Project Title

Designing an Electrical Service System by using AUTOCAD

Introduction:

This project aims to build an optimized electrical service plan for the Electrical Circuits Laboratory at BRAC University. The laboratory, situated on university grounds, needs a reliable and effective electrical system designed for an educational setting. The design includes essential factors such as sufficient lighting, appropriate ventilation, and dependable power delivery to facilitate diverse equipment and experiments. The project prioritizes safety, functionality, and energy efficiency, complying with both international and local requirements to provide an ideal learning environment for students and a conducive workspace for professors.

Objective:

The main goals of this project are:

- To provide an efficient and secure electrical service configuration for the BRAC University electrical circuits laboratory.
- To develop a foundational design using a single-line diagram that incorporates critical elements such as lights, fans, and plugs, carefully positioned for maximum efficiency and usefulness.
- To conduct comprehensive load calculations to ascertain the overall electrical demand and guarantee equitable load distribution.
- To investigate two alternative layout concepts that improve energy efficiency, cost-effectiveness, and space utilization.
- To comply with applicable safety and regulatory regulations, including the International Electrotechnical Commission (IEC) and the Bangladesh National Building Code (BNBC).
- To integrate danger and safety issues into the design, assuring the system's long-term durability and scalability.
- To enhance the design for environmental sustainability, social influence, and cultural relevance within the university setting.

Apparatus & software:

The accompanying equipment and software were used in the design and execution of this project:

1. AutoCAD: The principal program used for generating intricate electrical layout drawings and single-line diagrams.
2. Calculator: Utilised for load computations.
3. Electrical components (for design considerations):
    - Tube lights
    - Ceiling fans
    - Three-pronged electrical outlets
    - Circuit distribution panels
    - Main Distribution Board (MDB)

- Sub-Distribution Board (SDB)
- Wiring and conduits

Project specification:
The project focuses on designing, installing, and maintaining electrical systems for the architecture studio room(11A-08L) at Brac University. It starts with planning the placement of circuits, outlets, switches, and lights to make it more energy efficient. During installation, proper wiring and material selection are done to reduce energy losses and prevent hazards. Lighting design ensures both functionality and aesthetics for different areas. After installation, testing, and commissioning check that the system works correctly and meets the requirements. Regular maintenance keeps the system reliable, efficient, and safe. The design prioritizes good lighting, ventilation, and power distribution while saving energy, reducing waste, and minimizing environmental impact.

Non-technical constraints:
Our design focuses on environmental, health and safety, sustainability, and ethical issues to make a responsible and effective system. For environmental concerns, we use energy-efficient materials and components to reduce energy use and carbon footprint. We also avoid harmful materials to protect both the environment and people's health. To ensure health and safety, we follow safety standards and include features like circuit protection to prevent electrical accidents. For sustainability, we add renewable energy options like energy-saving lights and use strategies to reduce waste and make components last longer. Ethical practices include being honest about risks, protecting data, and ensuring privacy in smart grid systems. These steps help us create a safe, efficient, and trustworthy system for everyone.

Project Structure:
Dimensions of Layout

- Overall Room Dimensions:
  - Length: 29'-8"
  - Width: 35'-9"
- Lobby Area:
  - Length: 29'-8"
  - Width: 8'

Window Dimensions and Placement:

1. Windows on the Innerside: 16'-5"
2. Windows on the Outerside: 27'-4"

Wall Thickness: 7"

