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Load Demand Anaysis for Improved Electrical Service Design

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ABSTRACT
The increase demand of devices and other electrical gadgets has added complexity in any electrical system. The purpose of electrical service design is to solve challenges which are related to design and development to ensure that they are safe and reliable and to make powerful electrical system.In this paper the electrical services design of the electrical electronic department was carried out based on the provision on IEEE standards and regulations to improve its load efficiency. The results showed when the total load increased by 54.37%, the demand factor increased by 2.4% and the diversity factor by 62% due the addition of renewable energy devices, inverters and workshop flex cables. This improvement brought for more flexibility in the energy usage and cost savings improving its efficiency.

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I. INTRODUCTION

Load analysis is a power analysis survey taken on your electrical distribution system to ensure that your electrical system is balanced correctly and not overloaded in anyway. This enables the evaluation of the voltage, current flow, power consumption and to assess the power factor (Abubakar *et al*, 2015). In the generation of technological advancement building construction or remodelling building projects, the owners or occupants must first have a concept for the new design, and then the architect or designer can produce a set of building plans. These plans convey all the required information to the local inspection authority and associated building trades (Alamau, 2016). According to (Adelakun, 2018) commercial and industrial buildings contain several electrical systems, therefore these plans include specific electrical designs, calculations, and additional documentation to verify that the design conforms to all required building codes.Electrical service design entails planning, creating, or supervising the development and installation of electrical equipment including lighting equipment, power systems, power distribution, fire and life safety systems, electronic component, and voice and data communications infrastructure.Electrical service design is a vital component in any building and therefore it is necessary to engage proper services design principles that cover a method of wiring, wide range of practice experience, schemes of distribution, and protection for lighting and power installations. Here the engineer must consider various design goals in both quality and other specific requirements together with the price to provide an exclusive design. The electrical installation and unit of the apartment are different in terms of illumination level, the number of socket outlets, accessories, and electrical appliance. The illumination level of each portion is different depending on the purpose it is meant for. The design was based strictly following the institution of electrical engineers (lEEE) Regulations and several standard regulatory bodies while adequate provisions were made for flexibility to enable any necessary extension and alteration. The conduit system is chosen for durability so that the design can last for the lifetime of the installation.

II. METHODOLOGY

The following method will be used in achieving load demand analysis for electrical electronics building.
Demand Factor: The ratio of actual maximum demand on the system to the total rated load connected to the system is called the demand factor. It is always less than unity.

$$\text{Mathematically demand factor} = \frac{\text{Maximumdemand}}{\text{Connectedload}}$$

Average Load or Demand: The average load or demand on the power station is the average of loads occurring at various events. It can also be stated as the energy delivered in a given period divided by the number of hours in that period depending upon the duration of the periods such as a day, a month, or a year, we get daily, monthly, or annual average load.

$$\text{Daily average load} = \frac{\text{kWHsuppliedinaday}}{24}$$

$$\text{Annual average load} = \frac{\text{kWHsuppliedinayear}}{24 \times 365}$$

Load Factor: The ratio of average load to the maximum demand during a certain period such as a day or month or year is called the load factor.

$$\text{loadfactor} = \frac{\text{Averagedemand}}{\text{Maximumdemand}}$$

Diversity Factor:The maximum demands of all the consumers supplied from an installation do not occur usually the same time, maximum demand on the installation is.

$$Diversityfactor = \frac{sum\ of\ individual\ maximum\ demands}{Maximum\ demand\ of\ the\ deapartment}$$

Electrical Design Presentation

The packaging and presentation of electrical design comprises the drawing legend the design specifications/wiring notes, fully loaded floor plans, load schedules, and distribution board arrangement for each of the distribution units and the supply/ control board schematics.

Department's Electrical Equipment Ratings

Table 1 Load Data

TYPES OF EQUIPMENT	NUMBER	RATING (W)
Energy-saving wall bracket	28	18w each
Security lamp	10	40w each
Ceiling fans	27	80w each
13amp switch socket outlet	43	300w each
15amp switch socket outlet	10	1500w each
100amp Distribution Board	2	100 Amps

Table 2: Daily Load Demand

Time	Load	Remark
12midnight to 8am	400W	Only the outside security lamps are switched on
8am to 10am	2664W	Wall brackets and fans are switched on
10am to 12noon	15060W	Wall brackets fans, sockets(13amps) are switched on
12noon to 4pm	24060W	Wall-brackets, fans, sockets(13amps, 15amps) are switched on
4pm to 6pm	1224W	Wall brackets, fans, sockets are switched on
6pm to 12 midnight	400W	Only the outside security lamps are switched on

Table 1 and 2 shows the various equipment ratings which are found in the department to be used in the analysis. In figures 1, 2 and 3 the initial power and lighting installation of the building is presented this will be used to calculate the original building demand parameters. In figures 4 and 5 the distribution boards of the building was designed to using existing values and parametets.

