

Load calculation voltage drop and size cable



Before wiring installation process is carried out, it must follow the rules of Malaysia 1994. which requires all wiring, additional wiring or rewiring to carried out by Electrical Contractor or Electrical Wiring Unit require approval writing from the licensee or supply authority.

Wireman or Contractor need to plan and indentify the work want to carried out, so that work can be more clean, tidy and safe to uses. the wireman or contractor should:

Make a site visit

Follow the guideline regulation from JKR

identifies the user load requirement

calculate the maximum demand and total connected load

determine the equipment

submit plants, drawings and specifications

2. 0 Regulation and Nominal Voltage in Malaysia

2. 1 The Regulation

Electricity supplied to domestic consumers must be follow standard specification, which are:

MS

MSIEC

International Electro technical Commission, IEC

British Standard , BS

the current British standard has integrated with the European standard,
BSEN

European Standard, EN

Electricity supplied also need to refer “ akta bekaln elektrik” years 1990.

This act is to provide for the investing of property and liabilities of the lembaga listrik negara in a each company, to make financial arrangement for that company, to provide for matters relating to employee and for other matters connected therewith

Guidance notes for wiring regulation can refer IEE wiring regulation by Brian reference for all contractors, technicians and other professionals working in a non- supervisory capacity, as well as newcomers to the industry, all of whom are involved in inspecting and testing electrical installations, and need to ensure their work complies with the latest version of the Wiring Regulations.

The installation on equipment and so on need to follow regulation from JKR such as :

L-S1 : Specification for low voltage internal electrical installation system

L-S2 : Specification for low voltage automatic power factor correction

L-S3 : Specification for low voltage underground cable

L-S4 : Specification for low voltage overhead line distribution

L-S5 : Specification for three phase generator set

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L-S6 : Specification for acoustic treatment for generator room

L-S7 : Specification for single phase diesel generator set

L-S8 : Specification for lightning protection system(using stranded G. I wires)

L-S9 : Specification for lightning protection system for structures

2. 2 Nominal Voltage in Malaysia

The official mains power voltage is AC 230 V with the tolerance of +10%,-6%. However, the supplied voltage remains at 240 V, as the supplied voltage is within the allowed tolerance. Areas that rely on private power companies, like some parts of Penang and Kedah, receive a true 230 V supply. Remote villages which rely on off-grid localized diesel generators (i. e. small villages and/or isolated holiday resorts on islands too far away from the mainland to have viable underwater cabling) may receive unstable power with higher voltages, with some areas recorded to be as high as 260 V

Before this, the rated voltage in Malaysia is 240/415V with range +5% to -10%, and effective in January 2008 the rated change to 230/415V with range +10% to -6%

3. 0 Load Calculation

Each design want to be made need go through the process of load calculation, where the process is calculated from distribution board(DB), sub-switch board(SSB) and main switch board(MSB)

A distribution board is a panel or enclosure that houses the fuses, circuit breakers, and ground leakage protection units used to distribute electrical

power to numerous individual circuits or consumer points. The board typically has a single incoming power source and includes a main circuit breaker and a residual current or earth leakage protection device. A distribution board may be used to distribute either single or three phase supplies depending on the installation specifics. Although distribution board equipment, layouts, and legislative requirements differ from country to country, the basic principles of “ distributing” a single supply to various individual points while ensuring safety and control for each remains the same. sub-switchboard function is same as distribution board, but MSB is MSB is an assembly of distribution panels, each of which contains switches and breakers that allow electricity to be redirected to appropriate loads. The role of MSB is to divide the main current provided to the switchboard into smaller loads for further distribution and to provide switching, over-current protection and metering for these various loads.

3. 1 Type of load

Electrical load types fall into four categories: resistive, capacitive, inductive or a combination of these. Few loads are purely resistive, capacitive or inductive. The imperfect nature of how electrical and electronic devices are built causes inductance, capacitance and resistance to be an inherent part of many devices.

3. 1. 1 Resistive Loads

A resistor is a device that resists the flow of electricity. In doing so, some of the electrical energy is dissipated as heat. Two common resistive loads are incandescent light bulbs and electric heaters. Resistance (R) is measured in ohms.

An incandescent light bulb produces light by passing an electric current through a filament in a vacuum. The resistance of the filament causes it to heat up and the electrical energy is converted to light energy. Electric heaters work in the same way except they produce little, if any, light.

The electrical current and the voltage in a resistive load are said to be “in phase” with each other. As voltage rises or falls, the current also rises and falls with it.

