JUNE 2021

# Welcome

## Technical Sharing Session

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ABB

# Short Circuit Calculation

## IEC 60909

# Short Circuit Calculation

## IEC 60909

### IEC 60909 Part 0 to 4

- Part 0

  Calculation of currents
- Part 1

  Factors for the calculation of short circuit currents according to Part 0.
- Part 2

  Data of electrical equipment for short-circuit current calculations
- Part 3

  Currents during two separate simultaneous line-to-earth short circuits and partial short-circuit currents flowing through earth
- Part 4

  Examples for the calculation of short-circuit currents

# Short Circuit Calculation

## IEC 60909

### IEC 60909-0

Short-circuit currents in three-phase a.c. systems

- Terms and definitions
- Short-circuit currents
- Calculating Assumptions
- Short-circuit impedances of electrical equipment


IEC 60909-0

Edition 2.0 2016-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Short-circuit currents in three-phase a.c. systems –
Part 0: Calculation of currents

Courants de court-circuit dans les réseaux triphasés à courant alternatif –
Partie 0: Calcul des courants

# Short Circuit Calculation

## IEC 60909

### Terms & Definitions

- Short-circuit

  “Accidental or intentional conductive path between two or more conductive parts forcing the electric potential differences between these conductive parts to be equal or close to zero”

- Short-circuit current

  “Overcurrent resulting from a short-circuit in an electric system”

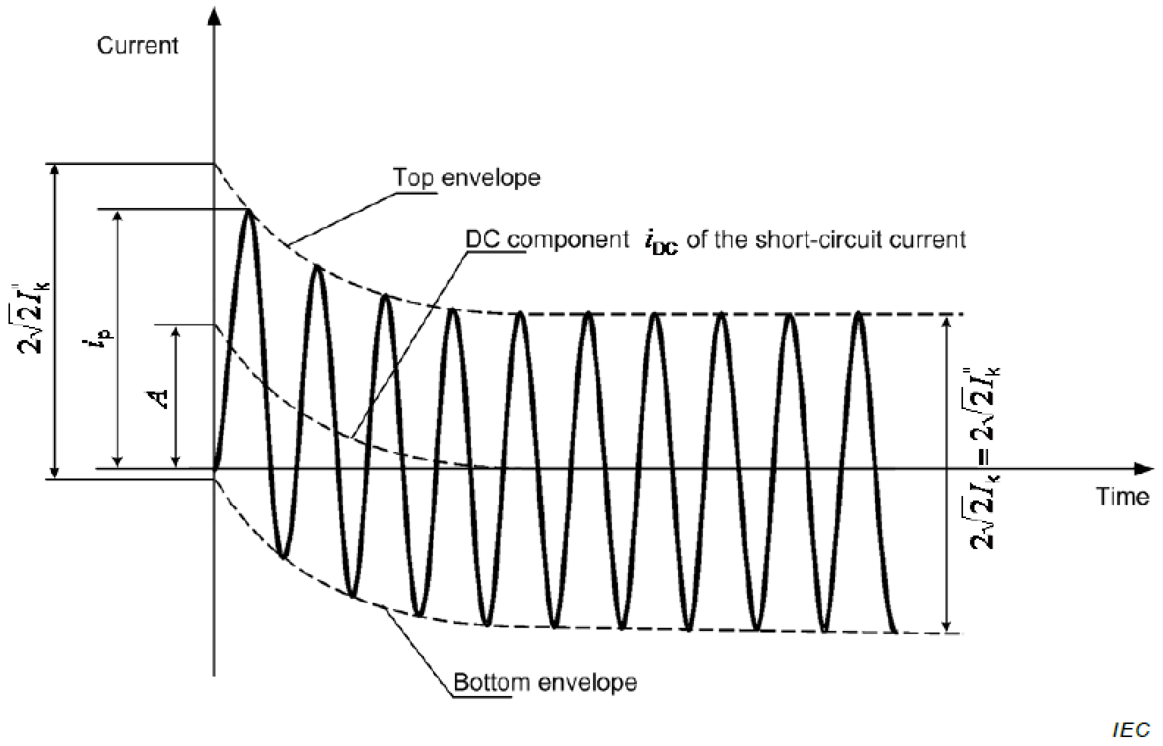
- Prospective short-circuit current

  “Current that would flow if the short circuit were placed by an ideal connection of negligible impedance without any change of the supply”

# Short Circuit Calculation

IEC 60909

## Short-circuit currents




**Key**

| | |
|---|---|
| $I_k''$ | initial symmetrical short-circuit current |
| $i_p$ | peak short-circuit current |
| $I_k$ | steady-state short-circuit current |
| $i_{DC}$ | DC component of short-circuit current |
| $A$ | initial value of the DC component $i_{DC}$ |

# Short Circuit Calculation

## IEC 60909

### Short-circuit currents

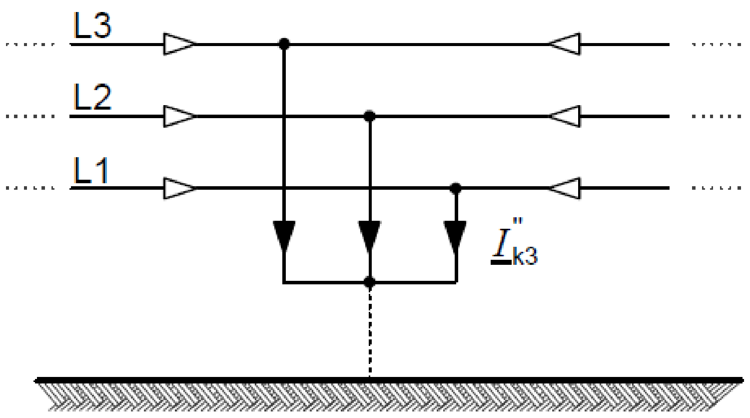



Figure 3a – Three-phase short circuit

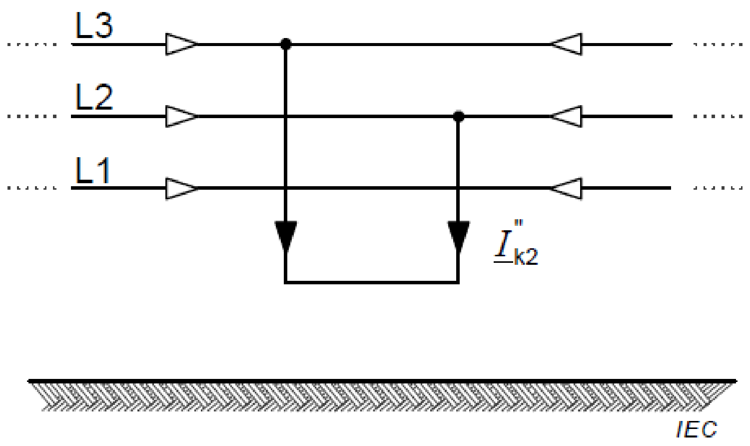



Figure 3b – Line-to-line short circuit

# Short Circuit Calculation

## IEC 60909

### Short-circuit currents

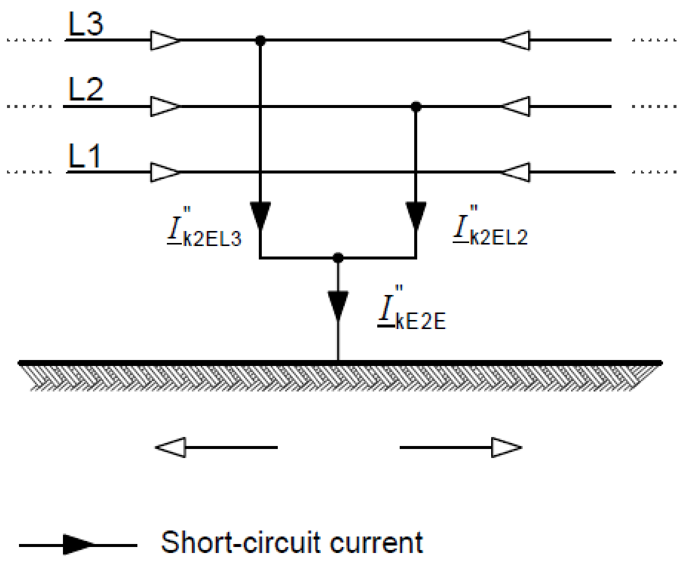



Figure 3c – Line-to-line short circuit with earth connection

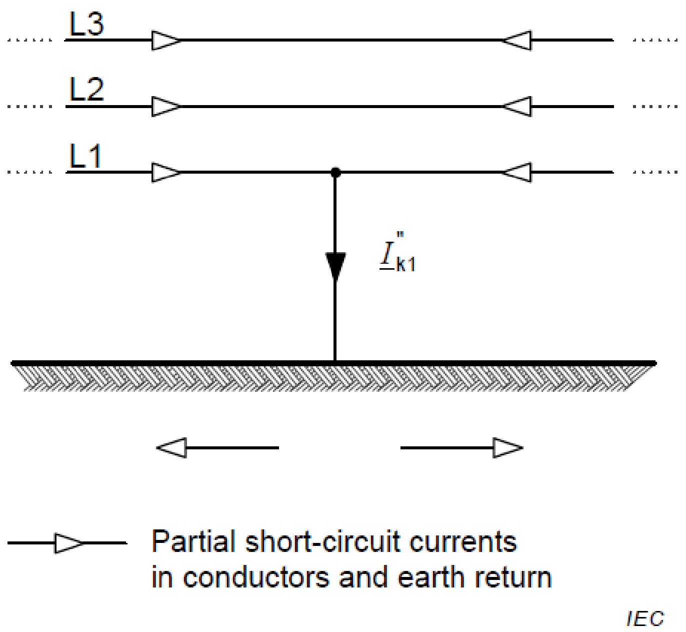



Figure 3d – Line-to-earth short circuit

# Short Circuit Calculation

IEC 60909

## Calculation assumptions

The calculation of maximum and minimum short-circuit currents is based on the following simplifications.

- For the duration of the short circuit there is no change in the type of short circuit involved, that is, a three-phase short-circuit remains three-phase and a line-to-earth short circuit remains line-to-earth during the time of short circuit.
- For the duration of the short circuit, there is no change in the network involved.
- The impedance of the transformers is referred to the tap-changer in main position.
- Arc resistances are not taken into account.
- Shunt admittances of non-rotating loads shall be neglected in the positive-, the negative and the zero-sequence system.
- Line capacitances shall be neglected in the positive- and negative-sequence system. Line capacitances in the zero-sequence system shall be taken into account in low-impedance
- Earthed networks having an earth-fault factor (see IEC 60027-1) higher than 1,4.
- Magnetising admittances of transformers shall be neglected in the positive and negative sequence system.

# Short Circuit Calculation

IEC 60909

## Method of calculation

Equivalent voltage source at the short-circuit location

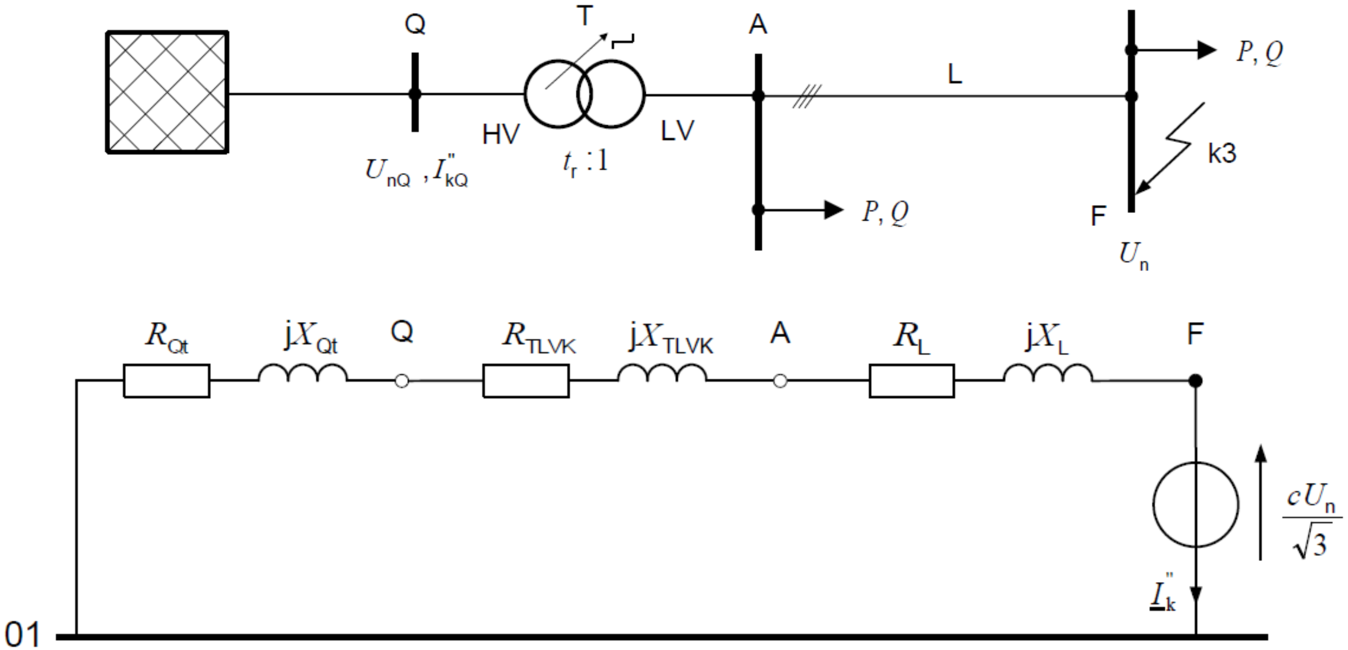



**Table 1 – Voltage factor $c$**

| Nominal system voltage $U_n$ | Voltage factor $c$ for the calculation of maximum short-circuit currents $c_{max}$ [a] | Voltage factor $c$ for the calculation of minimum short-circuit currents $c_{min}$ |
|---|---|---|
| Low voltage<br>100 V to 1 000 V<br>(IEC 60038:2009, Table 1) | 1,05[c]<br>1,10[d] | 0,95[c]<br>0,90[d] |
| High voltage[b]<br>>1 kV to 230 kV<br>(IEC 60038:2009, Tables 3, 4) | 1,10 | 1,00 |

[a] $c_{max}U_n$ should not exceed the highest voltage $U_m$ for equipment of power systems.

[b] If no nominal system voltage is defined $c_{max}U_n = U_m$ or $c_{min}U_n = 0{,}90 \cdot U_m$ should be applied.

[c] For low-voltage systems with a tolerance of ±6 %, for example systems renamed from 380 V to 400 V.

[d] For low-voltage systems with a tolerance of ±10 %.

[e] For nominal system voltages related to $U_m$ > 420 kV, the voltage factors c are not defined in this standard.

