



CHITTAGONG UNIVERSITY OF  
ENGINEERING AND TECHNOLOGY  
*Department of Electrical and Electronic Engineering*

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## Electrical Services Design for a 1-Storied Library with Archival Environmental Control

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*A Project Report Submitted by*

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# **1 Objective**

The primary objectives of this electrical service design are:

1. To design a safe, reliable, and code-compliant Low Voltage (LV) distribution system for the Archival Vault and Library complex, ensuring adequate power for lighting, HVAC, and equipment.
2. To implement a robust backup power strategy using an Automatic Transfer Switch (ATS) for generator integration and Online UPS systems for critical loads (CCTV, HMI, Sensors).
3. To provide comprehensive documentation including conduit layouts, Single Line Diagrams (SLDs), load calculations, and a Bill of Quantities (BOQ) for installation and cost estimation.

## 2 Abstract

This report details the electrical design for a multi-zone facility comprising an Archival Vault, Librarian Hub, Reading Rooms, Computer Room, and associated service areas. The design scope covers the complete electrical infrastructure from the main utility intake to final sub-circuits. Key features include a split-bus distribution system separating critical and non-critical loads, a dedicated UPS network for surveillance and environmental control (T/RH sensors, Dehumidifier), and PoE-based IP-CCTV infrastructure. The report includes detailed load calculations determining a total connected load of approximately 18 kW, protective device sizing (MCB/MCCB) based on cable thermal limits and load currents, and a complete set of CAD drawings (Layouts, SLDs). An earthing system design is also proposed to ensure personnel safety and equipment protection.

### **3 Codes and Standards Used**

The design adheres to the following relevant codes and standards:

- **BNBC 2020** (Bangladesh National Building Code) – Part 8: Building Services (Electrical).
- **BS 7671** (IET Wiring Regulations) – For cable sizing, circuit protection, and earthing requirements.
- **NFPA 72** (National Fire Alarm and Signaling Code) – For dedicated fire alarm circuit requirements.
- **IEEE 802.3af/at** (Power over Ethernet Standards) – For IP Camera and Network Switch power delivery.

## 4 Legend (Symbols)

	Wall light		Gas Nozzle
	15A 3 pin socket		Smoke Detector
	Switch Board with 5A 2pin socket		UPS
	HMI Controller		Thermostat
	AC Indoor Unit		Sub Distribution Board
	AC Outdoor Unit		Fire Alarm Control Panel
	CCTV Camera		Switch
	Main Distribution Board(MDB)		Regulator
	Dehumidifier		Exhaust Fan
			POE Switch
			NVR
			Router
			Network Switch

## 5 Drawings: Layouts and Conduits

### 5.1 Floor Plan

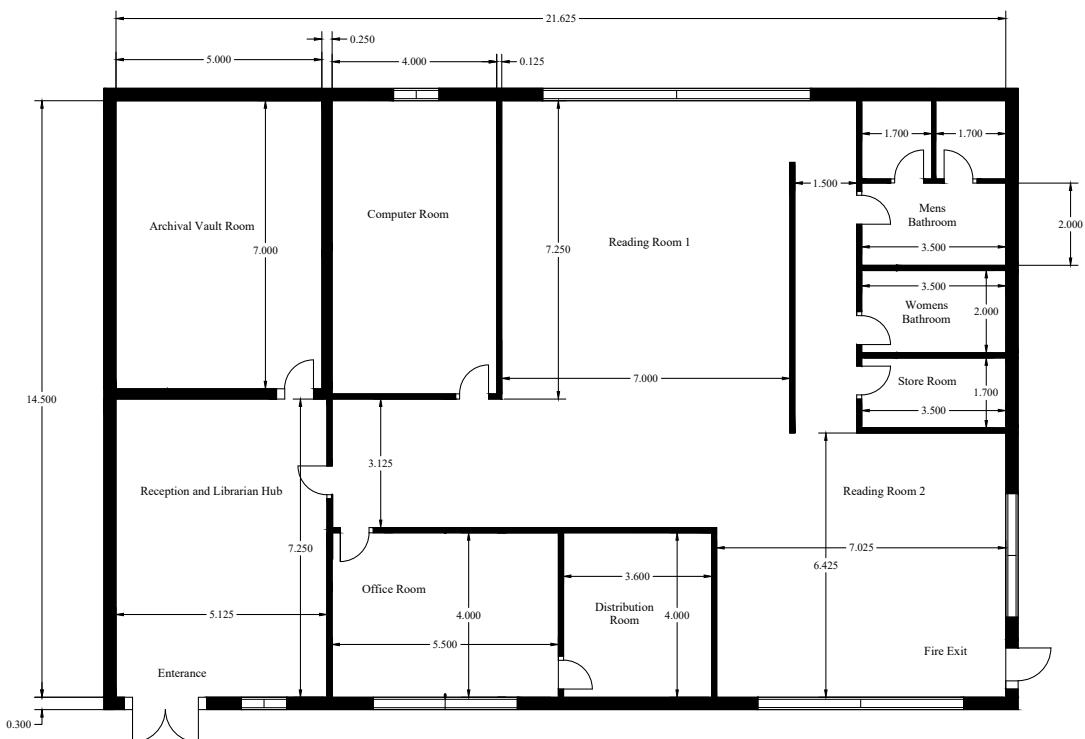


Figure 5.1: Architectural Floor Plan with Dimensions.

### 5.2 Fitting & Conduit Layouts

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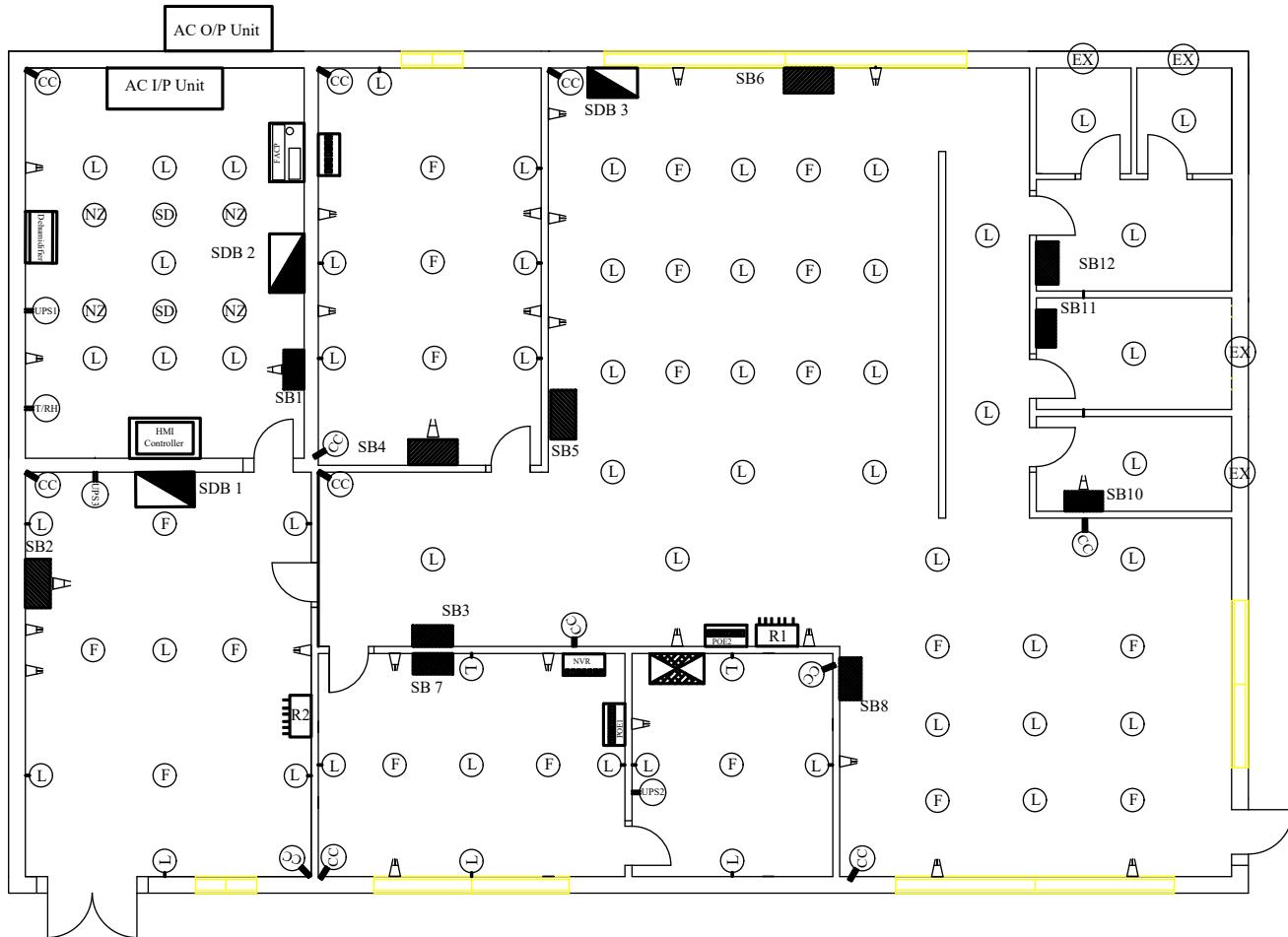


Figure 5.2: Fitting Layout: Placement of Lights, Fans, and Components.

