Sudan University of Sciences and Technology

College of Engineering

School of Electrical and Nuclear Engineering

Electrical Installation Calculation Software Using Visual Basic

برنامج حساب التمديدات الكهربائية باستخدام فيجوال بيسيك

A Project Submitted In Partial Fulfillment for the Requirements of the Degree of B.Sc. (Honor) In Electrical Engineering

Prepared By:

1. **Ibrahim Faisal Dafalla Ibrahim.**
2. **Mohamed Adel Mohamed El-Hassan.**
3. **Mohamed Mahmoud Hamid Mohamed.**
4. **Tilal Yahiya Mohamed Ahmed Erwa.**

Supervised By:

Ust. Maha Mohamed Osman.

October 2016

الآيـــــــة

" يَرْفَعِ اللَّهُ ٱلَّذِينَ آمَنُواْ مِنْكُمْ وَ ٱلَّذينَ أُوتُواْ الْعِلْمَ دَرَجَاتٍ

وَ اللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ "

المجادلة (11)

Dedication

To all of our beloved families

Thank for your endless love, sacrifices, prayers, support, and advices.

To our teachers

Those who gave us their knowledge

To our friends

Without whom none of our success would be possible

Acknowledgement

This project would not have been possible to accomplish without the kind support and help of many individuals. We would like to extend our sincere thanks to all of them.

First and foremost we would like to sincerely thank our supervisor **Ust. Maha Mohamed Osman** for her guidance and support throughout this project and especially for her confidence in us.

We express our heartfelt gratefulness for Eng. **Esraa Mohamed** for her assistance and encouragement throughout the startup of the project.

Also we would like to thank **MURTADA MUAZ CONSULT** Company in special way for the assistance and help.

We would like to thank **ALSHARG CABLES FACTORY** in special way for the assistance and help.

Abstract

Estimating power demand (or simply Load Calculation), is a combination of science and art. It's an area of electrical engineering where there is no specific final answer.

There was very little planning of wiring installations and electrical load calculation in the early days of electricity. But now, with supplies from the grid, very large sources of power are introduced into all premises which use electricity, and proper planning and design have become essential to guarantee electrical sustainability for any project.

This project aims to introduce an appropriate method to calculate the electrical loads in a building and design its wiring using computer software, taking into account the IEC Standard of Wiring.

المستخلص

تقدير الاحمال الكهربائية عبارة عن خليط بين العلم و الفن حيث انه يعتبرذلك الجزء من الهندسة الكهربائية الذي لا يحتوي على اجابة نهائية محددة.

في بداية عصر الكهرباء كان يعتبر التخطيط الجيد للتوصيلات الكهربائية امراً ثانوياً،لكن الآن مع توفر الإمدادات عبر الشبكة القومية للكهرباء فقد أصبحت المباني قابلة للتعرض إلى قيم عالية من الكهرباء التي تنقل عبر الشبكة.

لأجل ذلك أصبح التخطيط و التصميم الجيد لكيفية توصيل و توزيع الأحمال الكهربائية للمبنى أمراً مهماً لضمان إستمرارية الطاقة الكهربائة فيه.

يهدف هذا المشروع الى تقديم طريقة علمية لتقدير حسابات الأحمال الكهربائية في المباني مع الأخذ في الإعتبار المقاييس العالمية لتوصيل الأحمال للمباني،وايضاً استخدام برامج الحاسوب المساعدة لتصميم التمديدات الكهربائية فيها .

Table of Contents

List of Figures

List of tables

List of Abbreviations

LV	Low Voltage
MV	Medium Voltage
UPS	Uninterruptable Power Supply
CB	Circuit Breaker
KW	Kilo Watt
KVA	Kilo Volt Ampere
HRC	High rupturing capacity
Ku	Utilization Factor
Ks	Factor of Simultaneity
AC	Air Conditioning
ATS	Automatic Transfer Switch
DB	Distribution Board
SMDB	Sub-Main Distributed board

List of Symbols

Ia	Full-Load Current, Ampere
S	Apparent-Power demand,kVA
V	Phase-to-phase voltages,volt
cos Ø	Power factor
I	Design current, Ampere

CHAPTER ONE

INTRODUCTION

1.1 Overview

Like fire, electricity is a very good servant, but if not properly controlled and used it can prove to be a very dangerous master. The need for planned methods of wiring and installation works has long been recognized, and all kinds of regulations, requirements, recommendations, and codes of practice and so on have been issued. Some are mandatory and can be enforced by law, whilst others are merely recommendations.

There was very little planning of wiring installations in the early days of electricity, but now, with supplies from the grid, very large sources of power are introduced into all premises which use electricity, and proper planning and design have become essential.

In fact, electrical load estimation is very important in the draft design (early stage of the project); because it helps the "Head Engineer" in the arrangements for connecting the project to the upstream network (National Grid) and choosing the best transformer and main switchgear room for this mission. In addition to that, it helps in calculating the initial budget for the electrical works.

1.2 Problem Statement

The main problem that deriving us to do this project, the waste of time in calculation and wrong choosing the proper sizes of an electrical installation components.

1.3 Objectives

By using IEC standards the electrical load calculation is done to achieve these objectives:

- To choose the right size of cables, CBs, transformer, and standby generator to be installed.
- To minimize the power loss in the distribution system, and reduce the maintenance of the equipment.
- To get more accurate results by using of software program.

1.4 Methodology

In this project both software designed especially to electrical load calculation and practical method are used to obtain good and safety results.

1.5 Project Layout

This project is organized as follows:

- Chapter two (Literature review):

This chapter presents an overview of electrical installations as general.

- Chapter three (Methodology of electrical load calculation):

This chapter shows the methods and equations used for load calculation, cables and CBs sizing, and transformer and standby generator selection.

- Chapter four (Case study):

This chapter presents and discusses the results obtained from the calculation, and shows the best selection for the Cables, CBs, and the Transformer from both manual calculations and obtained results from software.

- Chapter five (Conclusions and recommendations):

The project is reviewed in this chapter, discussing the achieved objectives. In addition to the further developments that can improve the final result to a professional level.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

A project naturally progresses from design to the actual building going through stages. Figure 2.1 below illustrate project steps.