3. 1. 2 Capacitive Loads

A capacitor stores electrical energy. Two conductive surfaces are separated by a non-conductive insulator. When an electrical current is applied to a capacitor, electrons from the current gather on the plate attached to the terminal to which the electric current is applied. When the current is removed, the electrons will flow back through the circuit to reach the other terminal of the capacitor.

Capacitors are used in electric motors, radio circuits, power supplies and many other circuits. The capability of a capacitor to store electrical energy is called capacitance (C). The main unit of measure is the farad, but most capacitors are measured in microfarads.

The current leads the voltage of a capacitor. The voltage across the terminals starts out at zero volts while the current is at its maximum. As the charge builds on the capacitors plate, the voltage rises and the current falls. As a capacitor discharges, the current rises as the voltage falls.

3. 1. 3 Inductive Loads

An inductor may be any conductive material. When a changing current passes through an inductor, it induces a magnetic field around itself. Turning the inductor into a coil increases the magnetic field. A similar principal occurs when a conductor is placed within a changing magnetic field. The magnetic field induces an electrical current within the conductor.

Inductance (L) is measured in henries. The changing voltage and current in an inductor are out of phase. As current rises to a maximum, the voltage falls.

3. 1. 4 Combination Loads

All conductors have some resistance under normal conditions and also exhibit inductive and capacitive influences, but these small influences are generally dismissed for practical purposes. Other loads make use of various combinations of inductors, capacitors and resistors to perform specific functions.

The tuning circuit of a radio uses variable inductors or capacitors in combination with a resistor to filter out a range of frequencies while allowing just one narrow band to pass through to the rest of the circuit.

A cathode ray tube in a monitor or television makes use of inductors, resistors and the inherent capacitance of the tube to control and display a picture on the phosphor coatings of the tube.

Single phase motors often use capacitors to aid the motor during starting and running. The start capacitor provides an additional phase of voltage to

the motor since it shifts the current and voltage out of phase with each other.

3. 2 Total Connected Load(TCL) and Maximum Demand(MD)

One of the most calculation basic electrical calculation is to calculate the total connected load(TCL) and maximum demand(MD)

The TCL is the mechanical and electrical load that will be connected for that particular area, where all of the electrical loads in an installation be maximized and simultaneously,

The MD is the total kW that actually contributes the total power used in one time after applying the diversity factor based on the Total Connected Load calculated. It less than or equal to the connected load (TCL). Value of maximum demand of a building and ratio of diversity factor must be determined so as not overdesigned or under designed. By using MD also, many cost can be reduced as cable size, the size of the breaker, busbar size etc

By calculating the TCL, it can know the total load connected for a particular area and also can determine the sizing of cables. But, the most important thing is by having the TCL, it can determine the MD. This MD will be declared to the utility provider for the purpose of meter deposit and utility bill

3. 2. 1 Diversity Factor (DF)

Diversity factor is different or ratio between MD and TCL. the equation can relate MD, TCL to DF is :

$$MD = TCL \times DF$$

Should be reminded, to determined DF normally it can not be precisely determined. DF value is only an approximate value only based on the guidance or previous data. The diversity factor is almost always greater than 1 since all components would have to be on at simultaneously at full load for it to be one.

3. 2. 2 Increase Burden

After MD known then it should be added 20% at DB and 30% in SSB or MSB to determine the size of the incoming breaker. This is because taking into account the increase in the load in the future. it is known as increase burden.

The specification percent of increase burden:

Distribution Board

School: MD + 20%

Office : TCL

Hospital : TCL + 20%

Sub Switchboard and Main Switchboard

MD + 30%

3. 3 Circuit Breaker

To provided adequate over current protection, each circuit should be equipped with a circuit breaker for automatic interruption of supply in the event of overload current and fault current. the circuit breaker installed in a <https://assignbuster.com/load-calculation-voltage-drop-and-size-cable/>

circuit should break any fault current flowing in the circuit breaker before such current causes danger due to thermal or mechanical effect produced in the circuit or the associated connection. the characteristics of the breaker shall satisfy the condition that the breaking capacity should be greater than or equal to the prospective short circuit current or earth fault current at the point at which the breaker installed

The rated current of a circuit breaker is the current that it can carry continuously, generally for a duration of more than eight hours. The rated current must not cause a temperature is between -5C to 40C. Different temperature rise limits are specified for different parts of a circuit breaker. A circuit breaker will not operate (Trip) if the current passing through it is 105% to 113% of its rated current. It will take one or two hours to trip if the current passing through it is 130% to 145% of the rated current.

3. 4 Type of Circuit Breaker need to be determined

3. 4. 1 Miniature Circuit Breaker(MCB)

MCB are used extensively for the protection of final circuit in domestic and commercial installations. they offer these circuit protection, particularly when overload or short circuit conditions are being considered than the fuse alternatives.