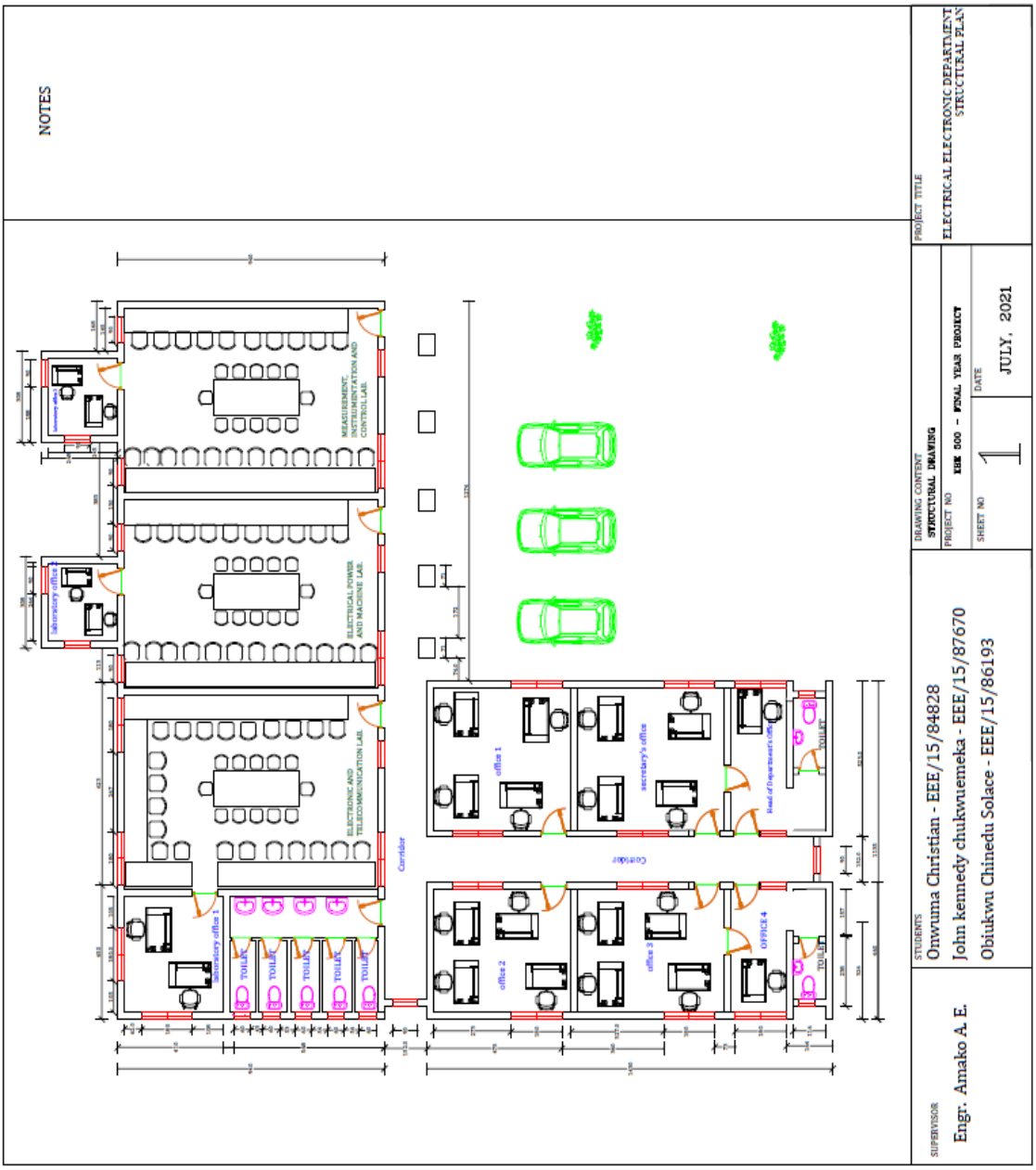


Figure 1: Department of Electrical Electronics Structural Plan

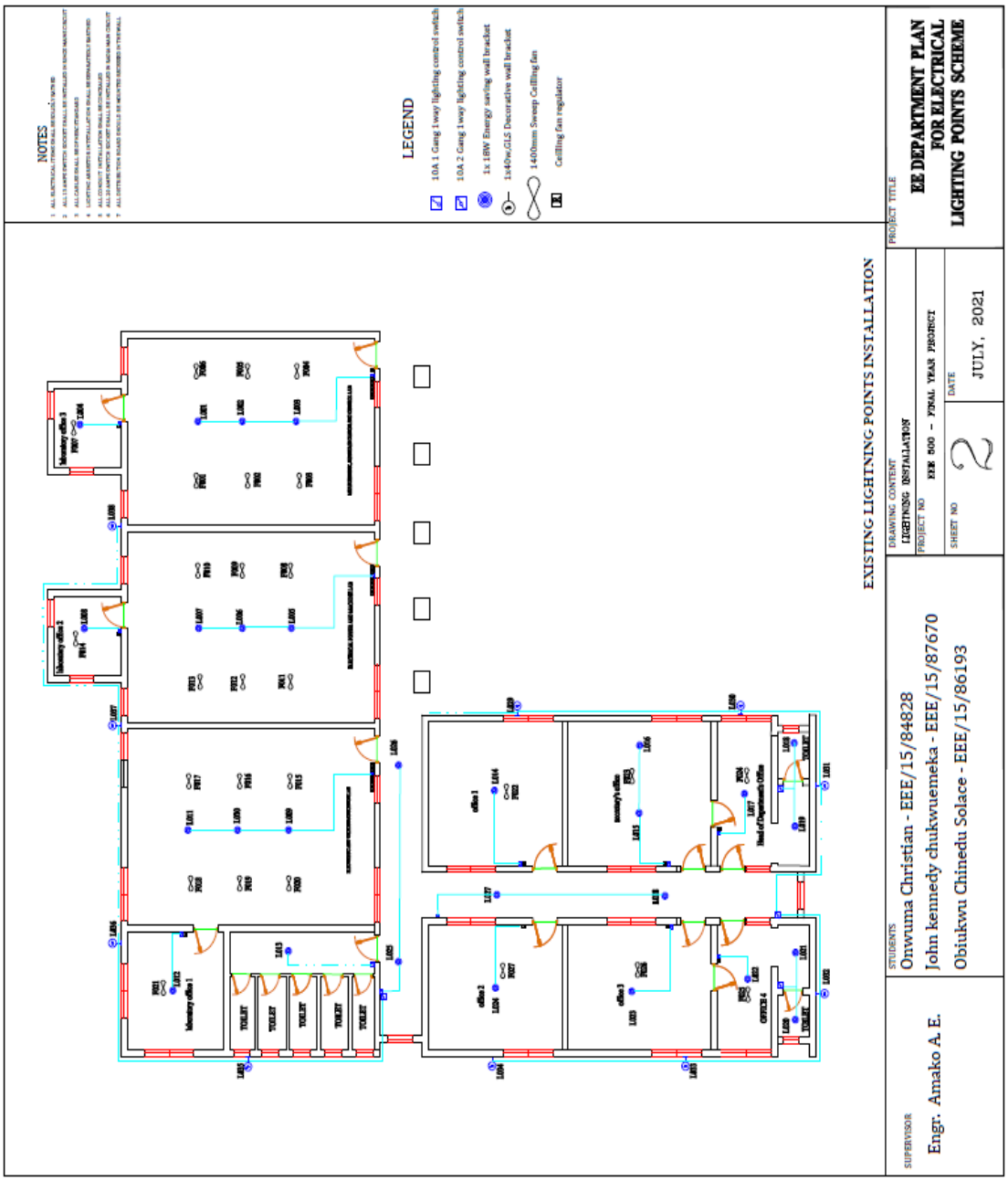