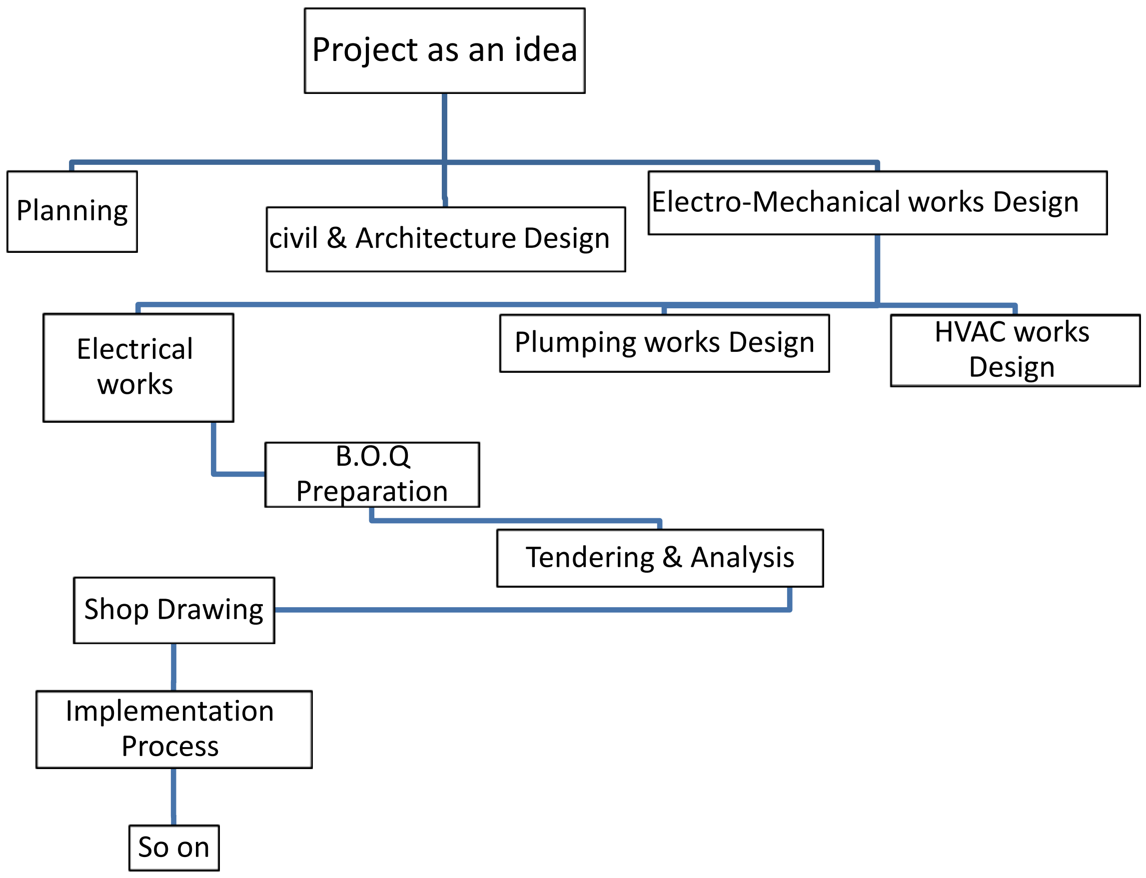


Figure 2.1: Project steps

The electrical design is the first step of any electrical project this step has two major concerns besides the basic knowledge of electrical engineering which are basic knowledge of Electrical Safety and Economical Design.

Whatever type of electrical equipment is installed, it has to be connected by means of cables and other types of conductors, and controlled by suitable switchgear. This is the work which is undertaken by the installation engineer, and no equipment, however simple or elaborate, can be used with safety unless this installation work has been carried out correctly.

2.2 Wiring Method

Materials for wiring interior electrical systems in buildings vary depending on:

- Intended use and amount of power demand on the circuit.
- Type of occupancy and size of the building.
- National and local regulations.
- Environment in which the wiring must operate.

Wiring systems in a single family home or duplex, for example, are simple, with relatively low power requirements, infrequent changes to the building structure and layout, usually with dry, moderate temperature and non-corrosive environmental conditions. In a light commercial environment, more frequent wiring changes can be expected, large apparatus may be installed and special conditions of heat or moisture may apply.

Low-voltage installations are governed by a number of regulatory and advisory texts, which may be classified as follows:

- Statutory regulations (decrees, factory acts, etc.).
- Codes of practice, regulations issued by professional institutions, job specifications.
- National and international standards for installations.
- National and international standards for products.

2.3 Electrical Wiring Standards

The architect uses symbols and notations to simplify the drawing and presentation of information concerning electrical devices, appliances, and equipment.

Most symbols have a standard interpretation throughout the country as adopted by ANSI electrical codes.

2.3.1 National electrical code (NEC)

The NEC is the electrical Code standard recognized by everyone in the Electrical industry. The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity.

The NEC is published by the National Fire Protection Association and is referred to as NFPA 70. The NEC was first published in 1897. It is revised every 3 years so as to be as up to date as possible. The NEC does not become law until adopted by official action of the legislative body of a city, municipality, county, or state. Because of the ever-present danger of fire or shock hazard through some failure of the electrical system, the electrician and the electrical contractor must use listed materials and must perform all work in accordance with recognized standards.

2.3.2 International electro-technical commission (IEC Standard)

The leading organization (founded in 1906) for the preparation and publication of International Standards for all electrical, electronic and related technology. Has been established by engineering experts of all countries in the world comparing their experience at an international level. Currently the safety principals of IEC 60364 series, IEC 61140, 60479 series, and IEC 61201 Are the fundamental of most electrical standard in the world.

2.3.3 British standard (BS 7671)

BS7671 (the IET Wiring Regulations) sets the standards for electrical installation in the UK and many other countries. The IET co-publishes the Regulations with the British Standards Institution (BSI) and is the authority on electrical installation.

The IET plays a key role in electrical installation standards and safety, and is known for its independent and trusted voice. It manages the national committee JPEL/64 and publishes the IET Wiring Regulations BS 7671 [1].

2.3.4 Local codes

In addition to these codes, local and state electrical codes must also be considered.

2.4 Electrical Wiring Basic Equipment

Generally the power distribution system consists of four groups:

- **Low voltage distribution network**

In cities and large towns, standardized LV distribution cables form a network through link boxes; it is usually (11kv).

Low voltage cables are used to transmit voltage from substations and distribute it to houses in cities.

- **Transformer**

The purpose of a Transformer is to convert, i.e. transform electrical energy from one voltage to a higher or lower voltage with a corresponding decrease or increase in current respectively. Transformers are used in many applications from small domestic products to electrical transition distribution systems.

It is not intention of this document to cover all possible application for transformer, rather those that are likely to be encountered by the building services, therefore this section will concentrate on power transformer that are installed to convert a supply voltage of 11 kV received from the grid to low voltage, or to convert one low voltage to another. The capacity of a power transformer is defined by the Full Load Power in kVA, at which the transformer is expected to operate making due allowance for future load expansion.

Nearly all power transformers encounter in building power systems are three-phase units. These normally have the primary winding connected as a delta arrangement, and the secondary windings connected in a star configuration to bring out the Neutral connection.

The size of the transformer is determined by its “Rating”, which is the product of the voltage and current that a particular unit can handle. This rating is given as kVA. And in order to assist in selection and sizing of power distribution transformers, manufacturer and international standards have adopted a table of standardized transformer rating. The typical size of power transformers found in buildings has primary and secondary currents as defined in table 2.1

Table 2.1: Transformers rating kVA

Rating /KVA	HV current /A	LV current /A	Impedance / %
200	9	240	4.75
315	17	455	4.75
500	27	722	4.75
630	34	909	4.75
800	43	1155	4.75
1000	54	1443	4.75
1250	67	1804	5.00
1600	86	2309	5.50
2000	108	2887	6.00
2500	135	3609	6.00
3150	170	4547	6.00
3500	189	5051	6.00
Note :transformer ratio 11000 V/416 V: 50 Hz, three phase			

- **Emergency generator**

It used to provide electrical energy for the emergency loads or important load at building, the loads can be transferred to transformer by mutual transfer switch (ATS) or manual. (MTS) is often installed where a backup generator (emergency generator) is located, so that the generator may provide temporary electrical power if the utility source fails.

In case of critical load such as the devices in hospital, the un-interrupted power supply (UPS) is used, which guarantee the continuity of electrical current.

- **Electrical distribution panels**

Is a component of an electricity supply system which divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit breaker for each circuit in a common enclosure. Normally, a main switch, and in recent boards, one or more residual-current devices (RCD) or residual current breakers with overcurrent protection (RCBO), are also incorporated.

For reasons of aesthetics and security, circuit breaker panels are often placed in out-of-the-way closets, attics, garages, or basements, but sometimes they are also featured as part of the aesthetic elements of a building (as an art installation, for example) or where they can be easily accessed.

There are many types of distribution panels, such as open frame construction, construction panels, cubicle construction, withdraw able unite, and box type construction.

2.5 Wires and Cables

The safety element is the most important element inside buildings. All conductors are put inside conduits; these conduits may be external or underground.

The most important points that must be taking into account are:

- Make sure that the number of conductors inside the conduit doesn’t exceed the maximum number of conductors according to conductor section and conduit diameter.
- Applying distance rules between conduit binding points.

Inside buildings another way of layout is used, called raceways or trunking made from plastic or metal. Some types of raceways are underground especially in offices and the others are built on walls.

The method using for cable layout depends on the nature of the project; in industrial projects it’s preferable to use cable trays for better heat dissipation and faults can easily be detected.

There are many ways for cables layout in an electrical project:

- Using conduits.
- Using cable trays.
- Buried under ground.

2.5.1 Cable structure

Consists of three major components: conductors, insulation, and protective jacket, the makeup of individual cables varies according to application.

Cables for direct burial or for exposed installations may also include metal armor in the form of wires spiraled around the cable.

Power cables use standard copper or aluminum conductors. Also small power cables may use solid conductors.

