ELECTRIFICATION SYSTEM DESIGN OF A TWO STOREY BUILDING

BY

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DEDICATION

This project work is dedicated to my lovely mother who always stood by me in praying for my success.

DECLARATION

I SHEHU ALKANCHI MUAZU, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ABSTRACT

This work is based on the modern system of electrical services design of the two storey building residential house which focuses on the illumination calculation and load power circuits requirements for 13A and 15A outlets of various rooms. Also the size of cables at each level of the installation (such as lighting, fan, socket outlets and sub-main cables) was considered, circuit breaker rating and fuse rating for the distribution board were also specified and determination of the earth electrode resistance. Another important thing in the design was the evaluation of the entire work through the cost analysis.

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CHAPTER ONE

INTRODUCTION

1.1 OVERVIEW

Engineering in electrification system design is the application of technological and engineering knowledge to planning, design, operation and maintenance of various electricity schemes for the benefit of man. Any engineering design start with an engineering problem[1].

Electrification design practically refers to the production of a standard electrical format and clear view of equipment and facilities provided in a scheme on paper or soft copy (in the case of a computer) prior to the start of the actual physical construction work. There is no such thing as a perfect design solution to an engineering problem, the design that is ultimately adopted is the best solution to the problem. It is a compromise that the engineers have to make to solve the problem in the most effective and economically feasible manner. Each design alternative will have its particular strengths and weaknesses that will need to be compared and evaluated to determine the best solution.

Designing a layout is the first step in providing electrical services for a building regardless of the wiring method to be adopted. In this project work, important parameters common to all electrical design are thoroughly taken into consideration. Such include:

a. Safety.

b. Economic liability

c. Maintenance.

d. Future expansion.

Safety: Is the probability that a system will either perform its functions correctly or will discontinue its functions in a well-defined.

Electricity is very dangerous but useful if control through the provision of appropriate equipment combine with quality workmanship goes along way with good electrical design to minimize danger

Economical liability: An uneconomical design will definitely not see the light of the day. This can be observed in the number of abandoned project in Nigeria. Consequently, adequate economic assignment of project must be carried out before commencement

Maintenance: The ease of carrying out maintenance of facilities provided should be maintain at minimum cost. Maintenance is the changes made on a system to fix errors to support new requirements or to make it more efficient safe manner

Future expansion: This involve forecasting. In view of the ever changing nature of man and continuous quest for growth and development.

A good electrification design in all building should be able to provide for efficient, safe and convenient living and working conditions.

1.2 AIMS AND OBJECTIVES

The aims and objectives of this project is

* To provide a good electrification design for a two storey building residential house.

* For energy saving.

* To also included earthing

* To adhere strictly with the IEERegulation in selection of cable and other components consideration

1.3 STATEMENT OF THE PROBLEM

Electrical installation in residential houses is normally done in such away that the lighting and power circuits each with only one source, so that if the phase have no current the whole circuit have no power to either illuminate or power the circuit. This project is design to provide solution to that problem whereby the house circuits (power and lighting circuits) will have two or three alternate source. For example a room will have two socket outlet with two different phases and different lighting circuit also with different phases, in case there is no current in the other phase or there is damage on the other line the user will have an alternative to switch to the live one for illumination or power purposes.

Care should be taken to choose a type of wiring system and safety that takes into consideration all the parameters. The designer should show full description so that the workman can check the installation properly after completion. Potentially, the design is first observed before the manual construction. The electrical design engineer needs to give full description for full understanding of the fundamentals of electrical engineering principles.

1.4 SCOPE AND LIMITATION OF THE STUDY

This project research work will give the complete electrical installation design of a building incorporated with power and lighting circuits, cabling and illumination calculations e.t.c. Though some engineering design is not only limited to the electrical design, it include mechanical, building etc designs. This work is limited to only electrical design of also a two storey residential house unlike other work that are associated with industrial or working areas.

The major limitation here is, it is not being implemented as a result of its hypothetical nature, the cost of design is not also taken into consideration in arriving at the total project cost. Another thing is that due to the fluctuation of the market prices design and implementation cost may vary

1.5 PROJECT METHODOLOGY

This project will be carried out or design through the use of fast growing device in any educational and global field which is a Computer using an AUTOCAD Software. Lastly, given the plan of the two storey building from the electrical services design, maintenances schedule can easily be carried out and safety is ensured by the minimization of faults and accidents, hence, one takes account of the cabling sizes, protective devices, protection and earthing system and operational requirements/observation.

1.6 PROJECT OUTLINE

This project work is carried out and analyzed into five chapters, the first chapter is the introductory part, the second chapter is the review of related literature, the third chapter deals with procedure, chapter four is concern with the evaluation of the design. Then the last chapter gives summary, conclusion, recommendations.

CHAPTER TWO

2.1 LITERATURE REVIEW

Electrical lighting had its real beginning in about 1870 with the development of commercially usable lamps and was given greater impetus nine (9yrs) years later by Edison's first practical incandescent lamp. Today's electric light sources fall in to three generic classifications: The incandescent lamp, the gaseous discharge lamp, and the electroluminescent sources.

Electrical power as described by Britannica (1987) is the energy generated through the conversion of other forms of energy such as mechanical, chemical or thermal energy. The institution of electrical regulation for the electrical equipment of building published in 1981 with amendment in January 1983 covers prevention of fire risk arising from industrial electrical installation work of a building.

2.2 DESIGN FACTORS

These are factors that are taken in consideration for a good installation work to be carried out. Some factors are of a standard values. Others are assumptions which other are worked for. And they are discussed below.

2.2.1 MAINTENANCE FACTOR (M.F)

Lighting out put from lamps could be reduced reasonably by dust and dirt or fittings. The ageing of lamps contributes to poor output illumination. In fact, maintenance factor is the ratio of the average illumination on the working plane after a specified period of use of a lighting installation to the average illumination obtained under the same conditions for a new installation. The figure could be between 0.7 – 0.8. The depreciation factor is the reciprocal of maintenance factor i.e.

$$\text{Depreciation factor} = \frac{1}{\text{Maintenance Factor}}$$

$$\text{Maintenance factor (M.F)} = \frac{\text{Illumination under working}}{\text{Illumination under perfectly clean place}}$$

2.2.2 COEFFICIENT OF UTILISATION

This is a factor in illumination engineering taking care of the utilized flux reaching the working plane, since sources of the emitted flux cannot get to the working plane. The effect of the above is to reduce the illumination on a working plane or contrarily, to increase the power of the light source in other to achieve a given illumination level. Therefore coefficient of utilization is the ratio of the utilized flux to the luminous flux emitted by the lamps.

2.2.3 SPACING – HEIGHT RATIO

It is essential to have reasonable mounting heights for luminaries. Glare could be eliminated by the choice of a good height. Excessive height will increase maintenance cost and reduce the illuminance on the working plane.

2.2.4 ROOM INDEX (K)

This is the ratio of the area of the room in particular to the product of the mounting height and the parameter of the room. The room index, K is a function of the room dimensions and determined with the formula:

$$K = \frac{L.B}{HM\,(L+B)}$$

Where L = Room length

B = Room breadth

HM = Mounting height.

2.2.5 MOUNTING HEIGHT (HM)

This is the virtual distance between the luminance and the working plane and some lines the distance between the floor and the luminance.

It can be calculated practically from the formula:

$$H.M = Hc - (Hs + Hw)$$

Where: Hs = Suspension height of luminance

Hw = Height of working plane

Hc = Ceiling height.

2.2.6 SUSPENSION HEIGHT

This is the distance between the ceiling and the luminance. IEE stipulates that the suspension height of any Lumina should not exceed 0.6m; in most cases it is to be zero. (IEE 15th EDITION).

2.2.7 DOWNWARD LIGHT OUTPUT RATIO (DLOR). This is the ratio of the flux emitted downward by the luminance to the total flux emitted by the luminous.

2.2.8 UPWARD LIGHT OUTPUT RATIO (ULOR). This is the ratio of the flux emitted upward by the luminance to the total flux emitted by the luminous.

2.3 OTHER FACTORS

2.3.1 LUMINOUS INTENSITY (I) CANDLE POWER:

This is the power of source of light energy. In other words, it is solid angular flux density of a source of light in a given direction.

Luminous flux, $\varnothing = 4\pi I$ lumen.

2.2.2 LUMINOUS FLUX (Ø):

It is the energy radiated out per second from a body in the form of luminous light wave. It is a sort of power unit. The unit is lumen (ln). It is called flux contained per unit solid angle of a source of one candela or standard candela.

2.2.3 ILLUMINANCE (E):

This is the amount of light falling on an area A of a surface. It is denoted by E. It is called the intensity of illumination; the unit is "lux". Good light is important in all building for efficient, safe and convenient living and working conditions. The goals of lighting design are to create an efficient and pleasing interior.

These goals are elaborated below:

i. Lighting must have the proper quality.

ii. Lighting levels should be adequate for efficient seeing of the particular task involved i.e. general lighting should be provided in all spaces, sufficient for movement and casual seeing.

iii. The entire lighting design must be accomplished efficiently in terms of capital and energy resource.

Illumination technology has become a highly specialized subject which is divided in to three broad areas namely:

i. Interior illumination of buildings for living and working.

ii. Exterior illumination for some special purpose.

iii. Illumination of streets and public highways.

2.4 ILLUMINATION LAWS

There are illumination laws and in calculating the illumination the types namely the inverse square law and the cosine law are used.

2.4.1 INVERSE SQUARE LAW.

This law states that the amount of light which falls on a unit area of a surface is inversely proportional to the square of the distance from the source.

i.e. $E = \frac{I}{d}$

Where: E = Illuminance,

d = Distance

I = Luminous intensity.

This is for the light source that is perpendicular to the working plane.

2.4.2 COSINE LAW

This is the law which states that the illumination on any surface depends on the cosine of the angle of incidence.

$E = \frac{I}{d2} \cos Ø$. lm/m^2

Where, E – illumination

I = luminous intensity

d = distance of separation

Ø = Angle of incidence.

Both the inverse square law and cosine law are mostly used for outdoor lighting design.

2.5.1 CABLES AND CONDUCTORS

Cables form the necessary connection between the supply and the apparatus. They comprise a very wide range of sizes and types. The necessary requirements of a cable are that it should conduct electricity efficiently, cheaply and safely. To this end it should not be too small son as to have a large voltage drop. The I.E.E Regulation stipulates that all cables carrying current must be so selected as to be able to carry their rated currents, without deterioration. This is why in choosing cables; two factors have to be born in mind namely:

(i) The current carrying capacity of a cable.

(ii) The voltage drop along the cable.