MCBs are available for both single phase and three phase circuit. In a single phase circuit, a single MCB may be used in the live conductor or a two-pole MCB connected in the live and natural conductor. three or four pole MCBs are used for protection in three phase supplies. If a fault current flow through even one pole of an MCB, all the three poles will be operated.

The main standard for MCBs in BS 3871. This standard covers MCB ratings up to 100A, breaking capacities up to 9 kA and voltage ratings up to 415V

The preferred value of the rated current are :

6, 8, 10, 13, 16, 20, 25, 32, 40, 50, 63, 80, 100, and 125A

Instead of specifying the breaking capacity, the standard specifies the value of the short circuit capacity. the short circuit capacity refers to the prospective current expressed by its r. m. s value which the MCB is designed to make (closed), to carry for its operating time and to break under the specified conditions. the standard value of rated short circuit are 1. 5, 3, 4. 5, 6 and 10kA. for values above 10kA up to and including 25kA, the preferred value 20kA

3. 4. 2 Moulded Case Circuit Breaker(MCCB)

Moulded case circuit breaker(MCCB) are required for installation which have higher fault level or higher current ratings exceeding 125A. MCCBs have several advantages over ordinary switches and fuses in the control and protection of circuit and apparatus. they have a repeatable non-destructive performance and are safe in operation under fault conditions. it has built-in mechanism to simultaneously open all three phases for a single phase fault.

These circuit breaker are mainly used to protect main feeder cables, for incoming supply to sub circuit/distribution boards and for large motor circuit. for installation, MCCBs are suitable as free standing units, or for building into compact cubic-type switchboards. Auxiliary items such as shunt trio

elements, status switches, interlocks and motor-operated mechanism for remote operating can all be integrated into the MCCB.

The main industrial standard for MCCBs are BS EN 60947-1 and BS EN 60947-2. these two standard define the characteristics, conditions for operation, methods for testing and the requirements for circuit breaker with rated voltages up to and including 1000V a. c or 1500 d. c.

As there are no other standard values specified in BS EN 60947, the followings are some typical technical data for reference :

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

Rated voltage : 380, 400, 415V

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

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

One minutes power

frequency withstand voltage : 2. 5kV

3. 4. 3 Residual Current-operated Circuit Breaker(RCCB)

The Residual Current-operated Circuit Breaker(RCCB) are primarily designed to protect against ' indirect contact' electric shock. The term ' indirect contact' refers to 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.

These exposed-conductive-parts are insulated from the live conductor and are connected to the earthing terminal and thus, should be at the earth potential. However, during an earth fault, as there is an earth fault current flowing from the live conductor through the exposed-conductive-part to the earth, the exposed metalwork may be at high potential relative to earth. Touching the exposed-conductive-parts at this instance may cause an electric shock if its potential to earth exceeds 50V. Furthermore, if it is a high impedance earth fault, the magnitude of the earth fault current may not activate the overcurrent protective device. Thus, a current will continue to flow to earth, possibly generating heat and causing fire. RCCB is designed to detect such a residual current (ie. earth leakage current), to compare it to reference value and to open the protected circuit when the residual current exceeds this reference value.

RCCBs are not designed to have a high breaking capacity and in fact, they have only a limited breaking capacity. They are therefore, not a replacement for other overcurrent protective devices which are designed to interrupt high fault current. There are four standards for RCCBs namely, BS4293, IEC 755, IEC 1008- 1 and Singapore standard SS 97.

Based on IEC 1008, RCCBs are specified as follows:

Preferred rated voltage : single phase, phase to neutral : 230V

: three phase, three wire : 400V

: three phase, 4 wire : 400V

Preferred rated current, I_N : 10, 13, 16, 20, 25, 32, 40, 63, 80, 100, 125A

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Rated residual operating

current, I_{res} , N : 0.006, 0.01, 0.03, 0.1, 0.3, 0.5A

Standard value of residual non

operating current : $0.5 I_{\text{res}}$, N

minimum value of the rated

making and breaking capacity : 10 IN or 500A whichever is greater

Rated condition short circuit

current : 3, 4.5, 6, 10, 20kA

Maximum break time : 0.3s for residual current equal to $0.5 I_{\text{res}}$, N

: 0.15s for residual current equal to $20.5 I_{\text{res}}$, N

: 0.04s for residual current equal to $50.5 I_{\text{res}}$, N

0.004s for residual current to 500A

4.0 Voltage Drop

Voltage drop difference in voltage from one point in a current path to any other point in the same current path. Voltage drop is the result that happens to a voltage value when it meets with resistance in any current path while current is flowing, it only happens when flowing current meets resistance in a current path, the higher the value of current flowing, the higher the voltage drop across any conductor, connection, or contact in the current path.