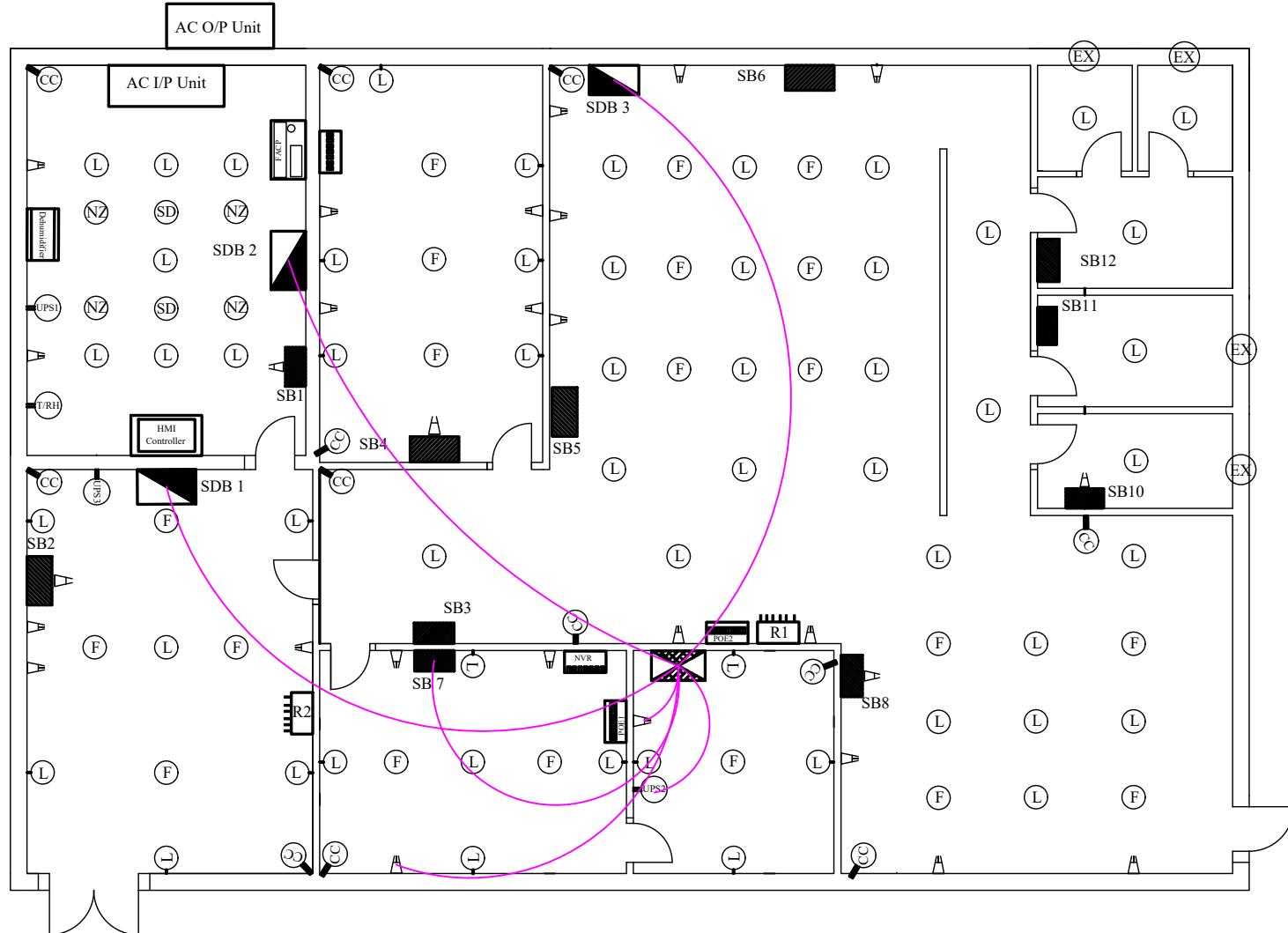


Figure 5.3: Conduit Layout: Main Distribution Routes (MDB to SDBs).

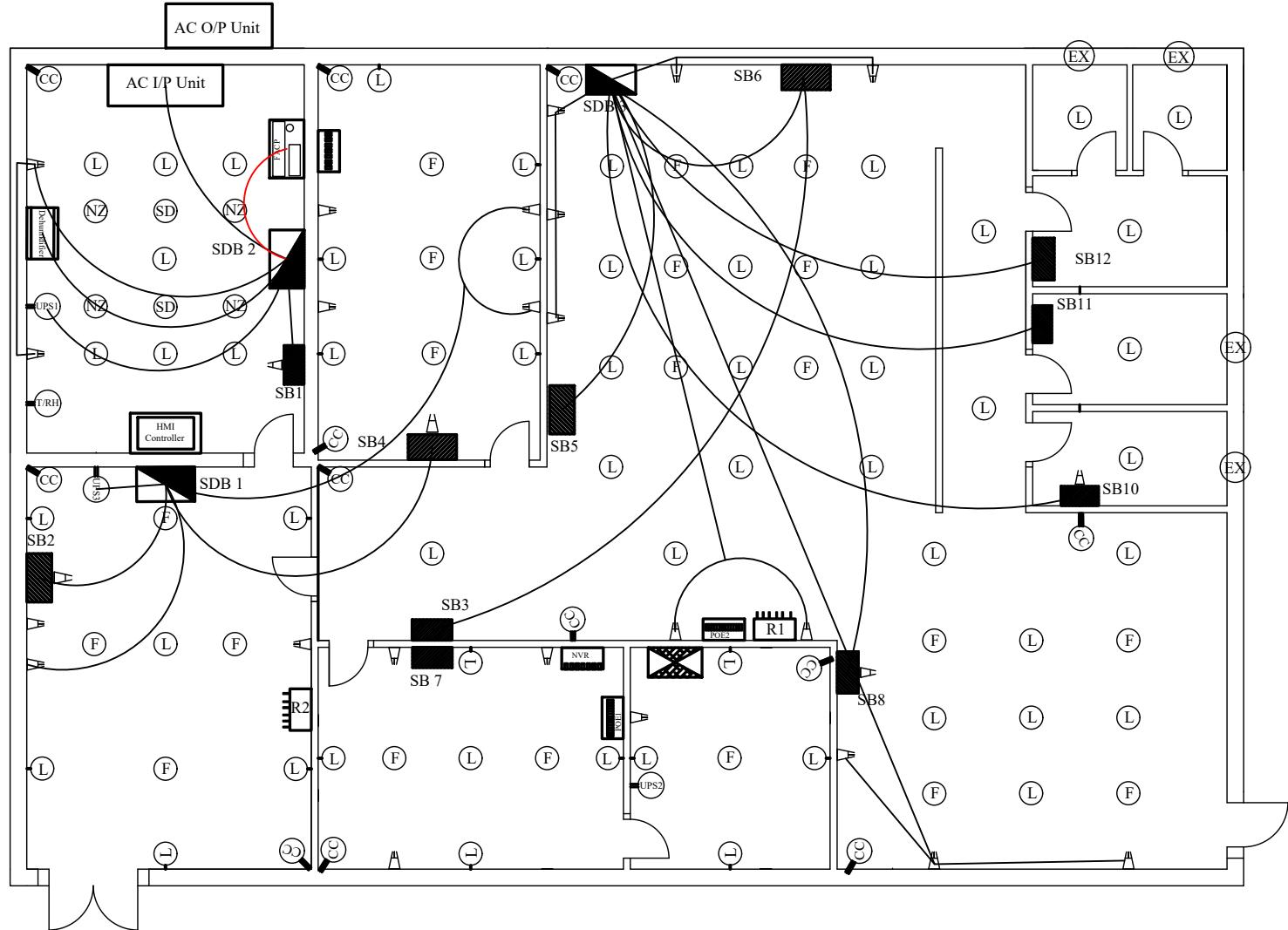


Figure 5.4: Conduit Layout: SDB to Switchboard Connections.

