Reticulation Cable Size and Voltage Drop Calculation

1.0 Introduction

The tabulated current-carrying capacity relates to a single circuit in the installation methods shown in Table 4A (Refer to IEE Wiring Regulation Sixteenth Edition page 181, 182, 183, 184 & 185), in an ambient air temperature of 30°C. The current-carrying capacities given in the tables for a.c operation apply only to frequencies in the range 49 to 61 Hz.

The tabulated current-carrying capacity relates to continuous loading and is also known as the 'full thermal current rating' of the cable, corresponding to the conductor operating temperature indicated in the headings to the tables concerned. It is intended to provide for a satisfactory life of conductor and insulation subject to the thermal effects of carrying current for sustained periods in normal service. A cable may be seriously damaged, leading to early failure, or its service life may be significantly reduced, if it is operated for any prolonged period at a temperature higher than the indicated value.

In addition, there are other consideration affecting the choice of the cross-sectional area of a conductor, such as the requirements for protection against electric shock, protection against thermal effects, over current protection, voltage drop and the limiting temperatures for terminals of equipment to which the conductors are connected.

Other than that, the conductors will need to be sized in accordance with the relevant circuit criteria. This sizing will also have to be taken into account the type of cable and its insulation. Other requirements that will also affect the size indirectly may include: availability, type of building, environment, security, life expectancy, adaptability, aesthetics and cost.

2.0 Correction factors for current-carrying capacity

In order to determine the current-carrying capacity of the cable, it may be necessary to apply one or more correction factors to the tabulated value given in the appropriate table for the cable.

a) For ambient temperature

Tables 4C1 and 4C2 (Refer to IEE Wiring Regulation Sixteenth Edition page 188) give the correction factor to be applied to the tabulated current-carrying capacity depending upon the actual ambient temperature of the location in which the cable is to be installed.

b) For grouping

Tables 4B1, 4B2 and 4B3 (Refer to IEE Wiring Regulation Sixteenth Edition page 186 & 187) give the correction factor to be applied to the tabulated current-carrying capacity where cables or circuits are grouped.

c) For thermal insulation

For a cable installed in a thermally insulating wall or above a thermally insulated ceiling the cable being in contact with a thermally conductive surface on one side, the rating factor to applied may, in the absence of more precise information, be taken as 0.75 times the current carrying capacity for that a cable likely to be totally surrounded by thermally insulation material. The applicable rating factor may be as low as 0.5

3.0 Relationship of current-carrying capacity to other circuit parameters

The relevant symbols used in the Regulations are as follows:

I_z the current-carrying capacity of a cable for continuous service, under the particular installation condition concerned

I_t the value of current tabulated in the Table with referring to the IEE Wiring Regulation Sixteenth Edition for the type of cable and installation method concerned, for a single circuit in an ambient temperature of 30°C

I_b the design current of the circuit, i.e. the current intended to be carried by the circuit in normal service

I_n the nominal current or current setting of the device protecting the circuit against over current

C a correction factor to be applied where the installation conditions differ from those for which values of current-carrying capacity are tabulated in IEE Wiring Regulation Sixteenth Edition. The various correction factors are identified as follows:

C_a for ambient temperature

C_g for grouping

C_i for thermal insulation

C_t for operating temperature of conductor

In all circumstances I_z must be not less than I_b and In also must be not less than I_b. However CKE practice is $\mathbf{I_z > I_n > I_b}$

4.0 Determination of the size of cable

As a preliminary step it is useful to identify the length of the cable run and the permissible voltage drop for the equipment being supplied. The permissible voltage drop in mV, divided by I_b and by the length of run, will give the value of voltage drop in mV/A/m which can be tolerated. A voltage drop not exceeding that value is identified in the appropriate table and the corresponding cross-sectional area of conductor needed on this account can be read off directly before any other calculation are made.

The conductor size necessary from consideration of the conditions of normal load and overload is then determined. All correction factors affecting I_z (i.e. the factors for ambient temperature, grouping and thermal insulation) can, if desired, be applied to the values of I_t as multipliers. This involves a process of trial and error until a cross-sectional area is reached which ensures that I_z is not less than I_b and not less than I_n of any protective device it is intended to select. In any event, if a correction factor for protection by a semi-enclosed fuse is necessary, this has to be applied to I_n as a divisor. It is therefore more convenient to apply all the correction factors to I_n as divisors.

Once the cable type and other characteristics have been considered, the conductor size can be determined. This size will be dependent upon the current required by the circuit load

The following procedure enables the designer to determine the size of cable it will be necessary to use in order to comply with the requirement for overland protection.