Figure 2: Lighting Installation Design

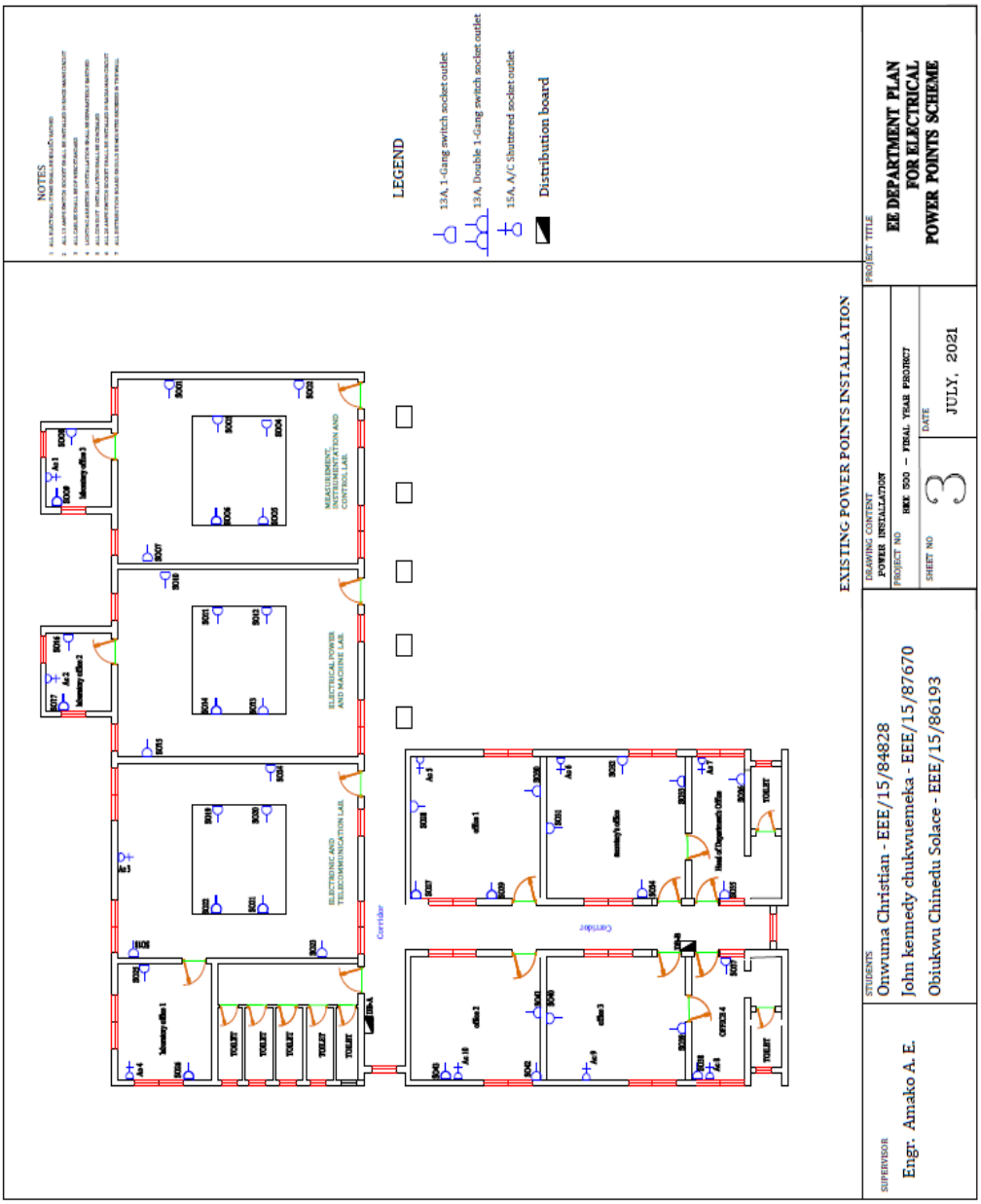
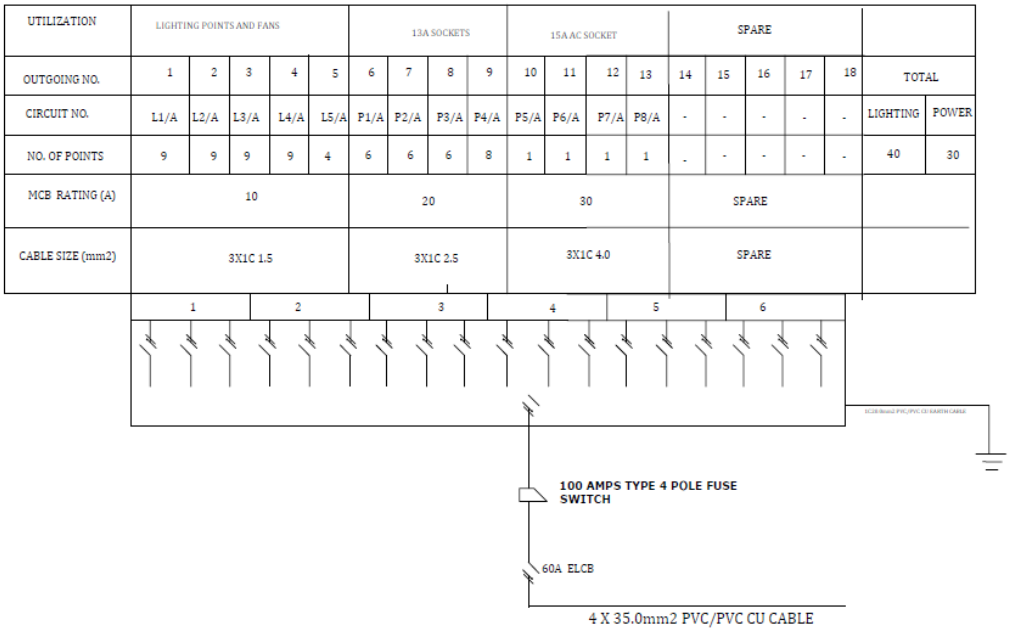


