3 Determination of voltage drop

3.2 Calculation of voltage drop in steady load conditions

Use of formulae

Figure G27 below gives formulae commonly used to calculate voltage drop in a given circuit per kilometre of length.

If:

- I_B: The full load current in amps
- L: Length of the cable in kilometres
- R: Resistance of the cable conductor in Ω/km

$$R = \frac{22.5\ \Omega\ mm^2/km}{S(\text{c.s.a. in } mm^2)} \text{ for copper}$$

$$R = \frac{36\ \Omega\ mm^2/km}{S(\text{c.s.a. in } mm^2)} \text{ for aluminium}$$

Note: R is negligible above a c.s.a. of 500 mm^2

- X: inductive reactance of a conductor in Ω/km

Note: X is negligible for conductors of c.s.a. less than 50 mm^2. In the absence of any other information, take X as being equal to 0.08 Ω/km.

- φ: phase angle between voltage and current in the circuit considered, generally:
  - Incandescent lighting: cos φ = 1
  - Motor power:

- At start-up: cos φ = 0.35
- In normal service: cos φ = 0.8

- Un: phase-to-phase voltage
- Vn: phase-to-neutral voltage

For prefabricated pre-wired ducts and bustrunking, resistance and inductive reactance values are given by the manufacturer.

Circuit	Voltage drop (ΔU)	
	in volts	in %
Single phase: phase/phase	$\Delta U = 2 I_B (R \cos\varphi + X \sin\varphi) L$	$\frac{100\ \Delta U}{Un}$
Single phase: phase/neutral	$\Delta U = 2 I_B (R \cos\varphi + X \sin\varphi) L$	$\frac{100\ \Delta U}{Vn}$
Balanced 3-phase: 3 phases (with or without neutral)	$\Delta U = \sqrt{3}\, I_B (R \cos\varphi + X \sin\varphi) L$	$\frac{100\ \Delta U}{Un}$

Fig. G27 : Voltage-drop formulae

Simplified table

Calculations may be avoided by using **Figure G28** next page, which gives, with an adequate approximation, the phase-to-phase voltage drop per km of cable per ampere, in terms of:

- Kinds of circuit use: motor circuits with cos φ close to 0.8, or lighting with a cos φ close to 1.
- Type of cable; single-phase or 3-phase

Voltage drop in a cable is then given by:

K x I_B x L

K is given by the table,

I_B is the full-load current in amps,

L is the length of cable in km.

The column motor power "cos φ = 0.35" of Figure G28 may be used to compute the voltage drop occurring during the start-up period of a motor (see example no. 1 after the Figure G28).