2.5.1 THE THREE MAIN PARTS OF A CABLE.

Cables used in electrical circuits consist of the following main parts.

(i) Conductor

(ii) Insulator

(iii)Mechanical protection.

2.5.2 CABLES USED IN INTERNAL WIRING

The wire employed in internal wiring of buildings may be divided into different groups according to (i) Conductor used (ii) Number of cores used (iii) Voltage grading and (iv) Type of insulation used.

2.6 ELECTRIC LIGHTING

Lighting designers must think of light in two ways. First levels of illumination are necessary for us to use a space. That is to see well enough to function at our designated tasks. However in addition, the forms and spaces themselves are perceived in terms of light. How one feels about a building is also determined by light. (Schiller 1992).

2.6.1 LIGHT SOURCES

Light is admitted in to building through windows by natural light (day light) and artificial light both in the daytime and at night. The characteristics of a good light source are:

i. Acceptable colour.

ii. Noise free.

iii. Absence of glare.

iv. Low cost.

2.6.2 TYPES OF LAMPS

The type of lamps available for lighting designs can be categorized as follows:

i. Fluorescent lamps (Average operating life is between 12,000 – 20,000 hours)

ii. Incandescent lamps.

iii. Energy saving lamps (these are special lamps which are usually compact long – arc, low mercury discharge lamps).

iv. High–intensity discharge (HID) lamps.(Operating life is 10,000–24,000 hours)

2.6.3 LIGHTING FITTING SCHEMES

The distribution of the light emitted by lamps is usually controlled to some extent by means of reflectors and translucent diffusing screens, or even lenses.

The interior lighting schemes may be classified as (i) direct lighting (ii) semi-direct lighting (iii) semi-indirect lighting (iv) indirect lighting and (v) general lighting.

1. Direct Lighting Distribution. It is the most commonly used type of lighting scheme. In this lighting scheme more than 90 percent of total light flux is made to fall directly on the working plane with the help of deep reflectors.

(i) 0 - 10% upward.

(ii) 90 - 100% downward.

2. Semi-direct Lighting Distribution. In this lighting scheme 60 to 90 percent of the total light flux is made to fall downwards directly with the help of semi-direct reflectors, remaining light is used to illuminate the ceiling and halls. Such a lighting scheme is the best suited to rooms with high ceiling where a high level of uniformly distributed illumination is desirable.

(i) 10 - 40% upward.

(ii) 60 - 90% downward

3. Semi-indirect Lighting Distribution. In this lighting scheme 60 to 90 percent of total light flux is thrown upwards to the ceiling for diffuse reflection and the rest reaches the working plane directly except for some absorption by the bowl. It is mainly used for indoor light decoration purposes.

(i) 60 - 90% upward.

(ii) 10 - 40% downward

4. Indirect Lighting Distribution. In this lighting scheme more than 90 percent of light flux is thrown upwards to the ceiling for diffuse reflection by using inverted or bowl reflectors. In such a system the ceiling act as the light source and the glare is reduced to minimum. It is used for decoration purposes in cinemas, theatres and hotels etc.

5. **General Lighting Distribution.** In this scheme lamps made of diffusing glass are used which give nearly equal illumination in all direction.

(i) 40 – 60 % upward.

(ii) 40 – 60% downward.

2.7 ILLUMINATION FORMULAE

The formula for obtaining the total number of lumens required for types of environment is as follows:

$$\text{Total lumens} = \frac{luminance \times Area\ of\ working\ plane}{MF \times CU}$$

From the above,

$$\text{Luminance, } E = \frac{Total\ lumens\ (lm) \times MF \times CU}{Area\ (m2)}$$

Also the formula for obtaining the total number of lamps required for a given illumination level is as follows:

$$\text{Number of lamps, } N = \frac{Total\ lumen}{Luminous\ Flux} = \frac{F}{\emptyset}$$

Where: MF = Maintenance factor

CU = Coefficient of utilization.

Ø = Luminous flux per lamp or lumens per lamp (lm)

2.8 CIRCUIT PROTECTION AND CONTROL

There are many ways of protecting both installation and the user from risk of electric shock or fire, which may occur under fault conditions. In general, a protective device is designed to disconnect the circuit whenever it detects a fault condition. The two most common devices employed are:

2.8.1 FUSE: A fuse provides the simplest form of over current protection. The following terms are used in connection

fusing current: This is the minimum current that will blow the fuse.

current rating: This is the maximum current that a fuse will carry indefinitely without undue deterioration of the fuse element.

fusing factor: This is the ratio of the fusing current to the current rating.

i.e., fusing factor $= \frac{Fusing\ current}{Current\ rating}$

2.8.2 CIRCUIT BREAKAR: This may be used to disconnect automatically a faulty circuit. Miniatures circuit – breakers (MCB) have been developed in recent years, as an alternative to fuse, as a means of protection for domestic installations and other small loads.

The part one of IEE regulation stipulates that, every electrical circuit and sub-circuit shall be protected against excess current by fuse, circuit breaker, or similar devices. These are expected to perform the following function:

i. Must be of adequate making and breaking capacity.
ii. Operate automatically at current values suitable related to the safe current rating of the circuit.
iii. Must be suitably located and of such construction as to prevent danger from overheating, scattering of hot metal when they come in to operation, and so as to permit ready renewal of fuse element without danger.

Some other means of protecting circuits' structures and apparatus are Earthing, Switchgear.etc.

2.9 EARTHING

An earth is defined as a connection to the general mass of the earth.

When insulation materials become damaged or if wire becomes displaced, any metal work directly in contact with the electrical wiring system could become live. If such metal work is touched there could be serious electric shock. Earthing of metal work prevents the risk of shock, so that a heavy current flows to earth.

The IEE regulations stipulates that every means of earthing and every protective conductor shall be selected and erected so as to satisfy the requirements of these regulations for the safety and proper functioning of the associated equipment of the installation.

A good connection to earth should have a low electrical resistance, ability to carry high current repeatedly, good corrosion resistance, and ability to perform above functions over a long period of time. Some factors exist which affect a good earthing system and these must be considered always. These include:

i. Earth electrode embedded in foundation.
ii. Earth rods or pipes.
iii. Metallic reinforcement of concrete.
iv. Earth plates.

2.9.1 EARTHING METHODS

The IEE regulations states that every installation must have earth cables which are wires normally 2.5mm^2 (minimum) cross sectional area. The earthing wires must be so fixed to the installation such as lighting system, water, or gas.

2.10 POWER DITRIBUTION

2.10.1 INCOMING SERVICE

The incoming supply enters through the supply company (PHCN) equipment to the main switch of the "link type" (i.e. a switch which breaks both poles of the supply).

From the main switch, the supply is fed to a distribution board containing fuses or other suitable over load protective equipment.

2.10.2 DISTRIBUTION BOARD

These are usually small panels from which the final sub-circuit power supply points are taken. They are usually manufactured in standard size and the rating factors are usually indicated by the number of ways (outgoings), maximum current capacity, and the number of phases.

Standard consumer control units in the market range from 4 – way 60A to 12 – way 100A SPN and 4 – way 60A to 12 – way 100A

2.10.3 FINAL SUB-CIRCUITS

It is a circuit which is connected to any way of a distribution fuse board, or switch fuse feeding one or more points without the intervention of a further distribution fuse board.

It can therefore be seen that from the definition of a final sub-circuit, it mainly consists of a pair of $1.5mm^2$ cables feeding a few lights or a very high 3-core cable feeding a large motor direct from a circuit breaker on the main switch board.

The IEE regulations have definite rules guiding final sub-circuits. The rules are necessary to ensure that wiring to sub-circuits and fuse protection is such that danger is prevented and satisfactory results are obtained.

TYPES OF FINAL SUB-CIRCUITS

Final sub-circuits are in the following categories:

1. A sub-circuit feeding 13A fuse plug.
2. A sub-circuit feeding a motor or rotating electrical machine.
3. A sub-circuit feeding fluorescent and other types of electric discharging lighting.
4. A sub-circuit with rated capacity not exceeding 15A.
5. A sub-circuit with rated capacity exceeding 15A.

2.10.4 POWER OUTLET CIRCUITS.

These are required to enable portable apparatus to be connected to the final sub circuits. A socketoulet is female socket connected to the power wiring in the building and will accept the male plug attached at the end of the flexible cord of an appliance such as vacuum cleaner or electronic equipment/appliance.

CHAPTER THREE

3.1 INTRODUCTION

To an average user the only important part of the electricity service is the outlet at which he receive electricity. To an engineer concern with the designing or installing the service, the illumination system, the system of cables which links these outlets and components to each other is just as important. This chapter will consider illumination calculation for lighting, the cable and the earth electrode resistance.

3.2 DESIGN PROCEDURE

3.2.1 LIGHTING

Illumination and the design of lighting layout is very important in electrical service system. It is necessary to design the circuit lighting system that provide good electrification atmosphere. The requirements of a lighting system depend to a considerable extent on the kind of lamps used as we are going to see.

Table 3.1: Dimensions of the properties of a single flat.

	LENGTH (m)	WITDTH (m)	AREA (m^2)	U.F	M.F
Toilet 1	2.70	1.70	4.60	0.85	0.75
Toilet 2	2.70	1.08	2.91	0.85	0.75
Toilet 3	2.70	1.50	4.05	0.85	0.75
Verandah 1	12.22	0.97	11.85	0.85	0.8
Verandah 2	7.52	1.30	9.78	0.85	0.8
Dinning	2.55	2.48	6.32	0.85	0.8
Lounge room	4.77	4.68	22.32	0.85	0.8
Bedroom 1	4.85	4.53	21.97	0.85	0.8
Bedroom 2	4.70	3.60	16.92	0.85	0.8
Stair	4.02	2.40	9.65	0.85	0.8
Store	1.40	1.25	1.75	0.85	0.75
Lobby	2.60	1.20	3.12	0.85	0.75

M.F = Maintenance Factor

U.F = Utilization Factor

3.2.2 DESIGN SPECIFICATIONS

1. Supply phases = 3 phases

2. Voltage = 400/230V

3. Type of wiring = PVC/PVC conduit.

3.3 CALCULATION OF ILLUMINATION AND LAMPS.

FOR FLAT ONE

<u>MAIN LOUNGE</u>

Given:

1. Area $A = (4.77 \times 4.68) = 22.32m^2$
2. Lamp fitting: 60watts incandescent lamp.
3. Lamp efficiency; γ = 36 lumens/ watt.
4. Maintenance factor, M.F = 0.8
5. Utilisation factor, U.F = 0.85
6. Illumination level, E = 150 lux

Applying the formula.

