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Totally Integrated Power

SIMARIS design SIMARIS project

Technical Manual

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1.1 Power Supply Systems, Connection to Earth

1.1.1 Introduction to Power Supply Systems

Power supply systems are distinguished according to their

- type and number of live conductors,
- type of connection to earth,
- and the design of this connection to earth.

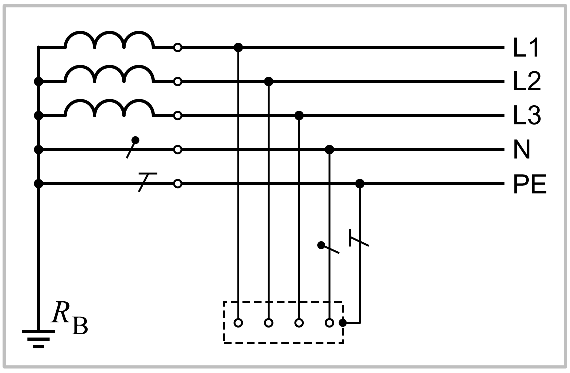
The code letters have the following meaning:

Code letter	Meaning in French	Meaning in English / German
T	terre	earth / Erde
I	isolé	isolated / isoliert
N	neutre	neutral / neutral
S	séparé	separated / getrennt
C	combiné	combined / kombiniert

The designation for the power system configuration is made up from the code letters as follows:

First letter: it characterizes the earthing condition of the supplying power source.	**T**	Directly earthed power source
	I	Insulation of live parts against earth or connection to earth via impedance
Second letter: it characterizes the earthing condition of the exposed conductive parts in the electrical installation.	**T**	Exposed conductive parts are connected to earth either separately, in groups or jointly.
	N	exposed conductive parts are directly connected to the earthed point of the electrical installation via protective conductors
Further letters: characterize the arrangement of the neutral conductor N and the protective conductor PE in the TN network.	**S**	Neutral conductor and protective conductor are wired as separate conductors.
	C	Neutral and protective conductor are combined in one conductor (PEN).

1.1.2 TN-S system



1.1.2.1 Features

- In the TN-S system, the neutral point of the voltage source is directly earthed (system earth electrode).
- Exposed conductive parts are connected to the neutral point of the voltage source through a defined connection.
- Throughout the entire network, the protective conductor is wired separate from the neutral conductor.
- There is only one central earthing point (CEP) for each subnetwork, from where PEN is split into PE+N.
- In the further course of the cable/busbar run, N+PE must not be connected any more.
- Thus, the entire system must be built up as a 5-conductor network starting from the main distribution board down to the final load level.

1.1.2.2 Advantages

- A short-circuit to an exposed conductive part becomes a fault with an appropriately high fault current.
- Simple protective devices, such as fuses or circuit-breakers, can take over the task to disconnect the faulted item of equipment.
- The separation of PE and N throughout the entire system ensures that no stray currents will flow through building constructions or conductor shields, which might cause disturbances in the IT systems or lead to corrosion.

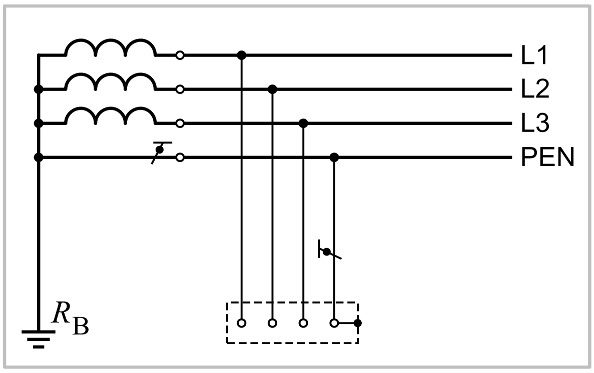
1.1.2.3 Disadvantages

- Five conductors are needed in the entire power system.
- Parallel network operation is not permitted, when subnetworks are connected.
- Subnetworks must be separated by 4-pole switching devices.
- It often happens that connections between PE+N are erroneously made in the further course of the network.

1.1.2.4 Precautions

- During installation, or respectively in case of system expansions, care must be taken that no further splitting bridge is used within a subnetwork downstream of the central earthing point (attention: national installation practice for HVAC!).
- In addition, a converter must be provided on the central earthing point that monitors the currents through PE with the aid of a current watchdog and renders appropriate feedback signals.

1.1.3 TN-C system



1.1.3.1 Features

- In the TN-C system, the neutral point of the voltage source is directly earthed (system earth electrode).
- Exposed conductive parts are connected to the neutral point of the voltage source through a defined connection.
- Starting from the feed-in point down to the loads, the PE+N function is implemented through a combined conductor, the PEN.
- Please observe that the PEN must be laid insulated throughout its entire course, also inside switchgear cabinets. For mechanical reasons it is mandatory that the conductor cross section of the PEN be ≥ 10 mm² for copper, and ≥ 16 mm² for aluminum.

1.1.3.2 Advantages

- A short-circuit to an exposed conductive part becomes a fault with an appropriately high fault current.
- Simple protective devices, such as fuses or circuit-breakers, can take over the task of disconnecting the faulted item of equipment.
- In the entire power system, only cables with a maximum of 4 conductors are laid, which will result in savings in the cable installation as compared to the TN-S system.
- The use of 3-pole protective devices is sufficient.

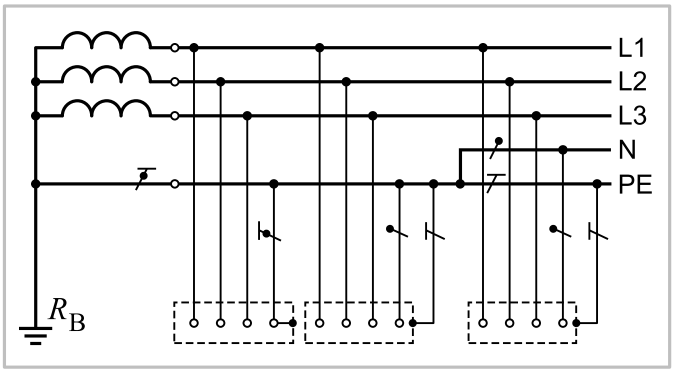
1.1.3.3 Disadvantages

- The jointly wired PE+N in form of one PEN conductor throughout the entire system results in undesired effects and dangerous consequential damage caused by stray currents. These currents strain electrical as well as metallic mechanical systems.
- Corrosion in the building construction, load and possible inflammations of data cable shields, interference to and corruption of data packages owing to induction, etc. are some of the examples of consequential damage that might arise.

1.1.3.4 Precautions

- When new installations are built, or the system is expanded, TN-S systems shall be used.

1.1.4 TN-C-S system



1.1.4.1 Features

- In the TN-C-S system, the neutral point of the voltage source is directly earthed (system earth electrode).
- Exposed conductive parts are connected to the neutral point of the voltage source through a defined connection.
- Starting from the feed-in point down to a certain point in the network, the PE+N function is covered by a combined conductor, the PEN.
- Please observe that within the range of this PEN, the PEN must be laid insulated throughout its entire course, also inside switchgear cabinets. For mechanical reasons, it is mandatory that the conductor cross section of the PEN be ≥ 10 mm^2 for copper, and ≥ 16 mm^2 for aluminum.
- Starting from this subnetwork, one or more 5-conductor networks (TN-S networks) with separate PE+N will branch.

1.1.4.2 Advantages

- A short-circuit to an exposed conductive part becomes a fault with an appropriately high fault current.
- Simple protective devices, such as fuses or circuit-breakers, can take over the task of disconnecting the faulted item of equipment.
- In some parts of the power system, only cables with a maximum of 4 conductors are laid, which will result in savings in the cable installation as compared to the pure TN-S system.

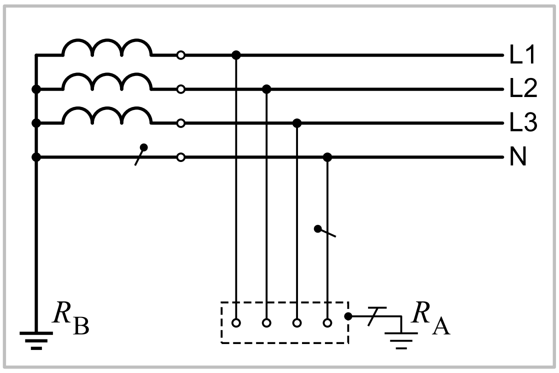
1.1.4.3 Disadvantages

- If a joint PEN is wired beyond the main distribution board, this will have undesired effects and result in dangerous consequential damage caused by stray currents. These currents strain electrical as well as metallic mechanical systems.
- Corrosion in the building construction, load and possible inflammations of data cable shields, interference to and corruption of data packages owing to induction, etc. are some of the examples of consequential damage that might arise.

1.1.4.4 Precautions

- When new installations are built, or the system is expanded, TN-S systems shall be relied on downward of the main distribution.

1.1.5 TT system



1.1.5.1 Features

- In the TT system, the neutral point of the voltage source is directly earthed (system earth electrode).
- The exposed conductive parts of the electrical installation are also directly earthed.
- System earth electrode and protective earthing of items of equipment are not conductively connected.
- The earthing system for the system earth electrode must be at a minimum distance of 20 m from that of the protective earthing.

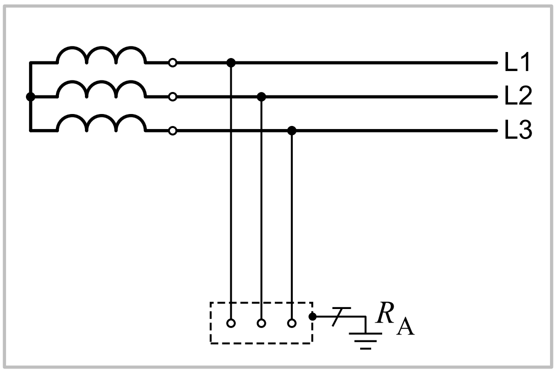
1.1.5.2 Advantages

- Protective conductors are used to earth equipment in protection class I at their mounting location.
- This means that the location and the exposed conductive part will take approximately the same electrical potential even in case of a short-circuit, so that the touch voltage UT = 0 V.
- A short-circuit to an exposed conductive part now becomes an earth fault, and not a short-circuit, as in the TN system.
- Therefore, the fault current is relatively low compared to the TN system.

1.1.5.3 Disadvantages

- The fault currents are not defined.
- If the earth electrode for the exposed conductive part is interrupted, the entire fault current will flow though the human body.
- Under unfavourable conditions, this current is lower that the trip current of an RCCD, but there is danger to life!
- Typically, protective devices in the form of fuses cannot be applied owing to the low fault current.
  Normally, RCDs (residual current devices, formerly "RCCBs", residual-current-operated circuit-breakers) are required.

1.1.6 IT system



1.1.6.1 Features

- In the IT system, the phase conductors and – if available, the neutral conductor of the voltage source, too – are isolated to earth under normal operating conditions, or they are high-resistance-earthed.
- The exposed conductive parts which are connected in the installation are individually or jointly connected to earth through a (joint) protective conductor.

1.1.6.2 Advantages

- In case of a single short-circuit or earth fault, hazardous shock currents cannot flow.
- The fault must merely be signalled, not disconnected (insulation monitoring).
- After the fault was indicated, the operator can take his time to locate the fault while the network remains operable.
- In case of a second fault, the network must be disconnected similar to the TN or TT system.
- High availability and ideal supply conditions for hazardous locations owing to missing internal arcs during the first fault.

1.1.6.3 Disadvantages

- Voltage increase during the healthy phases after occurrence of the first fault → for device selection, please bear in mind that the isolation value which is required is higher.
- In addition to insulation monitoring, protection against overload must be ensured through the use of fuses or circuit-breakers.
- Since conditions will not always be identical to that of the TN system after the first fault, but can possibly approximate the TT system owing to undefined earth connections, it is sometimes necessary to apply additional RCCBs to isolate low faults currents.

1.2 Degrees of Protection for Electrical Equipment

1.2.1 Designation Structure for Degrees of Protection

- The designation always starts with the letters IP ('international protection'),
- followed by a two-digit number. This number indicates which scope of protection an enclosure provides in terms of
  - contact or solid external bodies (first digit)
  - and humidity (second digit).
- Optionally, another letter plus a supplementary letter may follow after the two numbers. The additional letter is of significance for the protection of persons and renders information about the protection against access to dangerous parts
  - with the back of one's hand (A)
  - with a finger (B)
  - with tools (C)
  - and wire (D).

1.2.2 Degrees of Protection against Ingress of Foreign Bodies (first code number)

First code number	Short description	Definition
0	Not protected	--
1	Protected against ingress of foreign bodies of 50 mm in diameter and larger	The probe, a ball of 50 mm in diameter, must not fully penetrate*)
2	Protected against ingress of foreign bodies of 12.5 mm in diameter and larger	The probe, a ball of 12.5 mm in diameter, must not fully penetrate*)
3	Protected against ingress of foreign bodies of 2.5 mm in diameter and larger	The probe, a ball of 2.5 mm in diameter, must not penetrate at all
4	Protected against ingress of foreign bodies of 1 mm in diameter and larger	The probe, a ball of 1 mm in diameter, must not penetrate at all
5	Dust-protected	Ingress of dust is not completely prevented, but dust may not penetrate to such an extent that satisfactory device operation or the safety would be impaired
6	Dust-proof	No ingress of dust

*) Note: The full diameter of the probe must not fit through the opening of the enclosure.

1.2.3 Degrees of Protection against the Ingress of Water (second code number)

Second code number	Short description	Definition
0	Not protected	--
1	Protected against dripping water	Vertically falling drops must not have any harmful effect
2	Protected against dripping water if the enclosure is tilted up to 15°	Vertically falling drops must not have any harmful effect if the enclosure is tilted up to 15° to either side of the plum line
3	Protected against spray water	Water sprayed at a 60° angle of either side of the plumb line must not have any harmful effect
4	Protected against splash water	Water splashing onto the enclosure from any side must not have any harmful effect
5	Protected against jet water	Water in form of a water jet directed onto the enclosure from any side must not have any harmful effect
6	Protected against strong water jets (hose-proof)	Water splashing onto the enclosure from any side in form of a strong water jet must not have any harmful effect
7	Protected against the effects of temporary immersion in water	Water must not enter in such quantities that would cause harmful effects if the enclosure is temporarily fully immersed in water under standardized pressure and time conditions
8	Protected against the effects of permanent immersion in water	Water must not enter in such quantities that would cause harmful effects if the enclosure is permanently fully immersed in water under conditions to be agreed between manufacturer and user. The conditions must, however, be stricter than imposed for code number 7.

1.3 Explanations on the Consideration of Functional Endurance in the SIMARIS Planning Tools

1.3.1 Functional Endurance Basics

Construction regulations set special requirements on the electricity supply systems of safety facilities: the functionality of the cabling system must be ensured for a specific period of time even in case of fire.

This is ensured if the cables/wires and busbar trunking systems are used with a functional endurance classification E30, E60 or E90 in accordance with DIN 4102-12 and based on the rules of acceptance of these products.

This requires that the wires, cables or busbar trunking systems can resist a fire and do not cease to function because of a short-circuit, current interruption or loss of their insulation.

It must be verified that voltage drop and tripping conditions for personal protection (VDE 0100 Part 410) are also maintained under increased fire temperature conditions.

1.3.1.1 Fire Prevention for Building Structures of Special Type and Usage

"Fire protection equipment and fire prevention" for electrical installations are in particular necessary for building structures intended for special use. These are, for instance, hospitals or venues for public gathering. According to DIN VDE 0100-560 (previously DIN VDE 0100-718) "Communal facilities" and DIN VDE 0100-710
(previously DIN VDE 0107) "Medical locations", electrical installations must remain operable for a certain period of time, even in case of fire.

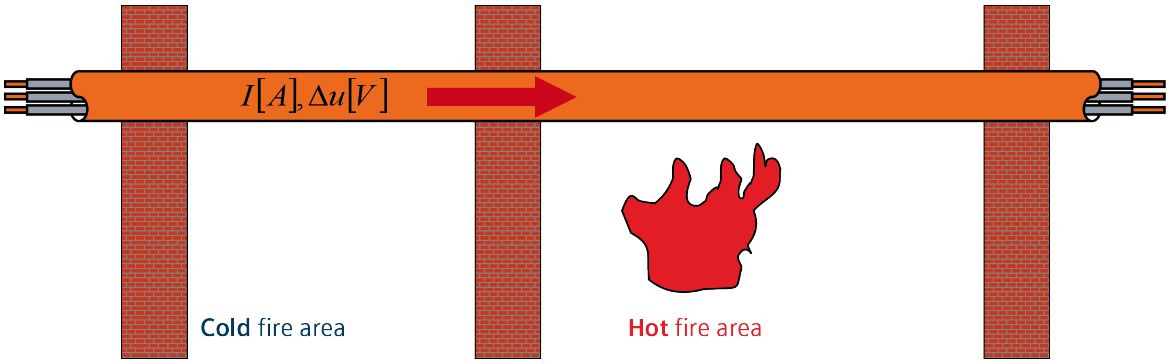
According to these standards, safety-relevant systems must remain operable for a specific period of time.

These are, for instance:

- Fire alarm systems
- Installations for alarming and instructing visitors and employees
- Safety lighting
- Ventilation systems for safety stairways, lift wells and machine rooms of fire fighting lifts, for which a 90-minute minimum time of operability under full fire conditions must be ensured
- Water pressure rising systems for the supply of fire-extinguishing water
- Smoke extraction systems
- Lift systems for evacuating people with an evacuation circuit, which must remain operable for a minimum time of 30 minutes under full fire conditions in the feeder cable area

1.3.1.2 Selection of Fire Areas for the Calculation of Voltage Drop and Tripping Condition

When functional endurance is calculated under increased fire temperatures, it is assumed that this fire temperature may only occur in one fire area, and that fire walls with a fire resistance class F90 will prevent spreading of the fire. This means that cables and busbar trunking systems can be divided into several sections, of which one section may be exposed to the fire temperature and the others to normal room temperature. If a cabling system crosses more than 1 fire area, the fire area with the longest cable route shall be factored into the calculation, this allows to always assume and calculate the most unfavourable case.



1.3.1.3 Calculation Basis

- The calculation establishes the increased active resistance arising due to the temperature rise in the fire.
- The voltage drop is individually determined, i.e. for the hot (= defined largest fire area) and each of the cold fire areas. This means that the higher temperature is used for calculating the "hot fire area".
- The entire voltage drop across all areas is used to verify and output the data.
- the minimum short-circuit current is calculating with the highest impedance. The overall impedance is the sum of all impedance values in the fire areas, dependent on the higher temperature in the hot area and the impedance of the cold areas with normal temperatures.

1.3.1.4 Types of Functional Endurance and how they are considered in SIMARIS design

The following options are available for ensuring functional endurance of a busbar/cabling system:
- Protection through enclosure of the busbar trunking systems
- Protection through enclosure of standard cables
- Laying of cables with integrated functional endurance

1.3.1.4.1 Enclosing Busbar Trunking Systems

A temperature of 150 °C is assumed for the busbar trunking systems. This temperature applies to all functional endurance classes. This temperature is only set and used for calculating the voltage drop and the tripping condition in the largest fire area. This default may, however, be subsequently altered depending on specific project conditions.

All enclosed busbar trunking systems require the consideration of derating factors. This must happen independent of the fact whether a fire area was defined or not.

For dimensioning, the current carrying capacity of the busbar trunking systems must be reduced accordingly on the basis of system-specific derating tables.

Enclosing busbar trunking systems is only permissible for the BD2, LD, LI and LX systems (both for Al and Cu).

The derating tables for the various busbar trunking systems are kept in SIMARIS design. The software automatically accesses these tables in the course of calculations, as soon as an enclosure is entered for the respective type of busbar trunking system. However, the user has no access to these tables in the software, e.g. to display data, etc.

The following derating tables for the various busbar trunking systems are kept in SIMARIS design. In the tables there is only the highest complied functional endurance class listed. The busbar trunking systems are nevertheless also suitable for lower functional endurance classes.

BD2 system

Mounting position flat, horizontal and vertical	Maximum current, vented from all sides	I_e with a plate thickness of 50 mm	Functional endurance class
System	$I_e[A]$	$I_e[A]$	
BD2A-160	160	100	E90
BD2A-250	250	160	E90
BD2A-400	400	250	E90
BD2A-630	630	400	E90
BD2A-800	800	500	E90
BD2A-1000	1000	630	E90

Mounting position flat, horizontal and vertical	Maximum current, vented from all sides	I_e with a plate thickness of 50 mm	Functional endurance class
System	$I_e[A]$	$I_e[A]$	
BD2C-160	160	100	E90
BD2C-250	250	160	E90
BD2C-400	400	250	E90
BD2C-630	630	400	E90
BD2C-800	800	500	E90
BD2C-1000	1000	630	E90
BD2C-1250	1250	800	E90

LD system

Mounting position	Maximum current	Current calculated with	Reduction factor	Functional endurance class	Current calculated with	Reduction factor	Functional endurance class	Current calculated with	Reduction factor	Functional endurance class
horizontal edgewise	IP34, vented from all sides	20 mm plates			40 mm plates			45 mm plates [1)]		
System	$I_e[A]$	$I_e[A]$			$I_e[A]$			$I_e[A]$		
LDA1	1100	675	0.61	E60	603	0.55	E90	550	0.50	E90
LDA2	1250	750	0.60	E60	670	0.54	E90	625	0.50	E90
LDA3	1600	912	0.57	E60	804	0.50	E90	800	0.50	E90
LDA4	2000	1140	0.57	E90	1005	0.50	E90	900	0.45	E90
LDA5	2500	1425	0.57	E90	1250	0.50	E90	1125	0.45	E90
LDA6	3000	1710	0.57	E90	1500	0.50	E90	1350	0.45	E90
LDA7	3700	2109	0.57	E90	1850	0.50	E90	1665	0.45	E90
LDA8	4000	2280	0.57	E90	2000	0.50	E90	1800	0.45	E90
LDC2	2000	1200	0.60	E60	1072	0.54	E90	1040	0.52	E90
LDC3	2600	1500	0.58	E60	1340	0.52	E90	1352	0.52	E90
LDC6	3400	1950	0.57	E90	1742	0.51	E90	1530	0.45	E90
LDC7	4400	2508	0.57	E90	2200	0.50	E90	1980	0.45	E90
LDC8	5000	2850	0.57	E90	2500	0.50	E90	2250	0.45	E90

Mounting position	Maximum current,	Current calculated with	Reduction factor	Functional endurance class	Current calculated with	Reduction factor	Functional endurance class	Current calculated with	Reduction factor	Functional endurance class
horizontal edgewise	IP54, vented from all sides	20 mm plates			40 mm plates			45 mm plates [1)]		
system	$I_e[A]$	$I_e[A]$			$I_e[A]$			$I_e[A]$		
LDA1	900	675	0.75	E60	603	0.67	E90	540	0.60	E90
LDA2	1000	750	0.75	E60	670	0.67	E90	600	0.60	E90
LDA3	1200	900	0.75	E60	804	0.67	E90	720	0.60	E90
LDA4	1500	1125	0.75	E90	1005	0.67	E90	900	0.60	E90
LDA5	1800	1350	0.75	E90	1206	0.67	E90	1080	0.60	E90
LDA6	2000	1500	0.75	E90	1340	0.67	E90	1200	0.60	E90
LDA7	2400	1800	0.75	E90	1608	0.67	E90	1440	0.60	E90
LDA8	2700	2025	0.75	E90	1809	0.67	E90	1620	0.60	E90
LDC2	1600	1200	0.75	E60	1072	0.67	E90	960	0.60	E90
LDC3	2000	1500	0.75	E60	1340	0.67	E90	1200	0.60	E90
LDC6	2600	1950	0.75	E90	1742	0.67	E90	1560	0.60	E90
LDC7	3200	2400	0.75	E90	2144	0.67	E90	1920	0.60	E90
LDC8	3600	2700	0.75	E90	2412	0.67	E90	2160	0.60	E90

LD system

Mounting position	Maximum current	Current calculated with	Reduction factor	Functional endurance class	Current calculated with	Reduction factor	Functional endurance class	Current calculated with	Reduction factor	Functional endurance class
flat horizontal	IP34 IP54 vented from all sides	20 mm plates			40 mm plates			45 mm plates [1)]		
System	$I_e[A]$	$I_e[A]$			$I_e[A]$			$I_e[A]$		
LDA1	700	602	0.86	E60	545	0.78	E90	486	0.69	E90
LDA2	750	645	0.86	E60	584	0.78	E90	521	0.69	E90
LDA3	1000	860	0.86	E60	778	0.78	E90	694	0.69	E90
LDA4	1200	1032	0.86	E90	934	0.78	E90	833	0.69	E90
LDA5	1700	1462	0.86	E90	1323	0.78	E90	1180	0.69	E90
LDA6	1800	1548	0.86	E90	1400	0.78	E90	1250	0.69	E90
LDA7	2200	1892	0.86	E90	1712	0.78	E90	1527	0.69	E90
LDA8	2350	2021	0.86	E90	1828	0.78	E90	1631	0.69	E90
LDC2	1200	1032	0.86	E60	934	0.78	E90	833	0.69	E90
LDC3	1550	1333	0.86	E60	1206	0.78	E90	1076	0.69	E90
LDC6	2000	1720	0.86	E90	1556	0.78	E90	1388	0.69	E90
LDC7	2600	2236	0.86	E90	2023	0.78	E90	1804	0.69	E90
LDC8	3000	2580	0.86	E90	2334	0.78	E90	2082	0.69	E90

Mounting position	Maximum current	Current calculated with	Reduction factor	Functional endurance class	Current calculated with	Reduction factor	Functional endurance class	current calculated with	Reduction factor	Functional endurance class
vertical	IP34, vented from all sides	20 mm plates			40 mm plates			45 mm plates [1)]		
System	$I_e[A]$	$I_e[A]$			$I_e[A]$			$I_e[A]$		
LDA1	950	675	0.71	E60	603	0.63	E90	475	0.50	E90
LDA2	1100	750	0.68	E60	670	0.61	E90	550	0.50	E90
LDA3	1250	900	0.72	E60	804	0.64	E90	625	0.50	E90
LDA4	1700	1125	0.66	E90	1005	0.59	E90	748	0.44	E90
LDA5	2100	1350	0.64	E90	1206	0.57	E90	924	0.44	E90
LDA6	2300	1500	0.65	E90	1340	0.58	E90	1012	0.44	E90
LDA7	2800	1800	0.64	E90	1608	0.57	E90	1232	0.44	E90
LDA8	3400	2025	0.60	E90	1809	0.53	E90	1496	0.44	E90
LDC2	1650	1200	0.73	E60	1072	0.65	E90	792	0.48	E90
LDC3	2100	1500	0.71	E60	1340	0.64	E90	1008	0.48	E90
LDC6	2700	1950	0.72	E90	1742	0.65	E90	1296	0.48	E90
LDC7	3500	2400	0.69	E90	2144	0.61	E90	1680	0.48	E90
LDC8	4250	2700	0.64	E90	2412	0.57	E90	2040	0.48	E90

LD system

Mounting position	Maximum current,	current calculated with	Reduction factor	Functional endurance class	current calculated with	Reduction factor	Functional endurance class	current calculated with	Reduction factor	Functional endurance class
vertical	IP54 freely ventilated	20 mm plates			40 mm plates			45 mm plates [1)]		
System	$I_e[A]$	$I_e[A]$			$I_e[A]$			$I_e[A]$		
LDA1	900	675	0.75	E60	603	0.67	E90	540	0.60	E90
LDA2	1000	750	0.75	E60	670	0.67	E90	600	0.60	E90
LDA3	1200	900	0.75	E60	804	0.67	E90	720	0.60	E90
LDA4	1500	1125	0.75	E90	1005	0.67	E90	900	0.60	E90
LDA5	1800	1350	0.75	E90	1206	0.67	E90	1080	0.60	E90
LDA6	2000	1500	0.75	E90	1340	0.67	E90	1200	0.60	E90
LDA7	2400	1800	0.75	E90	1608	0.67	E90	1440	0.60	E90
LDA8	2700	2025	0.75	E90	1809	0.67	E90	1620	0.60	E90
LDC2	1600	1200	0.75	E60	1072	0.67	E90	960	0.60	E90
LDC3	2000	1500	0.75	E60	1340	0.67	E90	1200	0.60	E90
LDC6	2600	1950	0.75	E90	1742	0.67	E90	1560	0.60	E90
LDC7	3200	2400	0.75	E90	2144	0.67	E90	1920	0.60	E90
LDC8	3600	2700	0.75	E90	2412	0.67	E90	2160	0.60	E90

LI system

Mounting position	Maximum current,	Current calculated with	Reduction factor	Functional endurance class	Current calculated with	Reduction factor	Functional endurance class	Current calculated with	Reduction factor	Functional endurance class
	IP55 freely ventilated	45 mm plates Horizontal edgewise			45 mm plates Horizontal flat			45 mm plates vertical		
System	$I_e[A]$	$I_e[A]$			$I_e[A]$			$I_e[A]$		
LI-A.0800	800	440	0.55	E90	440	0.55	E90	440	0.55	E90
LI-A.1000	1000	560	0.56	E90	560	0.56	E90	560	0.56	E90
LI-A.1250	1250	663	0.53	E90	663	0.53	E90	663	0.53	E90
LI-A.1600	1600	832	0.52	E90	832	0.52	E90	832	0.52	E90
LI-A.2000	2000	1120	0.56	E90	1120	0.56	E90	1120	0.56	E90
LI-A.2500	2500	1375	0.55	E90	1375	0.55	E90	1375	0.55	E90
LI-A.3200	3200	1824	0.57	E90	1824	0.57	E90	1824	0.57	E90
LI-A.4000	4000	2200	0.55	E90	2200	0.55	E90	2200	0.55	E90
LI-A.5000	5000	2700	0.54	E90	2700	0.54	E90	2700	0.54	E90
LI-C.1000	1000	570	0.57	E90	570	0.57	E90	570	0.57	E90
LI-C.1250	1250	663	0.53	E90	663	0.53	E90	663	0.53	E90
LI-C.1600	1600	832	0.52	E90	832	0.52	E90	832	0.52	E90
LI-C.2000	2000	1040	0.52	E90	1040	0.52	E90	1040	0.52	E90
LI-C.2500	2500	1200	0.48	E90	1200	0.48	E90	1200	0.48	E90
LI-C.3200	3200	1728	0.54	E90	1728	0.54	E90	1728	0.54	E90
LI-C.4000	4000	2000	0.50	E90	2000	0.50	E90	2000	0.50	E90
LI-C.5000	5000	2600	0.52	E90	2600	0.52	E90	2600	0.52	E90
LI-C.6300	6300	3654	0.58	E90	3654	0.58	E90	3654	0.58	E90

LX system

			Functional endurance class w. 40 mm Promat		Functional endurance class w. 50 mm Promat
System	$I_e[A]$	$I_e[A]$		$I_e[A]$	
LXA01...	800			480	E90
LXA02...	1000			600	E90
LXA04...	1250			750	E90
LXA05...	1600			960	E90
LXA06...	2000			1200	E90
LXA07...	2500			1500	E90
LXA08...	3200	2080	E90		
LXA09...	4000	2600	E90		
LXA10...	4500	2925	E90		
LXC01...	1000			600	E90
LXC02...	1250			750	E90
LXC03...	1400			840	E90
LXC04...	1600			960	E90
LXC05...	2000			1200	E90
LXC06...	2500			1500	E90
LXC07...	3200			1920	E90
LXC08...	4000	2600	E90		
LXC09...	5000	3250	E90		

[1)] On request

1.3.1.4.2 Enclosing Standard Cables

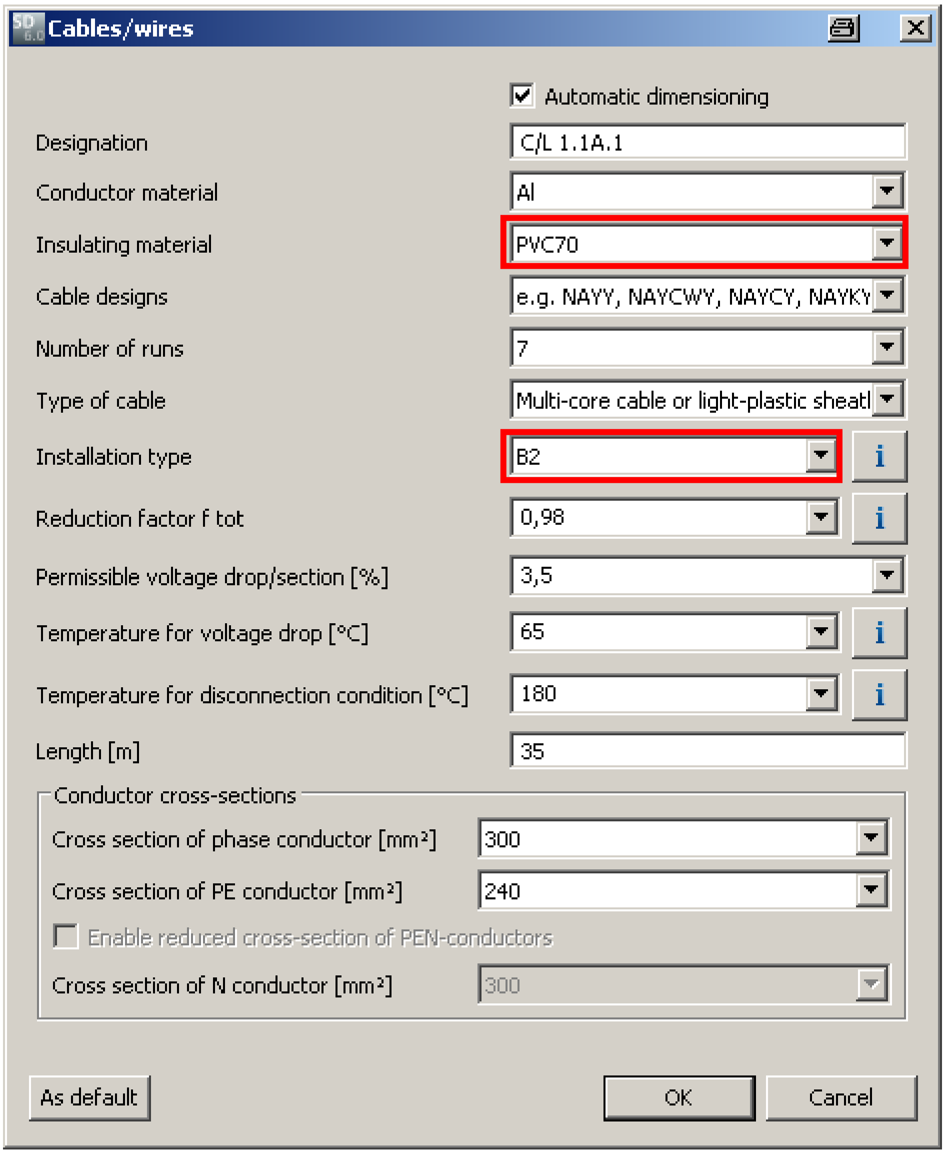
To calculate cables and wires, we recommend assuming a temperature of 150°C. This is true for all functional endurance classes. (Bibl.: Heinz-Dieter Fröse, Brandschutz für Kabel und Leitungen, Hüthig & Pflaum, 2005)

This temperature is only set and used for calculating the voltage drop and the tripping condition in the largest fire area. This default may, however, be subsequently altered depending on a specific project condition.

The current carrying capacity of enclosed cables can be compared to that of laying in hollow spaces.

Therefore, installation type B2 (= multi-core cable, or multi-core sheathed installation wire in an installation duct on a wall) instead of installation type C is automatically set as default in SIMARIS design for the enclosure of standard cables. The user may, however, subsequently alter this setting. This means, the choice of installation types is not restricted, but can be changed by the user at any time upon his own risk.

All insulation materials may be selected as enclosures, but PVC70 is automatically set as default.

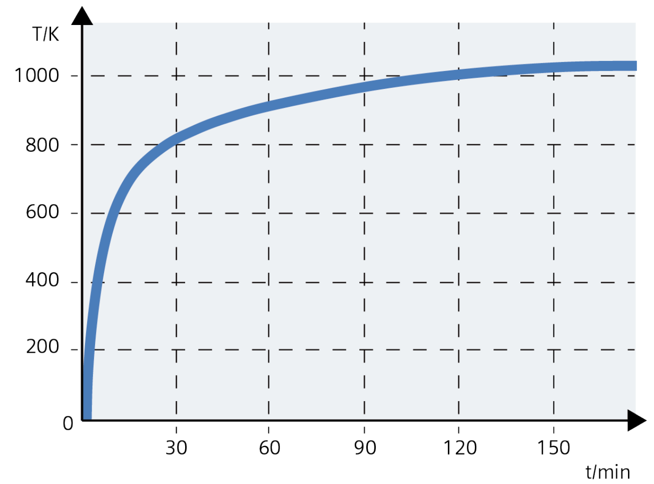


1.3.1.4.3 Cables with integrated Functional Endurance

The current carrying capacity of the cable cross section is determined under the same conditions as during normal operation in accordance with DIN VDE 0298.

The temperature for calculating the voltage drop and the temperature for the disconnection condition of the fire area is taken from the curve/table below, the standard temperature-time curve in the event of a fire is based on DIN 4102-2.

This data is automatically accessed by the software during a calculation operation.



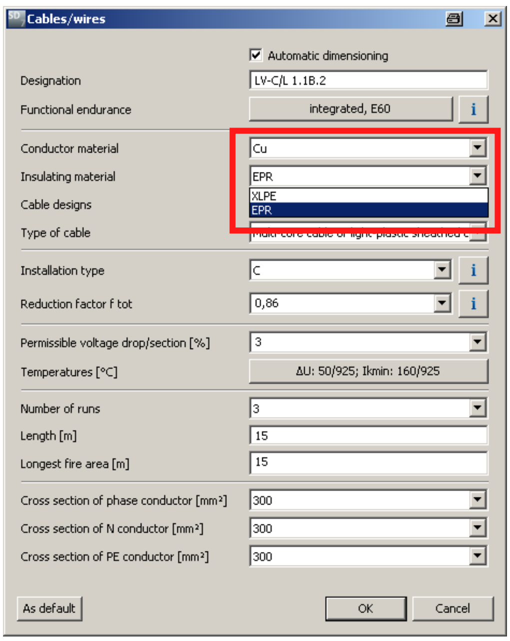
t min	$\vartheta - \vartheta_0$ K	corresponds to
0	0	
5	556	
10	658	
15	719	
30	**822**	**E30**
60	**925**	**E60**
90	**986**	**E90**
120	**1029**	**E120**
180	1090	
240	1133	
360	1194	

$\vartheta - \vartheta_0$ = 345 lg (8t + 1)
ϑ = fire temperature in K
ϑ_0 = temperature of the probes at test start in K
t = time in minutes

The use of cables with integrated functional endurance does not impose any constraints regarding their current carrying capacity and the choice of an installation type.

However the choice of the

- conductor material is limited to copper
- and the insulation material to EPR and XLPE.



1.3.2 Consideration of Functional Endurance in SIMARIS project

1.3.2.1 Preliminary Note

SIMARIS project cannot consider the functional endurance of cables. Usually, several cables are laid together on cable trays. For this reason, it doesn't make sense to consider using Promat® for individual cables, instead the "promating" of the entire cable tray should have to be considered. However, this is not possible based of the data available in SIMARIS project, since there is no reference to the real course of the cables or the cable trays in the building.

For this reason, the explanations in the following sections only deal with the functional endurance of busbar trunking systems and how it is considered in the software.

1.3.2.2 Functional Endurance for BD2, LD, LI und LX Busbar Trunking Systems

1.3.2.2.1 Regulations

You can find a short introduction to the relevant regulations in chapter Fire prevention for building structures of special type and usage.