# Short Circuit Calculation

IEC 60909

## Short-circuit impedances of electrical equipment

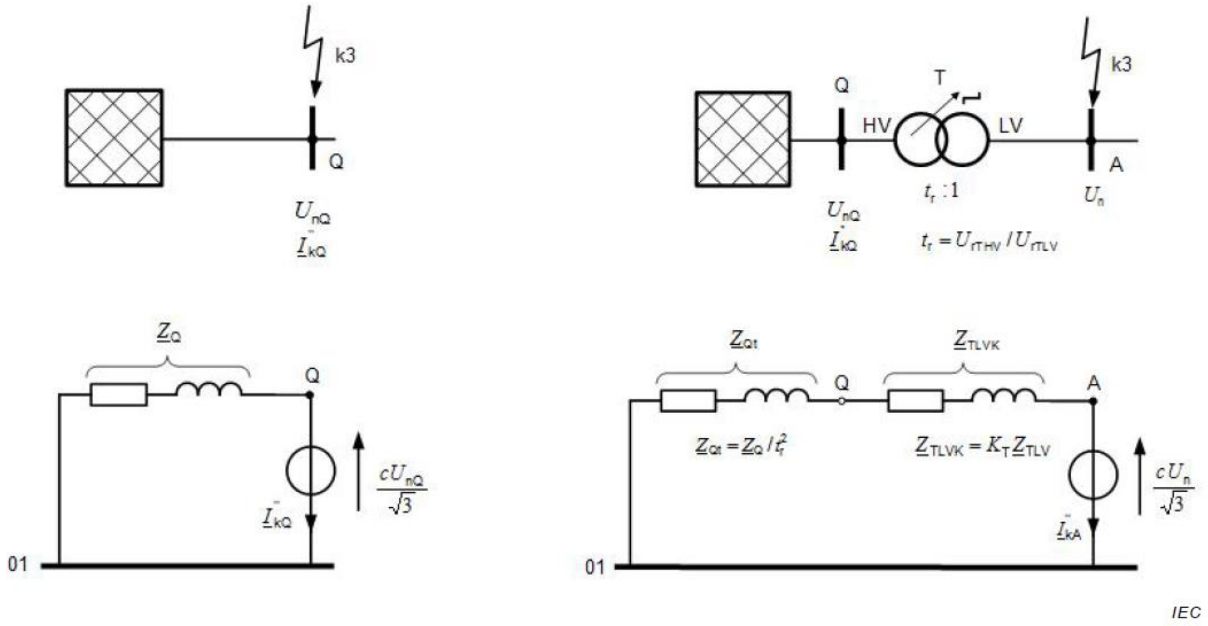



Figure 5a – Without transformer

Fig. 5b – With transformer

**Figure 5 – System diagram and equivalent circuit diagram for network feeders**

# Short Circuit Calculation

## IEC 60909

### Short-circuit impedances of two-winding transformer

The positive-sequence short-circuit impedances of two-winding transformers $Z_T = R_T + jX_T$ with and without on-load tap-changer can be calculated from the rated transformer data as follows:

$$Z_T = \frac{u_{kr}}{100\ \%} \cdot \frac{U_{rT}^2}{S_{rT}}$$

$$R_T = \frac{u_{Rr}}{100\ \%} \cdot \frac{U_{rT}^2}{S_{rT}} = \frac{P_{krT}}{3 \cdot I_{rT}^2}$$

$$X_T = \sqrt{Z_T^2 - R_T^2}$$

where

- $U_{rT}$ is the rated voltage of the transformer on the high-voltage or low-voltage side;
- $I_{rT}$ is the rated current of the transformer on the high-voltage or low-voltage side;
- $S_{rT}$ is the rated apparent power of the transformer;
- $P_{krT}$ is the total loss of the transformer in the windings at rated current;
- $u_{kr}$ is the short-circuit voltage at rated current in per cent;
- $u_{Rr}$ is the rated resistive component of the short-circuit voltage in per cent.

# Short Circuit Calculation

## IEC 60909

### Short-circuit impedances of Overhead lines and cables

The positive-sequence short-circuit impedance $Z_L = R_L + jX_L$ may be calculated from the conductor data, such as the cross-sections and the centre-distances of the conductors.

The effective resistance per unit length $R_L'$ of overhead lines at the conductor temperature 20 °C may be calculated from the nominal cross-section $q_n$ and the resistivity ρ :

$$R_L' = \frac{\rho}{q_n}$$

where

$d$ is the geometric mean distance between conductors, or the centre of bundles: $d = \sqrt[3]{d_{L1L2} \cdot d_{L2L3} \cdot d_{L3L1}}$;

$r$ is the radius of a single conductor. In the case of conductor bundles, $r$ is to be substituted by $r_B = \sqrt[n]{nrR^{n-1}}$, where $R$ is the bundle radius (see IEC TR 60909-2);

$n$ is the number of bundled conductors; for single conductors $n$ = 1;

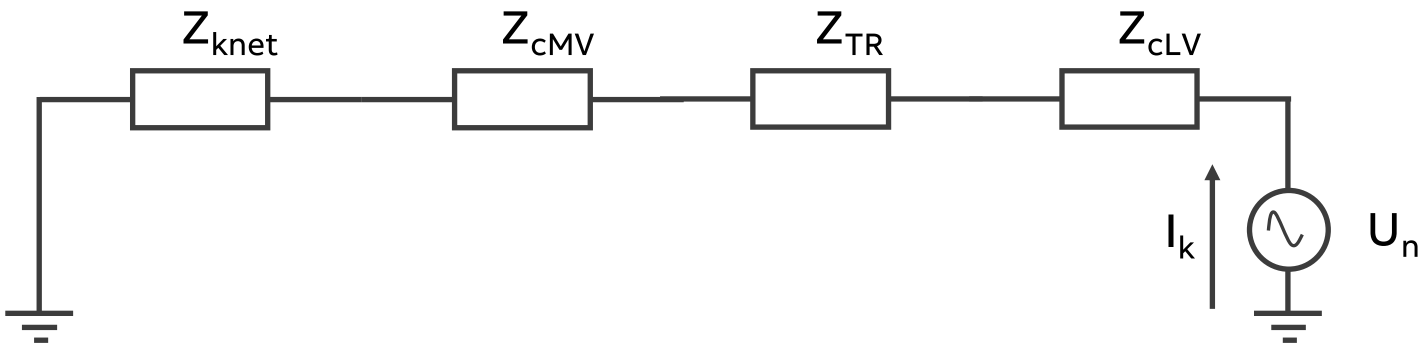
$\mu_0$ = $4\pi \cdot 10^{-4}$ H/km.

# Short Circuit Calculation

## IEC 60909

### Calculation of Short circuit currents

The equivalent network is solved according to standard electro-technical rules (circuits in series / in parallel)




$$I_k = \frac{U_n}{\sqrt{3} \cdot (Z_{knet} + Z_{cMV} + Z_{TR} + Z_{cLV})}$$

# Short Circuit Calculation

## Basic Principles

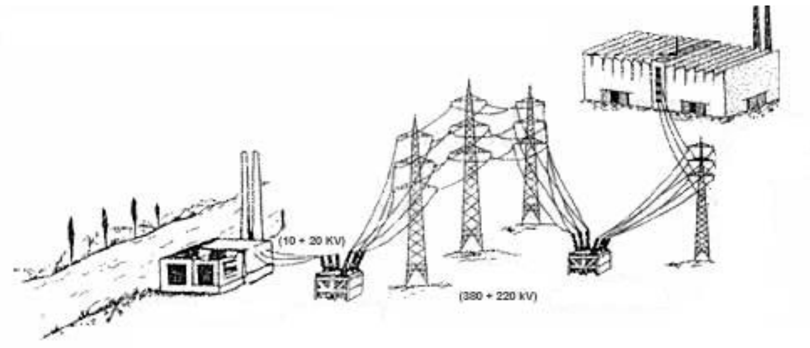
### Calculation of Short Circuit Currents

Distribution network

– It is necessary to know the network short-circuit power

- From 250MVA to 500MVA $U_n \leq 30kV$
- From 700MVA to 1500MVA Un > 30kV
- According to IEC 60076-5

$$Z_{knet} = \frac{U_n^2}{S_{knet}} = \frac{U_n}{\sqrt{3} \cdot I_{knet}}$$




| Distribution network voltage [kV] | Short-circuit apparent power Current European practice [MVA] | Short-circuit apparent power Current North-American practice [MVA] |
|---|---|---|
| 7.2–12–17.5-24 | 500 | 500 |
| 36 | 1000 | 1500 |
| 52–72.5 | 3000 | 5000 |

# Short Circuit Calculation

## Basic Principles

### Calculation of Short Circuit Currents

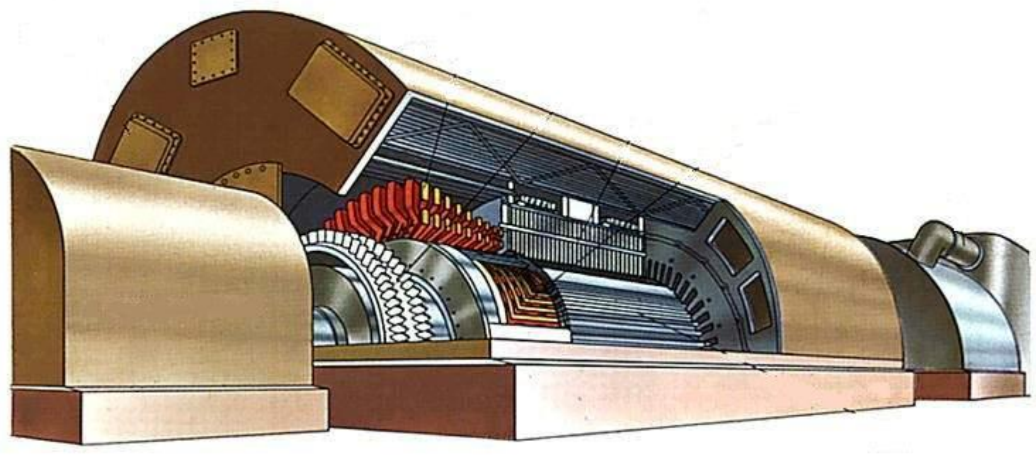
Generator short circuit impedance

– It is necessary to know the
  - Rated apparent power $S_n$
  - Rated voltage $U_n$
  - Subtransient reactance $X''_d$

from 10% to 20% smooth rotor (isotropic machines)

from 15% to 30% salient pole rotor (anisotropic machines)

$$X''_d = \frac{x''_d}{100} \cdot \frac{U_n^2}{S_n}$$



# Short Circuit Calculation

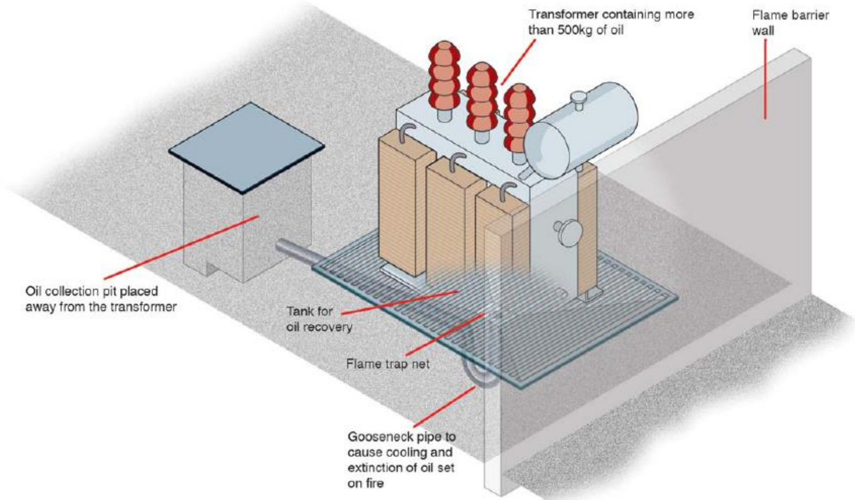
## Basic Principles

### Calculation of Short Circuit Currents

Transformers

– It is necessary to know the
  - Rated apparent power $S_n$
  - Primary rated voltage $V_{1n}$
  - Secondary rated voltage $V_{2n}$
  - Short-circuit voltage $u_{k\%}$(Between 4% to 8%)
  - According to IEC60076-5

$$Z_{TR} = \frac{u_{k\%}}{100} \cdot \frac{U_{2n}^2}{S_n}$$




| Rated apparent power $S_n$ [kVA] | Short-circuit voltage $v_{k\%}$ |
|---|---|
| ≤ 630 | 4 |
| $630 < S_n \leq 1250$ | 5 |
| $1250 < S_n \leq 2500$ | 6 |
| $2500 < S_n \leq 6300$ | 7 |
| $6300 < S_n \leq 25000$ | 8 |

# Short Circuit Calculation

## Basic Principles

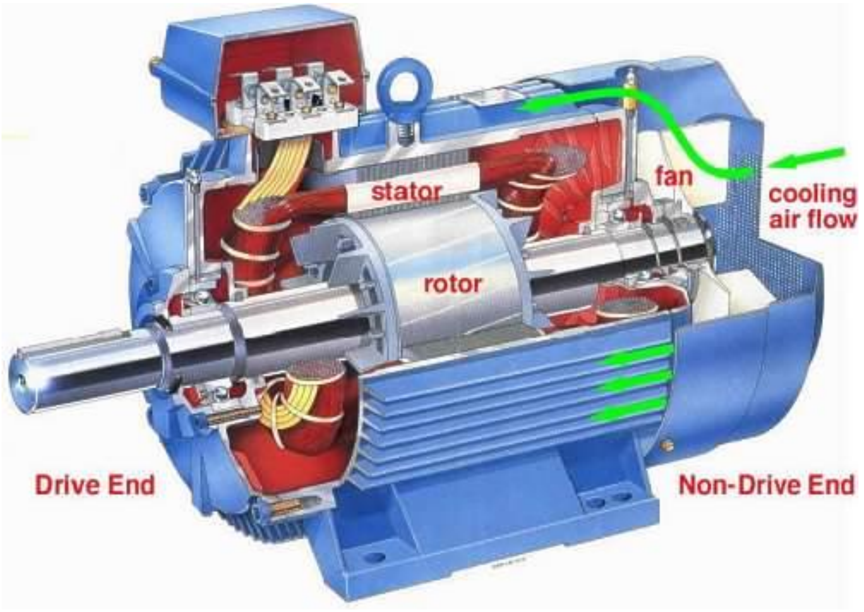
### Calculation of Short Circuit Currents

Asynchronous motors

- In case of short-circuit it functions as a generator with a $x''_d$ from 20% to 25%
- a current equal to 4-6 times the $I_n$ can be assumed as contribution to the short-circuit
- the minimum criteria for taking into consideration the phenomenon

$$\left(\sum I_{nM} > \frac{I_k}{100}\right)$$

(Ik short-circuit without motor contribution)



# Short Circuit Calculation

## Basic Principles

### Calculation of Short Circuit Currents

Example

$S_k$ = 500 MVA
$U_{MV}$= 20 kV

$Z_{cMV}$ = 0.01 Ω

$S_n$ = 400 kVA
U= 20/0.4 kV
$u_{k\%}$ = 4 %

$Z_{cLV}$ = 0.06 Ω

# Short Circuit Calculation

Basic Principles

## Calculation of Short Circuit Currents

Example

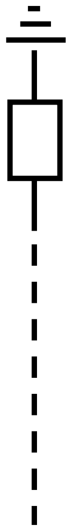
$$Z_{u20kV} = \frac{U^2}{S_k} = \frac{\left(20 \cdot 10^3\right)^2}{\left(500 \cdot 10^6\right)} = 0.8\Omega$$

$$Z_{u400V} = Z_{u20kV} \cdot \frac{(400)^2}{(20000)^2} = 3.2 \cdot 10^{-4}\Omega$$

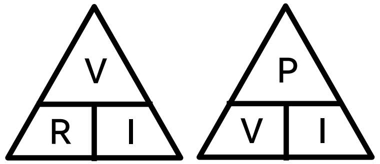



$S_k$ = 500 MVA
$U_{MV}$= 20 kV

$$\frac{V1}{V2} = \frac{N1}{N2} = \frac{I2}{I1}$$



$Z_u$ = 0.32 mΩ



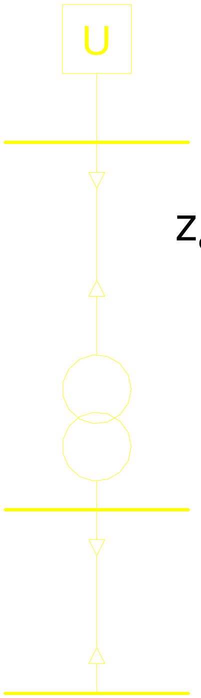
# Short Circuit Calculation

## Basic Principles

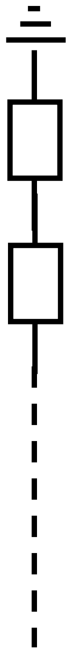
### Calculation of Short Circuit Currents

Example

$$Z_{cMV\,400\,V} = Z_{cMV\,20\,kV} \cdot \frac{(400)^2}{(20000)^2} = 4 \cdot 10^{-6}\,\Omega$$