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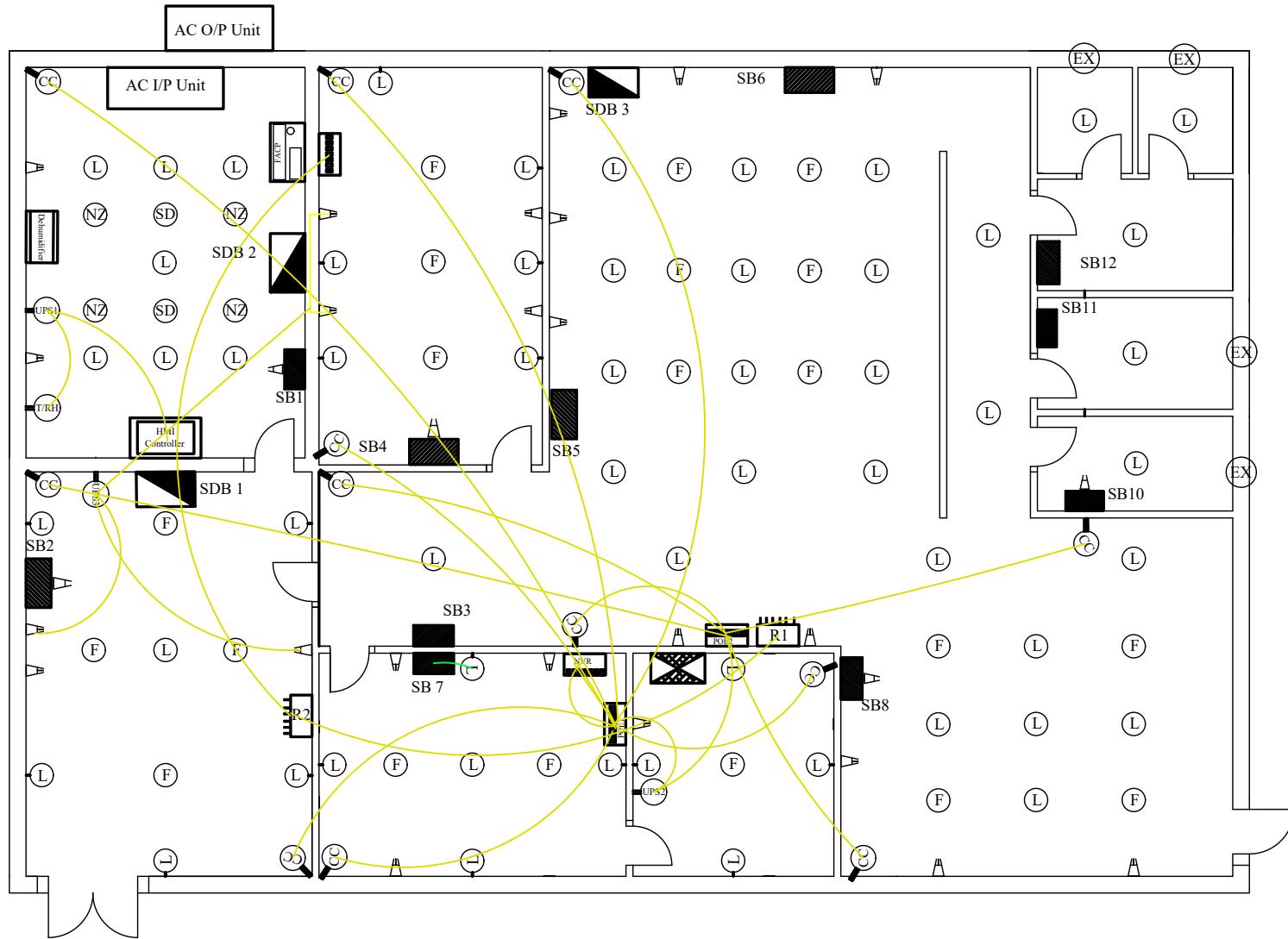


Figure 5.5: Conduit Layout: UPS to CCTvs

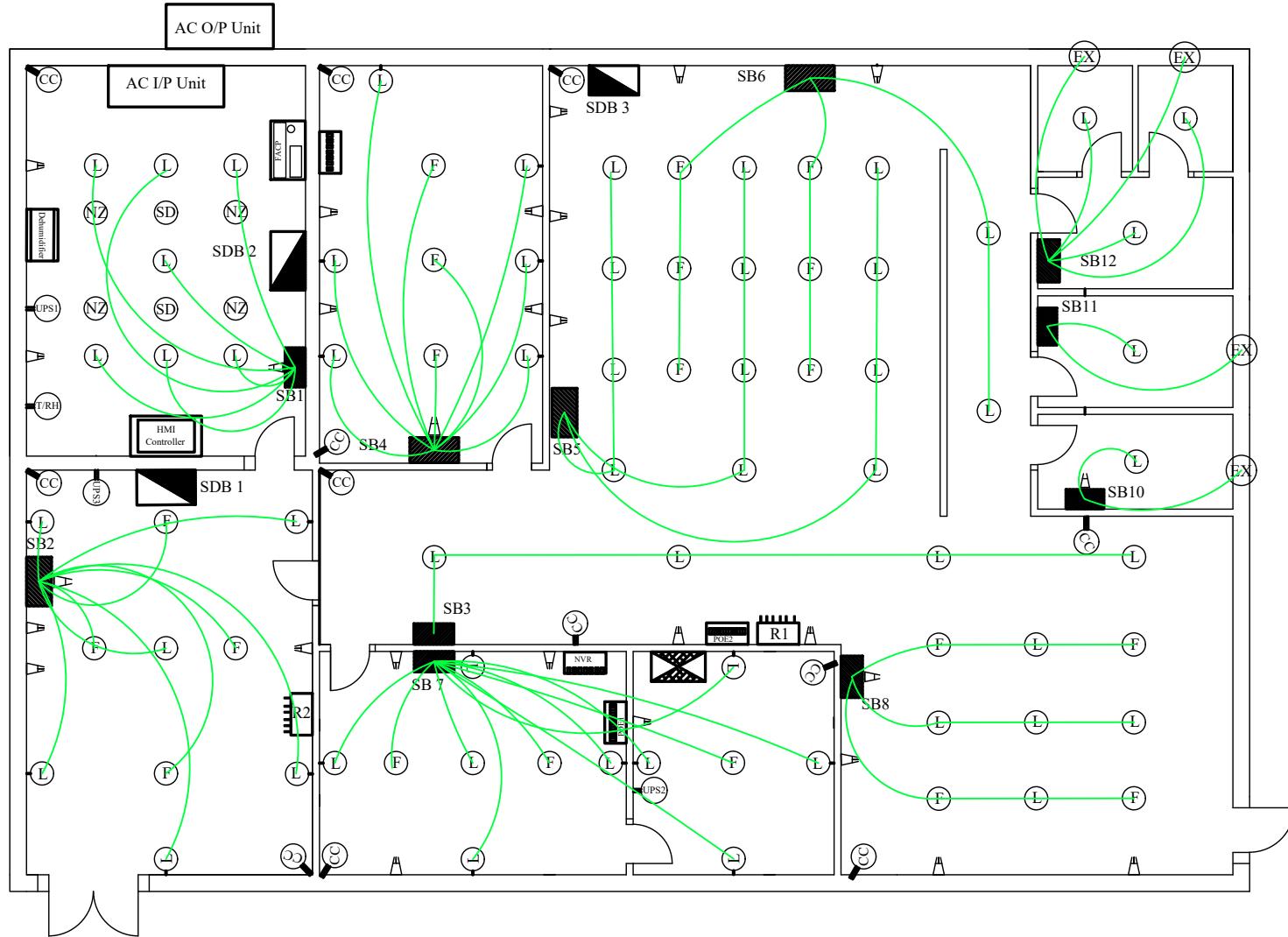


Figure 5.6: Conduit Layout: Final Circuits (Switchboards to Lights/Fans).