Figure 3: Power Installation Design

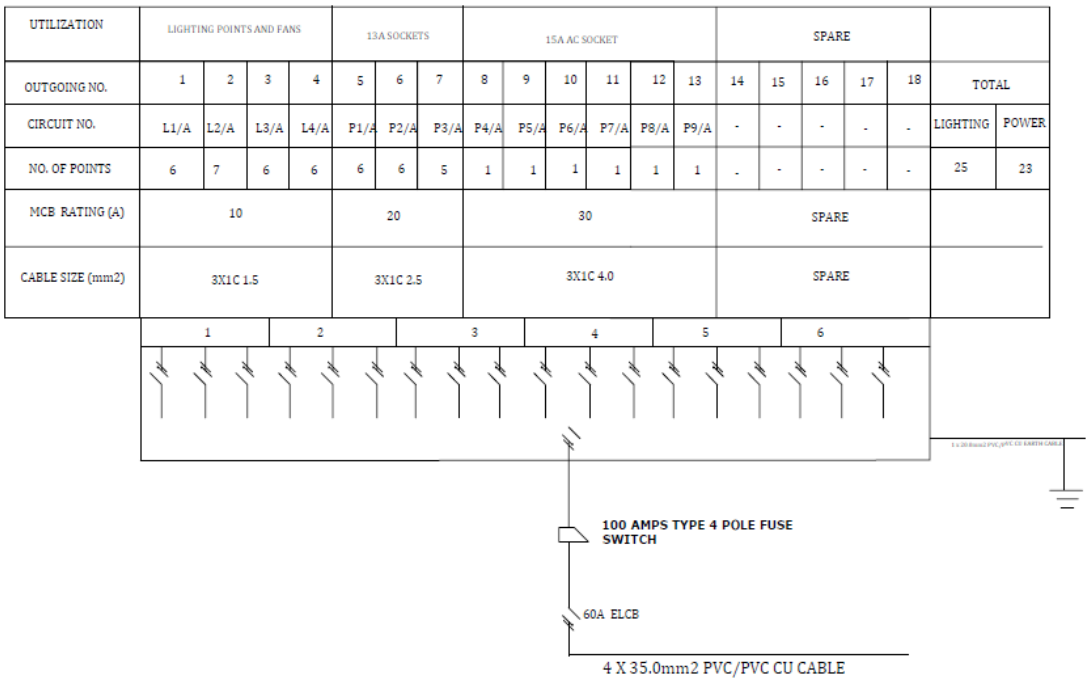
Table 3: PowerPoint Allocation

Power Switch no	Point controlled	
Sw1--- Sw43	S001--- S043	13 Amps Socket Outlet
Ac1 --- Ac10	A101—A0110	15Amps Socket outlet



LOAD DISTRIBUTION BOARD - A

Figure 4: Distribution BoardA Design



LOAD DISTRIBUTION BOARD -B

Figure 5: Distribution Board B Design

III. RESULTS AND DISSCUSSIONS

Table 4: Load Data Schedule of the Department

Time	Load	Remark
12midnight to 8am	400W	Only the outside security lamps are switched on
8am to 10am	2664W	Wall brackets and fans are switched on
10am to 12noon	15060W	Wall brackets fans, sockets(13amps) are switched on
12noon to 4pm	24060W	Wall-brackets, fans, sockets (13amps, 15amps) are switched on
4pm to 6pm	1224W	Wall brackets, fans, sockets are switched on
6pm to 12 midnight	400W	Only the outside security lamps are switched on

From table 4, it can be deduced that between the hours of 12pm – 4pm, the department consumes the highest power of 24060W. During this period, all the electrical equipment's in the department including lights, fans, and sockets (both 13A and 15A) are switched on excluding the outside security lamps. The period is usually called the peak-hour period. Also, from table 4, the hours of 6pm – 12 midnight and 12 midnight – 8am, there is less consumption of electric power ofabout 400W in the department because all the equipment and appliances have been switched off excluding the outside security lamps.Also from table 4, between the hours of 10AM – 12Noon, there was a higher power of 15060W consumed in the department. During this period, lights, and sockets (13A) are switched on.