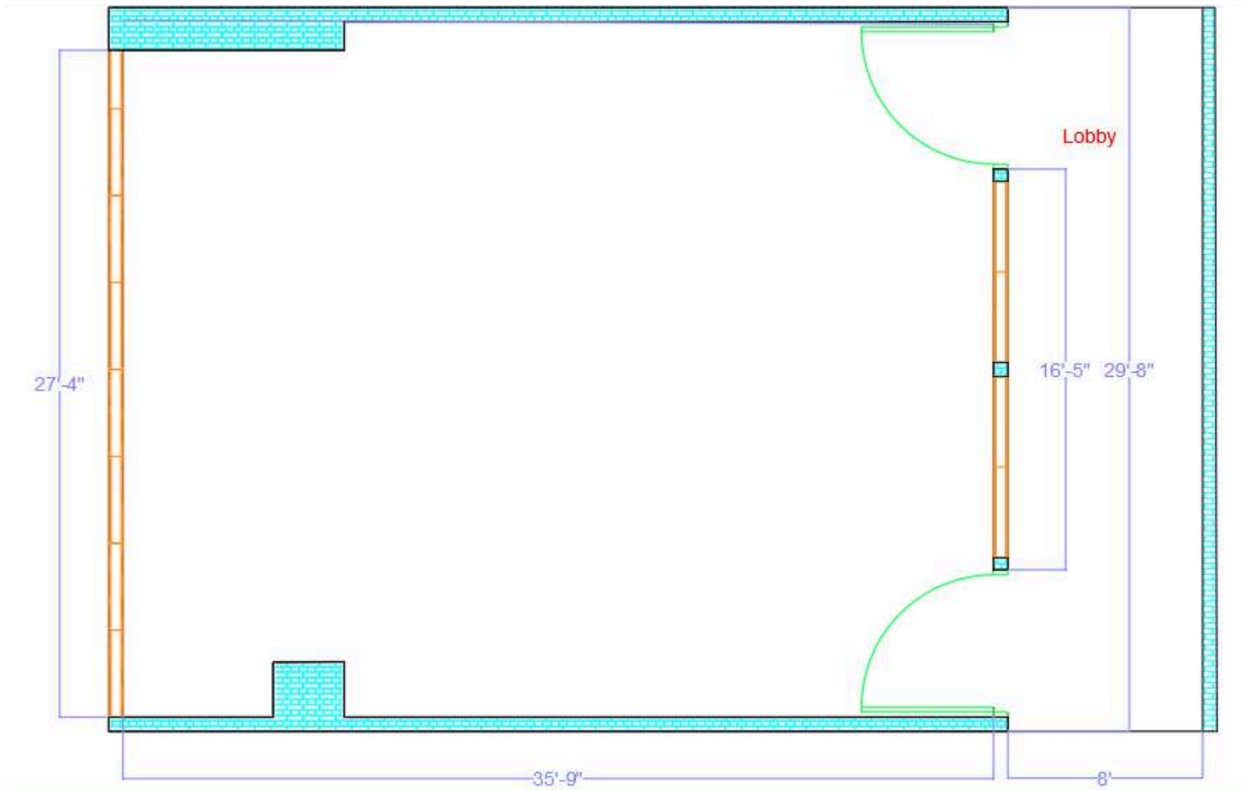


Fig: Project Base Structure

The layout includes a room with dimensions of 29'-8" in length and 35'-9" in width, along with a lobby measuring 29'-8" by 8'. The windows on the inner side are 16'-5", and the windows on the outside are 27'-4", allowing proper ventilation and natural light. The wall thickness is 7", which ensures durability. These measurements will help us create an accurate design in AutoCAD and ensure the final layout is precise and functional.

Base Design:

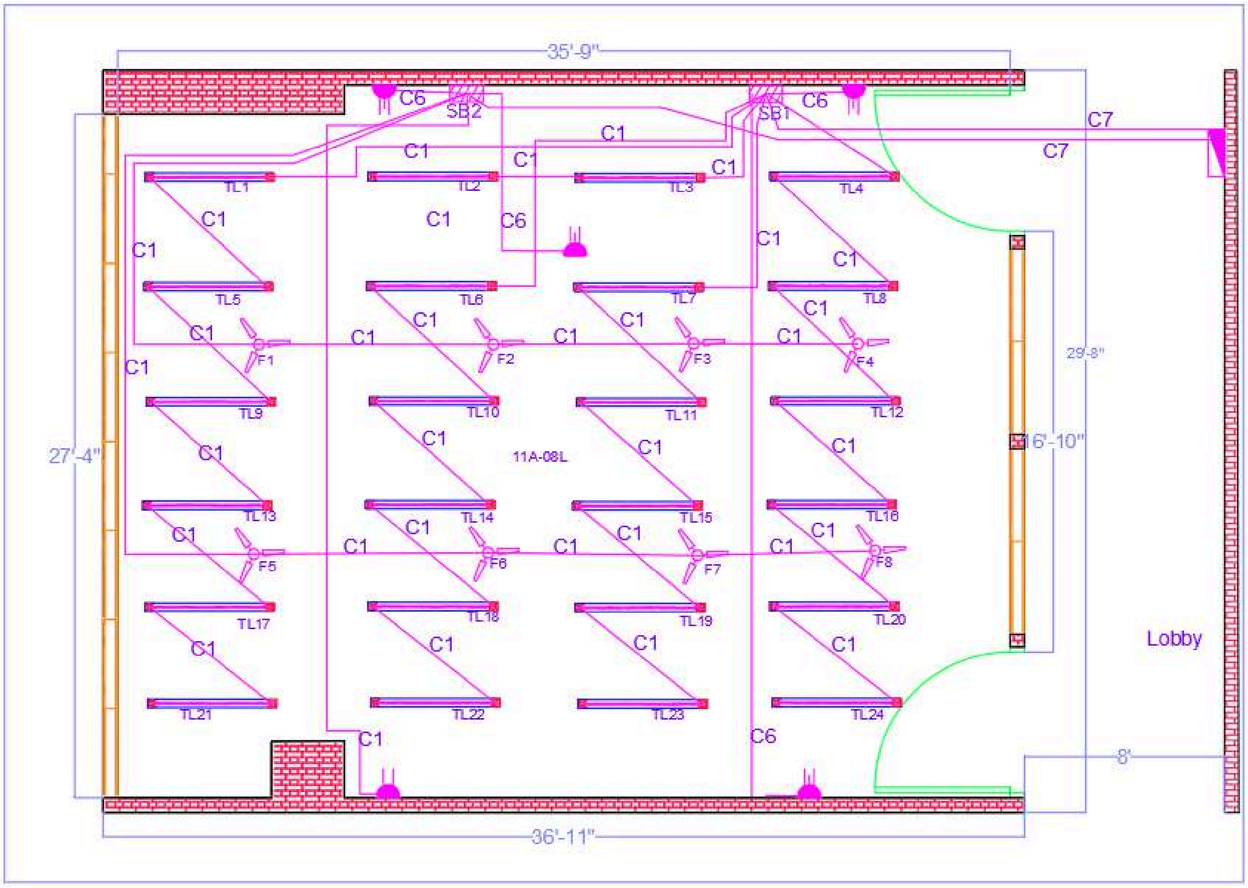


Fig: Base Design

In this room, there are in total 24 tube lights, 8 fans, 4 3-pins, 1 2-pins are present. All fans are connected to switchboard 2, and all lights are connected to switchboard 1. We can see that the Tube lights are located vertically aligned and are turned on when the press of a switch. Expect TL2 & TL3. They are separately connected with a switch located in switchboard 1. So there are a total of 5 switches for lights. So from there, we can assume that they are connected in series. We know in a series of connections, the same current follows through all the components. Similarly, all the fans connected in a row are in a series. Therefore, we used a C1 cable to connect them. Additionally, a C6 cable has been used to provide connections for the two 3-pin sockets on each switchboard, ensuring proper power distribution for these outlets.

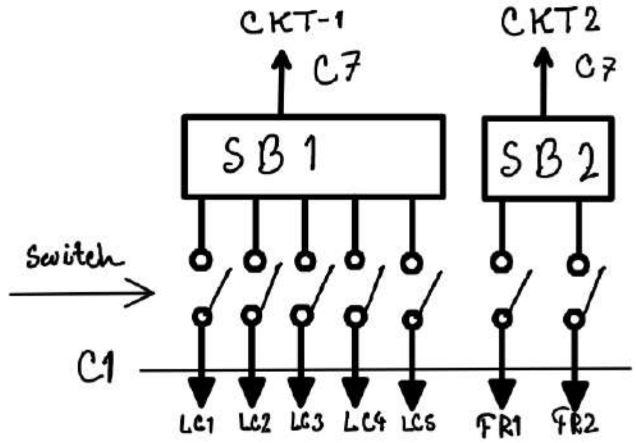


Fig: Base Design switch diagram

LC1= TL1 + TL5 + TL9 + TL13 + TL17 + TL21
LC2= TL6 + TL10 + TL14 + TL18 + TL22
LC3= TL7 + TL11 + TL15 + TL19 + TL23
LC4= TL4 + TL8 + TL12 + TL16 + TL20 + TL24
LC5= TL2 + TL3
FR1= F1 + F2 + F3 + F4
FR2= F5 + F6 + F7 + F8

Alternative Design Approach 1:

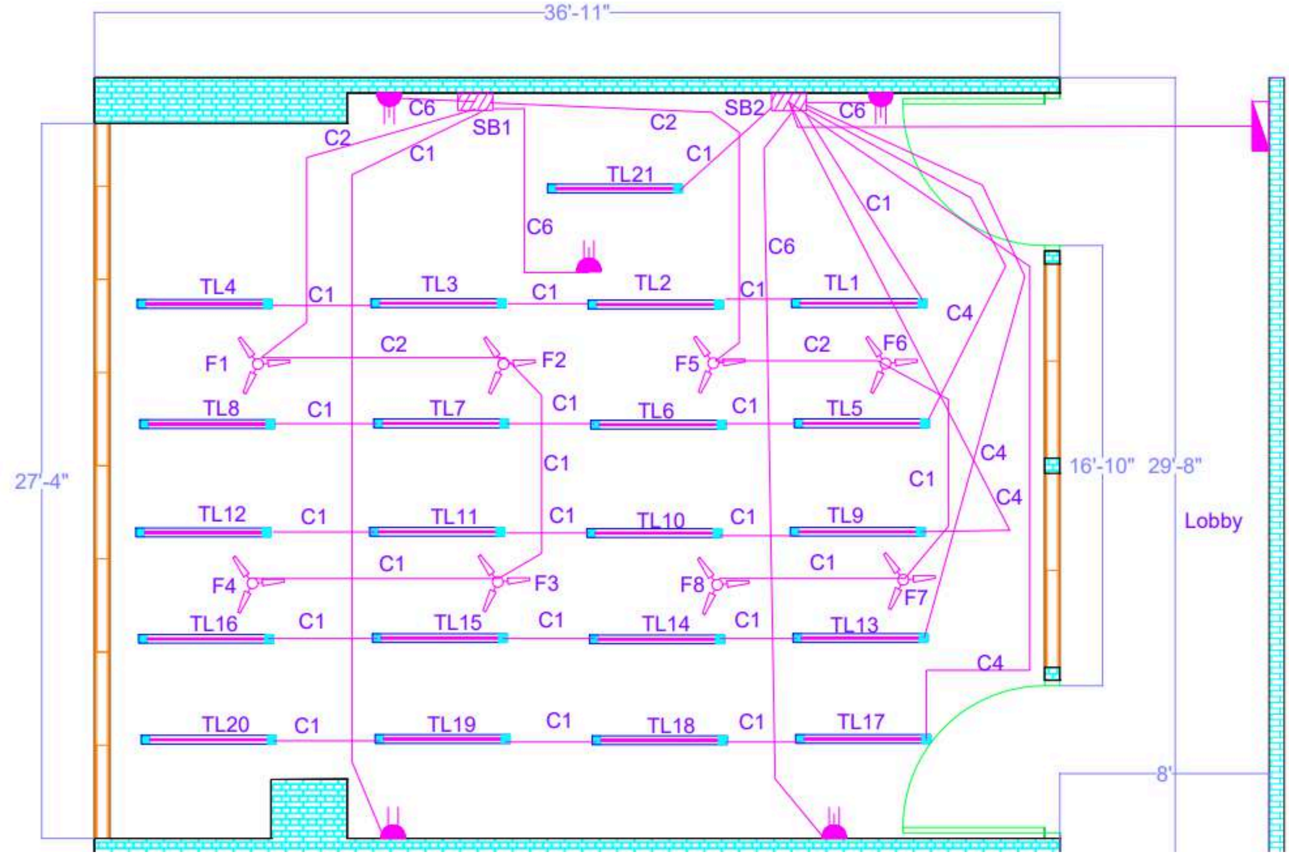


Fig: Alternative Design Approach 1

Series Connections:

$F_{R1} = F_1+F_2$

$F_{R2} = F_3+F_4$

$F_{R3} = F_5+F_6$

$F_{R1} = F_1+F_2$

$LT_{S1} = LT_1+ LT_2+ LT_3+ LT_4$

$LT_{S2} = LT_5+ LT_6+ LT_7+ LT_8$

$LT_{S3} = LT_9+ LT_{10}+ LT_{11}+ LT_{12}$

$LT_{S4} = LT_{13}+ LT_{14}+ LT_{15}+ LT_{16}$

$LT_{S5} = LT_{17}+ LT_{18}+ LT_{19}+ LT_{20}$

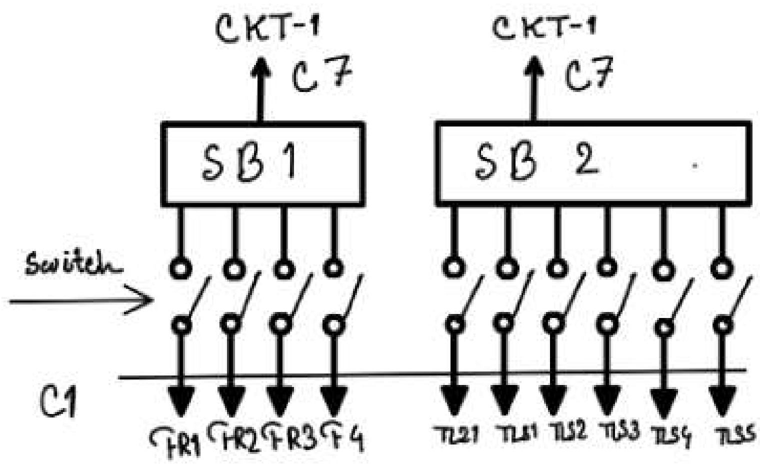


Fig: Single Line Diagram for Alternative Design Approach 1

In the alternate design approach 1, we arranged the electrical components in such a way that we could make the best use of them efficiently. Here we made some changes in the base design, like connecting the lights row-wise in series. If there are fewer students then we can save energy by turning off the back row lights. There are a total of 21 tube lights (TL1-TL21) and 8 fans (F1-F8.

We used a series connection with C1 wires to connect 4 (for example TL1-TL4) lights that will turn on by pressing only one switch. For 20 lights we use 5 switches in such a way. While observing the room we noticed that only one light in the first row is enough. We connect the light (TL21) with a C1 cable. We connected all the fans (F1-F8) with 2 different C2 cables. For 4 fans (F1-F4) we use C2 cable, 1st 2 fans (F1-F2) are connected with C2 cables in series, and the other 2 (F3-F4) are in series with C1 cable. The same goes for the other 4 fans (F5-F8). The lights and fans are connected in separate switchboards, fans are connected with SB1, and lights are connected with SB2. Also, there are two 3-pin ports, one is for the projector and another is in the back and we connect them with a c6 cable. There is also a 2-pin port in the back, connected with a C1 cable. It is safe to say that this design prioritizes convenience, and comfortability of the occupants while ensuring a shorter wiring solution to the engineers.

Alternative Design Approach 2:

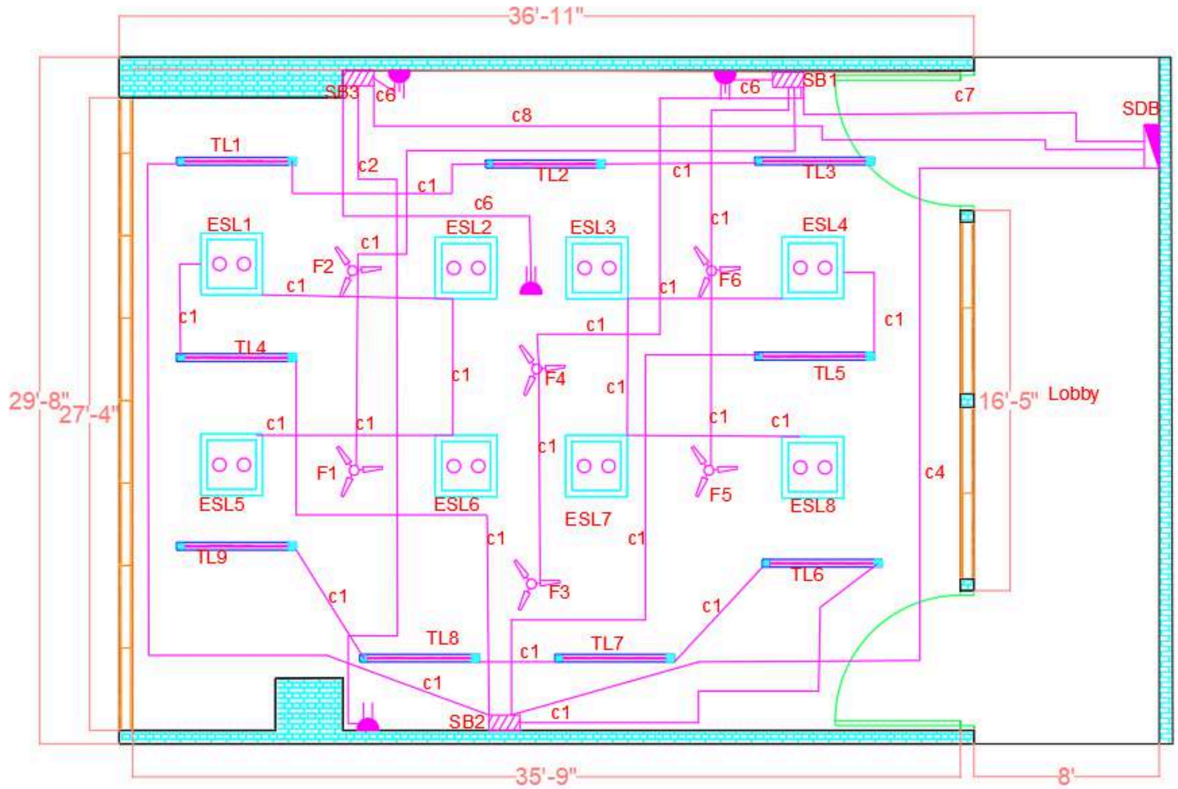
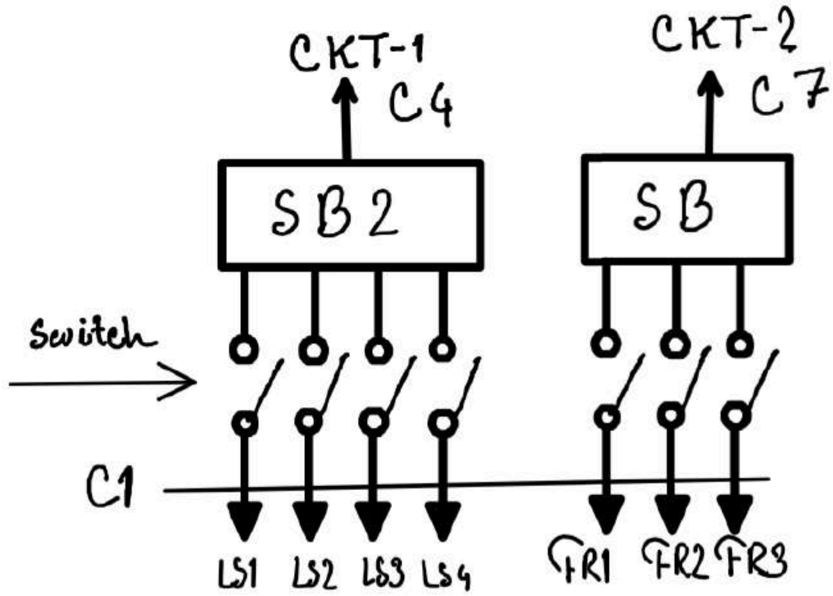


Fig: Alternative Design Approach 2

In Alternative Design 2, we carefully crafted the layout with a total of 9 tube lights, 8 energy-saving lamps, 6 fans, 3 three-pin sockets, and 1 two-pin socket. The fan arrangement is particularly interesting: we grouped them in three rows, with each row featuring two fans connected in series. For the lighting, we designed an efficient system by combining 4 energy-saving lamps and 1 tube light in a series setup, creating two identical light sets positioned on opposite sides of the room. Additionally, we placed 3 tube lights at the front and 4 at the back to ensure balanced illumination throughout the space. We strategically placed a switchboard at the back of the room to manage all lighting, while another switchboard at the front right corner handles the fans. Power access is conveniently distributed with three three-pin sockets: one at the front left for computer usage, another mounted on the ceiling for the projector, and a third at the front right for the sound system. A two-pin socket is subtly positioned at the back for additional needs. For seamless and efficient connectivity, we employed C1 wire for all series connections, ensuring consistent performance across the lighting and fan systems. The three-pin sockets are connected using C6 wire, chosen for its reliability. Each switchboard is linked using tailored wiring: C7 for switchboard-1, C4 for switchboard-2, and C8 for switchboard-3, ensuring optimal integration and functionality throughout the space.