## 6 Single Line Diagrams (SLDs)

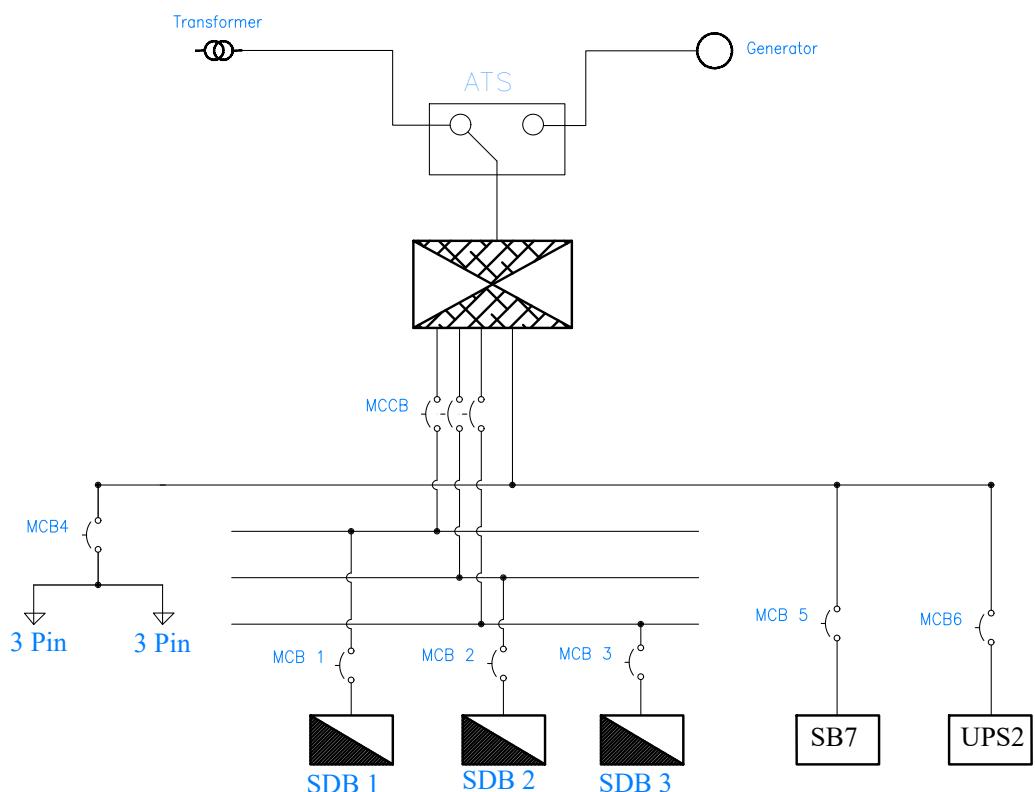


Figure 6.1: Main SLD: Utility/Generator Intake, ATS, MDB, and Feeders.

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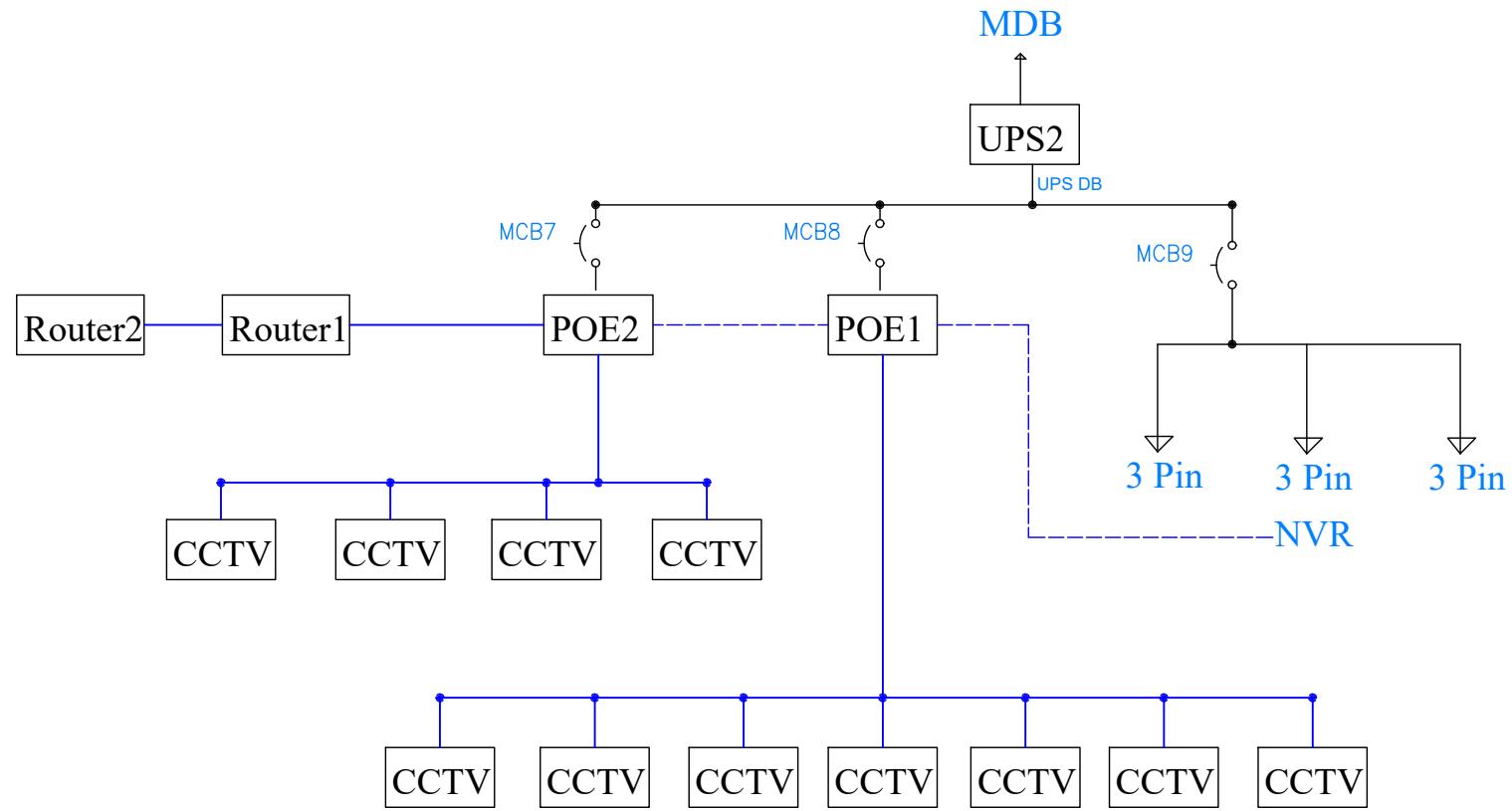


Figure 6.2: SLD: UPS 2 Distribution and CCTV Network (PoE).

