Cable reactance values can be obtained from the manufacturers. For c.s.a. of less than 50 mm² reactance may be ignored. In the absence of other information, a value of 0.08 mΩ/metre may be used (for 50 Hz systems) or 0.096 mΩ/metre (for 60 Hz systems). For prefabricated bus-trunking and similar pre-wired ducting systems, the manufacturer should be consulted.

- **Motors**

At the instant of short-circuit, a running motor will act (for a brief period) as a generator, and feed current into the fault.

In general, this fault-current contribution may be ignored. However, if the total power of motors running simultaneously is higher than 25% of the total power of transformers, the influence of motors must be taken into account. Their total contribution can be estimated from the formula:

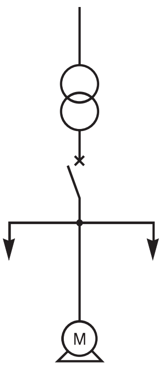
Iscm = 3.5 In from each motor i.e. 3.5*m*In for *m* similar motors operating concurrently.

The motors concerned will be the 3-phase motors only; single-phase-motor contribution being insignificant.

- **Fault-arc resistance**

Short-circuit faults generally form an arc which has the properties of a resistance. The resistance is not stable and its average value is low, but at low voltage this resistance is sufficient to reduce the fault-current to some extent. Experience has shown that a reduction of the order of 20% may be expected. This phenomenon will effectively ease the current-breaking duty of a CB, but affords no relief for its fault-current making duty.

- Recapitulation table (see **Fig. G36**)



Parts of power-supply system	R (mΩ)	X (mΩ)
Supply network Figure G34	$\frac{Ra}{Xa} = 0.1$	$Xa = 0.995\ Za;\ Za = \frac{U_{20}^2}{Psc}$
Transformer Figure G35	$Rtr = \frac{Pcu \times 10^3}{3 In^2}$ Rtr is often negligible compared to Xtr for transformers > 100 kVA	$\sqrt{Ztr^2 - Rtr^2}$ with $Ztr = \frac{U_{20}^2}{Pn} \times \frac{Usc}{100}$
Circuit-breaker	Negligible	X_D = 0.15 mΩ/pole
Busbars	Negligible for S > 200 mm² in the formula: $R = \rho \frac{L}{S}$ (1)	X_B = 0.15 mΩ/m
Circuit conductors(2)	$R = \rho \frac{L}{S}$ (1)	Cables: X_c = 0.08 mΩ/m
Motors	See Sub-clause 4.2 Motors (often negligible at LV)	
Three-phase short circuit current in kA	$Isc = \frac{U_{20}}{\sqrt{3}\sqrt{R_T^2 + X_T^2}}$	

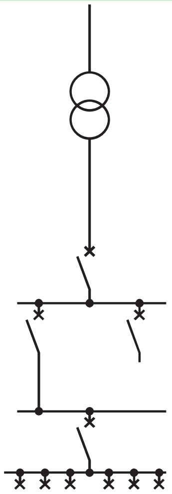
U_{20}: Phase-to-phase no-load secondary voltage of MV/LV transformer (in volts).
Psc: 3-phase short-circuit power at MV terminals of the MV/LV transformers (in kVA).
Pcu: 3-phase total losses of the MV/LV transformer (in watts).
Pn: Rating of the MV/LV transformer (in kVA).
Usc: Short-circuit impedance voltage of the MV/LV transfomer (in %).
R_T : Total resistance. X_T: Total reactance

(1) ρ = resistivity at normal temperature of conductors in service
- ρ = 22.5 mΩ x mm²/m for copper
- ρ = 36 mΩ x mm²/m for aluminium

(2) If there are several conductors in parallel per phase, then divide the resistance of one conductor by the number of conductors. The reactance remains practically unchanged.

