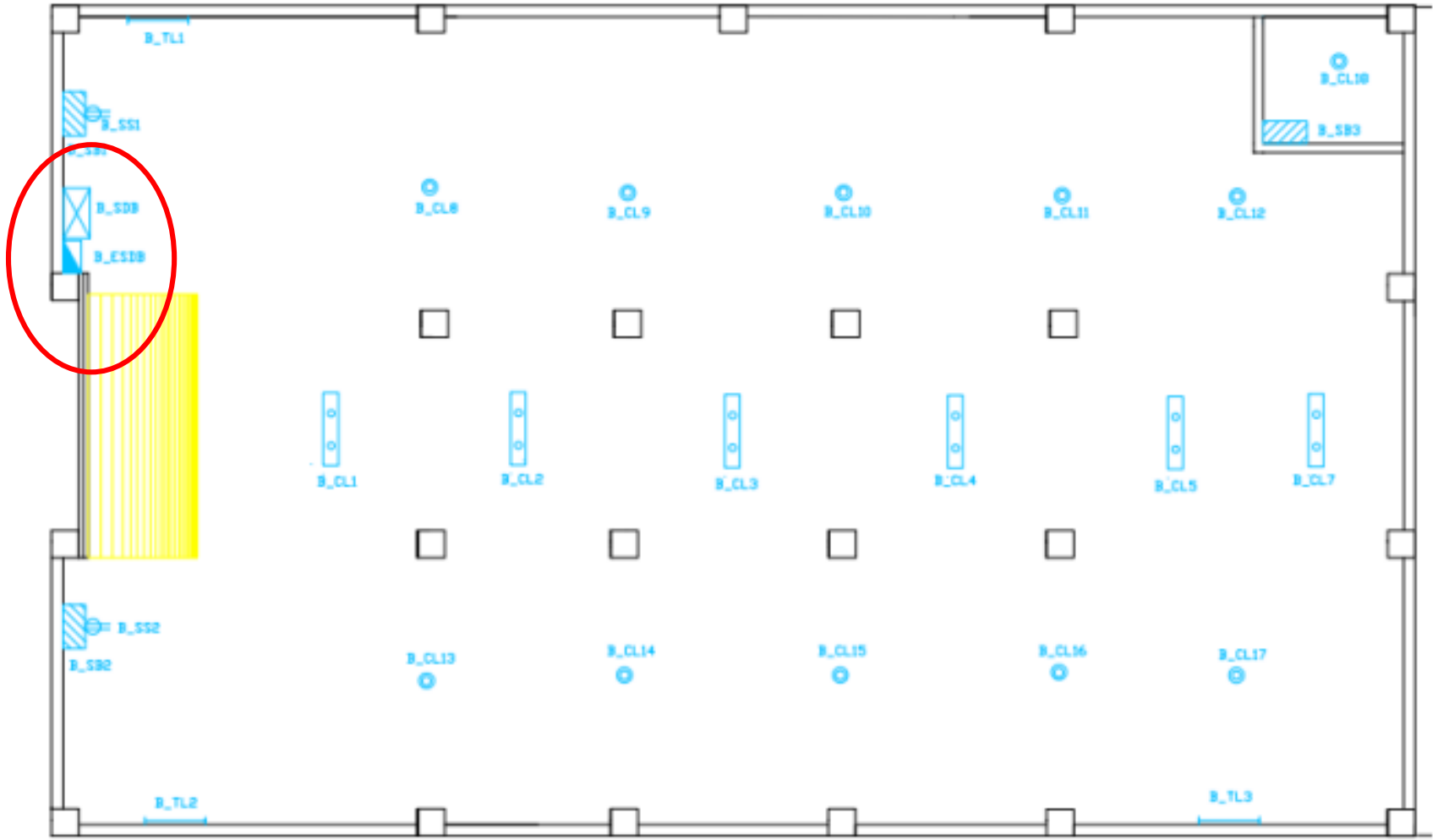
SDB and ESDB of Unit-1 and Unit-2



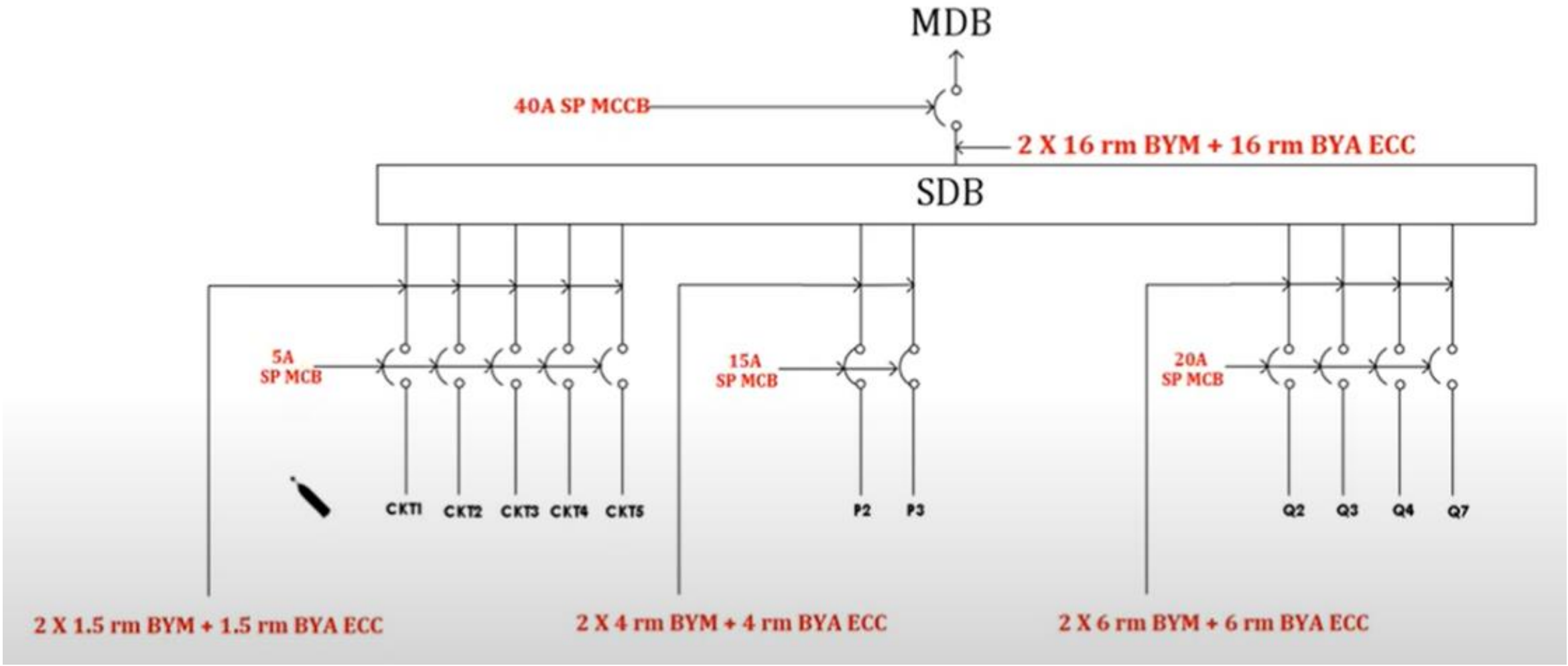
SDB and ESDB of Ground Floor