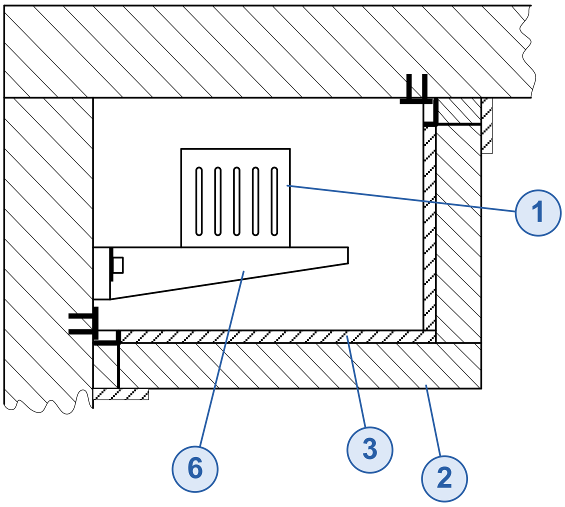
In order to be able to offer the required functional endurance of busbar trunking systems, successful material tests for BD2, LD, LI and LX busbar trunking systems were performed in cooperation with the Promat Company at the Materialprüfanstalt Braunschweig (an institute for material testing).

1.3.2.2.2 Execution

Essential parts for meeting the functional endurance requirement are special components for the functional endurance duct and the support construction for the duct and the BD2, LD, LI und LX busbar trunking systems. Dependent on the ambient conditions, several cable duct designs (compartmentalisation using 4-, 3-, 2-side partitions) and the support con-struction (fastening using threaded rods or wall brackets) are feasible. In this context, provisions made in test certificates issued by construction supervision authorities must be observed:

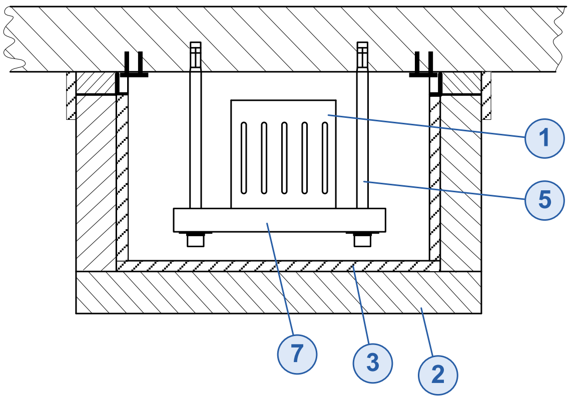
- The maximum permissible distances between fastenings and a maximum permissible tensile stress of 6 N/mm² must be kept
- Only fastenings, partition material and pertaining accessories approved by building authorities must be used

Depending on the installation of the busbar trunking systems 2-, 3-, or 4-side compartmentalisation may be required.



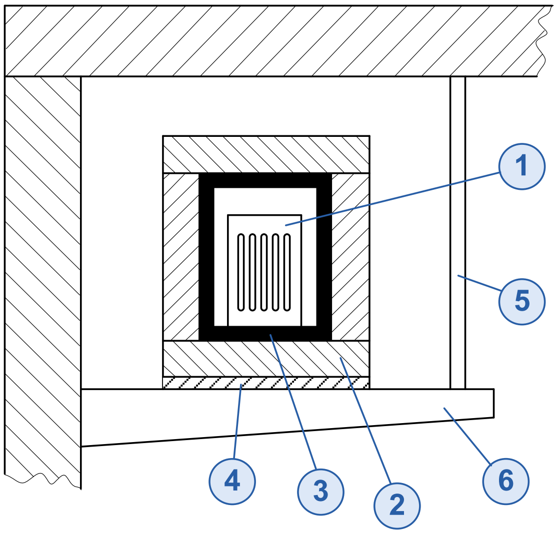
Functional endurance with 2-side compartmentalisation:

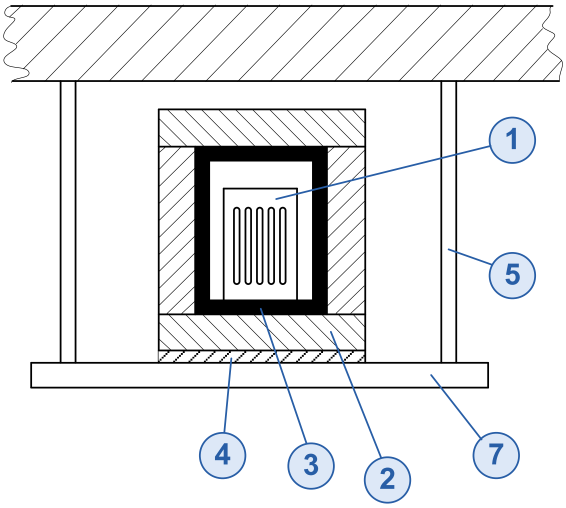
1. Busbar trunking system
2. Partition
3. Reinforcement of the partitions at the abutting edges
6. Brackets acc. to static requirements



Functional endurance with 3-side compartmentalisation:

(1) Busbar trunking system
(2) Partition
(3) Reinforcement of the partitions at the abutting edges
(5) Threaded rod (M12/M16)
(7) Support profile acc. to static requirements





Functional endurance with 4-side compartmentalisation:

(1) Busbar trunking system
(2) Partition
(3) Reinforcement of the partitions at the abutting edges
(4) Load distribution plate
(5) Threaded rod (M12/M16)
(6) Brackets acc. to static requirements
(7) Support profile acc. to static requirements

(4) + (5) + (6) or

(4) + (5) + (7) =

special support construction (as described in specification of works and services)

The price for the special support construction must be added to the budget price.

Note:
4-side compartmentalisation is only possible for horizontal installation.

- The required reduction factors are automatically considered in SIMARIS project according to the functional endurance class and mounting position selected for the project.
- When a project is imported from SIMARIS design, the functional endurance class and the resulting busbar trunking system as defined there are also imported.
- The matching plate thickness is then automatically selected by SIMARIS project based on the selected functional endurance class.
- Weight specifications and promating are based on manufacturer data.

1.4 Typification of Circuit-breakers in Medium-voltage Switchgear

Legend for the following tables		
•	Design variant	
–	Not available	
AR	Automatic reclosing	
NAR	Non-automatic reclosing	
CB-f	Circuit Breaker – fixed mounted	

If a transformer is selected as feed-in system in SIMARIS design, two types of circuit-breakers will be available for selection as "Type of switchgear" at the medium-voltage level.

In SIMARIS project, there is a corresponding selection possibility for the configuration of 8DJH medium-voltage switchgear that uses the cubicle type. The other medium-voltage switchgear in SIMARIS project is characterized by other features/designations for typifying switching devices. Please refer to tables in the following chapters.

1.4.1 NX PLUS C (primary distribution level)

The following table presents the circuit-breaker typification for NX PLUS C medium-voltage switchgear in a differentiated manner.

Circuit-breaker		**3AH55** **CB-f AR**	**3AH25** **CB-f AR**	**3AH55** **CB-f AR**
Rated voltage		max. 15 kV	max. 15 kV	max. 24 kV
Short-circuit breaking current		max. 31.5 kA	max. 31.5 kA	max. 25 kA
Rated switching sequence				
O - 0.3 s - CO - 3 min - CO		•	•	•
O - 0.3 s - CO - 15 s - CO		•	•	•
O - 3 min - CO - 3 min - CO		•	•	•
Number of				
break operations I_r		10,000	30,000	10,000
short-circuit break operations I_{SC}		max. 50	max. 50	max. 50
In a single cubicle	600 mm	•	•	•
In a single cubicle	900 mm	•	–	•

1.4.2 8DJH (secondary distribution level)

The following table presents the circuit-breaker typification for 8DJH medium-voltage switchgear in a differentiated manner.

Circuit-breaker		**Type 1.1 (CB-f AR)**	**Type 2 (CB-f AR)**
Rated voltage		max. 24 kV	max. 24 kV
Short-circuit breaking current		max. 25 kA	max. 20 kA *)
Rated switching sequence			
O - 0.3 s - CO - 3 min - CO		•	–
O - 0.3 s - CO - 15 s - CO		Upon request	–
O - 3 min - CO - 3 min - CO		–	•
Number of			
break operations I_r		10,000	2,000
short-circuit break operations I_{SC}		max. 50	max. 20
In a single panel	430 mm	•	•
	500 mm	•	•
In the panel block	430 mm	•	•

*) Max. 21 kA at 60 Hz

1.4.3 8DJH36 (secondary distribution level)

The following table presents the circuit-breaker typification for 8DJH36 medium-voltage switchgear in a differentiated manner.

Circuit-breaker		**Type 1.1 (CB-f AR)**	**Type 2 (CB-f AR)**
Rated voltage		max. 36 kV	max. 36 kV
Short-circuit breaking current		max. 20 kA	max. 20 kA
Rated switching sequence			
O - 0.3 s - CO - 3 min - CO		•	–
O - 0.3 s - CO - 15 s - CO		Upon request	–
O - 3 min - CO - 3 min - CO		–	•
Number of			
break operations I_r		10,000	2,000
short-circuit break operations I_{SC}		max. 50	max. 20
In a single panel	590 mm	•	•
In the panel block	590 mm	•	•

1.4.4 SIMOSEC (secondary distribution level)

The following table presents the circuit-breaker typification for SIMOSEC medium-voltage switchgear in a differentiated manner.

Circuit-breaker		CB-f AR	CB-f NAR
Rated voltage		max. 24 kV	max. 24 kV
Short-circuit breaking current		max. 25 kA	max. 25 kA
Rated switching sequence			
O - 0.3 s - CO - 3 min - CO		•	–
O - 0.3 s - CO - 15 s - CO		Upon request	–
O - 3 min - CO - 3 min - CO		–	•
Number of			
break operations I_r		10,000	2,000
short-circuit break operations I_{SC}		30 option: 50	20
In a single panel	590 mm	•	•
	750 mm	•	•

1.4.5 NXAIR (primary distribution level)

The following table presents the circuit-breaker typification for NXAIR medium-voltage switchgear in a differentiated manner.

Circuit-breaker		CB-f AR	CB-f AR	CB-f AR
Rated voltage		max. 17.5 kV	max. 17.5 kV	max. 24 kV
Short-circuit breaking current		max. 40 kA	max. 50 kA	max. 25 kA
Rated switching sequence				
O - 0.3 s - CO - 3 min - CO		•	–	•
O - 0.3 s - CO - 15 s - CO		•	•	•
O - 3 min - CO - 3 min - CO		•	•	–
Number of				
break operations I_r		10,000	10,000	10,000
short-circuit break operations I_{SC}		max. 300	max. 300	max. 300
In a single panel	600 mm	•	•	–
	800 mm	•	•	•
	1000 mm	•	•	•

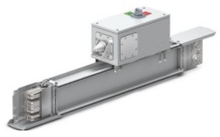
1.5 SIVACON 8PS Busbar Trunking Systems

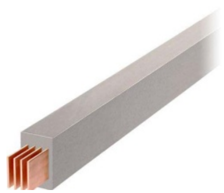
1.5.1 Overview of Busbar Trunking Systems from 40 up to 6,300 A

Busbar trunking system	Rated current Voltage Degree of protection	Conductor configuration	Tap-off points	Pluggable tap-off boxes	Dimensions B x H [cm]	Openings of fire walls B x H [cm]	Recommended horizontal fastening spaces	Criteria for decision-making	Application example
BD01 For small loads e.g. machinery or lighting 	40 A (Al) 63 A (Al) 100 A (Al) 125 A (Al) 160 A (Cu) 400 V AC IP54 / IP55	L1, L2, L3, N, PE	1-side every 0.5 / 1 m	max. 63 A	9x2.5	19x13	3 m	Flexible changes of direction Horizontal wiring	Workshops Furniture stores Department stores

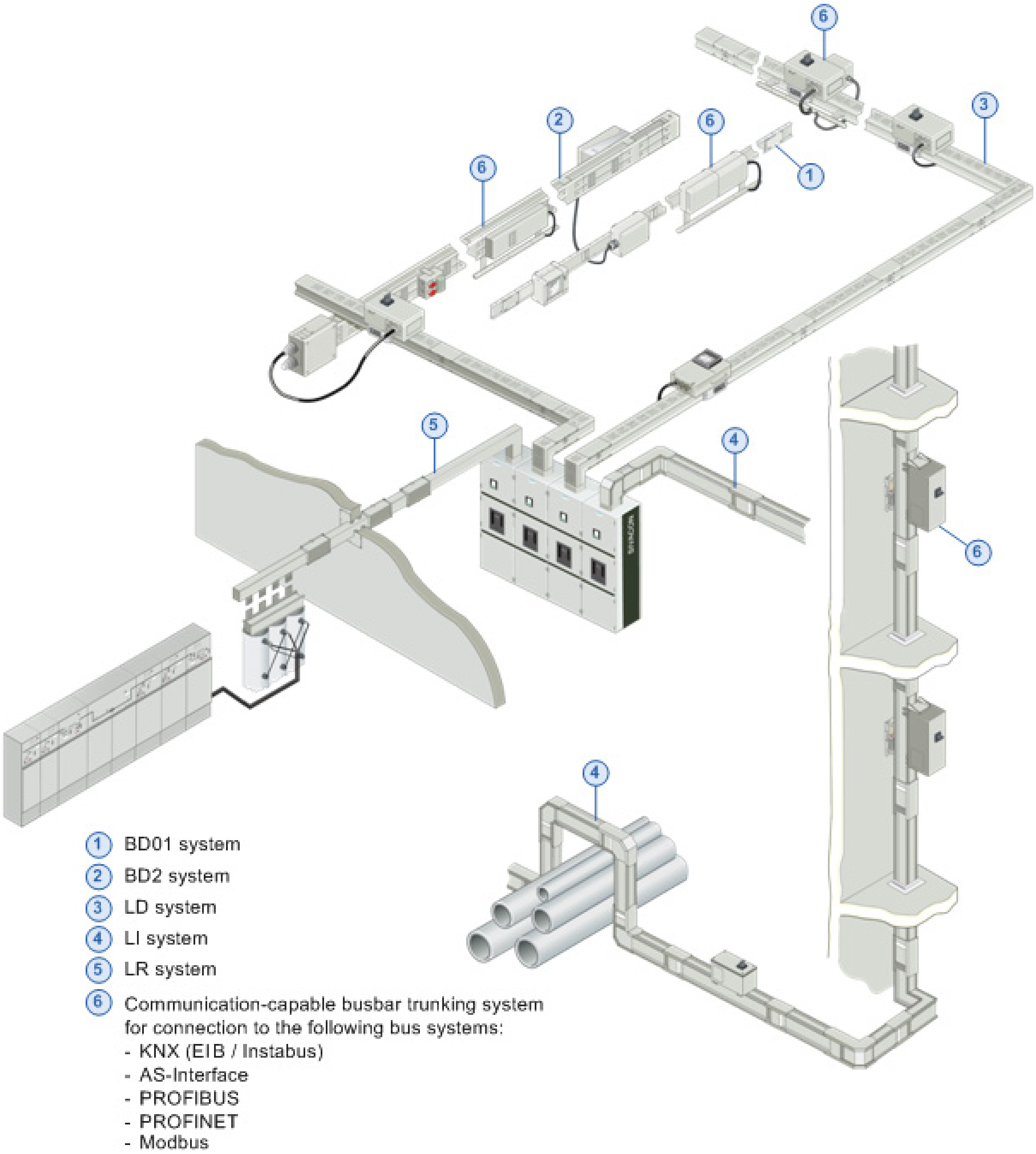
Busbar trunking system	Rated current Voltage Degree of protection	Conductor configuration	Tap-off points	Pluggable tap-off boxes	Dimensions B x H [cm]	Openings of fire walls B x H [cm]	Recommended horizontal fastening spaces	Criteria for decision-making	Application example
BD2 for medium-sized currents e.g. supply of building storeys Production lines 	160 – 1000 A (Al) 160 – 1250 A (Al) 690 V AC IP52 / 54 / IP55	L1, L2, L3, N, 1/2 PE L1, L2, L3, N, PE	without 2-side every 0.25 m (offset)	max. 630 A	16.7x6.8 up to 400 A 16.7x12.6 as of 500 A	27x17 up to 400 A 27x23 as of 500 A	1 x fastening per trunking unit 2.5 m for 1000 A	Small system offering a high degree of flexibility due to various changes in direction tap-off box starting from 16 A with a wide choice of equipment No derating in case of vertical wiring up to 1000 A	High-rise buildings Hotels Old people's homes Production lines Shopping centres Offices Schools / universities
LD vented system for high currents e.g. in industry 	1100 – 4000 A (Al) 2000 – 5000 A (Cu) 1000 V AC IP34 / 54	L1, L2, L3, N, PE L1, L2, L3, 1/2 N, 1/2 PE L1, L2, L3, N ,1/2 PE L1, L2, L3, PEN L1, L2, L3, 1/2 PEN	without 1-side every 1 m 2-side every 1 m	max. 1250 A	18x18 up to 2,600 A 24x18 up to 5000 A	42x42 up to 2,600 A 48x42 up to 5000 A	1 x fastening per IP34 trunking unit 2 m for 5000 A / IP34	Power distribution mostly horizontal IP34 sufficient Pluggable load feeders up to 1250 A High degree of short-circuit strength of the load feeders Low EMC values	Hospitals Airport Production lines Chemistry, pharmacy Exhibition halls Tunnels Wind power stations

Busbar trunking system	Rated current Voltage Degree of protection	Conductor configuration	Tap-off points	Pluggable tap-off boxes	Dimensions B x H [cm]	Openings of fire walls B x H [cm]	Recommended horizontal fastening spaces	Criteria for decision-making	Application example
LX sandwich system for high currents e.g. buildings 	800 – 4500 A (Al) 1000 – 5000 A (Al) 6300 A (Cu)* * Upon request 690 V AC IP54 / IP55	L1, L2, L3, PE L1, L2, L3, PEN L1, L2, L3, N, PE L1, L2, L3, 2N, PE L1, L2, L3, N, CE, PE L1, L2, L3, 2N, CE, PE L1, L2, L3, N, 2PE (only Cu) L1, L2, L3, 2N, 2PE (only Cu)	without 1-side every 0.5 m 2-side every 0.5 m	max. 630 A	14.5x13.7 up to 1250 A 14.5x16.2 up to 1600 A 14.5x20.7 at 2000 A 14.5x28.7 up to 3200 A 14.5x43.9 at 4000 A 14.5x59.9 at 5000 A	35x34 up to 1250 A 35x37 up to 1600 A 35x41 at 2000 A 35x49 at 3200 A 35x64 at 4000 A 35x80 at 5000 A	2 m	Power distribution mostly vertical Low fire load Higher cross section of N conductor (doubled) required Pluggable tap-off units up to 630 A are sufficient Degree of protection IP54 without derating	Banks Insurances Data centres Shopping centres Airport Tunnels

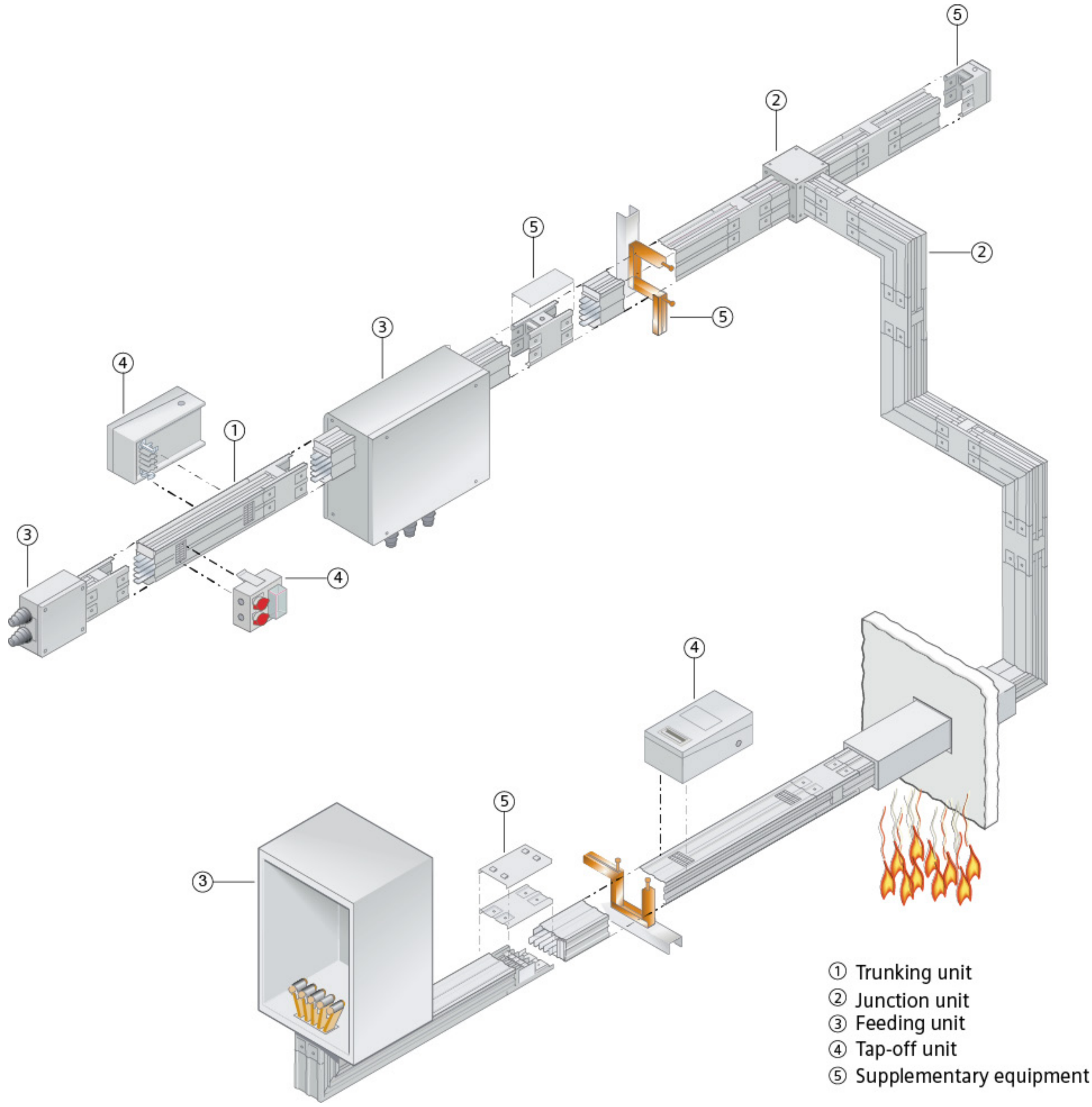
Busbar trunking system	Rated current Voltage Degree of protection	Conductor configuration	Tap-off points	Pluggable tap-off boxes	Dimensions B x H [cm]	Openings of fire walls B x H [cm]	Recommended horizontal fastening spaces	Criteria for decision-making	Application example
LI for power transmission up to 6300 A and distribution in high-rise buildings 	800 – 5000 A (AL) 1000 – 6300 A (AL) 1000 V AC IP55	L1, L2, L3, PE L1, L2, L3, PEN L1, L2, L3, N, PE L1, L2, L3, 2N, PE L1, L2, L3, N, CE, PE L1, L2, L3, 2N, CE, PE	without 1-side every 0,66m (max. 3 per trunking unit) 2-side every 0,66m (max. 6 per trunking unit)	Max. 1250A	15,5x11,1 at 800A (AL) 1000A (CU) 15,5x11,7 at 1250A (CU) 15,5x13,2 at 1000A (AL) 15,5x14,6 at 1250A (AL) 1600A (CU) 15,5x17,4 at 2000A (CU) 15,5x18,2 at 1600A (AL) 15,5x21,3 at 2500A (CU) 15,5x23,0 at 2000A (AL) 15,5x28,0 at 3200A (CU) 15,5x29,7 at 2500A (AL) 41,0 x 17,4 at 4000A (CU) 41,0 x 18,2 at 3200A (AL) 41,0 x 21,3 at 5000A (CU) 41,0 x 23,0 at 4000A (AL) 41,0 x 28,0 at 6300A (CU) 41,0 x 29,7 at 5000A (AL)	35x31 at 800 A (AL) 1000 A (CU) 35x33 at 1000 A (AL) 1250 A (CU) 35x35 at 1250 A (AL) 1600 A (CU) 35x38 at 1600 A (AL) 2000 A (CU) 35x43 at 2000 A (AL) 2500 A (CU) 35x50 at 2500 A (AL) 3200 A (CU) 61x38 at 3200 A (AL) 4000 A (CU) 61x43 at 4000 A (AL) 5000 A (CU) 61x50 at 5000 A (AL) 6300 A (CU)	edgewise 3m flat 2m	High degree of protection High short-circuit rating Low voltage drop Flexible tap-offs for loads Potential demands for increasing the cross-section of the neutral conductor can be met Clean Earth requirement for a separate PE conductor insulated to the busbar trunking system housing	High-rise buildings Data center Infrastructure Manufacturing industry

Busbar trunking system	Rated current Voltage Degree of protection	Conductor configuration	Tap-off points	Pluggable tap-off boxes	Dimensions B x H [cm]	Openings of fire walls B x H [cm]	Recommended horizontal fastening spaces	Criteria for decision-making	Application example
LR for the transmission of high currents at a high degree of protection 	630 – 6300 A (Al) 1000 V AC IP68	L1, L2, L3, N, PE L1, L2, L3, PEN	without	--	9x9 up to 1000 A 12x12 at 1350 A 12x15 up to 1,700 A 12x19 at 2000 A 22x22 at 2500 A 22x24 at 3150 A 22x38 at 4000 A 22x44 at 5000 A 22x48 at 6300 A	19x19 up to1000 A 22x22 up to 1350 A 22x25 up to 1700 A 22x29 at 2000 A 22x32 at 2500 A 22x34 at 3150 A 22x48 at 4000 A 22x54 at 5000 A 22x58 at 6300 A	1.5 m	Cast-resin system for a high degree of protection Power transmission only	Unprotected outdoor areas Aggressive ambient conditions

The following figure shows a graphic overview of the available busbar trunking systems.



The following overview states the designations of the various components of a busbar trunking system taking the BD2 system as an example.



1.5.2 Configuration Rules for Busbar Trunking Systems

1.5.2.1 Wiring Options for Busbar Trunking Systems

The following table provides an overview of the wiring options which are suitable for the respective busbar trunking system or the busbar mounting positions.

Meaning of the abbreviations used here	
HE	horizontal / edgewise
HF	horizontal / flat
V	vertical

Busbar trunking system	Possible installation types / mounting positions
BD 01	HE , HF , V
BD 2	HE , HF , V
LD	HE , HF , V
LI	HE , HF , V
LX	HE , HF , V
LR	HE , HF , V

Generally speaking, busbar trunking systems are dimensioned in terms of their current carrying capacity which is independent of their installation type / mounting position. But there are exceptions, which will be explained in more detail in the following.

SIMARIS design considers all of the configuration rules listed below for the dimensioning and checking of 8PS busbar trunking systems.

LD system

SIMARIS design considers the derating of the LD busbar trunking systems dependent on the degree of protection and installation type, when dimensioning and checking the busbar trunking system.

The following type key permits a precise definition of the required system.

Basic type

LD					

Conductor material

Al	**A**
Cu	**C**

Rated current I_e [A]

IP34						IP54				
horizontal edgewise						horizontal edgewise and vertical		horizontal flat		
incl. height rises < 1.3 m		incl. height rises > 1.3 m		vertical						
Al	Cu	Al	Cu	Al	Cu	Al	Cu	Al	Cu	
1100		950		950		900		700		**1**
1250	2000	1100	1650	1100	1650	1000	1600	750	1200	**2**
1600	2600	1250	2100	1250	2100	1200	2000	1000	1550	**3**
2000		1700		1700		1500		1200		**4**
2500		2100		2100		1800		1700		**5**
3000	3400	2300	2700	2300	2700	2000	3400	1800	2000	**6**
3700	4400	2800	3500	2800	3500	2400	4400	2200	2600	**7**
4000	5000	3400	4250	3400	4250	2700	5000	2350	3000	**8**

Design

4-conductor	**4**
5-conductor	**6**

N / PEN

½ L	**1**
L	**2**

Degree of protection

IP34	**3**
IP54	**5**

LI system

The basic components of the LI system are determined using a type code. The type is specified and selected on the basis of rated current, conductor material and system type or conductor configuration.

The following type code enables precise definition of the system.

Ordering type	LI	-					-		- ... -	

Conductor material	
Al	A
Cu	C

Insulation material	
Mylar foil	M
Epoxy hybrid	E
No selection	N

Rated current Inc [A]	
800 (Al only)	0800
1000	1000
1250	1250
1600	1600
2000	2000
2500	2500
3200	3200
4000	4000
5000	5000
6300 (Cu only)	6300

Configuration of the conductors	
L1 + L2 + L3 + PE[1)]	3B
L1 + L2 + L3 + PEN[4)]	4B
L1 + L2 + L3 + N + PE[1)]	5B
L1 + L2 + L3 + N + N[3)] +PE[1)]	5C
L1 + L2 + L3 + N + PE[4)] (PE bar 50 %)	5G
L1 + L2 + L3 + N + PE[4)] (PE bar 100 %)	5H
L1 + L2 + L3 + N + (PE)[2)] +PE[1)]	6B
L1 + L2 + L3 + N + N[3)] + (PE)[2)] + PE[1)]	6C

Degree of protection	
IP00	00
IP55	55

Busbar ends	
Hook - bolt	HB
Hook	H
Bolt	B

1) PE conductor = enclosure

2) Separate PE conductor routed through additionally insulated busbar (clean earth)

3) An additional busbar doubles the cross section of the neutral conductor (200 %)

4) PE or PEN conductor = enclosure and additional busbar

Figure 5-2 Type code of the LI system

LX system

For the following systems, the rated current is independent of the mounting position of the busbars. This means that derating is unnecessary.

	Ordering type				
Fire protection	+LX		-	S120-X	
Basic type	LX				- ....

Conductor material	
Al	A
Cu	C

Rated current I_e [A]			
Al	Cu		
800	1000		01
1000	1250		02
	1400		03
1250	1600		04
1600	2000		05
2000	2500		06
2500	3200		07
3200	4000		08
4000	5000		09
4500			10

Configuration of the conductors	
L1+L2+L3+PE[1)]	30
L1+L2+L3+PEN/PEN[4)]	41
L1+L2+L3+N+PE[1)]	51
L1+L2+L3+N+N[3)]+PE[1)]	52
L1+L2+L3+N+PE/PE[4)]	53
L1+L2+L3+N+N[3)]+PE/PE[4)]	54
L1+L2+L3+N+(PE)[2)]+PE[1)]	61
L1+L2+L3+N+N[3)]+(PE)[2)]+PE/PE[1)]	62

Fire protection	
Positioning (X*)	

1) PE conductor = enclosure
2) Separate PE conductor routed through additionally insulated busbar (clean earth)
3) An additional busbar doubles the cross section of the neutral conductor (200 %)
4) PE conductor = enclosure and additional busbar
5) Only available as a copper system (LXC)

One exception is the flat horizontal mounting position, for which a derating based on the table below must be considered:

system	horizontal on edge	flat horizontal
LXC 01....	1,000 A	800 A
LXC 03....	1,400 A	1,380 A
LXC 04....	1,600 A	1,570 A
LXC 05....	2,000 A	1,900 A
LXC 07....	3,200 A	3,100 A
LXA 07....	2,500 A	2,400 A
LXA 09....	4,000 A	3,800 A

1.5.2.2 Possible Combinations of different Busbar Trunking Systems within one Busbar Section

Busbar trunking system	Possible combinations with other types
BD 01	None.
BD 2A	None.
BD 2C	None.
LDA	LRA, LRC
LDC	LRA, LRC
LIA	LRA, LRC
LIC	LRA, LRC
LXA	LRA, LRC
LXC	LRA, LRC
LRA	LDA, LDC , LXA , LXC
LRC	LDA, LDC , LXA , LXC

1.5.2.3 Guidelines for Busbar Trunking Systems for their Direct Connection to a Switch and Current Feeding from Cables

BD01 system

As a rule, these busbar trunking systems must always be fed from cable connection boxes. There is no option for a direct switch connection in the installation. Therefore, these systems are unsuitable for power transmission and for this reason, this function cannot be selected in SIMARIS design.

BD 2 system

BD2 systems are suitable for connection by means of a cable connection box as well as direct connection to a switch in the installation, this applies to their entire current range rating (160 A – 1,250 A). There are no constraints. Therefore, these systems are technically suitable for power transmission and can be selected accordingly in SIMARIS design.

LD systems

LD systems are suitable for connection by means of a cable connection box as well as direct connection to a switch in the installation, this applies to their entire current range rating (1,100 A – 5,000 A). The following tables indicate which systems can also be fed from a cable connection box.

Conductor material	Type designation	Cable connection possible
Aluminum	LDA 1...	•
	LDA 2...	•
	LDA 3...	•
	LDA 4...	•
	LDA 5...	•
	LDA 6...	–
	LDA 7...	–
	LDA 8...	–
Copper	LDC 2...	•
	LDC 3...	•
	LDC 6...	–
	LDC 7...	–
	LDC 8...	–

LI systems

The distribution board and LI busbar trunking system are connected using an integrated busbar trunking connection unit for rated currents up to 6,300 A (I e = 6,300 A on request). The busbars can be connected:

- From above
- From below (on request)

The following tables indicate which systems can also be fed from a cable connection box.

Conductor material	Type designation	Cable connection possible
Aluminium	LIA 08...	•
	LIA 10...	•
	LIA 12...	•
	LIA 16...	•
	LIA 20...	•
	LIA 25...	•
	LIA 32...	•
	LIA 40...	–
	LIA 50...	–
Copper	LIC 10...	•
	LIC 12...	•
	LIC 16...	•
	LIC 20...	•
	LIC 25...	•
	LIC 32...	•
	LIC 40...	–
	LIC 50...	–
	LIC 63...	–

LX system

LX systems are suitable for connection by means of a cable connection box as well as direct connection to a switch in the installation, this applies to their entire current range rating (800 A – 6,300 A). The following tables indicate which systems can also be fed from a cable connection box.

Conductor material	Type designation	Cable connection possible
Aluminum	LXA 01..	•
	LXA 02..	•
	LXA 04..	•
	LXA 05..	•
	LXA 06..	•
	LXA 07..	•
	LXA 08..	–
	LXA 09..	–
	LXA 10..	–
Copper	LXC 01..	•
	LXC 02..	•
	LXC 03..	•
	LXC 04..	•
	LXC 05....	•
	LXC 06..	•
	LXC 07..	•
	LXC 08..	–
	LXC 09..	–
	LXC 10..	–

1.5.2.4 Possible Switching/Protective Devices in Tap-off Units for Busbar Trunking Systems

Type of switchgear top	Busbar trunking system				
	BD 01	BD 2	LD	LI	LX
Circuit-breaker	•	•	•	•	•
Switch disconnector with fuse [1]	–	•	–	•	•
Fuse switch disconnector [1]	–	•	•	•	–
Fuse with base	–	•	–	•	–

[1] No in-line type design permitted!

1.5.2.5 Device Selection of Switching/Protective Devices for Busbar Trunking Systems Featuring Power Transmission

Generally speaking, no in-line type switch disconnectors or air circuit-breakers (ACB) are selected and dimensioned for tap-off units for busbar trunking systems. A manual selection permits to select all of the switches suitable for the respective current range of the load feeder. In this context it should however be clarified with a Siemens sales office whether this feeder can be designed in form of a special tap-off unit.

Busbar trunking system	Device selection Automatic dimensioning
BD01	Miniature circuit-breaker (MCB) up to 63 A Fuse and base NEOZED up to 63 A
BD 2	Moulded-case circuit-breaker (MCCB) up to 530 A Miniature circuit-breaker (MCB) up to 125 A Switch disconnector with fuses up to 320 A Fuse switch disconnector up to 125 A Fuse and base NEOZED up to 63 A Fuse and base NH up to 530 A
LD	Moulded-case circuit-breaker (MCCB) up to 1,250 A Fuse switch disconnector up to 630 A
LI	Moulded-case circuit-breaker (MCCB) up to 1,250 A Switch disconnector with fuses up to 630 A Fuse switch disconnector up to 630 A Fuse and base NH up to 630 A
LX	Moulded-case circuit-breaker MCCB up to 1,250 A Switch disconnector with fuses up to 630 A

1.5.2.6 Matrix Table for Busbar Trunking Systems and Matching Tap-off units

Matching tap-off units to be used for the fuses and devices dimensioned in SIMARIS design and intended to be built into the power tap-off units of busbar trunking systems, can be found with the aid of the following table.

Busbar trunking system	Device selection			
	Dimensioned device		Devices to be tendered or ordered	
BD01	Miniature circuit-breaker MCB up to 63 A	 **5SJ.., 5SP.., 5SQ.., 5SX.., 5SY.**	Tap-off unit:	**BD01-AK1../.. BD01-AK2../..**
BD2	Circuit-breaker MCCB up to 530 A	 **3VL...**	Tap-off unit: max. 125 A max. 250 A max. 400 A max. 530 A	 **BD2-AK03X/.. BD2-AK04/.. BD2-AK05/.. BD2-AK06/..**
	Miniature circuit-breaker MCB up to 63 A	 **5SJ.., 5SP.., 5SQ.., 5SX.., 5SY...**	Tap-off unit: max. 16 A max. 63 A	 **BD2-AK1/.. BD2-AK02M/.. BD2-AK2M/..**
	Switch-disconnector with fuses max. 125 A Fuse:	 **3KL5..,** **3NA3.. size 00**	Tap-off unit: max. 125 A Fuse:	 **BD2-AK3X/..** **3NA3.. size 00**
	Fuse switch disconnector max. 400 A Fuse:	 **3NP4..** **3NA3.. up to size 2**	Tap-off unit: max. 125 A max. 250 A max. 400 A Fuse:	 **BD2-AK03X/.. BD2-AK04/.. BD2-AK05/..** **3NA3.. up to size 2**
	Fuse base NEOZED up to 63 A Fuse:	 **5SG5..** **5SE23..**	Tap-off unit: max. 63 A Fuse:	 **BD2-AK02X/.. BD2-AK2X/..** **5SE23..**
	DIAZED up to 63 A: Fuse:	**5SF..** **5SA.., 5SB..**	 Fuse:	 **5SA.., 5SB...**
LD	Circuit-breaker MCCB max. 1,250 A Fuse switch disconnector max. 630 A Fuse:	 **3VL** **3NP4..** **3NA3.. up to size 3**	Tap-off unit: Tap-off unit: Fuse:	**LD-K-AK./..** **LD-K-AK./..** **3NA3.. up to size 3**

Busbar trunking system	Device selection			
	Dimensioned device		Devices to be tendered or ordered	
LI	Circuit-breker MCCB up to 1,250 A	**3VL**	Tap-off unit:	**LI-T-...-..-..3VL...**
	Switch-disconnector with fuses max. 630 A Fuse	**FSF...** **3NA3.. up to size 3**	Tap-off unit: Fuse:	**LI-T-...-..-..FSF...** **3NA3.. up to size 3**
	Fuse switch disconnector up to 630 A Fuse	**3NP11..** **3NA3... up to size 3**	Tap-off unit: Fuse:	**LI-T-...-..-..3NP11...** **3NA3.. up to size 3**
	Fuse and base NH up to 630 A Fuse	**NH** **3NA3.. up to size 3**	Tap-off unit: Fuse:	**LI-T-...-..-..NH...** **3NA3.. up to size 3**
LX	Circuit-breaker MCCB max. 1,250 A	**3VL..**	Tap-off unit:	**LX-AK./FS..**
	Switch-disconnector with fuses max. 630 A	**3KL5/6..**		
	Fuse:	**3NA3.. up to size 3**	Fuse:	**3NA3.. up to size 3**

1.5.2.7 Particularities concerning the Simultaneity Factor of Busbar Trunking Systems for Power Distribution

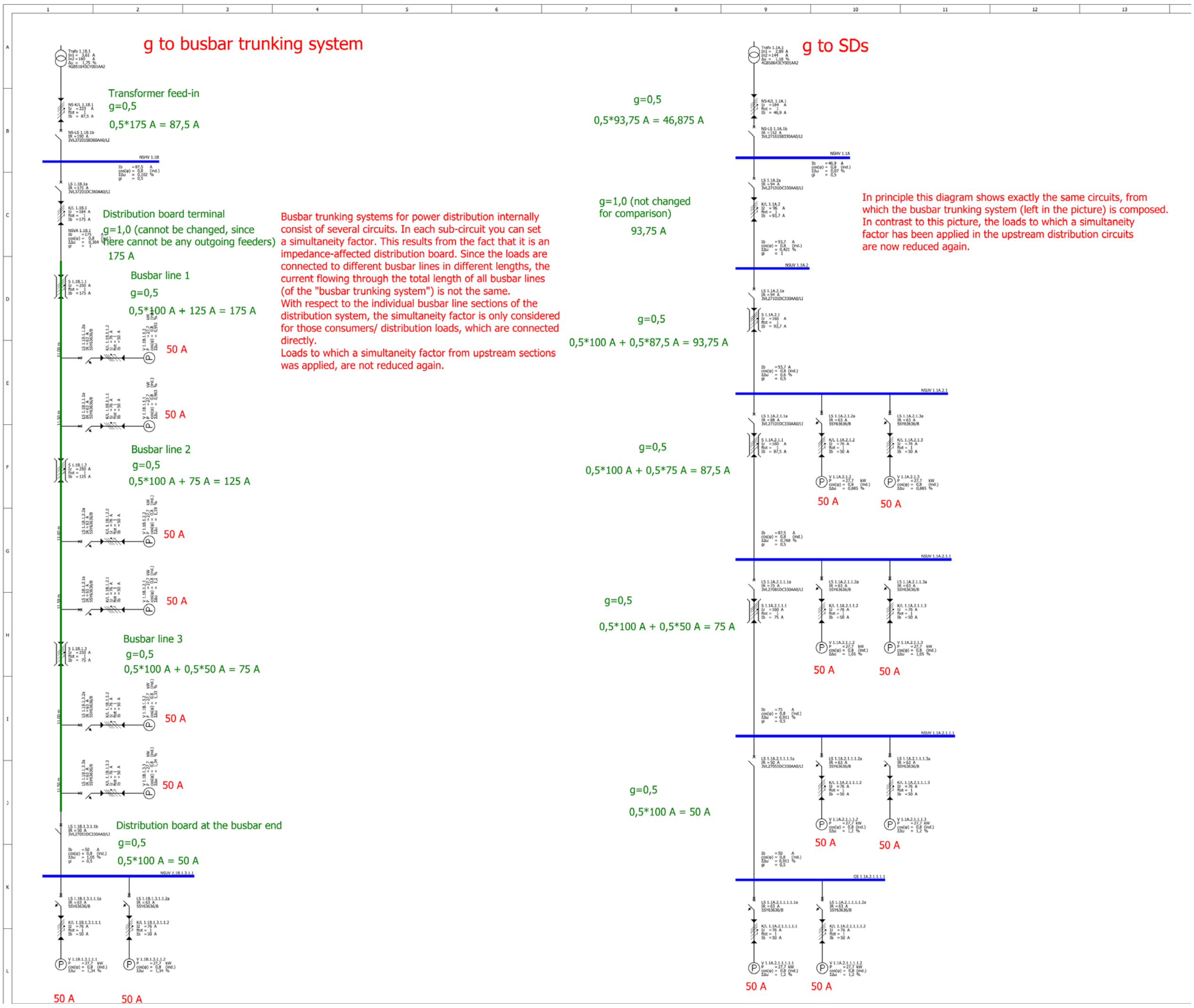
Busbar trunking systems for power distribution may be composed of several busbar sections. For each busbar section, a separate simultaneity factor referring to the loads connected may be entered in SIMARIS design. However, busbar sections indexed with a simultaneity factor do not reduce upstream busbar sections.