Based on Ohm's law; it takes one volt to push one amp through one ohm of resistance. The location of a voltage drop in a parallel circuit determines the affect it will have on the loads that are in parallel. When a voltage drop occurs before, or ahead of the last parallel splice in a parallel circuit, it will provide less than source voltage to all loads in parallel beyond the last parallel splice. When a voltage drop occurs after the last parallel splice in a parallel circuit, the same value of voltage drop has an identical affect on the load in the affected branch whether it appears on the voltage feed side, or on the ground side of the branch load.

When current flows through the cable, the voltage drop will result. This is based on a formula :

$V = I \times R$; I = current flows through the cable

R = Resistance of the cable

Based on requirement of IEE wiring regulation 525-01-01. " The voltage drop between the origin of the installation (usually the supply terminals) and terminals of the fixed current - using equipment does not exceed 4% of the nominal voltage of the supply."

The voltage drop for building must make sure it not more than 4% depend to nominal voltage, where :

4% of 11̂ = 4% of 240 V

= 9.6 Volt

4% of 3 1̂ = 4% of 415 V

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= 16.6 Volt

The voltage drop for outside building, must not exceed 20V from nominal voltage

4.1 The Voltage Drop is Closely Related with Size of Cable

Most circuits in a house do not have enough current or length to produce a high voltage drop. In the case of very long circuits, for example, connecting a home to a separate building on the same property, it may be necessary to increase the size of conductors over the minimum requirement for the circuit current rating. Heavily-loaded circuits may also require a cable size increase to meet voltage drop requirements in wiring regulations.

Voltage drop and size cable can related with equation :

VD – Total of voltage drop

Vd – Voltage drop on cable mV/A/m

In – Rated current of breaker (A)

L – Length of Cable (meter)

5.0 Cable

In electrical engineering cables are used to carry electric currents. Cables are the mean by which electrical energy is distributed from its source to its point of use. Copper wires in a cable may be bare, or they may be plated with a thin layer of another metal, most often tin but sometimes gold, silver or some other material. Tin, gold, and silver are much less prone to oxidation than copper, which may lengthen wire life, and makes soldering easier.

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<http://www.electronicsteacher.com/direct-current/dc-metering-circuits/00376.png>

5.1 Insulation

The insulation surrounds each conductor to prevent direct contact between individual conductors and earth. Type of insulation will depend on the voltage, the operating temperature of the conductor and the mechanical and environmental condition affecting the cable during both installation and operation. Type of insulation material:

Polyvinyl chloride (PVC)

Rubber

Cross-linked polyethylene (XLPE)

Powdered mineral

Oil impregnated paper tapes

5.2 Type of conductor

PVC, PVC/PVC

XLPE, XLPE/PVC (> 25 mm²)

PVC/SWA/PVC

XLPE/SWA/PVC (> 25 mm²)

Fire Rated Cable

MIMS (Mineral Insulated Mineral Sheathed Copper Conductor)

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MICC (Mineral Insulated Copper Clad Copper Conductor)

5.3 Installation method

GI Conduit – PVC

Galvanised/H. D. G. Trunking – PVC

Hot Dipped Galvanised Perforated Cable Tray – PVC/PVC, XLPE/PVC,
PVC/SWA/PVC, XLPE/SWA/PVC

Hot Dipped Galvanised Cable Ladder – PVC/PVC, XLPE/PVC, PVC/SWA/PVC,
XLPE/SWA/PVC

5.4 Cable type and selection

The current carrying capacity of a cable must be sufficient to cater for the maximum sustained current which will normally flow through it. The insulation must be adequate to deal with the voltage of the system and must not be damaged by the heat produced by the current flow, high ambient temperature or by heat transferred. Cable selection therefore is primarily related to the size of the cable which will carry the required current without the temperature of the surrounding insulation rising above a critical level which will result in the breakdown of the insulation.

5.5 Current rating of cable

The current rating of cable is determined by a number of factors:

Ambient temperature

Maximum allowable conductor temperature

Conductor material insulation material

Installation method

5. 6 Determine the Size cable

The proper sizing of an electrical (load bearing) cable is important to ensure that the cable can:

Operate continuously under full load without being damaged

Withstand the worst short circuits currents flowing through the cable

Provide the load with a suitable voltage (and avoid excessive voltage drops)

(optional) Ensure operation of protective devices during an earth fault

Selected the size cable can base on :

$$I_n \hat{=} I_b$$

$$I_z \hat{=} I_n$$

$$I_z \hat{=} I_n \hat{=} I_b$$

* I_n – rated current

I_z – rated current of cable

I_b – design current