$Z_{cMV} = 0.01\ \Omega$



$Z_u = 0.32\ \text{m}\Omega$

$Z_{cMV} = 4{\cdot}10^{-3}\ \text{m}\Omega$

# Short Circuit Calculation

Basic Principles

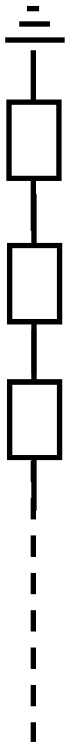
## Calculation of Short Circuit Currents

Example

$$Z_T = \frac{u_{k\%}}{100}\frac{U^2_{nLV}}{S_n} = \frac{4}{100}\cdot\frac{(400)^2}{400\cdot 10^3} = 0.016\Omega$$




$S_n$ = 400 kVA
U= 20/0.4 kV
$u_{k\%}$ = 4 %



$Z_u$ = 0.32 mΩ

$Z_{cMV} = 4\cdot10^{-3}$ mΩ

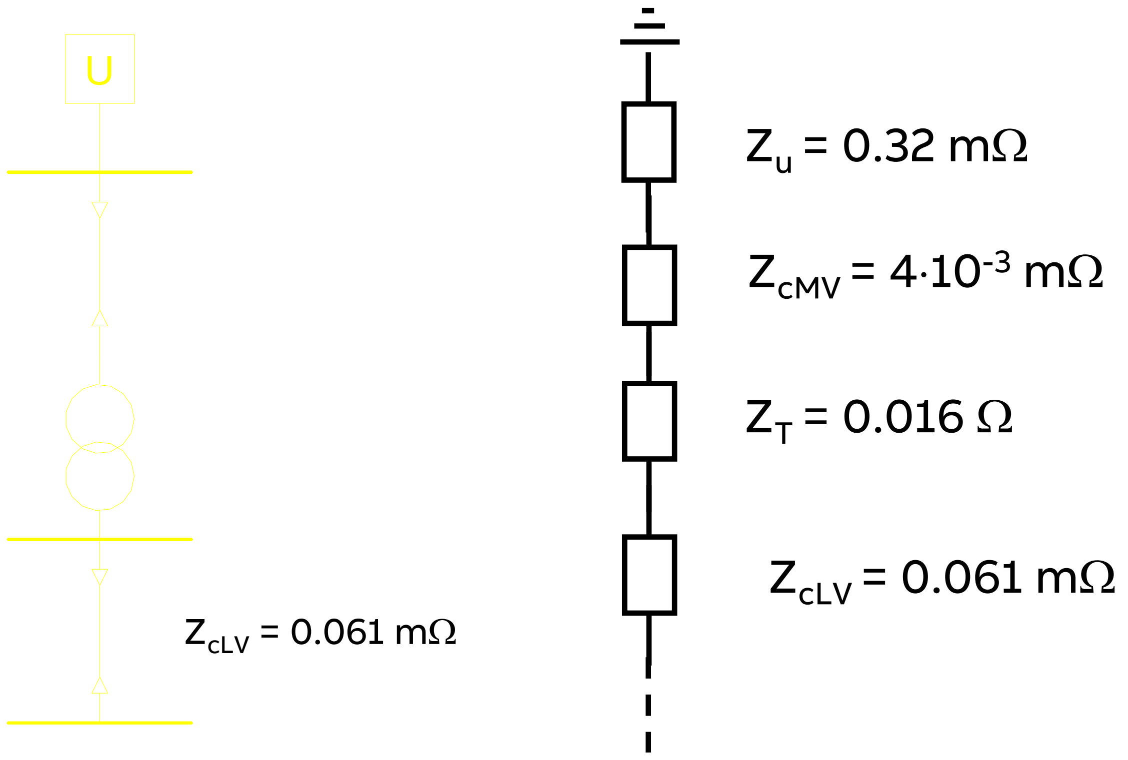
$Z_T$ = 0.016 Ω

# Short Circuit Calculation

## Basic Principles

### Calculation of Short Circuit Currents

Example



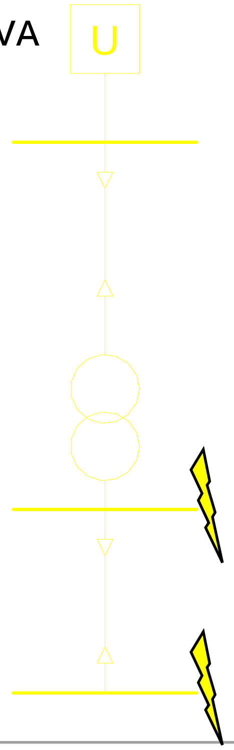
# Short Circuit Calculation

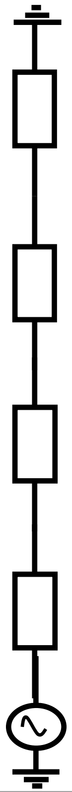
Basic Principles

## Calculation of Short Circuit Currents

Example

$S_k$ = 500 MVA
$U_{MV}$= 20 kV



$Z_u = 0.32\ m\Omega$

$Z_{cMV} = 4{\cdot}10^{-3}\ m\Omega$

$Z_T = 16\ m\Omega$

$Z_{cLV} = 0.061\ m\Omega$

$U_n = 400\ V$

$$I_k = \frac{U_n}{\sqrt{3}\cdot(Z_u + Z_{cMV} + Z_T)} \cong 14.1kA$$

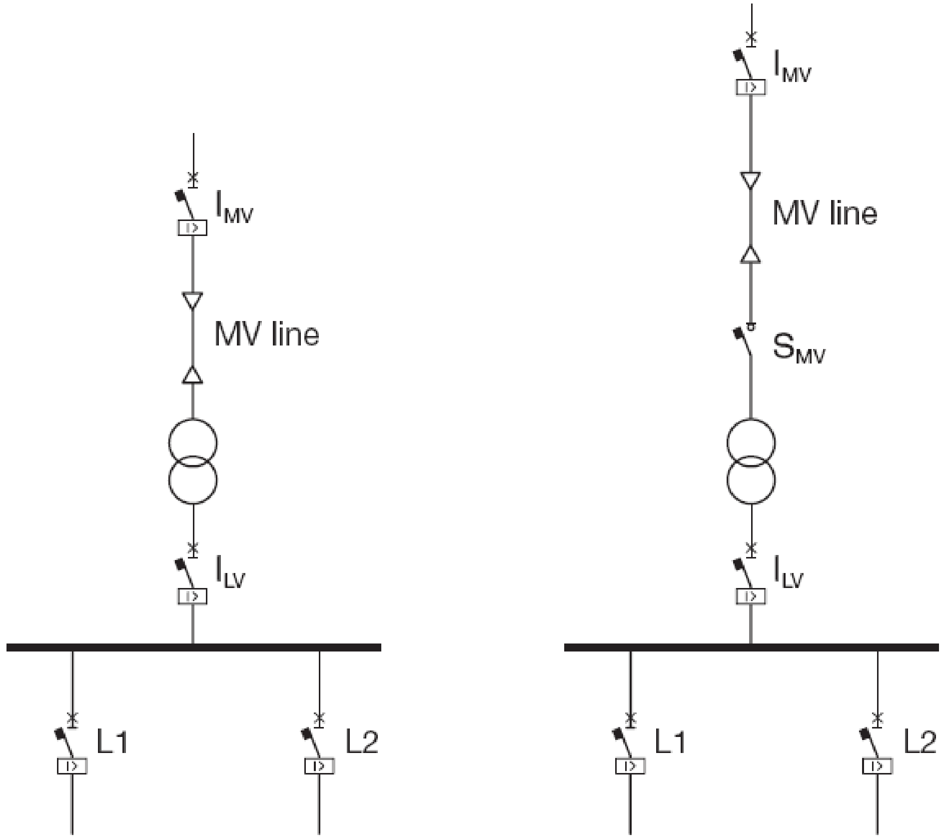
$$I_k = \frac{U_n}{\sqrt{3}\cdot(Z_u + Z_{cMV} + Z_T + Z_{cLV})} \cong 13.6kA$$

# Short Circuit Calculation

## Basic Principles

### Common Management Methods

Substation with single transformer
Typical single line diagrams

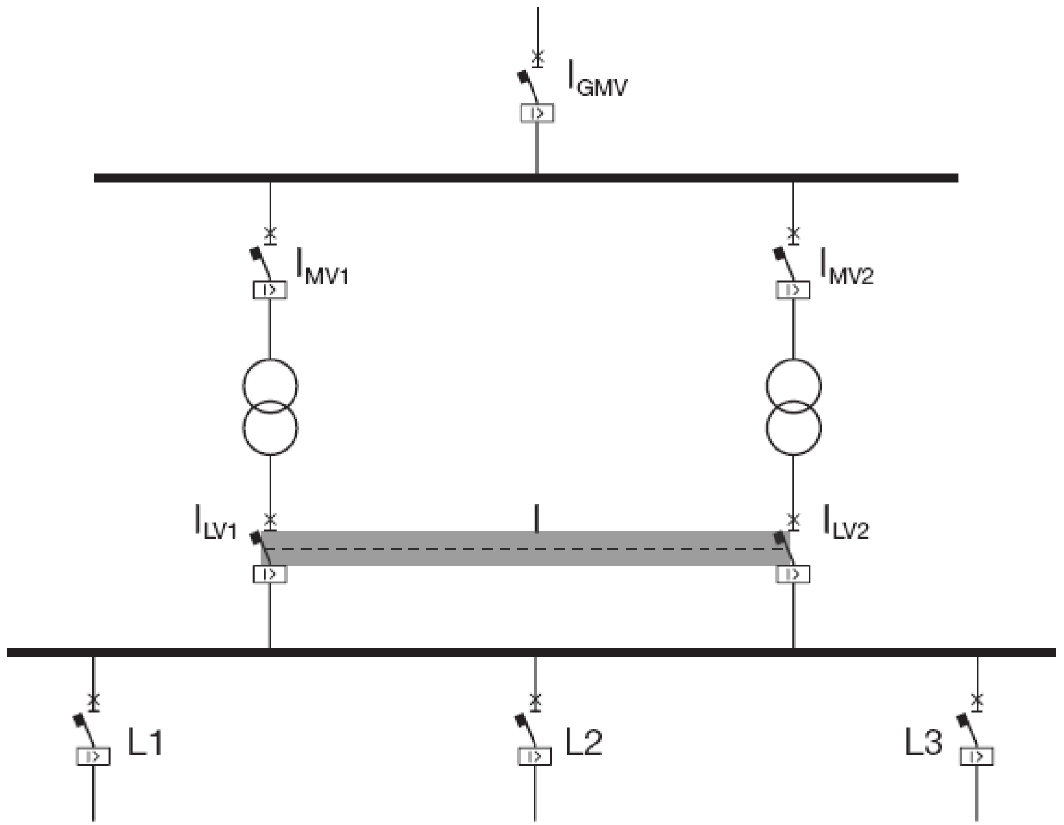


# Short Circuit Calculation

## Basic Principles

### Common Management Methods

Substation with two transformers
(One as spare for the other)
– The use of mechanical interlock between two ACBs

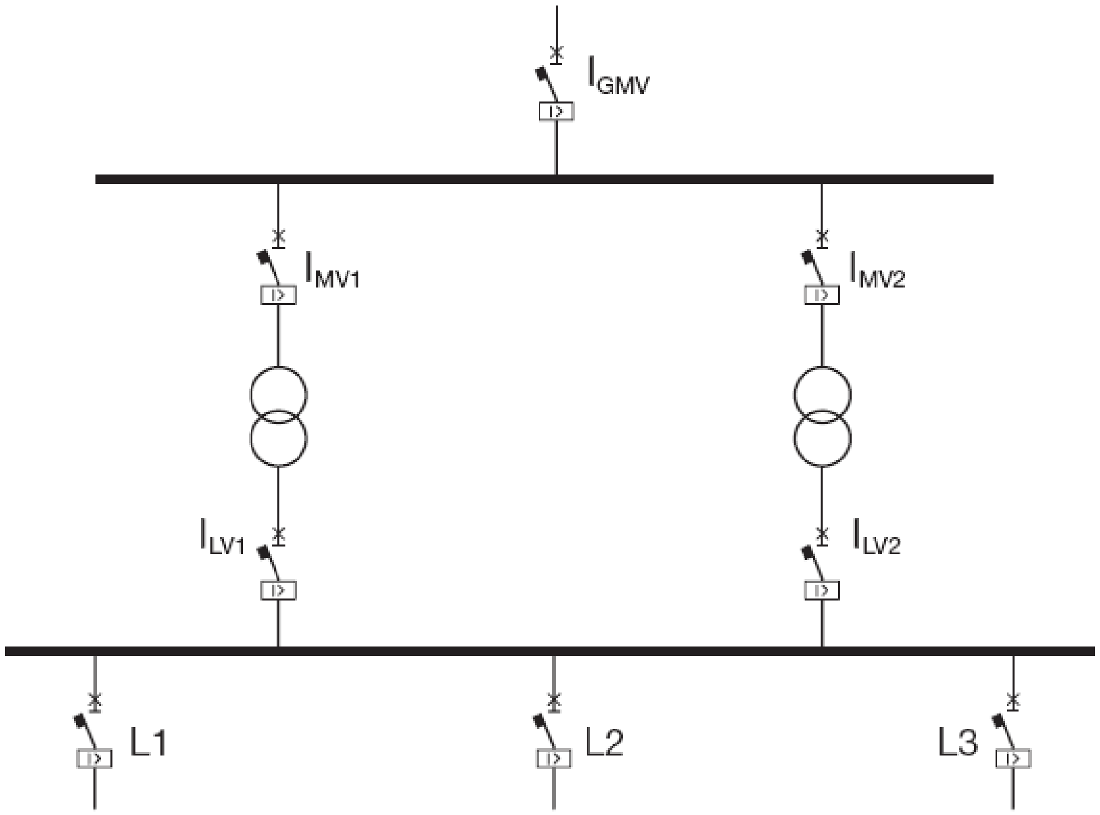


# Short Circuit Calculation

Basic Principles

## Common Management Methods

Substation with two transformers which operate in parallel



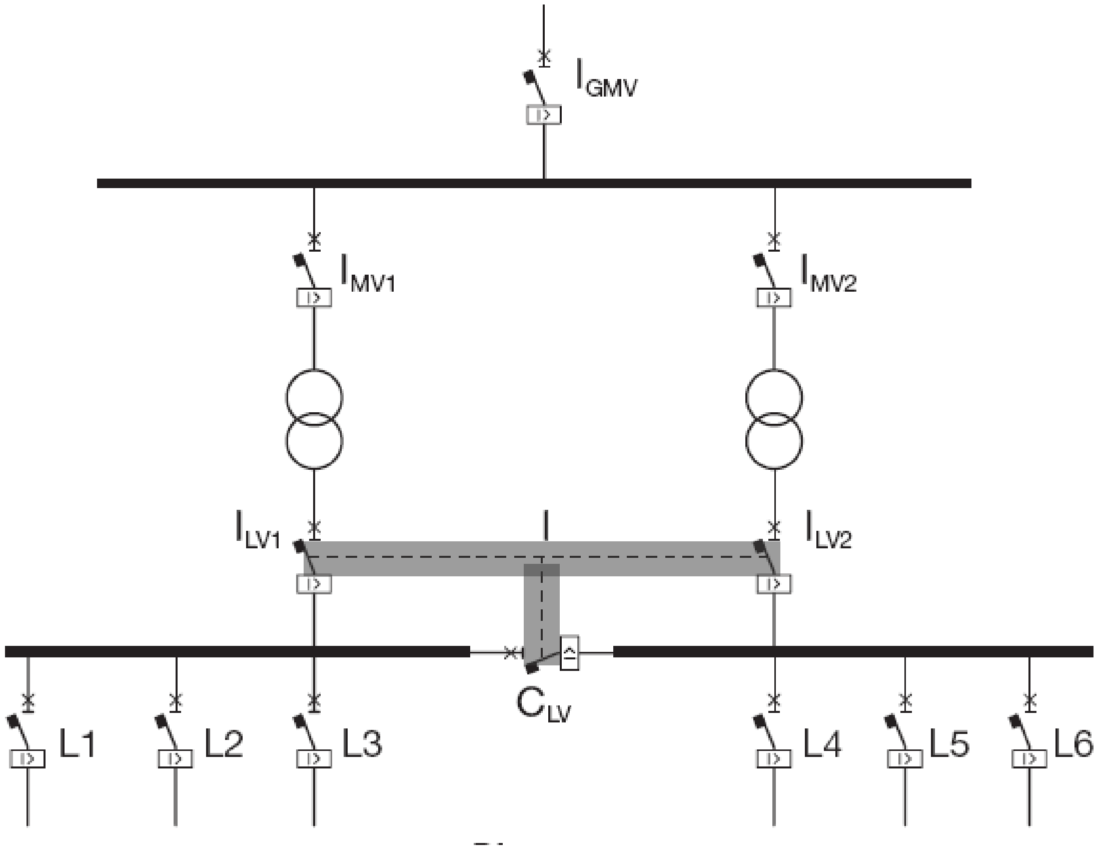
# Short Circuit Calculation

## Basic Principles

### Common Management Methods

Substation with two transformers which operate simultaneously on two separate half-busbars. (Two incoming with bus-coupler)