The behaviour shown in calculations in SIMARIS design differs from that of point-to-point distribution boards, since here, the loads connected to the upstream distribution board will be reduced again.

The graphics below show a comparison of both cases including the respective technical data in the possible graphical representations of the network diagram in SIMARIS design.

The technical data in these diagrams are only legible, if you zoom up the document very much, e.g. to 500%. Otherwise a legible graphic representation of the network diagram in the document format of this manual (DIN A4) would not have been possible.

Single-line diagram with load flow / load distribution



1.6 Parallel Cables in Network Calculation and System Planning

1.6.1 Considering Parallel Cables in Network Calculations

If two or more conductors in a circuit are connected with the same phase or pole of a circuit (parallel connection), it must be kept in mind, how the load current is split between the conductors.

An even splitting can be assumed if the conductors

- are made of the same material,

- have the same rated cross section
- approx. the same length,
- have no branches along the entire circuit length

and
- the conductors connected in parallel are contained in multi-core or twisted, single-core cables or lines,
- or the conductors connected in parallel in single-core cables or lines, in closely bundled or flat arrangement, have a rated cross section up to a maximum of 50 mm² Cu or 70 mm² Al,
- or the conductors connected in parallel in single-core cables or lines, in closely bundled or flat arrangement, have a higher rated cross section than 50 mm² Cu or 70 mm² Al while special installation measures were taken. These installation measures consist of a suitable phase sequence and spatial arrangement of the different phases or poles.

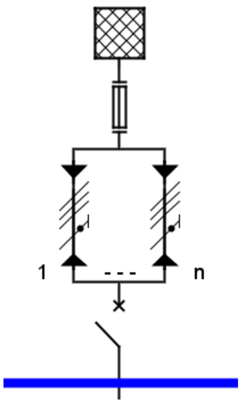
In this case, the current will rise at an even ratio in all cables connected in parallel in the event of overload.

Under such preconditions, it is possible to protect these parallel cables separately using protective devices of the same type and size.

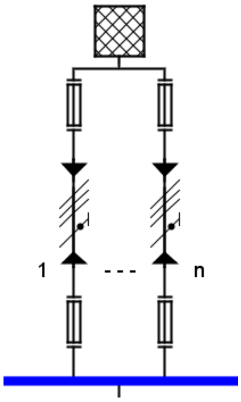
In SIMARIS design, these preconditions are regarded as given.

If the network diagram in SIMARIS design contains cable routes with parallel cables in the infeed, which were either determined by automatic dimensioning or manually set, there are the following protection options:

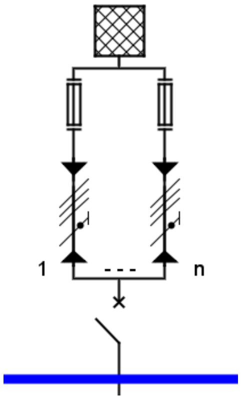
- Joint protection upstream and downstream of the respective route of parallel cables, i.e. prior to its splitting and after joining the cables:



- Separate protection at the beginning and end of the route of parallel cables, i.e. after its splitting and before joining the cables again:

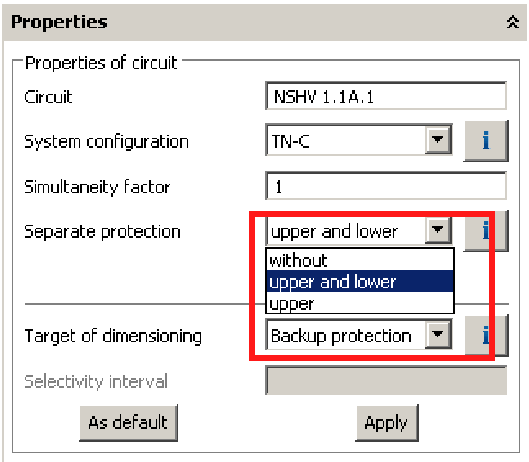


- Separate protection at the beginning and end of the route of parallel cables, i.e. after its splitting and before joining the cables again:



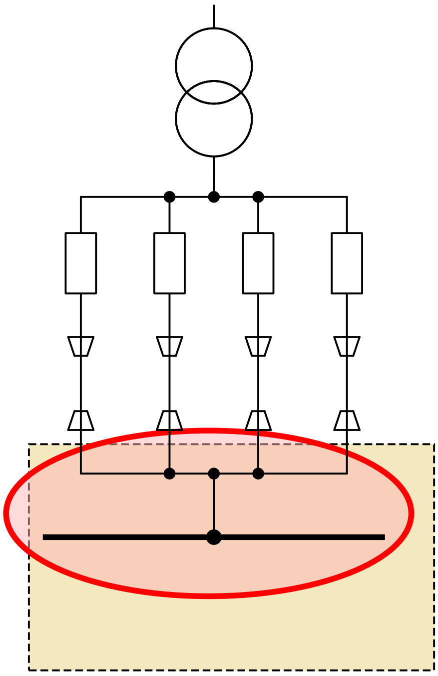
The network diagram in SIMARIS design does not represent this protection of parallel cable routes in such detail, but you can recognize and determine this configuration at the following points:

- The number of cables laid in parallel is only marked in the cable route labelling and not represented graphically. It results either from automatic dimensioning, or can be set manually in the "Properties" dialog of the cable route.
- The fuses or protective devices, too, are always graphically represented as one fuse or protective device, but in case of separate protection they are labelled with the corresponding factor. The selection, how separate protection shall be implemented, can be made by marking the feed-in circuit and choosing the desired separate protection in the respective circuit properties in the window section at the bottom left.



1.6.2 Parallel cables in incoming and outgoing feeders in the SIVACON S8 system (Low-voltage Power Distribution Board)

- Direct feed-in / outgoing feeder with parallel cables

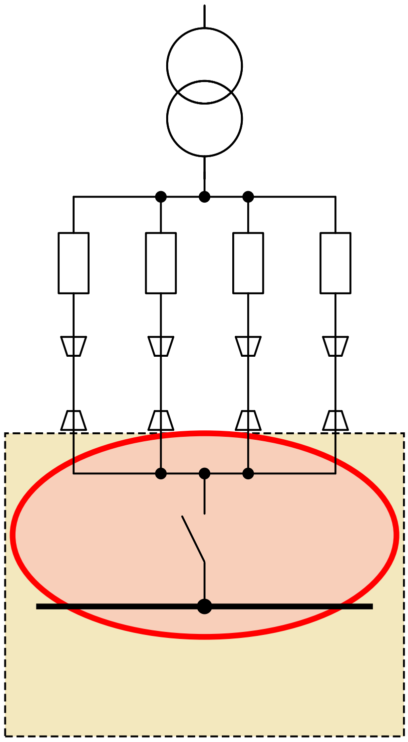


Please note that possible connection points for cables are limited in a cubicle for direct feed-in / outgoing feeders.

An overview of cable connections options in a cubicle for direct feed-in / outgoing feeders is given in the following table:

Cross section	Number of cable cross sections to be connected as a function of the rated current				
3½ conductors	**630 A**	**800 A**	**1,000 A**	**1,250 A**	**1,600 A**
max. 240 mm^2	4	4	4	6	6
3½ conductors	**2,000 A**	**2,500 A**	**3,200 A**	**4,000 A**	
max. 300 mm^2	9	9	11	14	

- Incoming/outgoing feeder with circuit-breaker



Please note that the possible connection points for cables are limited in an incoming/outgoing feeder cubicle for air circuit-breakers (ACB).

An overview of cable connections options in a cubicle for 3W. circuit-breakers is given in the following table:

Cross section	Number of cable cross sections to be connected as a function of the rated current				
3½ conductors	630 A	800 A	1,000 A	1,250 A	1,600 A
max. 240 mm ^{2}	4	4	4	6	6
3½ conductors	2,000 A	2,500 A	3,200 A	4,000 A	
max. 300 mm ^{2}	9	9	11	14	

1.7 Considering the Installation Altitude of Power Distribution Systems

1.7.1 Insulation Capacity of NXAIR, NXPLUS C and 8DJH Medium-voltage Systems Dependent on the Installation Altitude

- The insulation capacity is proved by testing the switchgear using rated values for the short-duration power-frequency withstand voltage and the lightning impulse withstand voltage in accordance with IEC 62271-1 / VDE 0671-1.
- The rated values are referred to the altitude zero above sea level and normal air conditions (1013 hPa, 20 °C, 11 g/m³ water content according to IEC 60071 and VDE 0111).
- The insulating capacity decreases in rising altitudes. For installation altitudes above 1000 m (above sea level) the standards do not provide any guidelines for assessing the insulation capacity, this is left to special arrangements.

All parts exposed to high voltage inside the system container are insulated against the earthed outer encapsulation using SF_6 gas.

The gas insulation with an excess gas pressure of 50 kPa allows for installation at any altitude above sea level without that the voltage strength would be impaired. This is also true for cable connections using

- plugged terminals for NXPLUS C systems
- cable T-plugs or angular cable plugs for 8DJH systems.

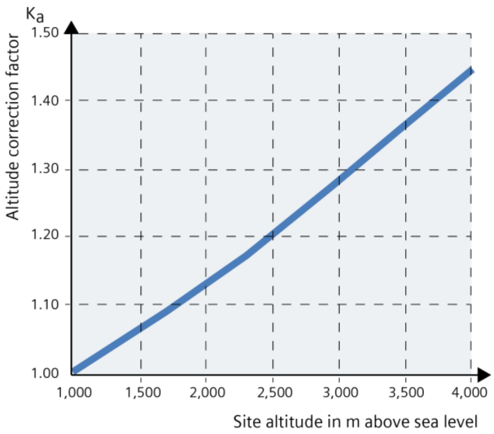
- In case of NXPLUS C switchgear, a reduction of the insulation capacity must merely be factored in for panels containing HV HRC fuses,
- in case of 8DJH switchgear, for both the panels with HV HRC fuses and air-insulated metering panels,

when the installation altitude rises.

A higher insulation level must be selected for installation altitudes above 1000 m. This value is gained from a multiplication of the rated insulation level for 0 m to 1,000 m applying an altitude correction factor K_a (see illustration and example).

For installation altitudes above 1,000 m we recommend an altitude correction factor K_a dependent on the installation altitude above sea level.

Curve $\boldsymbol{m} = \mathbf{1}$ applies to the rated short-duration power-frequency withstand voltage and the rated lightning impulse withstand voltage in accordance with IEC 62271-1.



Example:

- Installation altitude 3,000 m above sea level ($\boldsymbol{K_a} = \mathbf{1,28}$)
- Rated switchgear voltage: 17.5 kV
- Rated lightning impulse withstand voltage: 95 kV
- Rated lightning impulse withstand voltage to be selected $= \mathbf{95\ kV \cdot 1,28 = 122\ kV}$

Result:

According to the above table, a system should be selected that features a rated voltage of 24 kV and a rated lightning impulse withstand voltage of 125 kV.

1.7.2 Correction Factors for Rated Currents of S8 Low-voltage Switchboards Dependent on the Installation Altitudes

The low air density in altitudes higher than 2,000 m above sea level affects the electrical characteristics of the switchboard.

Therefore, the following correction factors for rated currents must be observed in installation altitudes higher than 2,000 m above sea level.

Altitude of the installation site	Correction factor
max. 2,000 m	1
max. 2,500 m	0.93
max. 3,000 m	0.88
max. 3,500 m	0.83
max. 4,000 m	0.79
max. 4,500 m	0.76
max. 5,000 m	0.70

In addition, a reduction of the equipment switching capacity must also be considered in installation altitudes higher than 2,000 m above sea level. Equipment correction factors must be taken from the technical documentation of the respective equipment.

1.7.3 Reduction Factors for Busbar Trunking Systems Dependent on the Installation Altitude

1.7.3.1 SIVACON 8PS – LD... Busbar Trunking System

The SIVACON 8PS - LD... system can be operated as power transmission system up to an installation altitude of 5,000 metres above sea level without the necessity to reduce its rated impulse withstand voltage and current.

The influence of heat dissipation can normally be neglected.

The lower cooling is balanced by lower ambient temperatures as result of rising altitudes of installation. so that a reduction of the current load is not required.

Exception:

If the busbar trunking system is installed in a climatized or heated switchgear room, this reason becomes obsolete and the current must be reduced by factor given in the table below.

Reduction factors for rated currents dependent on the altitude of installation:

	Test voltages and appropriate installation altutides											
	Mounting height [m]											
	0	200	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
	Room temperature [°C]											
Rated impulse withstand voltage U_{imp} [kV] 8	20	20	20	20	20	20	20	20	20	20	20	20
	Air pressure [kPa]											
	101.3	98.5	95.5	89.9	84.6	79.5	74.7	70.1	65.8	61.6	57.7	54.0
	Relative air density [kg/m³]											
	1.2	1.2	1.1	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6
	Correction factor											
	1.22	1.18	1.15	1.08	1.02	1.00	0.90	0.84	0.79	0.74	0.69	0.65
	U1.2/50 surge at AC and DC [kV]											
	16.5	16.0	15.5	14.6	13.8	13.6	12.2	11.4	10.7	10.0	9.4	8.8
	Current reduction factor											
	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.94	0.91	0.88	0.85	0.82

1.7.4 Reduction Factors for Equipment Dependent on the Installation Altitude

Depending on the real conditions on site, the ambient conditions present in altitudes of installation above approx. 2,000 m above the sea level may have a very strong influence on the electrical and/or electro-mechanical properties of switching and protective devices.

This requires an individualistic (project-specific) approach towards device dimensioning.

Besides the derating factors, further factors must be taken into account, which can be neglected in device dimensioning under "normal" ambient conditions.

Since these factors can be specified in a uniform manner for all devices, but are dependent on the respective devices, they must always be explicitly requested and considered accordingly.

1.8 Consideration of Compensation Systems in the Network Design with SIMARIS Planning Tools

1.8.1 Dimensioning of Compensation Systems

1.8.1.1 Electro-technical Basics: Power in AC Circuits

If an **inductive or capacitive** resistance is connected to an AC voltage source, in analogy to the **resistances** a reactive power component will be present in addition to the existing active power component.

The reactive power component is caused by the phase displacement between current and voltage of the **inductance** or the **capacity**. In a purely **ohmic resistance**, current and voltage are in the same phase, therefore a purely ohmic resistance does not have a reactive power component.

The reactive power component is called **reactive power $\boldsymbol{Q}$ [var]**.

The active component is called **active power $\boldsymbol{P}$ [W]**.

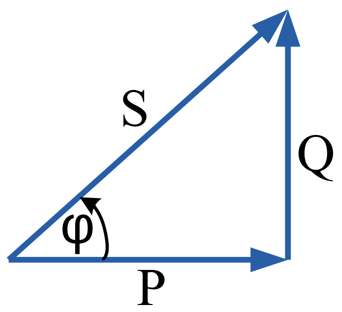
The total power in the AC circuit is the **apparent power $\boldsymbol{S}$ [VA]**.

Apparent power S can be calculated from active power $\boldsymbol{P}$ and reactive power $\boldsymbol{Q}$:

$$\boldsymbol{S} = \sqrt{\boldsymbol{Q}^2 + \boldsymbol{P}^2}$$

There is a phase displacement of 90° between active power $\boldsymbol{P}$ and reactive power $\boldsymbol{Q}$.

The correlations between active, reactive and apparent power are illustrated in the power triangle.



How to calculate the different power components in the AC circuit:

	Formula symbol	Unit	Formula	Formula
apparent power	$\boldsymbol{S}$	VA	$S = U \cdot I$	$S = \sqrt{Q^2 + P^2}$
active power	$\boldsymbol{P}$	W	$P = U \cdot I \cdot cos\varphi = S \cdot cos\varphi$	$P = \sqrt{S^2 + Q^2}$
reactive power	$\boldsymbol{Q}$	var	$Q = U \cdot I \cdot sin\varphi = S \cdot sin\varphi$	$Q = \sqrt{S^2 - P^2}$

The **power factor $\boldsymbol{cos\varphi}$** is called active power factor, shortened to power factor. It is often specified on the rating plates of electric motors.

The power factor $\boldsymbol{cos\varphi}$ represents the ratio between active power $\boldsymbol{P}$ and apparent power $\boldsymbol{S}$:

$$\boldsymbol{cos\varphi} = \frac{\boldsymbol{P}}{\boldsymbol{S}}$$

It indicates which proportion of apparent power is translated into the desired active power.

The reactive power factor $\boldsymbol{sin\varphi}$ represents the ratio of reactive power $\boldsymbol{Q}$ and apparent power $\boldsymbol{S}$:

$$\boldsymbol{sin\varphi} = \frac{\boldsymbol{Q}}{\boldsymbol{S}}$$

1.8.1.2 Central Compensation

In case of central compensation, the entire compensation system is installed at a central place, e.g. in the low-voltage distribution board. The entire demand of reactive power is covered. The capacitor power is split into several stages and adjusted to the load conditions by an automatic reactive power controller using contactors.

The compensation system is composed of modules comprising a fuse switch disconnector as short-circuit protection, a contactor with discharge resistors and the capacitor bank. Usually, the modules are connected to an internal, vertical cubicle busbar system.

Today, such a central compensation is implemented in most application cases. Central compensation can be easily monitored. Modern reactive power controllers permit continuous control of the switching state, $\cos\varphi$ as well as the active and reactive currents. This often allows to economize on capacitor power, i.e. use a lower total power, since the simultaneity factor of the entire plant can be taken into account for the layout. The installed capacitor power is better utilized.

However, the plant-internal wiring system itself is not relieved from reactive power, which does not constitute a disadvantage provided that the cable cross sections are sufficient. This means that this application can be used whenever the plant-internal wiring system is not under-dimensioned.

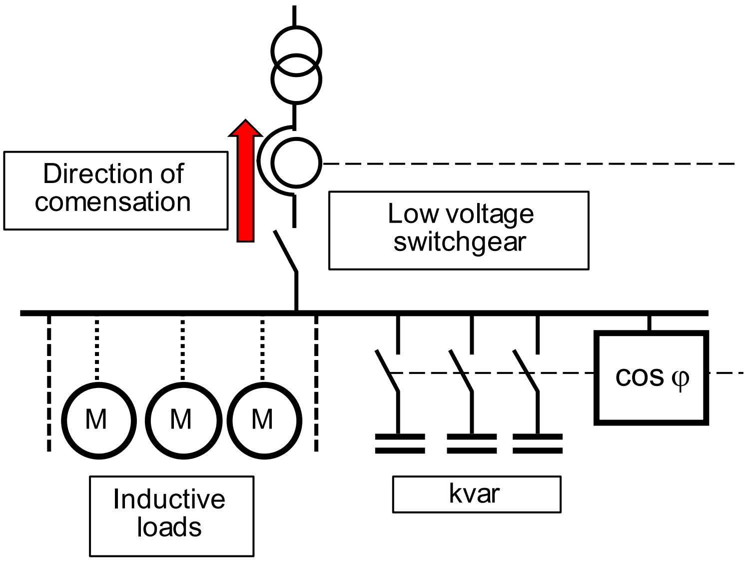
The central compensation panels can be directly integrated into the main busbar system of the LVMD or connected to the switchgear using an upstream group switch. Another option is to integrate the cubicles into the LVMD using a cable or busbar system. To this end, however, a switching/protective device must be provided as outgoing feeder from the distribution board.

Advantages:

- Clear and straightforward concept
- Good utilisation of the installed capacitor power
- Installation is often easier
- Less capacitor power required, since the simultaneity factor can be considered
- More cost-effective for networks with harmonic content, since reactive-power controlled systems can be more easily choked.

Disadvantages:

- The plant-internal power system is not relieved
- Additional layout for automatic control



1.8.1.3 Reactive Power Controller

These modern microprocessor-controlled reactive power controllers solve complex tasks which go far beyond pure reactive power compensation to a pre-selected target ***cosφ***. The innovative control behaviour responds to all requirements of modern industrial power systems and turns these controllers into a globally applicable solution.

Their high accuracy and sensitivity, even in power systems with a heavy harmonic load, must be emphasized as much as the fact that they can handle continuous or occasional energy recovery in power systems with their own in-plant power generation.

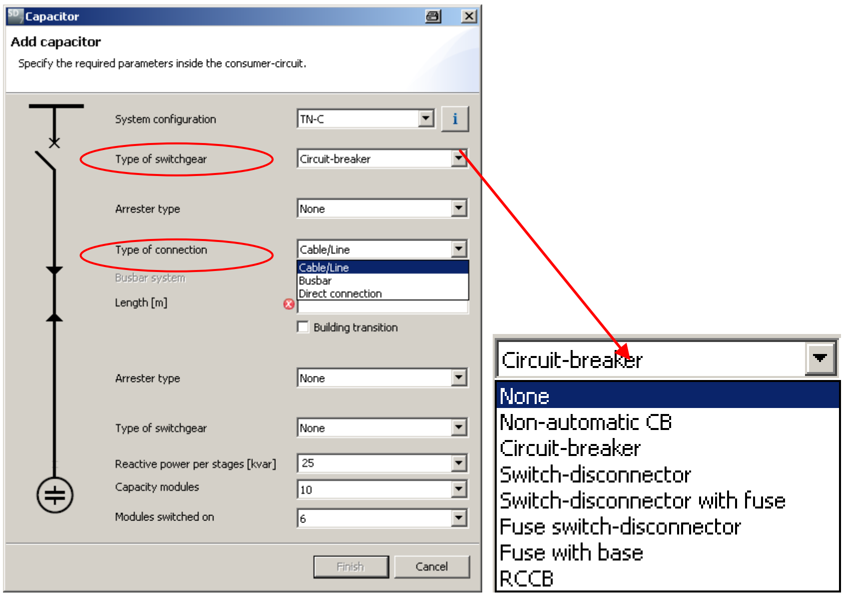
All components of the compensation system are treated gently by these controllers and protected against overload. This results in a much longer system life expectancy.

1.8.1.4 Consideration of Reactive Power Compensation in SIMARIS design

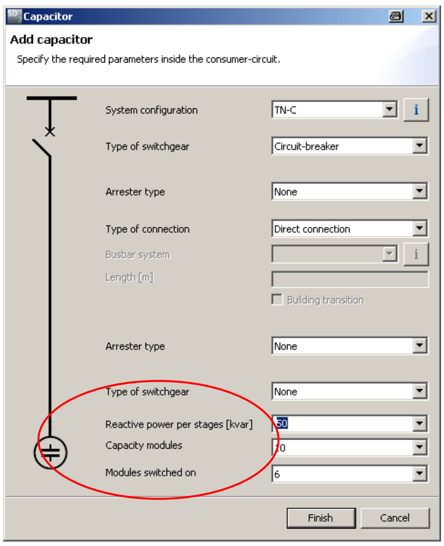
SIMARIS design maps an adjustable reactive power compensation system with several reactive power levels in respect of the capacitor power.

This compensation system can be directly integrated into the main busbar system of the switchgear installation using "Type of connection", or connected to an upstream protective device with cables or a busbar system.

In addition, you can select direct connection to the main busbar system or a connection by means of an group switch using "Type of switchgear".



The reactive power per stage in kvar, the number of stages and the modules switched on can also be set in this window.



At first, you roughly estimate the total capacitor power required to compensate the respective network.

Variant 1:

It can be estimated using the following factors:

- 25 - 30 % of the transformer output at $cos\varphi$ = 0.9
- 40 - 50 % of the transformer output at $cos\varphi$ = 1.0

Variant 2:

- The network diagram of SIMARIS design displays the reactive power Q = – ... kvar in the "Energy report" view.

Use the following formula to calculate the required capacitor power:

$$Q_C[kvar] = P[kW] \cdot (tan\varphi_1 - tan\varphi_2)$$

$$tan\varphi = \sqrt{\frac{1 - cos^2\varphi}{cos^2\varphi}}$$

Table: : $(tan\varphi1 - tan\varphi2)$ values to determine the capacitor power Q_C when compensated from $cos\varphi1$ to $cos\varphi2$: Planning Guide for Power Distribution Plants, H.Kiank, W.Fruth, 2011, p. 299

	$cos\varphi2$ / $cos\varphi1$	Target power factor										
		0.70	0.75	0.80	0.85	0.90	0.92	0.94	0.95	0.96	0.98	1.00
Actual power factor	0.40	1.27	1.41	1.54	1.67	1.81	1.87	1.93	1.96	2.00	2.09	2.29
	0.45	0.96	1.10	1.23	1.36	1.50	1.56	1.62	1.66	1.69	1.78	1.98
	0.50	0.71	0.85	0.98	1.11	1.25	1.31	1.37	1.40	1.44	1.53	1.73
	0.55	0.50	0.64	0.77	0.90	1.03	1.09	1.16	1.19	1.23	1.32	1.52
	0.60	0.31	0.45	0.58	0.71	0.85	0.91	0.97	1.00	1.04	1.13	1.33
	0.65	0.15	0.29	0.42	0.55	0.68	0.74	0.81	0.84	0.88	0.97	1.17
	0.70	---	0.14	0.27	0.40	0.54	0.59	0.66	0.69	0.73	0.82	1.02
	0.75	---	---	0.13	0.26	0.40	0.46	0.52	0.55	0.59	0.68	0.88
	0.80	---	---	---	0.13	0.27	0.32	0.39	0.42	0.46	0.55	0.75
	0.85	---	---	---	---	0.14	0.19	0.26	0.29	0.33	0.42	0.62
	0.90	---	---	---	---	---	0.06	0.12	0.16	0.19	0.28	0.48

Example:

In an uncompensated network with an active power of 780 kW and a power factor $cos\varphi1 = 0.8$, a target of $cos\varphi2 = 0.98$ shall be attained by compensation.

Using the above formula or table, you get $tan\varphi1 - tan\varphi2 = 0.55$.

This results in a required compensation power:

$$Q_C[kvar] = P[kW] \cdot (tan\varphi_1 - tan\varphi_2) = 780\ kW \cdot 0,55 = 429\ kvar$$

In the above window, reactive power per stage, the number of modules and the stages switched on can be set accordingly.

1.8.2 Compensation Systems in Power Systems with Harmonic Content

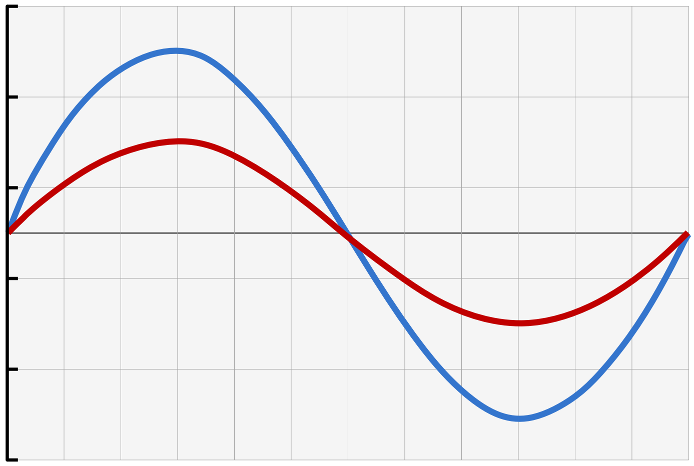
This content (texts and graphics) of the chapters Impact of linear and non-linear loads on the power system, Compensation systems in power systems with harmonic content, Choking of compensation systems and Ripple control frequency and its importance for the compensation system were taken from a brochure issued by Lechwerke AG (Schaezlerstraße 3, 86250 Augsburg).

Title:
Our service for you:
- Reactive current
- Compensation systems
- Proper choking.

Responsible for the content of the brochure according to the imprint: Steffen Götz

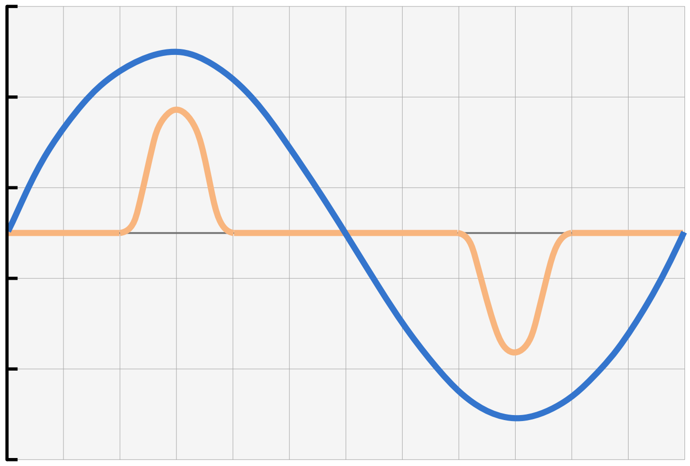
1.8.2.1 Impact of Linear and Non-linear Loads on the Power System

Linear loads such as incandescent lamps draw a **sinusoidal current**. Thus, the current curve basically has the same shape as the **sinusoidal voltage**. This sinusoidal current causes a voltage drop in the power system's impedances (AC resistors), which also shows a sine shape. For this reason, the voltage curve is only affected in its amplitude but not in its basic course. Therefore, the sine curve of the voltage is not distorted.



Current curve (red) for a linear load

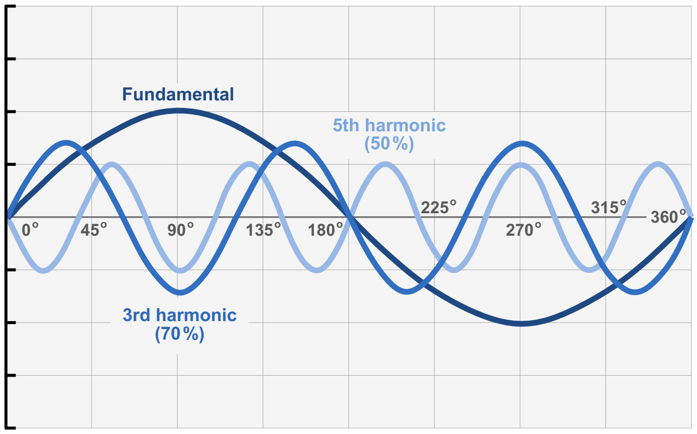
In the power supply networks of today, there is a trend towards power consuming appliances which draw a current from the supply network which is distinctly different from the sine shape. This **non-sinusoidal current** causes a voltage drop in the impedances of the power lines which is also not sinusoidal. This means that the voltage is not only altered in its amplitude but also in its shape. The originally sinusoidal **line voltage** is distorted. The distorted voltage shape can be decomposed into the fundamental (line frequency) and the individual harmonics. The harmonics frequencies are integer multiples of the fundamental, which are identified by the ordinal number "n" (see below).



Current curve (orange) for a non-linear load

Harmonics and their frequencies with the ordinal number "n"

Fundamental frequency 50 Hz
2nd harmonic 100 Hz
3rd harmonic 150 Hz
4th harmonic 200 Hz
5th harmonic 250 Hz
6th harmonic 300 Hz
7th harmonic 350 Hz

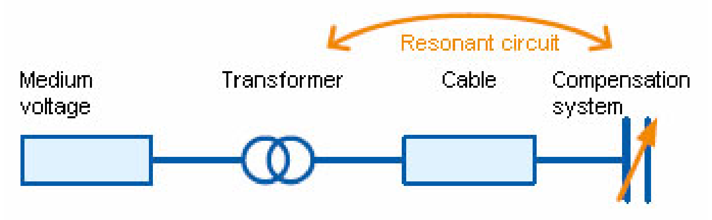


This means non-linear loads cause harmonic current content, which causes harmonic voltage content.

Linear loads are:
- ohmic resistances (resistance heating, incandescent lamps,...)
- 3-phase motors
- capacitors

Non-linear loads (causing harmonic content) are:
- converters
- rectifiers and inverters
- single-phase, fixed-cycle power supplies for electronic consumers such as TV sets, computers, electronic control gear (ECG) and compact energy-saving lamps

1.8.2.2 Compensation systems in power systems with harmonic content



Capacitors form a resonant circuit with the inductances in the power system (transformers, motors, cables and reactor coils). The resonance frequency can easily be established from a rule of thumb:

$$f_r = 50\ Hz \times \sqrt{\frac{S_k}{Q_c}}$$

f_r = resonance frequency [Hz]
S_k = short-circuit power at the connection point of a compensation system [kVA]
Q_c = reactive power of the compensation system [kvar]

or using the formula

$$f_r = 50\ Hz \times \sqrt{\frac{S_{Tr}}{Q_c \times u_k}}$$

f_r = resonance frequency [Hz]
S_{Tr} = nominal transformer output [kVA]
u_k = relative short-circuit voltage of the transformer (e.g 0.06 with 6 %)
Q_c = reactive power of the compensation system [kvar]

Example:
Operation of a compensation system, 400 kVA in 8 levels (modules), non-choked, supplied by a transformer with a nominal output of S_{Tr} = 630 kVA and a relative short-circuit voltage u_k of 6 %.
Dependent on the capacitors connected into supply, there will be resonance frequencies between 256 Hz and 725 Hz (see the table below).

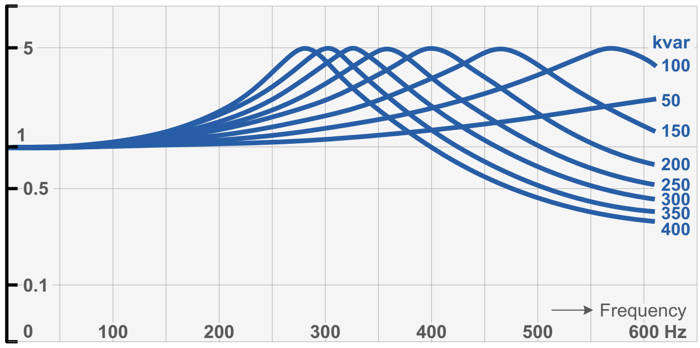
Resonance frequencies in case of differing compensation capacity and transformer with S_{Tr} = 630 kVA and u_k = 6 %

Capacitor power Q_c [kvar]	Resonance frequency f_r [Hz]
50	725
100	512
150	418
200	362
250	324
300	296
350	274
400	256

It becomes obvious that the values of the resonance frequency f_r are close to a harmonic frequency in several cases.

If the resonance frequency is the same as the harmonic frequency, this will result in a resonance-effected rise of the harmonic voltages.

And the current is increased between inductance and capacitance, which then rises to a multiple of the value fed into the power system from the harmonic "generator".



Amplification factors of harmonic voltages in case of non-choked compensation systems connected to a 1,000kVA transformer

Though the increase of the harmonic voltage rises the r.m.s. value of the voltage to a minor extent, the peak value of the voltage may rise substantially depending on harmonic content and phase angle (up to ≈ 15%). The increase of the harmonic current results in a significant increase of the r.m.s. value of the capacitor current. The combination of both effects may under certain circumstances cause an overloading of the capacitor and an additional load on the power consuming appliances and the transformer.

For this reason, compensation systems should always be equipped with capacitors showing a sufficient nominal voltage rating and a high current carrying capacity.

In order to prevent these resonance effects and the resulting capacitor overloading, reactor-connected compensation systems must be used.

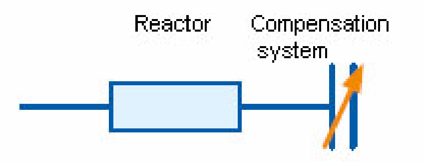
1.8.2.3 Choking of Compensation Systems

A compensation system should be choked if the ratio of harmonics (harmonic-generating equipment) to the total output of the plant exceeds a value of 15 %. This ratio must also be paid attention to in weak-load times, since displacements (no line attenuation caused by loads) may now occur which contribute to resonance formation. Another guidance value for the use of reactor-connected systems may be a harmonic voltage of 2 % in case of a 5th harmonic (250 Hz), or 3 % for the total harmonic content referred to the nominal voltage.

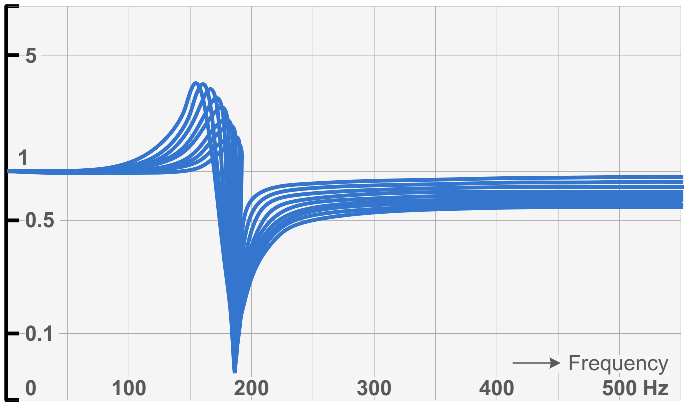
Owing to the increased use of non-linear consumer equipment, these values are attained in many power systems, at least sometimes. A power system analysis is required for detailed value findings.

Please note, however, that the values of the existing harmonic levels in the power system will tend to grow in the future, firstly for example, owing to the integration of more harmonic-generating equipment.
Secondly, resonances may occur even with less harmonic content. Choking is therefore recommended on principle.

