## ACKNOWLEDGMENT

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# ABSTRACT

VipCoda is intelligent software that can be used to automatically assess and evaluate any submitted electrical network systematically within a short time. However, this software also has the constraint which is not providing step-by-step of guidance of electrical installation according to IEE Wiring Regulation (British Standard, BS 7671). This problem can be overcome by develop the step-by-step procedures to assist the VipCoda user according to BS 7671. To provide accurate and safe design procedure that follows BS 7671, literature study help in identify the suitable circuit breaker, sizing of cable, current rating and voltage drop. To verify the calculation of low voltage design with VipCoda results, a case study was conducted. The case study consists of two final DBs which is there are three type of load connected to each DB. It was conducted to verify calculation that follow BS 7671 with the VipCoda results. By comparing the results, only 2% error occurs in calculation. Therefore, it shows that the step-by-step procedure to assist the VipCoda user is reliable.

# ABSTRAK

VipCoda adalah perisian pintar yang boleh digunakan untuk menilai secara automatik dan menilai mana-mana rangkaian elektrik dikemukakan secara sistematik dalam masa yang singkat. Walau bagaimanapun, perisian ini juga mempunyai kekangan yang mana tidak menyediakan langkah demi langkah panduan pemasangan elektrik mengikut IEE Wiring Regulation (British Standard, BS 7671).Masalah ini boleh diatasi dengan menyediakan prosedur langkah demi langkah untuk membantu pengguna VipCoda mengikut BS 7671.Untuk menyediakan prosedur reka bentuk yang tepat dan selamat merujuk BS 7671, kajian sastera membantu dalam mengenal pasti pemutus litar yang sesuai, saiz kabel, kedudukan arus, kejatuhan voltan. Untuk mengesahkan pengiraan reka bentuk voltan rendah dengan keputusan VipCoda, satu kajian kes telah dijalankan. Kajian ini terdiri daripada dua DB akhir yang terdapat tiga jenis beban disambungkan pada setiap DB. Ia telah dijalankan untuk mengesahkan pengiraan yang mengikuti BS 7671 dengan keputusan VipCoda. Dengan membandingkan keputusan, hanya 2% kesilapan berlaku dalam pengiraan. Oleh itu, ia menunjukkan bahawa prosedur langkah demi langkah untuk membantu pengguna VipCoda boleh dipercayai.

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| | | |
|---|---|---|
| BS | - | British Standard |
| CPC | - | Circuit Protective Conductor |
| DB | - | Distribution Board |
| MCB | - | Miniature Circuit Breakers |
| MCCB | - | Moulded Case Circuit Breaker |
| PVC | - | Polyvinyl Chloride |
| RCCB | - | Residual Current-Operated Circuit Breakers |
| SSO | - | Switch Socket Outlet |
| VipCoda | - | Visually Interactive Program for Consultant and Owner to Design and Assess |
| XLPE | - | Cross-Linked Polyethylene |

# CHAPTER 1

# INTRODUCTION

## 1.1 Research Background

In the electrical power system comprise of three important things which are generation, transmission and distribution energy in the form of electric current to the ultimate load. The distribution system consists of high voltage and low voltage. Normal voltages for high voltage are 33kV, 22kV and 11kV. From high voltage it will step down to low voltage power system, which are 240 V and 415 V. Voltage that normally used in industrial and commercial system should not exceed 1 kV [1].

The low-voltage is widely used in every industry in the society to connect the supply and marketing of the power energy and transfer the loss, comparing with the high-voltage grid. The low-voltage has characteristics as long circuitries, wide distribution, disordered layout, significant change, difficult management (due to many people engage in it), large loss and more accidents. Therefore, the authorities have to overcome these characteristics by following standard protective measures, properly installation and maintained. It is because to prevent persons from exposed to the risk of electric shock and being in contact with energized parts for a harmful length of time.

## 1.2 Project motivation

VipCoda is used to evaluate any submitted electrical network systematically within a short time. The current users of this visually interactive tool are Lakefront Residence Malaysia, Powerlite Engineering, Universiti Teknikal Malaysia Melaka (UTeM) and many more [2]. However, the VipCoda software alone will difficult to the new user such as UTeM because there are no step-by-step procedures that follow IEE wiring regulation (BS 7671). Therefore, this study will help the new user in design low voltage electrical installation according to standard design procedure BS 7671. This project is verified by VipCoda software results.