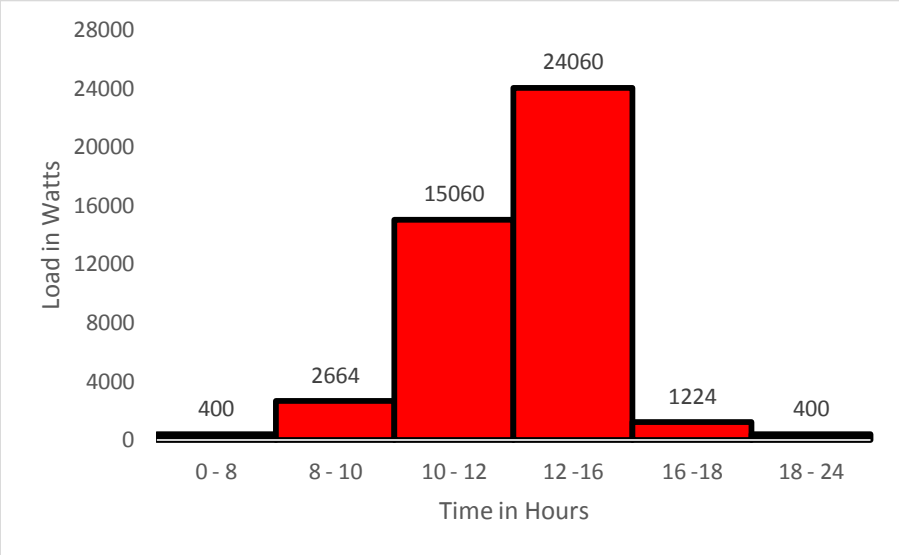


Figure 6: Load Time Graph of Electrical and Electronics Department

From figure 6,it can be seen that between the hours of 8am – 10am there was low power consumption because during this period all the wall brackets both in the offices and the laboratories are ON including fans and switches. Also, from figure 4. Between the hours of 4pm – 6pm there was a drop in load consumption because some equipment has been switched off.

Modified Electrical Electronics Engineering department installation.
Department's Electrical Equipment Ratings

Table 5: Load data

TYPES OF EQUIPMENT	NUMBER	RATING (W)
Energy-saving wall bracket	28	18w each
Security lamp	10	40w each
Ceiling fans	27	80w each
13amp switch socket outlet	43	300w each
15amp switch socket outlet	10	1500w each

100amp Distribution Board	2	100 Amps
Inverter system	9	2kva each
Workshop flex cable	3	25 Amps each

Table 5 shows the load modification values to be used. In figures 7 and 8 the power and lighting installation of the build is presented showing the improvements added and modifications. In figures 9 and 10 the modified distribution boards of the building was designed to accommodate the additions of inverters, energy meters and workshop flex cables.