2.5.2 Cable classification

There are so many kinds of cables according to:

- The rated voltage :
  - High voltage cables (more than 66Kv)
  - Middle voltage cables (more than 3.3kv)
  - Low voltage cables.
- Type of conductor:
  - Copper cables.
  - Aluminum cables.
- Type of insulation:
  - Polyvinyl Chloride (PVC) cables.
  - Cross-linked polyethylene (XLPE) cables.
  - Ethylene Propylene (EPR) cables.
- Core structure:
  - Armoured.

- Non-Armoured.
- Number of cores:
  - Single core.
  - Multi-cores.

2.5.3 Current carrying capacity of cables

The current carrying capacity of any cable depends on the cable layout method that determines the heat exchange efficiency between the cable and air.

2.5.4 Cables problems

- Power losses (losses in conductor resistance, insulation loss, metallic sheath loss).
- Leakage current or charging current.
- Change in cable resistance due to skin effect and eddy currents.
- Change in cable resistance due to heat.
- Cables are affected by moisture [2].

2.6 Electrical Protection Devices

The safety of equipment and personals are required, because that protection devices are installed in the circuit.

2.6.1 Circuit breakers

Circuit breaker is:

- A switching device.
- Capable of making, carrying and breaking normal or fault currents.
- Must offer short circuit current.

Circuit breaker types:

- MCB (miniature circuit breaker).
- MCCB (molded case circuit breaker).
- MPCB (motor protection circuit breaker).
- ACB (air circuit breaker)

Specifications:

- Rated operational voltage.
- Nominal rated current.
- Rated ultimate S/C breaking capacity (circuit breaker can break two faults of claimed value and can make one fault of the claimed value).
- Rated service S/C making capacity (circuit breaker can break three faults of claimed value and can make two fault of the claimed value.
- Rated short time withstands current.
- Utilization category.

2.6.2 Fuses

A fuse is a type of over-current protective device.

Fuse types:

- Low voltage fuses.
- High voltage fuses.

Low voltage fuses can be further divided into two classes:

1-Semi-enclosed or rewire able, it is the most commonly used fuse in house wiring.

2-Totally enclosed or cartridge type. The fuse element is enclosed in a totally enclosed container and is provided with metal contacts on both sides. These fuses are further classified as:

- D-type.
- Link type cartridge or high rupturing capacity (HRC).

2.7 Methods of Electrical Load Calculations:

There are various methods for calculations

2.7.1 Preliminary method

Preliminary methods are the methods of electrical load estimation and they divided to:

- Space by space "Functional area method".
- Building area method

2.7.2 "NEC" Load calculation

The NEC provides two dwelling service load calculation methods:

- Standard method : where the loads are divided to :-
  - General Lighting & Receptacle.
  - Small Appliance.
  - Branch Circuit(s).
- Optional method : and here the load are divided to:-
  - General Load.
  - Heating & Air-Conditioning Load.
  - Feeder/Service Conductors.

2.7.3 Final load calculation

This method depending on where your project is located; because different figures and procedures are used to estimate the power demand of an installation. This method sometimes refers to it as IEC Method (International Electro technical Commission).

2.7.4 General notes for the all methods

Here are some general notes for all electrical load calculation methods:

- Method Combination: A particular design may use one Preliminary load estimate method or a combination from two or even three methods, and that depends on the Engineer who is responsible for the design to gain the best possible results.
- System Loss: A system loss of approximately 4% to 6%, based on calculated maximum demand, should be added to the preliminary building load.
- Load Growth: Determining the requirements for load growth for

anticipated usage and life expectancy, with particular attention to the possibility of adding heavy loads in the form of Air-Conditioning ,electric heating, electric data processing and electronic communication equipment. No more than 10 % spare capacity should be considers during the design, unless it is noted that the building will have serious growth in the future, and in that case we should rise the margin of the spare capacity to 15-20% and that depends on the designer and his sight to the project.

2.8 Designs by Computer

The designer can expect to find a number of benefits from using computers for installation design:

- The speed at which calculation is carried out will clearly be much faster than with manual methods even with use of a calculator in the hands of an experienced designer; manual methods can take up to 20 minutes per circuit for all aspects to be properly assessed. The computer will be able to do the work in a fraction of the time.

- Nearly all the work of looking at tables can be eliminated. The key facts about cable ratings, volt drops, the fuse and earth fault loop impedance data, and even the manufacturers' characteristics on devices and equipment, can all be stored in the memory of the computer. Many electrical manufacturers are able to supply product data in computer format for the popular software packages, the disk contents being fed straight into the computer.

- Repetition of calculations can easily be carried out. In settling the question of the best location of a distribution board, or whether it would be more economical to avoid grouping by fixing cables separately, it is possible to quickly recalculate to decide the optimum condition. With manual methods, the work would be considerable and it is probable that only one set of calculations would be made.

- Potentially the computer method will be more accurate. This is of course fundamentally dependent upon the quality of the software, but provided this is satisfactory, the risk of human error, present in the manual methods, is avoided. Again speed of calculation is of advantage, as the simplified formulae sometimes used in manual methods can be avoided. The computer will be able to use the most appropriate and accurate method of calculation for every single circuit.

- Design data for the installation can be produced by computer print-out with little extra effort. The manually produced design data sheet which may take some time to prepare without computers is one of the tasks that can be done more quickly [3].

CHAPTER THREE

METHODOLOGY OF ELECRICAL LOAD CALCULATION

3.1 Introduction

Whatever type of electrical equipment is installed, it has to be connected by means of cables and other types of conductors, and controlled by suitable switchgear. This is the work which is undertaken by the installation engineer, and no equipment, however simple or elaborate, can be used with safety unless this installation work has been carried out correctly.

For these entire significant characteristic that can be gain from a good estimation, a lot of methods developed in order to make sure that the calculation is most accurate as possible.

This chapter will illustrate the information of estimation and how it used to estimate the total load and design the electrical wiring for. Figure 3.1 illustrates the steps of the wiring design.

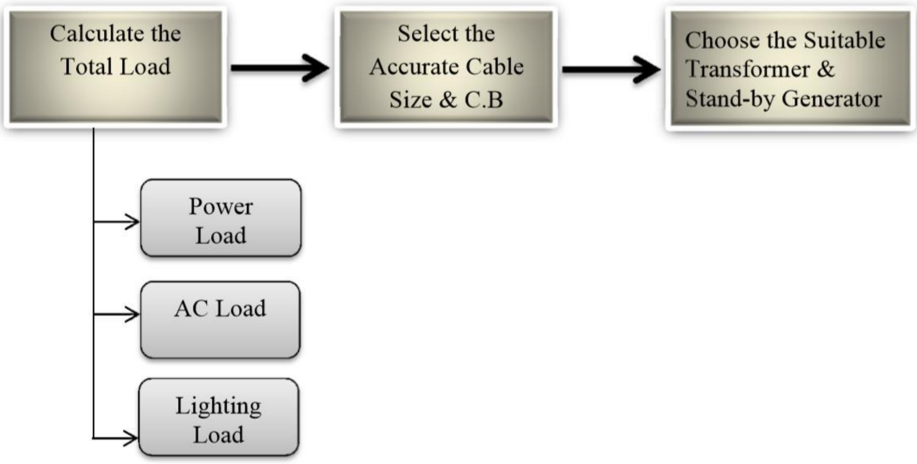


Figure 3.1: wiring design steps

3.2 Power Loading of an Installation

In order to design an installation, the actual maximum load demand likely to be imposed on the power-supply system must be assessed. To base the design simply on the arithmetic sum of all the loads existing in the installation would be extravagantly uneconomical, and bad engineering practice. So, we should take into account some factors in order to improve our calculation at section

3.3 (Factors for Estimating Actual Maximum kVA/kW Demand) and after that all existing and projected loads can be assessed.

In addition to providing basic installation-design data on individual circuits, the results will provide a global value for the installation, from which the requirements of a supply system (distribution network, MV/LV transformer, or generating set) can be specified.

3.2.1 Installed power (kW)

Most electrical appliances and equipment are marked to indicate their nominal power rating (Pn).