$E = \frac{\emptyset t \times U.F \times M.F}{A}$, lux (lumen/ m^2)

Where E, - Illumination in the lounge.

$\emptyset_t$ - Total luminous flux given to the lounge.

$\emptyset_t = \frac{E \times A}{U.F \times M.F} = \frac{200 \times 22.32}{0.85 \times 0.8} = 6564.70$ lumens.

P_t = Total power of lamps in watts.

$\emptyset_t$ = 30 lumen/watt.

$P_t = \emptyset_t \square \gamma = \frac{6564.70\ lumens}{30 lumens/watt}$ = 218.82 watts

n $= P_t \square P_L$

Where, n = number of lamps

P_t = Total power of lamps in watts.

P_L = Individual lamp power output, in watts.

$n = \frac{Pt}{PL} = \frac{218.82}{60} = 3.647 \approx 4$ lamps

4 lamps of 60 watts each shall be chosen.

BEDROOM 1

1. Area , A = (4.53 × 4.85) = $21.97m^2$
2. Lamp fitting; = 60 watts Incandescent lamp.
3. Lamp efficiency; γ = 30 lumens/ watt.
4. Maintenance factor, M.F = 0.8
5. Utilization factor, U.F = 0.85
6. Illumination level; E = 150 lux

Using the formula

$E = \frac{\emptyset t \times U.F \times M.F}{A}$, lux (lumens/$m^2$)

$\emptyset_t = \frac{E \times A}{U.F \times M.F} = \frac{150 \times 21.97}{0.85 \times 0.8}$ = 4846.32 lumens.

γ = 30lumens/watt

$P_t = \emptyset_t / \gamma = \frac{4846.32}{30}$ = 161.54 watts

$n = P_t / P_L$, where P_L = 60watts.

$= 161.54 / 60 = 2.7 \approx 3$ lamps

4 lamps of 60 watts each shall be chosen.

BEDROOM 2

1. Area , A = (4.70 × 3.60) = $16.92m^2$
2. Lamp fitting; = 60 watts incandescent lamp.
3. Lamp efficiency; γ = 30 lumens/ watt.
4. Maintenance factor, M.F = 0.8
5. Utilization factor, U.F = 0.85
6. Illumination level; E = 200 lux

$E = \frac{\emptyset t \times U.F \times M.F}{A}$, lux (lumens/$m^2$)

$\emptyset_t = \frac{E \times A}{U.F \times M.F} = \frac{200 \times 16.92}{0.85 \times 0.8} = 4976.47$ lumens.

γ = 30lumens/watt

$P_t = \emptyset_t / \gamma = \frac{4976.47}{30} = 165.88$ watts

$n = P_t / P_L$, where P_L = 60watts.

$= \frac{165.88}{60} = 2.7 \approx 3$ lamps

4 lamps of 60 watts each shall be chosen.

LOBBY

1. Area , A = (2.60 × 1.20) = $3.12m^2$
2. Lamp fitting; = 1.2m, 40 watts incandescent lamp.
3. Lamp efficiency; γ = 30 lumens/ watt.
4. Maintenance factor, M.F = 0.8

5. Utilization factor, U.F = 0.75

6. Illumination level; E = 150 lux

$E = \frac{\emptyset t \times U.F \times M.F}{A}$, lux (lumens/m^2)

$\emptyset_t = \frac{E \times A}{U.F \times M.F} = \frac{150 \times 3.12}{0.75 \times 0.8} = 780$ lumens.

γ = 13lumens/watt

$P_t = \emptyset_t / \gamma = \frac{780}{13} = 60$ watts

$n = P_t / P_L$, where P_L = 60watts.

$n = \frac{60}{60} = 1.0 \approx 1$ lamps

1 lamp of 60 watts shall be chosen.

DINNING

1. Area , A = (2.55 × 2.48) = 6.32m^2
2. Lamp fitting; = 60 watts lamp.
3. Lamp efficiency; γ = 13 lumens/ watt.
4. Maintenance factor, M.F = 0.8
5. Utilization factor, U.F = 0.85
6. Illumination level; E = 150 lux

Using the formula in eqn 3.1

$E = \frac{\emptyset t \times U.F \times M.F}{A}$, lux (lumens/m^2)

$\emptyset_t = \frac{E \times A}{U.F \times M.F} = \frac{150 \times 6.32}{0.85 \times 0.8} = 1394.12$ lumens.

γ = 13lumens/watt

$P_t = \emptyset_t / \gamma = \frac{1394.12}{13} = 107.23$ watts

$n = P_t / P_L$, where $P_L = 60$watts.

$= \frac{107.23}{60} = 1.7 \approx 2$ lamps

2 lamps of 40 watts each shall be chosen.

STORE

1. Area A = (1.40 × 1.25) = 1.75m^2.
2. Lamp fitting = 40watts incandescent lamp.
3. Lamp efficiency, γ = 13 lumens/watt.
4. Maintenance factor, M.F = 0.75
5. Utilisation factor, U.F = 0.85
6. Level of illumination, E = 100 lux.

$E = \frac{\emptyset t \times U.F \times M.F}{A}$, lux (lumens/m^2)

$\emptyset_t = \frac{E \times A}{U.F \times M.F} = \frac{100 \times 1.75}{0.85 \times 0.75} = 274.50$ lumens.

$\gamma = 13$ lumens/watt

$P_t = \emptyset_t / \gamma = \frac{274.50}{13} = 21.12$ watts.

$n = P_t / P_L$, where $P_L = 40$watts.

$= 21.12 / 40 = 0.53 \approx 1$ lamps

1 lamp of 40watts each shall be chosen.

ENT. VERANDAH

1. Area , A = (12.22 × 0.97) = 11.85m^2
2. Lamp fitting; = 60 watts incandescent lamp.

3. Lamp efficiency; γ = 30 lumens/ watt.

4. Maintenance factor, M.F = 0.8

5. Utilization factor, U.F = 0.85

6. Illumination level; E = 150 lux

$E = \frac{\phi t \times U.F \times M.F}{A}$, lux (lumens/m^2)

$\phi_t = \frac{E \times A}{U.F \times M.F} = \frac{150 \times 11.85}{0.85 \times 0.8}$ = 2613.97 lumens.

γ = 30lumens/watt

$P_t = \phi_t / \gamma = \frac{2613.97}{30}$ = 87.13 watts

$n = P_t / P_L$, where P_L = 100watts.

$n = \frac{87.13}{60} = 0.8 \approx 1$ lamps

1 lamp of 100 watts each shall be chosen.

VERANDAH

1. Area , A = (7.52 × 1.30) = 9.78m^2

2. Lamp fitting; = 60 watts incandescent lamp.

3. Lamp efficiency; γ = 30 lumens/ watt.

4. Maintenance factor, M.F = 0.8

5. Utilization factor, U.F = 0.85

6. Illumination level; E = 150 lux

$E = \frac{\phi t \times U.F \times M.F}{A}$, lux (lumens/m^2)

$\phi_t = \frac{E \times A}{U.F \times M.F} = \frac{150 \times 9.78}{0.85 \times 0.8}$ = 2157.35 lumens.

γ = 30lumens/watt

$P_t = \emptyset_t / \gamma = \frac{2157.35}{30} = 72.0$ watts

$n = P_t / P_L$, where P_L = 100watts.

$n = \frac{72.0}{100} = 0.7 \approx 1$ lamps

1 lamp of 100 watts each shall be chosen.

TOILET 1

1. Area A = (2.70 × 1.70) = 4.60m^2.
2. Lamp fitting = 60watts incandescent lamp.
3. Lamp efficiency, γ = 13 lumens/watt.
4. Maintenance factor, M.F= 0.75
5. Utilisation factor, U.F = 0.85
6. Illumination level, E = 100lux.

Applying the formula

$E = \frac{\emptyset t \times U.F \times M.F}{A}$, lux

$\emptyset_t = \frac{E \times A}{U.F \times M.F} = \frac{100 \times 4.60}{0.85 \times 0.75} = 721.56$ lumens.

γ = 13 lumens/watt.

$P_t = \frac{\emptyset t}{\gamma} = \frac{721.56}{13} = 55.50$ watts

$n = \frac{Pt}{Pl}$, where P_L = 60watts $\therefore n = \frac{55.50}{60} = 0.9 \approx 1$ lamp

TOILET 2

1. Area A = (2.70 × 1.08) = 2.91m^2.
2. Lamp fitting = 60watts incandescent lamp.
3. Lamp efficiency, γ = 13 lumens/watt.

4. Maintenance factor, M.F= 0.75

5. Utilization factor, U.F = 0.85

6. Illumination level, E = 100lux.

Applying the formula

$E = \frac{\emptyset t \times U.F \times M.F}{A}$, lux

$\emptyset_t = \frac{E \times A}{U.F \times M.F} = \frac{100 \times 2.91}{0.85 \times 0.75} = 456.50$ lumens.

$\gamma = 13$ lumens/watt.

$P_t = \frac{\emptyset t}{\gamma} = \frac{456.50}{13} = 35.11$ watts

$n = \frac{Pt}{Pl}$, where $P_L = 60$watts.

$\frac{35.11}{60} = 0.7 \approx 1$ lamp

<u>**TOILET 3**</u>

1. Area A = (2.70×1.50) = 4.05m^2.

2. Lamp fitting = 60watts incandescent lamp.

3. Lamp efficiency, $\gamma = 13$ lumens/watt.

4. Maintenance factor, M.F= 0.75

5. Utilization factor, U.F = 0.85

6. Illumination level, E = 100lux.

Applying the formula

$E = \frac{\emptyset t \times U.F \times M.F}{A}$, lux

$\emptyset_t = \frac{E \times A}{U.F \times M.F} = \frac{100 \times 4.05}{0.85 \times 0.75} = 635.29$ lumens.

γ = 13 lumens/watt.

$P_t = \frac{\phi t}{\gamma} = \frac{635.29}{13}$ = 48.86 watts

$n = \frac{Pt}{Pl}$, where P_L = 60watts.

$\frac{48.86}{60} = 0.81 \approx 1$ lamp

STAIRS

1. Area , A = (4.02× 2.40) = 9.65m^2
2. Lamp fitting; = 60 watts lamp.
3. Lamp efficiency; γ = 30 lumens/ watt.
4. Maintenance factor, M.F = 0.8
5. Utilization factor, U.F = 0.85
6. Illumination level; E = 150 lux

$E = \frac{\phi t \times U.F \times M.F}{A}$, lux (lumens/m^2)

$\phi_t = \frac{E \times A}{U.F \times M.F} = \frac{150 \times 9.65}{0.85 \times 0.8}$ = 2128.67 lumens.

