# How to determine the suitable size of cable for Electrical Wiring Installation

## Voltage drop in Cables

We know that all conductors and cables (except Super conductor) have some amount of resistance.

This resistance is directly proportional to the length and inversely proportional to the diameter of conductor $R \alpha L/a$ [Laws of resistance $R = \rho (L/a)$]

Whenever current flows through a conductor, a voltage drop occurs in that conductor. Generally, voltage drop may neglect for low length conductors but in a lower diameter and long length conductors, we cannot neglect that voltage drops.

According to IEE rule B-23, at any point between power supply terminal and installation, Voltage drop should not increase above 2.5% of provided (supply) voltage.

Example: if the Supply voltage is 220V, then the value of allowable voltage drop should be;

Voltage Drop = 220 x (2.5/100) = 5.5V

In electrical wiring circuits, voltage drops also occur from the distribution board to the different sub circuit and final sub circuits, but for sub circuits and final sub circuits, the value of voltage drop should be half of that allowable voltage drops

(i.e. 2.75V of 5.5V in the above case)
There are two methods to define the voltage drop in a cable which we will follow.

In SI (System international and metric system) voltage drop is described by ampere per meter.

In FPS (foot pound system) voltage drop is described in 100feet.

## Tables for Suitable Cable & Wire Sizes

Below are the important Tables which you should follow for determining the proper size of cable for Electrical Wiring Installation.

TABLE 1 CURRENT RATING OF COPPER CABLE AT $86^0$F OR $30^0$C

| SURFACE WIRING (A) | CONDUITING OR TRUNKING INSTALLATION (A) | AREA ($MM^2$) |
|---|---|---|
| 17.5 | 5.5 | 1 |
| 23 | 8 | 1.5 |
| 31 | 11 | 2.5 |
| 41 | 24 | 4 |
| 54 | 31 | 6 |
| 74 | 42 | 10 |
| 99 | 56 | 16 |
| 130 | 73 | 25 |
| 161 | 90 | 35 |
| 209 | 145 | 50 |
| 268 | 185 | 70 |
| 326 | 230 | 95 |
| 379 | 278 | 120 |
| 436 | 318 | 150 |
| 500 | 362 | 185 |
| 590 | 424 | 240 |

TABLE 2 CABLE SIZE, CURRENT RATING WITH VOLTAGE DROP

| **SINGLE PHASE ONE CABLE** | | **THREE PHASE THREE OR FOUR CORE CABLE** | | **CROSS SECTION AREA ($MM^2$)** |
|---|---|---|---|---|
| CURRENT RATING (A) | VOLT DROP AMP- METER | Current Rating (A) | VOLT DROP AMP-METER | |
| 11 | 41 | 9 | 35 | 1 |
| 13 | 28 | 12 | 24 | 1.5 |
| 18 | 17 | 16 | 15 | 2.5 |
| 24 | 11 | 22 | 9.1 | 4 |
| 31 | 7 | 27 | 6 | 6 |
| 40 | 4.1 | 37 | 3.6 | 10 |
| 53 | 2.6 | 47 | 2.2 | 16 |
| 60 | 1.7 | 53 | 1.5 | 25 |
| 74 | 1.2 | 65 | 1 | 35 |

TABLE 3 TEMPERATURE FACTOR

| TEMP.FACTOR | 1.02 | 1 | 0.97 | 0.94 | 0.91 | 0.88 | 0.77 | 0.63 |
|---|---|---|---|---|---|---|---|---|
| TEMP $F^O$ | 77 | 86 | 95 | 104 | 113 | 122 | 1131 | 140 |
| TEMP. $C^O$ | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TEMP. $K^O$ | 298.15 | 303.15 | 308.15 | 313.15 | 318.15 | 318.15 | 328.15 | 333.15 |

To find voltage drop in a cable, follow these simple steps

First of all, find the maximum allowable voltage drop

Now, Find load current

Now, according to load current, select a proper cable (which current rating should be nearest to the calculated load current) from table 1

From Table 1, find the voltage drop in meter or 100feet (what system you prefer) according its rated current

(Stay cool we will follow both methods and system for finding voltage drops (in meter and 100feet) in our solved example for whole electrical installation wiring).

Now, calculate the voltage drop for the actual length of wiring circuit according to its rated current with the help of following formulas.

(Actual length of circuit x volt drop for 1m) /100 —-> to find Volt drop in per meter.

(Actual length of circuit x volt drop for 100ft) /100—> to find volt drop in 100feet.

Now multiply this calculated value of volt drop by load factor where;

Load factor = Load Current to be taken by Cable/ Rated Current of Cable given in the table.

This is the value of Volt drop in the cables when load current flow through it.