In reactor-connected (choked) compensation systems, every capacitor module is series-connected to a reactor.
This creates a series resonant circuit. Reactor dimensioning determines the series resonance frequency of the series resonant circuit. This resonance frequency must be below the lowest occurring harmonic
(mostly the 5th harmonic).



A series resonant circuit becomes inductive above the resonance frequency. Therefore, resonance cannot be excited any more in such a case. Below its resonance frequency, it is capacitive and serves for reactive power compensation.



Attenuation of harmonic voltages of a compensation system with 7 % choking in case of different capacitor modules (levels).

The resonance frequency f_r of a compensation system is calculated from the choking factor p of the system:

$$f_r = 50\ Hz \times \sqrt{\frac{1}{p}}$$

f_r = resonance frequency [Hz]
p = choking factor

Example:
If a compensation system is choked at 7 % (=0.07), its resonance frequency is at 189 Hz. Consequently, the resonance frequency is below the 5th harmonic (250 Hz), as described above.

The choking factor $\boldsymbol{p}$ reflects the ratio of reactances, i.e. the ratio of the inductive reactance of the reactor to the capacitive reactance of the capacitor at line frequency.

$$\boldsymbol{p = \frac{X_L}{X_C}}$$

$\boldsymbol{p}$ = choking factor
$\boldsymbol{X_L}$ = inductive reactance of the reactor (at 50 Hz) [$\boldsymbol{\Omega}$]
$\boldsymbol{X_C}$ = capacitive reactance of the capacitor (at 50 Hz)

If a compensation system is choked at 7 %, the reactance (inductive reactance) of the reactor is 7 % of the capacitive reactance of the capacitor at line frequency (50 Hz). Reactances are calculated from the capacitance, or respectively from the reactor inductance, on the basis of the following formulae:

$$\boldsymbol{X_C = \frac{1}{2 \cdot \pi \cdot f \cdot C}}$$

$\boldsymbol{X_C}$ = capacitive reactance of the capacitor (at 50 Hz) [$\boldsymbol{\Omega}$]
$\boldsymbol{f}$ = frequency [Hz]
$\boldsymbol{C}$ = capacitance [F]

$$\boldsymbol{X_L = 2 \cdot \pi \cdot f \cdot L}$$

$\boldsymbol{X_L}$ = inductive reactance of reactor [$\boldsymbol{\Omega}$]
$\boldsymbol{f}$ = frequency [Hz]
$\boldsymbol{L}$ = reactor inductance [H]

1.8.2.4 Ripple Control Frequency and its Importance for the Compensation System

Most distribution system operators (DSO) emit ripple control signals (audio frequencies) to control night-current storage heaters, tariff switchovers and street lighting, etc. The signal levels for audio-frequency control systems overlaying the power system are between 110 Hz and 2,000 Hz, dependent on the DSO. These signals are received by audio frequency receivers which perform the required switching. In this context it is important that the signals are not influenced and transmitted – i.e. received – at a sufficiently high voltage level.

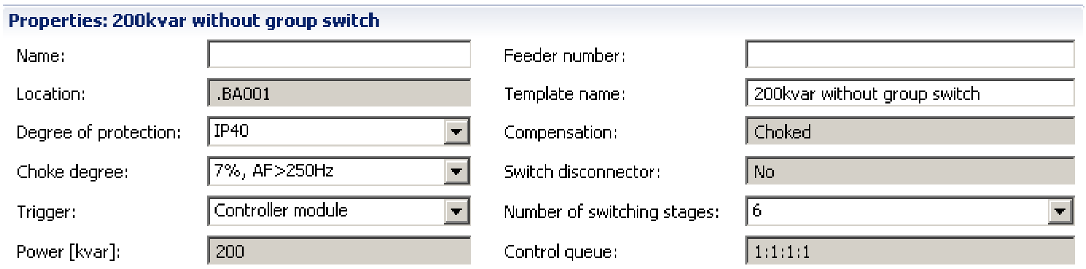
To ensure this, the use of audio frequency suppression is required, which prevents the absorption of ripple control signals from the power system by means of a compensation system.

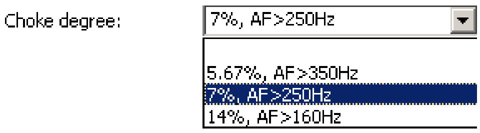
The audio frequency suppression device to be used depends on the frequency of the ripple control signal of the respective DSO.

1.8.2.5 Consideration of Choking Rate and Audio Frequency Suppression in SIMARIS project

In SIMARIS project, SIVACON S8 low-voltage switchboard can be configured to include reactive power compensation, if necessary. To set values for a specific project as required, the choking rate and appropriate audio frequency suppression can be selected in the properties of the reactive power compensation assembly.

These properties are displayed in the program step "System Planning" → "Front View", as soon as the respective reactive power compensation assembly is marked in the graphic area.





In the Project Output of "tender specification texts", the parameters are applied as selected and integrated into the description.

1.9 Frequency converters

In the SIMARIS planning tools there are frequency converters available which can be integrated in a switchgear (built-in units) and as well frequency converters which are delivered in a separate cabinet (Cabinet unit).

You can find more information regarding frequency converters in the following chapters:

2.14 Frequency converters in SIMARIS design

3.13.7 Frequency converters in SIMARIS project

Converter type	Mounting technique	Power ranges [kW] 3AC380 - 480V	Power ranges [kW] 3AC500 - 600V	Power ranges [kW] 3AC660 - 690V
G120 (PM240-2)	Built-in unit	0.55 – 132	11 - 132	11 - 132
G120P cabinet	Cabinet unit	110 – 400	-	-
G150	Cabinet unit	110 – 560	110 - 560	75 - 800

Performance / Use	Basic		Medium	
Pumping/ ventilating/ compressing	Centrifugal pumps Radial/ axial fans Compressors	G120 G120P cabinet G150	Centrifugal pumps Radial/ axial fans Compressors	G120 G120P cabinet G150
Moving	Belt conveyors Roller conveyors Chain conveyors	G120 G150	Belt conveyors Roller conveyors Chain conveyors Vertical/horizontal material handling Elevators Escalators Gantry cranes Ship's drives Cable railways	G120 G150
Processing	Mils Mixers Kneaders Crushers Agiators Centrifuges	G120 G150	Mils Mixers Kneaders Crushers Agiators Centrifuges Extruder Rotary furnaces	G120 G150

1.10 The Technical Series of Totally Integrated Power

The Technical Series of Totally Integrated Power documents further technical support for some very special cases of network design. Each edition of this documentation series considers a special case of application and illustrates, how this case is mapped in network design and calculation using SIMARIS design.

The following topics are currently available:

- Modelling IT isolating transformers in SIMARIS design for hospital applications
- Use of switch-fuse combinations at the medium-voltage level for the protection of distribution transformers
- Modelling uninterruptible Power Supply (UPS) in SIMARIS design for the Use in data centres
- Modelling the use of selective main circuit-breakers without control circuit (SHU) with SIMARIS design 8.0
- Load impact in the feed-in circuit on life cycle energy costs
- Special application: short-circuit protection for the "isolated-parallel" UPS system
- Arcing faults in medium and low voltage switchgear
- SIESTORAGE energy storage systems – a technology for the transformation of energy system
- Electrical infrastructure for e-car charging stations
- Liberalised energy market - smart grid, micro grid
- The Energy Management Standard DIN EN ISO 50001
- Cable sizing with SIMARIS design for cable burying
- Electric Power Distribution in Data Centres Using L-PDUs
- Influence of Modern Technology on Harmonics in the Distribution Grid
- Direct and Alternating Power Supply in a Data Center

If you are interested in the content of the technical series, you can download the PDF-documents at www.siemens.com/tip-cs/technical-series .

1.11 Planning Manuals of Totally Integrated Power

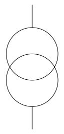
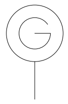
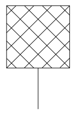
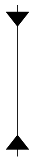
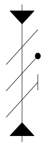
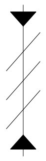
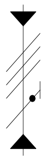
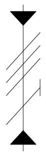
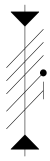
You can also find bedrock support for your project planning in the planning manuals of Totally Integrated Power, which are available for download in the corresponding section of our download page at www.siemens.com/tip-cs/downloadcenter.

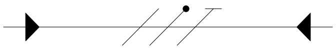
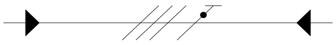
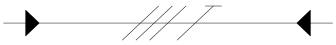
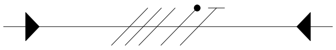
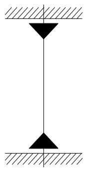
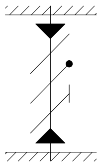
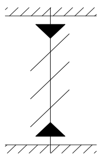
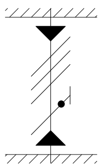
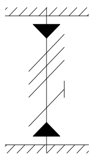
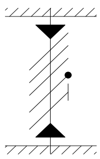
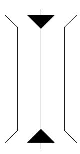
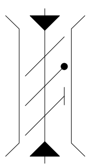
The following Planning Manuals are currently available:

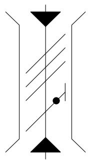
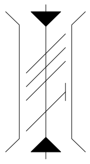
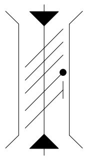
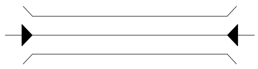
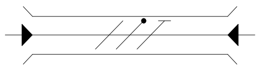
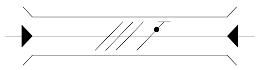
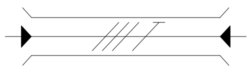
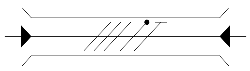
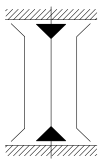
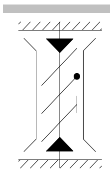
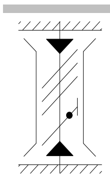
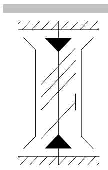
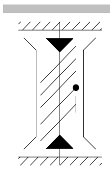
- Planning of Electric Power Distribution – Technical Principles
- Application Models for Power Distribution – High-rise Buildings
- Application Models for Power Distribution – Data Centres
- Application Models for Power Distribution – Hospitals

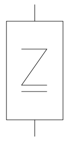
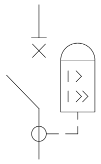
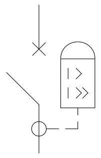
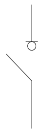
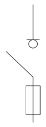
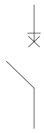
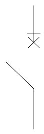
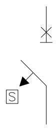
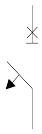
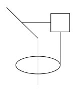
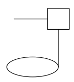
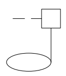
2 Special Technical Information about Network Calculation in SIMARIS design

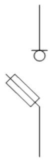
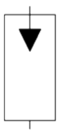
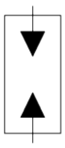
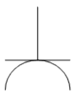
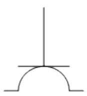
2.1 Symbols for representing the network diagram in SIMARIS design

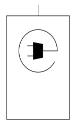
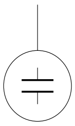
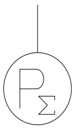
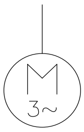
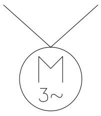
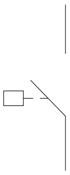
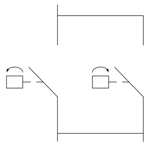
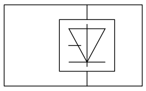
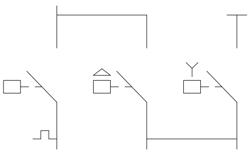
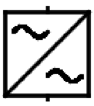
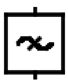
Symbols in the network diagram	Meaning
System infeeds	
	Transformer
	Generator without DMT
	System infeed (neutral, definition by way of impedances, loop impedance or short-circuit currents)
Cable connections	
	Cable
	Cable, 3-core, with N and PE
	Cable, 3-phase
	Cable, 4-core, with PEN
	Cable, 4-core, with PEN
	Cable, 5-core, with N and PE

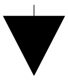
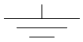
Symbols in the network diagram	Meaning
Cable connections	
	Cable within a coupling
	Cable, within a coupling, 3-core, with N and PE
	Cable, within a coupling, 4-core, with PEN
	Cable, within a coupling, 4-core, with PE
	Cable, within a coupling, 5-core, with N and PE
	Cable, wall to wall
	Cable, 3-core, with N and PE, wall to wall
	Cable, 3-phase, wall to wall
	Cable, 4-core, with PEN, wall to wall
	Cable, 4-core, with PE, wall to wall
	Cable, 5-core, with N and PE, wall to wall
Busbar connections	
	Busbar
	Busbar, 3-core, with N and PE

Symbols in the network diagram	Meaning
Busbar connections	
	Busbar, 4-core, with PEN
	Busbar, 4-core, with PE
	Busbar, 5-core, with N and PE
	Busbar within a coupling
	Busbar, within a coupling, 3-core, with N and PE
	Busbar, within a coupling, 4-core, with PEN
	Busbar, within a coupling, 4-core, with PE
	Busbar, within a coupling, 5-core, with N and PE
	Busbar, wall to wall
	Busbar, 3-core, with N and PE, wall to wall
	Busbar, 4-core, with PEN, wall to wall
	Busbar, 4-core, with PEN, wall to wall
	Busbar, 5-core, with N and PE, wall to wall

Symbols in the network diagram	Meaning
Other symbols within distributions	
	Equivalent impedance
Switching and protective devices, fuses	
	Circuit-breaker with isolating function, medium voltage
	Circuit-breaker, medium voltage
	Switch disconnector, low voltage
	Switch disconnector with fuse, low voltage
	Non-automatic air circuit breaker, low voltage
	Circuit-breaker, low voltage
	Main miniature circuit breaker (SHU), low voltage
	Miniature circuit-breaker, low voltage
	Residual current operated circuit-breaker, low voltage
	RCD for circuit-breaker, low voltage, with mechanical release of disconnection
	RCD for circuit-breaker, low voltage, with electronic trip of discon-nection

Symbols in the network diagram	Meaning
Switching and protective devices, fuses	
	(Overload) relay
	Fuse
	Fuse with base
	Fuse switch disconnector
	Surge arrester type 1
	Surge arrester type 2
	Surge arrester type 3
	Surge arrester type 1/2
Load	
	Stationary load
	Power outlet circuit (load)
	Power outlet circuit, outdoor area, wet zone

Symbols in the network diagram	Meaning
Load	
	Charging unit for electrical vehicles as consumers
	Capacitor
	Dummy load (definition by way of nominal current and active power)
	Motor
	Motor, in star-delta connection
	Motor starter, direct on-line starter
	Motor starter combination, reversing mode
	Motor starter combination, soft starter
	Motor starter combination, star-delta starter
	Frequency converter
	Frequency converter, filter
	Frequency converter, reactor

Other symbols	
	Incoming feeder
	Outgoing feeder
	Earth

2.2 Power Sources

Power sources	Transformer	Generator	UPS
Selection	Quantity and power rating corresponding to the power required for normal power supply	Quantity and power rating corresponding to the total power of consumers to be supplied if the transformers fail	Quantity, power, and energy quantity dependent on the duration of independent power supply and total power consumption of the consumers to be supplied by the UPS
Requirements	▪ High reliability of supply ▪ Overload capability ▪ Low power loss ▪ Low noise ▪ No restrictions with regard to installation ▪ Observance of environment, climate and fire protection categories	▪ Energy coverage for standby power supply ▪ in case of turbosupercharger motors, load sharing in steps ▪ Availability of sufficient continuous short-circuit power to ensure tripping conditions	▪ Stable output voltage ▪ Availability of sufficient continuous short-circuit power to ensure tripping conditions ▪ Low-maintenance buffer batteries for power supply, observance of noise limits ▪ Little harmonic load for the upstream network
Rated current	$I_N = \frac{S_N}{\sqrt{3} \cdot U_N}$	$I_N = \frac{S_N}{\sqrt{3} \cdot U_N}$	$I_N = \frac{S_N}{\sqrt{3} \cdot U_N}$

Power sources	Transformer	Generator	UPS
Short-circuit currents	■ Continuous short-circuit current, 3-phase: $I_{K3} \approx \frac{I_N \cdot 100\,\%}{U_K}$ ■ Continuous short-circuit current,2-phase: $I_{K2} \approx I_{K3} \frac{\sqrt{3}}{2}$ ■ Continuous short-circuit current, 1-phase: $I_{K1} \approx I_{K3}$	■ Continuous short-circuit current, 3-phase: $I_{K3,D} \approx 3 \cdot I_N$ ■ Continuous short-circuit current,1-phase: $I_{K1,D} \approx 5 \cdot I_N$ ■ Initial AC fault current: $I_K'' \approx \frac{I_N \cdot 100\,\%}{x_d''}$	■ Short-circuit current, 3-phase: $I_{K3} \approx 2{,}1 \cdot I_N$ (for 0.02 s) $I_{K3} \approx 1{,}5 \cdot I_N$ (for 0.02 – 5 s) ■ Short-circuit current, 1-phase: $I_{K1} \approx 3 \cdot I_N$ (for 0.02 s) $I_{K1} \approx 1{,}5 \cdot I_N$ (for 0.02-5 s)

Legend	
I_N	Rated current
U_N	Nominal voltage
U_K	Rated short-circuit voltage
S_N	Nominal apparent power

Power sources	Transformer	Generator	UPS
Advantages	■ High transmission capacity possible ■ Stable short-circuit currents ■ Electrical isolation	■ Distributed availability ■ Independent power generation	■ Low power loss ■ Voltage stability ■ Electrical isolation
Disadvantages	■ High inrush currents ■ Dependency on the public grid	■ System instability in case of power system fluctuations ■ Small short-circuit currents	■ Very small short-circuit currents

2.3 Directional and Non-directional Couplings

2.3.1 Design Principles of Directional and Non-directional Couplings

Non-directional couplings are couplings with a non-defined direction of energy flow for mapping a normal power supply grid.

Directional couplings, in which the direction of energy flow is defined, are required to build a supply network integrating normal and safety power supply. The classic application case of directional couplings is given in a hospital, where the power supply network is built up on the basis of VDE 0100 Part 710 (hospital NPS/SPS network). Networks with directional couplings do not permit parallel network operation and energy recovery for the power supply system of the power supplier.

2.3.2 Load Transfer Switches in Accordance with DIN VDE 0100 Part 710 (IEC 60364-7-71) (medical locations)

A changeover connection is a circuit combination for coupling networks for normal power supply with the safety supply.

The standard requires reliable isolation between systems for automatic load transfer switches. The maximum total disconnect time (from the moment of fault occurrence until arc quenching in the overcurrent protection device) must be lower than the minimum transfer delay time of the automatic load transfer switch.

The lines between the automatic load transfer switch and the downstream overcurrent protection device must be laid short-circuit- and earth-fault-proof.

Load transfer switches in the sense of this standard shall automatically ensure direct power supply from th3e two independent systems at each distribution point (main distribution board and distribution boards for medical locations of group 2).

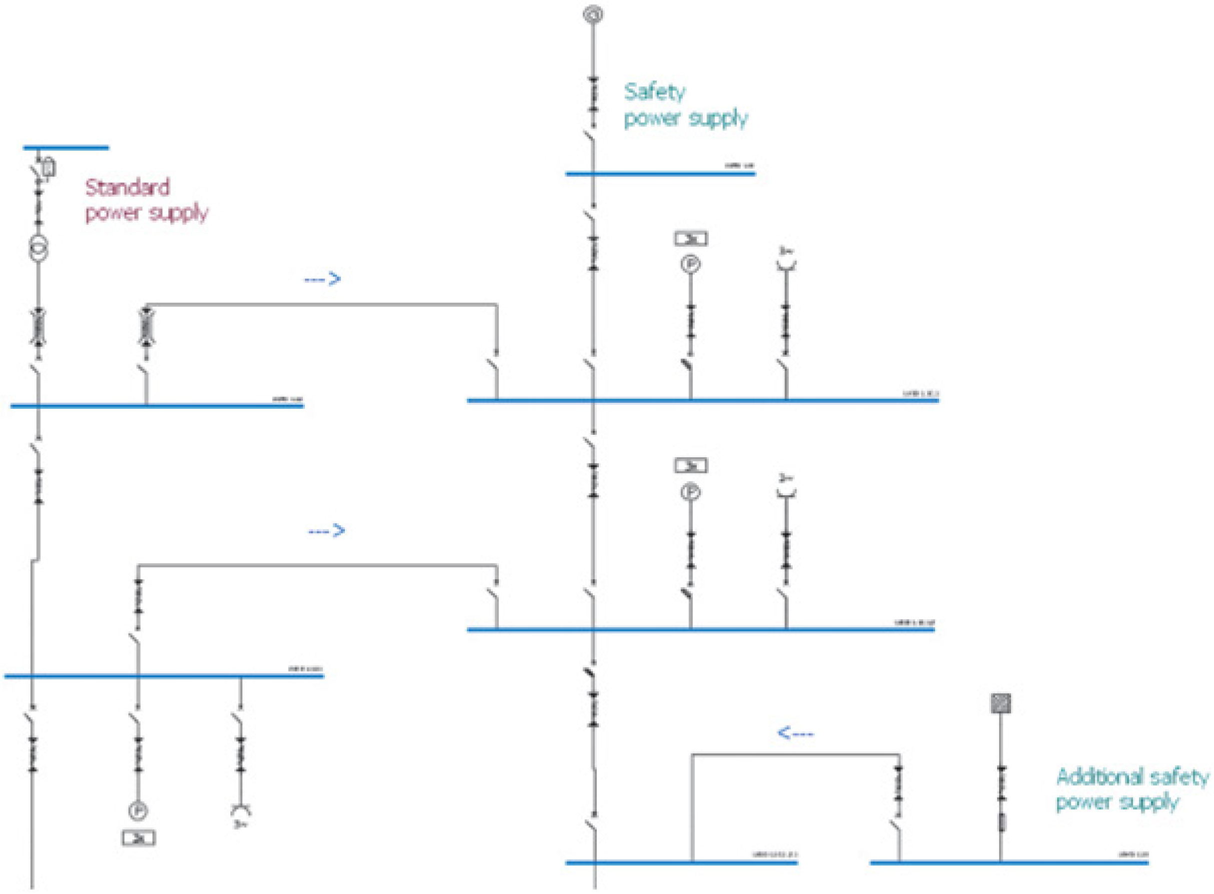
Continuous operability must be ensured.

This means if there is a voltage failure in one or more phases in the main distribution board, a safety power supply system must automatically take over. Take-over of supply shall be delayed, so that short-time interruptions can be bridged.

In practice, these load transfer switches are used dependent on the network configuration.

DIN VDE 0100 Part 710 mandatorily requires network calculations and proofs of selectivity, i.e. appropriate documentation must be available.

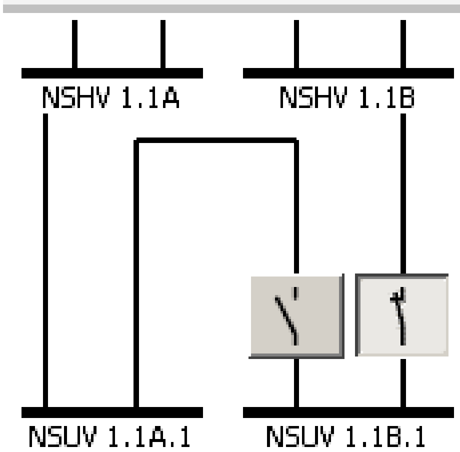
Planning with SIMARIS design can take account of this DIN requirement, by mapping and appropriately dimensioning the changeover connection between the normal and the safety power supply system.



Example for the representation of a changeover connection in SIMARIS design professional

2.3.3 Creating Emergency Power Supply Systems

Example



- **Normal operation**

In an active safety power supply system, the coupling switch in the LVMD is closed as the only connection of both networks during normal operation.

In the building's main distribution board and in the sub-distribution boards, the coupling switches are open and the feed-in circuit-breakers are switched on.

The NPS and SPS networks are both active and operated separately.

- **Operation under fault conditions:**

If the normal power supply (NPS) fails due to a fault, the safety power supply (SPS) autonomously continues to supply its power consumers.

If a fault occurs in the SPS, the changeover switch closest to the fault location ensures continuous operation of the SPS consumers via the NPS.

Therefore, the NPS source must be dimensioned for the load of NPS and SPS consumers.

2.4 Dimensioning of Power Transmission and Power Distribution Lines

	Overload protection	Short-circuit protection	Protection by disconnection in the TN system	Voltage drop
Re-quirement	Line protection against overload shall prevent damage from the connection itself (conductor insulation, connection points, terminals, etc.) and its immediate environment, which could be caused by excessive heating.	Line protection against overload shall prevent damage from the connection itself (conductor insulation, connection points, terminals, etc.) and its immediate environment, which could be caused by excessive heating. The current breaking capacity of the short-circuit protection device must be rated in such a way that it is capable of breaking the maximum possible short-circuit at the mounting location.	The loop impedance Z_S of the supply line must be dimensioned in such a way that the resulting short-circuit current will cause an automatic tripping of the protective device within the defined period of time. In this context, it must be assumed that the fault will occur between a phase conductor and a protective conductor or an exposed conductive part somewhere in the installation, where the impedance can be neglected.	The maximum permissible voltage drop for power consumers must be taken into account for cable rating.
Features	$I_B \leq I_N \leq I_Z$ The cable load capacity $\boldsymbol{I_Z}$ is rated for the maximum possible operating current $\boldsymbol{I_B}$ of the circuit and the nominal current $\boldsymbol{I_N}$ of the protection device. $I_2 \leq 1{,}45 \cdot I_Z$ The conventional tripping current $\boldsymbol{I_2}$, which is defined by the upstream protective device, is lower, at most equal to the 1.45-fold of the maximum permissible cable load capacity $\boldsymbol{I_Z}$.	$I^2 \cdot t \leq k^2 \cdot S^2$ The maximum period of time t until a short-circuit current $\boldsymbol{I}$ is broken, measured at any point in the circuit, may only last so long that the energy produced by the short-circuit does not reach the energy limit which would cause damage or destruction of the connection line.	$Z_S \cdot I_a \leq U_o$ The loop impedance $\boldsymbol{Z_S}$ of the supply line must be dimensioned in such a way that the resulting short-circuit current will cause an automatic tripping of the protective device within the defined period of time. In this context, it must be assumed that a fault will occur between a phase conductor and a protective conductor or an exposed conductive part somewhere in the installation, where the impedance can be neglected.	Voltage drop in the three-phase system $\Delta U = \frac{I \cdot L \cdot \sqrt{3} \cdot (R'_W \cdot cos\varphi + X'_L \cdot sin\varphi)}{U_N} \cdot 100\ \%$ Voltage drop in the AC system $\Delta U = \frac{2 \cdot I \cdot L \cdot (R'_W \cdot cos\varphi + X'_L \cdot sin\varphi)}{U_N} \cdot 100\ \%$

	Overload protection	Short-circuit protection	Protection by disconnection in the TN system	Voltage drop
Particularities	■ Overload protection devices may be used at the beginning or end of the cable line to be protected. ■ Following VDE 0298 Part 4, the permissible load capacity I_Z of cables or wires must be determined in accordance with the real wiring conditions. ■ If gL-fuses are used as the sole protection device, short-circuit protection is also given, when the overload protection criterion is met.	■ A short-circuit protection device must always be mounted at the beginning of the cable line. ■ When short-circuit protection is tested, the PE/PEN conductor must always be included. ■ In the tripping range < 100 ms the I^2 values given by the equipment manufacturer t must be considered.	■ The permissible disconnection time, reached by I_a for consumers ≤ 32 A is 0.4 s for alternating current and 5 s for direct current. ■ The permissible tripping time, reached by I_a for consumers > 32 A and distribution circuits is 5 s. ■ Additional protection ensured by RCD (≤ 30 mA) is required for general-purpose sockets and sockets to be used by ordinary persons (sockets ≤ 20 A). ■ Additional protection ensured by RCD (≤ 30 mA) is required for final circuits for outdoor portable equipment with a current rating ≤ 32 A.	$R_W = R_{55°C} = 1.14 \cdot R_{20°C}$ $R_{80°C} = 1.24 \cdot R_{20°C}$ ■ The resistance load per unit length of a cable is temperature-dependent ■ An increased resistance in case of fire must be considered for the dimensioning of cables and wires with functional endurance in order to ensure fault-free starting of safety-relevant consumers. ■ It is always the voltage drop at the transformer which must be also taken into account, e.g. 400 V, the secondary transformer voltage is a no-load voltage! ■ Voltage tolerances for equipment and installations are defined in IEC 60038.

For an explanation of the formula symbols, please refer to section 2.18

2.5 Note on the Dimensioning of 8PS Busbar Trunking Systems

Busbar trunking systems are tested for thermal short-circuit strength and overload protection.

Dynamic short-circuit strength is present if both attributes are fulfilled (see IEC 60364-4-43 Clause 434).
Dynamic short-circuit strength is not tested.

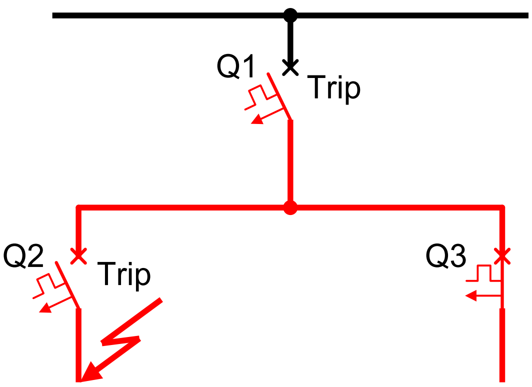
Owing to the constructive features of busbar trunking systems and their special methods of installation based on manufacturer instructions, the occurrence of the maximum to be expected theoretical peak short-circuit current acc. to VDE 0102 or respectively IEC 60909 can usually be ruled out.

In special cases, a verification of this assumption must be performed by the user.

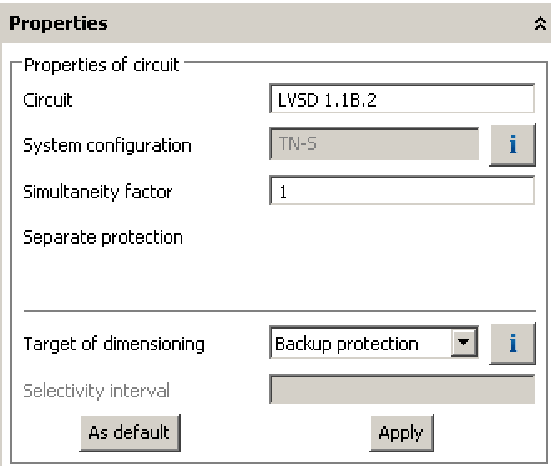
2.6 Selectivity and Backup Protection

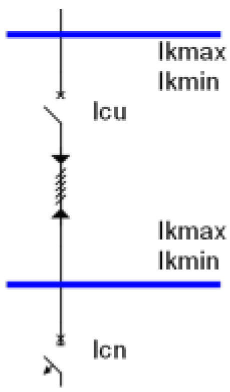
2.6.1 Backup Protection

The prerequisite is that $Q1$ is a current-limiting device. If the fault current in case of a short-circuit is higher than the rated breaking capacity of the downstream protection device, it is protected by the upstream protection device. $Q2$ can be selected with an I_{cu} or I_{cn} value lower than I_{kmax} of $Q2$. But this allows for partial selectivity only (see the following illustration).



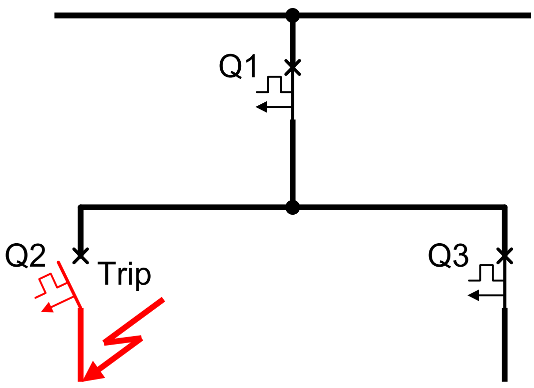
2.6.2 Backup Protection as Dimensioning Target in SIMARIS design



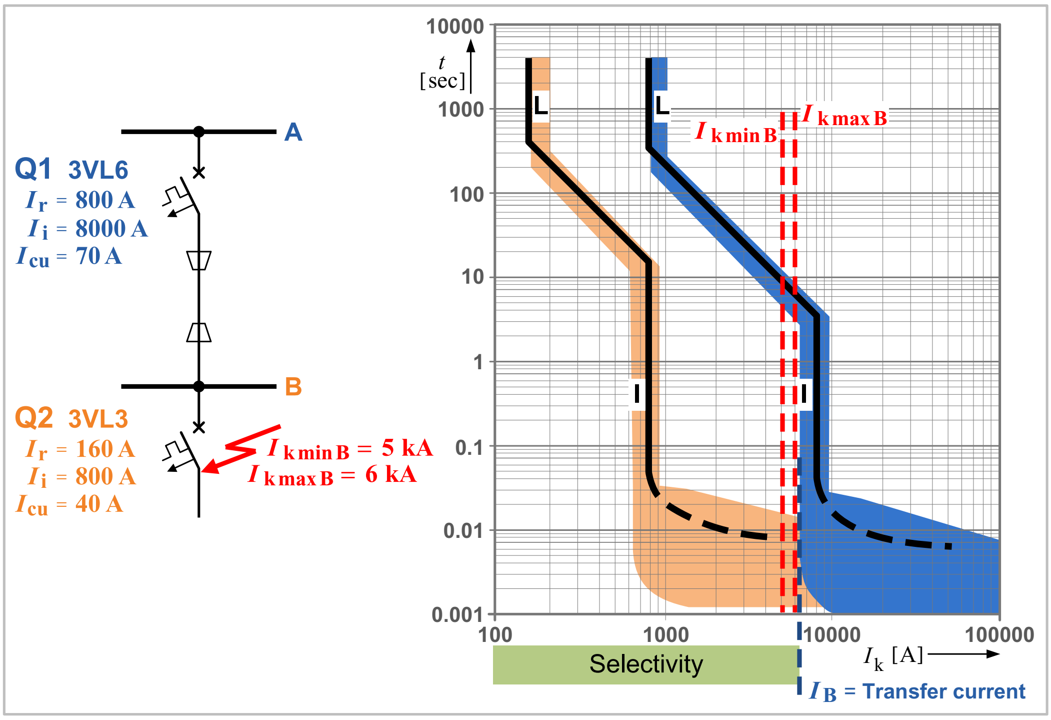
	When the dimensioning target "Backup protection" is set, SIMARIS design selects such switching and protective devices that they will protect themselves or will be protected by an upstream-connected switching device in case of a possible short-circuit. The algorithm applied may result in deviations from the published tables on backup protection.

2.6.3 Selectivity

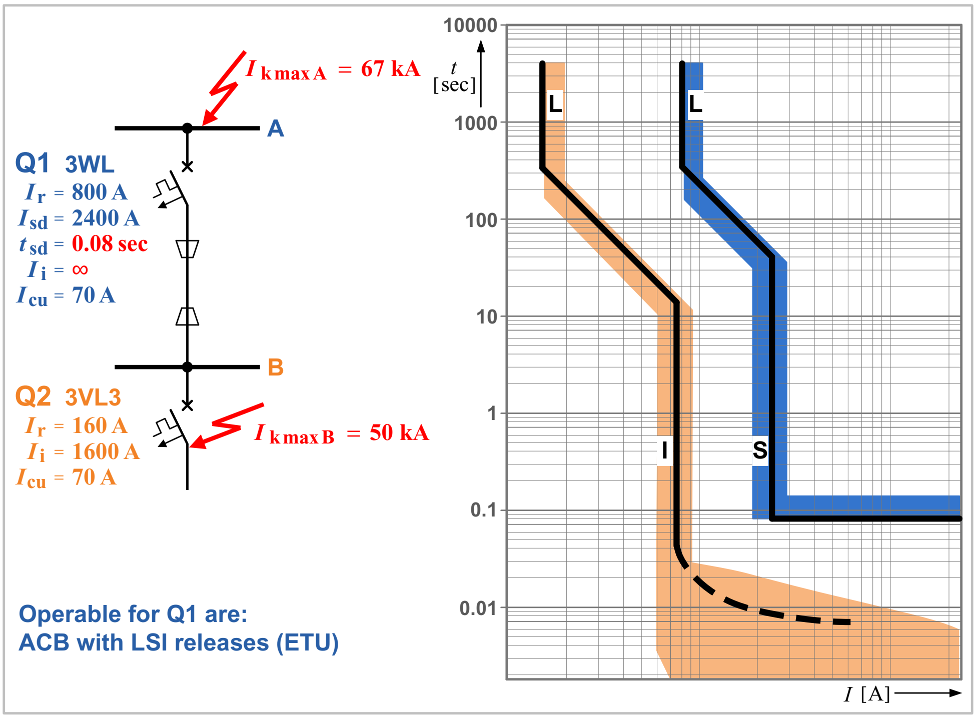
When several series-connected protective devices cooperate in graded disconnection operations, the protective device ($Q2$) closest to the fault location must disconnect. The other upstream devices (e.g. $Q1$) remain in operation. The effects of a fault are spaciously and temporally limited to a minimum, since unaffected branch circuits (e.g. $Q3$) continue to be supplied.



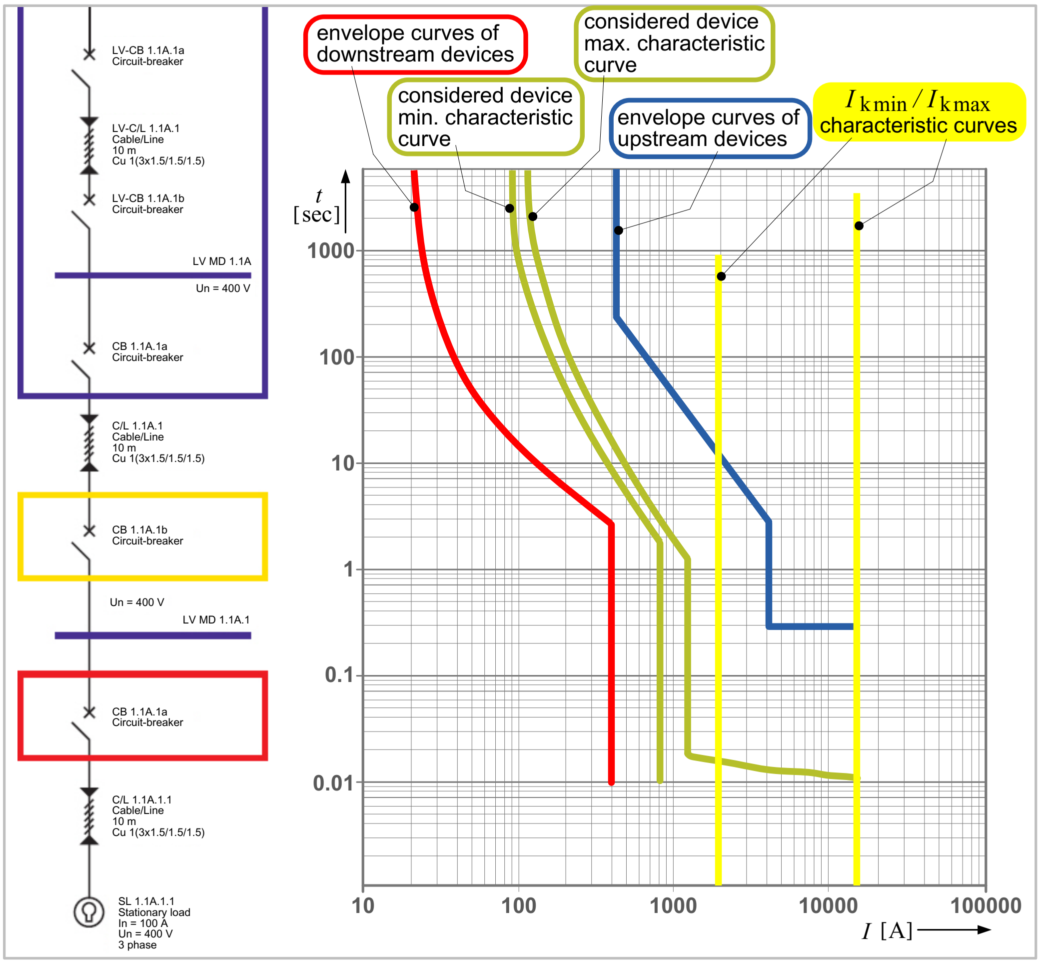
- Current selectivity is attained by the different magnitudes of the tripping currents of the protective devices.