The installed power is the sum of the nominal powers of all power-consuming devices in the installation. This is not the power to be actually supplied in practice. This is the case for electric motors, where the power rating refers to the output power at its driving shaft. The input power consumption will evidently be greater Fluorescent and discharge lamps associated with stabilizing ballasts, are other cases in which the nominal power indicated on the lamp is less than the power consumed by the lamp and its ballast. The power demand (kW) is necessary to choose the rated power of a generating set or battery, and where the requirements of a prime mover have to be considered. For a power supply from a LV public supply network, or through a MV/LV transformer, the significant quantity is the apparent power in kVA.

3.2.2 Installed apparent power (kVA)

The installed apparent power is commonly assumed to be the arithmetical sum of the kVA of individual loads. The maximum estimated kVA to be supplied however is not equal to the total installed kVA.

The apparent-power demand of a load (which might be a single appliance) is obtained from its nominal power rating, and the application of the (cos (φ) = the power factor = kW / kVA) the apparent-power kVA demand of the load (S) is Power in from this value, the full-load current Ia (A) taken by the load will be:

$$Ia = \frac{Pa \times 1000}{\sqrt{3} \times V} \tag{3.1}$$

Where:

Ia= the full-load current

Pa = the apparent-power kVA demand of the load

V = phase-to-phase voltage (volts) = 415 V

It may be noted that, strictly speaking, the total kVA of apparent power is not the arithmetical sum of the calculated kVA ratings of individual loads (unless all loads are at the same power factor). It is common practice however, to make a simple arithmetical summation, the result of which will give a kVA value that exceeds the true value by an acceptable "design margin" [4].

3.3 Factors For Estimating Actual Maximum kVA/kW Demand

All individual loads are not necessarily operating at full rated nominal power nor necessarily working at the same time. For that reason we introduce some factors to help us in the calculation so we can get the most proper results when determining the actual power demand [4].

3.3.1 Factor of maximum utilization (Ku)

In normal operating condition the power consumption of a load is sometimes less than that indicated as its nominal power rating, and this is a fairly common occurrence that justifies the application of a Utilization Factor (Ku) in the estimation of realistic values.

This factor must be applied to each individual load, and have some standards values:

For motors = 0.75 or 0.8

For Incandescent-Lighting and Heat Loads = 1

For Socket-Outlet Circuits: it depends entirely on the type of the type of appliances being supplied from the socket (in the most application usually this value is equals to 1).

3.3.2 Factor of Simultaneity (Ks)

This factor must be applied to each group of loads, and changes depending on the number of loads in the group .The determination of this factor is the responsibility of the designer so he can choose the right factor for the right group of loads. It requires a detailed knowledge of the installation and the conditions in which the individual circuit are to be exploited.

- **Ks according to circuit function**

Here the factor refers to how often the circuit is being operating, as an example, if I have 5 sockets in an office there will not be all operating at the same time " mostly", so their Ks is going to be too small. However, the all the Lighting is operating at same time, so the Ks will be bigger than the socket. Again, this depends on the designer and how he sees the situation (especially in industrial installation, where the values become higher than the usual), so he can choose the most suitable Ks. And here are the (Ks) values in Table 3.1.

Table 3.1: Ks according to circuit function

Circuit Function		Ks
Lighting		1
Heating and air conditioning		1
Socket-outlets		0.1 to 0.2
Lefts and motors	For the most powerful motor	1
	For the 2nd most powerful motor	0.75
	For all rest motors	0.60

3.4 Load Assessment

Most of the equipment at any installation has its nominal power at kW, and it’s easy to convert this into kVA using:

$$\boldsymbol{Power\ in\ KVA = \frac{power\ in\ Kw}{cos\emptyset}} \tag{3.2}$$

3.4.1 **Lighting load**

The lighting load is given in kW, so it must be multiplied by the quantity to get the total power in kW for a specific type of light, from which the power in kVA can be calculated using equation 3.2, and by taking the Power Factor (CosØ)=0.8[2].

- Incident lamps or spots P = 20≈ 200 watts

-For florescent lamps 2 × 36 watt 4 × 18 watt 2 × 55 watt

- For chandeliers P= 150≈500 watt.

3.4.2 Sockets load

The sockets load is given by its rated current, so we most convert that into power in kW and then into power in kVA, which equals 250 VA for power sockets. Definitely it's so difficult to know type of load connected to sockets .So 250 kVA is just estimation to simplified calculations.

3.4.3 Air-Conditioning (AC) Load Assessment

Air-conditioning is one of the building mechanical services that include plumbing, fire protection, and escalators. Air-conditioning refers to any form of cooling, heating, ventilation or disinfection that modifies condition of air.

3.5 Cable Sizing

Power cables are used to feed circuits with the required power. So, cables selection must be according to transfer a full power to certain load, that mean the cables must transfer the full current with no or limited voltage drop to ensure full power transfer. In order to determine a correct individual cable size it is important to obtain or calculate an accurate circuit design current. This may not be critical for short or lightly loaded circuits, but becomes critical when sizing heavily loaded circuits with long cable runs of, say, over 75 m. At longer circuit lengths, voltage drop requirements can lead to cable sizes significantly larger than the base size. In order to minimize this in calculations, an accurate design current "I" can be calculated in order to ensure a good design.

The basic formula to obtain a design current is as follows:

$$I = \frac{Power\ (Kw)\times 1000}{\sqrt{3}\times V\times cos\emptyset} \tag{3.3}$$

Where:

I= design current

V= Line Voltage

And by taking the V= 400 volts (Line voltage), and from Equation 3.3 this equation can be written as flows:

$$\mathrm{I} = \mathrm{Power\ (kVA)}\ \times 1.4 \tag{3.4}$$

I= design current

3.6 Circuit Breakers Selection

The distribution board selection is done according to the current of the load that has been found .Circuit breakers sizes available in the market are:

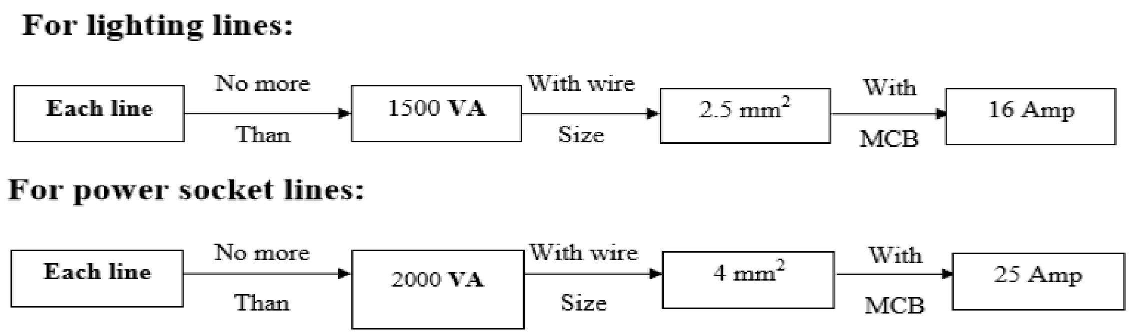
10 – 16 – 20 – 25 – 32 – 40 – 50 – 60 – 63 – 75 – 80 – 100 – 125 – 160 – 200 – 250 – 320 – 400 – 500 – 630 – 800 – 1000 – 1250 – 1600 – 2000 – 2500 – 3200 – 4000 – 5000 – 6300 Amp., from which the appropriate one is chosen.

3.7 Transformer and Standby Generator Selection

The transformer and standby generator are selected according to the total load in kVA using transformer and generator catalogs.

3.8 Electric Lines Calculations

After distributing lighting fixtures and sockets, it must be fed from a main panel board. Each group of lighting fixtures or group of sockets has one line to the main panel board .Figure 3.2 illustrate electric lines [5].