## 1.3 Problem Statement

In the design of low-voltage systems in buildings, safety of life and preservation of property are the first two important factors to be considered. The safety requirements should follow the established codes such as the IEE Wiring Regulations, CP5 or NEC [2][3][4]. Therefore, to make the proper design in low voltage installation the standard BS 7671 should be follow correctly. Recently, in advance technology there is software that can display the best installation for engineers which is VipCoda. VipCoda is intelligent software can automate the design process producing a sound and reliable. However, the constraint of VipCoda is not providing step-by-step of guidance of electrical installation. It wills difficult to the new user that needs guidance of electrical installation by following the standard BS 7671. To make proper and accurate guidance of low voltage installation, verification of VipCoda software with design calculation according to Standard BS 7671 was complied.

## 1.4 Project Objective

The objectives of this study are:

1. To examine the steps in low voltage design system according to BS 7671
2. To verify the calculation of low voltage design with VipCoda results
3. To develop the step-by-step verification procedures to assist the VipCoda user

## 1.5 Project Scope

The scopes of this research are:

i. The design for low voltage installation (240/415 V).
ii. The steps for design low voltage installation are following the British Standard (BS 7671).
iii. The type of load has been used in this study are normal load, motor load and lighting load.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Each circuit should be equipped with a circuit breaker for automatic interruption of supply in the event of overload current and fault current to provide adequate overcurrent protection. The important equipment in this study such as circuit breaker, cable, voltage drop will be discussed in the following sub-section. The current rating in each protective device is following the IEE Wiring Regulations (BS 7671).

## 2.2 Circuit Breaker

Circuit-breakers are the most important equipment in power systems. It is an interrupting device to use in normal operation and during faults. It is expected that circuit-breakers must be operated in any applications without problems. Without damaging of insulation, the circuit breaker must be able to interrupt short-circuit currents, capacitive currents and small inductive currents [5]. There are a few characteristic circuit breaker should be fulfil which is capable of being safely closed within the making capacity of the device. It also should safely open at any current up to the breaking capacity.

For selection of a circuit breaker, it is should follow the correct current rating, which is carry the required current without overheating. It also should have the correct voltage rating which is switch and isolate or disconnect the load from the source at the given system voltage. Lastly, circuit breaker should have the correct interrupting rating which is can interrupt any abnormally high operating current or short-circuit current likely to be encountered during operation [6]. The circuit breakers to be discussed are MCB, MCCB and RCCB. The details information of these circuit breakers is explained in the following sub-section.

### 2.2.1 Type of circuit breaker

Protective device is the equipment applied to electric power system to detect abnormal and intolerable conditions and to initiate appropriate corrective actions. The protective devices that use in this project are MCB, MCCB and RCCB. The sub-section below will explain the detail of the protective device that used.

#### 2.2.1.1 Miniature Circuit Breakers (MCB)

MCB are available for single and three phases. The MCB are used for protection final circuits in domestic and commercials installations. Most MCBs are provided with two types of tripping mechanisms which is bi-metallic thermal trip and the electromagnetic of tripping. The current rating for this type of circuit breaker are 6, 8, 10, 15, 16, 20, 25, 32, 40, 50, 63, 80, 100 and 125 A [5]. For the standard values of rated short-circuit capacity are 1.5, 3, 4.5, 6 and 10 kA. For values above 10 kA, up to and including 25 kA, the preferred value is 20 kA. Figure 2.1 shows the example of MCB in the market.


Figure 2.1: MCB in the market [7]

#### 2.2.1.2 Moulded Case Circuit Breaker MCCB

In low-voltage electrical equipment, MCCB is important belonging to the class of electrical protection. It has manual and automatically operation that can lose voltage, under voltage, overload and short circuit protection. It is used in low-voltage distribution circuit for motor or other electrical devices, and it takes in charge of make-on, carrying and breaking current in normal or abnormal conditions such as short circuit [8]. Figure 2.2 below shows the example of MCCB in the market.