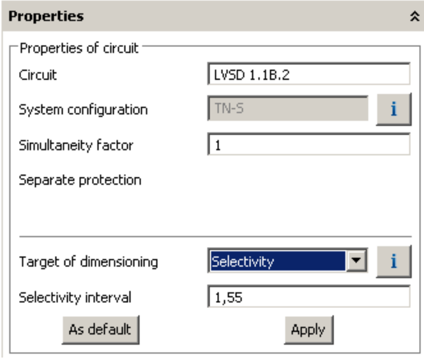
- Time selectivity is attained by the temporal tripping delay of the upstream protection devices.

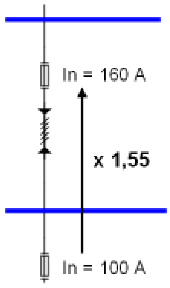
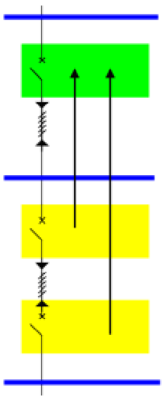


- Representation of the selective layout of the network



2.6.4 Selectivity as Dimensioning Target in SIMARIS design



	When "Selectivity" is set as dimensioning target in SIMARIS design, it is applied circuit by circuit. In order to attain current selectivity, the switching devices are staggered between the circuits according to their current values during automatic dimensioning with selectivity intervals. Here, electronic trip units are used for circuit-breakers which are equipped with time-delayed short-circuit releases characterized as "S", they allow to attain time selectivity in addition to current selectivity.
	Selectivity evaluation is performed on the basis of existing limit values in the overload range $< I_{kmin}$ (Isel-over) and in the short-circuit range $> I_{kmin}$ (Isel-short). The upper tolerance band of the respective switching device is compared to the envelope curve of the lower tolerance band of all upstream switching devices. When the tripping times are above 80 ms the intersections are graphically analysed; if the tripping times are under this limit, selectivity limits are queried from an integrated selectivity limit table. If there are two protective devices in the circuits (top and bottom switch), they are not compared to one another but evaluated against the protective devices in the upstream circuits, see picture.

2.7 Dimensioning the Network acc. to I_{cu} or I_{cn}

2.7.1 Areas of Application for Miniature Circuit-breakers

Miniature circuit-breakers (MCB) are used at different mounting locations in electrical installations.

Electrical installations accessible for ordinary persons

Circuit-breakers are subjected to higher test requirements with regard to their rated short-circuit breaking current I_{cn} in electrical installations which are accessible for ordinary persons. This is regulated in IEC 60898.

The rated short-circuit breaking current I_{cn} is the short-circuit current (r.m.s. value), which can disconnect the miniature circuit-breaker at a rated operating voltage (+/- 10 %) and a specified $\cos\varphi$.

This is tested using the test sequence 0 - t - CO - t - CO. The rated operational short-circuit breaking capacity I_{cs} is tested.

Attention:

Changes in the overload release characteristics are not permitted any more after this test!

electrical installations inaccessible for ordinary persons

In electrical installations which are inaccessible for ordinary persons, e.g. industrial plants, miniature circuit-breakers, such as the MCCB, are tested with respect to their rated ultimate short-circuit breaking capacity I_{cu}. This test is performed in accordance with IEC 60947-2.

The shortened test sequence 0 - t - CO is used here.

Attention:

Changes in the overload release characteristics ARE permitted after this test!

Legend for the test sequence	
0	Break operation
CO	Make, break operation
t	Pause

2.7.2 Selection of Miniature Circuit-Breakers acc. to I_{cn} or I_{cu} in SIMARIS design

In SIMARIS design, miniature circuit-breakers can be dimensioned according to both requirements, or they can be selected manually using the Catalogue function.

Attention:

The function named "Selection according to I_{cn} or I_{cu}" is only available for final circuits.

Device selection or check takes place during the dimensioning process dependent on the setting made, either corresponding to I_{cn} or I_{cu}.

All devices have been tested based on both test standards (IEC 60898 and IEC 60947-2) and the miniature circuit-breaker check process is based on both test standards.

However, the function "Selection acc. to I_{cn} or I_{cu}" is not available for device categories such as RCBOs (5SU1, 5SU9).

Device group	Type	I_{cn} [kA]	I_{cu} [kA]
5SY	MCB	6 / 10 / 15	10...50
5SY60	MCB	6	6
5SX	MCB	6 / 10	10 / 15
5SX1	MCB	3	4.5
5SQ	MCB	3	4.5
5SJ....-.CC	MCB	6 / 10 / 15	10 / 15 / 25
5SP4	MCB	10	10
5SY8	MCB	--	20...70
5SL6	MCB	6	6
5SL4	MCB	10	10
5SL3	MCB	4.5	4.5

2.8 Overcurrent protection

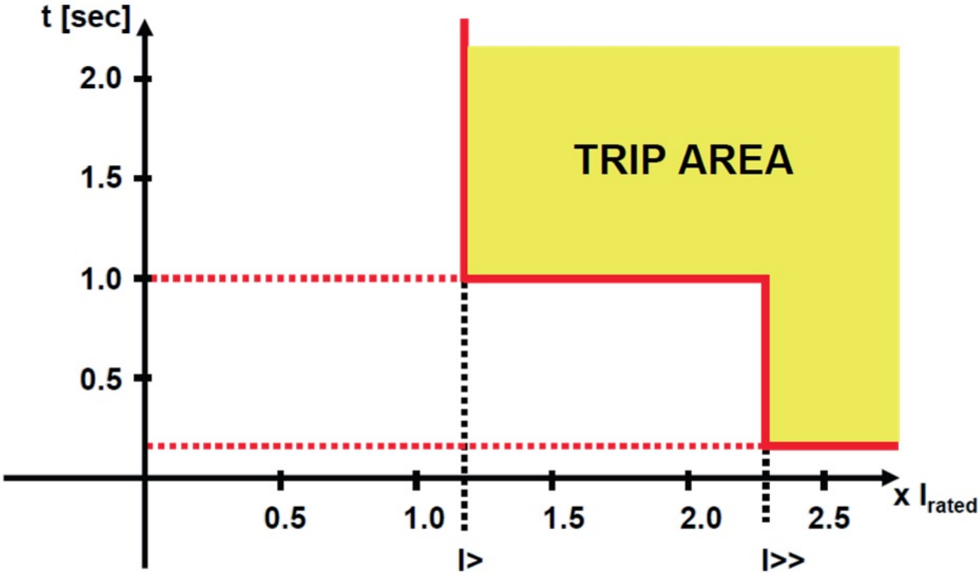
The overcurrent protection devices detect a fault on account of its amperage and clear the fault after a certain delay time has elapsed. Overcurrent protection devices either work with current-independent current thresholds (DMT – definite time overcurrent protection) or with a current-dependent tripping characteristic (IDMTL –inverse definite minimum time). Modern digital devices work phase-selective and can be configured especially for earth-fault detection (DMT / IDMT).

2.8.1 DMT (definite-time overcurrent protection)

You can use DMT as main protection always if it is possible to differ only on basis of the amperage between operation current and fault current. Selectivity can be achieved via delay time grading.

Advantage:

- Accurately defined tripping time at DMT dependent on current threshold(s)



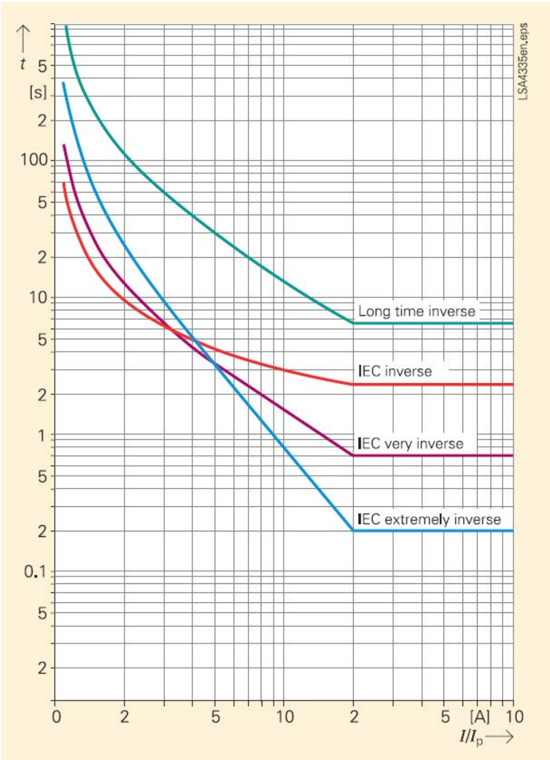
Trip characteristic of a two-stage (50) protection
(definite time-overcurrent)

2.8.2 IDMT (inverse-time overcurrent protection)

In case of inverse definite minimum time (inverse-time overcurrent protection) the tripping time depends on the amperage of the fault current. Due to the configuration possibilities of the IDMT tripping characteristics a similar tripping performance as by using fuses can be reached. "Inverse" indicates a curve shape of tripping characteristics proportional to 1/(current*). Concrete formulas can be found at IEC 60255-151.

Advantage:

- variable, (invers-)stromabhängige Auslösezeit bei AMZ



IEC characteristics

IEC invers: $$t = \frac{0{,}14}{(I/I_p)^{0{,}02} - 1} \cdot T_p$$

IEC very invers: $$t = \frac{13{,}5}{(I/I_p)^{1} - 1} \cdot T_p$$

IEC extreme invers: $$t = \frac{80}{(I/I_p)^{2} - 1} \cdot T_p$$

IEC long time invers: $$t = \frac{120}{(I/I_p)^{1} - 1} \cdot T_p$$

2.9 Transformers with ventilation

The performance of GEAFOL transformers can be enhanced by using cross-flow fans. If they are installed in an open space and sufficiently ventilated, a performance increase of up to 50% can be achieved. In practice, and in particular if transformer housings are used, the maximum output will be limited to 140% of the power rating of the distribution transformer. Besides the performance increase, cross-flow fans can be employed to ensure the nominal transformer output continuously even under hot ambient conditions. Since losses rise as a square of the load current, cross-flow fans are only cost-efficient above a transformer output of 400 kVA.

Without additional ventilation, the transformer power is marked as AN (air natural), with additional ventilation, it is marked as AF (air forced). For recommended circuit breakers see Info. The selection and settings are made automatically.

The following must be kept in mind when switch-fuse combinations are selected:
If transformers with cross-flow fans shall be protected by means of a switch-fuse combination, the device combination dimensioned in SIMARIS design for non-ventilated operation must be checked as to its load carrying capacity with an increased nominal current

Switch-fuse combinations for the protection of transformers that use cross-flow fans for output enhancements can normally only be used for outputs below that of forced-ventilated transformer output, meaning that they can only be fully utilized if the AF transformer output (140% of the nominal transformer rating) is only applied for a very short time.

Owing to the fact that these HV HRC fuses are used in moulded plastic containers in gas-insulated switchgear applications, their power loss must not exceed a defined value so that their contact material is not damaged and the fuse does not blow (false tripping) as a result of excess heat. In this respect, the values of the table below for the corresponding switchboards should be noted.

Matching fuse/transformer classifications can be found in the Technical Series No. 2 at www.siemens.com/tip-cs/downloadcenter.

Max. load of HV HRC fuse – type SIBA – for 8DJH and NXPLUS C										
Fuse			HHD				SSK			
			8DJH	NXPLUS C			8DJH	NXPLUS C		
Ur [kV]	Length	Ir [A]	Ibmax [A]		Pv [W]	MLFB	Ibmax [A]		Pv [W]	MRPD
		10	8,1	9,2	17	SIB:3 0098 13-10	–	–	–	–
		16	13,1	14	17	SIB:3 0098 13-16	–	–	–	–
		20	16,3	18,4	13	SIB:3 0098 13-20	–	–	–	–
		25	20,4	23	16	SIB:3 0098 13-25	–	–	–	–
		31,5	25,7	29	21	SIB:3 0098 13-31.5	–	–	–	–
3-7.2	292	40	32,7	36,8	27	SIB:3 0098 13-40	–	–	–	–
		50	40,8	46	30	SIB:3 0098 13-50	–	–	–	–
		63	51,5	58	38	SIB:3 0099 13-63	–	–	–	–
		80	53	63,2	47	SIB:3 0099 13-80	–	–	–	–
		100	54,5	79	64	SIB:3 0099 13-100	–	–	–	–
		10	8,1	9,2	28	SIB:3 000413-10	–	–	–	–
		16	13,1	14,7	28	SIB:3 000413-16	–	–	–	–
		20	16,3	18,4	23	SIB:3 000413-20	–	–	–	–
		25	20,4	23	29	SIB:3 000413-25	–	–	–	–
		31,5	25,7	25,7	38	SIB:3 000413-31.5	–	–	–	–
	292	40	26,2	29,3	50	SIB:3 000413-40	–	–	–	–
		50	32,8	36,6	56	SIB:3 000413-50	–	–	–	–
		63	46,2	49,8	63	SIB:3 001213-63	46.1	46.1	62	SIB:3 001243-63
		80	49,9	55	76	SIB:3 001213-80	49.9	55.0	76	SIB:3 001243-80
		100	53,7	62	104	SIB:3 001213-100	54.5	62.5	98	SIB:3 001243-100
		125	–	–	–	–	65.0	74.0	135	SIB:3 002043-125
6-12		10	8,2	8,2	28	SIB:3 010113-10	–	–	–	–
		16	13,2	13,2	19	SIB:3 010113-16	–	–	–	–
		20	16,5	16,5	22	SIB:3 010113-20	–	–	–	–
		25	20,6	20,6	28	SIB:3 010113-25	–	–	–	–
		31,5	26	26	37	SIB:3 010113-31.5	–	–	–	–
	442	40	33	33	48	SIB:3 010113-40	–	–	–	–
		50	36	40,4	54	SIB:3 010113-50	–	–	–	–
		63	42,5	51	58	SIB:3 010213-63	–	–	–	–
		80	54	54	70	SIB:3 010213-80	54.0	55.2	72	SIB:3 010243-80
		100	59,2	68	96	SIB:3 010213-100	60.6	69.0	93	SIB:3 010243-100
		125	–	–	–	–	72.2	81.0	128	SIB:3 010343-125
		10	8,1	8,1	38	SIB:3 0255 13-10	–	–	–	–
		16	13,1	13,1	37	SIB:3 0255 13-16	–	–	–	–
		20	16,3	16,3	40	SIB:3 0221 13-20	–	–	–	–
		25	16,9	19,7	56	SIB:3 0221 13-25	–	–	–	–
	292	31,5	21,3	21,6	65	SIB:3 0221 13-31.5	–	–	–	–
		40	26,2	26,2	84	SIB:3 0221 13-40	–	–	–	–
		50	28,9	31,2	101	SIB:3 0221 13-50	–	–	–	–
		63	35,7	37,3	106	SIB:3 0222 13-63	–	–	–	–
		80	41,3	47	137	SIB:3 0222 13-80	–	–	–	–
		6	5,2	5,2	21	SIB:3 0231 13-6.3	–	–	–	–
10-17.5		10	8,3	8,3	38	SIB:3 0231 13-10	–	–	–	–
		16	13,2	12,7	37	SIB:3 0231 13-16	–	–	–	–
		20	16,5	16,5	42	SIB:3 0231 13-20	–	–	–	–
		25	20,4	20,4	56	SIB:3 0231 13-25	–	–	–	–
	442	31,5	22,7	22,4	60	SIB:3 0231 13-31.5	–	–	–	–
		40	24,5	27,2	84	SIB:3 0231 13-40	–	–	–	–
		50	30	34	101	SIB:3 0232 13-50	–	–	–	–
		63	37,8	43	106	SIB:3 0232 13-63	–	–	–	–
		80	41,8	46	137	SIB:3 0232 13-80	–	–	–	–
		100	48,1	55	182	SIB:3 0233 13-100	–	–	–	–
		6	5,2	5,2	29	SIB:3 0006 13-6.3	–	–	–	–
		10	8,3	8,3	52	SIB:3 0006 13-10	–	–	–	–
		16	12,7	12,7	59	SIB:3 0006 13-16	–	–	–	–
		20	16,5	16,5	46	SIB:3 0006 13-20	–	–	–	–
		25	20,4	20,4	56	SIB:3 0006 13-25	–	–	–	–
10-24	442	31,5	22,7	22,4	72	SIB:3 0006 13-31.5	–	–	–	–
		40	24,5	27,2	106	SIB:3 0006 13-40	–	–	–	–
		50	32	34	108	SIB:3 001413-50	–	–	–	–
		63	33,5	36,2	132	SIB:3 001413-63	33.5	–	–	–
		80	37,8	46	174	SIB:3 001413-80	41.8	46.0	143	SIB:3 001443-80
		100	–	53	234	SIB:3 002213-100	48.1	58.0	188	SIB:3 002243-100

2.10 Explanations about the Energy Efficiency Analyses in SIMARIS design

The issue of energy efficiency is gaining more and more importance owing to continuously rising energy costs and limited fossil resources. Therefore, it should also be taken into account when planning the power distribution system.

SIMARIS design gives an overview of the power loss in individual circuits as well as the distance to the main distribution:

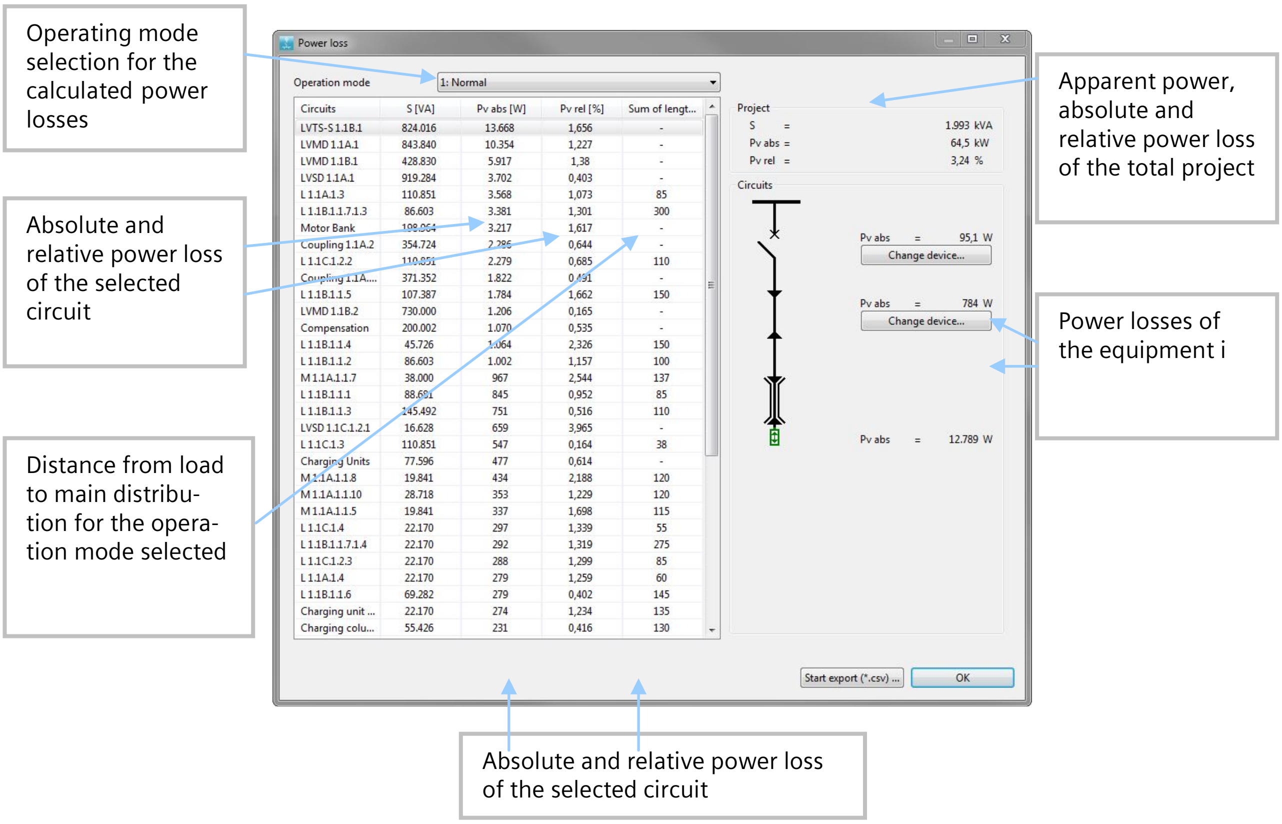
- System infeed / Coupling
- Distribution board
- Final circuits

Within these circuits, the losses of the individual power system components are displayed in detail:

- Transformers
- Busbar trunking systems
- Cables
- Switching devices and protective devices
- Compensation systems

In order to gain an overview of possible optimisation potential quickly, relative as well as absolute losses of the circuits are listed. The table can either be sorted according to the magnitude of the absolute or relative circuit losses by clicking the respective column header, so that the circuits with the greatest losses can be identified and analysed further.

The following illustration shows the dialog for data display of power losses by circuits:



Only one operating mode can be viewed and analysed at a time, i.e. in a project in which different operating modes were defined, these operating modes can be viewed one after the other by selecting them accordingly in the drop-down menu.

The losses for the entire configured network (for the selected operating mode) are the sum of the losses of the individual circuits:

$$P_{Vabs\_project} = \sum_{circuit} P_{Vabs\_circuit}$$

$$P_{Vrel\_project} = \frac{P_{Vabs\_project}}{S_{nproject}}$$

$P_{Vabs\_project}$ = Absolute power loss of the configured network [W]
$P_{Vabs\_circuit}$ = Absolute power loss of a circuit [W]
$P_{Vrel\_project}$ = Relative power loss of the configured network [%]
$S_{n\_project}$ = Apparent power of the configured network [VA]

The circuit losses add up of the losses of its individual components dependent on the circuit composition:

$$P_{Vabs} = P_{Vabs\_Tr} + P_{Vabs\_TS} + P_{Vabs\_C} + P_{Vabs\_BS} + P_{Vabs\_Cap}$$

Tr ......= Transformer
TS ......= Top switch
C ....= Connection
BS ......= Bottom switch
Cap ...= Capacitor

$$P_{Vrel\_circuit} = \frac{P_{Vabs\_circuit}}{S_{n\_circuit}}$$

$P_{Vrel\_circuit}$ = Relative power loss of circuit [%]
$S_{n\_circuit}$ = Apparent power of the circuit [VA]

Power losses are calculated based on the load currents of the respective circuits. Simultaneity and capacitor factors which were entered are also considered here.

In the power loss dialogue (see above) the respective circuits can be selected in the list and individual components can be replaced using the "Change device" button (on the right). The power loss which was possibly changed will be displayed right above the button and the summated circuit value is also adjusted in the list dependent on the new selection. In addition, the circuit selected in the list is highlighted on the network diagram by a blue frame.

A holistic approach to power loss optimisation should always be preferred and the effects on network dimensioning must be considered accordingly. Therefore these changes are always verified in SIMARIS design for correctness with regard to network dimensioning rules.

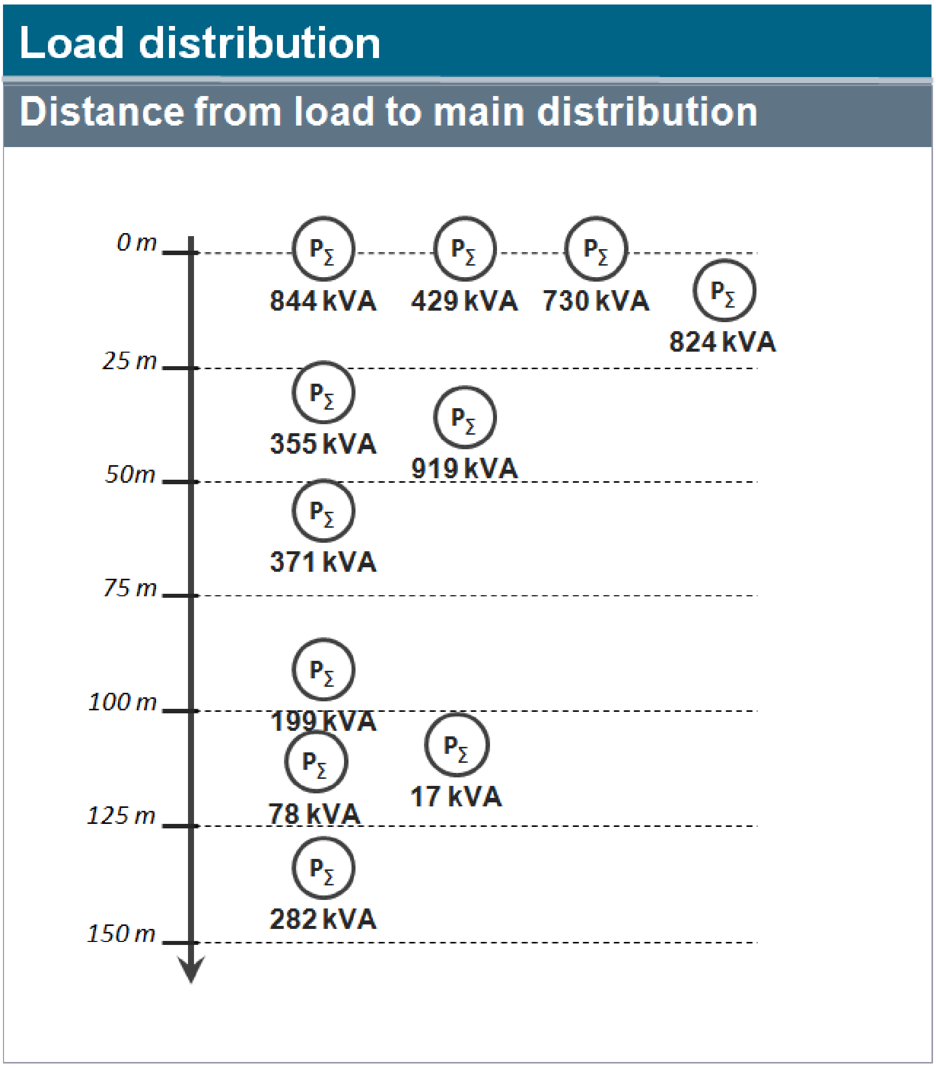
If a violation of the configuration rules kept in the system occurred as a result of changes in the loss optimisation made, the user would be notified by an error message (displayed below the network diagram). This error can either be remedied by performing another redimensioning cycle or by a manual adjustment on the network diagram.

Example:

When a transformer with a higher nominal power is selected, the transformer's power loss can be reduced. A more powerful transformer will have a higher current rating, but also higher short-circuit currents. The other components in the circuit, such as busbars, cables, switching and protective devices must be matched accordingly. SIMARIS design performs this adjustment automatically by starting another redimensioning cycle.

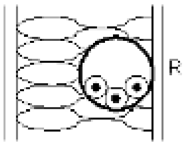
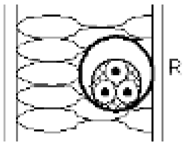
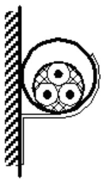
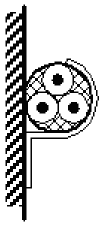
Based on the IEC 60364-8-1 respectively VDE 0100 part 801 „Low-voltage electrical installations - Energy efficiency" you will find the accumulated length of the separate current circuits at the program menu „Energy efficiency" → „Power loss". The sum of length shows the distance between the current circuit selected and the main distribution. The interpretation of the standard in SIMARIS design follows the Barycentre method which is described in the standard. SIMARIS design calculates the accumulated length on the basis of the already entered cable lengths and busbar lengths.

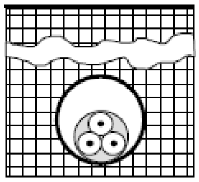
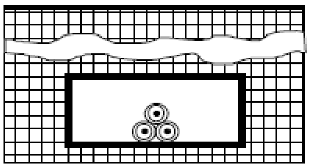
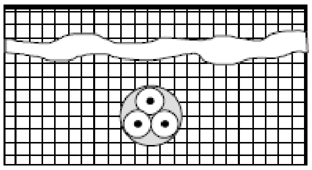
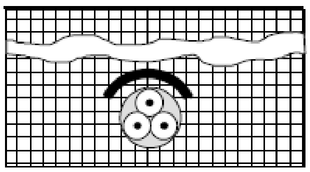
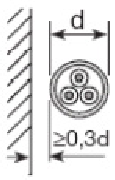
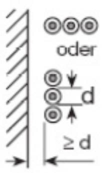
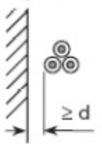
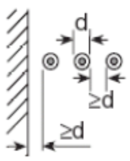
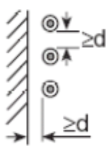
The chart below shows an example of how the separate main- and sub-distribution board loads can be displayed graphically with their accumulated lengths and how an overview of the load distribution can be given. The vertical axis shows the distance to the main distribution and the apparent power is displayed below the separate load symbols. The separate loads could be illustrated here as well.



2.11 Installation Types of Cables and Wires (Excerpt)

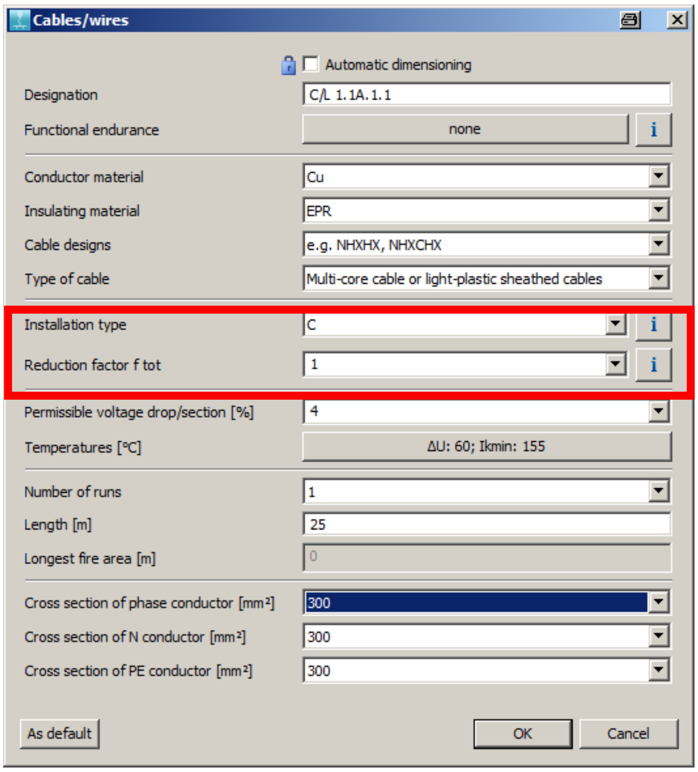
2.11.1 Installation Types in Accordance with IEC 60364-5-523/99 (excerpt)

Reference installation type		Graphical representation (Example)	Installation conditions
Installation in heat-insulted walls	A		■ Single-core cables in an electrical installation conduit in a thermally insulated wall
	A		■ Multi-core cable, or multi-core sheathed installation wire in a conduit in a thermally insulated wall
Installation in electrical installation conduits	B		■ Single-core cables in an electrical installation conduit on a wall
	B2		■ Multi-core cable, or multi-core sheathed installation wire in a conduit on a wall
Direct installation	C		■ Single- or multi-core cable, or single- or multi-core sheathed installation wire in a conduit on a wall

Reference installation type		Graphical representation (Example)	Installation conditions
Installation in the ground	**D1**	 	■ Multi-core or single-core cable in conduit or in cable ducting in the ground
	D2	 	■ Sheated single-core or multi-core cables direct in the ground – without added mechanical protection – with added mechanical protection
Installation suspended in air	**E**		■ Multi-core cable, or multi-core sheathed installation wire suspended in air at a distance of at least 0.3 x diameter ***d*** from the wall
	F	 	■ Single-core cable, or single-core sheathed installation wire, can be touched, suspended in air at a distance of at least 1 x diameter ***d*** from the wall
	G	 	■ Single-core cables, or single-core sheathed installation wires, at a distance d, suspended in air at a distance of at least 1 x diameter ***d*** from the wall

2.11.2 Consideration of installation types in SIMARIS design

When dimensioning cables and wires, SIMARIS design takes into account the installation type by means of appropriate adjustment factors in accordance with the international standard IEC 60364-5-52, or respectively the German standard DIN VDE 0298-4: 2013-06. The selection of the installation type, as depicted below, automatically factors in the appropriate rated values I_r for the cable's current carrying capacity in reference installation type A1, A2, B1, B2, C, D1, D2, E, F or G. A distinction is made according to conductor material and conductor insulation material.



According to the above mentioned standards relating to the permissible current carrying capacity, conversion factors for deviating conditions must additionally be factored in.

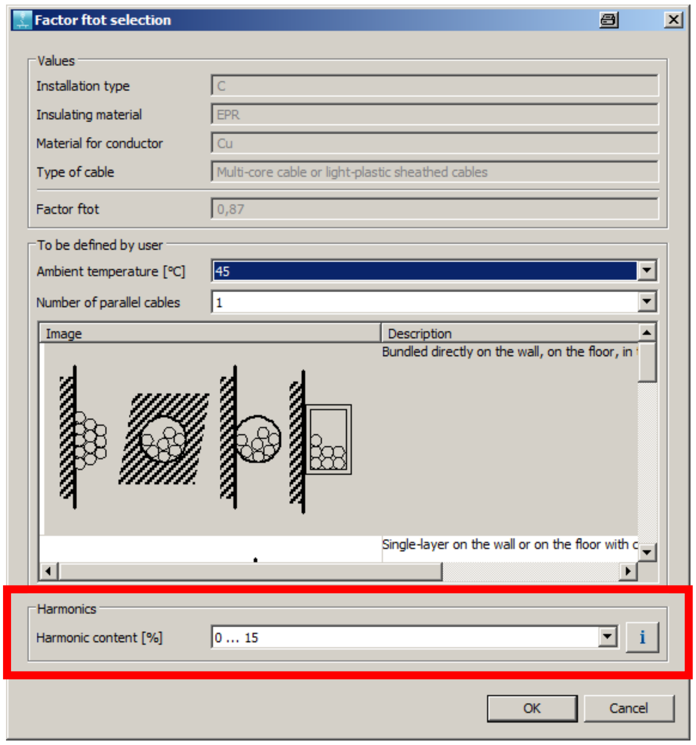
$$I_z = I_r \cdot \Pi f$$

I_r permissible current carrying capacity of the cable
I_z rated value for the cable's current carrying capacity in reference installation type A1, A2, B1, B2, C, D1, D2, E, F or G
Πf product of all of the required conversion factors f for deviating conditions

SIMARIS design automatically calculates and considers the conversion factors when the following information is entered:

- Installation in air: air temperature, accumulation of cables
- Installation in the ground: Soil temperature, soil heat resistance, accumulation of cables, spacing of systems

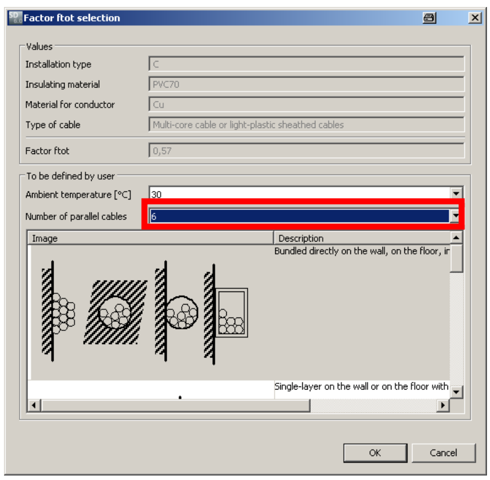
In addition, a reduction factor in accordance with DIN VDE 0100 520 Addendum 3 can be considered in SIMARIS design if loads causing harmonic content are used. The factor is defined in an interactive dialogue which is called up with the aid of the i-button next to the input field for reduction factor f_{ges} tot.



Note: A conversion factor is also considered for busbar systems if a deviating ambient temperature is entered.

2.12 Accumulation of Cables and Lines

The IEC 60364-5-52, or respectively DIN VDE 0298 Part 4 standard defines the accumulation of cables and lines. Since accumulation is relevant for cable/cord sizing, it can also be considered in SIMARIS design.

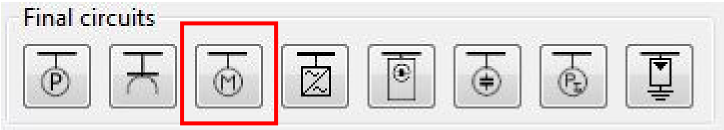


The sum of the recently edited cables/cords plus the number of cables/cords to be laid in parallel must here be entered as the number of parallel lines. When single cores are to be laid, this addition shall include only the number of AC circuits or three-phase circuits which consist of several single-core cables or lines. This means that the two or three live conductors are counted as one circuit each in such a case.

For detailed information about the accumulation of cables and lines please refer to the original texts of the above standards.

2.13 Special Conditions in Motor Circuits and their Consideration in SIMARIS design

2.13.1 Special Properties of Motor Circuits



Motor circuits show deviating properties compared to other power consumers. Therefore, they are considered separately in SIMARIS design. This means they have their own icon that represents them on the network diagram. This enables these special conditions in motor circuits to be considered accordingly in the dimensioning process.

2.13.1.1 Short-circuit Behaviour

The basis for short-circuit calculations in SIMARIS design is EN 60909-0, or respectively VDE 0102.

In the event of a short circuit, motor consumers are driven by the driven machines and their mass moment of inertia owing to the fact that they are mechanically coupled to them. Here, they act as generator and feed their share of the short-circuit current to the point of fault.

Section 3.8 (asynchronous motors) calls for this share to be always

- considered in industrial networks and the auxiliary installations in power plants,
- and considered in public power supply networks if their contribution to the short-circuit current is $I''_K > 5$ % of the initial short-circuit current which was established without motors.

Those motors may be neglected in the calculation which cannot be switched on simultaneously according to the type of circuitry (interlocking) or process control.

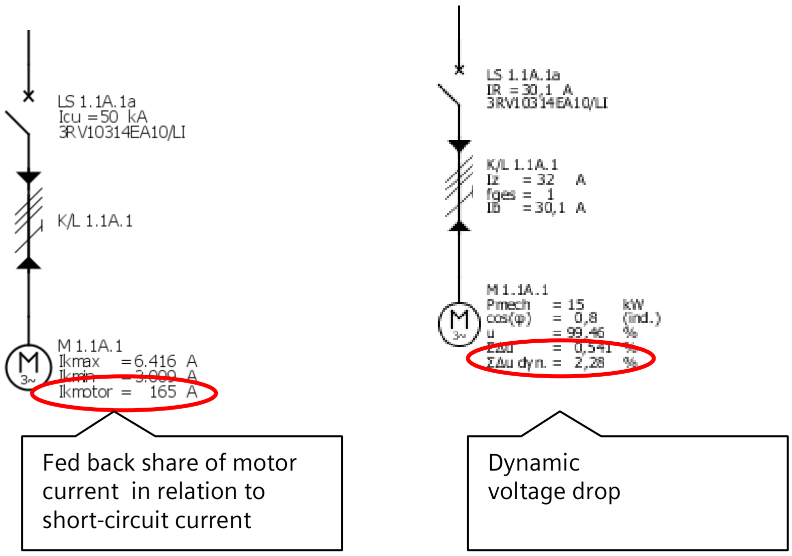
In contrast to other loads, the proportion of short-circuit current fed back is considered in the calculation in SIMARIS design if a motor circuit is the load.