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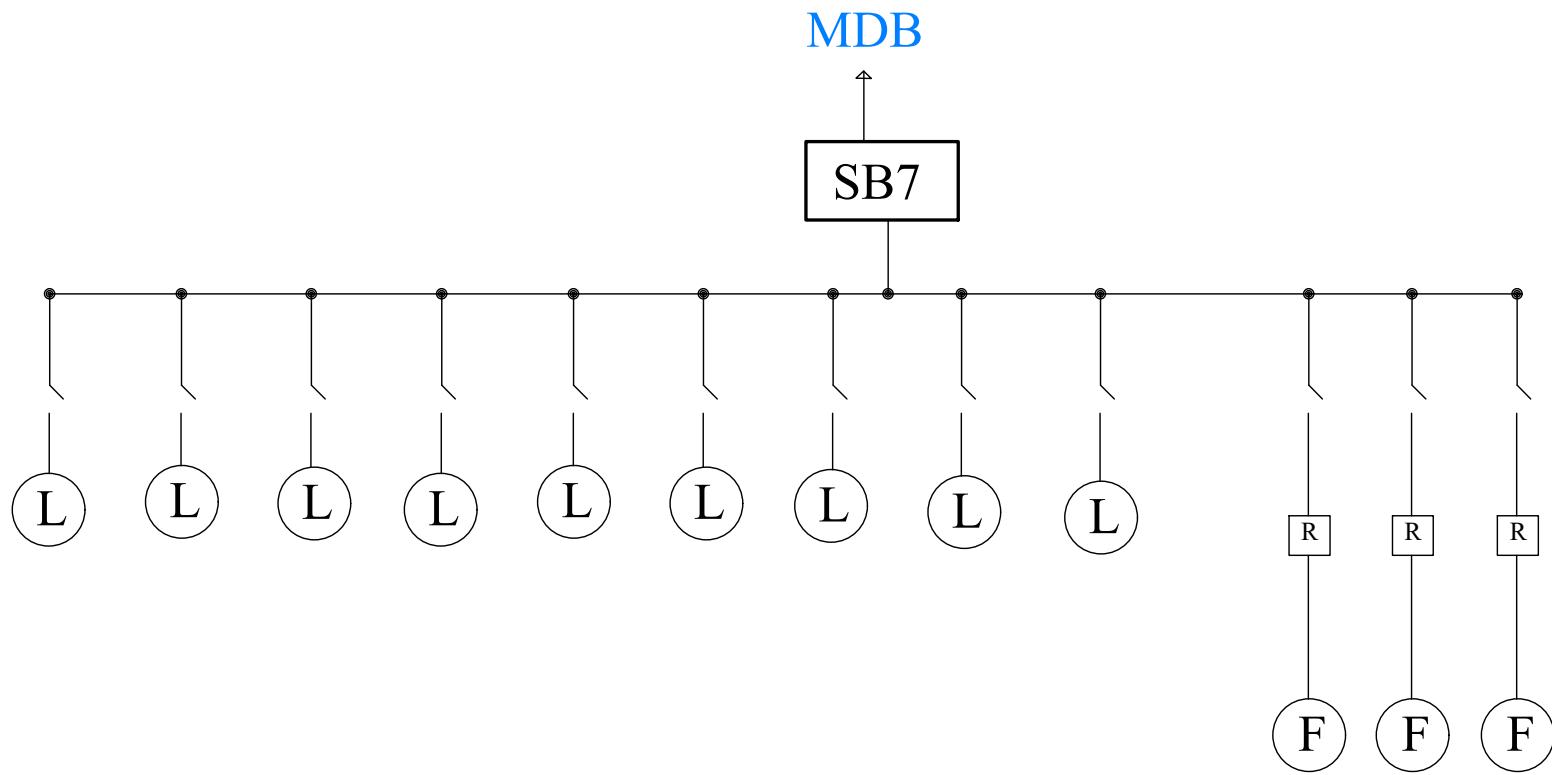


Figure 6.3: SLD: Office Room Switchboard (SB7).

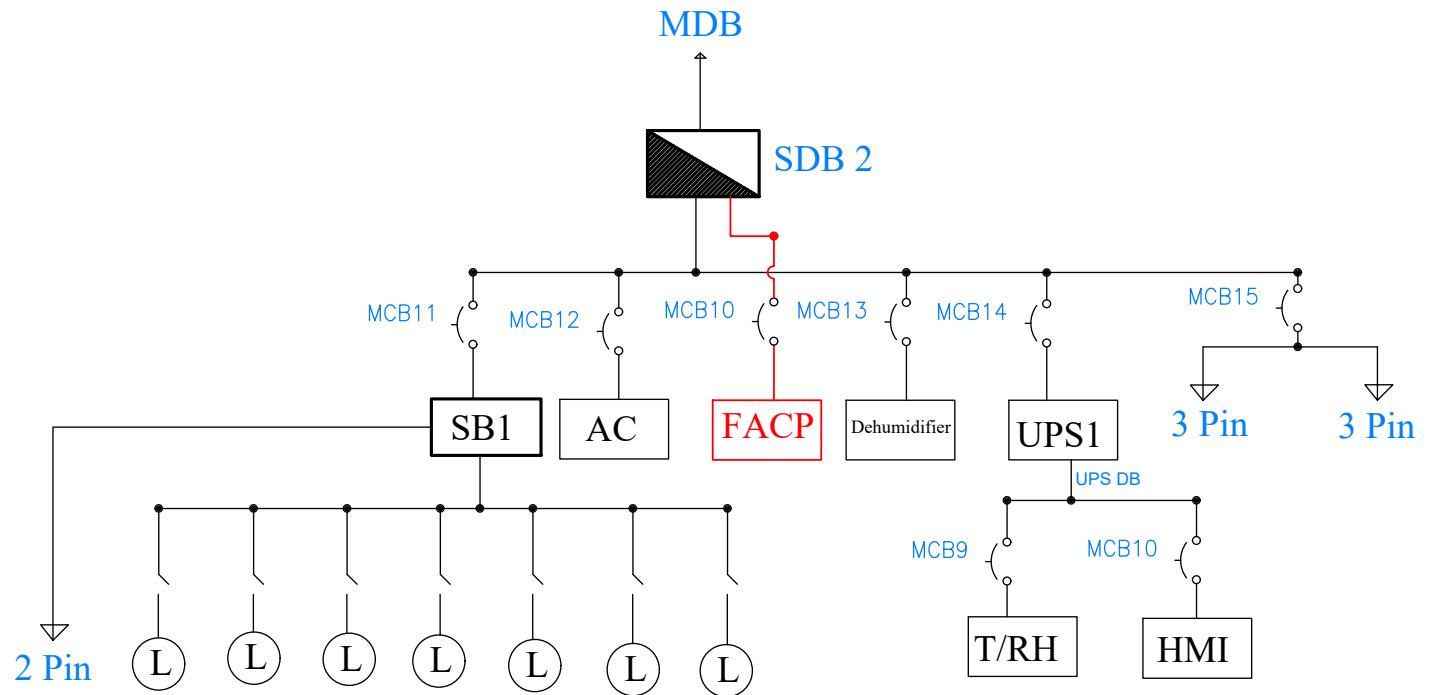


Figure 6.4: SLD: Archival Vault Distribution (SDB 2) & Critical Controls.

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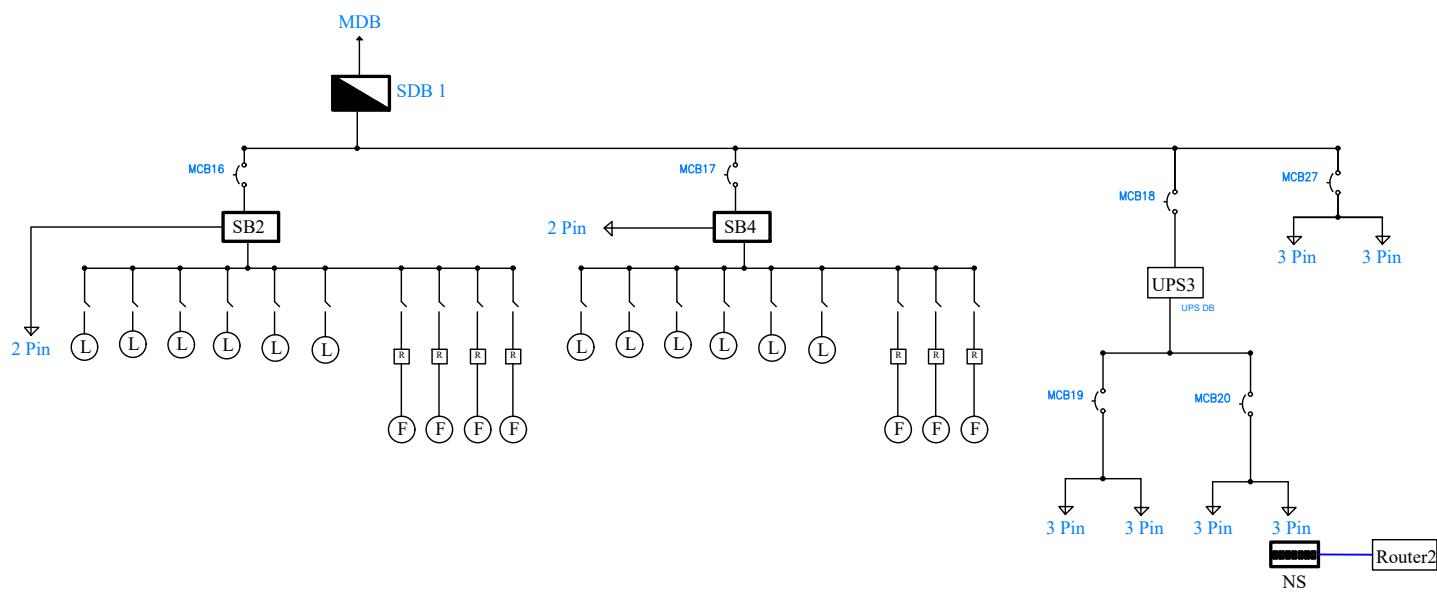