Fig. G36 : Recapitulation table of impedances for different parts of a power-supply system

■ Example of short-circuit calculations (see **Fig. G37**)



LV installation	R (mΩ)	X (mΩ)	RT (mΩ)	XT (mΩ)	$Isc = \frac{420}{\sqrt{3}\sqrt{R_T^2 + X_T^2}}$
MV network Psc = 500 MVA	0.035	0.351			
Transformer 20 kV/420 V Pn = 1000 kVA Usc = 5% Pcu = 13.3 x 10^3 watts	2.24	8.10			
Single-core cables 5 m copper 4 x 240 mm^2/phase	$R_C = \frac{22.5}{4} x \frac{5}{240} = 0.12$	X_C = 0.08 x 5 = 0.40	2.41	8.85	Isc1 = 26 kA
Main circuit-breaker	R_D = 0	X_D = 0.15			
Busbars 10 m	R_B = 0	X_B = 1.5	2.41	10.5	Isc2 = 22 kA
Three-core cable 100 m 95 mm^2 copper	$R_C = 22.5 x \frac{100}{95} = 23.68$	X_C = 100 x 0.08 = 8	26.1	18.5	Isc3 = 7.4 kA
Three-core cable 20 m 10 mm^2 copper final circuits	$R_C = 22.5 x \frac{20}{10} = 45$	X_C = 20 x 0.08 = 1.6	71.1	20.1	Isc4 = 3.2 kA

Fig. G37 : Example of short-circuit current calculations for a LV installation supplied at 400 V (nominal) from a 1,000 kVA MV/LV transformer

4.3 Isc at the receiving end of a feeder as a function of the Isc at its sending end

The network shown in **Figure G38** typifies a case for the application of **Figure G39** next page, derived by the «method of composition» (mentioned in Chapter F Sub-clause 6.2). These tables give a rapid and sufficiently accurate value of short-circuit current at a point in a network, knowing:

■ The value of short-circuit current upstream of the point considered

■ The length and composition of the circuit between the point at which the short-circuit current level is known, and the point at which the level is to be determined

It is then sufficient to select a circuit-breaker with an appropriate short-circuit fault rating immediately above that indicated in the tables.

If more precise values are required, it is possible to make a detailled calculation (see Sub-Clause 4.2) or to use a software package, such as Ecodial. In such a case, moreover, the possibility of using the cascading technique should be considered, in which the use of a current limiting circuit-breaker at the upstream position would allow all circuit-breakers downstream of the limiter to have a short-circuit current rating much lower than would otherwise be necessary (See chapter H Sub-Clause 4.5).

Method

Select the c.s.a. of the conductor in the column for copper conductors (in this example the c.s.a. is 47.5 mm^2).

Search along the row corresponding to 47.5 mm^2 for the length of conductor equal to that of the circuit concerned (or the nearest possible on the low side). Descend vertically the column in which the length is located, and stop at a row in the middle section (of the 3 sections of the Figure) corresponding to the known fault-current level (or the nearest to it on the high side).

In this case 30 kA is the nearest to 28 kA on the high side. The value of short-circuit current at the downstream end of the 20 metre circuit is given at the intersection of the vertical column in which the length is located, and the horizontal row corresponding to the upstream Isc (or nearest to it on the high side).

This value in the example is seen to be 14.7 kA.

The procedure for aluminium conductors is similar, but the vertical column must be ascended into the middle section of the table.

In consequence, a DIN-rail-mounted circuit-breaker rated at 63 A and Isc of 25 kA (such as a NG 125N unit) can be used for the 55 A circuit in Figure G38.

A Compact rated at 160 A with an Isc capacity of 25 kA (such as a NS160 unit) can be used to protect the 160 A circuit.

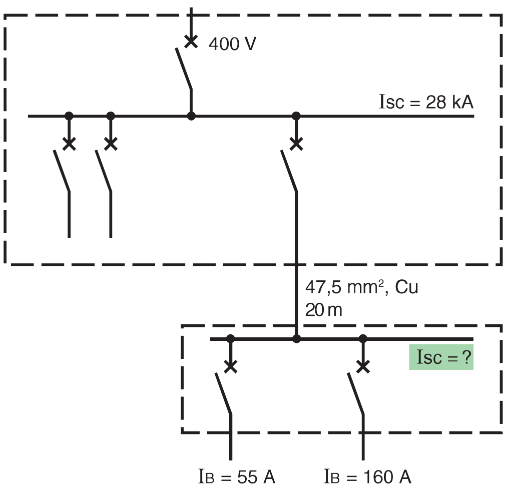


Fig. G38 : Determination of downstream short-circuit current level Isc using Figure G39