γ = 30lumens/watt

$P_t = \phi_t / \gamma = \frac{2128.67}{30}$ = 70.95 watts

$n = P_t / P_L$, where P_L = 60watts.

$= \frac{70.95}{60} = 1.1 \approx 1$ lamps

1 lamps of 60 watts each shall be chosen.

This illumination calculation is also applied to Fat two since they have the dimension hence same components are use.

SECURITY LIGHTING AROUND THE BUILDING PERIMETER.

Given:

1. Total distance round the building (perimeter) = 71.12m
2. Hanging height of the lamp = 2.5m from floor level.
3. Distance from lamp for E_{min} = 2.5 lux is 3m.

Using point to point lumen computation, the formula below can be employed

$E = \frac{I\cos\theta}{d2}$, lux

$I = \frac{Ed2}{Cos\,\theta}$

Where $I = \frac{\emptyset}{4\pi}$ Candela.

$d = \sqrt{2.5 + 3} = 3.9m$

$Cos\theta = \frac{2.5}{3.9} = 0.641$

$I = \frac{Ed2}{Cos\theta} = \frac{2.5 \times 3.9}{0.641} = 59.32$ Candela.

To find $\emptyset = I \times 4\pi = 59.32 \times 4 \times 3.142 = 745.53$ lm.

Efficiency, γ of incandescent lamp = 13lm/w

Lamp to be used = $\frac{745.53}{13} = 57.3$ watts

Incandescent lamp of 60watts shall be chosen and hung 6m apart round the building. Number of lamps round the building = $\frac{57.3}{6} = 9.55 \approx 12$ lamps of 60watts each.

3.4 CALCULATING THE SIZES OF CABLE.

The cables from final sub circuit power socket outlets (13A and 15A) are usually standard cables and are given in the IEE table wiring regulation of 15^{th} Edition.

3.4.1 LIGHTING AND FAN CIRCUITS

Phase Voltage = 230A

Each of the lighting circuit is having 25 lamps of different wattage of total 1280watts

Phase Voltage = 230V

Phase current = $\frac{1280}{230}$ = 5.3A

Fuse rating = 5A

From the table 9D2

1.5mm^2 pvc cable can carry 14A

Volt drop/A/m = 42mV

Total length of cable = 20m

Ambient temperature = 35^0

Temperature correction factor = 0.94

Load/Phase/circuit I = $\frac{1280}{230}$ = 5.3A

Applying the correction factor I = $\frac{5.3}{0.94}$ = 5.67A of appendix 9

Volt drop = $5.67 \times 20 \times 42$ = 4.76V

Permitted voltage drop = 2.5% of 230 = 5.7V

Hence 1.5mm^2 size is suitable for fan.

3.4.2 POWER CIRCUITS

13A, SWITCH SOCKET OUTLET POWER CIRCUITS

1, 13A S.S.O circuit has 7 number of 13A S.S.O = total load = 3500watts

Phase Voltage = 230A

Phase current I = $\frac{3500}{230}$ = 15.2A

Length of cable =20m

Ambient temperature = 35^0

Temperature correction factor = 0.94

Applying the correction factor I = 15.2/0.94 = 15.4A

2.5mm^2 cable with 17mV/A/M can carry in table 9D2 and current carrying capacity of 24A

Voltage drop = I× L × ΔV = 15.4× 20 × 17mV

ΔV = 5.2V

Permitted voltage drop = 2.5% of 230 = 5.7V

Hence 2.5mm^2 size is suitable for 13A S.S.O. circuit.

15A, SWITCH SOCKET OUTLET POWER CIRCUITS

Assumed 1, 15A .S.S.O = 2.5KW load.

1, 15A S.S.O circuit has a TOTAL LOAD = 4000VA with power factor of 0.7

Phase Voltage = 230V

Phase current I = $\frac{4000}{230}$ = 16.6A

Length of cable =20m

Ambient temperature = 35^0

Temperature correction factor = 0.94

Applying the correction factor I = 16.6/0.94 = 17.7A

Fuse rating = 17.7×1.5 = 26.60A

In table 9D2, of the IEE regulation we shall choose a cable of 4.0mm^2 with voltage drop of 11mV/A/m with current carrying capacity of 32A

Voltage drop = I× L ×ΔV

= 17.7× 20 × 11mV/A/M

$\Delta V = 3.8V$

Permitted voltage drop = 2.5% of 230 = 5.7V

Hence $4.0mm^2$ size is suitable for 15A S.S.O. circuit.

It is assumed that the 3 air condition with maximum power (2×1.5hp and 1×2.5hp) are connected with efficiency of 74% and P.F of 0.7 and, thus;

For 1.5hp the Input power = $\frac{1.5\times0.75\times1000}{0.7\times0.74}$ = 2171.81VA then 2×2171.81 = 4343.6

For 2.5hp air condition = $\frac{2.5\times0.75\times1000}{0.7\times0.74}$ = 3571VA

Total input power = 4343.6+3571= 7914.6VA

3.4.2 SELECTION OF SUB-MAIN CABLE FEEDING THE DISTRIBUTION BOARD

Assumed length of cable = 30m

Ambient temperature = 35^0c

Temperature correction factor = 0.94

Maximum Demand Load (3 phase) P_T = 22960VA

Nominal Voltage = 400V

Current per phase = $I = \frac{PT}{\sqrt{3}V} = \frac{22960}{1.732\times400}$ = 33.17A

Applying correction factor = $I = \frac{33.17}{0.94}$ = 35.29A

Fuse rating of 60A is recommended

Cable 1 × 4 × $25mm^2$ with 95A and 1.6 mV/A/ m

Voltage drop = 95 × 30 × (1.6 ×10^{-3})

$\Delta V = 4.56$

Permitted voltage drop = 2.5% × 230V = 5.7V

$\Delta V = 4.56 < 6V$

Hence $1 \times 4 \times 16mm^2$ cable will be chosen according to Appendix 9, tab. 9D2 15th Edition of I.E.E. regulations

We can see here that what is in the ground floor is the same with first and second floor only that the ground floor is having the security light in the perimeter.

DISTRIBUTION BOARD SELECTION

Total power of the flat is 11690VA

Current $= \frac{11690}{230} = 51.0A$

Distribution board of 60A was selected.

Therefore for each flat (SIX FLATS) of the whole building, the same lighting and power points are use also the same cables and distribution board are selected.

3.5 RESISTANCE OF THE EARTH ELECTRODE

For the whole building, the design of the earth electrode resistance depend on the following:

The highest Distribution Board Circuit Breaker = 100A

Expected Excess current = $1.5 \times 100 = 150A$

Phase Voltage = 230A

Earth Electrode Resistance = $R = \frac{V}{1.5 \times 100} = \frac{230}{150} = 1.5\Omega$

CHAPTER FOUR

4.1 DESIGN EVALUATION

Design and operation of electricity systems require continuous and comprehensive analysis in order to evaluate the system performance and to determine the effectiveness of alternative plans for system expansion. These project provide the average cost analysis of various components in the building even though there is variation and test in the implementation of the work. The design play an important role in providing a standardization and qualitativeness of components and ensure maximum utilization of electricity through load balancing.

The tables below shows the descriptions, quantities and the cost of the components required for the individual flat and the entire building itself.

TABLE 4.1: Cost table for lamps FLAT 1

S/N	DESCRIPTION	RATING in W	QUANTITY	UNITCOST (N)	TOTAL COST (N)
1	Incandescent lamp	60	10	40	400
2	Incandescent lamp	40	4	40	160
3	Incandescent lamp	100	8	50	800
4	Fluorescent lamp	40	2	150	300

TABLE 4.2: Cost table for power and others

S/N	DESCRIPTION	QUANTITY	UNIT COST (N)	TOTAL COST (N)
1	13A Socket outlet	9	350	3,150
2	15A Socket outlet	4	450	1800

3	5A Intermediate switch	15	100	150
4	5A One gang One way switch		100	
5	5A Two gang One way switch		150	
6	5A One gang Two way switch	12	150	1800
7	5A Two gang Two way switch		150	
8	5A Three gang One way switch		150	
9	Wall bracket fitting	12	700	8400
10	Chandelier fitting	1	11,000	11,000
11	Security lighting fitting	6	450	2700
12	Ceiling fan/regulator	5	4500	22,500
13	Double 13A socket outlet	2	1150	2300
14	1.5mm² PVC copper core roll	4	2000	8000
15	2.5mm² PVC copper core roll	4	3500	14,000
16	4.0mm² PVC copper core roll	2	3500	7000
17	6.0mm² PVC copper core roll	2	4500	9000
18	Cooker control unit (C.C.U)	1	1500	1500
19	Water heater switch	2	1500	3000
20	60A E.L.C.B	3	2200	6600
21	60A Distribution Board (DB)	1	8000	8000
22	Antenna/Satellite terminal	3	300	900

Having the cost analysis of a single flat in the building (storey building) we can assign the individual flat a cost table and hence the overall cost table for the entire building.

TABLE 4.3: Cost table for each flat

S/N	DESCRIPTION	TOTAL COST (N)
1	FLAT ONE	114,960
2	FLAT TWO	114,960
3	FLAT THREE	114,960

4	FLAT FOUR	114,960
4	FLAT FIVE	114,960
6	FLAT SIX	114,960

TABLE 4.4: Cost table for each FLOOR

S/N	DESCRIPTION	TOTAL COST (N)
1	GROUND FLOOR	229,920
2	FIRST FLOOR	229,920
3	SECOND FLOOR	229,920

TABLE 4.5: Cost table for other components in the main building

S/N	DESCRIPTION	QUANTITY	UNIT COST (N)	TOTAL COST (N)
1	30A TP&N	1	8000	8000
2	100A main switch	1	14,000	14,000
3	200A change over switch	1	25,000	25,000
4	16.0mm^2 PVC/SWA/PVC Cable	30	1800/metre	54,000
5	25.0mm^2 PVC/SWA/PVC cable	20	1800/metre	36,000
6	Main circuit circuit breaker (MCCB)	1	50,000	50,000

TABLE 4.6. OVARALL BUILDING ELECTRICAL COMPONENTS COST

DESCRIPTION	COST (N)
MAIN BUILDING	876,760

CHAPTER FIVE

5.1 SUMMARY

The project was design purposely for the electrification system of two storey building residential house with principal objective of providing standard in the electrical services with strict adherence to the regulation for the electrical equipment of building of the IEE regulations thereby provide basic knowledge in the process of electrical design.