Mechanical Interlock between three ACBs



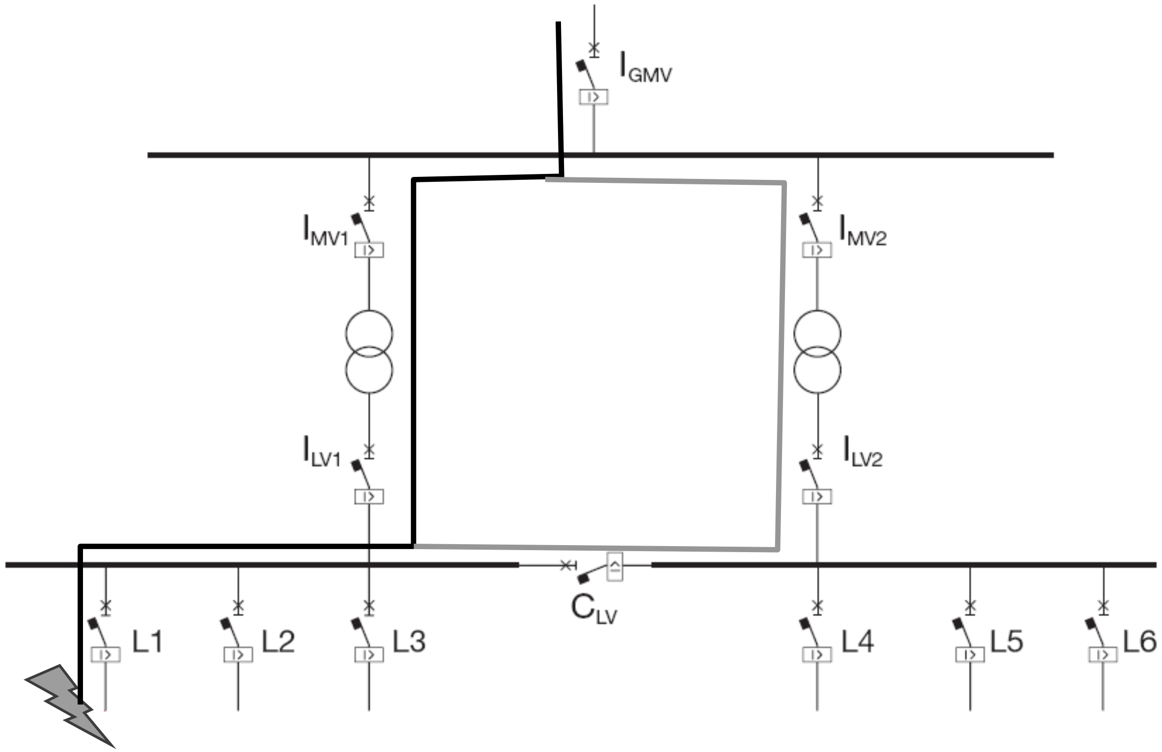
# Short Circuit Calculation

Basic Principles

## Management philosophy for the protections

To ensure continuity of service to sound parts of the installation

– Circuit breaker L1 must trip and clear the fault



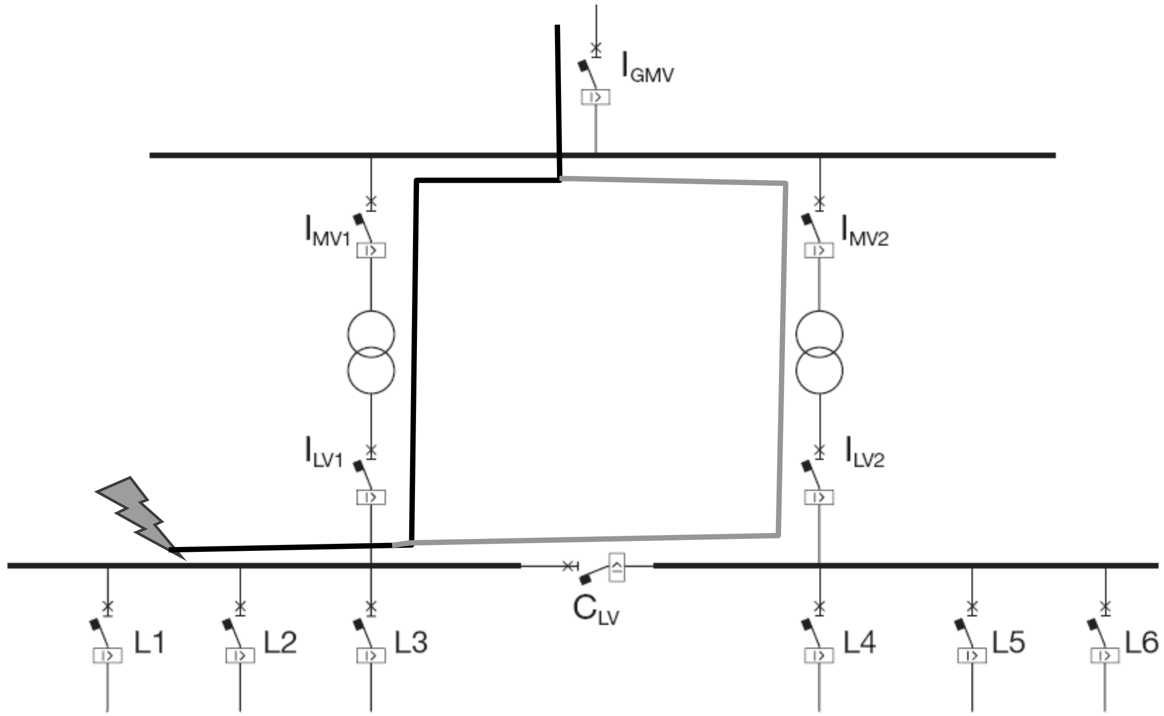
# Short Circuit Calculation

## Basic Principles

### Management philosophy for the protections

To ensure continuity of service to sound parts of the installation

- Circuit breaker $I_{LV1}$ must trip and clear the fault
- If $C_{LV}$ is closed $I_{LV2}$ must trip as well. Depending if $C_{LV}$ is an ACB or just a bus coupler.



# Short Circuit Calculation

Basic Principles

## Management philosophy for the protections

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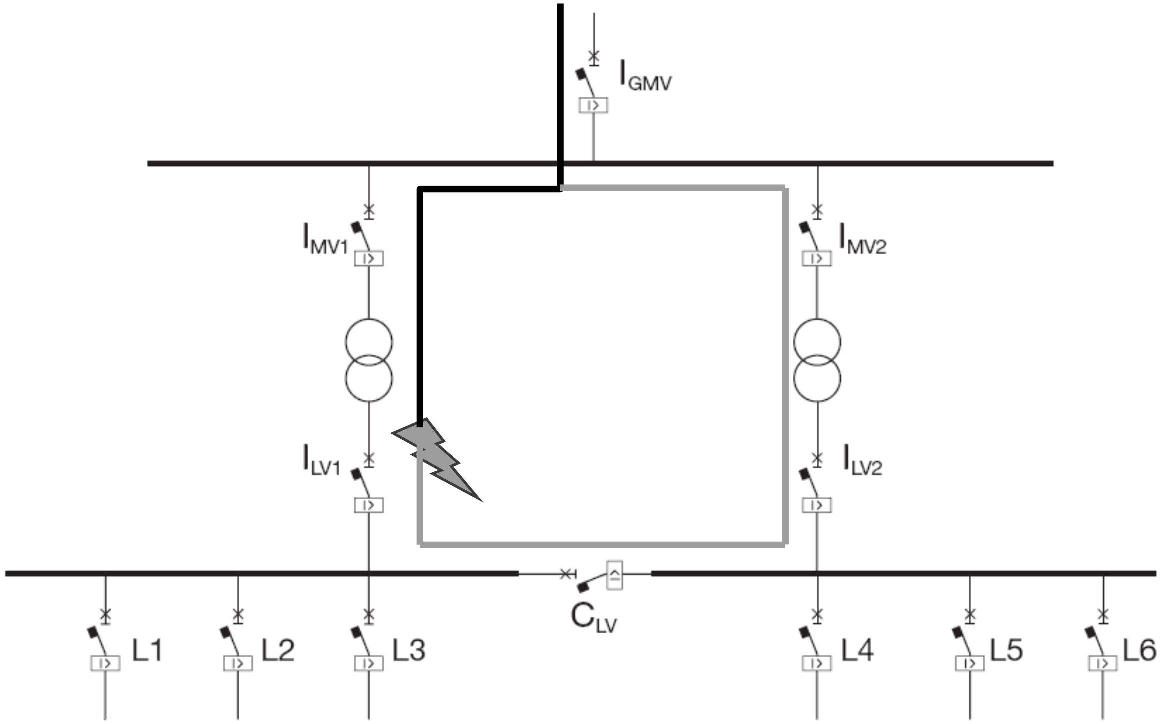


# Short Circuit Calculation

## Basic Principles

### Short Circuit Calculations Single Transformer

MV Level 22kV 750MVA

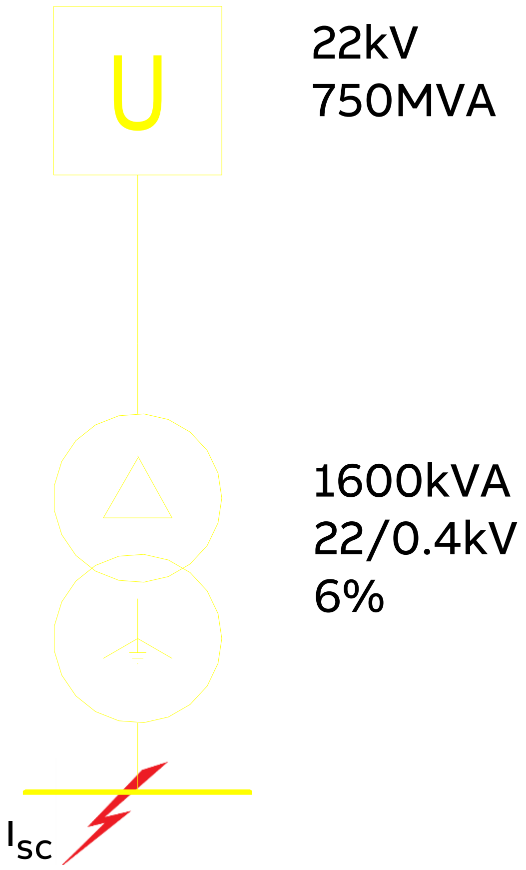
$$Z_{22kV} = \frac{(22k)^2}{750M} = 0.6453\ \Omega$$

$$Z_{400V} = 0.6453 \times \frac{400^2}{22000^2} = 0.2133\ m\Omega$$

$$Z_{TX} = \frac{6}{100} \times \frac{400^2}{1.6M} = 6\ m\Omega$$

$$Z_{Total} = 6.2133\ m\Omega$$

$$I_{sc} = \frac{400}{\sqrt{3} \times 6.2133m} = 37.168kA$$





ABB

# Short Circuit Calculation

## Basic Principles

### Short Circuit Calculations two transformers in parallel

MV Level 22kV 750MVA

$$Z_{22kV} = \frac{(22k)^2}{750M} = 0.6453\ \Omega$$

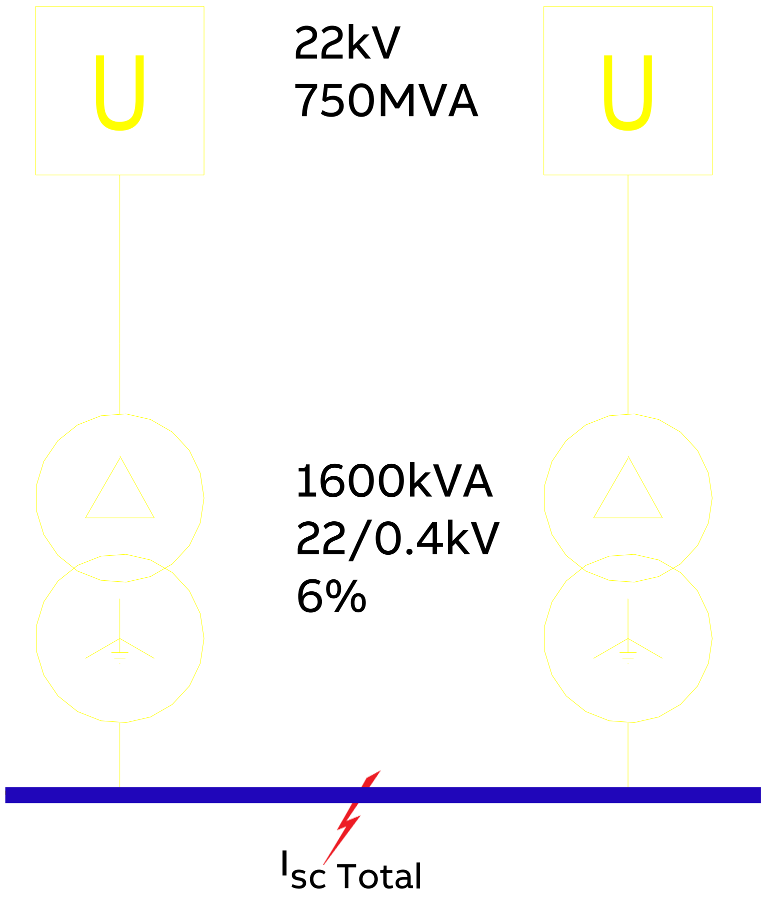
$$Z_{400V} = 0.6453 \times \frac{400^2}{22000^2} = 0.2133\ m\Omega$$

$$Z_{TX} = \frac{6}{100} \times \frac{400^2}{1.6M} = 6\ m\Omega$$

$$Z_{Total} = 6.2133\ m\Omega$$

$$I_{sc} = \frac{400}{\sqrt{3} \times 6.2133m} = 37.168kA$$

$$I_{SC\ Total} = 37.168 \times 2 = 74.336kA$$



# Short Circuit Calculation

## Basic Principles

### Short Circuit Calculations two transformers in parallel

MV Level 22kV 750MVA

$$Z_{22kV} = \frac{(22k)^2}{750M} = 0.6453\ \Omega$$

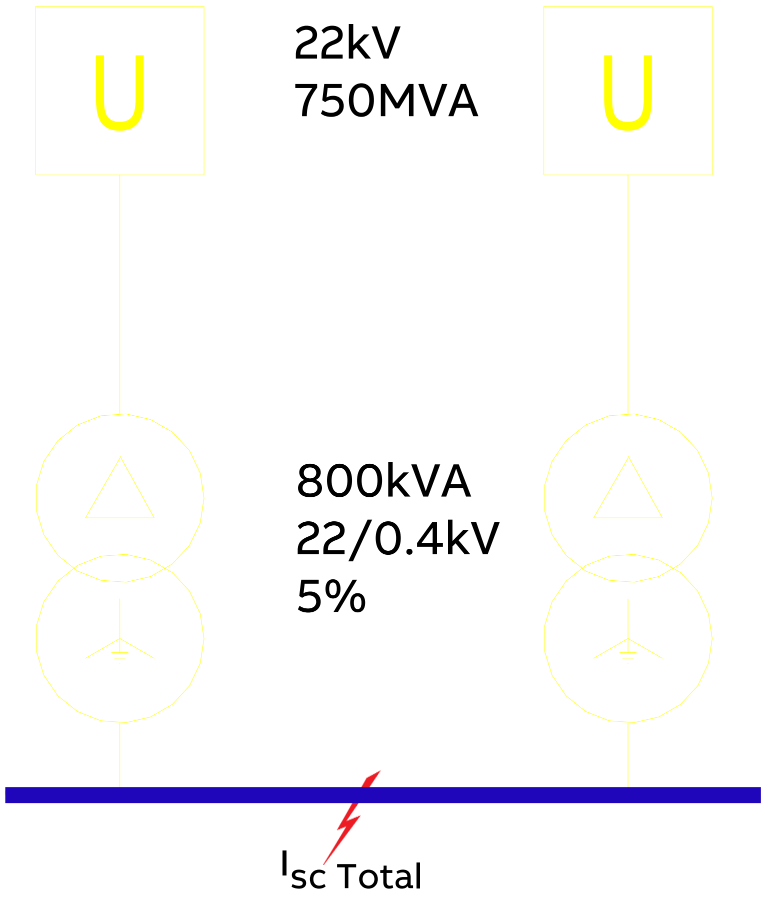
$$Z_{400V} = 0.6453 \times \frac{400^2}{22000^2} = 0.2133\ m\Omega$$