2.13.1.2 Switch-on and Start-up Behaviour

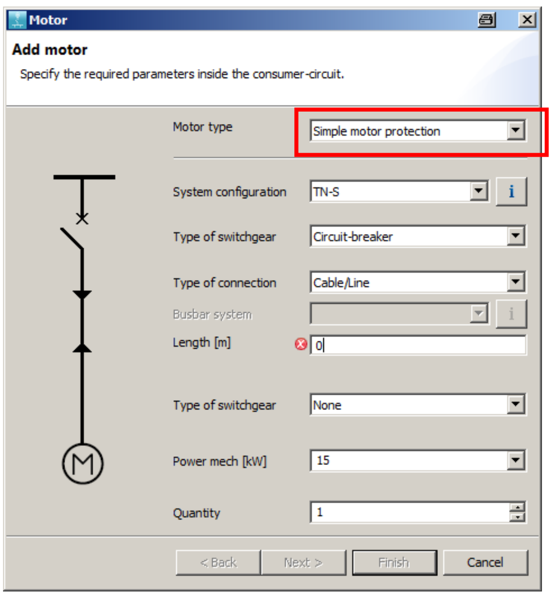
Owing to the high inrush current for accelerating the centrifugal mass and due to the fact that the inductive rotor resistance is greatly reduced in the instant of on-switching, the dynamic voltage drop must be considered in this operating case in addition to the static voltage drop.

2.13.1.3 Use of Special Switching and Protective Devices in Motor Circuits

The performance described in the Switch-on and start-up behaviour determines a special selection and setting of **protective devices (fuseless/fused) and their switching devices.**



2.13.2 Motor Consumers with Simple Motor Protection

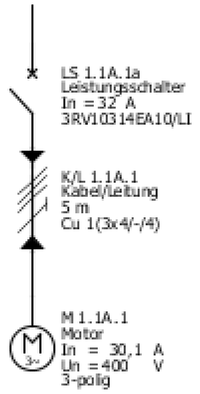


In the selection window, which is displayed as soon as a motor is added to the network diagram, the option of "Simple motor protection" can be chosen in the field "Motor type". This selection protects the drive by a circuit-breaker ("fuseless"). Fused technology is not supported at this point.

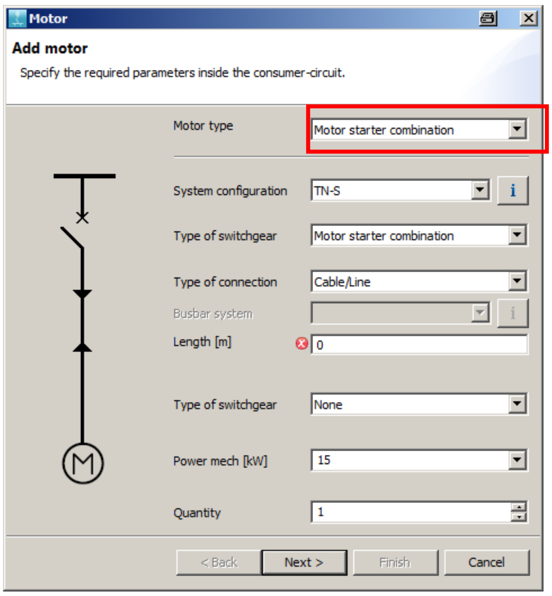
Dependent on the motor power, motor protection circuit-breakers (MSP/3RV), moulded-case circuit-breakers (MCCB/3VL) with releases for motor protection, and as of a nominal motor current > 500A air circuit-breakers (ACB/3WL) are sized in the dimensioning process.

This selection allows to calculate drives up to 1,000 kW in SIMARIS design.

In practice however, you should consider sidestepping to medium-voltage motors when planning drive performances of 300 kW/400 V or higher, since the dynamic voltage drop and the high start-up currents may cause problems in the low-voltage network.



2.13.3 Motor Consumers as Motor Starter Combination



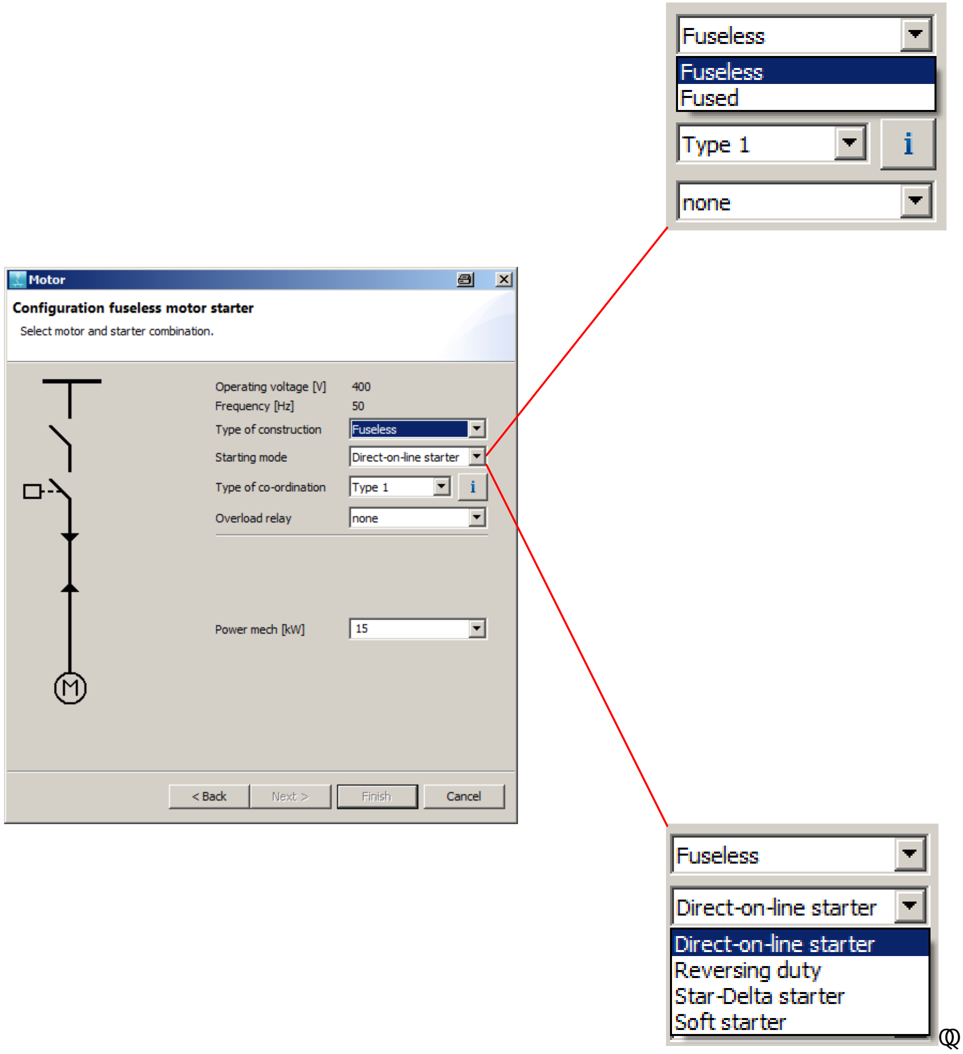
The selection window, which is displayed as soon as a motor is added to the network diagram, also allows to choose the option of "Motor starter combination" in the field "Motor type".

This selection is used to configure drives which are kept as tested motor starter combinations – protective device (circuit-breaker / fuse) plus switching device for switching during normal operation (contactors / soft starters) – in the database.

The motor data contains standardized Siemens low-voltage motors as default values. However, an appropriately tested started combination can also be dimensioned for any motor.

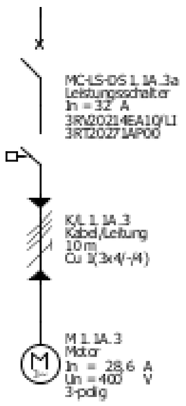
Dimensioning of the motor starter combination is effected on the basis of the nominal motor current. When motor data is changed, its starter combination must be adapted by performing another dimensioning run. A direct selection of the starter combination from the product catalogue is not supported, so that the use of a tested combination is ensured by the program.

The following selection window allows both the selection of a fuseless (circuit-breaker protected) and fused technology.

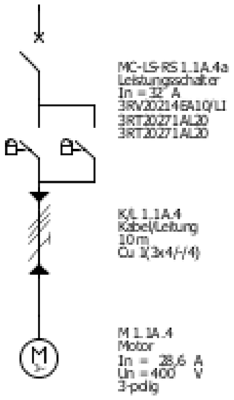


The selection of different motor starter types is possible, too.

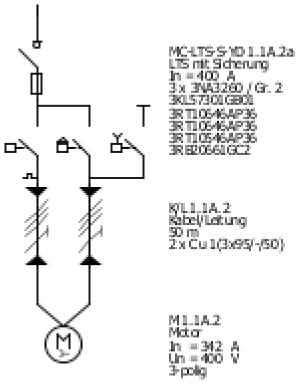
- Direct on-line starter (direct on/off switching)



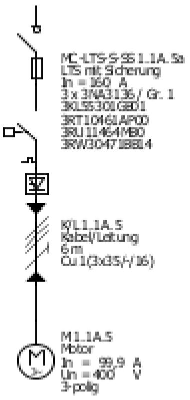
- Reversing duty (direct on/off switching with change of the direction of rotation)



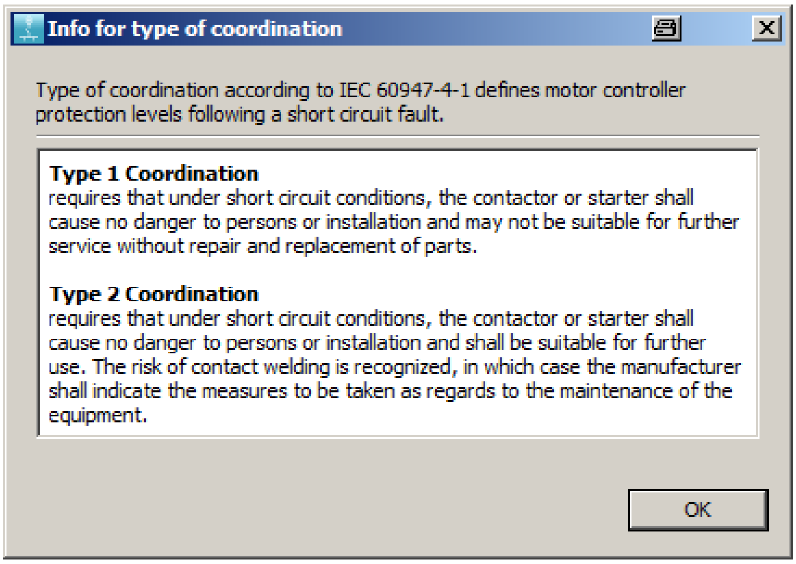
- Star/Delta starter (starting current limiting through change of the winding circuitry)



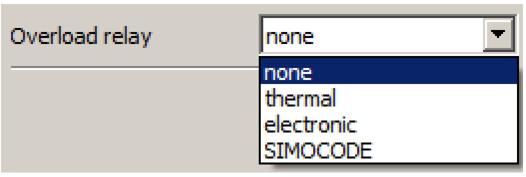
- Soft starter (starting current limiting through electronic turn-on phase angle control)



Depending on the permissible degree of damage to equipment, coordination type 1 or 2 can be selected for the motor starter types.



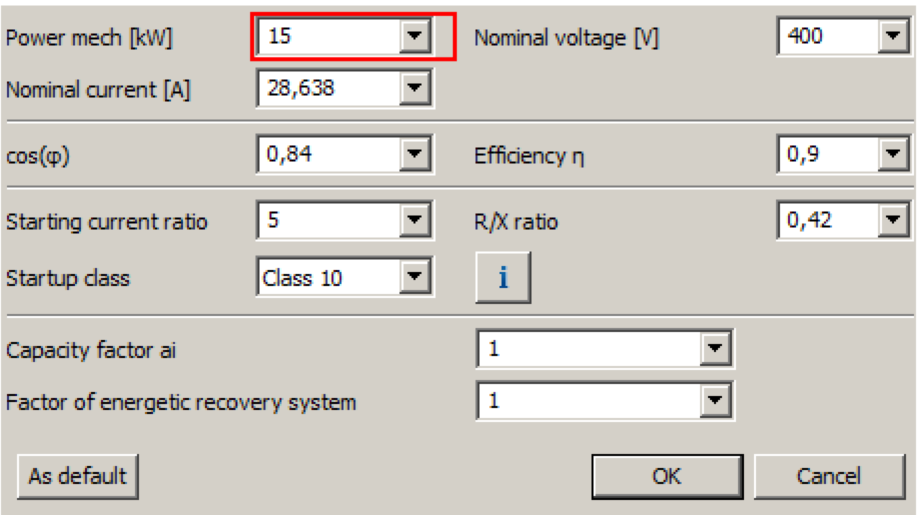
The following types are available for selection as overload relay:



In Simaris design, motor starter combinations can only be selected with a voltage setting of 400 V, 500 V and 690 V (+/-5 %) in the low-voltage network in accordance with the tested combinations available. The voltage setting for the low-voltage network can be viewed and adjusted in the program step "Project Definition".

You can find a list with the motor starter combinations provided in SIMARIS design at www.siemens.com/simaris/faq in the category FAQ-SIMARIS design → Motors/Motor Starters.

2.13.4 Description of Motor Parameters



- Power mech.: [kW] → mechanical power of the drive

$$P_{mech.} = P_{elektr.} \cdot \eta$$

- Nominal voltage → Nominal voltage of the drive
  The nominal voltage of the drive can deviate from the system voltage, for example a 400 V drive can be operated in a 380 V network (deviating current consumption).

- Nominal current → Nominal current of the drive
  Assuming constant active power, the nominal current will change as a function of power factor $\boldsymbol{cos\varphi}$ or the system voltage.

- Power factor $\boldsymbol{cos\varphi}$
  The power factor is defined as the ratio of the amount of active power $\boldsymbol{P}$ to apparent power $\boldsymbol{P}$. It is equal to the cosine of the phase displacement angle $\boldsymbol{\varphi}$

- Efficiency $\boldsymbol{\eta}$
  Efficiency $\boldsymbol{\eta}$ is a measure for the efficiency of energy transformation and transmission.

  $$\eta = \frac{P_{ab}}{P_{zu}} = \frac{P_{mech.\ shaft}}{P_{electric}}$$

- Power calculation for an electric drive

  $$P_{mech.} = U \cdot I \cdot \sqrt{3} \cdot cos\varphi \cdot \eta$$

  $$\boxed{15\ kW} = 0.4\ kV \cdot 28.64\ A \cdot 1.732 \cdot 0.84 \cdot 0{,}9$$

- Starting current ratio
  Asynchronous motors have a high switch-on current, because more power, and thus more current, is needed to accelerate the rotating centrifugal mass up to nominal speed than for maintaining the speed. Moreover, the inductive resistance of the winding is greatly reduced at standstill, because the rotor (squirrel cage type) acts similar to a shorted secondary transformer winding. The inductive resistance will only rise when the rotor reaches its positive-sequence speed, this means when the rotor speed nearly equals the speed of the rotating field.
  Thus, the starting current ratio has an effect on the proportion of regenerative feedback of the short-circuit current and the dynamic voltage drop.
  Dependent on the power and the machines to be driven (e.g. heavy duty starting), the starting current of an asynchronous motor can be 10 times the value of its nominal current.
  The following values are kept as defaults in SIMARIS design:
  → 5 for direct on-line starting
  → 3 for soft starting
  → 1.7 for star/delta starting
  These values can be adjusted by users according to project-specific needs.

- R/X ratio
  The R/X ratio (active resistance R_M/X_M reactance) of a motor is used in network calculations to determine the impedance Z_M of the motor consumer for starting.

  $$X_M = \frac{Z_M}{\sqrt{1+(R_M/X_M)^2}}$$

  $$R_M = X_M \cdot (R_M/X_M)$$

  It influences the calculation of the dynamic voltage drop. Moreover, it serves for determining the angle in the share of short-circuit current feedback.

  Angle calculation in inductive operating mode:

  $$\varphi_{kM} = -arctan\left(\frac{1}{R_M/X_M}\right)$$

  Owing to the much higher short-circuit power of the whole network compared to the share fed back by the motor, the modified share of feedback cannot be identified by the modified angle.
  In SIMARIS design, a default value of 0.42 is kept, which is suitable for most cases of application.

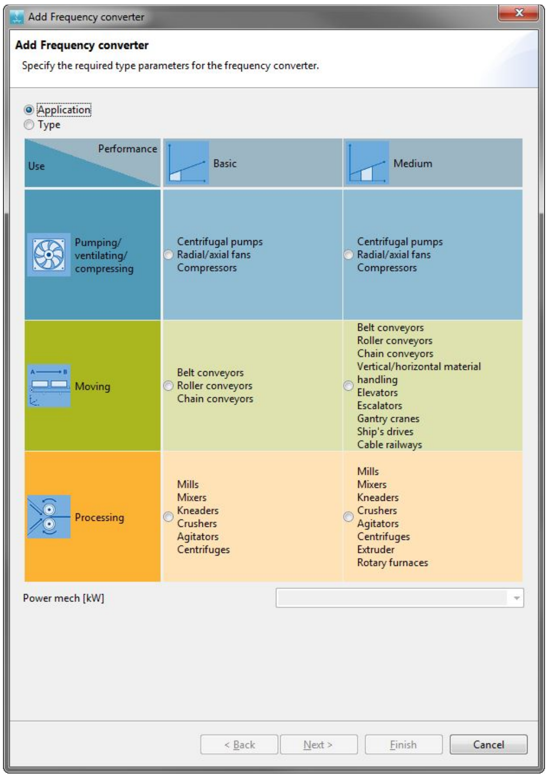
- Start-up class
  The start-up class indicates the starting behaviour of an asynchronous motor.
  IEC 60947-1 distinguishes Start-up Class 10, Class 20, Class 30 and Class 40. Here, the starting times of the drives in seconds until the nominal speed is reached serves for classification (max. 10, max. 20, max. 30 and up to 40 seconds).
  In Simaris design, you can select Class 10 or Class 20 as start-up class of a motor consumer with simple motor protection. This dimensions different releases with regard to their inertia in the range of MSP Sirius 3 RV motor protection circuit-breakers. With other circuit-breakers, the overload releases are set to 10 or 20 seconds of inertia during dimensioning.
  It is not possible to differentiate start-up classes for motor consumers laid out as motor starter combinations, since these are tested combinations, as described above, whose basis is start-up class 10.

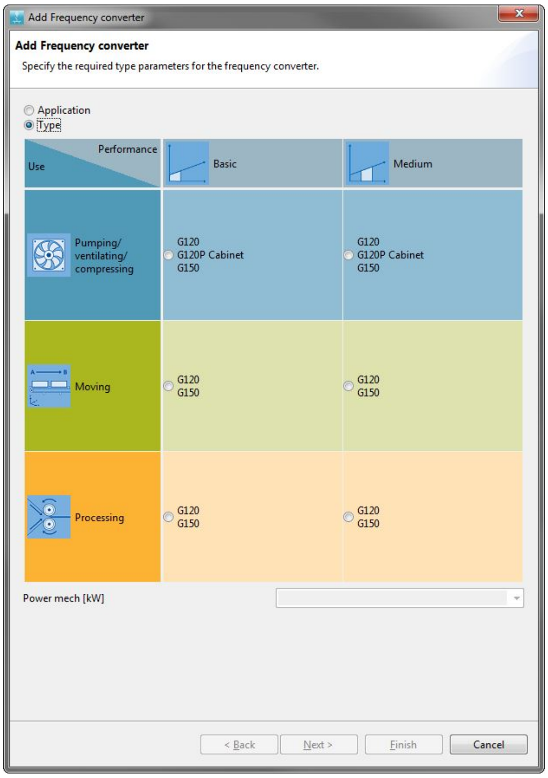
- Capacity factor ai
  The capacity factor, which is defaulted as 1 in SIMARIS design, allows to reduce the nominal motor current of the drive. This function can be used when a drive was oversized in terms of its mechanical power $P_{mech.}$, but is not run at full load in the specific case of operation.
  Please note in this context that the entire nominal current will be used for dimensioning in the motor circuit and referred to and displayed in the "Load flow" network diagram view. But for the voltage drop calculation and for referring the motor current to the upstream circuits in the network, the reduced nominal motor current will be considered.

- Factor of energetic recovery system
  In practice, there needn't always be a power transmission in case of fault from the driven machine to the electric motor owing to the mechanical coupling between motor and machine (e.g. electric motors with braking system).
  In such cases, a reduced short-circuit current share will be fed from the drive to the point of fault during a short circuit.
  In order to be able to map such cases of application in SIMARIS design, you can reduce the percentage of short-circuit current which is fed back by using the factor of the energetic recovery system.
  When a motor feeder (equivalent circuit mapping for the sum of several motors) is mapped, too, the number of drives to be considered (probability of simultaneous operation of motors which are continuously switched on and off) can be represented by the factor of the energetic recovery system.

2.14 Frequency converters

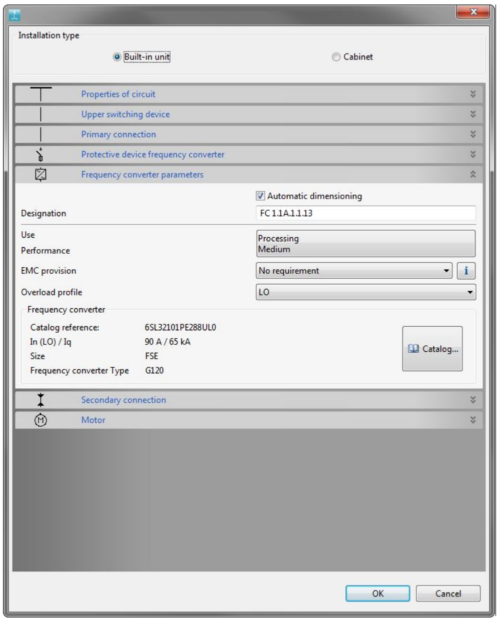
2.14.1 Selection using the application matrix

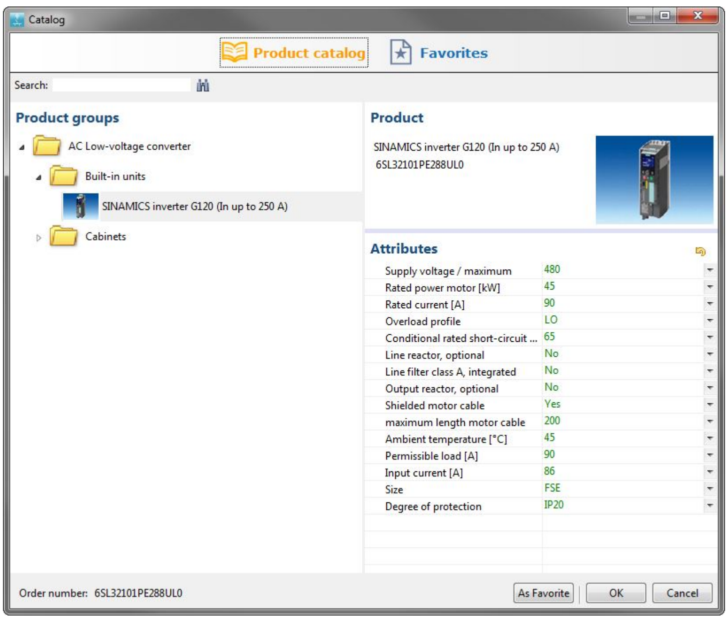




Frequency converters can either be selected dependent on their intended application or they can be selected by type if the frequency converter type has already been determined.

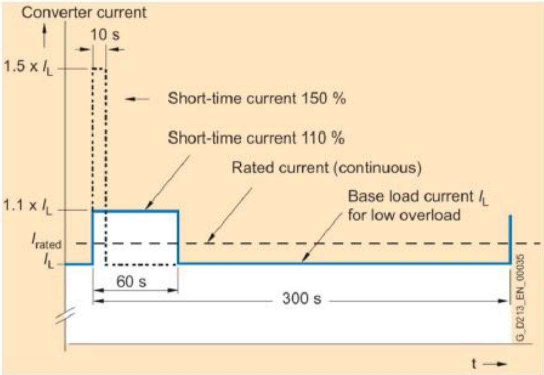
The performance “Basic” or “Medium” helps to distinguish requirements as to torque/speed/positioning accuracy, axis coordination and functionality. Currently, SIMARIS design provides frequency converters intended for basic and medium performance.



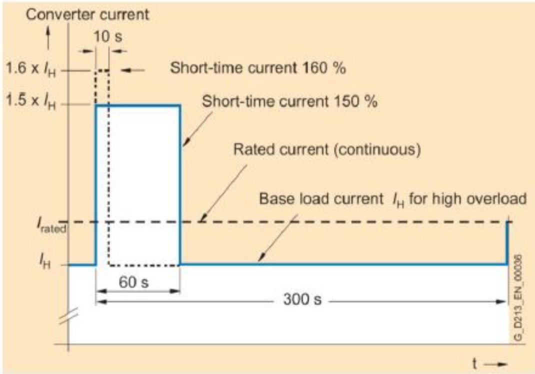


2.14.2 Standard load cycle

Every selectable frequency converter can either be chosen with a load cycle featuring "Low Overload" or "High Overload". If "High Overload" was selected, the frequency converter can be overloaded with a higher current for a period not extending 60s, however, its base load is lower.



Definition of the standard load duty cycle low overload



Definition of the standard load duty cycle high overload

2.14.3 Use in the IT network

When converters are installed in or commissioned for the IT network, the earth connection of the radio interference suppressor filter for "Second environments", which is integrated as standard in SINAMICS G150/G120P Cabinet devices, must be interrupted (this filter complies with Category C3 of the EMC product standard EN 61800-3). This is done by simply removing the metal shackle on the filter as described in its operating instructions. If this is neglected, the capacitors of the radio interference suppressor filter will be overloaded in case of a motor-side earth fault and possibly destroyed. After removal of the earth connection of the standard type radio interference suppressor filter, the converters comply with Category C4 of the EMC product standard EN 61800-3. For more details please refer to the chapter "EMC design guideline".

If SINAMICS G120 converters with Power Module 240-2 are installed in IT systems, you should select the variant without an integrated line filter.

	Adjustable speed electrical power drive systems PDS			
	C1	C2	C3	C4
Environment	"First" environment (residential, business, and commercial areas)		"Second" environment (industrial areas)	
Voltage or current	< 1000 V			≥ 1000 V or ≥ 400 A
Specialist EMC knowledge required?	No	Installation and commissioning must be carried out by specialist personnel		

Overview of categories C1 to C4 according to the EMC product standard EN 61800-3

2.14.4 Cable dimensioning

The primary cable is dimensioned in accordance with the applicable dimensioning rules for low-voltage cables based on the disconnect requirement, the nominal current of the protective device for the frequency converter, the short-circuit current and the voltage drop. In this context, the effects of frequency converter harmonics are taken into account by means of the total power factor λ.

The secondary cable is a recommendation based on the frequency converter, no further calculations or verifications are performed.

2.14.5 Transformer rating

In order to factor in eddy current losses of the transformer as well, which is caused by the harmonics generated in the frequency converter, the following formula applying to transformers should be considered:

$$S \geq k \cdot \frac{P_w}{\lambda \cdot \eta_{converter} \cdot \eta_{motor}}$$

P_w	Motor shaft power or type rating of the matched converter
η_{motor}	Motor efficiency
$\eta_{converter}$	Converter efficiency
λ	Line-side total power factor
k	Factor which accounts for the effects of additional transformer loss as a result of line-side harmonic currents

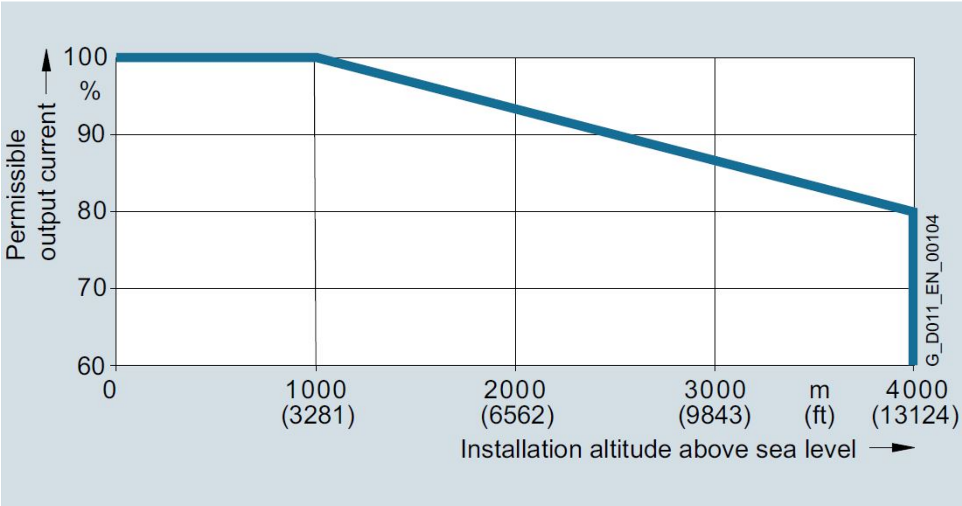
k = 1.20 if a standard distribution transformer is used in combination with G120, G120P Cabinet and G150 converters

2.14.6 Altitude of installation

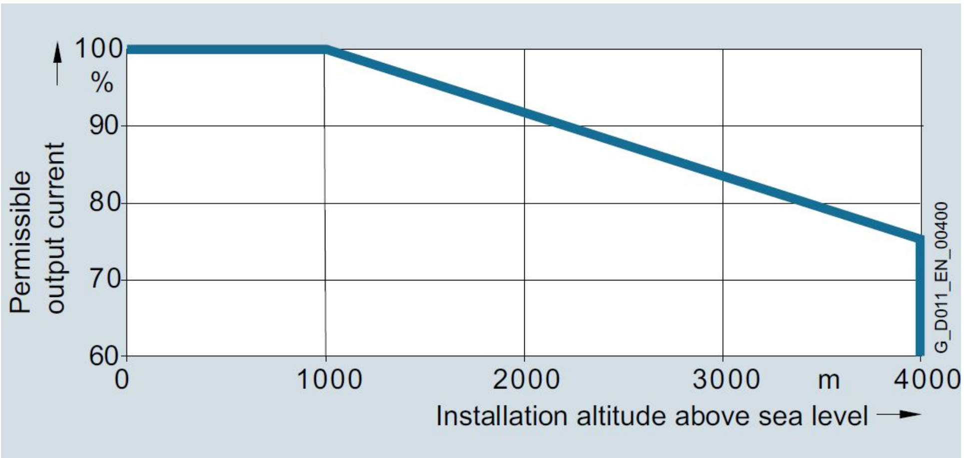
In altitudes > 2,000 m above sea level, you must be aware of the fact that the air pressure, and hence the air density, decreases with increasing altitude, which affects electrical installations. This effect reduces both the cooling effect and the insulating capacity of air.

Permissible power systems in dependency of the altitude of installation

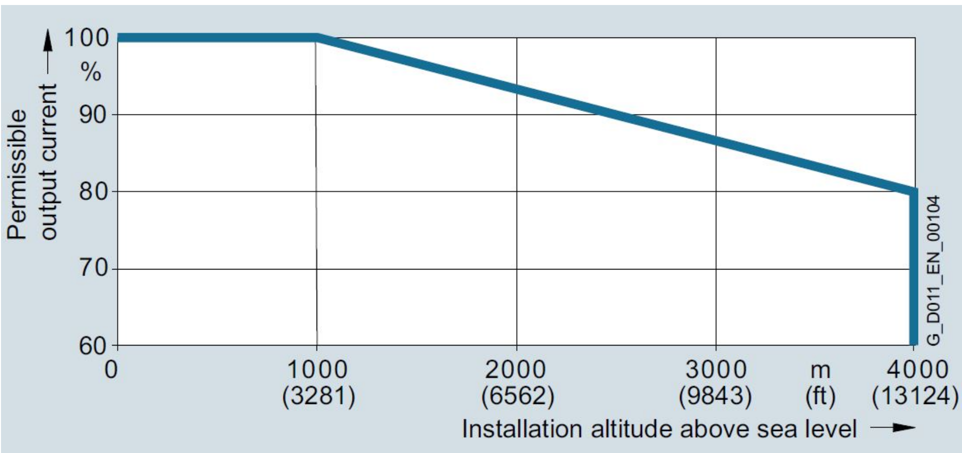
- Altitudes of installation up to max. 2,000 m above sea level
  - Any type of system which is permitted for the converter
- Altitudes of installation from 2,000 m up to 4,000 m above sea level
  - Connection only to a TN system with earthed neutral
  - TN systems with earthed polyphase line conductors are not permitted
  - The TN system with earthed neutral can be implemented by using an isolating transformer
  - The phase-to-phase voltage does not need to be reduced



Permissible output current dependent on the altitude of installation for Power Modules PM240-2



Permissible output current dependent on the altitude of installation for SINAMICS G120P Cabinet, size GX



Permissible output current dependent on the altitude of installation for SINAMICS G120P Cabinet, size HX

Degree of protection	Installation altitude above sea level	Current derating factor (as a % of the rated current) at an ambient ambient/intake air temperature of						
	m	20 °C	25 °C	30 °C	35 °C	40 °C	45 °C	50 °C
IP20, IP21, IP23 and IP43	0 ... 2000						93.3 %	86.7 %
	2001 ... 2500					96.3 %		
	2501 ... 3000		100 %		98.7 %			
	3001 ... 3500							
	3501 ... 4000			96.3 %				
	4001 ... 4500		97.5 %					
	4501 ... 5000	98.2 %						

Current derating factors for SINAMICS G150 converters installed in cabinets dependent on ambient/intake air temperature and altitude of installation

2.14.7 Compensation systems in power systems with harmonic content

Since frequency converters are subject to harmonics, section "1.8.2 Compensation systems in power systems with harmonic content" must be noted in this context.

In SIMARIS project, compensation systems are selected as "choked" as standard.

2.14.8 Motor selection

The motor data contains standardized Siemens low-voltage motors as default values. However, it is also possible to dimension a matching combination of switching/protective devices, frequency converter and motor for any other motor.

Dimensioning of this combination is effected on the basis of the nominal motor current. When motor data is changed, this combination must be adapted by performing another dimensioning run. Or, you can also configure the frequency converter with the aid of a catalog including its optional accessories.

2.15 Standards for Calculations in SIMARIS design

Title	IEC	HD	EN	DIN VDE
Erection of low-voltage installations *)	60364-1...6	384		0100 – 100...710
Short-circuit currents in three-phase networks – Current calculation	60909		60909	0102
Short-circuit currents - Calculation of effects Definitions and calculation methods	60865		60865	0103
Low-voltage switchgear and controlgear – Circuit-breakers	60947-2		60947-2	0660 – 101
Low-voltage switchgear and controlgear assemblies	61439		61439	0660 – 600
A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear	60890+C	528 S2		0660 – 507
Use of cables and cords for power installations – Recommended current-carrying capacity for sheathed and nonsheathed cables for fixed wirings in and around buildings and for flexible cables and cords	60364-5-52	384		0298 – 4
Electrical insulation material - Miniature circuit-breakers for house installations and similar purposes	60898-1		60898-1	0641 – 11
High-voltage switchgear and controlgear high-voltage switch-fuse combinations	62271		62271	0671 – 105
Low-voltage electrical installations – Selection and erection of electrical equipment –Isolation, switching and control – Clause 534: Devices for protection against overvoltages	60364-5-53	60364-5-534		0100-534
Low-voltage electrical installations – Protection for safety – Protection against voltage disturbances and electromagnetic disturbances – Clause 443: Protection against overvoltages of atmospheric origin or due to switching	60364-4-44	60364-4-443		0100-443
Lightning protection – Part 1...4	62305-1...4			0185 – 1...4
Low-voltage surge protective devices – Surge protective devices connected to low-voltage power systems – Requirements and tests	61643-11			0675-6-11
Tests for electric cables under fire conditions – Circuit integrity	60331-11, 21		50200	0472-814 0482-200
Fire behaviour of building materials and building components — Part 12: Circuit integrity maintenance of electric cable systems, requirements and testing				4102-12 : 1998-11

Title	IEC	HD	EN	DIN VDE
Electrical equipment of electric road vehicles – Electric vehicles conductive charging system	61851		61851	

*) Those special national requirements acc. to Appendix ZA (mandatory) and the A-deviations acc. to Appendix ZB (informative) of DIN VDE 0100-410 (VDE 0100-410): 2007-06 are not mapped and must be considered separately!

2.16 Additional Protection by RCDs in Compliance with DIN VDE 0100-410 (IEC 60364-4-41)

In AC systems, additional protection must be provided by means of residual-current-operated devices (RCDs) for:
a) sockets with a rated max. current not exceeding 20 A, which are intended to be used by unskilled, ordinary users and for general-purpose applications;
b) final circuits in outdoor areas used for portable equipment, with a rated current of no more than 32 A.

Annotation on a):
An exception may be made for:
- sockets which are supervised by electrically skilled or instructed persons, as for example in some commercial or industrial installations, or
- sockets that have been installed for connecting one specific item of equipment.

Special protection arrangements for the exclusive use of electrically skilled persons see Appendix C (non-conductive environment, local protective equipotential bonding, protective isolation).

2.16.1 Altered Maximum Disconnection Times in TN and TT System in Compliance with DIN VDE 0100-410

Maximum disconnection times for final circuits with a rated current no greater than 32 A:

TN system		
50 V < U ≤120 V	AC	0.8 s
	DC	5 s (disconnection may be required here for other reasons)
120 V < U ≤ 230 V	AC	0.4 s
	DC	5 s
230 V < U ≤ 400 V	AC	0.2 s
	DC	0.4 s
U > 400 V	AC	0.1 s
	DC	0.1 s

In TN systems, a disconnection time of no greater than 5 s is permitted for distribution board circuits and any other circuit.

TT system		
50 V < U ≤ 120 V	AC	0.3 s
	DC	5 s (disconnection may be required here for other reasons)
120 V < U ≤ 230 V	AC	0.2 s
	DC	0.4 s
230 V < U ≤ 400 V	AC	0.07 s
	DC	0.2 s
U > 400 V	AC	0.04 s
	DC	0.1 s

In TT systems, a disconnection time of no greater than 1 s is permitted for distribution board circuits and any other circuit.

2.16.2 National Deviations from IEC 60364-4-41

2.16.2.1 The Netherlands

- The above table with max. disconnection times (above section Altered Maximum Disconnection Times in TN and TT System in Compliance with DIN VDE 0100-410) applies to all circuits supplying power outlets and all final circuits up to 32 A.
- For TT systems: as a rule, R_a must not exceed 166 Ω.

2.16.2.2 Norway

- Installations which are part of an IT system and are supplied from the public grid must be disconnected from supply on occurrence of the first fault. Table 41.1 of the standard applies.
- The use of a PEN conductor downstream of the main distribution is generally not permitted.

2.16.2.3 Belgium

- Each electrical installation which is supervised by ordinary persons (i.e. not skilled or instructed in electrical installation matters) must be protected by a residual-current-operated circuit-breaker. The magnitude of the maximum permissible rated fault current ΔI_n depends on the circuit to be protected and the earthing resistance.

Circuit type	$R_{a\,max.}$	$\Delta I_{n\,max.}$
	$R_a > 100\ \Omega$ **generally not permissible for domestic installations.**	
Household (bathroom, washing machines, dishwashers etc.)		30 mA
General protection for dwellings	30 - 100 Ω	

Circuits for sockets in domestic installations: the number of simple or multiple sockets is limited to 8 per circuit and the minimal cross section is 2.5 mm².

The use of the PEN conductor (TNC) is not allowed for installations in dwellings and installations with increased fire or explosion risk (BE2-BE3 art. 101.03 and art. 104.05 GREI).

2.16.2.4 Ireland

- Regulation on the use of RCDs with $\Delta I_N < 30\ mA$ for all circuits up to 32 A

2.16.2.5 Spain

- Regulation on the use of RCDs as an additional protection for sockets up to 32 A which are intended to be used by ordinary persons.

2.17 Country-specific Particularities

2.17.1 India

- Parallel operation of transformers and diesel generators is not permitted according to the rules established by the Indian Electricity Board.