Current rating: 10, 16, 20, 32, 40, 50, 63, 80, 100, 200, 300, 400, 630, 800 1250 A.

Rated voltage: 380, 400, 415 V.

Rated breaking capacity: 10, 20, 25, 35, 65, 85 kA (r.m.s)

Rated making capacity: 17, 44, 53, 63, 84, 143 kA (peak)

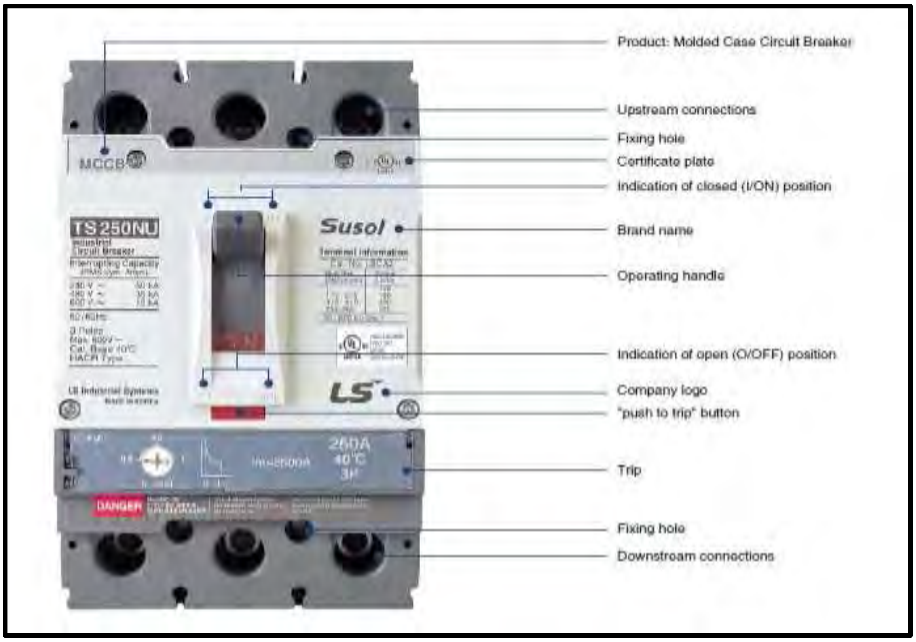


Figure 2.2: MCCB in the market [9]

#### 2.2.1.3 Residual Current-Operated Circuit Breakers (RCCB)

RCCB are primarily designed to protect against ‘indirect contact’ electric shock. The term ‘indirect contact’ means the contact of the supply voltage indirectly through the touching of the exposed-conductive-part such as the metallic enclosures of electrical appliances, the metallic conduit, trunking or cable tray. During an earth fault, there is an earth fault current flowing from the live conductor through the exposed-conductive parts to earth, the exposed metalwork may be at a high potential relative to earth. Based on IEC 1008, RCCBs are specified as the following [10]. The example of RCCB in the market is shown in the Figure 2.3 below.

**Preferred rated voltage**

Single-phase, phase-to-neutral: 230 V

Three-phase, three-wire: 400 V

Three-phase, 4-wire: 400 V

**Preferred rated current (IN)**

10, 13, 16, 20, 25, 32, 40, 63, 80, 100, 125 A

**Rated residual operating current (IΔN)**

0.006, 0.01, 0.03, 0.1, 0.3, 0.5 A


Figure 2.3: RCCB in the market [11]

## 2.3 Installation Method

In the low installation of electrical network, there are many method of installation including trunking method, clip-direct, tray and many more. For the cable trunking, a manufactured enclosure for the protection of cables, normally of rectangular cross section which one side is removable or hinged. Figure 2.4 shows the trunking installation method in house. For cable tray, a cable support consisting of a continuous base with raised edges and no covering. A cable tray is considered to be non-perforated, where less than 30% of the material is removed from the base. The example of cable tray installation is as in Figure 2.5 below. For the clipped-direct, the installation method is Non-sheathed cables in conduit mounted on a wooden or masonry wall. The example clipped-direct installation is shown in Figure 2.6.