5.2 CONCLUSION

The project was design successfully using modern electrification system. The standard was followed in the design process with the calculation of interior illumination, sizes of cable (such as internal lighting cable,).Distribution board of the individual flat breakers, main circuit breaker, current rating and voltage drop of the cable.

Another important thing in the design was the analysis of the cost of each flat and the entire building with special consideration on the average cost and standardization of the component used, even though there is different product with different cost which as a result causes the market price fluctuation. But as a result of the hypothetical nature of the project, the project was not being implemented and the design cost was not taken into consideration.

5.3 RECOMMENDATION

Considering the modern design, it is recommended that in the event of component consideration the high standard and quality component should be used in the implementation process of the project. Another thing is that energy saving lamps should be used because of their nature of advantages over the other lamps(such as low power consumption, non-pollution and the glare.

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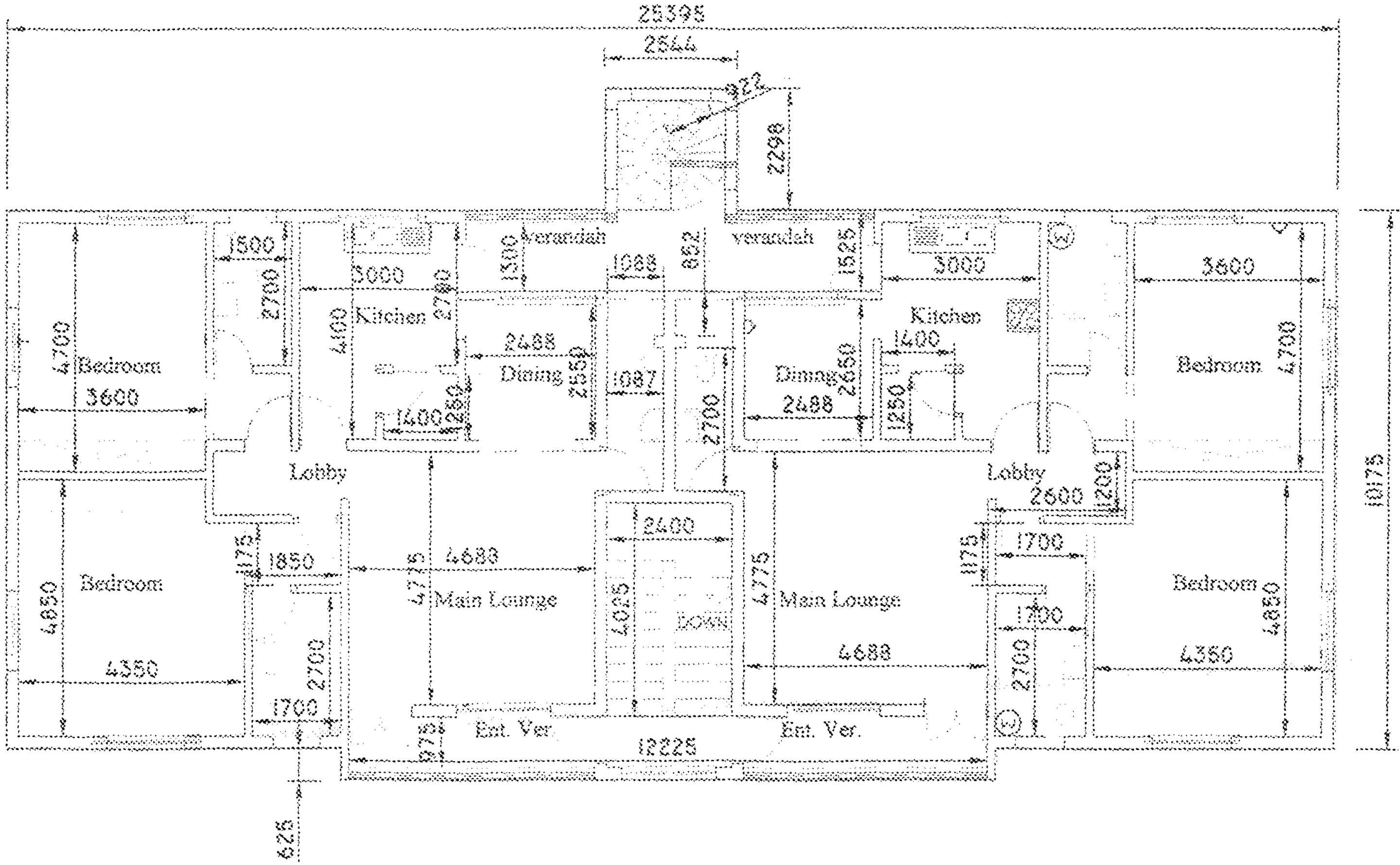
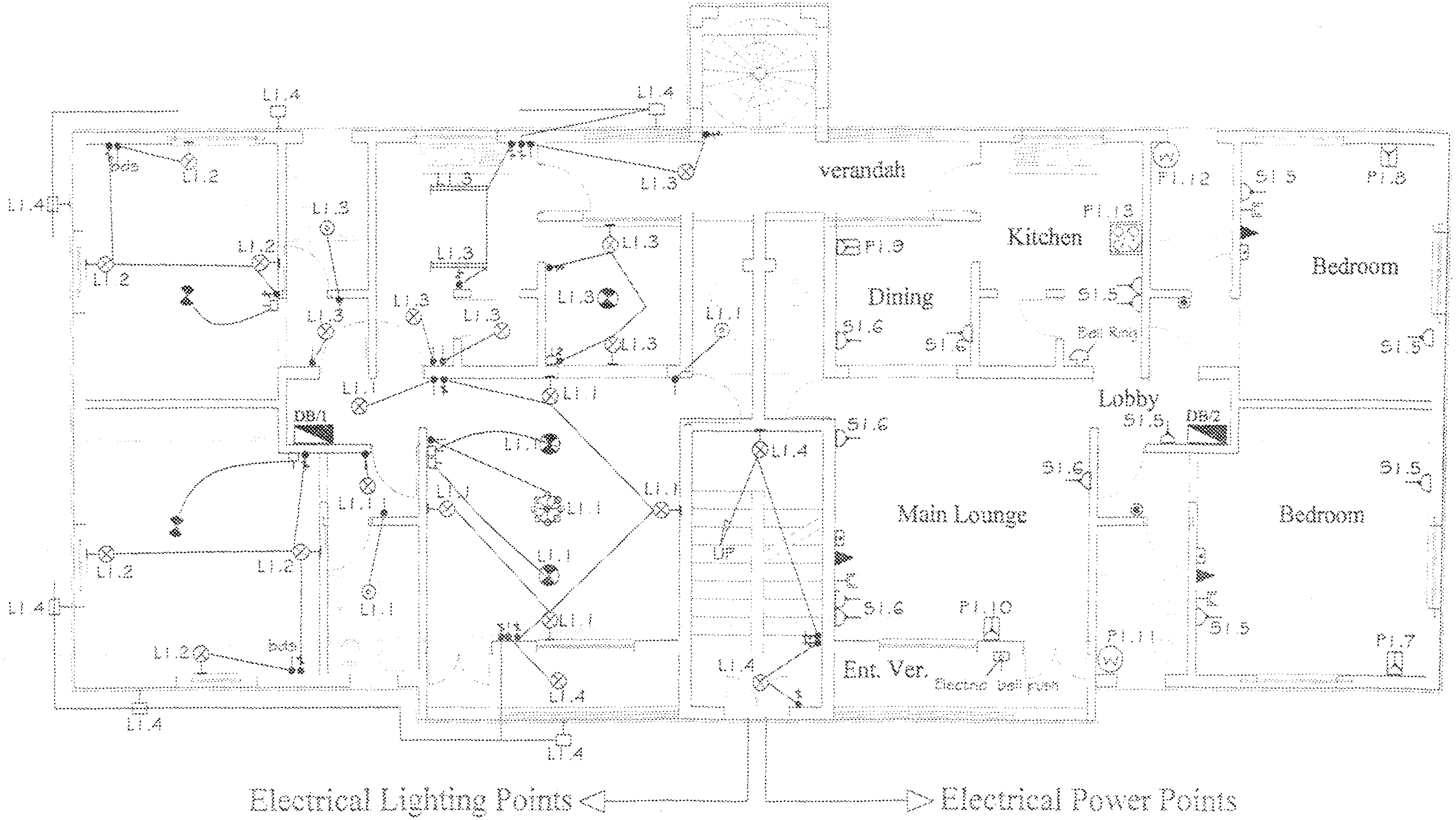