Figure 6.5: SLD: SDB 1 (Reception, Librarian Hub, Computer Room).

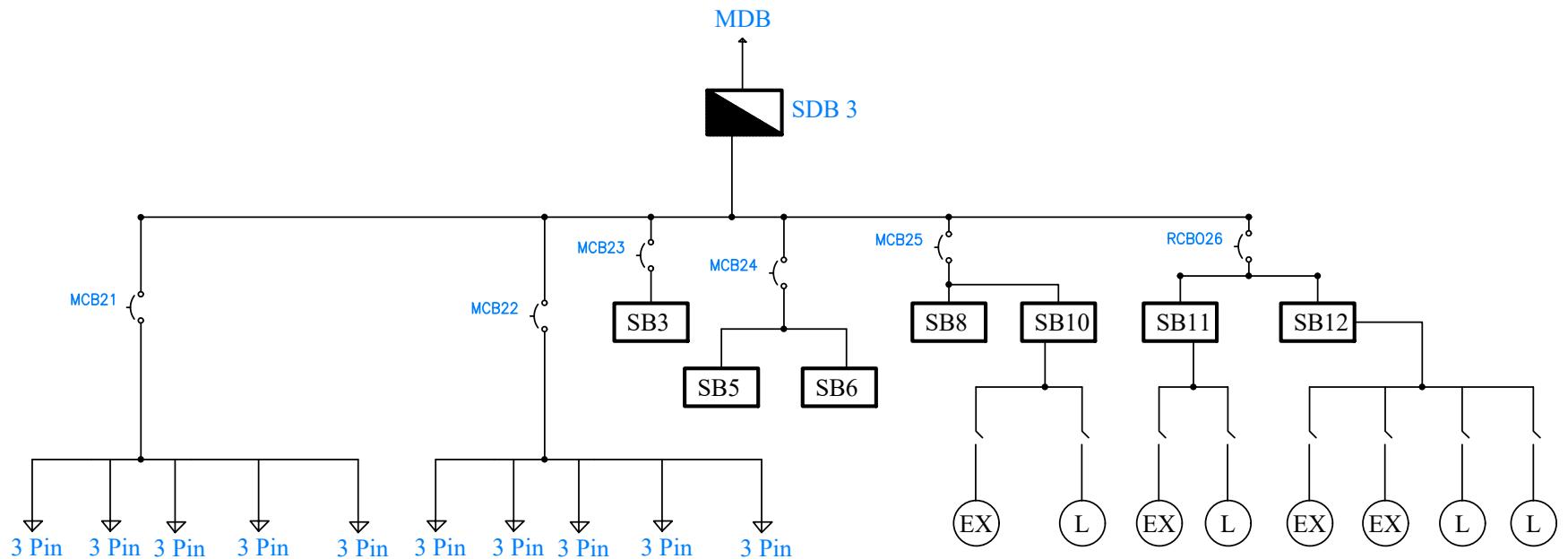


Figure 6.6: SLD: SDB 3 Feeding Reading Room Switchboards.

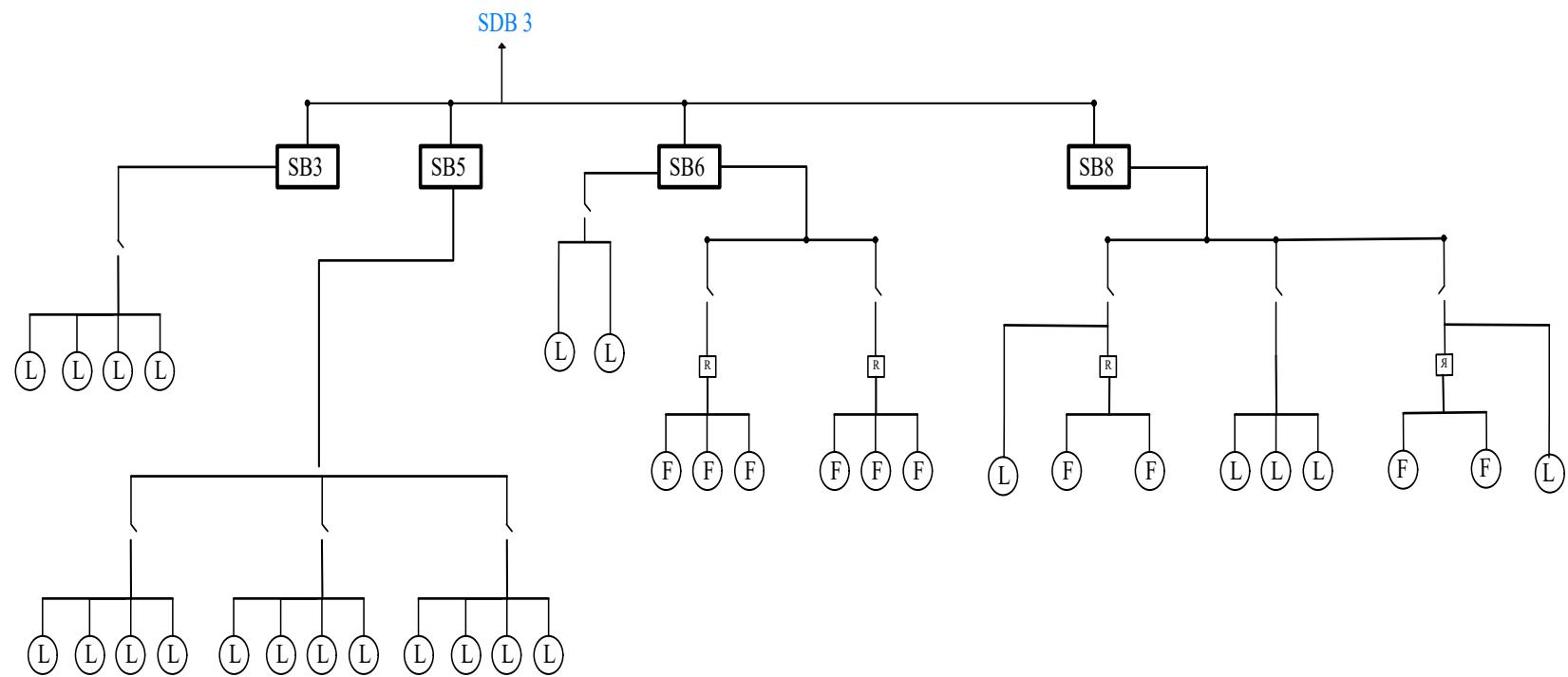


Figure 6.7: SLD: Office Switchboard (SB7) Connection.

## 7 Earthing System Design

### 7.1 Lightning Risk Assessment (BNBC 2020)

A risk assessment was conducted based on the Bangladesh National Building Code (BNBC) 2020 standards to determine the necessity of a Lightning Protection System (LPS).