Figure 2.4: Cable trunking [12]

Figure 2.5: Cable tray [13]

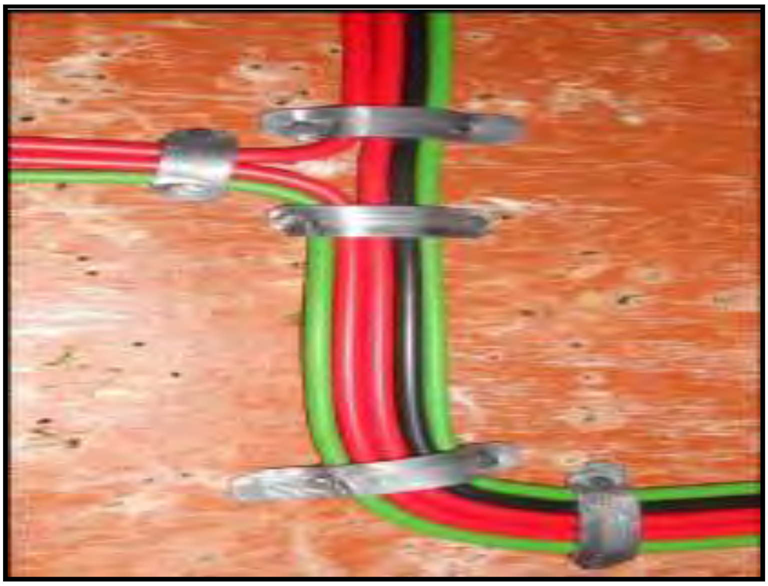

Figure 2.6: Clip direct [14]

## 2.4 Cable

A cable is length of insulated single conductor or two or more such conductors each provided with its own insulation which are laid up together. There are two type of insulation which is single-core and multi-core. The single-core cable is a cable that has only one insulated conductor with its own cable sheath while multi-core has multiple cores of insulated conductors within one common sheath. The example of single-core and multi-core is shown in Figure 2.7 and 2.8. The cable consists of conductor that provides electrical paths. The range standard metric cross-sectional area of conductors is 1.5mm2 to 1000mm2. Copper and aluminium are the two common types of material of conductor. The specific resistance of copper and aluminium at 70 C is 0.017 and 0.0283 Ω per mm2 per metre [5].

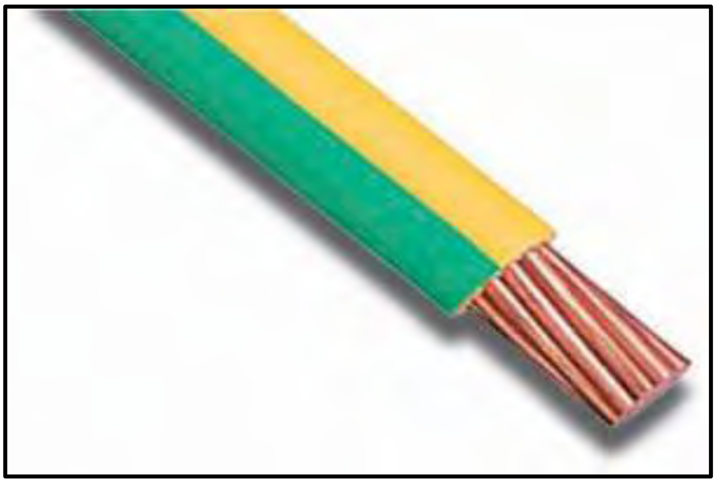

Figure 2.7: Single Core Cable [15]

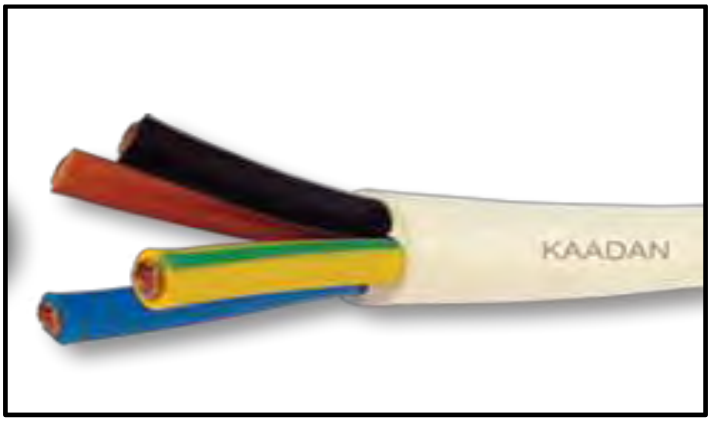


Figure 2.8: Multi-core Cable [15]