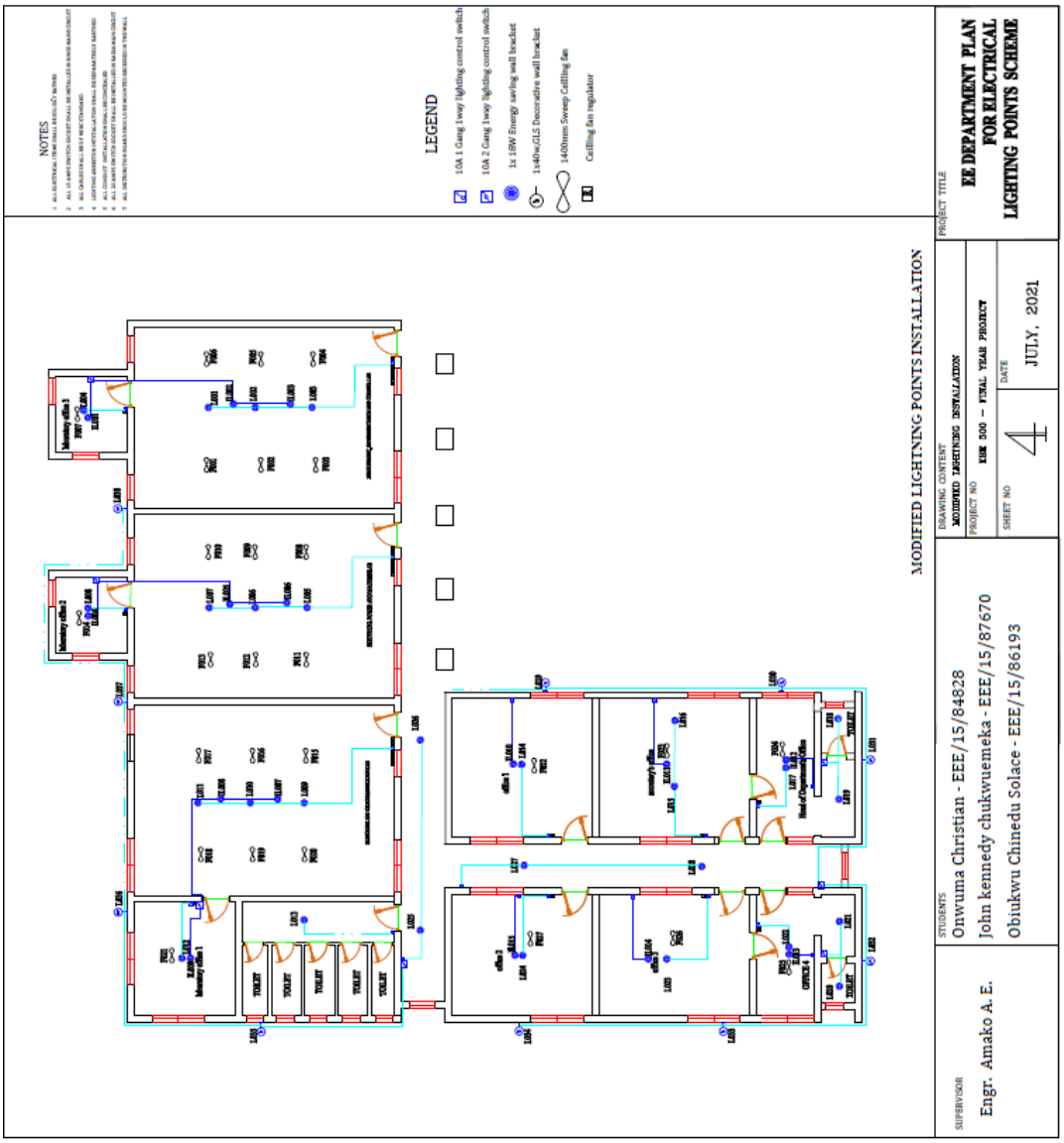


Figure 7: Modified Lighting Installation Design