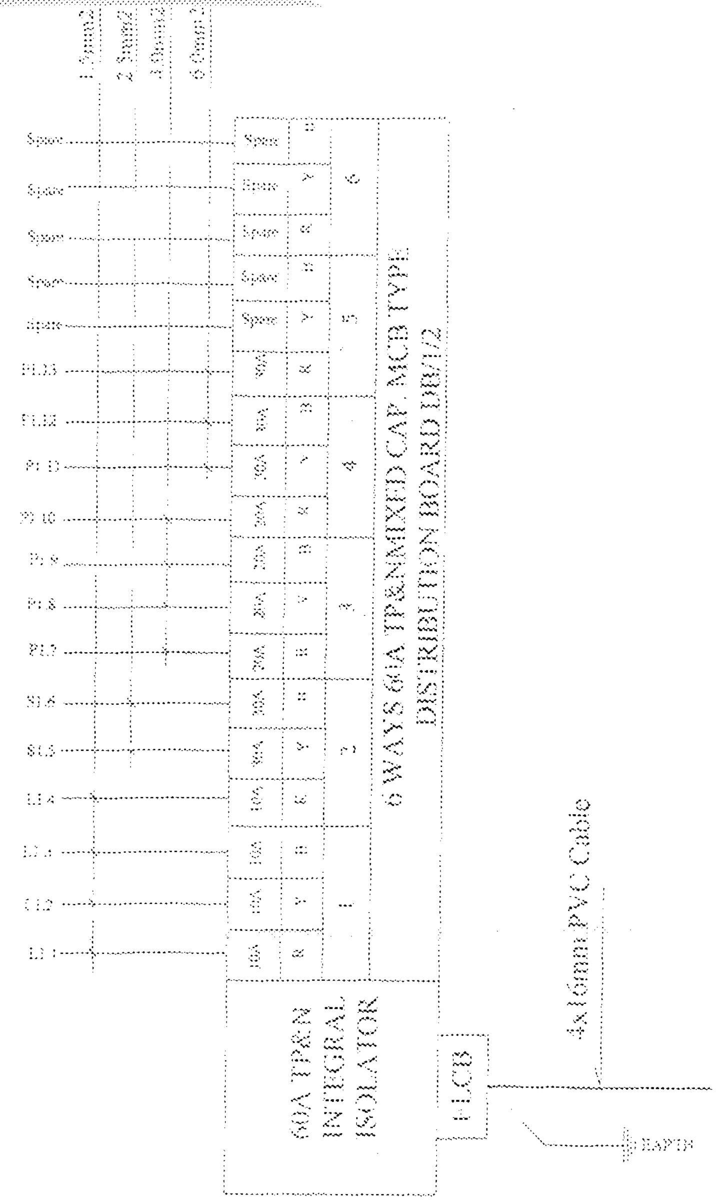
Ground Floor Plan



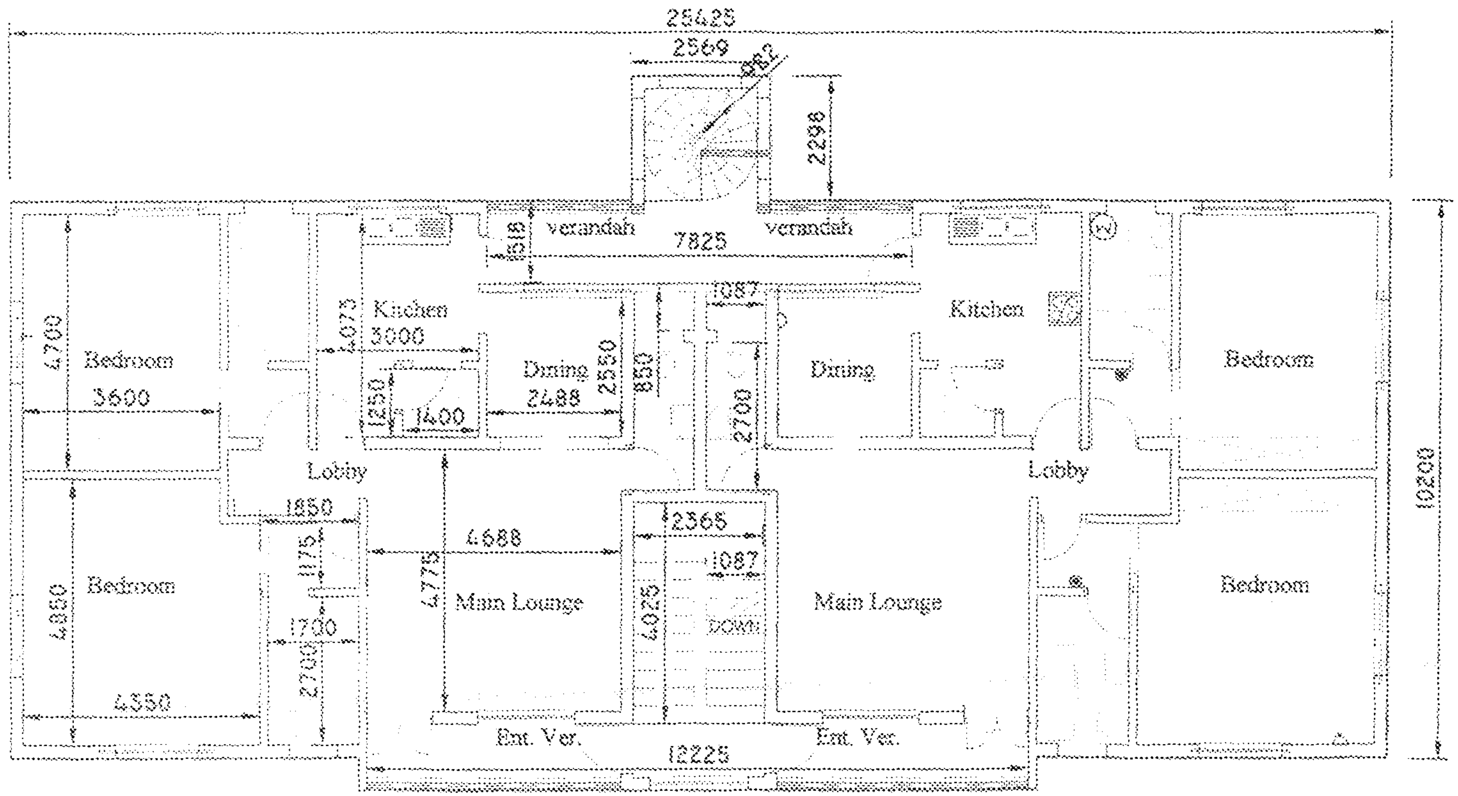
Ground Floor Plan Electrical Installation

DISTRIBUTION BOARD DB/1/2 CAPACITY/RATING 60A TP&N
LOCATION :-GROUND FLOOR 6 WAYS 60A TP&N

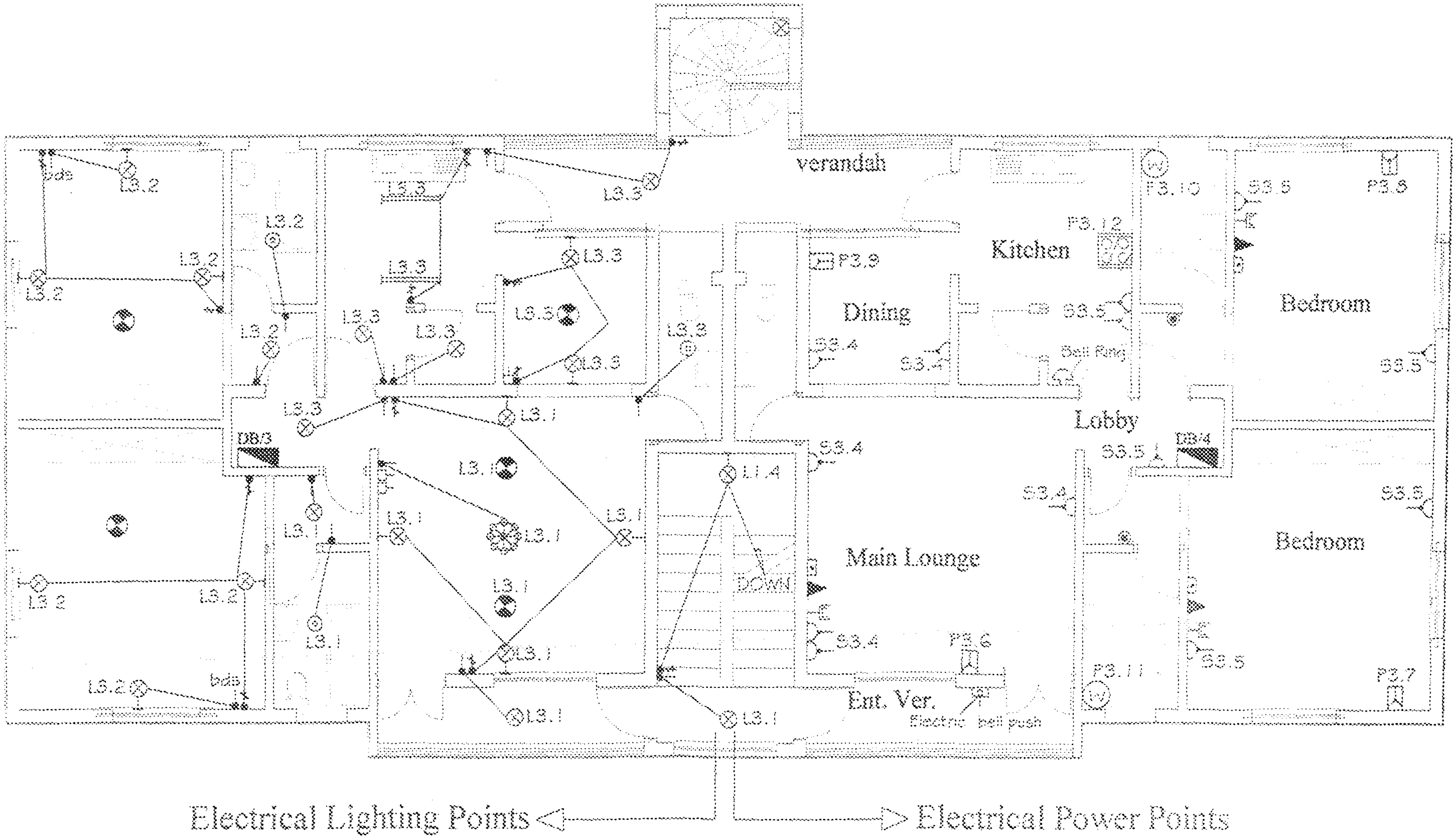
S/NO	[illegible]	NO. OF POINT	LOAD WATT	CIRCUIT NO	R	Y	B	MCB RATING	CABLE SIZE
1	Lighting	11	660	L1.1		660		10A	1.5mm
2	Lighting	8	480	L1.2			480	10A	1.5mm
3	Lighting	10	600	L1.3		600		10A	1.5mm
4	Lighting	9	540	L1.4	540			10A	1.5mm
5	Socket	7	1400	S1.5		1400		30A	2.5mm
6	Socket	6	1200	S1.6			1200	30A	2.5mm
7	A/C	1	2000	P1.7	2000			20A	4.0mm
8	A/C	1	2000	P1.8		2000		20A	4.0mm
9	A/C	1	2000	P1.9			2000	20A	4.0mm
10	A/C	1	2000	P1.10	2000			20A	4.0mm
11	HWH	1	3000	P1.11		3000		30A	6.0mm
12	HWH	1	3000	P1.12	3000			30A	6.0mm
13	CCD	1	4500	P1.13			4500	30A	6.0mm
14	Spare	------	------	------	------	------	------	------	------
15	Spare	------	------	------	------	------	------	------	------
16	Spare	------	------	------	------	------	------	------	------
17	Spare	------	------	------	------	------	------	------	------
18	Spare	------	------	------	------	------	------	------	------
	TOTAL LOAD		23380		7540	7060	8780		