### 2.4.1 Cable insulation

To prevent direct contact between individual conductors and earth, insulation surrounds each conductor is required. The type of insulation will depends on the voltage of the system, the operating temperature of conductors and the mechanical and environmental conditions affecting the cable during installation and operation. There are types of insulation materials which are polyvinyl chloride (PVC), rubber, cross-linked polyethylene (XLPE), powdered mineral, and oil impregnated paper tapes.

Low-voltage power cables are generally rated at 450/750 V or 600/1000 V regardless of the voltage used, be it 120 V, 230 V, 240 V or 400 V. The important thing of cable is current rating. It will be discussed in the sub-section 2.3.2.

### 2.4.2 Current rating of cable

The current rating of a cable is determined by a number of factors, namely ambient temperature, maximum allowable conductor temperature, conductor material, insulation material and installation methods.

To protect the cables from damage and for a reasonable service life, temperature at conductors of a cable are allowed to operate continuously depends on the insulation material used and the construction of the cable. The tabulated values of ambient temperature correction factor will ensure that excessive temperatures are not reached.

#### 2.4.2.1 Ambient Temperature Correction Factor (Ca)

Correction factors for ambient temperature in determining the current carrying capacity of a cable are provided in Table 4C1 of IEE Regulation or CP5 [2][3]. For an ambient temperature higher than the specified temperature of 30°C, the rate of flow of heat out of the conductor will be lower than that of the specified condition. This will increase the conductor's operating temperature above the value permitted. This means that the current carrying capacity of the conductor has to be reduced to compensate for the reduction in the heat lost from the conductor. Table 2.1 shows the values of temperature correction factors for PVC cable.

Table 2.1: Temperature Correction Factors for PVC Cable [5]

| Ambient Temperature °C | 25 | 30 | 35 | 40 | 45 | 50 |
|---|---|---|---|---|---|---|
| Correction Factor Ca | 1.03 | 1.0 | 0.94 | 0.87 | 0.79 | 0.71 |

#### 2.4.2.2 Grouping Correction Factor (Cg)

Cables will get hot when installed it is bundled together because they are carrying current. Those close to the edges of the enclosures will be able to release heat outward but will be restricted in losing heat inwards towards other hot cables. For the cables in the centre of the enclosure will difficult to lost heat and will thus increase the conductor temperature. Correction factors for groups of more than one circuit of a single-core cable, or more than one multi-core cable are summarised in Table 2.2.

Table 2.2: Grouping correction factors have to be applied. [5]

| No. of circuits or multi-core cables | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Bunched and clipped direct | 1 | 0.8 | 0.7 | 0.65 | 0.6 | 0.57 |
| Single layer clipped direct and touching | 1 | 0.85 | 0.79 | 0.75 | 0.73 | 0.72 |
| Single layer clipped direct and Spaced * | 1 | 0.94 | 0.90 | 0.90 | 0.90 | 0.90 |

#### 2.4.2.3 Thermal Insulation Correction Factor (Ci)

Many new buildings are now provided with better thermal insulating material for roofs and cavity walls to reduce the energy cost for heating, ventilation and air-conditioning (HVAC). It means to reduce the heat loss. As thermal insulation is designed to limit heat flow, a cable in contact with it will tend to become warmer than the preferred operation conditions. IEE Regulation 523-04 [2] recommends that for a single cable which is likely to be surrounded by thermally insulating material over a length of 0.5 m, the thermal correction factor (Ci) is 0.5 times the tabulated current carrying capacity for that cable clipped direct to a surface (method 1). If the surrounded length is less than 0.5 m, the correction factor (Ci) can be higher than 0.5 [5].