For air conditioners:

Each unit takes a separate line:

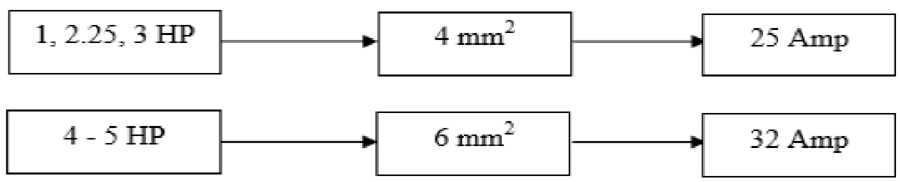


Figure 3.2: Electric lines

3.9 Load Balancing

Given that the network is featuring a star connection as shown in figure 3.3. It's important to achieve I1 ≈ I2 ≈ I3 to reach neutral current (In) of nearly equal zero.

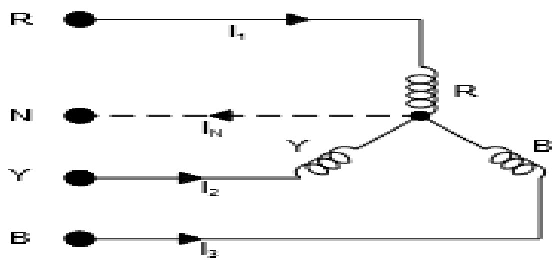


Figure 3.3: Star connected network

- **Balance Check**

For any panel board, there is a balance check for three phase loads due to reducing neutral current and unbalanced stresses on circuit breakers.

Unbalance ratio can be calculated by:

$$\text{Unbalance ratio}(\%) = \frac{\text{largest phase load} - \text{smallest phase load}}{\text{largest phase load}} \times 100 \quad (3.5)$$

3.10 Wiring Design Using Software Program

With this tool electrical networks can be dimensioned automatically with a minimum of manual entries.

It is used for equipment selection and sizing, which saves the time-consuming research in catalogues.

The Architecture informations are given to the software as input. The software then selects all the cables and distribution boards sizes, it also selects the transformer, standby generator, the main circuit breaker and cable.

CHAPTER FOUR

CASE STUDY

4.1 Introduction

In this chapter the constitutional a building has been taken as a case study.

The layout drawings of the building which contain all electrical equipment information have been used as initial data to calculate electrical load.

In addition to the manual load estimation a software program designed especially by VISUAL STUDIO 2008, was used for the selection of the distribution boards, cables, CBs and transformer.

4.2 Load Description

In load description only type of load and its quantity mentioned

4.2.1 Lighting load

From electrical layout drawings of the building the lighting load description has been obtained as illustrated in table 4.1, which gives the type of load and its total quantity in each floor.

Table 4.1: lighting load description

	Quantity				
Type of load	**Ground Floor**	**1st Floor**	**2nd Floor**	**3rd Floor**	**4th Floor**
240V,interior Incident lamps	54	54	54	54	54
Chandelier	2	2	2	2	2

4.2.2 Sockets load

Table 4.2 shows the sockets quantity in each floor.

Table 4.2: sockets load description

	Quantity				
Type of load	**Ground Floor**	**1st Floor**	**2nd Floor**	**3rd Floor**	**4th Floor**
Sockets	40	40	40	40	40
Microwave	2	2	2	2	2
Suction Fan	6	6	6	6	6
Heater	4	4	4	4	4

4.2.3 AC Load

Table 4.3 shows the cooling capacity of AC load in each floor which is calculated from electrical layout drawings of the building.

Table 4.3: AC load description

Floor	Cooling capacity(kW)
Ground floor	12
1st floor	12
2nd floor	12
3rd Floor	12
4th Floor	12

4.3 Load calculation

In load calculation, type of load, its quantity, its VA and its factor of Simultaneity mentioned and total demand KVA are calculated.

A) Ground Floor

Using the manual load calculation methods and the load description tables the full load for the ground has been calculated as shown in table 4.4.

Table 4.4: Ground floor load calculation

Type of load	Quantity	Power in VA	Total Full Load (KVA)	Ks	Demand Full load(KVA)
240V,interior Incident lamps	54	25	1.35	1	1.35
Chandelier	2	187.5	0.375	1	0.375
Sockets	40	250	10.0	0.2	2.0
Microwave	2	3125	6.25	1	6.25
Suction Fan	6	187.5	1.125	1	1.125
Heater	4	1875	7.5	1	7.5
Fans	14	125	1.75	1	1.75
TOTAL			28.35		20.35

B) First Floor:

Using the manual load calculation methods and the load description tables the full load for the first floor has been calculated as shown in table 4.5.

Table 4.5: first floor load calculation

Type of load	Quantity	Power in VA	Total Full Load (KVA)	Ks	Demand Full load(KVA)
240V,interior Incident lamps	54	25	1.35	1	1.35

Continue Table 4.5: first floor load calculation

Chandelier	2	187.5	0.375	1	0.375
Sockets	40	250	10.0	0.2	2.0
Microwave	2	3125	6.25	1	6.25
Suction Fan	6	187.5	1.125	1	1.125
Heater	4	1875	7.5	1	7.5
Fans	14	125	1.75	1	2
TOTAL			28.35		20.35

C) Second Floor

Using the manual load calculation methods and the load description tables the full load for the second floor has been calculated as shown in table 4.6.

Table 4.6: Second floor load calculation

Type of load	Quantity	Power in VA	Total Full Load (KVA)	Ks	Demand Full load(KVA)
240V,interior Incident lamps	54	25	1.35	1	1.35
Chandelier	2	187.5	0.375	1	0.375
Sockets	40	250	10.0	0.2	2.0
Microwave	2	3125	6.25	1	6.25
Suction Fan	6	187.5	1.125	1	1.125
Heater	4	1875	7.5	1	7.5
Fans	14	125	1.75	1	2
TOTAL			28.35		20.35

D) Third Floor

Using the manual load calculation methods and the load description tables the full load for the third floor has been calculated as shown in table 4.7.

Table 4.7: Third floor load calculation

Type of load	Quantity	Power in VA	Total Full Load (KVA)	Ks	Demand Full load(KVA)
240V,interior Incident lamps	54	25	1.35	1	1.35
Chandelier	2	187.5	0.375	1	0.375
Sockets	40	250	10.0	0.2	2.0
Microwave	2	3125	6.25	1	6.25
Suction Fan	6	187.5	1.125	1	1.125
Heater	4	1875	7.5	1	7.5
Fans	14	125	1.75	1	1.75
TOTAL			28.35		20.35

E) Fourth Floor

Using the manual load calculation methods and the load description tables the full load for the third floor has been calculated as shown in table 4.8.

Table 4.8: Fourth floor load calculation

Type of load	Quantity	Power in VA	Total Full Load (KVA)	Ks	Demand Full load(KVA)
240V,interior Incident lamps	54	25	1.35	1	1.35

Continue Table 4.8: Fourth floor load calculation

Chandelier	2	187.5	0.375	1	0.375
Sockets	40	250	10.0	0.2	2.0
Microwave	2	3125	6.25	1	6.25
Suction Fan	6	187.5	1.125	1	1.125
Heater	4	1875	7.5	1	7.5
Fans	14	125	1.75	1	1.75
TOTAL			28.35		20.35

F) AC load

The total AC load for all floors has been calculated as shown in table 4.9, using the manual load calculation methods and the load description table for ac load.

Table 4.9: AC load calculation

Floor	Cooling capacity(kW)	Power in KVA
Ground floor	12	15
1^{st} floor	12	15
2^{nd} floor	12	15
3^{rd} floor	12	15
4^{th} floor	12	15
TOTAL		75

G) Elevators

There is one elevator in the building of 16 kVA

Elevator load = 1*16 = 16 kVA

H) Water Pump:

There is one water pump in building of 1.875 kVA added to ground.

4.4 Selection of Cables and Distribution Boards

Table 4.10 below shows the selected cables and distribution-boards for the load of Lights and sockets per floor, and air conditioning.

The AC is added to its floor.

Table 4.10: Selection of cables and distribution boards

Distribution board	Power In KVA	Design current I	SMDB (Amp)	Cable size(mm^2)
Ground	37.225	52.115	80	25
1st floor	35.35	49.49	63	16
2nd floor	35.35	49.49	63	16
3rd floor	35.35	49.49	63	16
4th floor	35.35	49.49	63	16
Elevator	16	22.4	32	6
MDB	194.625	272.473	400	120

4.5 Transformer and Standby Generator Selection

According to the total load obtained for the building, the most suitable transformer rated that could be used is 200 kVA, according to Table 2.1. Also, the most suitable Stand-by generator that we could use is 200 kVA.