If the calculated value of voltage drop is less than the value calculated in step (1) (Maximum allowable voltage drop), than the size of selected cable is proper

If the calculated value of voltage drop is greater than the value calculated in step (1) (Maximum allowable voltage drop), than calculate voltage drop for the next (greater in size) cable and so on until the calculated value of voltage drop became less than the maximum allowable voltage drop calculated in step (1)

How to determine the proper Cable Size for Given Load (with Examples)

For a given load, cable size may be found with the help of different tables but we should keep in mind and follow the rules about voltage drop.

Determining the size of cable for a given load, take into account the following rules.

For a given load except the known value of current, there should be 20% extra scope of current for additional, future or emergency needs.

From Energy meter to Distribution board, Voltage drop should be 1.25% and for final sub circuit, voltage drop should not exceed 2.5% of Supply voltage.

Consider the change in temperature, when needed, use temperature factor (Table 3)

Also, consider the load factor when finding the size of cable

When determining the cable size, consider the wiring system i.e. in open wiring system, temperature would be low but in conduit wiring, temperature increases due to the absence of air.

**DIVERSITY FACTOR:** Is the ratio of the sum of the individual maximum demands of the various subdivision of the system (or part of the system) to the maximum demand of the whole system**.**

**DIVERSITY FACTOR OF ELECTRICAL WIRING INSTALLATION**

In a building, the whole load of electrical wiring installation doesn't use at the same time. In other words, we do not use all the loads at once at home i.e. switching ON all the fans, light points, Air conditioner, TV, fridge, Water gazer, heater, Electric iron etc at once. Therefore, we consider diversity factor while selecting the proper size of cables and wires for electrical wiring installation.

Diversity Factor = Total Connected Load / Actual Maximum Load

Good to know:

- Diversity factor may be neglected in case of final sub circuits.
- Except of homes and buildings, diversity factor in electrical wiring installation may be neglected in offices or those places where all connected loads operate at once.

https://www.electricaltechnology.org/wp-content/uploads/2013/10/Table-25286-2529-Diversity-Factor-for-Electrical-Wiring-Installation-.png

Example:

In a flat, the max demand of load current is follow (90 Amp).

| Connected Load | Amperes | Maximum to be expected | Amperes |
|---|---|---|---|
| Three 15 Amp socket Outlets | 45 A | 100% of one socket (15Amp) + 40% of reminder 2 sockets | 27 A |
| Four 5A socket outlets | 20 A | 100% of One Socket (5A) + 40% of reminder 3 sockets | 11 A |
| Water heater | 6 A | 100% | 6 A |
| Lighting points | 7 A | 66% of load | 4.5A |
| Water pump | 4 A | 30% | 1.2 A |
| Air Conditioner | 8 A | 30% | 2.4 |
| Total Load | 90 Amp | | 52 A |

Table (6) Diversity Factor for Electrical Wiring Installation

But with the help of using diversity factor, we found total load current about 52A.

In this case, consider 52A (+ 20% for future load = 62.4A) instead of 90A for calculation and selection of proper size of cable for wiring installations.

Note: Keep in mind Diversity Factor in Electrical Wring Installation while selecting the proper size of cable for electrical wiring installation

Following are the examples of determining the proper Size of cables for electrical wiring installation which will make it easy to understand the method of "how to determine the proper size of cable for a given load"

**Example 1**. For Electrical wiring installation in a building, Total load is 4.5kW and total length of cable from energy meter to sub circuit distribution board is 35 feet. Supply voltages are 220V and temperature is 40°C (104°F). Find the most suitable size of cable from energy meter to sub circuit if wiring is installed in conduits.

Solution:-

Total Load = 4.5kW = 4.5 x1000W = 4500W

20% additional load = 4500 x (20/100) = 900W

Total Load = 4500W + 900W = 5400W

Total Current = I = P/V = 5400W /220V =24.5A

Now select the size of cable for load current of 24.5A (from Table 1) is 31A it means we can use it, temperature factor in Table 3, is 0.94 at 40°C (104°F) and current carrying capacity of cable is 31A, therefore, current carrying capacity of this cable at 40°C (104°F) would be;

Current rating for 40°C (104°F) =31 x 0.94 = 29.14 Amp.

Since the calculated value (26.32 Amp) at 40°C (104°F) is less than that of current carrying capacity of cable which is 31A, therefore this size of cable is also suitable with respect to temperature.

Now find the voltage drop for 100feet for this cable from Table 2 is 7V, But in our case, the length of cable is 35 feet. Therefore, the voltage drop for 35feet cable would be;

Actual Voltage drop for 35feet = (7 x 35/100) x (24.5/31) = 1.94V

And Allowable voltage drop = (2.5 x 220)/100 = 5.5V

Here The Actual Voltage Drop (1.94) is less than that of maximum allowable voltage drop of 5.5V. Therefore, the appropriate and most suitable cable size is 6mm$^2$ for that given load for Electrical Wiring Installation.