SCHEMATIC DB/1/2

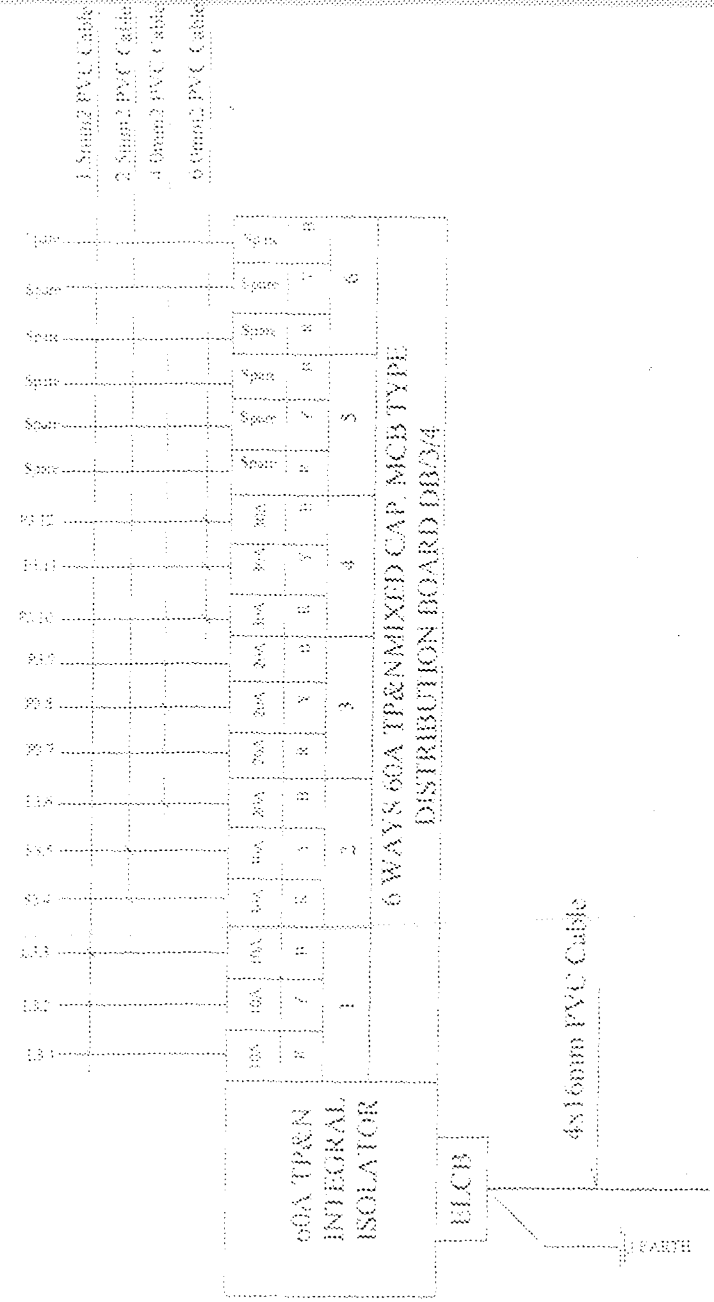


First Floor Plan Electrical Installation

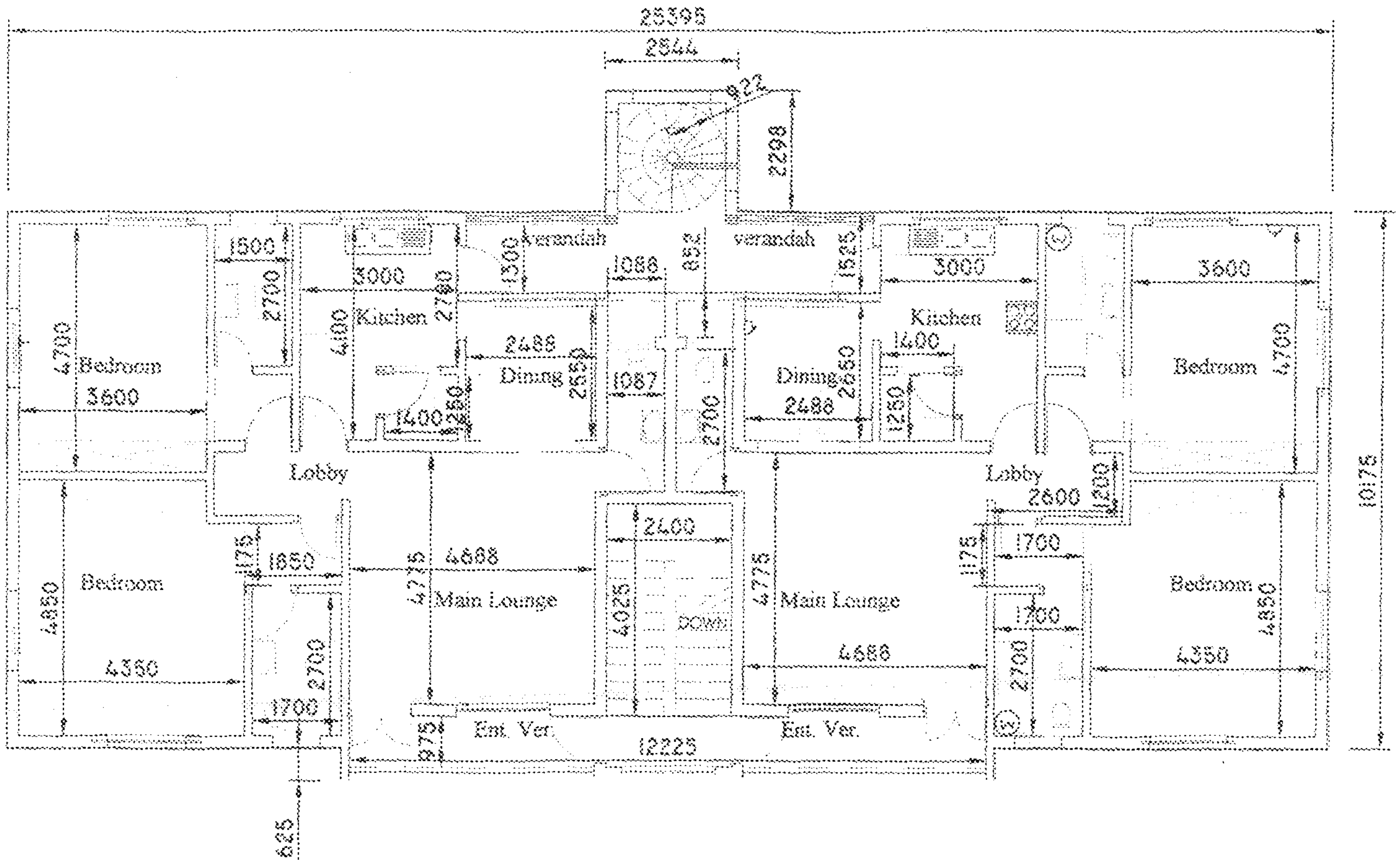


First Floor Plan Electrical Installation

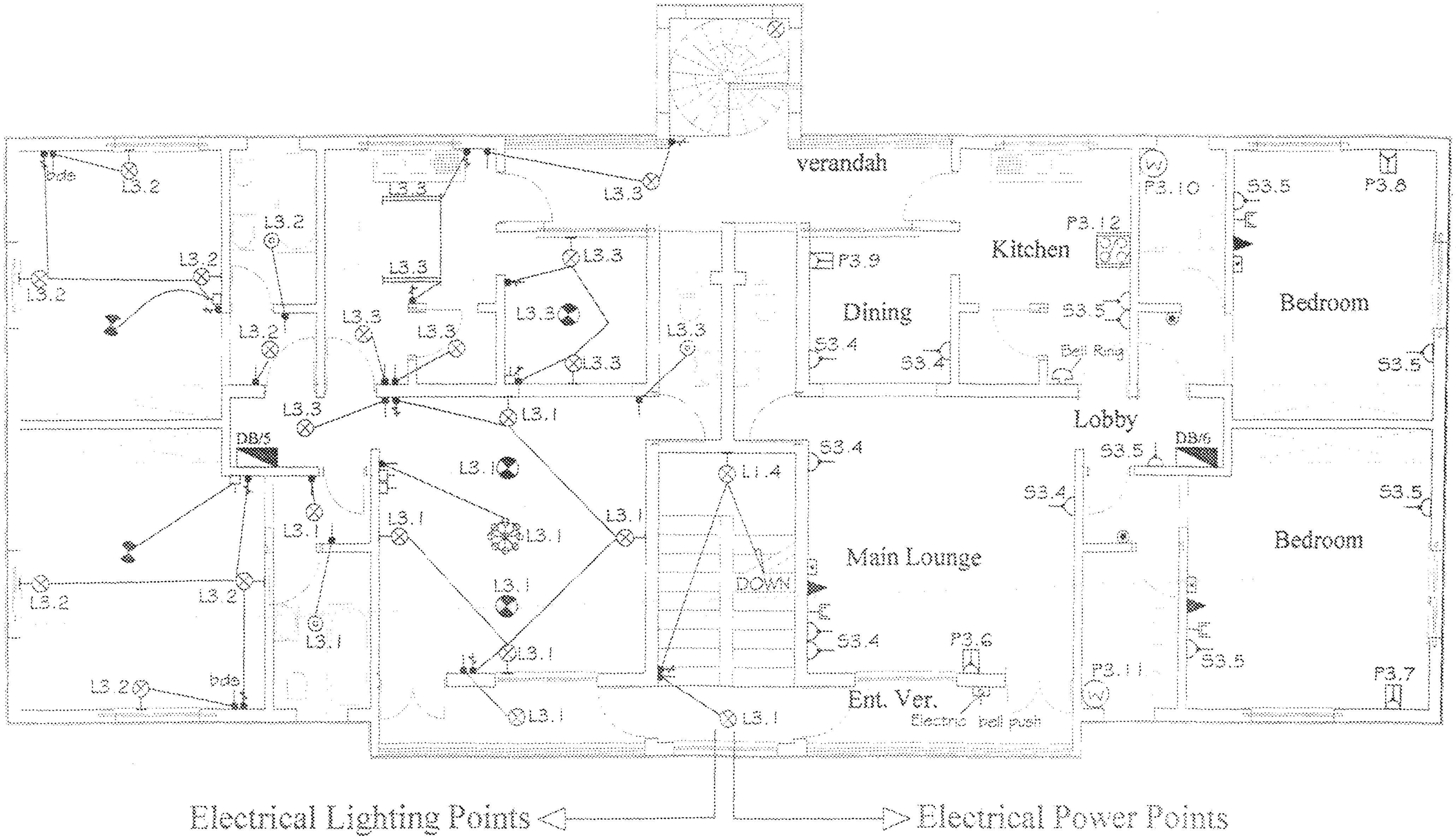
DISTRIBUTION BOARD DB/3/4 CAPACITY/RATING 60A TP&N LOCATION -FIRST FLOOR 6 WAYS 60A TP&N									
S/NO.	DESCRIPTION	NO. OF POINT	LOAD WATT	CIRCUIT NO.	PHASE			MCB RATING	CABLE SIZE
					R	Y	B		
1	Lighting	11	600	L3.1	600			10A	1.5mm
2	Lighting	10	600	L3.2		600		10A	1.5mm
3	Lighting	10	600	L3.3			600	10A	1.5mm
4	Socket	6	1200	S3.4	1200			30A	2.5mm
5	Socket	7	1400	S3.5		1400		20A	2.5mm
6	A/C	1	2000	P3.6			2000	20A	4.0mm
7	A/C	1	2000	P3.7	2000			20A	4.0mm
8	A/C	1	1500	P3.8		2000		20A	4.0mm
9	A/C	1	1500	P3.9			2000	20A	4.0mm
10	EWH	1	3000	P3.10		3000		30A	6.0mm
11	EWH	1	3000	P3.11			3000	30A	6.0mm
12	CCU	1	4500	P3.12	4500			30A	6.0mm
13	Spare	------	------	------	------	------	------	------	------
14	Spare	------	------	------	------	------	------	------	------
15	Spare	------	------	------	------	------	------	------	------
16	Spare	------	------	------	------	------	------	------	------
17	Spare	------	------	------	------	------	------	------	------
18	Spare	------	------	------	------	------	------	------	------
	TOTAL LOAD		22500		1500	7000	7500		