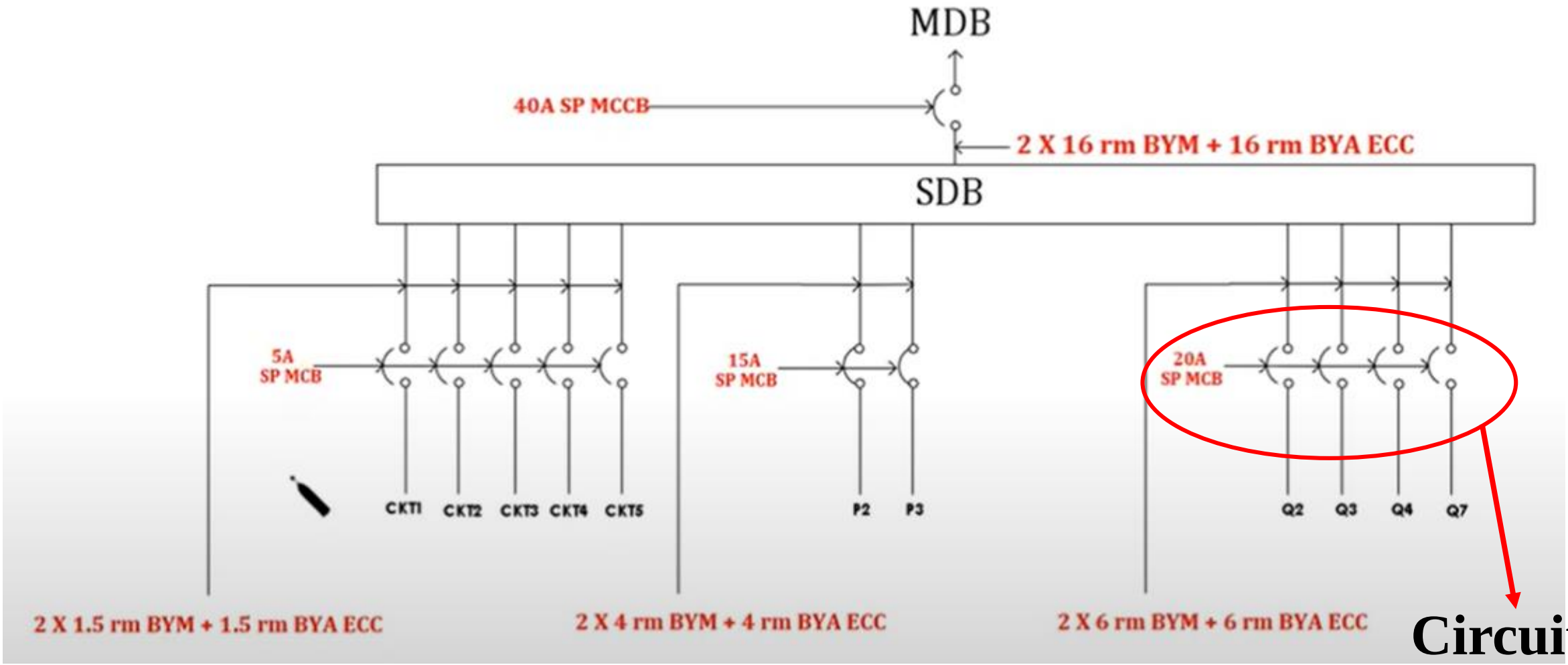
SDB and ESDB of Basement



SDB Diagram

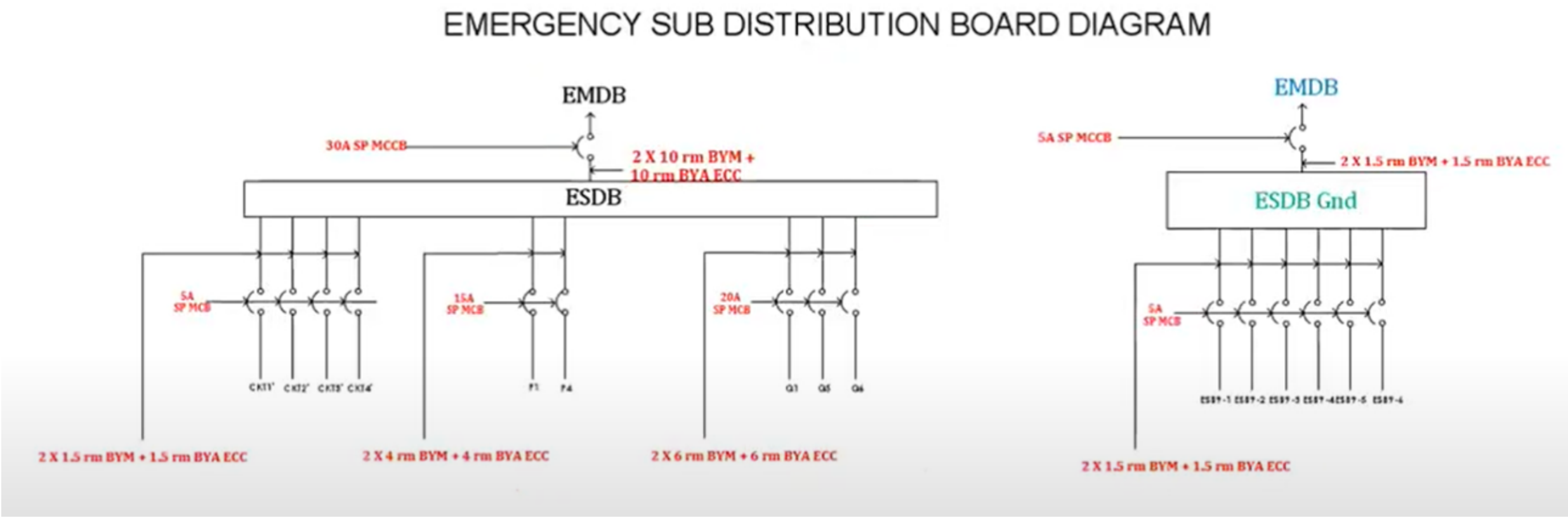

MDB
40A SP MCCB
2 X 16 rm BYM + 16 rm BYA ECC
SDB
5A
SP MCB
15A
SP MCB
20A
SP MCB
CKT1
CKT2
CKT3
CKT4
CKT5
P2
P3
Q2
Q3
Q4
Q7
2 X 1.5 rm BYM + 1.5 rm BYA ECC
2 X 4 rm BYM + 4 rm BYA ECC
2 X 6 rm BYM + 6 rm BYA ECC