$$Z_{TX} = \frac{5}{100} \times \frac{400^2}{8ooK} = 0.01\ \Omega$$

$$Z_{Total} = 10.2133\ m\Omega$$

$$I_{sc} = \frac{400}{\sqrt{3} \times 10.2133m} = 22.611\ kA$$

$$I_{SC\ Total} = 22.611 \times 2 = 45.22\ kA$$



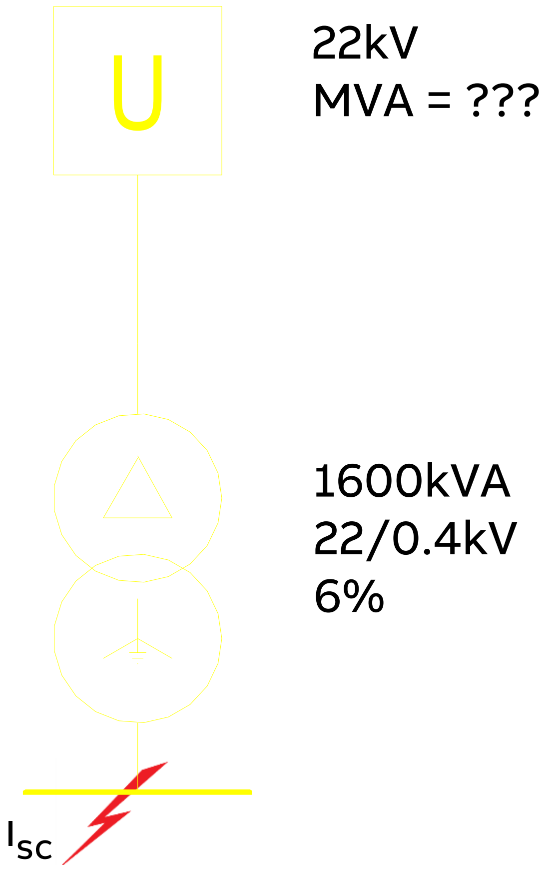
# Short Circuit Calculation

Basic Principles

## Short Circuit Calculations Single Transformer

$$Z_{TX} = \frac{6}{100} \times \frac{400^2}{1.6M} = 6\ m\Omega$$

$$I_{sc} = \frac{400}{\sqrt{3} \times 6m} = 38.49kA$$

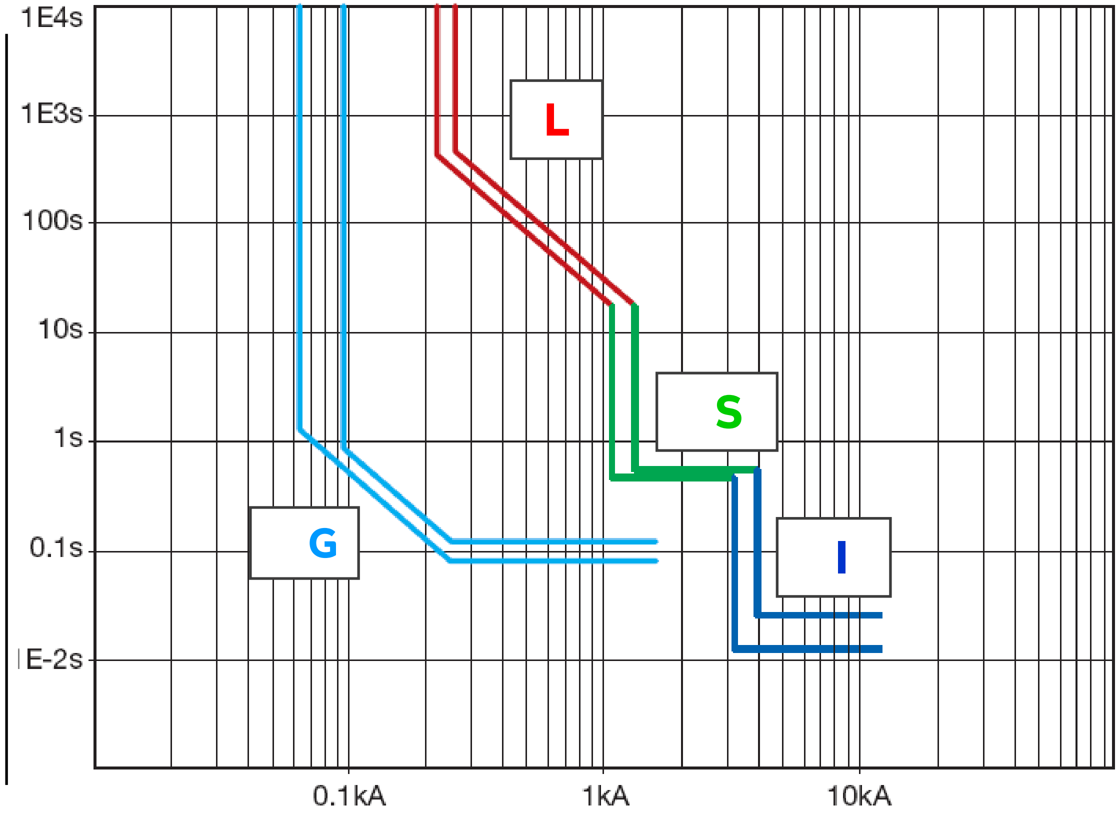


# Short Circuit Calculation

## Basic Principles

### Time Current curves of Circuit breakers

- **L function** protection against  overload
- **S function** protection against delayed short-circuit
- **I function** protection against instantaneous short-circuit
- **G function** protection against earth-fault

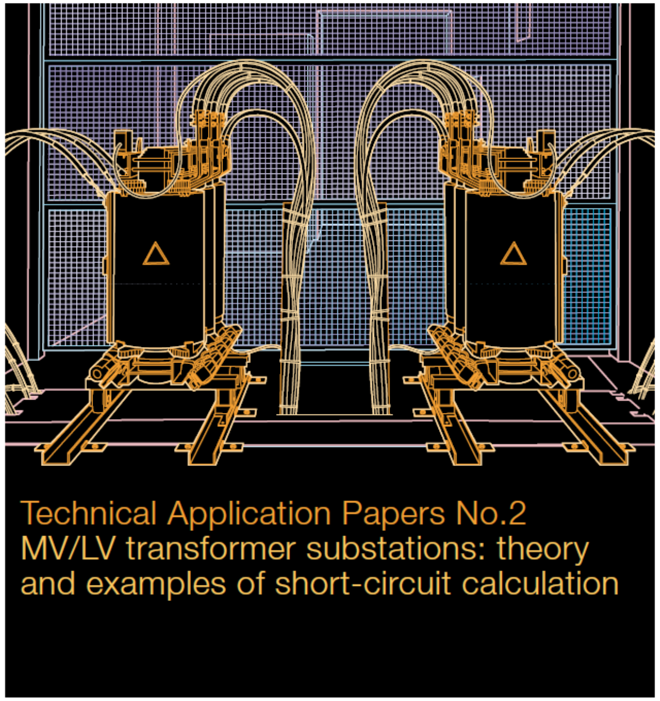


# Short Circuit Calculation

Basic Principles

## Calculation of Short Circuit Currents

### Technical Application Paper




Technical Application Papers

http://new.abb.com/low-voltage
http://new.abb.com/low-voltage/business/epc

MV/LV transformer substations: theory and examples of short-circuit calculation

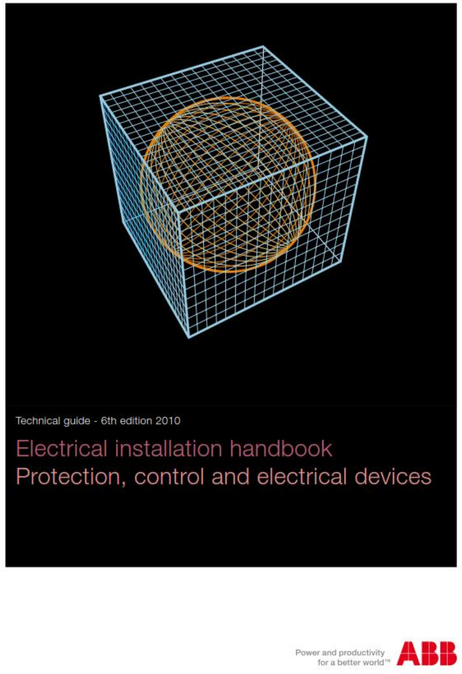
Index

# Short Circuit Calculation

## Basic Principles

### Calculation of Short Circuit Currents

Electrical Installation Handbook




**6 Calculation of short-circuit current**

**6.4 Determination of the short-circuit current $I_k$ downstream of a cable as a function of the upstream one**

The table below allows the determination, in a conservative way, of the three-phase short-circuit current at a point in a 400 V network downstream of a single pole copper cable at a temperature of 20 °C. Known values:
- the three-phase short-circuit current upstream of the cable;
- the length and cross section of the cable.

| Cable section [mm²] | Length [m] | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.5 | | | | | | | | | | | | | | | | 0.9 | 1.1 | 1.4 | 1.8 | 2.5 | 3.5 | 5.3 | 7 | 9.4 | 14 |
| 2.5 | | | | | | | | | | | | | 0.9 | 1 | 1.2 | 1.5 | 1.8 | 2.3 | 2.9 | 4.1 | 5.9 | 8.8 | 12 | 16 | 24 |
| 4 | | | | | | | | | | | 0.9 | 1.2 | 1.4 | 1.6 | 1.9 | 2.3 | 2.8 | 3.7 | 4.7 | 6.6 | 9.4 | 14 | 19 | 25 | 38 |
| 6 | | | | | | | | | 0.8 | 1.1 | 1.4 | 1.8 | 2.1 | 2.5 | 2.8 | 3.5 | 4.2 | 5.6 | 7 | 10 | 14 | 21 | 28 | 38 | 56 |
| 10 | | | | | | | 0.9 | 1.2 | 1.4 | 1.9 | 2.3 | 2.9 | 3.5 | 4.1 | 4.7 | 5.8 | 7 | 9.4 | 12 | 16 | 23 | 35 | 47 | 63 | 94 |
| 16 | | | | | 0.9 | 1.1 | 1.5 | 1.9 | 2.2 | 3 | 3.7 | 4.7 | 5.6 | 6.5 | 7.5 | 9.3 | 11 | 15 | 19 | 26 | 37 | 56 | 75 | 100 | 150 |
| 25 | | | 0.9 | 1.2 | 1.4 | 1.7 | 2.3 | 2.9 | 3.5 | 4.6 | 5.8 | 7.2 | 8.7 | 10 | 12 | 14 | 17 | 23 | 29 | 41 | 58 | 87 | 116 | 155 | 233 |
| 35 | | | 1.2 | 1.6 | 2 | 2.4 | 3.2 | 4 | 4.8 | 6.4 | 8 | 10 | 12 | 14 | 16 | 20 | 24 | 32 | 40 | 56 | 80 | 121 | 161 | 216 | 324 |
| 50 | | 1.1 | 1.7 | 2.3 | 2.8 | 3.4 | 4.5 | 5.7 | 6.8 | 9 | 11 | 14 | 17 | 20 | 23 | 28 | 34 | 45 | 57 | 79 | 113 | 170 | 226 | 303 | 455 |
| 70 | 0.8 | 1.5 | 2.3 | 3.1 | 3.8 | 4.6 | 6.2 | 7.7 | 9.2 | 12 | 15 | 19 | 23 | 27 | 31 | 38 | 46 | 62 | 77 | 108 | 154 | 231 | 308 | 413 | |
| 95 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 16 | 20 | 25 | 30 | 35 | 40 | 50 | 60 | 80 | 100 | 140 | 200 | 300 | 400 | | |
| 120 | 1.2 | 2.4 | 3.6 | 4.8 | 6 | 7.2 | 10 | 12 | 14 | 19 | 24 | 30 | 36 | 42 | 48 | 60 | 72 | 96 | 120 | 168 | 240 | 360 | 481 | | |
| 150 | 1.4 | 2.8 | 4.2 | 5.6 | 7 | 8.4 | 11 | 14 | 17 | 23 | 28 | 35 | 42 | 49 | 56 | 70 | 84 | 113 | 141 | 197 | 281 | 422 | | | |
| 185 | 1.6 | 3.2 | 4.8 | 6.4 | 8 | 10 | 13 | 16 | 19 | 26 | 32 | 40 | 48 | 56 | 64 | 80 | 96 | 128 | 160 | 224 | 320 | 480 | | | |
| 240 | 1.8 | 3.7 | 5.5 | 7.3 | 9.1 | 11 | 15 | 18 | 22 | 29 | 37 | 46 | 55 | 64 | 73 | 91 | 110 | 146 | 183 | 256 | 366 | 549 | | | |
| 300 | 2 | 4 | 6 | 8 | 10 | 12 | 16 | 20 | 24 | 32 | 40 | 50 | 60 | 70 | 80 | 100 | 120 | 160 | 200 | 280 | 400 | | | | |
| 2x120 | 2.4 | 4.8 | 7.2 | 10 | 12 | 14 | 19 | 24 | 29 | 38 | 48 | 60 | 72 | 84 | 96 | 120 | 144 | 192 | 240 | 336 | 481 | | | | |
| 2x150 | 2.8 | 5.6 | 8.4 | 11 | 14 | 17 | 23 | 28 | 34 | 45 | 56 | 70 | 84 | 98 | 113 | 141 | 169 | 225 | 281 | 394 | 563 | | | | |
| 2x185 | 3.2 | 6.4 | 10 | 13 | 16 | 19 | 26 | 32 | 38 | 51 | 64 | 80 | 96 | 112 | 128 | 160 | 192 | 256 | 320 | 448 | | | | | |
| 3x120 | 3.6 | 7.2 | 11 | 14 | 18 | 22 | 29 | 36 | 43 | 58 | 72 | 90 | 108 | 126 | 144 | 180 | 216 | 288 | 360 | 505 | | | | | |
| 3x150 | 4.2 | 8.4 | 13 | 17 | 21 | 25 | 34 | 42 | 51 | 68 | 84 | 105 | 127 | 148 | 169 | 211 | 253 | 338 | 422 | | | | | | |
| 3x185 | 4.8 | 10 | 14 | 19 | 24 | 29 | 38 | 48 | 58 | 77 | 96 | 120 | 144 | 168 | 192 | 240 | 288 | 384 | 480 | | | | | | |