Figure 4.1 shows the final manual design results for the building, including the Cable sizes, DB rated current, Transformer Size and the Stand-by Generator.

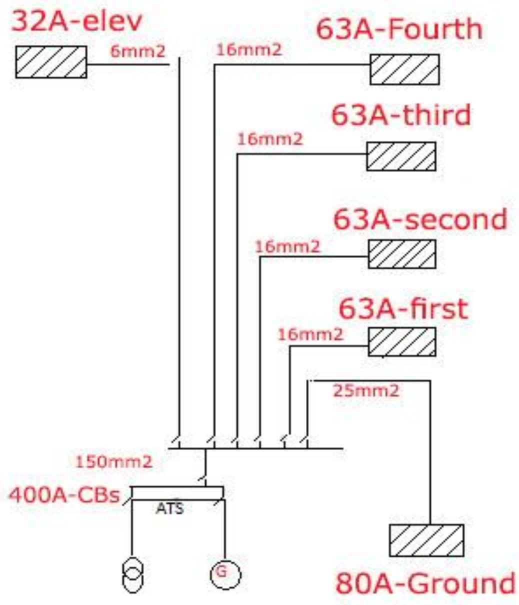
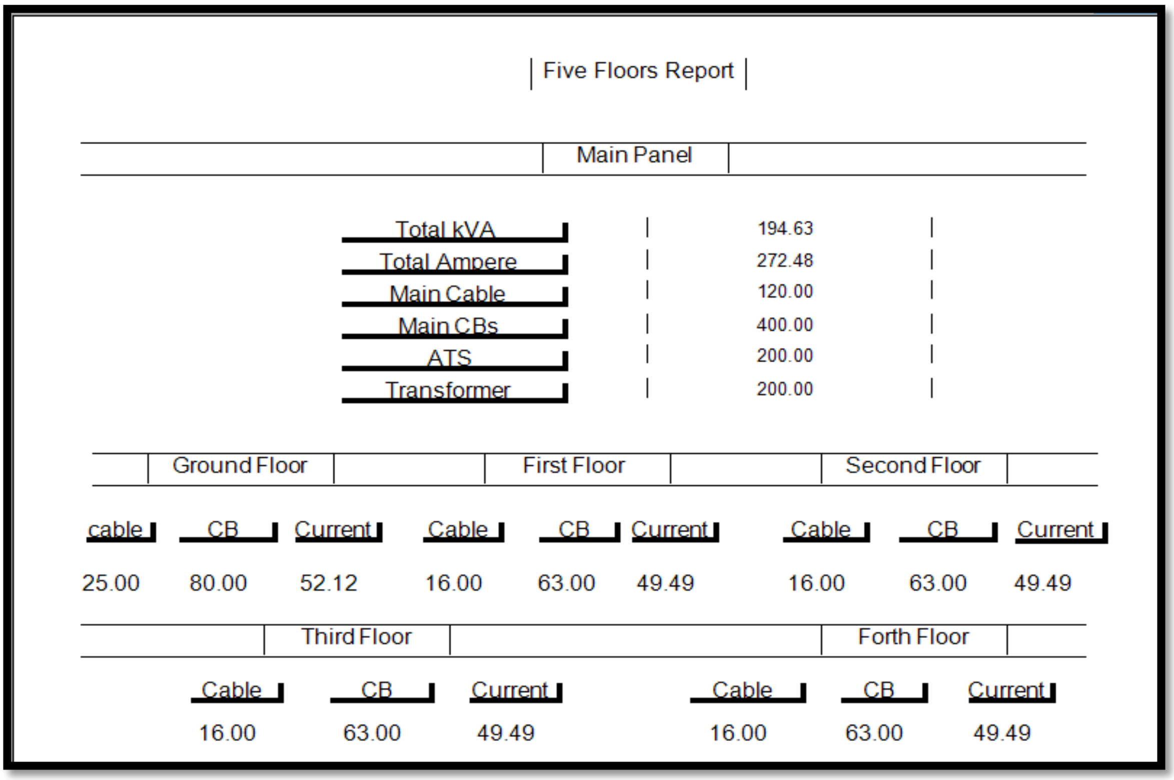


Figure 4.1: power distribution diagram

4.6 Software Results

The power distribution details obtained from the program is shown in Fig 4.2, which illustrates cables sizes, distribution boards, and transformer rating kVA.



Five Floors Report

Main Panel

Total kVA	194.63
Total Ampere	272.48
Main Cable	120.00
Main CBs	400.00
ATS	200.00
Transformer	200.00

Ground Floor			First Floor			Second Floor		
cable	CB	Current	Cable	CB	Current	Cable	CB	Current
25.00	80.00	52.12	16.00	63.00	49.49	16.00	63.00	49.49

Third Floor			Forth Floor		
Cable	CB	Current	Cable	CB	Current
16.00	63.00	49.49	16.00	63.00	49.49

Figure 4.2: Power distribution details obtained from the program

4.7 Discussion

The lighting loads were calculated straight ahead, since the original data came with loads in kW, which is only needed to be converted into kVA using equation 3.2.

One of the problems that faces us is the estimating of the kVA power for the sockets because they have been given in their rated current. Starting with the load of the power socket 13 Amps, it was obviously to us that this value of Amps may never occurred, so, we alter this value by taking a percentage of it. When we check the market and the well-known value that proudly used in the calculation was 250VA. So we take this value into our calculation and from it we obtained the corresponding electrical load.

We did not have sufficient information about the elevator, so we assumed a standard elevator of 16 kVA to be in our study.

In General, the calculated results of the total Loads was done using the appropriate equations and standards. These values were used to calculate the corresponding CB, and Cable Sizes.

When it comes to Selection of Cables, the most appropriate cables are the Copper. We used the copper conductor as our choosing cable type because it is cheaper than the Aluminum and it can sustain more than it.

The problem was how to choose the right method. For our building the appropriate method for the inner cables is Laid in Conductor And the main cable is in free air and can carry high current due to high heat dissipation.

There are a lot of coefficients were introduced in chapter three that we did not take it into account in our calculation, instead we toke the full rated current for the full load, in order to simplify our calculation and also make sure of the safety factor, since the actual load may never reach to the full load, hence the building will always be in safe and sustain state.

We multiply the design current by 1.25 to choose the CBs .and multiply the answer by 1.2 to choose the cables sizing. So we choose the cable size with such a caution, because in occurrence of damage, it is easy to replace a CB, while it’s so difficult to replace a cable.

For the software part the results were almost identical to our manual calculations except for a few cables and circuit breakers size as shown in the table 4.11.

Table 4.11: software results versus manual calculation results

	software results		manual calculation results	
Distribution board	**SMDB (Amp)**	**Cable size(mm^2)**	**SMDB (Amp)**	**Cable size(mm^2)**
Ground	**80**	**25**	**80**	**25**
1st floor	**63**	**16**	**63**	**16**
2nd floor	**63**	**16**	**63**	**16**
3rd floor	**63**	**16**	**63**	**16**
4th floor	**63**	**16**	**63**	**16**
Elevator	**32**	**6**	**32**	**6**
MDB	**400**	**120**	**400**	**120**

Most of these calculations depend on the engineering sense of the engineer, because there are a lot of factors and standards that the engineer must achieve, but only a good engineer can have these standers and factors, but yet, using it in a compatible way with his surrounding environ.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In this project all methods and equations needs for an appropriate good electrical load calculation were covered.

The total electrical load of the case study been successfully calculated and a satisfying results have been obtained, the total electrical load was **195.625** kVA. The right sizes of cables and CBs have been successfully selected. Hence a transformer of 200 kVA and standby generator of 200 kVA have been selected.

Also the designed program results were almost same as manual results.

5.2 Recommendations

- Improve the software program that to be able to do a Finance Estimation of various types of buildings.
- Earthing system design and lightning protection of the building can be done to have a full covered project.
- Learn how to use "AUTOCAD Electric ", which is considered the most powerful program related to Electrical Load Calculations from the drawing aspect, because it has very powerful feature that can guarantee to the student to get a well and professional drawing and plans, and that could help him to start the project from scratch.
- Taking electrical installation as an important course in universities.