2.18 Used Formula Symbols

Formula symbol	Unit	Description
η		Efficiency
φ1ph_n	°	Phase angle at Ik1ph_n min/max
φ1ph_pe	°	Phase angle at Ik1ph_pe min/max
φ1 min/max	°	Phase angle at Ik1 min/max
φ2	°	Phase angle at Ik2min
φ3	°	Phase angle at Ik3 min/max
φ3 min/max	°	Phase angle at Ik3 min/max
φmotor	°	Phase angle at Ikmotor
Δu	%	Relative voltage drop between the beginning and end of a line section
ΔU	V	Relative voltage drop between the beginning and end of a line section
Δu_tr	%	Relative voltage drop over the transformer winding
ΔU_tr	V	Absolute voltage drop over the transformer winding
∑Δu	%	Summated relative voltage drop up to a given point with/without voltage drop over the transformer winding according to the selected settings
∑ΔU	V	Summated absolute voltage drop up to a given point with/without voltage drop over the transformer winding according to the selected settings
∑Δu dyn.	%	Summated relative voltage drop at the starting motor with/without voltage drop over the transformer winding according to the selected settings
∑ΔU dyn.	V	Summated absolute voltage drop at the starting motor with/without voltage drop over the transformer winding according to the selected settings
ai		Capacity factor
c min/max		Minimum/maximum voltage factor in accordance with IEC 60909-0
cos(φ)		Power factor
F1		The indicated short-circuit current refers to a fault in the medium-voltage busbar
F2		The indicated short-circuit current refers to a fault at the primary side of the transformer
F3		The indicated short-circuit current refers to a fault at the secondary side of the transformer
F4		The indicated short-circuit current refers to a fault at the end of the secondary-side connection of the transformer.

Formula symbol	Unit	Description
ftot		Reduction factor
fn	Hz	Nominal frequency
gf		Simultaneity factor
gi		Simultaneity factor
HO		High overload
I>	A	Phase energizing current of overcurrent module of DMT relay
I>>	A	Phase energizing current of high-current module of DMT relay
I>>>	A	Phase energizing current of high-current module of DMT relay
θΔu	°C	Conductor temperature of MV cable / Conductor temperature of LV cable for voltage drop calculation
θΔIkmax	°C	Conductor temperature of MV cable / Conductor temperature of LV cable at Ikmax
θΔIkmin	°C	Conductor temperature of MV cable / Conductor temperature of LV cable during disconnection
I2	A	Conventional fusing current
I^2t	kA^2s	Let-through energy
I^2t a	kA^2s	Let-through energy downstream of the lower switching device or at the target distribution board / consumer
I^2t b	kA^2s	Let-through energy upstream of the lower switching device
I^2t c	kA^2s	Let-through energy downstream of the upper switching device
I^2t d	kA^2s	Let-through energy at the output distribution board or upstream of the upper switching device
I^2t(Ii)	kA^2s	Let-through energy of the switching device at the transition to the I-release
I^2t(Ikmax)	kA^2s	Let-through energy of the switching device in the event of maximum short-circuit current
I^2t(Ikmin)	kA^2s	Let-through energy of the switching device in the event of minimum short-circuit current
I^2t(RCD)	kA^2s	Rated let-through energy of RCD
I^2t(fuse)	kA^2s	Let-through energy of fuse
I^2t(set-point)	kA^2s	Let-through energy requirement on the connecting line
I^2t value		Let-through energy of the switching device at Ikmax from the characteristic curve file
I^2tmax(base)	kA^2s	Permissible I2t value of the fuse base

Formula symbol	Unit	Description
Ia/In		Starting current ratio
Ib	A	Operating current
Ibb	A	Reactive load current
Ibel	A	Load current
Ir	A	Rated setpoint current of the switching device
Ibs	A	Apparent load current
Ibw	A	Active load current
Ib_out	A	Load output current
Îc value	kA	Cut-off current of the switching device at Ikmax from the characteristic curve file (instantaneous value)
Ic (fuse)	kA	Cut-off current of the fuse
Icm	kA	Rated short-circuit making capacity
Icmax (base)	kA	Rated short-circuit current of the fuse base
Icn	kA	Rated short-circuit breaking capacity acc. to IEC 60898-1
Icu	kA	Rated ultimate short-circuit breaking capacity acc. to IEC 60947-2
Icu korr a	kA	Requirement on the rated ultimate short-circuit breaking capacity downstream of the lower switching device or at the target distribution board (controlled short-circuit current)
Icu korr b	kA	Requirement on the rated ultimate short-circuit breaking capacity upstream of the lower switching device (controlled short-circuit current)
Icu korr c	kA	Requirement on the rated ultimate short-circuit breaking capacity downstream of the upper switching device (controlled short-circuit current)
Icu korr d	kA	Requirement on the rated ultimate short-circuit breaking capacity at the output distribution board or upstream of the upper switching device (controlled short-circuit current)
Icu(fuse)	kA	Rated ultimate short-circuit breaking capacity – fuse
Icu/Icn required	kA	Required short-circuit breaking capacity for the protective device at the mounting location
Icw 1s	kA	Rated short-time withstand current 1s
Ie	A	Earth energizing current of the DMT relay / of the RCD module
Ig	A	Setting value of the release for earth fault detection
Igb	A	Total reactive current

Formula symbol	Unit	Description
Igs	A	Total apparent current
Igw	A	Total active current
Ig_out	A	Rated output current of frequency converter for selected overload cycle
IHHmin	A	Minimum tripping current of the high-voltage high-rupturing capacity fuse (HV HRC fuse)
Ii	A	Setting value of instantaneous short-circuit (I)-release
Ik1D	kA	1-phase continuous short-circuit current
Ik1max	kA	Maximum 1-phase short-circuit current
Ik1max(F1)	kA	Maximum 1-phase short-circuit current in the event of a fault in the medium-voltage bus-bar
Ik1maxph_n	kA	Maximum 1-phase short-circuit current phase to neutral conductor
Ik1maxph_pe	kA	Maximum 1-phase short-circuit current phase to protective conductor
Ik1min	kA	Minimum 1-phase short-circuit current
Ik1min(F2)	kA	Minimum 1-phase short-circuit current in the event of a fault at the transformer primary side
Ik1min(F3)	kA	Minimum 1-phase short-circuit current in the event of a fault at the transformer secondary side
Ik1min(F4)	kA	Minimum 1-phase short-circuit current in the event of a fault at the end of the secondary-side connection of the transformer
Ik1minph_n	kA	Minimum 1-phase short-circuit current phase to neutral conductor
Ik1minph_pe	kA	Minimum 1-phase short-circuit current phase to protective conductor
Ik2min	A	Minimum 2-pole short-circuit current
Ik2min(F2)	kA	Minimum 2-pole short-circuit current in the event of a fault at the transformer primary side
Ik2min(F3)	kA	Minimum 2-pole short-circuit current in the event of a fault at the transformer secondary side
Ik2min(F4)	kA	Minimum 2-pole short-circuit current in the event of a fault at the end of the secondary-side connection of the transformer
Ik3(F3)	kA	3-pole short-circuit current in the event of a fault at the transformer secondary side
Ik3D	kA	3-pole continuous short-circuit current
Ik3max	kA	Maximum 3-pole short-circuit current
Ik3max(F1)	kA	Maximum 3-pole short-circuit current in the event of a fault in the medium-voltage busbar

Formula symbol	Unit	Description
Ik3min	kA	Minimum 3-pole short-circuit current
Ikmax	A	Maximum short-circuit current of all short-circuit currents
Ikmax a	kA	Maximum short-circuit current downstream of the lower switching device or at the target distribution board (uncontrolled short-circuit current)
Ikmax b	kA	Maximum short-circuit current upstream of the lower switching device (uncontrolled short-circuit current)
Ikmax c	kA	Maximum short-circuit current downstream of the upper switching device (uncontrolled short-circuit current)
Ikmax d	kA	Maximum short-circuit current at the output distribution board or upstream of the upper switching device (uncontrolled short-circuit current)
Ikmax/Ikmin		Ratio of maximum/minimum short-circuit current
Ikmin	A	Minimum short-circuit current of all short-circuit currents
Ikmotor	kA	3-pole short-circuit current proportion of the motor
Ikre		Factor of energetic recovery – short-circuit current
Imax	A	Maximum rated current of busbar system
In	A	Nominal/rated current
In (RCD)	mA	Rated current of RCD
In (switch)	A	Nominal/rated current of medium-voltage switchgear
In (fuse)	A	Nominal/rated current of medium-voltage fuse
In max	A	Rated device current at 40 °C standard temperature
In zul	A	Permissible switch load according to ambient temperature
In1	A	Rated current of transformer, primary side
In2	A	Rated current of transformer, secondary side
Inenn	A	Nominal transformer current at nominal power
In_max	A	Nominal transformer current at maximum power with fan mounted
Ip	A	Configuration value for current at IDMT protection
Ipk	kA	Peak short-circuit current
Ipk	kA	Short-circuit strength of the lightning current/overvoltage arrester in case of maximum permissible size of backup fuse
Iq	kA	Conditional rated short-circuit current – motor starter combination

Formula symbol	Unit	Description
IR	A	Setting value for overload (L)-release
Isd	A	Setting value of short-time delayed short-circuit (S)-release
Isel-short	A	Calculated selectivity limit value between Ikmin and Ikmax
Isel overload	A	Calculated selectivity limit value in range less than Ikmin
Iz, Izul	A	Permissible load current of a connecting line
I_in	A	Rated input current of frequency converter for selected overload cycle
I_out	A	Rated output current of frequency converter for selected overload cycle
IΔn	mA	Rated earth-fault current – RCD protection
LO		Low Overload
L		Phase
L1		Phase 1
L2		Phase 2
L3		Phase 3
max		Maximum
min		Minimum
MRPD		Machine-readable product designation
MV		Medium voltage
N		Neutral conductor
LV		Low voltage
P	kW	Active power, electric
PE		Protective earth conductor
Pmech	kW	Active power, mechanical
Pn	kW	Nominal active power
P0	kW	No-load losses
Pv, Pk	kW	Short-circuit losses
pz		Number of poles, switchgear

Formula symbol	Unit	Description
Q	kvar	Reactive power
Qe	kvar	Effective reactive capacitor power
Qn	kvar	Nominal reactive power
R/X		Ratio of resistance to reactance
R0	mΩ	Resistance in the zero phase-sequence system
R0 min/max	mΩ	Minimum/maximum resistance in the zero phase-sequence system
R0 N	mΩ	Resistance in the zero phase-sequence system, phase – N
R0 PE(N)	mΩ	Resistance in the zero phase-sequence system, phase – PE(N)
R0ΔU	mΩ	Resistance in the zero phase-sequence system for the voltage drop
R0/R1		Resistance ratio of zero/positive phase-sequence system
r0ph-n	mΩ/m	Specific active resistance of the zero phase-sequence system for the phase to neutral conductor loop
r0ph-pe(n)	mΩ/m	Specific active resistance of the zero-phase-sequence system for the phase to PE conductor loop
r1	mΩ/m	Specific active resistance of positive phase-sequence system
r1	%	Related resistance value in the positive phase-sequence system
R1	mΩ	Resistance in the positive phase-sequence system
R1ΔU	mΩ	Resistance in the positive phase-sequence system for the voltage drop
R1 min/max	mΩ	Minimum/maximum resistance in the positive phase-sequence system
Ra+Rb max	mΩ	Sum of resistances of the earth electrode and possibly wired protective conductor between exposed conductive part and earth in the IT or TT network
Rs min/max	mΩ	Minimum/maximum loop resistance
S	kVA	apparent power
S2K2		Thermal fault withstand capability of the cable
Sn	kVA	Nominal apparent power
SnT	kVA	Nominal apparent power of transformer
SnT_max	kVA	Maximum apparent power of transformer with fan mounted
t>	s	Delay time for the overcurrent module of DMT relay
t>>	s	Delay time for the high-current module of DMT relay

Formula symbol	Unit	Description
ta zul (Ii)	s	Permissible switch disconnection time for the setting value of the I-release, without violating the condition k2S2>I2t
ta zul (Ikmax)	s	Permissible switch disconnection time at maximum short-circuit current, without violating the condition k2S2>I2t
ta zul (Ikmin)	s	Permissible switch disconnection time at minimum short-circuit current, without violating the condition k2S2>I2t
ta zul ABS	s	Permissible disconnection time in compliance with DIN VDE 0100-410 (IEC 60364-4-41)
ta(min abs)	s	Switchgear disconnection time for disconnect condition
ta(min kzs)		Switchgear disconnection time for short-circuit protection
ta_max	s	Maximum disconnection time of the switchgear to be evaluated
te	s	Delay time of the earth energizing current of the DMT relay / of the RCD module
tg	s	Time value of the G-release (absolute)
tp	s	Configuration value of time multiplicator for IDMT protection
tR	s	Time value of the L-release
tsd	s	Time value of the S-release
Tu	°C	Ambient device temperature
u	%	Relative voltage
ukr	%	Relative rated short-circuit voltage
Umax	V	Maximum rated voltage of the busbar system
Un	V	Nominal voltage
Uprim	kV	Primary voltage
Usec	V	Secondary voltage
LVSD		Low-voltage sub-distribution (system)
V		Loads
X0 min/max	mΩ	Minimum/maximum reactance in the zero phase-sequence system
X0 N	mΩ	Reactance of phase-N in the zero phase-sequence system
X0 PE(N)	mΩ	Reactance of phase-PE(N) in the zero phase-sequence system
X0ΔU	mΩ	Reactance of the zero phase-sequence system for voltage drop, independent of temperature

Formula symbol	Unit	Description
X0/X1		Reactance ratio of zero/positive phase-sequence system
x0ph-n	mΩ/m	Specific reactive resistance of the zero phase-sequence system for the phase to neutral conductor loop
x0ph-pe(n)	mΩ/m	Specific reactive resistance of the zero-phase-sequence system for the phase to PE conductor loop
x1	mΩ/m	Specific reactive resistance of positive phase-sequence system
X1	mΩ	Reactance in the positive phase-sequence system
X1 min/max	mΩ	Minimum/maximum reactance in the positive phase-sequence system
X1ΔU	mΩ	Reactance in the positive phase-sequence system for the voltage drop
xd"	%	Subtransient reactance
Xs min/max	mΩ	Minimum/maximum loop reactance
Z0	mΩ	Impedance of zero phase-sequence system
Z0 min/max	mΩ	Minimum/maximum impedance in the zero phase-sequence system
Z0ΔU	mΩ	Impedance in the zero phase-sequence system for the voltage drop
Z1	mΩ	Impedance of positive phase-sequence system
Z1 min/max	mΩ	Minimum/maximum impedance in the positive phase-sequence system
Z1ΔU	mΩ	Impedance in the positive phase-sequence system for the voltage drop
Zs		Loop impedance
Zs min/max		Minimum/maximum loop resistance

3 Special Technical Information about System Planning in SIMARIS project

3.1 Technical Data of 8DJH Gas-insulated Medium-voltage Switchgear

3.1.1 Electrical utility company (EUC) requirements

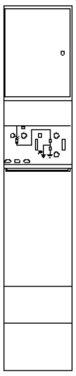
Requirements based on the relevant Technical Supply Conditions must be inquired about and observed.

3.1.2 Current Transformer

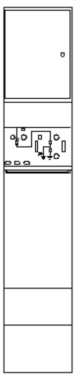
In order to size a combination of current transformer plus protection device optimally, please get in touch with your Siemens contact in charge, who can perform a separate calculation of the required current transformers or protection devices for you.

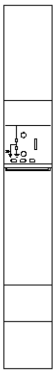
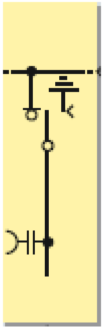
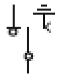
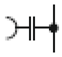
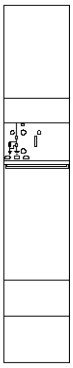
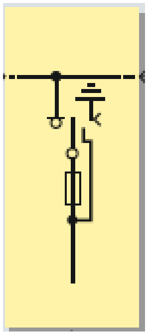
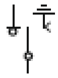
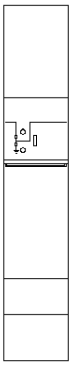
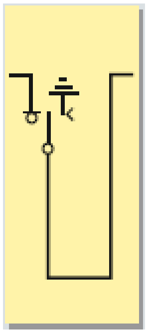
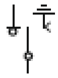
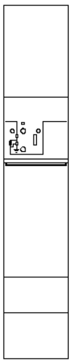
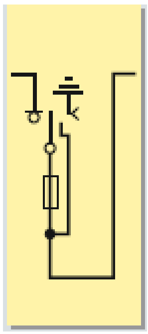
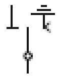
3.1.3 Panels

Circuit-breaker panel L (Type1.1, Automatic reclosing)

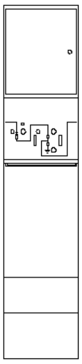
	AR = Automatic reclosing		
	Number of current break operations I_r	n	10,000 / M2
	Rated switching sequence		O – 0.3s – CO – 3min –CO
	Number of short-circuit isolations I_{sc}	n	25 or 50

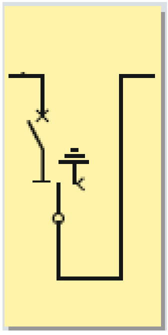
Circuit-breaker panel L (Type2, Non automatic reclosing)

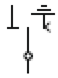
	NAR = Non automatic reclosing		
	Number of current break operations I_r	n	2,000 / M1
	Rated switching sequence		O – 3min – CO – 3min –CO
	Number of short-circuit isolations I_{sc}	n	6 or 20

	Ring-main cable panel R		
		 Three-position switch-disconnector	 Capacitive voltage detecting system
	Transformer panel T		
		 Three-position switch-disconnector	 HV HRC fuse
	Busbar sectionalizer panel S (with switch disconnector)		
		 Three-position switch-disconnector	
	Busbar sectionalizer panel H (with HV HRC fuse)		
		 Three-position disconnector	 HV HRC fuse

Bus sectionalizer panel V (with circuit-breaker type 1.1, Automatic reclosing)



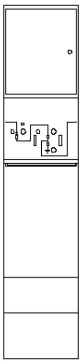


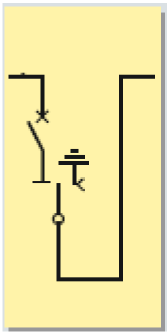


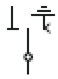
Three-position disconnector

Vacuum circuit-breaker

Bus sectionalizer panel V (with circuit-breaker type 2, Non automatic reclosing)



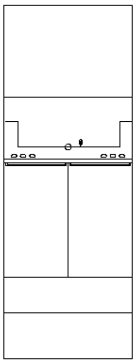




Three-position disconnector

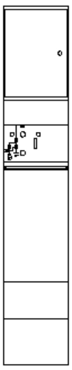
Vacuum circuit-breaker

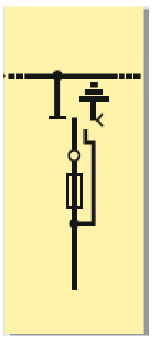
Billing metering panel M

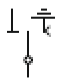


Necessary current transformers must be supplied by the customer (electrical utility company)

Busbar voltage metering panel, fused on the primary side M(430)

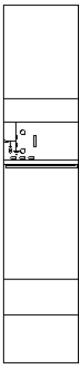
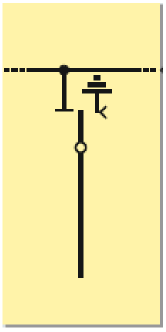
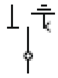
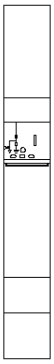
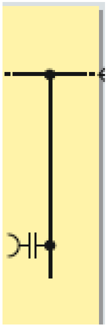
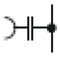
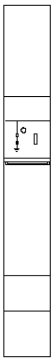
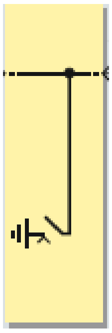






Three-position disconnector

HV HRC fuse

	Busbar voltage metering panel M(500)		
		 Three-position disconnector	
	Cable connection panel K		
		 Capacitive voltage detecting system	
	Busbar earthing panel E		
			

For more information about this switchgear, please refer to:
www.siemens.com/8djh

3.1.4 Panel blocks

You can configurate the following panel blocks.

2 panels	RR, RT, RK, RL, RS, RH, K(E)L, K(E)T, KL, KR, KT, LR, LK, LL, TK, TR, TT
3 panels	RRR, RRT, RRL, RRS, RRH, RTR, RTT, RLL, RLR, LLL, LLR, LRL, LRR, TRR, TTT
4 panels	RRRR, RRRH, RRRL, RRRS, RRRT, RRTR, RRTT, RRLL; RRLR, RTRR, RTRT, RTTT, RTTR, RLLL, RLLR, RLRL, RLRR, LLLL, LLLR, LLRL, LLRR, LRLL, LRLR, LRRL, LRRR, TRRR, TRRT, TRTR, TRTT, TTRR, TTRT, TTTR, TTTT
5 panels (only China)	RRRRR, RRRRT, RRRRL, RLLLL, RLLLR, RRRTT, RTTTT, RTTTR
6 panels (only China	RRRRRR , RRRRRL,RRRRLL, RRRRRT, RRRRTT

Legend:

H	Bus sectionalizer panel H (with HV-fuse)
K	Cable connection panel K
K(E)	Cable connection panel K with earthing switch
L	Circuit-breaker panel L(type1, AR) respectively L(type2, NAR)
R	Ring-main panel R
S	Bus sectionalizer panel S (with switch disconnector)
T	Transformer panel T

Please note:

- Panels in a panel block can only be 310mm or respectively 430mm wide
- Within one panel block there may only be circuit-breaker panels of type 1 or type 2

3.2 Technical Data of 8DJH compact Gas-insulated Medium-voltage Switchgear

- Space-efficient ring net switchgear in block-type construction
- Width RRT = 700 mm (comparison: 8DJH standard 1050 mm)
- Further scheme versions: RRT-R and RRT-RRT
- Transformer connection: in the back above (for direct connection to eine direkte Verbindung zum Verteiltransformator), alternatively to the right or above
- Functionalities of   der switching devices (Switch disconnector, switch-fuse combination) as in the standard version
- 8DJH Compact can be easily installed in new local transformer substations, and is the ideal retrofit switchgear for existing compact substations

3.3 Technical Data of 8DJH36 Gas-insulated Medium-voltage Switchgear

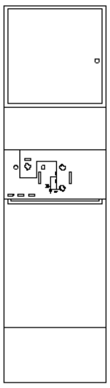
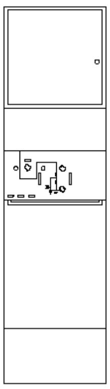
3.3.1 Electrical utility company (EUC) requirements

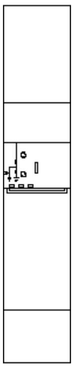
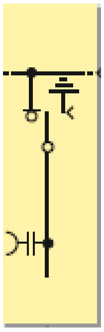
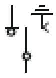
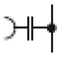
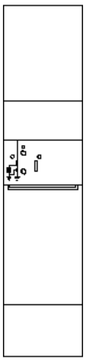
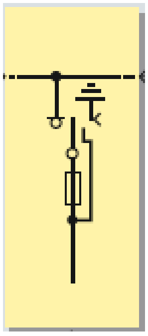
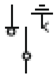
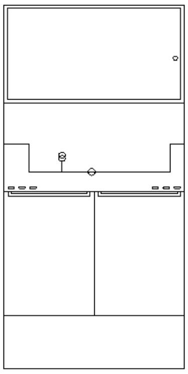
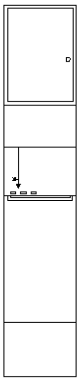
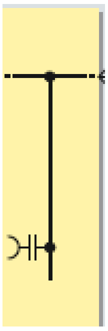
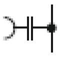
Requirements based on the relevant Technical Supply Conditions must be inquired about and observed.

3.3.2 Current Transformer

In order to size a combination of current transformer plus protection device optimally, please get in touch with your Siemens contact in charge, who can perform a separate calculation of the required current transformers or protection devices for you.

3.3.3 Panels

	Circuit-breaker panel L1 (Type 1, AR)		
	AR = Automatic reclosing		
	Number of breaking operations ***Ir***	n	10,000 / M2
	Rated operating sequence		O – 0,3s – CO – 3min –CO
	Number of short-circuit breaking operations ***Isc***	n	25 or 50
	Circuit-breaker panel L2 (Type 2, NAR)		
	NAR = Non automatic reclosing		
	Number of breaking operations ***Ir***	n	2,000 / M1
	Rated operating sequence		O – 3min – CO – 3min –CO
	Number of short-circuit breaking operations ***Isc***	n	6 or 20

	Ring-main panel R		
		 Three-position switch-disconnector	 Capacitive voltage detecting system
	Transformer panel T		
		 Three-position switch-disconnector	 HV HRC fuse
	Metering panel M		
	Necessary transformer must be provided by customer (power supplier)		
	Cable Connection panel K		
		 Capacitive voltage detecting system	

For more information about this switchgear, please refer to: www.siemens.com/8djh36

3.4 Technical Data of NX PLUS C Gas-insulated Medium-voltage Switchgear

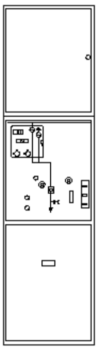
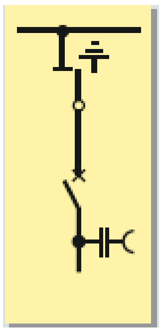
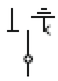
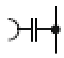
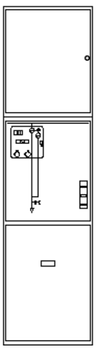
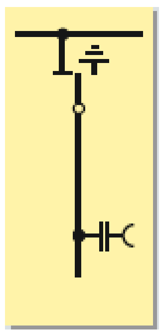
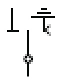
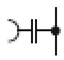
3.4.1 Electrical utility company (EUC) requirements

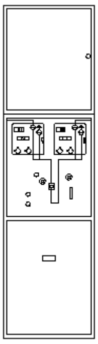
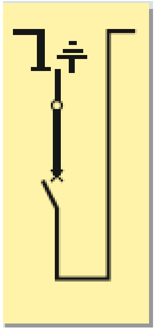
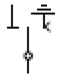
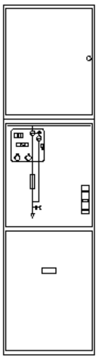
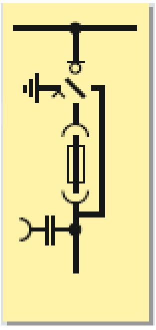
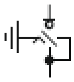
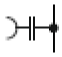
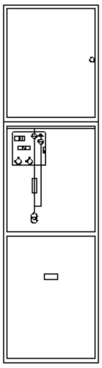
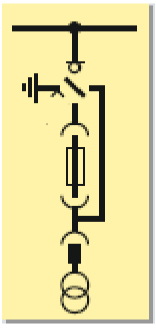
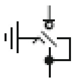
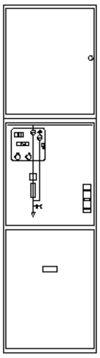
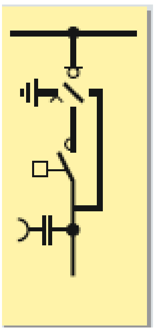
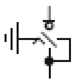
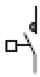
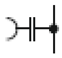
Requirements based on the relevant Technical Supply Conditions must be inquired about and observed.

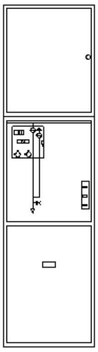
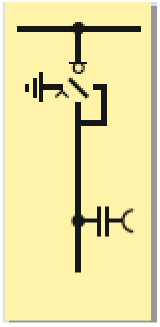
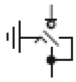
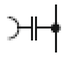
3.4.2 Current Transformer

In order to size a combination of current transformer plus protection device optimally, please get in touch with your Siemens contact in charge, who can perform a separate calculation of the required current transformers or protection devices for you.

3.4.3 Cubicles

	LS circuit-breaker panel			
		 Three-position disconnector	 Vacuum circuit-breaker	 Capacitive voltage detecting system
	Disconnector panel TS			
		 Three-position disconnector		 Capacitive voltage detecting system

	Sectionalizer (in one panel) LK			
		 Three-position disconnector	 Vacuum circuit-breaker	
	Switch disconnector panel TR			
		 Three-position switch-disconnector	 HV HRC fuses	 Capacitive voltage detecting system
	Metering panel ME			
		 Three-position switch-disconnector	 HV HRC fuses	 Plug-in voltage transformer
	Contactor panel VS			
		 Three-position switch-disconnector	 Vacuum contactor	 Capacitive voltage detecting system

	Ring-main cable panel RK			
		 Three-position switch-disconnector		 Capacitive voltage detecting system

For more information about this switchgear, please refer to:
www.siemens.com/nxplusc

3.4.4 Operating cycles

For circuit breaker panels LS up to 31.5kA you can select the following operating cycles:

- 2,000/1,000/10,000 up to 24kV all rated normal current of feeder
- 5,000/5,000/30,000 up to 15kV rated normal current of feeder: 1,000A and 1,250A
- 10,000/10,000/30,000 up to 15kV rated normal current of feeder: 1,000A and 1,250A

For vacuum contactor panel VS up to 24kV, up to 31.5kA you can select the following operating cycles:

- 2,000/1,000/500,000 without closing latch
- 2,000/1,000/100,000 with closing latch

3.5 Technical Data of SIMOSEC Air-insulated Medium-voltage Switchgear

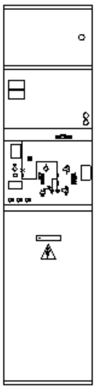
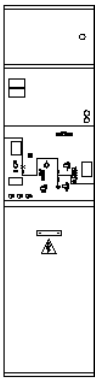
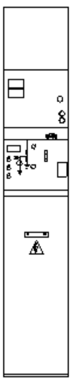
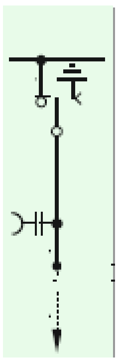
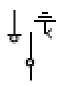
3.5.1 Electrical utility company (EUC) requirements

Requirements based on the relevant Technical Supply Conditions must be inquired about and observed.

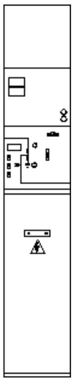
3.5.2 Current Transformer

In order to size a combination of current transformer plus protection device optimally, please get in touch with your Siemens contact in charge, who can perform a separate calculation of the required current transformers or protection devices for you.

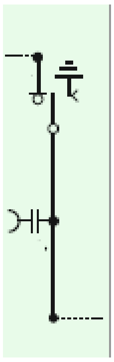
3.5.3 Panels

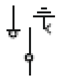
	Circuit-breaker panel, type L **Single panel**		
	Automatic reclosing AR: Number of breaking operations Ir	n	10,000 / M2
	Rated switching sequence		O – 0,3s – CO – 30s –CO
	Number of short-circuit breaking operations Isc Without automatic reclosing NAR: Number of breaking operations Ir	n n	30 or 50 2,000 / M1
	Rated switching sequence		O – 0,3s – CO – 30s –CO
	Number of short-circuit breaking operations Isc	n	20
	Circuit-breaker panel, type L (T) **Combination panel**		
	Automatic reclosing AR: Number of breaking operations Ir	n	10,000 / M2
	Rated switching sequence		O – 0,3s – CO – 30s –CO
	Number of short-circuit breaking operations Isc Without automatic reclosing NAR: Number of breaking operations Ir	n n	30 or 50 2,000 / M1
	Rated switching sequence		O – 0,3s – CO – 30s –CO
	Number of short-circuit breaking operations Isc **Combinations possible** with ■ High-rising panel, type H ■ Ring cable panel, type R (T) ■ Metering panel, type M and M(-K)	n	20
	Ring cable panel, type R **Single panel**		
		 Three-position switch-disconnector	 Capacitive voltage detecting system

Ring cable panel type R(T)
Combination panel

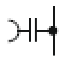


Combinations possible with
- Circuit-breaker panel, type L(T)
- High-rising panel, type H
- Ring cable panel, type R (T)
- Metering panel, type M and M(-K)



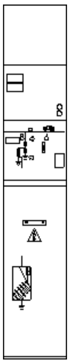


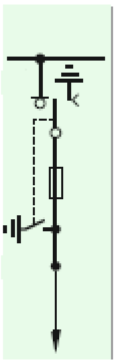
Three-position switch-disconnector

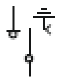


Capacitive voltage detecting system

Transformer panel, type T
Single panel



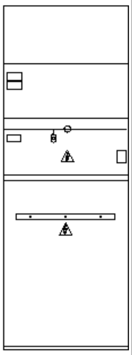




Three-position switch-disconnector

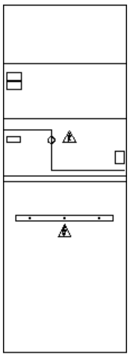
Earthing switch

Metering Panel Type M
Single panel



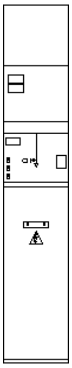
Current transformers, if required, must be provided by the customer (utilities company).

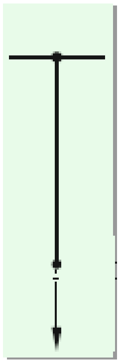
Metering panel, type M and Typ M(-K)
Combination panel



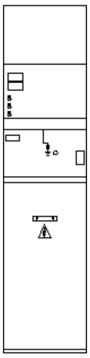
Combinations possible with
- Circuit-breaker panel, type L(T)
- Ring cable panel, type R (T)

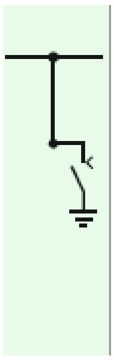
Cable panel, type K
Single panel

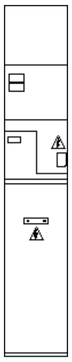
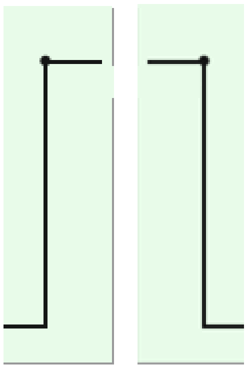




Busbar earthing panel, type E
Single panel





	High-rising panel, type H Combination panel
	**Combinations possible** with ■ Circuit-breaker panel, type L(T) ■ Ring cable panel, type R (T) 

For more information about this switchgear, please refer to: www.siemens.com/simosec

3.6 Technical Data of NXAIR Air-insulated Medium-voltage Switchgear

3.6.1 Electrical utility company (EUC) requirements

Requirements based on the relevant Technical Supply Conditions must be inquired about and observed.

3.6.2 Current transformer

For optimal design of the combination transformer-protection, please approach your responsible Siemens contact person, who can create a separate calculation of necessary transformer or protection devices.

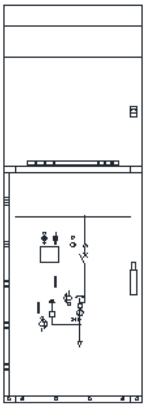
3.6.3 Important engineering notes

- Regarding pressure absorbers please note the following:
  - Having not selected "pressure relief duct", you have to stipulate pressure absorbers in some panels
  - Pressure absorbers are not displayed in the front view of SIMARIS project, as depending on the projection only some
    panels need an absorber. But the necessary room height will be considered in SIMARIS project.
  - Pressure absorbers are only allowed to be installed in non-ventilated panels, this means a system which is exclusively equipped
    with ventilated panels can only be realized with pressure relief duct.
- For earthing switch, connection or voltage transformer in busbar compartments a top box will be supplemented automatically.
  CAUTION: Having not selected "pressure relief duct", it is not allowed to configure a top box before or after another panel with top box!
- Before and after a bus sectionalizer (with or without disconnector) there must be at least two other arbitrary NXAIR panels before another
  bus sectionalizer (with or without disconnector) may be inserted or the switchgear ends.