| $I_k$ upstream [kA] | | | | | | | | | | | | $I_k$ downstream [kA] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 96 | 92 | 89 | 85 | 82 | 78 | 71 | 65 | 60 | 50 | 43 | 36 | 31 | 27 | 24 | 20 | 17 | 13 | 11 | 7.8 | 5.6 | 3.7 | 2.7 | 2.0 | 1.3 |
| 90 | 86 | 83 | 81 | 78 | 76 | 72 | 67 | 61 | 57 | 48 | 42 | 35 | 31 | 27 | 24 | 20 | 17 | 13 | 11 | 7.8 | 5.6 | 3.7 | 2.7 | 2.0 | 1.3 |
| 80 | 77 | 75 | 73 | 71 | 69 | 66 | 62 | 57 | 53 | 46 | 40 | 34 | 30 | 27 | 24 | 20 | 17 | 13 | 10 | 7.7 | 5.5 | 3.7 | 2.7 | 2.0 | 1.3 |
| 70 | 68 | 66 | 65 | 63 | 62 | 60 | 56 | 53 | 49 | 43 | 38 | 33 | 29 | 26 | 23 | 19 | 16 | 13 | 10 | 7.6 | 5.5 | 3.7 | 2.7 | 2.0 | 1.3 |
| 60 | 58 | 57 | 56 | 55 | 54 | 53 | 50 | 47 | 45 | 40 | 36 | 31 | 28 | 25 | 23 | 19 | 16 | 12 | 10 | 7.5 | 5.4 | 3.7 | 2.7 | 2.0 | 1.3 |
| 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 41 | 39 | 35 | 32 | 29 | 26 | 23 | 21 | 18 | 15 | 12 | 10 | 7.3 | 5.3 | 3.6 | 2.6 | 2.0 | 1.3 |
| 40 | 39 | 39 | 38 | 38 | 37 | 37 | 35 | 34 | 33 | 31 | 28 | 26 | 24 | 22 | 20 | 17 | 15 | 12 | 10 | 7.1 | 5.2 | 3.6 | 2.6 | 2.0 | 1.3 |
| 35 | 34 | 34 | 34 | 33 | 33 | 32 | 32 | 31 | 30 | 28 | 26 | 24 | 22 | 20 | 19 | 16 | 14 | 11 | 10 | 7.1 | 5.1 | 3.5 | 2.6 | 2.0 | 1.3 |
| 30 | 30 | 29 | 29 | 29 | 28 | 28 | 28 | 27 | 26 | 25 | 23 | 22 | 20 | 19 | 18 | 16 | 14 | 11 | 9.3 | 7.0 | 5.0 | 3.5 | 2.6 | 1.9 | 1.3 |
| 25 | 25 | 24 | 24 | 24 | 24 | 24 | 23 | 23 | 22 | 21 | 21 | 19 | 18 | 17 | 16 | 14 | 13 | 11 | 9.0 | 6.8 | 5.0 | 3.4 | 2.6 | 1.9 | 1.3 |
| 20 | 20 | 20 | 20 | 19 | 19 | 19 | 19 | 18 | 18 | 18 | 17 | 16 | 15 | 15 | 14 | 13 | 12 | 10 | 8.4 | 6.5 | 4.8 | 3.3 | 2.5 | 1.9 | 1.3 |
| 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 13 | 13 | 12 | 12 | 12 | 11 | 10 | 8.7 | 7.6 | 6.1 | 4.6 | 3.2 | 2.5 | 1.9 | 1.3 |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 9.3 | 8.8 | 7.8 | 7.0 | 5.7 | 4.4 | 3.1 | 2.4 | 1.9 | 1.3 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9.5 | 9.4 | 9.2 | 9.0 | 8.8 | 8.5 | 8.3 | 8.1 | 7.7 | 7.3 | 6.5 | 5.9 | 5.0 | 3.9 | 2.9 | 2.3 | 1.8 | 1.2 |
| 8.0 | 8.0 | 7.9 | 7.9 | 7.9 | 7.8 | 7.8 | 7.7 | 7.7 | 7.6 | 7.5 | 7.4 | 7.2 | 7.1 | 6.9 | 6.8 | 6.5 | 6.2 | 5.7 | 5.2 | 4.5 | 3.7 | 2.8 | 2.2 | 1.7 | 1.2 |
| 6.0 | 6.0 | 5.9 | 5.9 | 5.9 | 5.9 | 5.8 | 5.8 | 5.8 | 5.7 | 5.6 | 5.5 | 5.4 | 5.3 | 5.2 | 5.1 | 4.9 | 4.8 | 4.4 | 4.1 | 3.6 | 3.1 | 2.4 | 2.0 | 1.6 | 1.1 |
| 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.8 | 2.8 | 2.8 | 2.7 | 2.7 | 2.6 | 2.5 | 2.4 | 2.2 | 2.0 | 1.7 | 1.4 | 1.2 | 0.9 |

ABB | Electrical devices 497

Determination of short-circuit current downstream of a cable as a function of the upstream short-circuit current (Table 6.4).

| Cable section [mm²] | Length [m] | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.5 | | | | | | | | | | | | | | | | 0.9 | 1.1 | 1.4 | 1.8 | 2.5 | 3.5 | 5.3 | 7 | 9.4 | 14 |
| 2.5 | | | | | | | | | | | | | | 0.9 | 1 | 1.2 | 1.5 | 1.8 | 2.3 | 2.9 | 4.1 | 5.9 | 8.8 | 12 | 16 | 24 |
| 4 | | | | | | | | | | | | 0.9 | 1.2 | 1.4 | 1.6 | 1.9 | 2.3 | 2.8 | 3.7 | 4.7 | 6.6 | 9.4 | 14 | 19 | 25 | 38 |
| 6 | | | | | | | | | 0.8 | 1.1 | 1.4 | 1.8 | 2.1 | 2.5 | 2.8 | 3.5 | 4.2 | 5.6 | 7 | 10 | 14 | 21 | 28 | 38 | 56 |
| 10 | | | | | | | 0.9 | 1.2 | 1.4 | 1.9 | 2.3 | 2.9 | 3.5 | 4.1 | 4.7 | 5.8 | 7 | 9.4 | 12 | 16 | 23 | 35 | 47 | 63 | 94 |
| 16 | | | | | 0.9 | 1.1 | 1.5 | 1.9 | 2.2 | 3 | 3.7 | 4.7 | 5.6 | 6.5 | 7.5 | 9.3 | 11 | 15 | 19 | 26 | 37 | 56 | 75 | 100 | 150 |
| 25 | | | 0.9 | 1.2 | 1.4 | 1.7 | 2.3 | 2.9 | 3.5 | 4.6 | 5.8 | 7.2 | 8.7 | 10 | 12 | 14 | 17 | 23 | 29 | 41 | 58 | 87 | 116 | 155 | 233 |
| 35 | | | 1.2 | 1.6 | 2 | 2.4 | 3.2 | 4 | 4.8 | 6.4 | 8 | 10 | 12 | 14 | 16 | 20 | 24 | 32 | 40 | 56 | 80 | 121 | 161 | 216 | 324 |
| 50 | | 1.1 | 1.7 | 2.3 | 2.8 | 3.4 | 4.5 | 5.7 | 6.8 | 9 | 11 | 14 | 17 | 20 | 23 | 28 | 34 | 45 | 57 | 79 | 113 | 170 | 226 | 303 | 455 |
| 70 | 0.8 | 1.5 | 2.3 | 3.1 | 3.8 | 4.6 | 6.2 | 7.7 | 9.2 | 12 | 15 | 19 | 23 | 27 | 31 | 38 | 46 | 62 | 77 | 108 | 154 | 231 | 308 | 413 | |
| 95 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 16 | 20 | 25 | 30 | 35 | 40 | 50 | 60 | 80 | 100 | 140 | 200 | 300 | 400 | | |
| 120 | 1.2 | 2.4 | 3.6 | 4.8 | 6 | 7.2 | 10 | 12 | 14 | 19 | 24 | 30 | 36 | 42 | 48 | 60 | 72 | 96 | 120 | 168 | 240 | 360 | 481 | | |
| 150 | 1.4 | 2.8 | 4.2 | 5.6 | 7 | 8.4 | 11 | 14 | 17 | 23 | 28 | 35 | 42 | 49 | 56 | 70 | 84 | 113 | 141 | 197 | 281 | 422 | | | |
| 185 | 1.6 | 3.2 | 4.8 | 6.4 | 8 | 10 | 13 | 16 | 19 | 26 | 32 | 40 | 48 | 56 | 64 | 80 | 96 | 128 | 160 | 224 | 320 | 480 | | | |
| 240 | 1.8 | 3.7 | 5.5 | 7.3 | 9.1 | 11 | 15 | 18 | 22 | 29 | 37 | 46 | 55 | 64 | 73 | 91 | 110 | 146 | 183 | 256 | 366 | 549 | | | |
| 300 | 2 | 4 | 6 | 8 | 10 | 12 | 16 | 20 | 24 | 32 | 40 | 50 | 60 | 70 | 80 | 100 | 120 | 160 | 200 | 280 | 400 | | | | |
| 2x120 | 2.4 | 4.8 | 7.2 | 10 | 12 | 14 | 19 | 24 | 29 | 38 | 48 | 60 | 72 | 84 | 96 | 120 | 144 | 192 | 240 | 336 | 481 | | | | |
| 2x150 | 2.8 | 5.6 | 8.4 | 11 | 14 | 17 | 23 | 28 | 34 | 45 | 56 | 70 | 84 | 98 | 113 | 141 | 169 | 225 | 281 | 394 | 563 | | | | |
| 2x185 | 3.2 | 6.4 | 10 | 13 | 16 | 19 | 26 | 32 | 38 | 51 | 64 | 80 | 96 | 112 | 128 | 160 | 192 | 256 | 320 | 448 | | | | | |
| 3x120 | 3.6 | 7.2 | 11 | 14 | 18 | 22 | 29 | 36 | 43 | 58 | 72 | 90 | 108 | 126 | 144 | 180 | 216 | 288 | 360 | 505 | | | | | |
| 3x150 | 4.2 | 8.4 | 13 | 17 | 21 | 25 | 34 | 42 | 51 | 68 | 84 | 105 | 127 | 148 | 169 | 211 | 253 | 338 | 422 | | | | | | |
| 3x185 | 4.8 | 10 | 14 | 19 | 24 | 29 | 38 | 48 | 58 | 77 | 96 | 120 | 144 | 168 | 192 | 240 | 288 | 384 | 480 | | | | | | |

| $I_k$ upstream [kA] | $I_k$ downstream [kA] | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 96 | 92 | 89 | 85 | 82 | 78 | 71 | 65 | 60 | 50 | 43 | 36 | 31 | 27 | 24 | 20 | 17 | 13 | 11 | 7.8 | 5.6 | 3.7 | 2.7 | 2.0 | 1.3 |
| 90 | 86 | 83 | 81 | 78 | 76 | 72 | 67 | 61 | 57 | 48 | 42 | 35 | 31 | 27 | 24 | 20 | 17 | 13 | 11 | 7.8 | 5.6 | 3.7 | 2.7 | 2.0 | 1.3 |
| 80 | 77 | 75 | 73 | 71 | 69 | 66 | 62 | 57 | 53 | 46 | 40 | 34 | 30 | 27 | 24 | 20 | 17 | 13 | 10 | 7.7 | 5.5 | 3.7 | 2.7 | 2.0 | 1.3 |
| 70 | 68 | 66 | 65 | 63 | 62 | 60 | 56 | 53 | 49 | 43 | 38 | 33 | 29 | 26 | 23 | 19 | 16 | 13 | 10 | 7.6 | 5.5 | 3.7 | 2.7 | 2.0 | 1.3 |
| 60 | 58 | 57 | 56 | 55 | 54 | 53 | 50 | 47 | 45 | 40 | 36 | 31 | 28 | 25 | 23 | 19 | 16 | 12 | 10 | 7.5 | 5.4 | 3.7 | 2.7 | 2.0 | 1.3 |
| 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 41 | 39 | 35 | 32 | 29 | 26 | 23 | 21 | 18 | 15 | 12 | 10 | 7.3 | 5.3 | 3.6 | 2.6 | 2.0 | 1.3 |
| 40 | 39 | 39 | 38 | 38 | 37 | 37 | 35 | 34 | 33 | 31 | 28 | 26 | 24 | 22 | 20 | 17 | 15 | 12 | 10 | 7.1 | 5.2 | 3.6 | 2.6 | 2.0 | 1.3 |
| 35 | 34 | 34 | 34 | 33 | 33 | 32 | 32 | 31 | 30 | 28 | 26 | 24 | 22 | 20 | 19 | 16 | 14 | 11 | 10 | 7.1 | 5.1 | 3.5 | 2.6 | 2.0 | 1.3 |
| 30 | 30 | 29 | 29 | 29 | 28 | 28 | 28 | 27 | 26 | 25 | 23 | 22 | 20 | 19 | 18 | 16 | 14 | 11 | 9.3 | 7.0 | 5.0 | 3.5 | 2.6 | 1.9 | 1.3 |
| 25 | 25 | 24 | 24 | 24 | 24 | 24 | 23 | 23 | 22 | 21 | 21 | 19 | 18 | 17 | 16 | 14 | 13 | 11 | 9.0 | 6.8 | 5.0 | 3.4 | 2.6 | 1.9 | 1.3 |
| 20 | 20 | 20 | 20 | 19 | 19 | 19 | 19 | 18 | 18 | 18 | 17 | 16 | 15 | 15 | 14 | 13 | 12 | 10 | 8.4 | 6.5 | 4.8 | 3.3 | 2.5 | 1.9 | 1.3 |
| 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 13 | 13 | 12 | 12 | 12 | 11 | 10 | 8.7 | 7.6 | 6.1 | 4.6 | 3.2 | 2.5 | 1.9 | 1.3 |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 9.3 | 8.8 | 7.8 | 7.0 | 5.7 | 4.4 | 3.1 | 2.4 | 1.9 | 1.3 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9.5 | 9.4 | 9.2 | 9.0 | 8.8 | 8.5 | 8.3 | 8.1 | 7.7 | 7.3 | 6.5 | 5.9 | 5.0 | 3.9 | 2.9 | 2.3 | 1.8 | 1.2 |
| 8.0 | 8.0 | 7.9 | 7.9 | 7.9 | 7.8 | 7.8 | 7.7 | 7.7 | 7.6 | 7.5 | 7.4 | 7.2 | 7.1 | 6.9 | 6.8 | 6.5 | 6.2 | 5.7 | 5.2 | 4.5 | 3.7 | 2.8 | 2.2 | 1.7 | 1.2 |
| 6.0 | 6.0 | 5.9 | 5.9 | 5.9 | 5.9 | 5.8 | 5.8 | 5.8 | 5.7 | 5.6 | 5.5 | 5.4 | 5.3 | 5.2 | 5.1 | 4.9 | 4.8 | 4.4 | 4.1 | 3.6 | 3.1 | 2.4 | 2.0 | 1.6 | 1.1 |
| 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.8 | 2.8 | 2.8 | 2.7 | 2.7 | 2.6 | 2.5 | 2.4 | 2.2 | 2.0 | 1.7 | 1.4 | 1.2 | 0.9 |

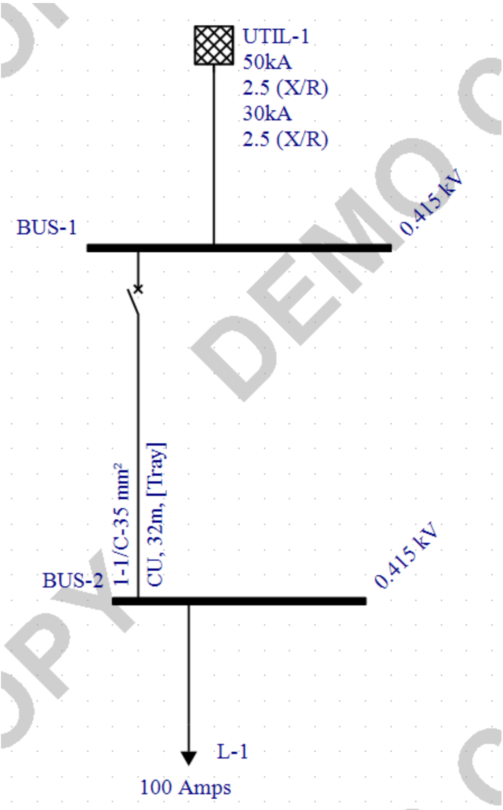
Determination of short-circuit current downstream of a cable as a function of the upstream short-circuit current (Table 6.4).