REFERENCES

[1] Ray C.Mullin Phil Simmons, "Electrical Wiring Residential" 17th edition. Cengage, 2012.

[2] Jillany, "Electrical installation, Technician Inferior".1th edition Cairo 2010.

[3] T.A.Stubbs W.E.Steward, "Modern Wiring Practice", Design and Installation. England, 2005.

[4] CIBSE Guide K, Electricity in Buildings. England: The Chartered Institution of Building Services, 2004.

[5]Mohamed Tharwat, "Basics of Electrical Works design for projects". Cairo 2013/2014.

Appendix A

A. Electrical drawings of the building

Figure A.1 : Elevation of the Building

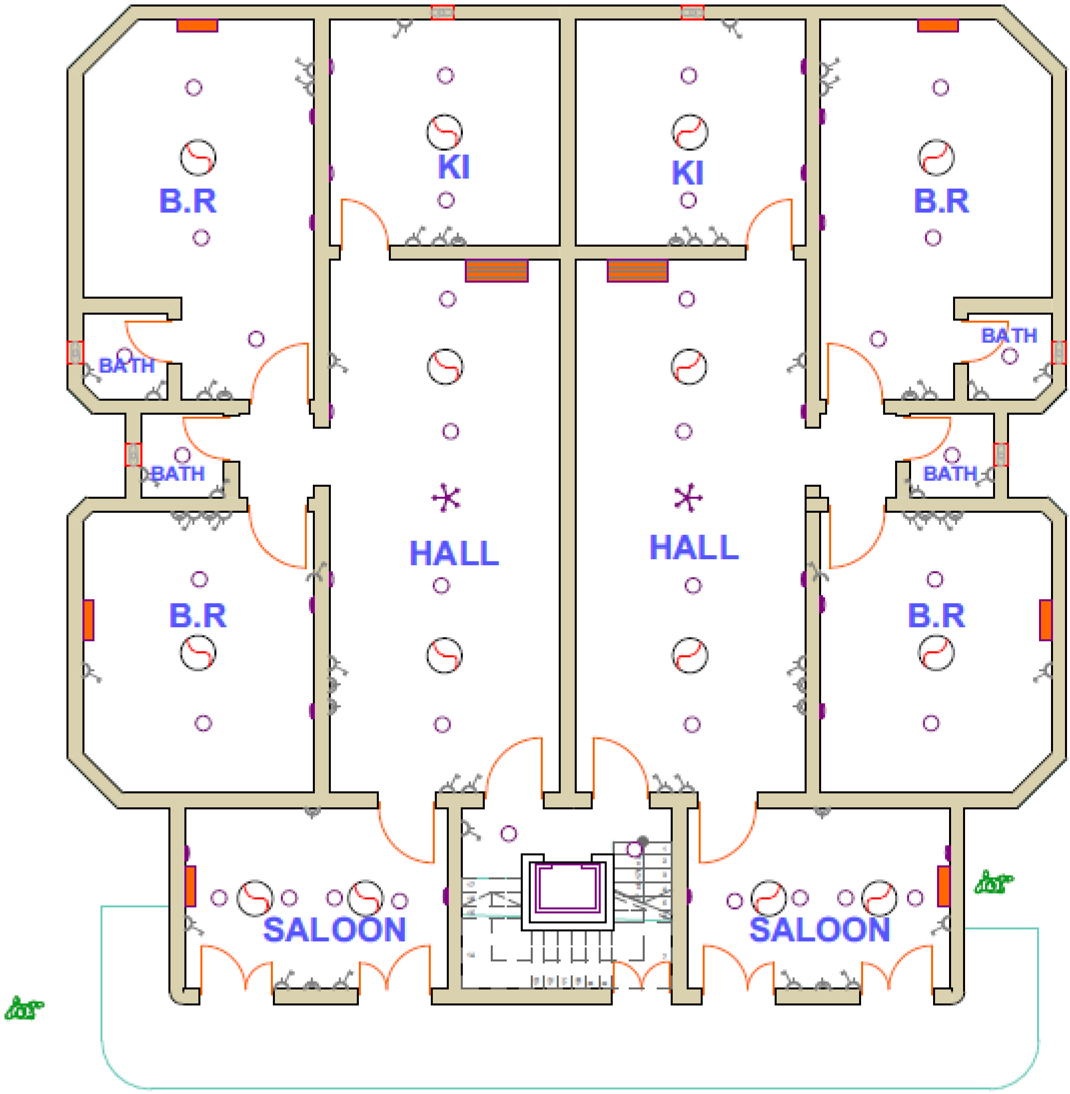


Figure A.2: Electrical drawing

Appendix B

B. Cables Size Table

Nominal Cross Section	Nominal Insulation Thickness	Approx. Overall Diameter	Max DC Resistance At 20̊C/ Ohm/km	Current Rating		Stand-ard Length	Approx. Cable Weight
mm^2	Mm	Mm	Ohm/km	Laid in Conductor/ /A	Laid in Fresh Air /A	(mts ±5%)	Kg/km
1.5	**0.7**	**2.8**	**12.1**	**21**	**28**	**100**	**20**
2.5	**0.8**	**3.4**	**7.41**	**27**	**38**	**100**	**30**
4	**0.8**	**3.9**	**4.61**	**34**	**50**	**100**	**46**
6	**0.8**	**4.4**	**3.08**	**43**	**66**	**100**	**66**
10	**1**	**5.6**	**1.83**	**60**	**89**	**100**	**106**
16	**1**	**7.1**	**1.15**	**78**	**115**	**100**	**177**
25	**1.2**	**8.7**	**0.727**	**103**	**152**	**1000**	**278**
35	**1.2**	**9.9**	**0.524**	**126**	**189**	**1000**	**371**
50	**1.4**	**11.8**	**0.387**	**157**	**235**	**1000**	**514**
70	**1.4**	**13.3**	**0.286**	**196**	**291**	**1000**	**711**
95	**1.6**	**15.7**	**0.193**	**239**	**350**	**500**	**967**
120	**1.6**	**19**	**0.153**	**280**	**410**	**500**	**1240**
150	**1.8**	**21**	**0.124**	**316**	**473**	**500**	**1500**
185	**2**	**23.5**	**0.0991**	**364**	**545**	**500**	**1822**
240	**2.2**	**26.5**	**0.0745**	**430**	**566**	**500**	**2475**
300	**2.4**	**29.3**	**0.0601**	**494**	**690**	**500**	**2977**
400	**2.6**	**33.5**	**0.0470**	**560**	**916**	**500**	**3910**

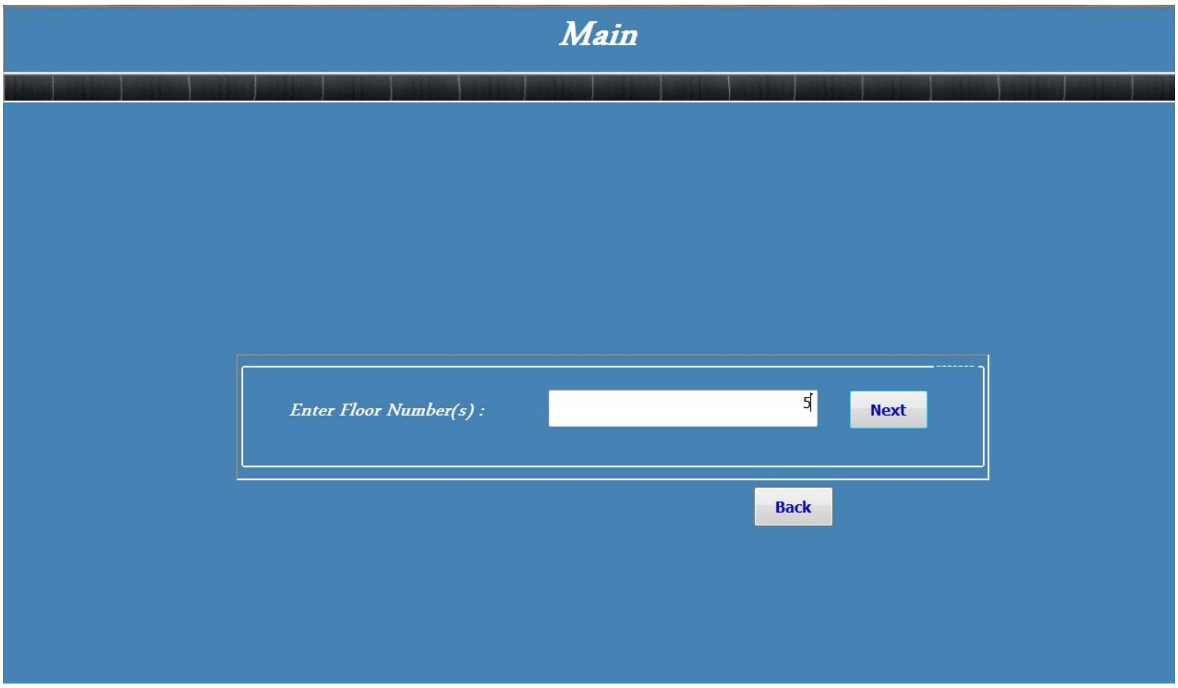
*note: the above data approximate and subject to Manufacturing tolerance.