SCHEMATIC DB/3/4



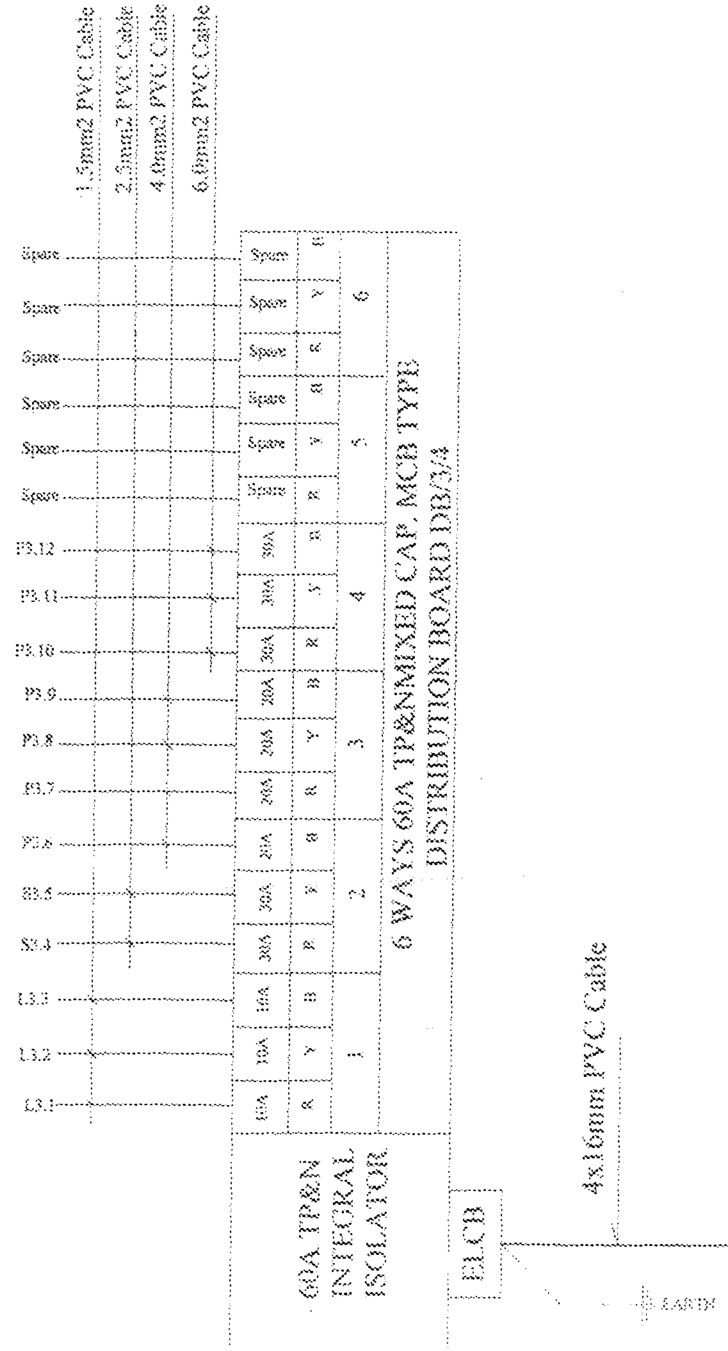
second Floor Plan



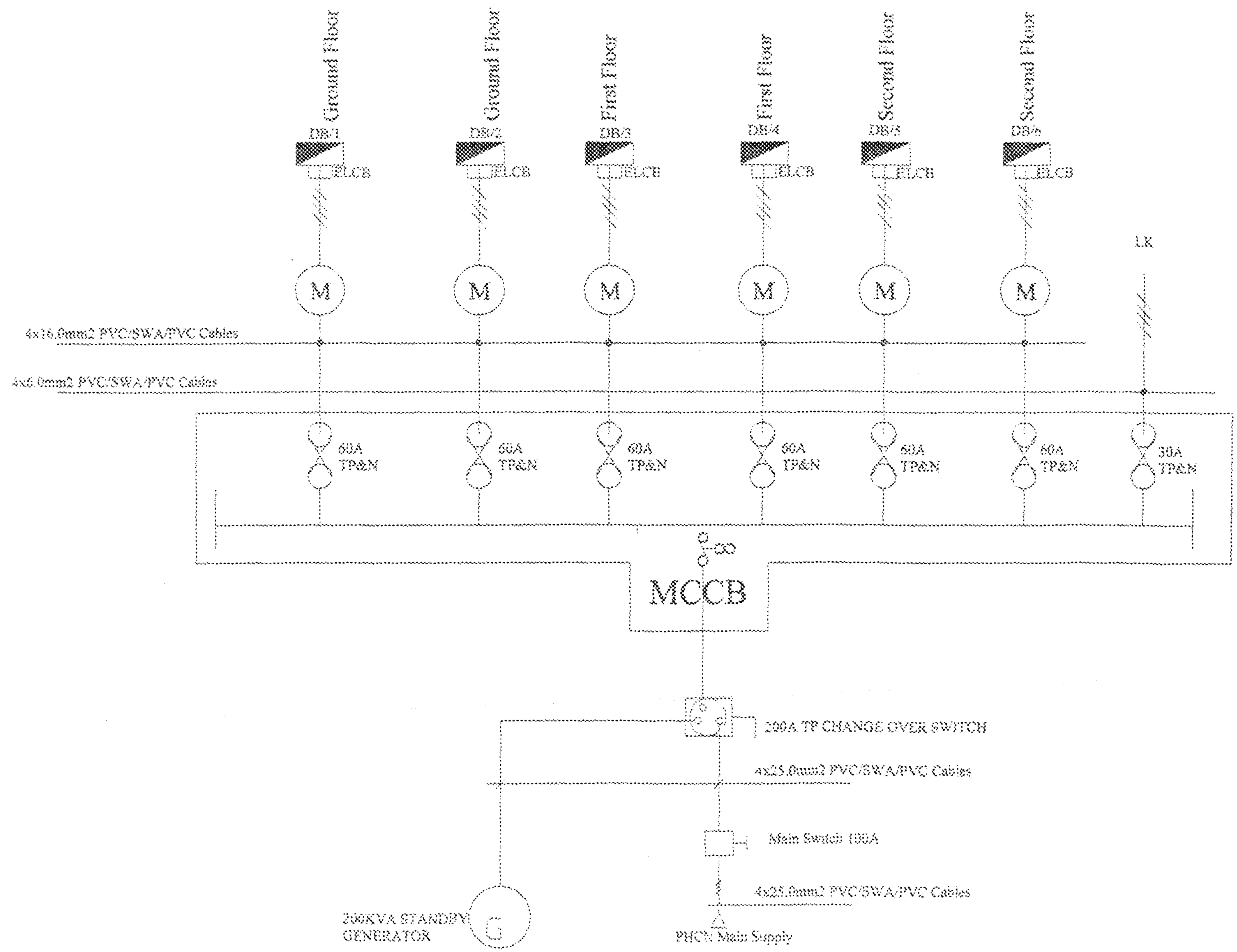
second Floor Plan Electrical Installation

DISTRIBUTION BOARD DB/5/6 CAPACITY/RATING 60A TP&N
LOCATION :-SECOND FLOOR 6 WAYS 60A TP&N

S/NO	DESCRIPTION	NO OF POINT	LOAD WATT	CIRCUIT NO	PHASE R	PHASE Y	PHASE B	MCB RATING	CABLE SIZE
1	Lighting	11	660	L3.1	660			10A	1.5mm
2	Lighting	10	600	L3.2		600		10A	1.5mm
3	Lighting	10	600	L3.3			600	10A	1.5mm
4	Socket	6	1200	S3.4	1200			30A	2.5mm
5	Socket	7	1400	S3.5		1400		30A	2.5mm
6	A/C	1	2000	P3.6			2000	20A	4.0mm
7	A/C	1	2000	P3.7	2000			20A	4.0mm
8	A/C	1	1500	P3.8		2000		20A	4.0mm
9	A/C	1	1500	P3.9			2000	20A	4.0mm
10	BWH	1	3000	P3.10		3000		30A	6.0mm
11	BWH	1	3000	P3.11			3000	30A	6.0mm
12	CCU	1	4500	P3.12	4500			30A	6.0mm
13	Spare	----	----	----	----	----	----	----	----
14	Spare	----	----	----	----	----	----	----	----
15	Spare	----	----	----	----	----	----	----	----
16	Spare	----	----	----	----	----	----	----	----
17	Spare	----	----	----	----	----	----	----	----
18	Spare	----	----	----	----	----	----	----	----
TOTAL LOAD			22960		8360	7000	7600		



SCHEMATIC DB/3/4



GENERAL SCHEMATIC DIAGRAM

LEGEND

SYMBOL	DESCRIPTION
	13A power outlet socket
	15A power outlet socket
	Double 13A power outlet socket
	Cooking control unit (CCU)
	1200 sweep ceiling fan with regulator
	1x125w pole top street lighting philips cat No HPC 133 Mounted on 5m high column
	1200mm flourescent fittings
	1x60w Ceiling mounted incand lighting fittings
	1x60w wall braket incand lighting fan
	1x60w Screwneck lighting
	1x60w Security lighting fitting
	Antenna outlet
	Telephone outlet
	Satellite terminal point
	Twin flourescent fittings
	5A Intermediate switch
	5A One gang one way switch
	5A Two gang one way switch
	5A One gang two way switch
	5A Two gang two way switch
	Three gang one way switch
	Hot Water heater/ control switch
	Distribution board
	2x60w each chandlier lighting fitting