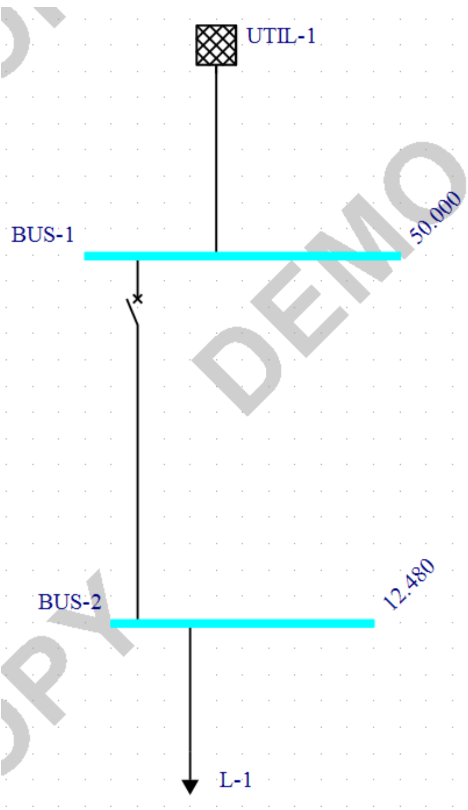
# Short Circuit Calculation

Basic Principles

## EasyPower Short Circuit Calculation

Example



# Short Circuit Calculation

## Basic Principles

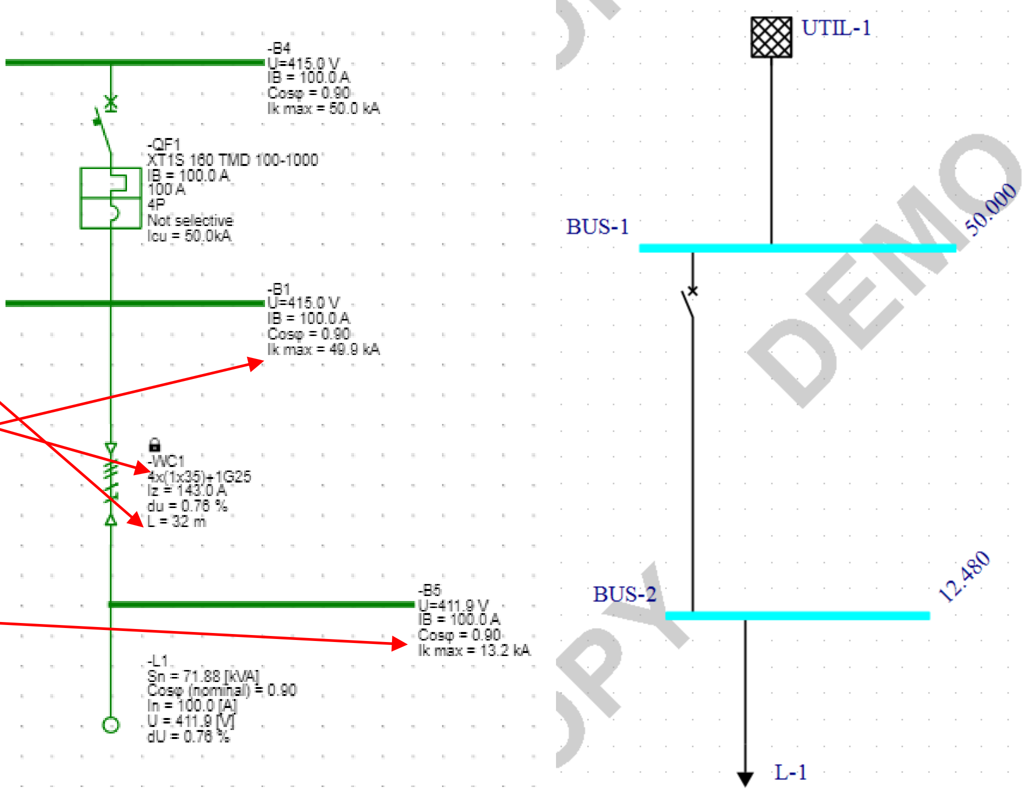
### Calculation of Short Circuit Currents

Manual Verification

- Example 1

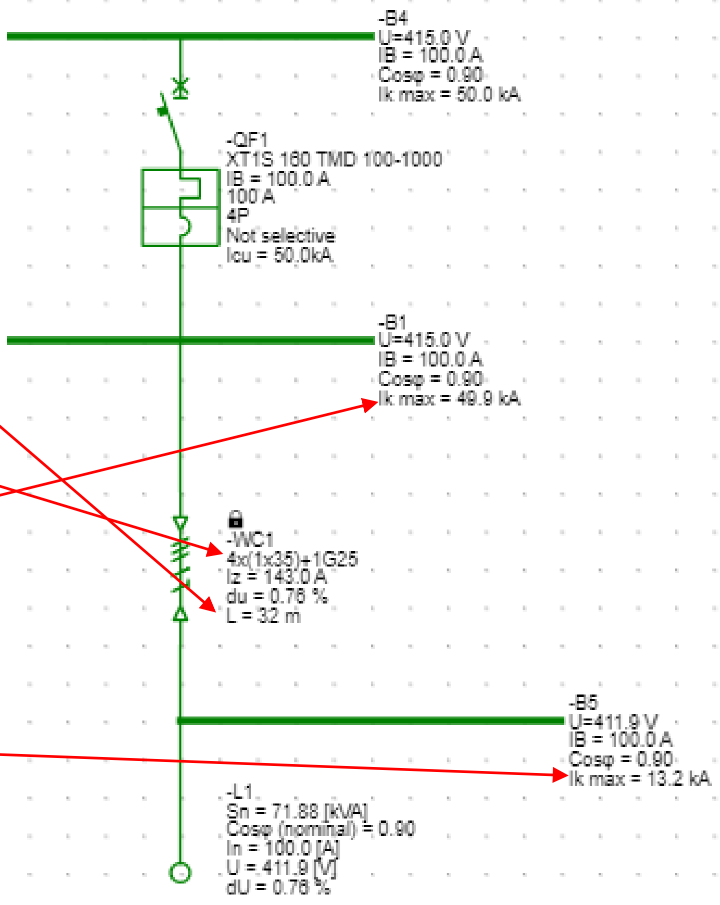
| Cable section [mm²] | Length [m] | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.5 | | | | | | | | | | | | | | | | 0.9 | 1.1 | 1.4 | 1.8 | 2.5 | 3.5 | 5.3 | 7 | 9.4 | 14 |
| 2.5 | | | | | | | | | | | | | 0.9 | 1 | 1.2 | 1.5 | 1.8 | 2.3 | 2.9 | 4.1 | 5.9 | 8.8 | 12 | 16 | 24 |
| 4 | | | | | | | | | | | 0.9 | 1.2 | 1.4 | 1.6 | 1.9 | 2.3 | 2.8 | 3.7 | 4.7 | 6.6 | 9.4 | 14 | 19 | 25 | 38 |
| 6 | | | | | | | | | 0.8 | 1.1 | 1.4 | 1.8 | 2.1 | 2.5 | 2.8 | 3.5 | 4.2 | 5.6 | 7 | 10 | 14 | 21 | 28 | 38 | 56 |
| 10 | | | | | | | 0.9 | 1.2 | 1.4 | 1.9 | 2.3 | 2.9 | 3.5 | 4.1 | 4.7 | 5.8 | 7 | 9.4 | 12 | 16 | 23 | 35 | 47 | 63 | 94 |
| 16 | | | | | 0.9 | 1.1 | 1.5 | 1.9 | 2.2 | 3 | 3.7 | 4.7 | 5.6 | 6.5 | 7.5 | 9.3 | 11 | 15 | 19 | 26 | 37 | 56 | 75 | 100 | 150 |
| 25 | | | 0.9 | 1.2 | 1.4 | 1.7 | 2.3 | 2.9 | 3.5 | 4.6 | 5.8 | 7.2 | 8.7 | 10 | 12 | 14 | 17 | 23 | 29 | 41 | 58 | 87 | 116 | 155 | 233 |
| 35 | | | 1.2 | 1.6 | 2 | 2.4 | 3.2 | 4 | 4.8 | 6.4 | 8 | 10 | 12 | 14 | 16 | 20 | 24 | 32 | 40 | 56 | 80 | 121 | 161 | 216 | 324 |
| 50 | | 1.1 | 1.7 | 2.3 | 2.8 | 3.4 | 4.5 | 5.7 | 6.8 | 9 | 11 | 14 | 17 | 20 | 23 | 28 | 34 | 45 | 57 | 79 | 113 | 170 | 226 | 303 | 455 |
| 70 | 0.8 | 1.5 | 2.3 | 3.1 | 3.8 | 4.6 | 6.2 | 7.7 | 9.2 | 12 | 15 | 19 | 23 | 27 | 31 | 38 | 46 | 62 | 77 | 108 | 154 | 231 | 308 | 413 | |
| 95 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 16 | 20 | 25 | 30 | 35 | 40 | 50 | 60 | 80 | 100 | 140 | 200 | 300 | 400 | | |
| 120 | 1.2 | 2.4 | 3.6 | 4.8 | 6 | 7.2 | 10 | 12 | 14 | 19 | 24 | 30 | 36 | 42 | 48 | 60 | 72 | 96 | 120 | 168 | 240 | 360 | 481 | | |
| 150 | 1.4 | 2.8 | 4.2 | 5.6 | 7 | 8.4 | 11 | 14 | 17 | 23 | 28 | 35 | 42 | 49 | 56 | 70 | 84 | 113 | 141 | 197 | 281 | 422 | | | |
| 185 | 1.6 | 3.2 | 4.8 | 6.4 | 8 | 10 | 13 | 16 | 19 | 26 | 32 | 40 | 48 | 56 | 64 | 80 | 96 | 128 | 160 | 224 | 320 | 480 | | | |
| 240 | 1.8 | 3.7 | 5.5 | 7.3 | 9.1 | 11 | 15 | 18 | 22 | 29 | 37 | 46 | 55 | 64 | 73 | 91 | 110 | 146 | 183 | 256 | 366 | 549 | | | |
| 300 | 2 | 4 | 6 | 8 | 10 | 12 | 16 | 20 | 24 | 32 | 40 | 50 | 60 | 70 | 80 | 100 | 120 | 160 | 200 | 280 | 400 | | | | |
| 2x120 | 2.4 | 4.8 | 7.2 | 10 | 12 | 14 | 19 | 24 | 29 | 38 | 48 | 60 | 72 | 84 | 96 | 120 | 144 | 192 | 240 | 336 | 481 | | | | |
| 2x150 | 2.8 | 5.6 | 8.4 | 11 | 14 | 17 | 23 | 28 | 34 | 45 | 56 | 70 | 84 | 98 | 113 | 141 | 169 | 225 | 281 | 394 | 563 | | | | |
| 2x185 | 3.2 | 6.4 | 10 | 13 | 16 | 19 | 26 | 32 | 38 | 51 | 64 | 80 | 96 | 112 | 128 | 160 | 192 | 256 | 320 | 448 | | | | | |
| 3x120 | 3.6 | 7.2 | 11 | 14 | 18 | 22 | 29 | 36 | 43 | 58 | 72 | 90 | 108 | 126 | 144 | 180 | 216 | 288 | 360 | 505 | | | | | |
| 3x150 | 4.2 | 8.4 | 13 | 17 | 21 | 25 | 34 | 42 | 51 | 68 | 84 | 105 | 127 | 148 | 169 | 211 | 253 | 338 | 422 | | | | | | |
| 3x185 | 4.8 | 10 | 14 | 19 | 24 | 29 | 38 | 48 | 58 | 77 | 96 | 120 | 144 | 168 | 192 | 240 | 288 | 384 | 480 | | | | | | |

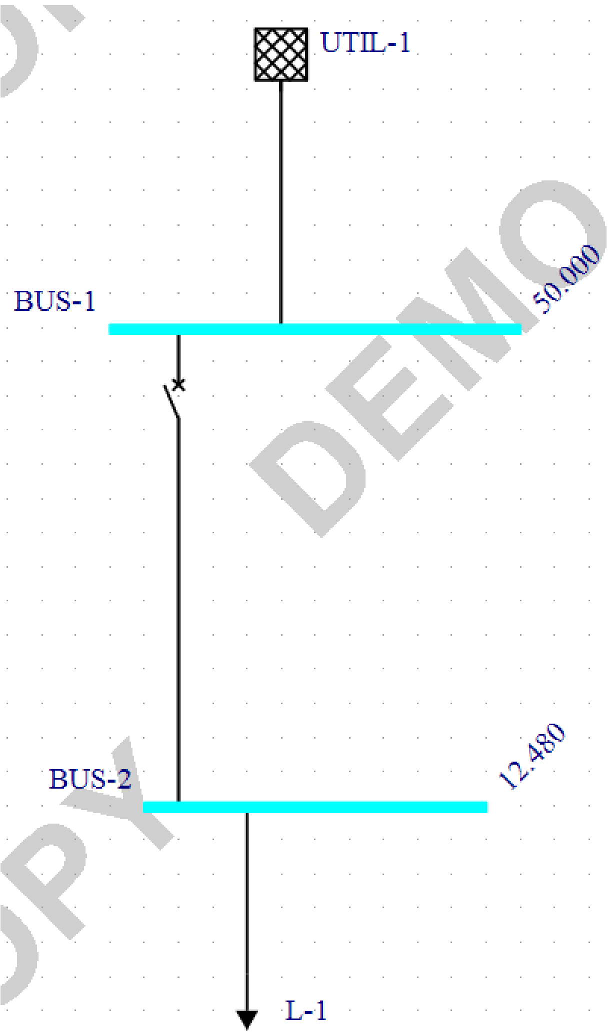
| $I_k$ upstream [kA] | $I_k$ downstream [kA] | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 96 | 92 | 89 | 85 | 82 | 78 | 71 | 65 | 60 | 50 | 43 | 36 | 31 | 27 | 24 | 20 | 17 | 13 | 11 | 7.8 | 5.6 | 3.7 | 2.7 | 2.0 | 1.3 |
| 90 | 86 | 83 | 81 | 78 | 76 | 72 | 67 | 61 | 57 | 48 | 42 | 35 | 31 | 27 | 24 | 20 | 17 | 13 | 11 | 7.8 | 5.6 | 3.7 | 2.7 | 2.0 | 1.3 |
| 80 | 77 | 75 | 73 | 71 | 69 | 66 | 62 | 57 | 53 | 46 | 40 | 34 | 30 | 27 | 24 | 20 | 17 | 13 | 10 | 7.7 | 5.5 | 3.7 | 2.7 | 2.0 | 1.3 |
| 70 | 68 | 66 | 65 | 63 | 62 | 60 | 56 | 53 | 49 | 43 | 38 | 33 | 29 | 26 | 23 | 19 | 16 | 13 | 10 | 7.6 | 5.5 | 3.7 | 2.7 | 2.0 | 1.3 |
| 60 | 58 | 57 | 56 | 55 | 54 | 53 | 50 | 47 | 45 | 40 | 36 | 31 | 28 | 25 | 23 | 19 | 16 | [illegible] | 10 | 7.5 | 5.4 | 3.7 | 2.7 | 2.0 | 1.3 |
| 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 41 | 39 | 35 | 32 | 29 | 26 | 23 | 21 | 18 | 15 | 12 | 10 | 7.3 | 5.3 | 3.6 | 2.6 | 2.0 | 1.3 |
| 40 | 39 | 39 | 38 | 38 | 37 | 37 | 35 | 34 | 33 | 31 | 28 | 26 | 24 | 22 | 20 | 17 | 15 | 12 | 10 | 7.1 | 5.2 | 3.6 | 2.6 | 2.0 | 1.3 |
| 35 | 34 | 34 | 34 | 33 | 33 | 32 | 32 | 31 | 30 | 28 | 26 | 24 | 22 | 20 | 19 | 16 | 14 | 11 | 10 | 7.1 | 5.1 | 3.5 | 2.6 | 2.0 | 1.3 |
| 30 | 30 | 29 | 29 | 29 | 28 | 28 | 28 | 27 | 26 | 25 | 23 | 22 | 20 | 19 | 18 | 16 | 14 | 11 | 9.3 | 7.0 | 5.0 | 3.5 | 2.6 | 1.9 | 1.3 |
| 25 | 25 | 24 | 24 | 24 | 24 | 24 | 23 | 23 | 22 | 21 | 21 | 19 | 18 | 17 | 16 | 14 | 13 | 11 | 9.0 | 6.8 | 5.0 | 3.4 | 2.6 | 1.9 | 1.3 |
| 20 | 20 | 20 | 20 | 19 | 19 | 19 | 19 | 18 | 18 | 18 | 17 | 16 | 15 | 15 | 14 | 13 | 12 | 10 | 8.4 | 6.5 | 4.8 | 3.3 | 2.5 | 1.9 | 1.3 |
| 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 13 | 13 | 12 | 12 | 12 | 11 | 10 | 8.7 | 7.6 | 6.1 | 4.6 | 3.2 | 2.5 | 1.9 | 1.3 |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 9.3 | 8.8 | 7.8 | 7.0 | 5.7 | 4.4 | 3.1 | 2.4 | 1.9 | 1.3 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9.5 | 9.4 | 9.2 | 9.0 | 8.8 | 8.5 | 8.3 | 8.1 | 7.7 | 7.3 | 6.5 | 5.9 | 5.0 | 3.9 | 2.9 | 2.3 | 1.8 | 1.2 |
| 8.0 | 8.0 | 7.9 | 7.9 | 7.9 | 7.8 | 7.8 | 7.7 | 7.7 | 7.6 | 7.5 | 7.4 | 7.2 | 7.1 | 6.9 | 6.8 | 6.5 | 6.2 | 5.7 | 5.2 | 4.5 | 3.7 | 2.8 | 2.2 | 1.7 | 1.2 |
| 6.0 | 6.0 | 5.9 | 5.9 | 5.9 | 5.9 | 5.8 | 5.8 | 5.8 | 5.7 | 5.6 | 5.5 | 5.4 | 5.3 | 5.2 | 5.1 | 4.9 | 4.8 | 4.4 | 4.1 | 3.6 | 3.1 | 2.4 | 2.0 | 1.6 | 1.1 |
| 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.8 | 2.8 | 2.8 | 2.7 | 2.7 | 2.6 | 2.5 | 2.4 | 2.2 | 2.0 | 1.7 | 1.4 | 1.2 | 0.9 |