Example 2

What type and size of cable suits for given situation

Load = 5.8Kw

Volts = 230V

Length of Circuit = 35meter

Temperature = 35°C (95°F)

Solution:-

Load = 5.8kW = 5800W

Voltage = 230V

Current = I = P/V = 5800 / 230 = 25.2A

20% additional load current = (20/100) x 25.2A = 5A

Total Load Current = 25.2A + 5A = 30.2A

Now select the size of cable for load current of 30.2A (from Table 1) which is 31 Amperes it means we can use $6mm^2$ cable according table 1.

Now check the selected cable with temperature factor in Table 3, so the temperature factor is 0.97 (in table 3) at 35°C (95°F) and current carrying capacity of is 31A, therefore, current carrying capacity of this cable at 35°C (95°F) would be;

Current rating for 35°C (95°F) = 31 x 0.97 = 30 Amp.

Since the calculated value (30 Amp) at 35°C (95°F) is less than that of current carrying capacity of $6mm^2$ cable which is 31A, therefore this size of cable $6mm^2$ is also suitable with respect to temperature.

Now find the voltage drop for per ampere meter for this cable from (Table2) which is 7mV, But in our case, the length of cable is 35 meter. Therefore, the voltage drop for 35 meter cable would be:

Actual Voltage drop for 35meter =

= mV x I x L

(7/1000) x 30×35 = 7.6V

And Allowable voltage drop = (2.5 x 230)/100 = 5.75V

Here the actual Voltage drop (7.35V) is greater than that of maximum allowable voltage drop of 5.75V. Therefore, this is not suitable size of cable for that given load. So we will select the next size of selected cable 10mm and find the voltage drop again. According to Table (2) the current rating of is 42 Amperes and the voltage drop in per ampere meter is 4.1 V (See table (2)). Therefore, the actual voltage drop for 35 meter cable would be;

Actual Voltage drop for 35meter =

= mV x I x L

(4.1/1000) x 40×35 = 7.35V = 5.74V

This drop is less than that of maximum allowable voltage drop. So this is the most appropriate and suitable cable or wire size.

Example 3

Following Loads are connected in a building:-

Sub-Circuit 1

2 lamps each o 1000W and

4 fans each of 80W

2 TV each of 120W

Sub-Circuit 2

6 Lamps each of 80W and

5 sockets each of 100W

4 lamps each of 800W

If supply voltages are 230V then calculate circuit current and Cable size for each Sub-Circuit?

Solution:-

Total load of Sub-Circuit 1

= (2 x 1000) + (4 x 80) + (2×120)

= 2000W + 320W + 240W = 2560W

Current for Sub-Circuit 1 = I = P/V = 2560/230 = 11.1A

Total load of Sub-Circuit 2

= (6 x 80) + (5 x 100) + (4 x 800)

= 480W + 500W + 3200W= 4180W

Current for Sub-Circuit 2 = I = P/V = 4180/230 = 18.1A

Therefore, Cable suggested for sub circuit 1 = 24A which is $4mm^2$

Cable suggested for Sub-Circuit 2 = 24A WHICH IS $4mm^2$

Total Current drawn by both Sub-Circuits = 11.1A + 18.1A = 29.27

So cable suggested for Main-Circuit = 31A which is $6mm^2$

## How to Calculate an Air Conditioner Circuit Breaker

Because air conditioners only advertise the type of voltage and wattage they require, you might run into some confusion when thinking about what kind of strength your circuit breaker should have. Since circuit breakers measure their capacity in amps, you must do a bit of math before coming to a suitable conclusion. Getting an undersized circuit breaker

will cause your air conditioner to trip the breaker every time it demands too much current from it.

### *Step 1*

Check your air conditioner's wattage in its specification sheet. Write down the maximum wattage it uses. If it doesn't mention wattage, check the SEER rating of your air conditioner and the cooling BTU number. Make sure you use the input BTU and not the output BTU, if both are listed. Divide the input BTU of your air conditioner by the SEER rating to get the amount of watts it requires, and write that down.

### *Step 2*

Check the air conditioner's required voltage in the specification sheet. If you don't see a voltage requirement, check the plug on the air conditioner. If you see a normal household plug on it with three straight prongs, assume 120 V of power requirement. If you see a plug with two diagonal prongs and one straight prong under it, assume 240 V of power requirement.

### *Step 3*

Divide the wattage number from Step 1 by the voltage number from Step 2. This gives you the amount of amps you need your circuit breaker to resist.