Here,

LS1 = TL4+ESL1+ESL2+ESL6+ESL5 (Series Connection)

LS1 = TL5+ESL4+ESL3+ESL7+ESL8 (Series Connection)

FR1 = F1+F2 (Series Connection)

FR2 = F3+F4 (Series Connection)

FR3 = F5+F6 (Series Connection)

Load calculation :
For the load calculation, we considered the following components:

- Tubelight with a wattage of 60W,
- Energy saver lamp at 40W,
- Ceiling fan at 75W,
- 2-pin switched socket at 25W, and
- 3-pin switched socket at 300W.

Also, the value of pf is assumed to be 0.8 to ensure accurate and practical results.

Load calculation of Base Design:

Component details	Quantity	Watt Per Load (W)	Total Watt (W)
TubeLight	24	60	1440
Ceiling Fan	8	75	600
(5A,240V)-2 Pin Switched Socket	1	25	25
(5A,240V)-3 Pin Switched Socket	4	300	1200
		Total =	3265 W

All components are connected to the generator. As a result, the value of emergency power is equal to the total watt=3265 W or 3.265 KW.

Normal Power:
Light-Fan [Normal Power]   =3.265 KW
Light-Fan [Emergency Power]=3.265 KW

Total=6.530 KW

Transformer: 6.530 *60%= 3.918 KW/0.8(pf)=4.8975 KVA ≈ 5 KVA

Emergency Power:
Light-Fan [Emergency Power]=3.265 KW
Generator: 3.265 KW /0.8(pf value)=4.08 KVA ≈ 5 KVA generator

Load calculation of Alternative Design-1

Component details	Quantity	Watt Per Load (W)	Total Watt (W)
TubeLight	21	60	1260
Ceiling Fan	8	75	600
(5A,240V)-2 Pin Switched Socket	1	25	25
(5A,240V)-3 Pin Switched Socket	4	300	1200
		Total=	3085 W

All components are connected to the generator. As a result, the value of emergency power is equal to the total watt=3085 W or 3.085 KW.

Normal Power:
Light-Fan [Normal Power]   =3.085 KW
Light-Fan [Emergency Power]=3.085 KW

Total=6.170 KW

Transformer: 6.170 *60%= 3.702 KW/0.8(pf)=4.6275 KVA ≈ 5 KVA

Emergency Power:
Light-Fan [Emergency Power]=3.085 KW
Generator: 3.085 KW /0.8(pf value)=3.856 KVA ≈ 4 KVA generator

Load calculation Alternative Design 2

Component details	Quantity	Watt Per Load (W)	Total Watt (W)
TubeLight	9	60	540
Energy Saver Lamp	8	40	320
Ceiling Fan	6	75	450
(5A,240V)-2 Pin Switched Socket	1	25	25
(5A,240V)-3 Pin Switched Socket	3	300	900
		Total=	2235 W

All components are connected to the generator. As a result, the value of emergency power is equal to the total watt=2235 W or 2.235 KW.

Normal Power:
Light-Fan [Normal Power]   =2.235 KW
Light-Fan [Emergency Power]=2.235 KW

Total=4.47 KW
Transformer: 4.47 *60%= 2.682 KW/0.8(pf)=3.3525 KVA ≈ 4 KVA

Emergency Power:
Light-Fan [Emergency Power]=2.235 KW
Generator: 2.235 KW /0.8(pf value)=2.79 KVA ≈ 3 KVA generator

Comparison-

	Base Design	**Alternative Design 1**	**Alternative Design 2**
Total Load	3.265 KW	3.085 KW	2.235 KW
Transformer Rating	5 KVA	5 KVA	4 KVA
Generator Rating	4 KVA	4 KVA	3 KVA

From the table, it is evident that Alternative Design 2 is the most efficient in terms of power usage. It has the lowest total load of 2.235 kW, significantly reducing the energy demand compared to the Base Design (3.265 kW) and Alternative Design 1 (3.085 kW). Additionally, Alternative Design 2 requires a smaller transformer rating of 4 kVA and a generator rating of 3 kVA, which are lower than those required for the other designs. This reduction in power demand directly translates to lower operational costs, improved energy efficiency, and a more sustainable design. By minimizing the power usage and equipment ratings, Alternative Design 2 stands out as the most cost-effective and practical solution.