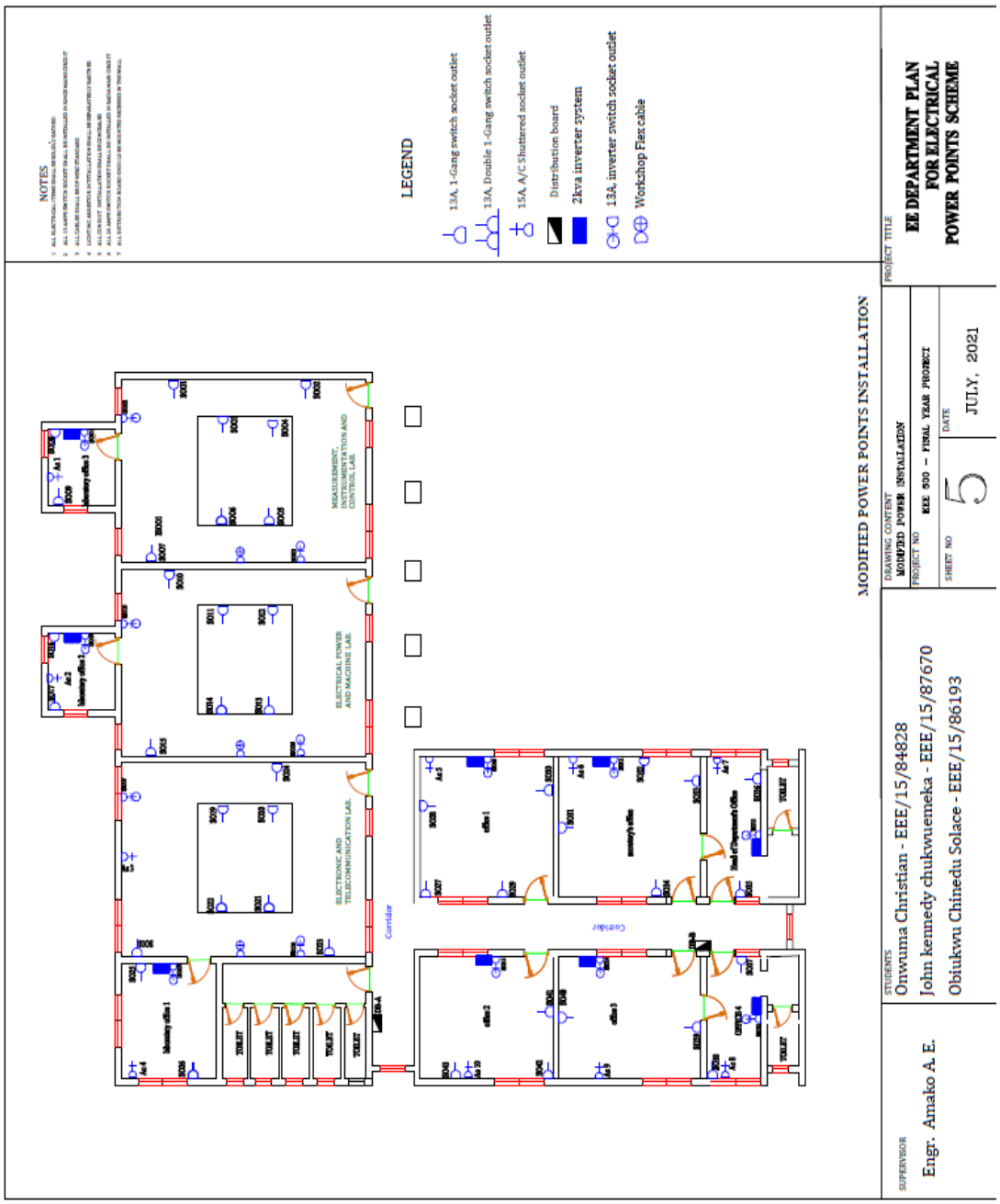
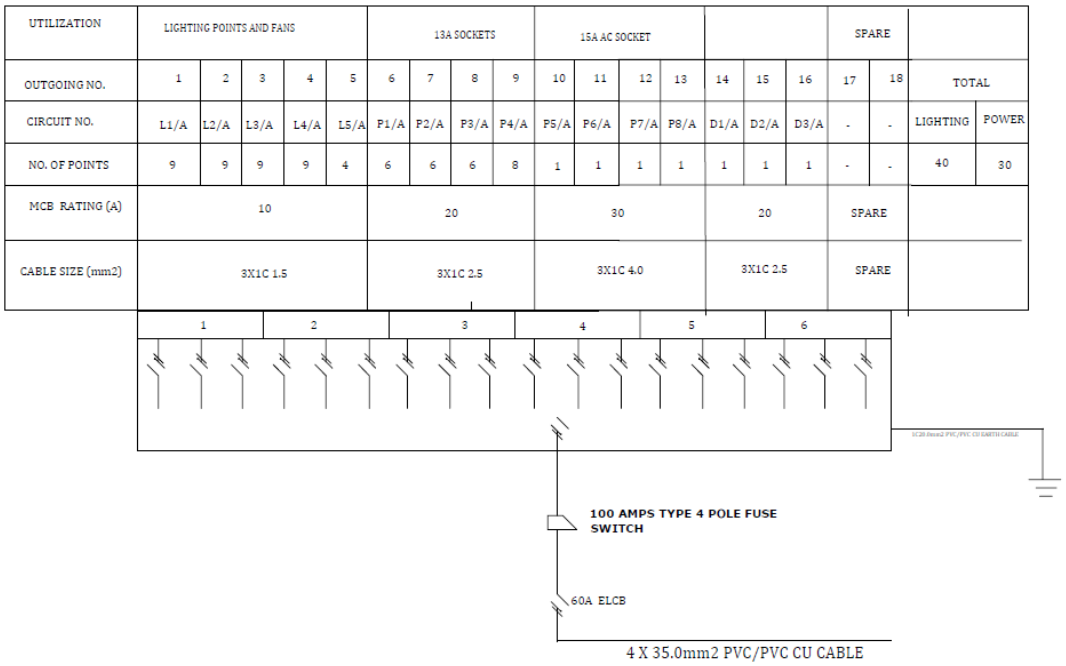
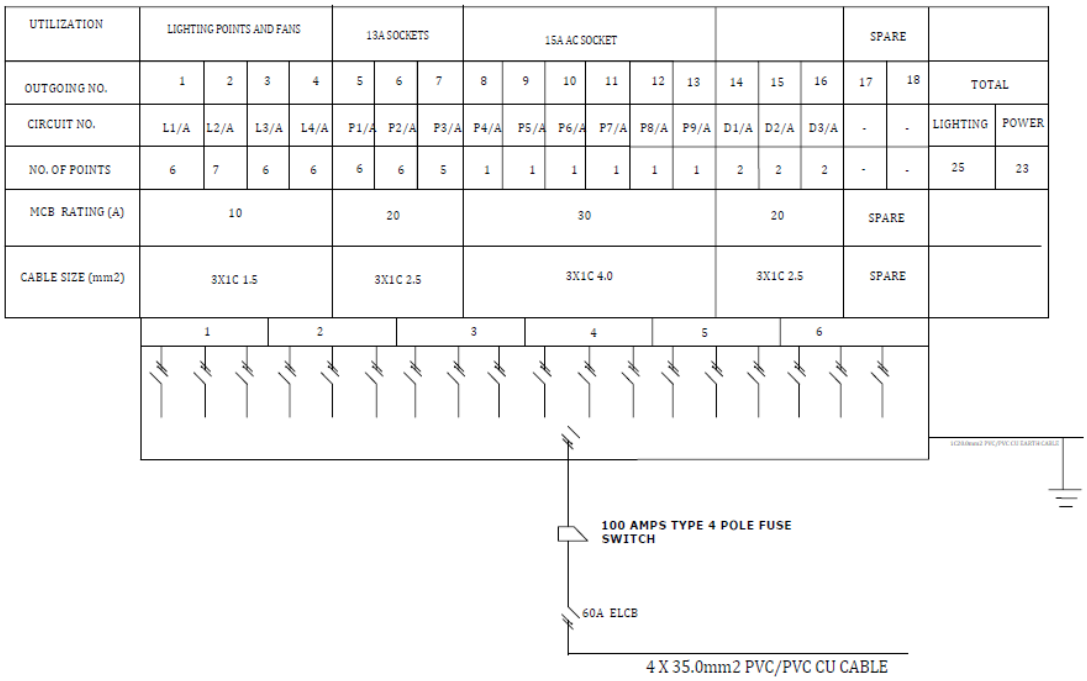