SDB Diagram

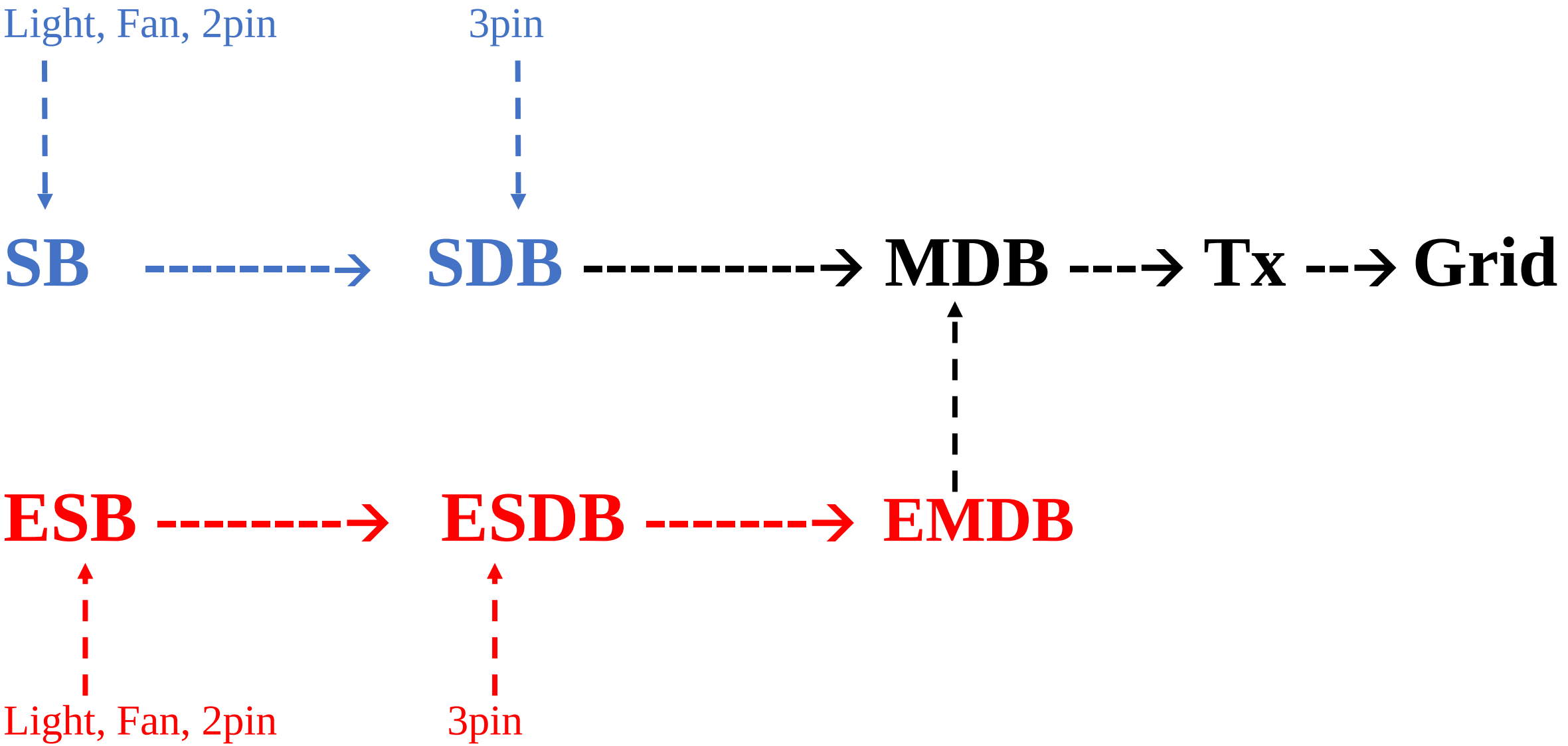


Circuit Breakers

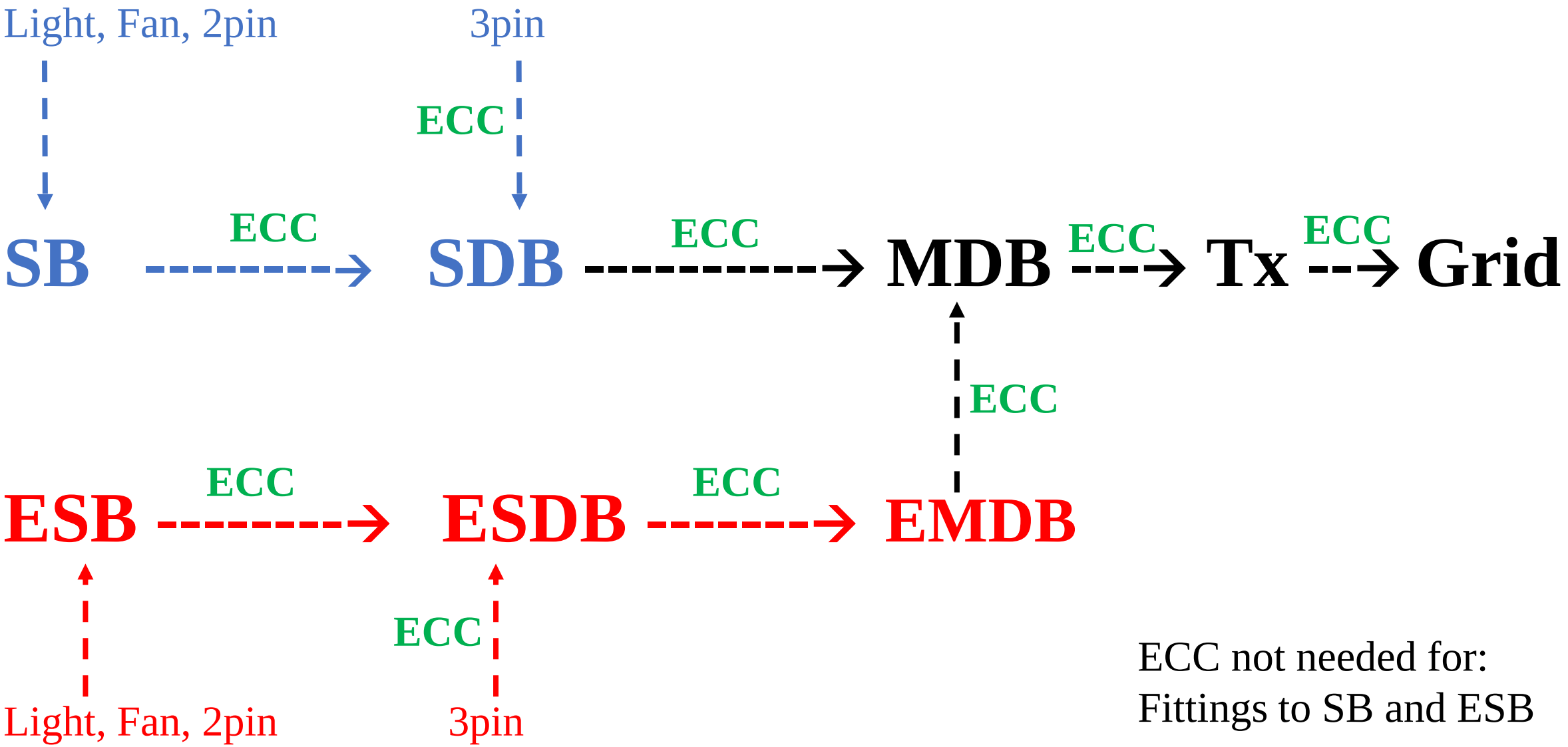
ESDB Diagram



Connection Flow

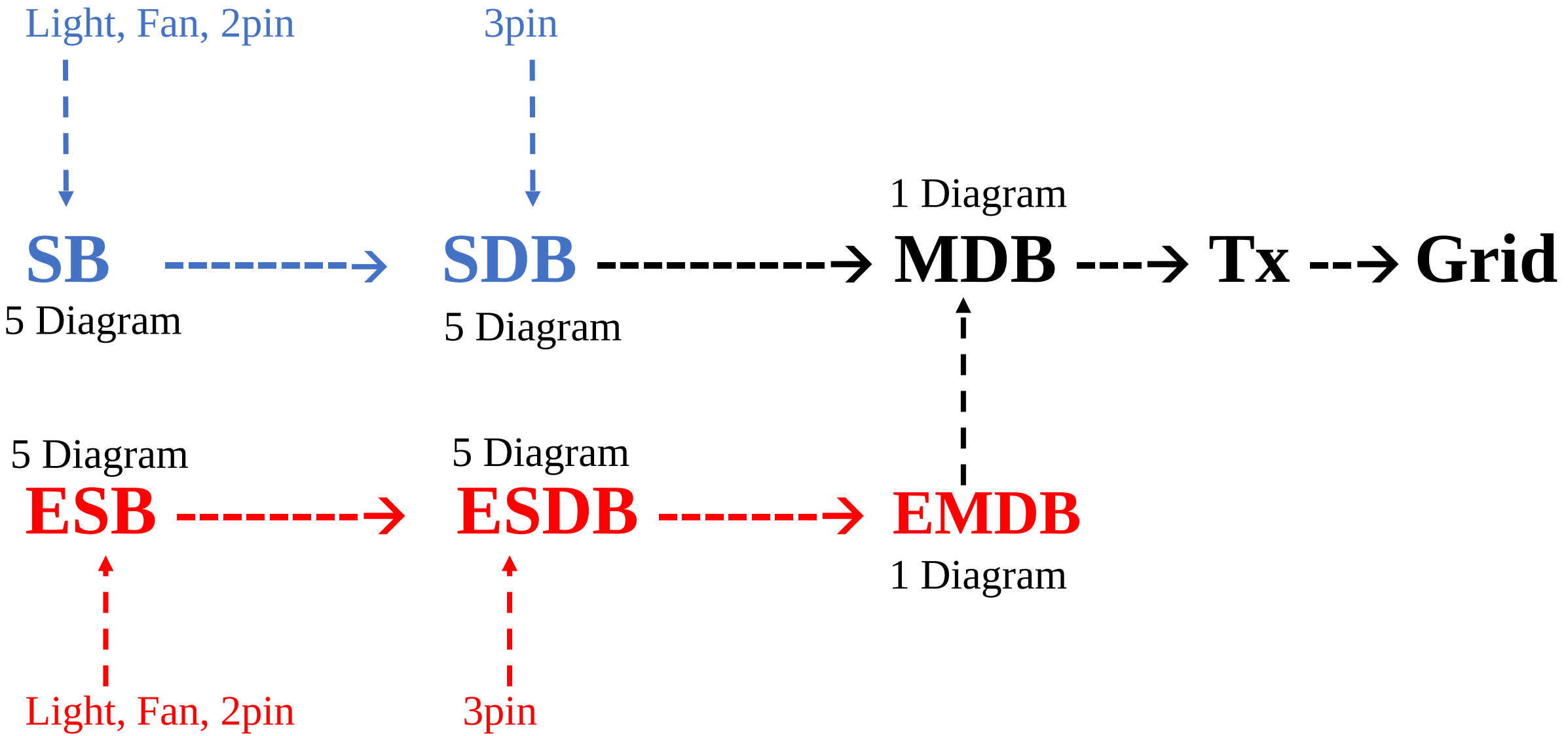


ECC Connection



ECC not needed for:
Fittings to SB and ESB

Connection Flow



SDB ESDB Diagram

Total SDB diagram

1. Unit-1
2. Unit-2
3. Ground Floor
4. Basement
5. Roof

Total ESDB diagram

1. Unit-1
2. Unit-2
3. Ground Floor
4. Basement
5. Roof