1. For single circuits

   Divide the nominal current of the protective device (I_n) by any applicable correction factor for ambient temperature (C_a) given in Table 4C1 and then further divide by any applicable correction factor for thermal insulation (C_i).

   The size of cable to be used is to be such that it's tabulated current-carrying capacity (I_t) is not less than the value of nominal current of the protective device adjusted as below:

$$I_t \geq \frac{I_n}{C_a C_i}$$

2. For groups

   Divide the nominal current of the protective device (I_n) by the correction factor for grouping (Cg) given in Tables 4B1, 4B2 or 4B3:

$$I_t \geq \frac{In}{C_g}$$

Where a rewire able fuse to BS036 is to be used, an additional factor (0.725) must be included, hence

$$I_t \geq \frac{I_n}{0.725 C_a C_i C_g}$$

Thus, the factors to determining current carrying capacity of conductors will be such as:

a. cross-sectional area
b. type of cable or conductor
c. method of installation
d. number of conductors grouped together

e. Environmental conditions, e.g. high ambient temperature, enclosure in thermally insulating material.

Once the factors that apply to a particular conductor have been ascertained the value of I_t can be found by calculation and reference then made to the relevant table i.e. 4D1A (single core PVC insulated), to obtain the cable size.

5.0 Voltage Drop

Values of voltage drop are tabulated for a current of one ampere for a meter run i.e. for a distance of 1 m along the route taken by the cables, and then present the result of the voltage drops in the entire circuit conductor. For any given run the values need to be multiplied by length of the run in meters and by the current the cables are to carry, in amperes. The voltage drop for any particular cable run must be such that the voltage drop in the circuit of which the cable forms a part does not exceed 4% of the nominal voltage of the supply. As a guide, refer to the following diagram. Volt drop from DB to final point need not be calculated. It is assumed to be negligible since we are limiting our final circuit to not more than 80 meters from the DB.

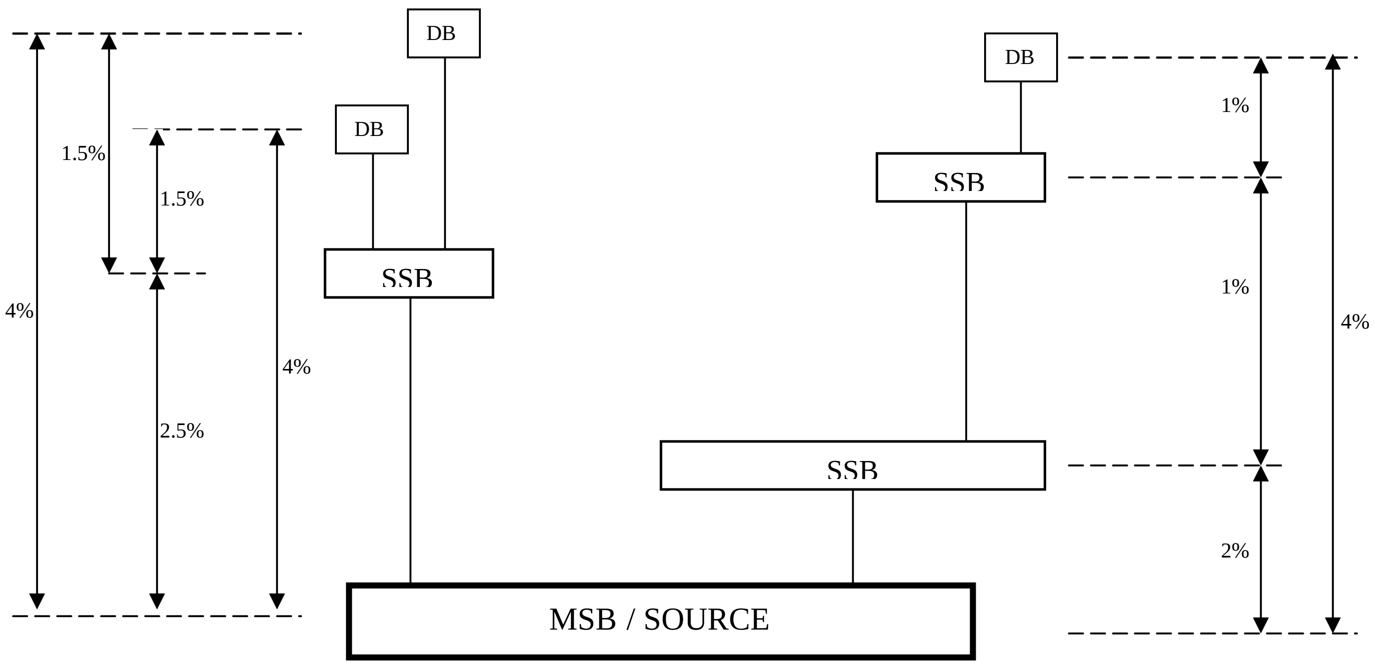

Diagram 1

However for external lighting the volt drop from DB to final point must be calculated. The total must not exceed 4%.