Table 7.1: Lightning Risk Index Calculation

Index Type	Index Details	Index Value
A (Use of Structure)	Historic buildings, museums, libraries	8
B (Type of Construction)	Reinforced Concrete (RCC) frame	2
C (Contents)	Valuable or irreplaceable contents (Archives)	8
D (Degree of Isolation)	Structure in an area with a few other structures	5
E (Type of Terrain)	Hilly terrain (Raozan area)	2
F (Height of Structure)	Up to 9m (1-Story)	2
G (Lightning Prevalence)	Thunderstorm days per year: 15 (Range: 12-15)	12
<b>Total Risk Index</b>	<b>Summation of A to G</b>	<b>39</b>

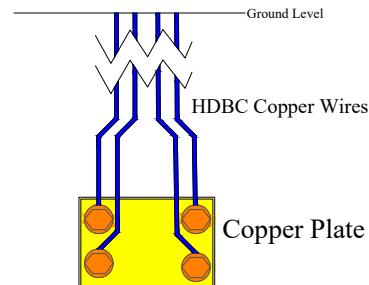
**Conclusion:** The calculated risk index is **39**. According to BNBC standards, since the index is below 40, a comprehensive Lightning Protection System is not mandatory. However, due to the presence of irreplaceable archival documents, a basic protection system connected to the building earth is recommended as a safety precaution.

### 7.2 Earth Technique

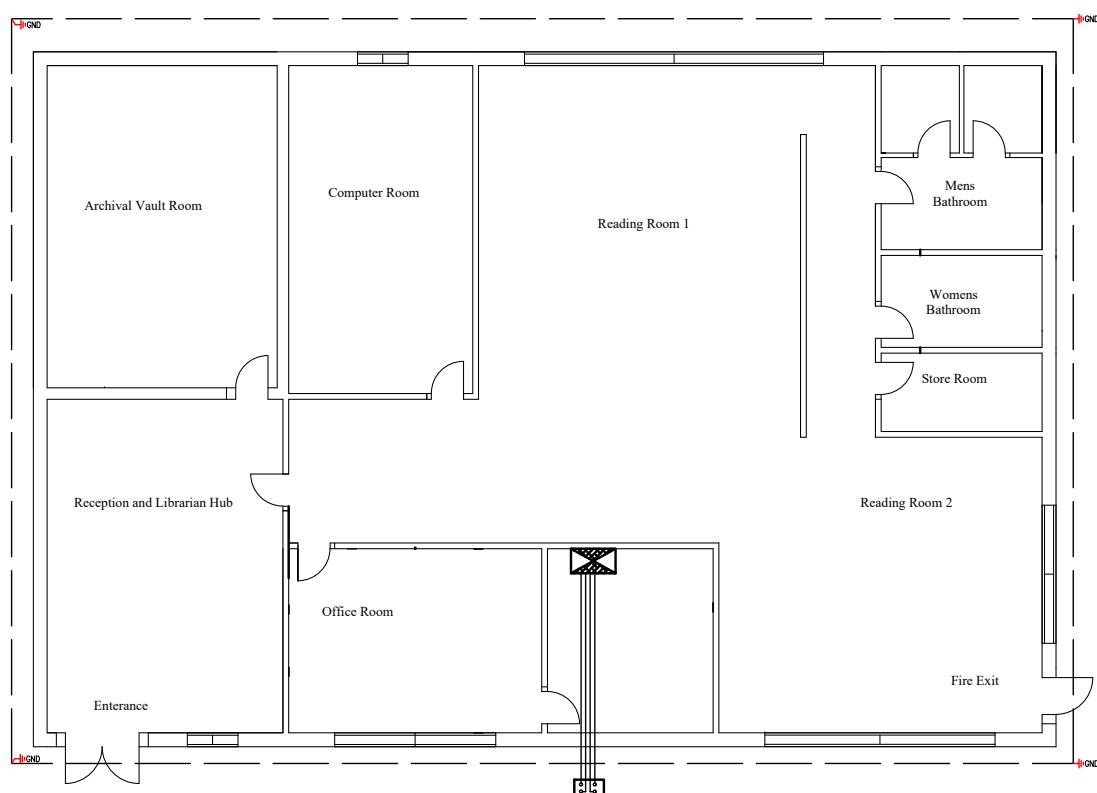
- **Type:** Copper Plate Electrode.
- **Dimensions:**  $600mm \times 600mm \times 3mm$  (Standard Copper Plate).
- **Installation:** Buried vertically at a depth of at least 3 meters below ground level.
- **Backfill:** The plate is surrounded by alternate layers of charcoal and salt (or earth-enhancing compound) to maintain moisture and lower resistivity.
- **Target Resistance:**  $< 1$  Ohms.

### 7.3 Protective Conductors

- **Main Earthing Conductor:** 4 runs of Hard Drawn Bare Copper (HDBC) wire connected directly from the Copper Plate Electrode to the Main Earth Bar (MEB).



(a) Copper Plate Earthing



(b) Earthing Layout

Figure 7.1: Earthing system details

## 8 Load Calculation

### 8.1 Design Parameters

- **Voltage:** 220V Single Phase / 400V Three Phase, 50Hz.
- **Power Factor:** 0.8 (standard assumption).
- **Safety Factor:** 110% applied to Total Load.
- **Wiring System:**
  - **Internal circuit wiring (in conduit):** Copper BYM is used for phase and neutral conductors, and Copper BYA is used as the Earth Continuity Conductor (ECC/CPC) (Green/Yellow), routed in PVC conduit as per the circuit schedule (e.g., 2 × 1.5 mm<sup>2</sup> BYM + 1.5 mm<sup>2</sup> BYA ECC for lighting/fan circuits; 2 × 2.5 mm<sup>2</sup> BYM + 1.5 mm<sup>2</sup> BYA ECC for socket circuits).
  - **Main earthing conductor (electrode to MEB):** 4 runs of Hard Drawn Bare Copper (HDBC) conductor from the copper plate earth pit to the Main Earth Bar (MEB).

### 8.2 Connected Load Summary

#### Room Areas & Lighting Load Calculation

Room	Area (m <sup>2</sup> )	Lux	LED Type & Wattage	Quantity	Total Load (W)
Archival Vault	35.00	400	35W LED	7	245
Reception & Librarian Hub	37.14	300	30W LED	6	180
Computer Room	27.90	500	35W LED	6	210
Office Room	22.00	500	35W LED	5	175
Distribution Room	14.40	150	10W LED	4	40
Reading Room-1	85.125	300	35W LED	12	420
Reading Room-2	45.14	300	35W LED	7	245
Male Toilet	9.975	150	7W IP65 LED	4	28
Female Toilet	7.00	150	7W IP65 LED	2	14
Storeroom	5.95	150	15W LED	1	15
<b>Total Lighting</b>					<b>1,597 W</b>

## Required Fan Fittings

According to BNBC recommended fan sizes (Table 8.1.20),

Location	Area (m <sup>2</sup> )	Fan Type & Load	Fan Sweep (m)	No.	Total Load (W)
Reception & Librarian Hub	37.14	Ceiling Fan, 80W	1.442	4	320
Distribution Room	14.4	Ceiling Fan, 80W	1.442	1	80
Computer Room	27.9	Ceiling Fan, 80W	1.442	3	240
Office Room	22	Ceiling Fan, 80W	1.442	2	160
Reading Room-1	85.125	Ceiling Fan, 80W	1.442	6	480
Reading Room-2	45.14	Ceiling Fan, 80W	1.442	4	320
Male Toilet	9.975	Exhaust Fan, 40W		2	80
Female Toilet	7	Exhaust Fan, 40W		1	40
Storeroom	17.535	Exhaust Fan, 40W		1	40
<b>Total Loads</b>					<b>1,760 W</b>

## Overall Load Summary

SL No.	Electrical Fixture	Quantity	Load (W)	Diversity Factor	Total Load (W)
1	Light Load	—	1597	0.7	1118
2	Fan Load	—	1760	0.7	1232
3	FACP	1	780 (Peak)	1.0	780
4	3 pin 5 A Power Socket	21	300	0.8	5040
5	3 pin 15 A Power Socket	5	1500	1.0	7500
6	2 pin 5 A Power Socket	3	300	0.8	720
<b>Total Electrical Load</b>					<b>16,390 W</b>