MDB EMDB Diagram

MDB and EMDB Diagram

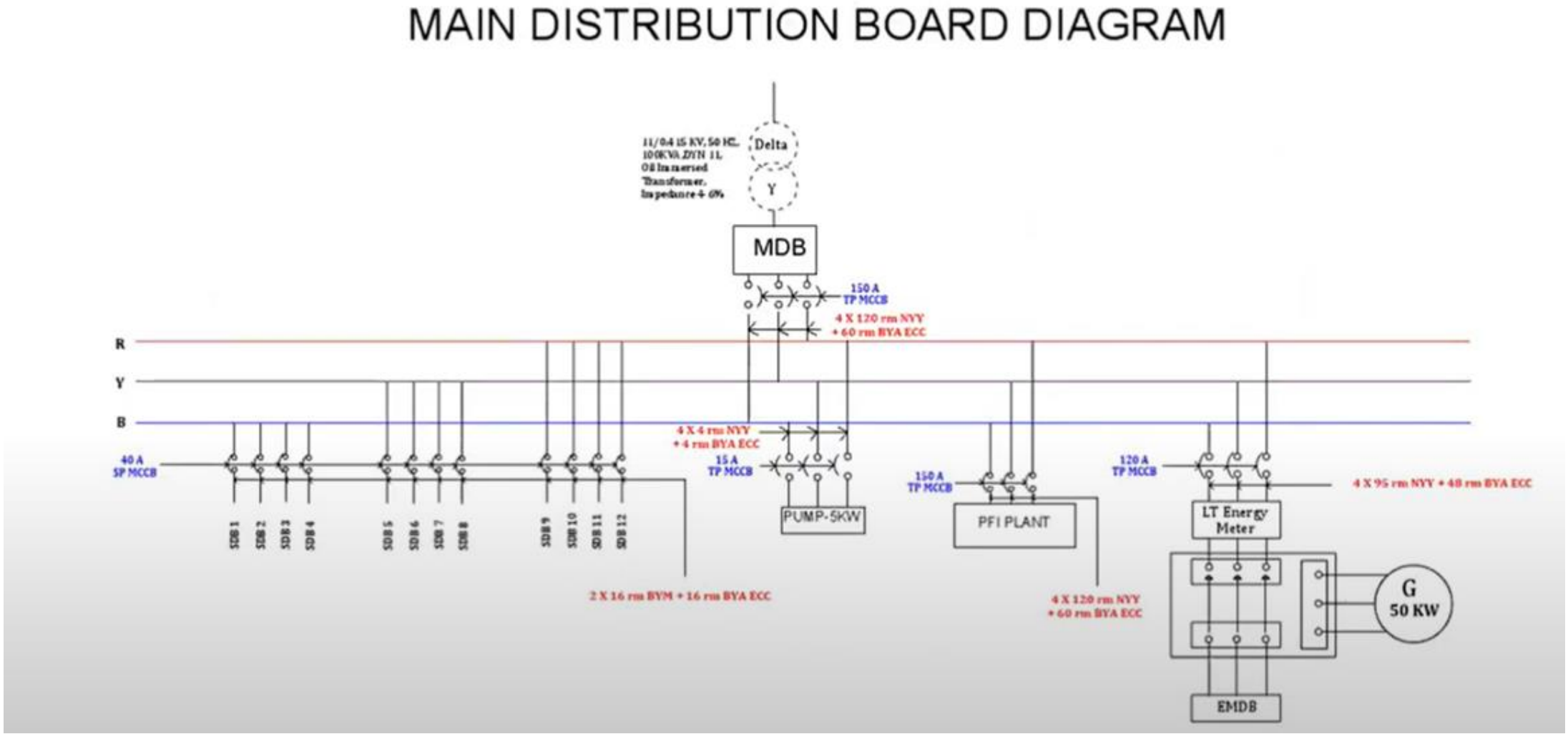
Main-Distribution Board (MDB) diagram

1. One MDB for the building
2. Shows the connections from **SDB to MDB**
3. **Pump, PFI plant, EMDB connection**

Emergency Main-Distribution Board (EMDB) diagram

1. One EMDB for the building
2. Shows the connections from **ESDB to EMDB**
3. **EMDB is connected to MDB via ATS and Generator**

MDB Diagram


MAIN DISTRIBUTION BOARD DIAGRAM
11/0.4 15 KV, 50 HZ.
100KVA ,DYN 11,
Oil Immersed
Transformer,
Impedance 4 6%
Delta
Y
MDB
150 A
TP MCCB
4 X 120 rm NYY
+ 60 rm BYA ECC
R
Y
B
40 A
SP MCCB
SDB 1
SDB 2
SDB 3
SDB 4
SDB 5
SDB 6
SDB 7
SDB 8
SDB 9
SDB 10
SDB 11
SDB 12
2 X 16 rm BYM + 16 rm BYA ECC
4 X 4 rm NYY
+ 4 rm BYA ECC
15 A
TP MCCB
PUMP-5KW
150 A
TP MCCB
PFI PLANT
4 X 120 rm NYY
+ 60 rm BYA ECC
120 A
TP MCCB
4 X 95 rm NYY + 48 rm BYA ECC
LT Energy
Meter
G
50 KW
EMDB