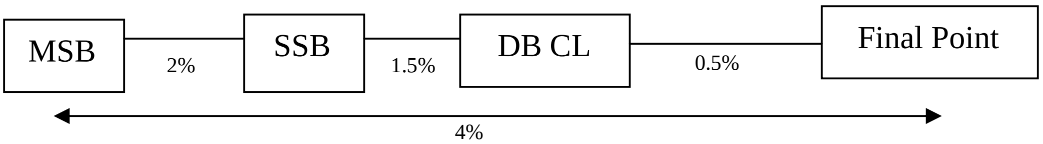

Diagram 2

The voltage drop calculated from the formula:-

Voltage Drop V_D $= \frac{V_d \times L \times I_n}{1000}$

Where V_d = permissible voltage drop (mV/A/m)
I_n = the device current of the circuit (A)
V_D = volt drop (V)
L = length of cable (m)

It is pertinent to point out that the cable rating must always be higher than (or equal to) that of the fuse or circuit breaker that is supposed to protect that part of the installation.

6.0 Type of cables commonly used

It used to be a standard practice in CKE to use PVC/PVC cables for non conduit wiring (surface and concealed). However these two (2) types of wiring are not used anymore in CKE. All wiring must now be in conduit using PVC insulated cables.

Underground cables that are widely used:

i) PILCDSTAS Cable (Paper Insulated, Lead Covered, Double Steel Tape Armoured and Served cable).

This is use conjunction with cable-box termination and is available only in the 3 phase 4 core types, normally used when the 3 phase line current exceeds 40A.

ii) PVC/SWA/PVC Cable (Polyvinyl Chloride / Steel Wire Armoured / Polyvinyl Chloride Cable).

This cable is used with cable gland terminations and is available both in the 3 phase 4 core as well as in the single phase 2 core. It is generally used when the current demand is less than 60A.

iii) XLPE / SWA / PVC Cable. (Crosslinked Polyethylene / Steel Wire Armoured / Polyvinyl Chloride Cable)

Normally used for $35mm^2$ and above.

For more information on other types of cables refer to manufacturers.

Unless otherwise required all cables used for JKR projects shall be copper.

7.0 Practical Design Example

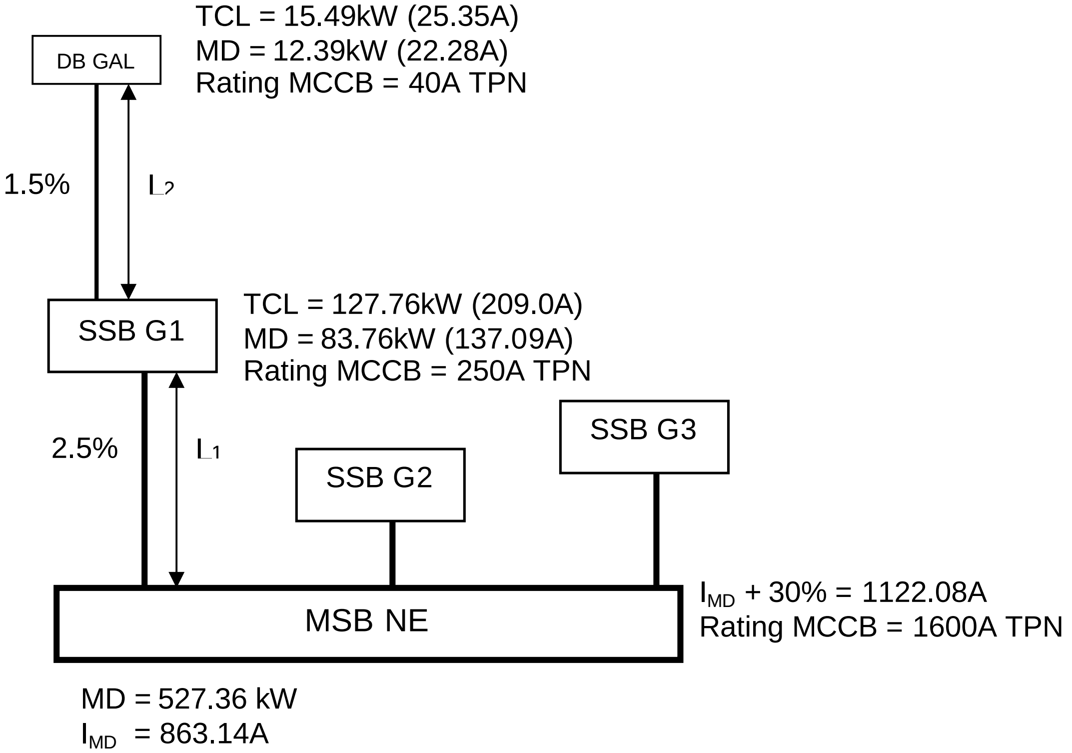

Diagram 3

Allowable voltage drop:

2.5% = 10.375V
1.5% = 6.225V } 3 phase

$I_z > I_n > I_b$

i) **Calculate cable size used and voltage drop from SSB G to DB GAL**

a) Consider copper conductor used e.g. single core PVC insulated cable and installation method is enclosed in conduit on a wall where L_2 = 60 metre.

$I_z > I_n > I_b$

Refer to table 4D1A from IEE Wiring Regulation Sixteenth Edition, I_z = 50A

$I_z > 40 > 22.28$

$50 > 40 > 22.28$

From value of I_z we get cable size of 10mm².

From table 4D1B voltage drop (per ampere per metre), V_d = 4.4 mV/A/m

Voltage drop (V_D) $= V_d \times L_2 \times I_n / 1000$
$= 4.4 \times 60 \times 40 / 1000$

= 10.56V

Therefore cable to be used is 4 x 10mm² PVC in conduit.

b) Say L_2 is longer i.e. L_2 = 80 metre

Voltage drop (V_D) = V_d x L_2 x I_n / 1000
= 4.4 x 80 x 40 / 1000
= 7.84V
(exceeding allowable voltage drop of 6.225V)

Thus, 4 x 10mm² PVC in conduit cannot be used.

Check again the I_z value.

Refer to table 4D1A from IEE Wiring Regulation Sixteenth Edition, I_z = 68A

I_z > 40 > 22.28

68 > 40 > 22.28

From value of I_z we get cable size of 16mm².

From table 4D1B voltage drop (per ampere per metre), V_d = 2.8 mV/A/m

Voltage drop (V_D) = V_d x L_2 x I_n / 1000
= 2.8 x 80 x 22.28 / 1000
= 4.99V

Therefore cable to be used is 4 x 16mm² PVC in conduit.

ii) **Calculate cable size used and voltage drop from MSB NE to SSB G**

a) Consider copper conductor XLPE/SWA/PVC cable, installed underground where L_1 = 110 metre

Iz > In > Ib

Refer to table 4E4A from IEE Wiring Regulation Sixteenth Edition, I_z = 251A

I_z > 250 > 137.09

251 > 250 > 137.09

From value of I_z we get cable size of 70mm².

From table 4E4B voltage drop (per ampere per metre), V_d = 0.60 mV/A/m

Voltage drop (V_D) = V_d x L_1x I_n / 1000
= 0.60 x 110 x 137.09 / 1000
= 9.05V

Therefore cable to be used is 4 core 70mm² XLPE/SWA/PVC laid in the ground.

b) Say L_1 is longer i.e. L_1 = 155 metre

Voltage drop (V_D) = V_d x L_1 x I_n / 1000
= 0.60 x 155 x 137.09 / 1000
= 12.75V
(exceeding allowable voltage drop of 10.375V)

Thus, 4 core 70mm² XLPE/SWA/PVC cannot be used.

Check again the I_z value.

Refer to table 4E4A from IEE Wiring Regulation Sixteenth Edition, I_z = 304A

I_z > 250 > 137.09

304 > 250 > 137.09

From value of I_z we get cable size of 95mm².

From table 4E4B voltage drop (per ampere per metre), V_d = 0.45 mV/A/m

Voltage drop (V_D) = V_d x L_1 x I_n / 1000
= 0.45 x 155 x 137.09 / 1000
= 9.56V

Therefore cable to be used is 4 core 95mm² XLPE/SWA/PVC laid in the ground.

c) Say L_1 is longer i.e. L_1 = 250 metre

Voltage drop (V_D) = V_d x L_1 x I_n / 1000
= 0.60 x 250 x 137.09 / 1000
= 20.56V
(exceeding allowable voltage drop of 10.375V)

Thus, 4 core 70mm² XLPE/SWA/PVC cannot be used.

Check again the I_z value.

Refer to table 4E4A from IEE Wiring Regulation Sixteenth Edition.

Refer next value of I_z and calculate the volt drop until the acceptable volt drop is achieved. In this case the I_z that result in an acceptable volt drop is I_z = 406A

I_z > 250 > 137.09

406 > 250 > 137.09

Therefore cable to be used is 4 core 150mm² XLPE/SWA/PVC laid in the ground.