Justification of the best design:

In comparing the three designs, the lighting configuration in the Base Design uses 24 tube lights aligned vertically, controlled by five switches. This layout provides ample lighting but lacks energy efficiency due to the high number of tube lights. Design Approach 1 attempts to mitigate this by reducing the tube lights to 21 and arranging them in rows, allowing selective control that can save energy when fewer students are present. However, Alternative Design 2 optimizes the setup further by incorporating a mix of 9 tube lights and 8 energy-saving lamps. This design achieves balanced illumination with fewer fixtures, enhancing energy efficiency and reducing power consumption compared to the other designs.

The fan arrangement also varies significantly. The Base Design includes 8 fans connected in series within rows but without any notable optimization for airflow or control flexibility. Design Approach 1 retains the same number of fans but introduces some improvements by using different cables and series connections. In contrast, Alternative Design 2 refines this setup by using only 6 fans, organized in three rows with two fans each connected in series. This not only ensures sufficient airflow but also simplifies control, making it a more efficient solution.

Power distribution in the Base Design consists of 4 three-pin sockets and 1 two-pin socket, with a basic connection scheme. Design Approach 1 offers a slight improvement by specifying socket placement for specific uses like a projector and general back usage. However, Alternative Design 2 goes further by providing two strategically positioned three-pin sockets one for a computer and another for the sound system at the front right along with a two-pin socket at the back for auxiliary needs. This setup eliminates the previously irrelevant back three-pin socket, ensuring a more practical and streamlined power distribution.

The control system in the Base Design separates light and fan controls into two switchboards but does not optimize for convenience. Design Approach 1 mirrors this layout but introduces energy-saving features with selective lighting controls. Alternative Design 2, however, enhances user convenience by placing switchboards at the back and front right corner of the room, allowing easy management of lights and fans. This strategic placement simplifies operation, making it the most user-friendly and efficient option among the three.

An additional strength of Alternative Design 2 is its user-centric approach. We discussed the design with students who use the classroom, identifying the primary work zones where lighting and ventilation are most needed. This feedback was instrumental in setting up the main work zones to ensure that the most critical areas are well-lit and comfortable. This collaborative effort ensures that the design meets practical needs effectively, further justifying its selection as the ideal choice.

Furthermore, Alternative Design 2 adheres to the Bangladesh National Building Code (BNBC) guidelines and International Electrotechnical Commission (IEC) standards. For example, the lighting system follows BNBC requirements for classroom illumination, ensuring that the light levels meet the prescribed lux values for educational spaces. The wiring and electrical components comply with IEC standards, specifically IEC 60364 for low-voltage electrical installations, which guarantees safety, reliability, and efficiency. This adherence to both BNBC and IEC codes ensures that the design not only meets functional and user-centric needs but also complies with established safety and quality standards, further solidifying its selection as the ideal design.

Result & Discussion:

In this project, we have learned to make an architectural layout of our base design by taking measurements physically of 11A-08L of BRAC University. Besides, we found two alternate ways to design the allocated rooms and tried to make our designs more efficient (in terms of power usage and efficiency) by changing the number or location of loads. We have found that in the base design, certain loads are not necessary; also, by changing some locations of the loads, we can minimize the number of loads without hampering efficiency. In alternate design 2, we tried our best to design in such a way that every load is properly utilized, resulting in the minimum watt consumption. However, while designing, we came across some obstacles, such as adding hatches. There were tiny gaps in the boundary of the rooms which could not be easily spotted by the naked eye. When we were going to add the hatches, it showed a pop-up window that said gaps were found between the boundary objects (windows) and the boundary; however, it did not locate the gaps directly. We had to zoom in at every point to find the gaps and clear them out for the successful addition of hatches. Also, once we were having issues with the layout, some wires were not showing up there. Nevertheless, overcoming these obstacles is part of the project, and we can confidently say that we have done so. To conclude, our alternate design approach 2, with its focus on maximizing natural light and using energy-efficient fixtures, emerged as the most effective solution, demonstrating the importance of thoughtful design choices in promoting sustainability and efficiency.

Google Drive link (of the .dwg file and schematic PDF):
https://drive.google.com/drive/folders/1k1OdY2NQnOzgZaEPilvQ3i6evyeOUcw5?usp=drive_link