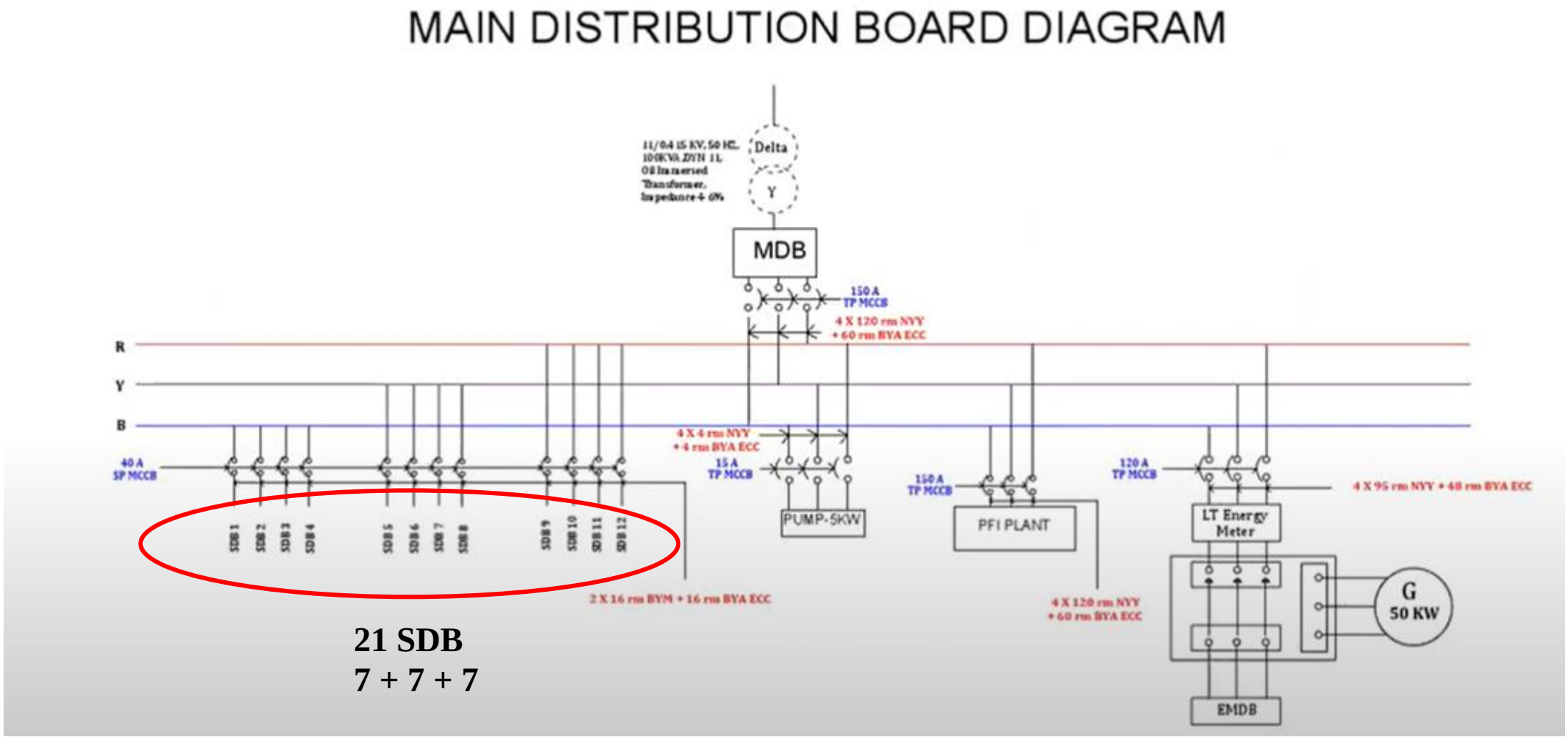
MDB Diagram

Sample Calculation
Total Number of SDB Connected to MDB = 21

9 Apartments * 2 units Each = 18
Ground Floor = 1
Basement = 1
Roof = 1

7 SDB connected to each phase (21/3 = 7)

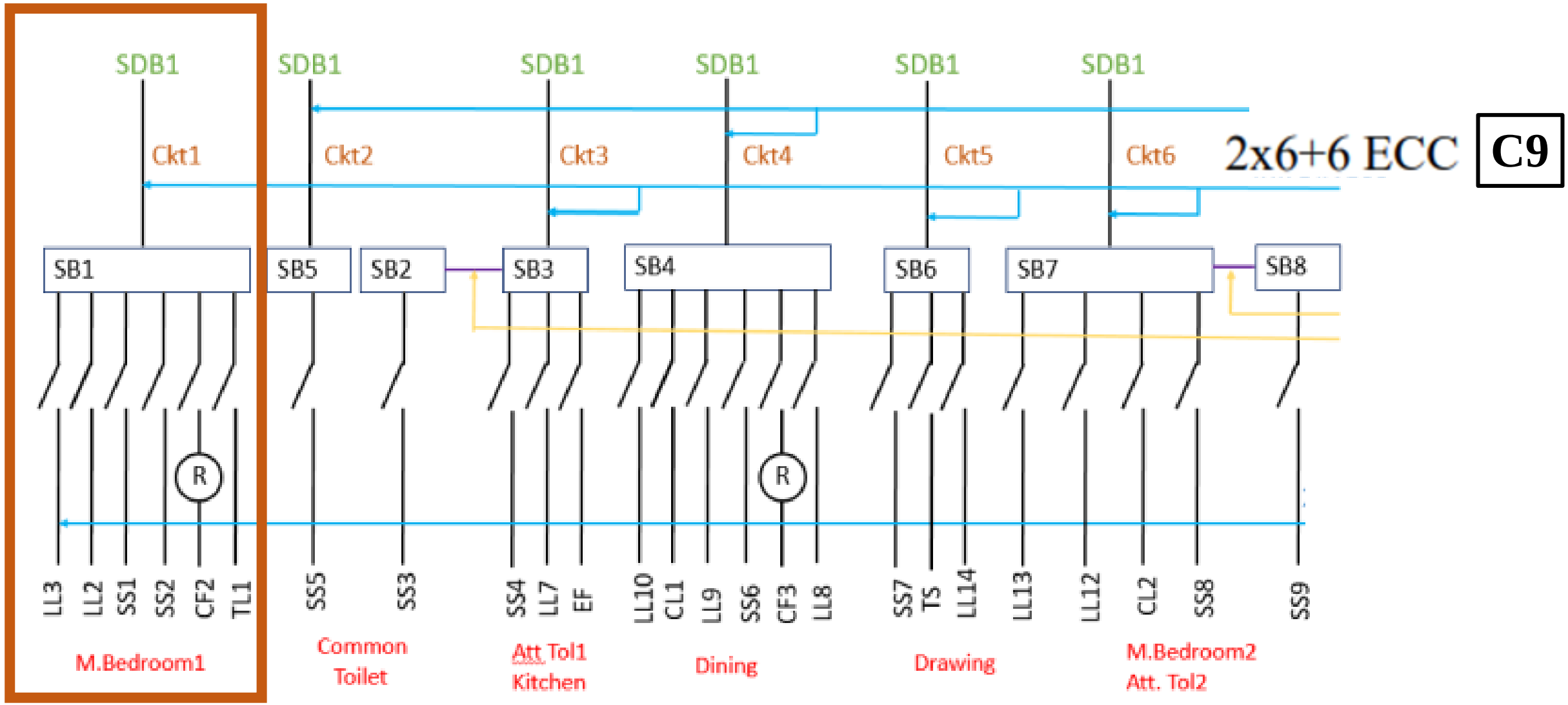
MDB Diagram



21 SDB
7 + 7 + 7

Power Calculations

Calculation For SB Diagram



Calculation For SB Diagram

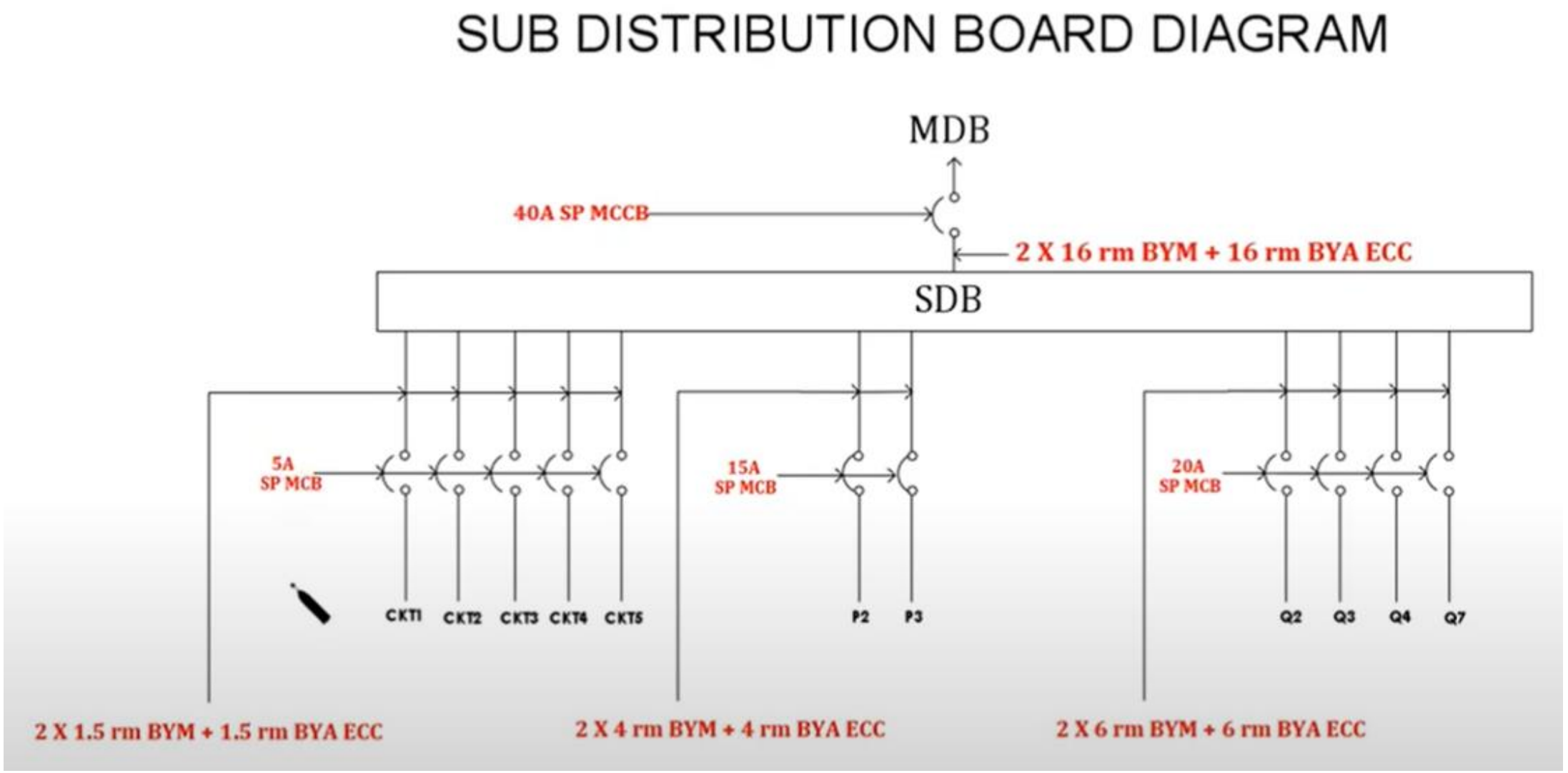
Room Name	Circuit No.	Switch Board	Fixture	Power	Current Rating	Total		Wire Rating	Breaker To SDB
Master Bedroom 1	CKT1	SB1	LL2 LL3 SS1 SS2 CF2 TL1	20 20 - - 75 20	.101 .101 5 5 .3788 .101	10.6818	10.6818	C9	15A

P = V*I*pf

V = 230V rms

pf = 0.7 to 0.8

SDB Diagram


SUB DISTRIBUTION BOARD DIAGRAM
MDB
40A SP MCCB
2 X 16 rm BYM + 16 rm BYA ECC
SDB
5A
SP MCB
15A
SP MCB
20A
SP MCB
CKT1
CKT2
CKT3
CKT4
CKT5
P2
P3
Q2
Q3
Q4
Q7
2 X 1.5 rm BYM + 1.5 rm BYA ECC
2 X 4 rm BYM + 4 rm BYA ECC
2 X 6 rm BYM + 6 rm BYA ECC