| Cable section [mm²] | Length [m] | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.5 | | | | | | | | | | | | | | | 0.9 | 1.1 | 1.4 | 1.8 | 2.5 | 3.5 | 5.3 | 7 | 9.4 | 14 |
| 2.5 | | | | | | | | | | | | 0.9 | 1 | 1.2 | 1.5 | 1.8 | 2.3 | 2.9 | 4.1 | 5.9 | 8.8 | 12 | 16 | 24 |
| 4 | | | | | | | | | | 0.9 | 1.2 | 1.4 | 1.6 | 1.9 | 2.3 | 2.8 | 3.7 | 4.7 | 6.6 | 9.4 | 14 | 19 | 25 | 38 |
| 6 | | | | | | | | 0.8 | 1.1 | 1.4 | 1.8 | 2.1 | 2.5 | 2.8 | 3.5 | 4.2 | 5.6 | 7 | 10 | 14 | 21 | 28 | 38 | 56 |
| 10 | | | | | | 0.9 | 1.2 | 1.4 | 1.9 | 2.3 | 2.9 | 3.5 | 4.1 | 4.7 | 5.8 | 7 | 9.4 | 12 | 16 | 23 | 35 | 47 | 63 | 94 |
| 16 | | | | 0.9 | 1.1 | 1.5 | 1.9 | 2.2 | 3 | 3.7 | 4.7 | 5.6 | 6.5 | 7.5 | 9.3 | 11 | 15 | 19 | 26 | 37 | 56 | 75 | 100 | 150 |
| 25 | | 0.9 | 1.2 | 1.4 | 1.7 | 2.3 | 2.9 | 3.5 | 4.6 | 5.8 | 7.2 | 8.7 | 10 | 12 | 14 | 17 | 23 | 29 | 41 | 58 | 87 | 116 | 155 | 233 |
| 35 | | 1.2 | 1.6 | 2 | 2.4 | 3.2 | 4 | 4.8 | 6.4 | 8 | 10 | 12 | 14 | 16 | 20 | 24 | 32 | 40 | 56 | 80 | 121 | 161 | 216 | 324 |
| 50 | 1.1 | 1.7 | 2.3 | 2.8 | 3.4 | 4.5 | 5.7 | 6.8 | 9 | 11 | 14 | 17 | 20 | 23 | 28 | 34 | 45 | 57 | 79 | 113 | 170 | 226 | 303 | 455 |
| 70 | 0.8 | 1.5 | 2.3 | 3.1 | 3.8 | 4.6 | 6.2 | 7.7 | 9.2 | 12 | 15 | 19 | 23 | 27 | 31 | 38 | 46 | 62 | 77 | 108 | 154 | 231 | 308 | 413 |
| 95 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 16 | 20 | 25 | 30 | 35 | 40 | 50 | 60 | 80 | 100 | 140 | 200 | 300 | 400 | |
| 120 | 1.2 | 2.4 | 3.6 | 4.8 | 6 | 7.2 | 10 | 12 | 14 | 19 | 24 | 30 | 36 | 42 | 48 | 60 | 72 | 96 | 120 | 168 | 240 | 360 | 481 | |
| 150 | 1.4 | 2.8 | 4.2 | 5.6 | 7 | 8.4 | 11 | 14 | 17 | 23 | 28 | 35 | 42 | 49 | 56 | 70 | 84 | 113 | 141 | 197 | 281 | 422 | | |
| 185 | 1.6 | 3.2 | 4.8 | 6.4 | 8 | 10 | 13 | 16 | 19 | 26 | 32 | 40 | 48 | 56 | 64 | 80 | 96 | 128 | 160 | 224 | 320 | 480 | | |
| 240 | 1.8 | 3.7 | 5.5 | 7.3 | 9.1 | 11 | 15 | 18 | 22 | 29 | 37 | 46 | 55 | 64 | 73 | 91 | 110 | 146 | 183 | 256 | 366 | 549 | | |
| 300 | 2 | 4 | 6 | 8 | 10 | 12 | 16 | 20 | 24 | 32 | 40 | 50 | 60 | 70 | 80 | 100 | 120 | 160 | 200 | 280 | 400 | | | |
| 2x120 | 2.4 | 4.8 | 7.2 | 10 | 12 | 14 | 19 | 24 | 29 | 38 | 48 | 60 | 72 | 84 | 96 | 120 | 144 | 192 | 240 | 336 | 481 | | | |
| 2x150 | 2.8 | 5.6 | 8.4 | 11 | 14 | 17 | 23 | 28 | 34 | 45 | 56 | 70 | 84 | 98 | 113 | 141 | 169 | 225 | 281 | 394 | 563 | | | |
| 2x185 | 3.2 | 6.4 | 10 | 13 | 16 | 19 | 26 | 32 | 38 | 51 | 64 | 80 | 96 | 112 | 128 | 160 | 192 | 256 | 320 | 448 | | | | |
| 3x120 | 3.6 | 7.2 | 11 | 14 | 18 | 22 | 29 | 36 | 43 | 58 | 72 | 90 | 108 | 126 | 144 | 180 | 216 | 288 | 360 | 505 | | | | |
| 3x150 | 4.2 | 8.4 | 13 | 17 | 21 | 25 | 34 | 42 | 51 | 68 | 84 | 105 | 127 | 148 | 169 | 211 | 253 | 338 | 422 | | | | | |
| 3x185 | 4.8 | 10 | 14 | 19 | 24 | 29 | 38 | 48 | 58 | 77 | 96 | 120 | 144 | 168 | 192 | 240 | 288 | 384 | 480 | | | | | |

| $I_k$ upstream [kA] | $I_k$ downstream [kA] | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 96 | 92 | 89 | 85 | 82 | 78 | 71 | 65 | 60 | 50 | 43 | 36 | 31 | 27 | 24 | 20 | 17 | 13 | 11 | 7.8 | 5.6 | 3.7 | 2.7 | 2.0 | 1.3 |
| 90 | 86 | 83 | 81 | 78 | 76 | 72 | 67 | 61 | 57 | 48 | 42 | 35 | 31 | 27 | 24 | 20 | 17 | 13 | 11 | 7.8 | 5.6 | 3.7 | 2.7 | 2.0 | 1.3 |
| 80 | 77 | 75 | 73 | 71 | 69 | 66 | 62 | 57 | 53 | 46 | 40 | 34 | 30 | 27 | 24 | 20 | 17 | 13 | 10 | 7.7 | 5.5 | 3.7 | 2.7 | 2.0 | 1.3 |
| 70 | 68 | 66 | 65 | 63 | 62 | 60 | 56 | 53 | 49 | 43 | 38 | 33 | 29 | 26 | 23 | 19 | 16 | 13 | 10 | 7.6 | 5.5 | 3.7 | 2.7 | 2.0 | 1.3 |
| 60 | 58 | 57 | 56 | 55 | 54 | 53 | 50 | 47 | 45 | 40 | 36 | 31 | 28 | 25 | 23 | 19 | 16 | 12 | 10 | 7.5 | 5.4 | 3.7 | 2.7 | 2.0 | 1.3 |
| 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 41 | 39 | 35 | 32 | 29 | 26 | 23 | 21 | 18 | 15 | 12 | 10 | 7.3 | 5.3 | 3.6 | 2.6 | 2.0 | 1.3 |
| 40 | 39 | 39 | 38 | 38 | 37 | 37 | 35 | 34 | 33 | 31 | 28 | 26 | 24 | 22 | 20 | 17 | 15 | 12 | 10 | 7.1 | 5.2 | 3.6 | 2.6 | 2.0 | 1.3 |
| 35 | 34 | 34 | 34 | 33 | 33 | 32 | 32 | 31 | 30 | 28 | 26 | 24 | 22 | 20 | 19 | 16 | 14 | 11 | 10 | 7.1 | 5.1 | 3.5 | 2.6 | 2.0 | 1.3 |
| 30 | 30 | 29 | 29 | 29 | 28 | 28 | 28 | 27 | 26 | 25 | 23 | 22 | 20 | 19 | 18 | 16 | 14 | 11 | 9.3 | 7.0 | 5.0 | 3.5 | 2.6 | 1.9 | 1.3 |
| 25 | 25 | 24 | 24 | 24 | 24 | 24 | 23 | 23 | 22 | 21 | 21 | 19 | 18 | 17 | 16 | 14 | 13 | 11 | 9.0 | 6.8 | 5.0 | 3.4 | 2.6 | 1.9 | 1.3 |
| 20 | 20 | 20 | 20 | 19 | 19 | 19 | 19 | 18 | 18 | 18 | 17 | 16 | 15 | 15 | 14 | 13 | 12 | 10 | 8.4 | 6.5 | 4.8 | 3.3 | 2.5 | 1.9 | 1.3 |
| 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 13 | 13 | 12 | 12 | 12 | 11 | 10 | 8.7 | 7.6 | 6.1 | 4.6 | 3.2 | 2.5 | 1.9 | 1.3 |
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 11 | 11 | 11 | 11 | 10 | 10 | 10 | 9.3 | 8.8 | 7.8 | 7.0 | 5.7 | 4.4 | 3.1 | 2.4 | 1.9 | 1.3 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9.5 | 9.4 | 9.2 | 9.0 | 8.8 | 8.5 | 8.3 | 8.1 | 7.7 | 7.3 | 6.5 | 5.9 | 5.0 | 3.9 | 2.9 | 2.3 | 1.8 | 1.2 |
| 8.0 | 8.0 | 7.9 | 7.9 | 7.9 | 7.8 | 7.8 | 7.7 | 7.7 | 7.6 | 7.5 | 7.4 | 7.2 | 7.1 | 6.9 | 6.8 | 6.5 | 6.2 | 5.7 | 5.2 | 4.5 | 3.7 | 2.8 | 2.2 | 1.7 | 1.2 |
| 6.0 | 6.0 | 5.9 | 5.9 | 5.9 | 5.9 | 5.8 | 5.8 | 5.8 | 5.7 | 5.6 | 5.5 | 5.4 | 5.3 | 5.2 | 5.1 | 4.9 | 4.8 | 4.4 | 4.1 | 3.6 | 3.1 | 2.4 | 2.0 | 1.6 | 1.1 |
| 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.8 | 2.8 | 2.8 | 2.7 | 2.7 | 2.6 | 2.5 | 2.4 | 2.2 | 2.0 | 1.7 | 1.4 | 1.2 | 0.9 |



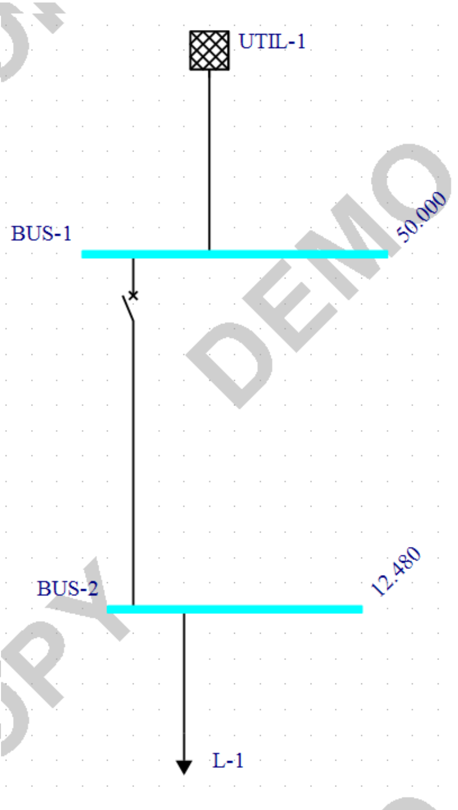
# Short Circuit Calculation

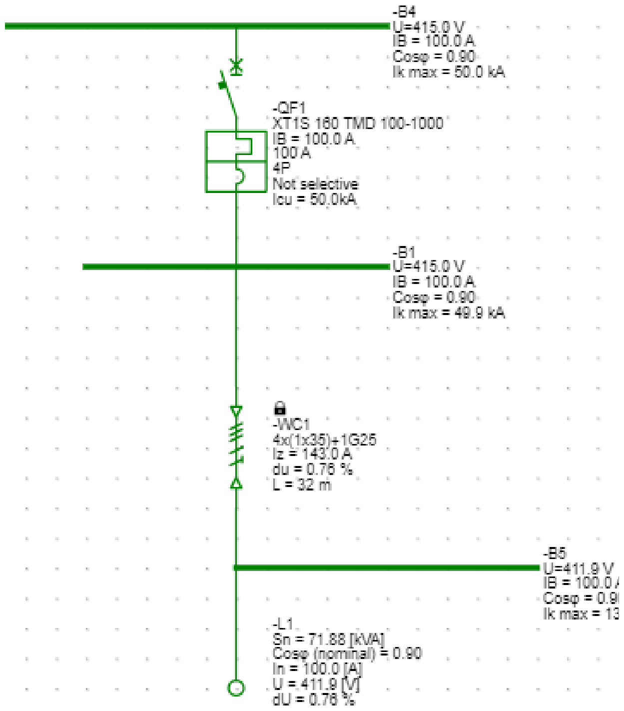
Basic Principles

## Calculation of Short Circuit Currents

Manual Verification

- Example 1




$\text{Voltage} = \sqrt{3} * R * I$

$I_1 = 50kA$

$R_1 = \frac{V}{\sqrt{3} * I_1}$

$= \frac{400}{\sqrt{3} * 50} = 4.618\ m\Omega$

$R_{cable} = 16.923\ m\Omega$ (from cable database @ $20^0C$)

$(R_1 + R_{cable}) = 21.541\ m\Omega$

$I_2 = \frac{V}{\sqrt{3} * (R_1 + R_{cable})}$

$= \frac{400}{\sqrt{3} * 21.541} = 10.72\ kA$

ABB