General specifications:

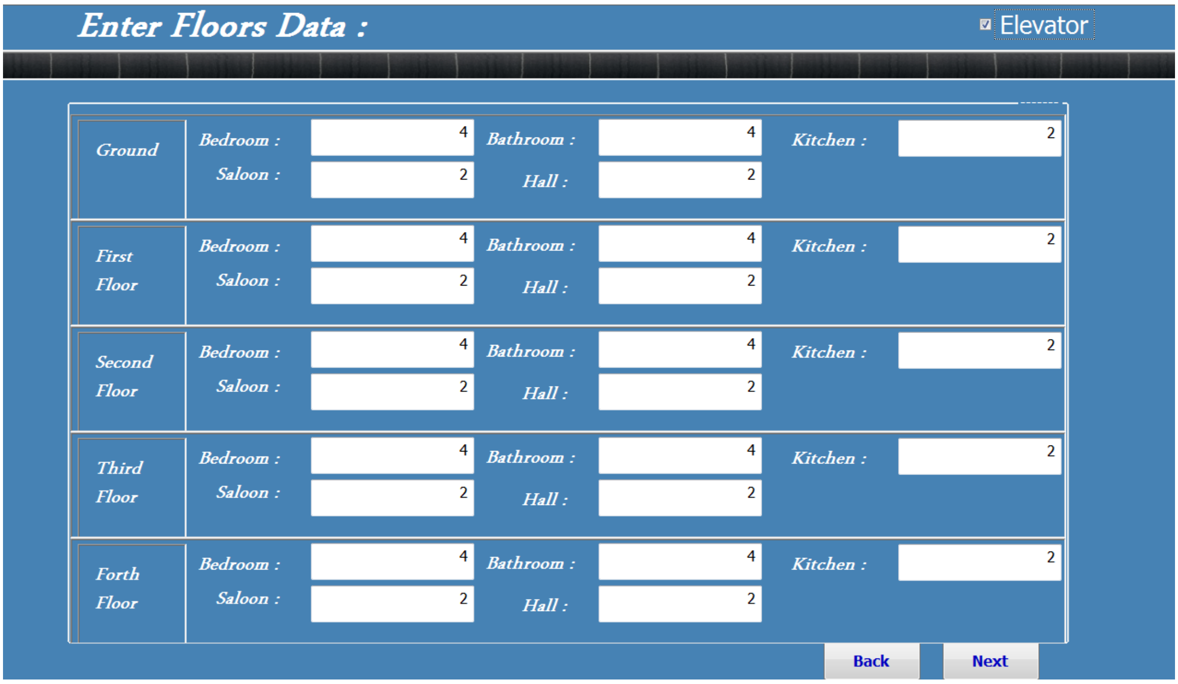
- **Type:** *CU/PVC.*
- **Standard:** *BS 6004 & IEC 60227*

Appendix C

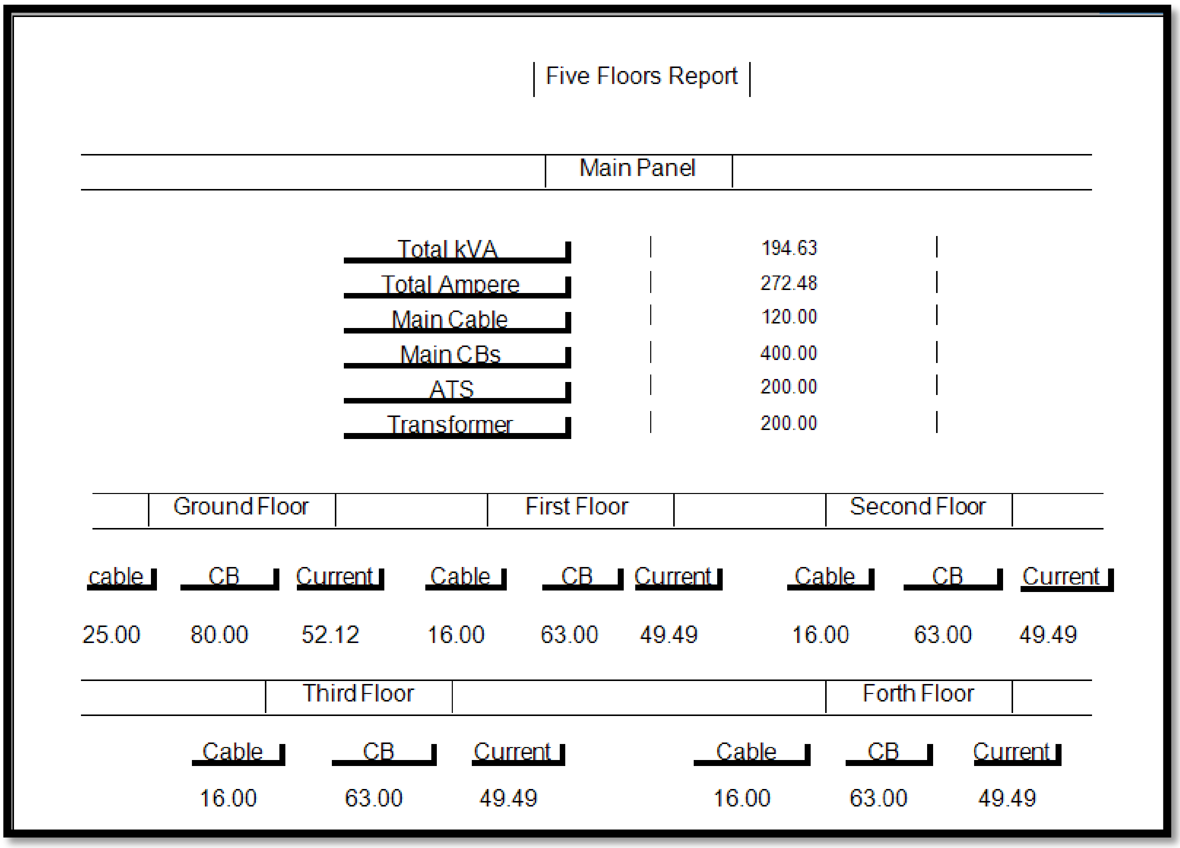
C. Software screens



Screen (1): Entries Number of floors



Screen (2): Entries Data of floors


Five Floors Report

Main Panel

Total kVA	194.63
Total Ampere	272.48
Main Cable	120.00
Main CBs	400.00
ATS	200.00
Transformer	200.00

Ground Floor			First Floor			Second Floor		
cable	CB	Current	Cable	CB	Current	Cable	CB	Current
25.00	80.00	52.12	16.00	63.00	49.49	16.00	63.00	49.49

Third Floor			Forth Floor		
Cable	CB	Current	Cable	CB	Current
16.00	63.00	49.49	16.00	63.00	49.49

Screen (3): Report screen