Figure 8: Modified Power Installation Design



MODIFIED LOAD DISTRIBUTION BOARD - A

Figure 9: Modified Distribution Board Design A



MODIFIED LOAD DISTRIBUTION BOARD -B

Figure 10: ModifiedLoad Distribution Board Design B

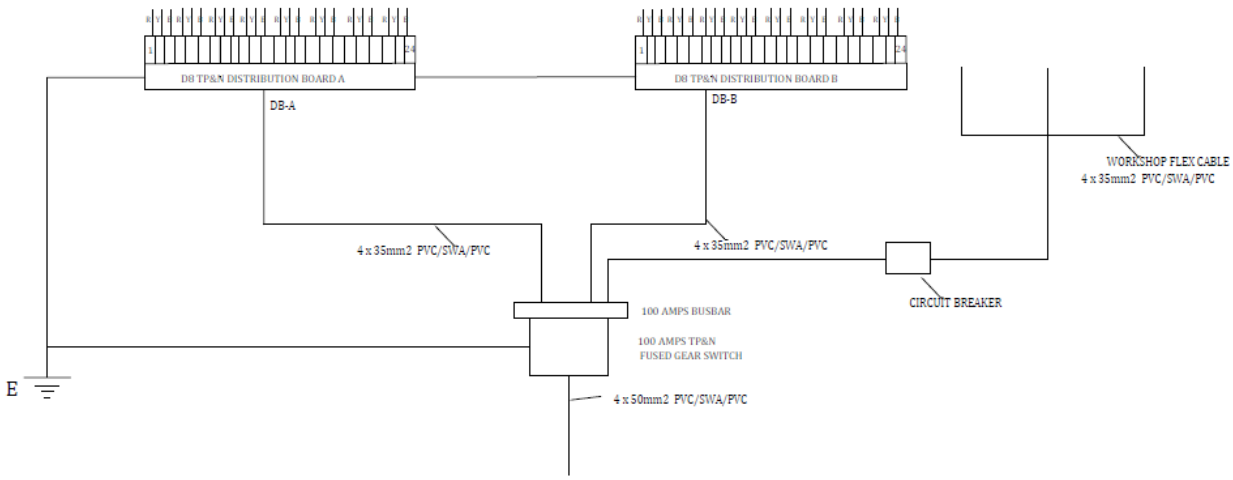


Figure 11: Modified Distribution Board schematics

Table 6: Distribution boards Allocations and ratings

	Existing Distribution Board Allocation		Modified Distribution Board Allocation	
	Board A	Board A	Board A	Board B
Red Phase	3906	4672	7373	8702
Yellow Phase	6512	4912	8512	8912
Blue Phase	5333	4450	8606	10250
Diversity x Rate(W)	15904	15054	21751	26034

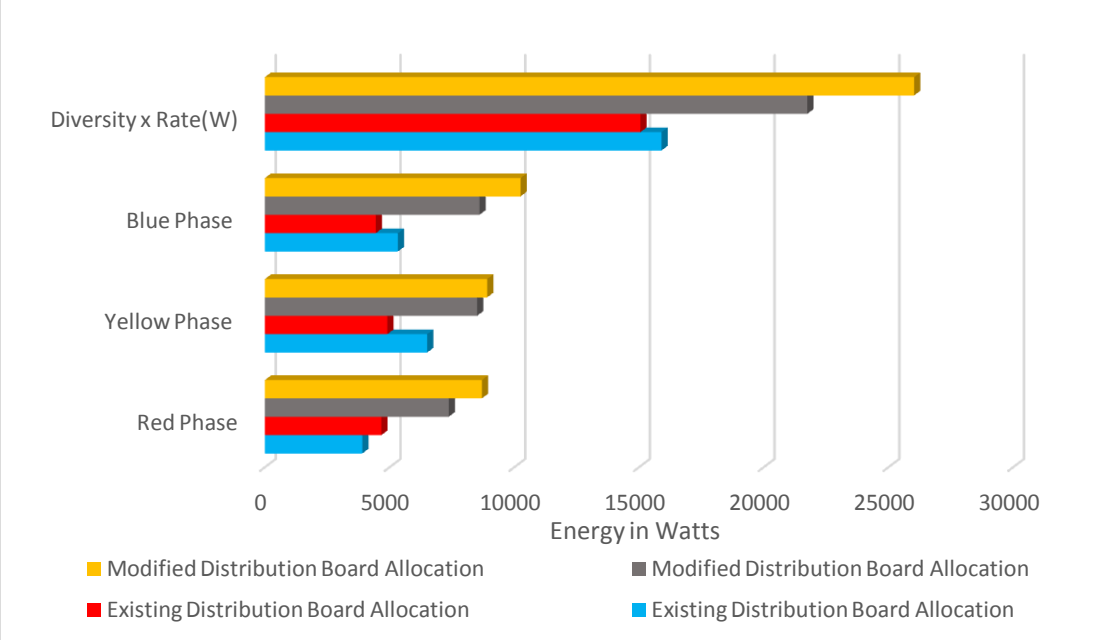


Figure 12: Distribution board allocation and ratings

Table 7: load demand calculations

Load Terminology Calculations	**Existing Network**	**Modified Network**
Total load	30954 W	47785W
Demand factor	0.776	0.795
Average demand	5.8 kW	7.4Kw
Load factor	24.2 %	19.47%
Diversity factor	0.8	1.3

The table 7 shows the load demand calculations of the department of E.E.E after several modifications has been made. Duringthis modification there were additions of inverters and 25Amps workshop flex wire.

IV. CONCLUSION

In this paper, the load demand analysis of the electrical electronic engineering department was carried out in accordanceto IEEE regulations. The load demand analysis was done using the lighting, PowerPoint, and distribution board arrangements and the existing lighting, PowerPoint, and distribution board calculation of the department of electrical/electronic were obtained as follows: The total load of the department was gotten as 31000W (31KW), the total demand factor is 5.8KWh, the total load factor is 18.7 and the total diversity factor was gotten as 0.8.furthermore, since the standby generator in the department (3.2kVA) can no longer accommodate the total load in the department, hence there is need for modification. During the modification the following was added: three (3) 2kva inverters in the laboratories and six (6) 2kva inverters in all offices and 25amps workshop flex cables for the laboratories. After the additions of these equipment the total load of the department was rated as 47785W, demand factor 0.795, load factor 19.4% and diversity factor as 1.3. This modification improves the department efficiency and reduces its cost on fuel usage.

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