Taking safety factor = 110%,

$$\text{Total Load} = 18,029.00 \text{ W} \approx \mathbf{18 \text{ kW}}$$

## Circuit Breakers Ratings

<b>MCB</b>	<b>Fixture Type</b>	<b>Qty</b>	<b>Load (W)</b>	<b>MCB Rating</b>
MCB27	3 Pin Socket	2	600	6A SP
MCB25	Light, Exhaust Fan	5, 4	163	6A SP
MCB22	3 Pin Socket	5	1500	10A SP
MCB21	3 Pin Socket	5	1500	10A SP
MCB20	3 Pin Socket	2	600	6A SP
MCB19	3 Pin Socket	2	600	6A SP
MCB18	3 Pin Socket (UPS3)	1	1500	10A SP
MCB17	Light, Fan, 2 Pin Socket	6, 3, 1	750	6A SP
MCB16	Light, Fan, 2 Pin Socket	6, 4, 1	800	6A SP
MCB15	3 Pin Socket	2	600	6A SP
MCB14	3 Pin Socket (UPS1)	1	1500	10A SP
MCB13	3 Pin Socket (Dehumidifier)	1	1500	10A SP
MCB12	3 Pin Socket (AC)	1	1500	10A SP
MCB11	Light, 2 Pin Socket	7, 1	510	6A SP
MCB10	3 Pin Socket (HMI)	1	300	6A SP
MCB9	3 Pin Socket (T/RH)	1	300	6A SP
MCB FACP	FACP	1	250	6A SP
MCB8	3 Pin Socket (POE1)	1	300	6A SP
MCB7	3 Pin Socket (POE2)	1	300	6A SP
MCB6	MCB 7, 8		600	6A SP
MCB5	Light, Fan	9, 3	455	6A SP
MCB4	3 Pin Socket	2	600	6A SP
MCB3	Light, Fan (SDB3)		1512	10A SP
MCB2	SDB2		5860	40A SP
MCB1	SDB1		3650	25A SP
MCBB	MDB	1	11022	80A DP

**Fundamental Rule (BNBC / IEC concept):**

For proper protection:

$$I_b \leq I_n \leq I_z$$

Where:

- $I_b$  = Design load current
- $I_n$  = MCB rated current
- $I_z$  = Cable current carrying capacity

## 9 Bill of Quantities (BOQ)

### Light Estimation for Ground Floor

Description	Wattage (W)	Quantity	Unit Price (Tk.)	Total Price (Tk.)
Click Rocket LED Bulb (B22)	35	37	740	27380
Walton Public Series A-30W (B22/E28)	30	6	700	4200
Walton Public Series A-15W (B22)	15	1	300	300
Walton Public Series A-9W (B22)	9	4	230	920
Walton WLED-HP7WB22	7	6	300	1800
<b>Total</b>				<b>34600</b>

### Fan Estimation for Ground Floor

Type	Description	Wattage	Quantity	Unit Price (Tk.)	Total Price (Tk.)
Ceiling Fan (F)	VISION Super Ceiling Fan Ivory 56"	80W	20	3750	75000
Exhaust Fan	VISION Exhaust Fan 10"	40W	4	1150	4600
<b>Total</b>					<b>79600</b>

### Switch Socket Estimation

SL No.	Description	Brand	Qty	Unit Price (Tk.)	Total (Tk.)
1	Switch Board (02-Gang)	Walton	2	190	380
2	Switch Board (03-Gang)	Walton	3	280	840
3	Switch Board (04-Gang)	Walton	5	365	1825
4	Switch Board (05-Gang)	Walton	5	430	2150
<b>Total SB Price</b>					<b>5195</b>

SL No.	Description	Brand	Qty	Unit Price (Tk.)	Total (Tk.)
1	1 Gang 5A 2 Pin	Walton	3	200	600
2	1 Gang 5A 3 Pin	Walton	21	250	5250
3	1 Gang 15A 3 Pin	Walton	5	432	2160
<b>Total Socket Price</b>					<b>8010</b>

## Conduit & Wiring Estimation for Ground Floor

Item Description	Unit	Quantity	Unit Rate (Tk)	Total amount (Tk)
.75" PVC pipe	m	150	55	8250
1" PVC pipe	m	100	62	6200
1.5" PVC pipe	m	40	115	4600
2" PVC pipe	m	20	165	3300
Cat6 UTP	box(305m/box)	1	16500	16500
1C-2x1.5 sqmm (BYM) cable with 1.5 sqmm (BYA) ECC wire	m	150	35.72	5358
1C-2x2.5 sqmm (BYM) cable with 2.5 sqmm (BYA) ECC wire	m	100	41.58	4158
1C-2x4 sqmm (BYM) cable with 4 sqmm (BYA) ECC wire	m	20	63	1260
1C-2x10 sqmm (BYM) cable with 10 sqmm (BYA) ECC wire	m	20	165.13	3306
1C-2x35 sqmm (BYM) cable with 35 sqmm (BYA) ECC wire	m	20	892.5	17850
<b>Total cost</b>				<b>70780</b>

## Distribution Boards & Protection

Item Description	Unit	Quantity	Unit Rate (Tk)	Total amount (Tk)
Digital energy meter (kWh meter)	Each	1	6589.00	6600
Main Distribution Board (MDB) – Powder coated box with 150A MCCB Incomer	Set	1	11250.00	11250
Sub Distribution Board (SDB) – 12 Way	Set	3	2250	6750
Automatic Transfer Switch (ATS) unit	Set	1	8500	8500
6A SP MCB	Each	16	320	5120
10A SP MCB	Each	7	380	2660
25A SP MCB	Each	1	450	450
40A SP MCB	Each	1	245	245
10A 30mA RCBO (Toilet circuits)	Each	1	1450	1450
<b>Total</b>				<b>43025</b>

## Critical Systems

Item Description	Unit	Quantity	Unit Rate (Tk)	Total Amount (Tk)
UPS 1000VA	Each	3	12500	37500
Dehumidifier	Each	1	29500	29500
Fire Alarm Control Panel	Set	1	137700	137700
Air Conditioner	Each	1	81000	81000
PoE Switch (8-Port)	Each	2	10500	21000
Smoke Detector	Each	2	2300	4600
Nozzle	Each	4	400	1600
IP CCTV Dome Camera	Each	11	1300	14300
Network Video Recorder (NVR)	Each	1	8200	8200
Automatic Transfer Switch (ATS)	Set	1	5000	5000
30 kW Diesel Generator	Set	1	550000	550000
<b>Total</b>				<b>8,904,00</b>

## Total Electrical Estimated Cost

Sl. No.	Item	Total Cost (Tk)
1	Lighting	34600
2	Fan	79600
3	Distribution Boards & Protection	43025
4	Critical Systems	890400
5	Switches	5195
6	Sockets	8010
7	Conduit & Wiring	70780
<b>Total</b>		<b>11,31,610</b>

## Design, Labor & Inspection Costs

- **Design Cost:** Estimating 4% of total electrical cost,  $= 0.04 \times 1131610 = 45264.4 \approx 45,000$  BDT (rounded).
- **Labor Cost:** Estimating 12% of total electrical cost,  $= 0.12 \times 1131610 = 135793.2 \approx 1,35,000$  BDT (rounded).
- **Inspection Cost:** Estimating 2% of total electrical cost,  $= 0.02 \times 1131610 = 22632.2 \approx 22,500$  BDT (rounded).

### Total Cost:

$$1130000 + 45000 + 135000 + 22500 = 1332500 \text{ BDT.}$$

## 10 Conclusion

The electrical service design for the Archival Vault and Library successfully addresses the project requirements for reliability, safety, and functionality. The proposed system ensures:

- **Continuous Operation:** Critical monitoring systems remain active during power outages via the designed UPS and Generator integration.
- **Safety Compliance:** Implementation of RCBOs for wet areas and proper earthing mitigates shock hazards.
- **Future Scalability:** The distribution boards and cable sizing allow for reasonable future load expansion.

This design package, comprising the report, calculations, and drawings, is ready for review and subsequent installation phases.