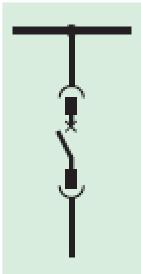
3.6.4 Panels

3.6.4.1 NXAIR 17.5 kV

Circuit-breaker panel
Individual panel

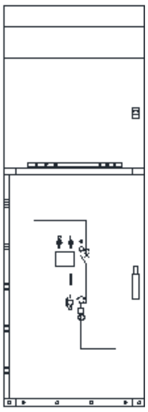


Rated short-time current Ik [kA]: 25; 31.5; 40; 50
Rated voltage Ur [kV]: 7.2; 12; 17.5
Rated normal current [A]: 630 – 4,000
Panel width [mm] : 600; 800; 1,000

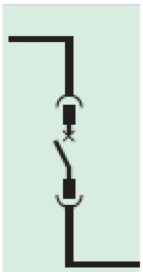


Circuit-breaker up to 40 kA	
Amount Operating cycles	10,000 / C2, E2, M2
Rated operating sequence	O – 0.3s – CO – 3min –CO O – 0.3s – CO – 15s –CO O – 3min – CO – 3min –CO
Circuit-breaker up to 50 kA	
Amount Operating cycles	10,000 / C2, E2, M2
Rated operating sequence (at normal current)	O – 3min – CO – 3min –CO O – 0.3s – CO – 15s –CO

Circuit-breaker panel (Bus sectionalizer)
Combination panel



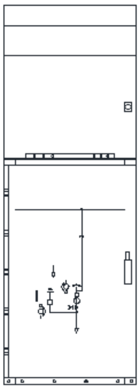
Rated short-time current Ik [kA]: 25; 31.5; 40; 50
Rated voltage Ur [kV]: 7.2; 12; 17.5
Rated normal current [A]: 630 – 4,000
Panel width [mm] : 600; 800; 1,000



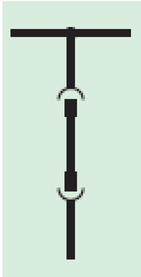
Circuit-breaker up to 40 kA	
Amount Operating cycles	10,000 / C2, E2, M2
Rated operating sequence	O – 0.3s – CO – 3min –CO O – 0.3s – CO – 15s –CO O – 3min – CO – 3min –CO
Circuit-breaker 50 kA	
Amount Operating cycles	10,000 / C2, E2, M2
Rated operating sequence (at normal current)	O – 3min – CO – 3min –CO

Combination possibility with
- Bus riser panel with disconnector
- Bus riser panel without disconnector

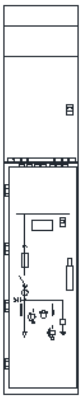
Disconnecting panel
Individual panel



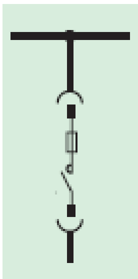
Rated short-time current Ik [kA]: 25; 31.5; 40; 50
Rated voltage Ur [kV]: 7.2; 12; 17.5
Rated normal current [A]: 630 – 4,000
Panel width [mm] : 800; 1,000



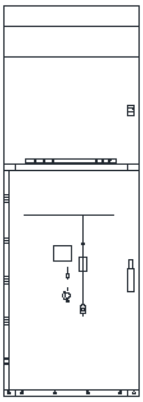
Contactor panel
Individual panel



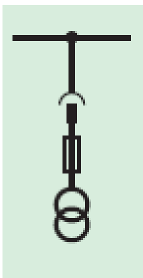
Rated short-time current Ik [kA]: 25; 31.5; 40; 50
Rated voltage Ur [kV]: 7.2; 12
Rated normal current [A]: 400
Panel width [mm] : 435; 600



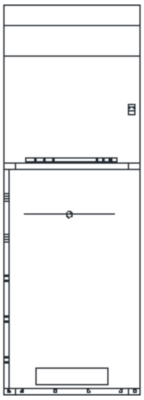
Metering panel
Individual panel



Rated short-time current Ik [kA]: 25; 31.5; 40; 50
Rated voltage Ur [kV]: 7.2; 12; 17.5
Rated normal current [A]: -
Panel width [mm] : 800

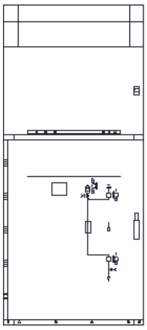


Busbar current metering panel
Individual panel



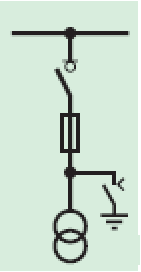
Rated short-time current Ik [kA]: 25*); 31.5*); 40; 50
Rated voltage Ur [kV]: 7.2; 12; 17.5
Rated normal current [A]: -
Panel width [mm] : 800
*) 25kA and 31kA only available on Ir 3,150A rated normal current of busbar

Transformer panel for auxiliaries service
Individual panel

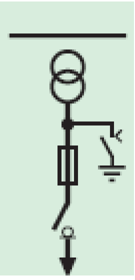


Rated short-time current Ik [kA]: 25; 31.5
Rated voltage Ur [kV]: 7.2; 12
Rated normal current [A]: -
Panel width [mm] : 1,000

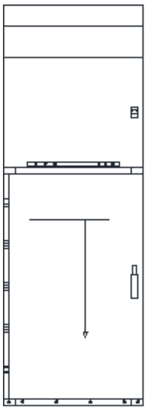
Feeder busbar:



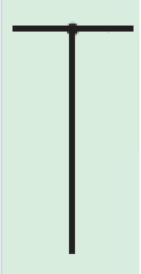
Feeder cable:



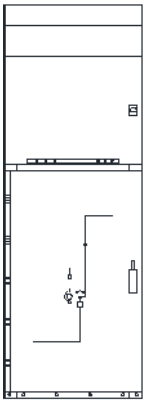
Busbar connection panel
Individual panel



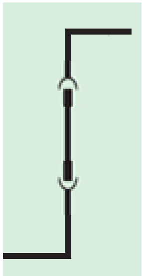
Rated short-time current Ik [kA]: 25; 31.5; 40; 50
Rated voltage Ur [kV]: 7.2; 12; 17.5
Rated normal current [A]: 1,250; 2,500; 3,150; 4,000
Panel width [mm] : 800; 1,000



Bus riser panel with disconnector
Combination panel



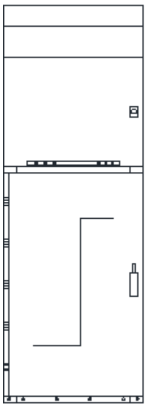
Rated short-time current Ik [kA]: 25; 31.5; 40; 50
Rated voltage Ur [kV]: 7.2; 12; 17.5
Rated normal current [A]: 1,250 – 4,000
Panel width [mm] : 800; 1,000



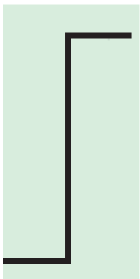
Combination possibility with

- Circuit-breaker panel (Bus sectionalizer)

Bus riser panel without disconnector
Combination panel



Rated short-time current Ik [kA]: 25; 31.5; 40; 50
Rated voltage Ur [kV]: 7.2; 12; 17.5
Rated normal current [A]: 1,250 – 4,000
Panel width [mm] : 800; 1,000
Measurement module: optional

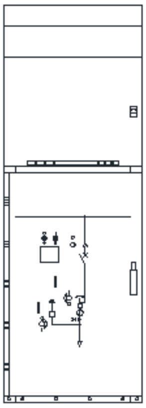


Combination possibilities with

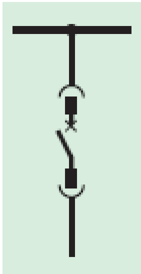
- Circuit-breaker panel (Bus sectionalizer)

3.6.4.2 NXAIR 24 kV

Circuit-breaker panel
Individual panel



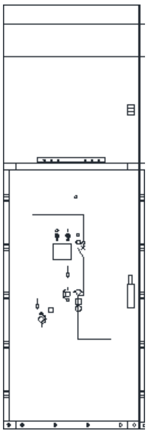
Rated short-time current Ik [kA]: 16; 20; 25
Rated voltage Ur [kV]: 24
Rated normal current [A]: 800 – 2,500
Panel width [mm] : 800; 1,000



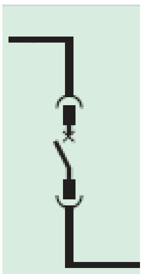
Circuit-breaker up to 25kA

Amount operating cycles	10,000 / C2, E2, M2
Rated operating sequence	O – 0.3s – CO – 3min –CO O – 0.3s – CO – 15s –CO

Circuit-breaker panel (Bus sectionalizer)
Combination panel



Rated short-time current Ik [kA]: 16; 20; 25
Rated voltage Ur [kV]: 24
Rated normal current [A]: 1,250 – 2,500
Panel width [mm] : 800; 1,000

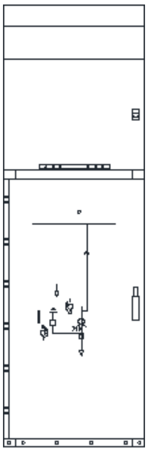


Circuit-breaker up to 25kA

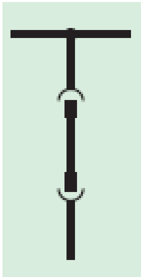
Amount operating cycles	10,000 / C2, E2, M2
Rated operating sequence	O – 0.3s – CO – 3min –CO O – 0.3s – CO – 15s –CO

Combination possibilities with
- Bus riser panel with disconnector
- Bus riser panel without disconnector

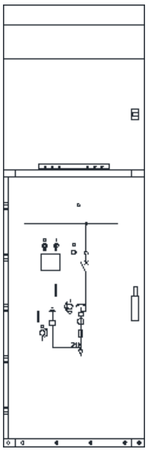
Disconnecting panel
Individual panel



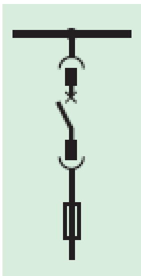
Rated short-time current Ik [kA]: 16; 20; 25
Rated voltage Ur [kV]: 24
Rated normal current [A]: 800 – 2,500
Panel width [mm] : 800; 1,000



Circuit-breaker fuse panel
Individual panel

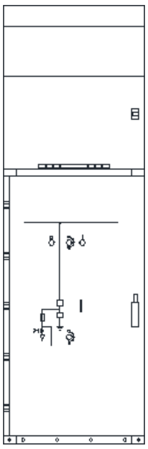


Rated short-time current Ik [kA]: 16; 20; 25
Rated voltage Ur [kV]: 24
Rated normal current [A]: 800 *)
Panel width [mm] : 800

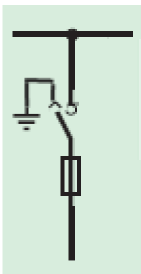


*) The output current is limited via fuse

Switch-disconnector / fuse combination panel
Individual panel

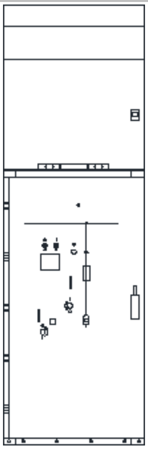


Rated short-time current Ik [kA]: 16; 20; 25
Rated voltage Ur [kV]: 24
Rated normal current [A]: 200*)
Panel width [mm] : 800

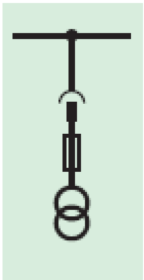


*) The output current is limited via fuse

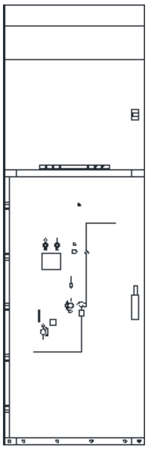
Metering panel
Individual panel



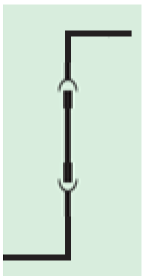
Rated short-time current Ik [kA]: 16; 20; 25
Rated voltage Ur [kV]: 24
Rated normal current [A]: -
Panel width [mm] : 800



Bus riser panel with disconnector
Combination panel

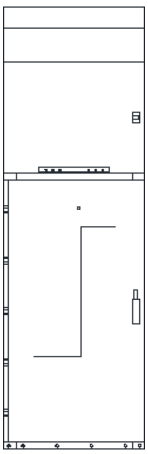


Rated short-time current Ik [kA]: 16; 20; 25
Rated voltage Ur [kV]: 24
Rated normal current [A]: 1,250 – 2,500
Panel width [mm] : 800; 1,000

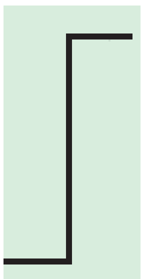


Combination possibility with
- Circuit-breaker panel (Bus sectionalizer)

Bus riser panel without disconnector
Combination panel



Rated short-time current Ik [kA]: 16; 20; 25
Rated voltage Ur [kV]: 24
Rated normal current [A]: 1,250 – 2,500
Panel width [mm] : 800; 1,000
Measurement module: optional



Combination possibility with
- Circuit-breaker panel (Bus sectionalizer)

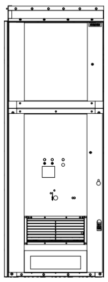
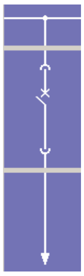
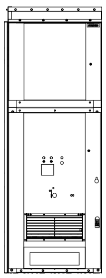
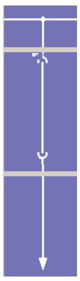
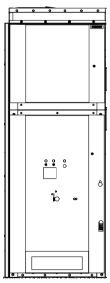
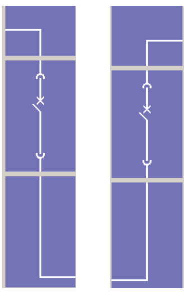
3.7 Technical Data of NXAir Air-insulated Medium-voltage Switchgear (only for China)

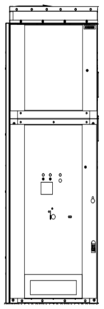
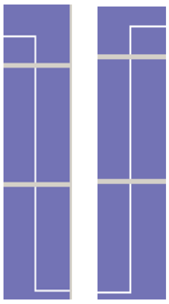
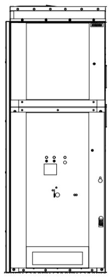
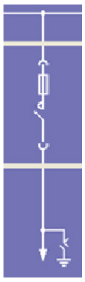
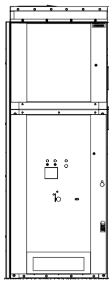
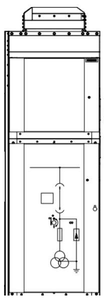
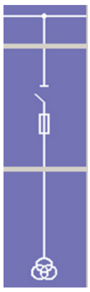
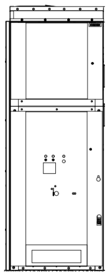
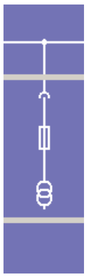
3.7.1 NXAir 12 kV

3.7.1.1 Current Transformer

For optimal design of the combination transformer-protection, please approach your responsible Siemens contact person, who can create a separate calculation of necessary transformer or protection devices.

3.7.1.2 Panels

	Circuit breaker panel		
		Withdrawable Vacuum Circuit Breaker	
		Mechanical endurance	30,000 / M2
		Rated short-time withstand current	up to 40 kA 4 s
		Internal arc fault current	up to 40 kA 1 s
	Disconnecting panel		
		Withdrawable disconnector left	
	Bus sectionalizer: circuit breaker panel		
		Mechanical endurance	30,000 / M2
		Rated short-time withstand current	up to 40 kA 4 s
		Internal arc fault current	up to 40 kA 1 s
		Bus sectionalizer to the right	
		Bus sectionalizer to the left	

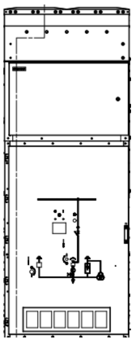
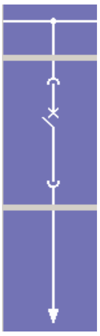
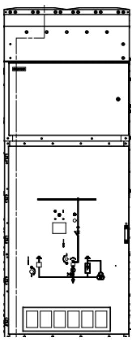
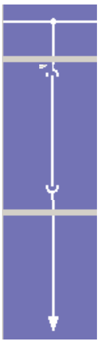
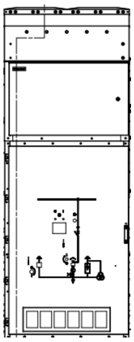
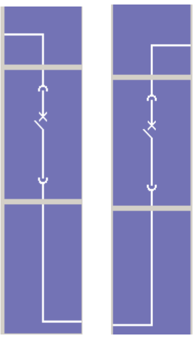
	Bus riser panel without disconnecting module		
		Bus riser to the right	
		Bus riser to the left	
	Vacuum contactor panel		
		Rated current: 400 A	
		Main circuit resistance ≤ 180	
		Rated current operating cycle : ■ Electrical latching: 1,000,000 ■ Mechanical latching: 100,000	
	Bus connecting panel		
		Busbar compartment	
		Switching device compartment	
		Connection compartment	
	Transformer panel		
		Busbar compartment	
		Switching device compartment	
		Connection compartment	
	Metering panel		
		Busbar compartment	
		Switching device compartment	

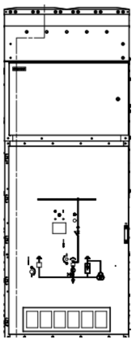
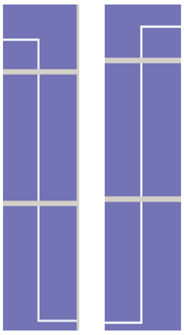
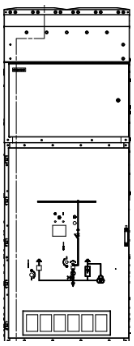
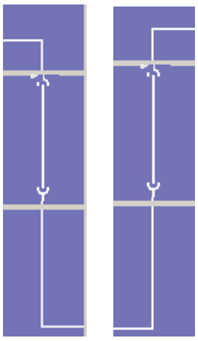
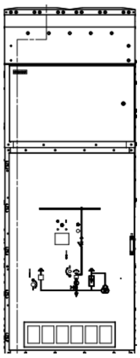
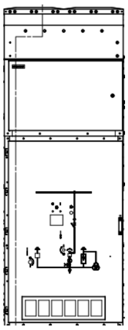
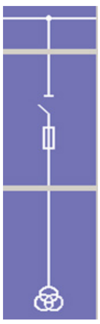
3.7.2 NXAir 24 kV

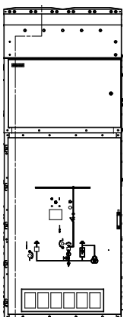
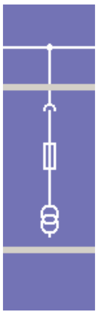
3.7.2.1 Current Transformer

For optimal design of the combination transformer-protection, please approach your responsible Siemens contact person, who can create a separate calculation of necessary transformer or protection devices.

3.7.2.2 Panels

	Circuit-breaker panel		
		Mechanical endurance	30,000 / M2
		Rated short-time withstand current	up to 31.5 kA 4 s
		Internal arc fault current	up to 31.5 kA 1 s
		Partition class	PM
	Disconnecting panel		
		Withdrawable disconnector left	
	Bus sectionalizer: circuit breaker panel		
		Number of breaking operations I_r	30,000 / M2
		Rated short-time withstand current	up to 31.5 kA 4 s
		Internal arc fault current	up to 31.5 kA 1 s
		Partition class	PM
		Bus sectionalizer to the right	
		Bus sectionalizer to the left	

		Bus riser panel without disconnecting module	
		Bus riser to the right	
		Bus riser to the left	
		Bus riser panel with disconnecting module	
		Bus riser to the right	
		Bus riser to the left	
		Bus connecting panel	
		Busbar compartment	
		Switching device compartment	
		Connection compartment	
		Transformer panel	
		Busbar compartment	
		Switching device compartment	
		Connection compartment	

	Metering panel		
		Busbar compartment	
		Switching device compartment	

3.8 ANSI Codes for protection devices

B = basic
O = optional (additional price)
– = not available
1) via CFC

ANSI	Functions	Abbr.	7SD80	7SD610	7SJ82	7SJ80	7SJ61	7SJ62	7SJ63	7SJ64	7SJ45	7SJ46	7SJ600	7SJ602	7SR11	7SR12	7SK80	7UM62	7UT612	7VE6
	Protection functions for 3-pole tripping	3-pole	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	O
	Protection functions for 1-pole tripping	1-pole	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14	Locked rotor protection	I> + V<	–	–	–	–	O	O	O	O	–	–	–	–	–	–	B	O	–	–
21	Distance protection	Z<	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–
24	Overexcitation protection	V/f	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–
25	Synchrocheck, synchronizing function	Sync	–	–	O	O	–	O	–	O	–	–	–	–	–	–	–	–	–	B
25	Synchronizing function with balancing commands	Sync	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B
27	Undervoltage protection	V<	O	O	O	O	–	O	O	O	–	–	–	–	–	B	O	B	–	O
27	Undervoltage protection, 3–phase	V<	O	O	O	O	–	O	O	O	–	–	–	–	–	B	O	–	–	–
27	Undervoltage protection, positive–sequence system	V1<	O	O	O	O	–	O	O	O	–	–	–	–	–	–	O	B	–	–
27	Undervoltage protection, 1–phase, Vx	Vx<	O	O	O	O	–	O	–	O	–	–	–	–	–	–	O		–	O
27TN/59TN	Stator ground fault 3rd harmonics	V0<,>(3.Harm.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–
	Undervoltage–controlled reactive power protection	Q>/V<	–	–	O	O	–	O	–	O	–	–	–	–	–	–	–	–	–	–
32	Directional power supervision	P<>, Q<>	–	O	O	O	–	O	–	O	–	–	–	–	–	–	O	B	–	–
32F	Forward power supervision	P>, P<	–	O	O	O	–	O	–	O	–	–	–	–	–	–	O	O	–	–
32R	Reverse power protection	P>, P<	–	O	O	O	–	O	–	O	–	–	–	–	–	–	O	B	–	–
37	Undercurrent protection, underpower	I<, P<	–	–	B	B	B	B	B 1)	B	–	–	–	B	B	B	B	O	–	–
38	Temperature supervision	˘ >	–	–	O	–	O	O	O	O	–	–	–	O	–	–	B	O	O	–
38	Bearing temperature supervision		–	–	–	–	O	O	O	O	–	–	–	O	–	–	B	O	–	–
40	Underexcitation protection	1/XD	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–
46	Unbalanced–load protection	I2>	–	–	B	B	B	B	B	B	–	–	B	B	B	B	B	O	O	–
46	Negative–sequence system overcurrent protection	I2>, I2/I1>	–	–	B	B	B	B	B	B	–	–	B	B	B	B	B	O	O	–
46	Unbalanced–load protection (thermal)	$I2^2$ t >	–	–	B	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–
46	Negative–sequence system overcurrent protection	I2>, I2/I1>	–	–	B	B	B	B	B	B	–	–	B	B	B	B	B	B	O	–
46	Negative–sequence system overcurrent protection	I2>, I2/I1>	–	–	B	B	B	B	B	B	–	–	B	B	B	B	B	O	O	–
	Negative–sequence system overcurrent protection with direction	I2>, ∠V2/I2	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
47	Phase–sequence–voltage supervision	LA, LB, LC	–	B	B	O	B	B	B	B	–	–	–	–	–	B	O	B	B	–
47	Overvoltage protection, negative–sequence system	V2>	O	O	O	O	–	O	O	O	–	–	–	–	–	B	O	O	–	–
48	Starting–time supervision	I^2_{start}	–	–	–	–	O	O	O	O	–	–	–	–	–	–	B	O	–	–
49	Thermal overload protection	¸>, I^2t	B	B	B	B	B	B	B	B	–	–	B	B	B	B	B	B	B	–
49R	Rotor overload protection	I^2t	–	–	–	–	O	O	O	O	–	–	–	O	–	–	B	–	–	–
49S	Stator overload protection	I^2t	–	–	–	–	O	O	O	O	–	–	–	O	–	–	B	B	–	–
50/ 50N	Definite time–overcurrent protection	I>	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	–
50 TD/ 50N TD	Definite time–overcurrent protection	I>	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	–
50/ 50N	Instantaneous overcurrent protection	I>, IN>	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	–
50HS	High speed instantaneous overcurrent protection	I>>>	–	B	B	B	B	B	–	B	–	–	B	B	B	B	B	–	–	–
SOTF	Instantaneous tripping at switch onto fault		B	B	B	B	B	B	B	B	–	–	B	B	B	B	B	B	B	B
AFD	Arc–protection		–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

B = basic
O = optional (additional price)
– = not available
1) via CFC

ANSI	Functions	Abbr.	7SD80	7SD610	7SJ82	7SJ80	7SJ61	7SJ62	7SJ63	7SJ64	7SJ45	7SJ46	7SJ600	7SJ602	7SR11	7SR12	7SK80	7UM62	7UT612	7VE6
50Ns	Sensitive ground–current protection	$I_{Ns}>$	–	–	B	O	O	O	O	O	–	–	–	O	O	O	O	B	–	–
-	Intermittent ground–fault protection	Iie>	–	–	O	B	O	O	–	O	–	–	–	–	–	–	B	–	–	–
50BF	Circuit–breaker failure protection	CBFP	B	O	O	B	B	B	B	B	–	–	B	B	B	B	B	B	O	–
50RS	Circuit–breaker restrike protection	CBRS	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
51 /51N	Inverse time–overcurrent protection	I_P, I_{Np}	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	–
50L	Load–jam protection	$I>_L$	–	–	–	–	O	O	O	O	–	–	–		–	–	B	–	–	–
51C	Cold load pickup		–	–	B	B	B	B	B	B	–	–	–	–	B	B	B	–	–	–
51V	Voltage dependent overcurrent protection	t=f(I)+V<	–	–	O	O	–	B	–	B	–	–	–	–	–	B	O	B	–	–
51V	Overcurrent protection with voltage release	t=f(I)+V<	–	–	O	O	–	B	–	B	–	–	–	–	–	B	O	B	–	–
51V	Overcurrent protection with voltage–dependent current threshold	t=f(I,V)	–	–	O	O	–	B	–	B	–	–	–	–	–	–	O	B	–	–
55	Power factor	cosj	–	B 1)	B 1)	O	–	O	B 1)	O	–	–	–	–	–	–	O	O	B	–
59	Overvoltage protection	V>	O	O	O	O	–	O	O	O	–	–	–	–	–	B	O	B	–	O
59	Overvoltage protection, 3–phase	V>	O	O	O	O	–	O	O	O	–	–	–	–	–	B	O	O	–	–
59	Overvoltage protection, positive–sequence system	V1>	O	O	O	O	–	O	–	O	–	–	–	–	–	–	O	O	–	–
59	Overvoltage protection, Compounding	V1comp>	–	O	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
59	Overvoltage protection, 1–phase, Vx	Vx>	–	O	O	O	–	O	–	O	–	–	–	–	–	–	O	–	–	O
	Peak overvoltage protection, 3–phase, for capacitors	V> cap.	–	–	O	–	–	–	–	–	–	–	–	–			–	–	–	–
59N	Overvoltage protection, zero–sequence system	V0>	O	O	O	O	–	O	O	O	–	–	–	O	–	B	O	B	–	–
59R, 27R	Rate–of–voltage–change protection	dV/dt	–	–	–	O	–	O	–	O	–	–	–	–	–	–	O	–	–	–
60C	Current–unbalance protection for capacitor banks	$I_{unbal}>$	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
60FL	Measuring–voltage failure detection		O	O	B	O	–	B	B	B	–	–	–	–	–	B	O	B	–	–
64	Sensitive ground–fault protection (machine)		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–
64S	Stator ground–fault protection	V0>, 3I0>	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–
64S 100	100% stator ground–fault protection (3rd harmonic)	$U0_{3H}<$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–
64S 100	100% stator ground–fault protection (20Hz)	R_{SGF}	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–
64R	Rotor ground–fault protection	R_{RGF}	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–
64R	Rotor ground–fault protection (current measurement)	$I_{LES}>$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–
66	Restart inhibit	I^2t	–	–	–	–	O	O	O	O	–	–	–	O	–	–	B	O	–	–
67	Directional time–overcurrent protection, phase	I>,I_P ∠ (V,I)	O	O	O	O	–	O	O	O	–	–	–	–	–	B	–	B	–	–
67N	Directional time–overcurrent protection for ground–faults	$I_N>$, I_{NP} ∠ (V,I)	O	O	O	O	–	O	O	O	–	–	–	–	–	B	O	B	–	–
67Ns	Dir. sensitive ground–fault detection for systems with resonant or isolated neutral	$I_{Ns}>$, ∠(V,I)	–	–	O	O	–	O	O	O	–	–	–	O	–	B	O	B	–	–
67Ns	Sensitive ground–fault detection for systems with resonant or isolated neutral with admittanz method	?			O	–	–	–	–	–	–	–	–	–	–	–	–	–		
67Ns	Transient ground–fault function, for transient and permanent ground faults in resonant–grounded or isolated networks	W0p,tr>	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Directional intermittent ground fault protection	Iie dir>	–	–	O	O	–	O	–	O	–	–	–	–	–	–	O	–	–	–
68	Power–swing blocking	” Z/” t	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	
74TC	Trip–circuit supervision	TCS	B	B	B	B	B	B	B	B	–	–	B	B	B	B	B	B	O	B
78	Out–of–step protection	” Z/” t	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–

B = basic
O = optional (additional price)
– = not available
1) via CFC

ANSI	Functions	Abbr.	7SD80	7SD610	7SJ82	7SJ80	7SJ61	7SJ62	7SJ63	7SJ64	7SJ45	7SJ46	7SJ600	7SJ602	7SR11	7SR12	7SK80	7UM62	7UT612	7VE6
79	Automatic reclosing	AR	O	O	O	O	O	O	O	O	–	–	O	O	O	O	–	–	–	–
81	Frequency protection	f<, f>	O	O	O	O	–	O	O	O	–	–	–	–	–	B	O	B	–	O
81O	Overfrequency protection	f>	O	O	O	O	–	O	O	O	–	–	–	–	–	B	O	B	–	O
81U	Underfrequency protection	f<	O	O	O	O	–	O	O	O	–	–	–	–	–	B	O	B	–	O
81R	Rate–of–frequency–change protection	df/dt	O	–	O	O	–	O	–	O	–	–	–	–	–	–	O	O	–	O
	Vector–jump protection	ΔÆ>	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	O
81LR	Load restoration	LR	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
85	Teleprotection		B	B	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
85 DT	Circuit–breaker intertripping scheme		B	B	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
86	Lockout		B	B	B	B	B	B	B	B	–	–	–	–	B	B	B	B	B	–
87	Differential protection	” I	B	B	O	–	–	–	–	–	–	–	–	–	–	–	–	B	B	–
87G	Differential protection, generator	” I	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	B	–
87T	Differential protection, transformer	” I	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	B	B	–
87B	Differential protection, busbar	” I	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	–
87M	Differential protection, motor	” I	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	B	–
87L	Differential protection, line	” I	B	B	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	–
87C	Differential protection, capacitor bank	” I	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
87N	Differential ground–fault protection	” I_N	B	O	O	O	O	O	O	O	–	–	–	O	O	O	–	O	O	–
87N T	Low impedance restricted ground–fault protection	” I_N	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	O	O	–
87N H	High impedance restricted ground–fault protection	” I_N	–	–	O	O	O	O	O	O	–	–	–	O	O	O	–	–	O	–
87N L	3I0 Differential protection	” 3I0	B	O	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–	–
87Ns L	Ground–fault differential protection for systems with resonant or isolated neutral	” I_{Nsens}	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	O	–
	Broken–wire detection for differential protection		B	B	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	–
90V	Automatic voltage control 2 winding transformer		–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
90V	Automatic voltage control 3 winding transformer		–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
90V	Automatic voltage control grid coupling transformer		–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
FL	Fault locator	FL	–	B	O	O	–	O	O	O	–	–	–	–	–	–	–	–	–	–

3.9 Medium Voltage Protective Devices

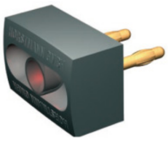
7SD61	**Differential protection relay for 2 line ends with 4–line display** The 7SD610 relay is a differential protection relay suitable for all kinds of applications, providing all functions required for the differential protection of lines, cables and transformers. Transformers and compensation coils within the differential protection zone are protected by integrated functions which were previously found in the differential protection of transformers only. Moreover, it is also well–suited for complex applications such as series and parallel compensation of lines and cables.
7SD80	**Line Differential Protection** The line differential protection SIPROTEC 7SD80 has been conceived for selective line protection of power cables and overhead lines up to 24km for all kind of starpoint configurations. The implemented phase comparison algorithm is a fast and stable method for line protection in industry and distribution grids. The protection interface communication is carried out directly without external equipment over copper wires, optical fibers or both in redundancy. The wide scope of non directional and directional functions can be applied miscellaneously as emergency functions as well as backup functions.
7SJ600	**Digital overcurrent, motor and overload protection relay** The SIPROTEC 7SJ600 is a numerical overcurrent protection relay which, in addition to its primary use in radial distribution networks and motor protection, also be employed as backup protection for feeder, transformer and generator differential protection.
7SJ602	**Multi–function overcurrent and motor protection relay** The SIPROTEC 7SJ602 is a numerical overcurrent protection relay which, in addition to its primary use in radial distribution networks and motor protection, can also be used as backup protection for the differential protection of lines, transformers and generators. The SIPROTEC 7SJ602 provides both definite–time and inverse–time overcurrent protection along with overload protection and protection against unbalanced loads (negative phase–sequence system) for a very comprehensive relay package.
7SJ63	**Multi–function protection relay** The SIPROTEC 4 7SJ63 can be used as protection relay for controlling and monitoring outgoing distribution feeders and transmission lines in at any voltage level in power systems which are characterized by an earthed, low–resistance earthed, non–earthed or a compensated neutral point topology. The relay is suitable for radial and looped networks and for lines with single or multi–terminal feeds. Regarding the time–overcurrent/directional time–overcurrent protection, its characteristics can either be definite time or inverse time or user–defined.
7SJ64	**Multi–function protection relay with synchronisation** The SIPROTEC 4 7SJ64 can be used as protection relay for controlling and monitoring outgoing distribution feeders and transmission lines at any voltage level in power systems which are characterized by an earthed, low–resistance earthed, non–earthed or a compensated neutral point topology. The relay is suitable for radial and looped networks and for lines with single or multi–terminal feeds. The SIPROTEC 4 7SJ64 is equipped with a synchronisation function which provides the operation modes 'synchronisation check' (classical) and 'synchronous/asynchronous switching' (which factors in the mechanical circuit–breaker delay). Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor, load jam protection as well as motor statistics.
7SJ80	**Multi–function protection relay** The SIPROTEC Compact 7SJ80 relays can be used for line/feeder protection of high and medium voltage networks with earthed, low–resistance earthed, isolated or a compensated neutral point. The relays have all the required functions to be applied as a backup protection to a transformer differential protection relay.
7SJ81	**Overcurrent Protection Relay** The SIPROTEC Compact 7SJ81 relays can be used for line/feeder protection of high and medium–voltage networks with grounded, low–resistance grounded isolated or a compensated neutral point. The relays have all the functionality to be applied as a backup relay to a transformer differential relay.
7SJ82	**Overcurrent Protection Device** The overcurrent protection device SIPROTEC 7SJ82 is a universal protection, control and automation device on the basis of the SIPROTEC 5 system. It is especially designed for the protection of branches and lines.

7SK80	**Motor Protection Relay** The SIPROTEC Compact 7SK80 is a multi–functional motor protection relay. It is designed for protection of asynchronous motors of all sizes. The relays have all the required functions to be applied as a backup relay to a transformer differential relay. The SIPROTEC Compact 7SK80 features “flexible protection functions”.
7SN60	**Transient earth–fault protection relay** The highly sensitive 7SN60 transient earth–fault relay determines the direction of transient and continuous earth faults in systems with isolated neutral, in systems with high–impedance resistive earthing and in compensated systems. Continuous earth faults are indicated with a delay, either in conjunction with a transient earth fault and subsequently persisting displacement voltage, or with just the displacement voltage present.
7SR11	**Overcurrent and Earth Fault protection** The 7SR11 series of relays provide overcurrent and earth fault protection. These relays are typically applied to provide the main protection on feeders and interconnectors and the back–up protection on items of plant such as transformers. On distribution system circuits overcurrent and earth fault protection is often the only protection installed.
7SR12	**Overcurrent and Earth Fault protection** The 7SR12 includes for directional control of the overcurrent and earth fault functionality and is typically installed where fault current can flow in either direction i.e. on interconnected systems.
7UM62	**Multi–function generator and motor protection relay** SIPROTEC 4 7UM62 protection relays can do more than just protect. They also provide numerous additional functions. Be it earth faults, short–circuits, overload, overvoltage, overfrequency or underfrequency asynchronous conditions, protection relays assure continued operation of power stations. The SIPROTEC 4 7UM62 protection relay is a compact unit which has been specially developed for the protection of small, medium–sized and large generators.
7UT612	**Differential protection relay for transformers, generators, motors and busbars** The SIPROTEC 7UT612 differential protection relay is used for fast and selective fault clearing of short–circuits in two winding transformers of all voltage levels and also in rotating electric machines like motors and generators, for short two–terminal lines and busbars up to 7 feeders.
7VE61	**Multi–function parallelling devices** The 7VE61 and 7VE63 parallelling devices of the SIPROTEC 4 family are multi–functional compact units used for parallelling power systems and generators.

For more information about these protection relays, please refer to:
www.siemens.com/protection

3.10 Capacitive Voltage Detector Systems

Voltage detector systems IEC /EN 61243–5 bzw. VDE 0682–415

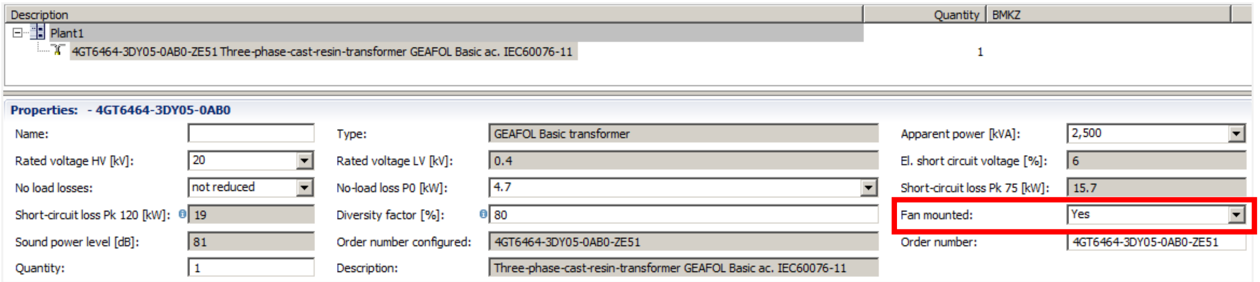
HR / LRM 	■ Pluggable voltage display unit ■ Isolation from supply tested phase by phase, plugging the unit into the proper socket pairs ■ Display unit is suitable for continuous duty ■ Safe to touch ■ Routine–tested ■ Measurement system and voltage display unit can be tested ■ Voltage display unit flashes, when high voltage is appplied
VOIS+ 	■ Integrated display ■ Display "A1" to "A3" – "A1": Operating voltage ready – "A2": Operating voltage not available – "A3": Phase failure in phase L1, e.g. earth fault, operating voltage present at L2 and L3 ■ No maintenance, repeat test required ■ Integrated 3–phase LRM measuring point for phase comparison
VOIS R+ 	■ Integrated display ■ Display "A1" to "A3" – "A1": Operating voltage ready – "A2": Operating voltage not available – "A3": Phase failure in phase L1, e.g. earth fault, operating voltage present at L2 and L3 ■ No maintenance, repeat test required ■ Integrated 3–phase LRM measuring point for phase comparison ■ Integrated signalling relay
WEGA 1.2 	■ Integrated display ■ No maintenance ■ Integrated repeat test of the interface (self–testing) ■ Integrated function test (without auxiliary power) by pressing the "Display Test" key ■ Integrated 3–phase LRM measuring point for phase comparison ■ Display "A1" to "A5" – "A1": Operating voltage ready – "A2": Operating voltage not available – "A3": Phase failure in phase L1, e.g. earth fault, operating voltage present at L2 and L3 – "A4": Voltage present. Shown in the range of 0.10...0.45 · U_n – "A5": Display of "Test" OK ■ Without auxiliary power ■ Without signalling relay

WEGA 2.2 	■ Integrated display ■ No maintenance ■ Integrated repeat test of the interface (self–testing) ■ Integrated function test (without auxiliary power) by pressing the "Display Test" key ■ Integrated 3–phase LRM measuring point for phase comparison ■ Display "A0" to "A6" – "A0": Operating voltage not available. Active zero–voltage display – "A1": Operating voltage ready – "A2": Auxiliary power not available – "A3": Phase failure in phase L1, e.g. earth fault, operating voltage present at L2 and L3 – "A4": Voltage present. Shown in the range of 0.10...0.45 · U_n – "A5": Display of "Test" OK – "A6": Display of "Test" OK ■ Signalling relay (integrated, auxiliary power required)
CAPDIS–S1+ 	■ No maintenance ■ Integrated display ■ Integrated repeat test of the interfaces (self–testing) ■ Integrated function test (without auxiliary power) by pressing the "Test" key ■ Integrated 3–phase LRM measuring point for phase comparison ■ Display "A1" to "A5" – "A1": Operating voltage ready – "A2": Operating voltage not available – "A3": Phase failure in phase L1, e.g. earth fault, operating voltage present at L2 and L3 – "A4": Voltage present. Shown in the range of 0.10...0.45 · U_n – "A5": Display of "Test" OK ■ Without auxiliary power ■ Without signalling relay (without auxiliary contacts)
CAPDIS–S2+ 	■ No maintenance ■ Integrated display ■ Integrated repeat test of the interfaces (self–testing) ■ Integrated function test (without auxiliary power) by pressing the "Test" key ■ Integrated 3–phase LRM measuring point for phase comparison ■ Display "A0" to "A6" – "A0": Operating voltage not available. Active zero–voltage display – "A1": Operating voltage ready – "A2": Auxiliary power not available – "A3": Phase failure in phase L1, e.g. earth fault, operating voltage present at L2 and L3 – "A4": Voltage present. Shown in the range of 0.10...0.45 · U_n – "A5": Display of "Test" OK – "A6": Display of ERROR, e.g. wire breakage or aux. power missing ■ Signalling relay (integrated, auxiliary power required)

3.11 Fans added to GEAFOL and GEAFOL basic transformers

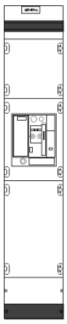
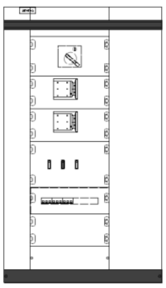
- Some of the GEAFOL transformers could be operated at a 40% higher output if a fan were added.
- Some of the GEAFOL basic transformers could be operated at a 20% higher output if a fan were added.

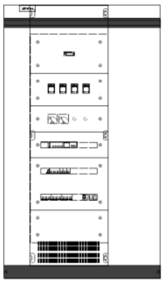
However, the "Fan added" property is not prompted when the transformer is created in step "1 Project Definition" → "B Create Project Structure", but can be selected in step "2 System Planning" as a property of the respective transformer.

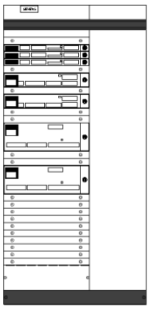


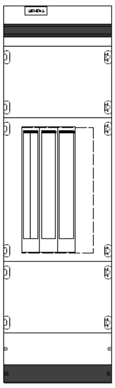
3.12 Technical Data for SIVACON S4 Low-voltage Switchboard

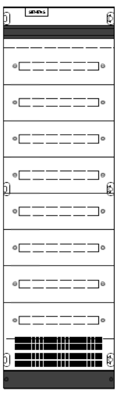
3.12.1 Cubicles

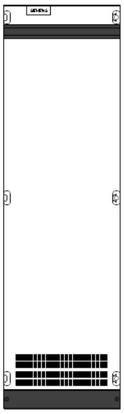
	Circuit–breaker design	
	Mounting design	Fixed–mounted, withdrawable–unit design
	Functions	Incoming/outgoing feeder, coupling
	Rated current I_n	max. 3,200 A
	Connection type	Top / Bottom
	Cubicle width [mm]	400 / 600 / 800 / 1,200
	Internal subdivision	Form 1, 2b, 3b, 4a, 4b
	Busbar position	At the top
	Fixed–mounting design with module doors	
	Mounting design	Withdrawable unit, fixed–mounted, socket with module doors
	Functions	Cable outlets
	Rated current I_n	max. 1,600 A
	Connection type	Front and rear side
	Cubicle width [mm]	1,200 / 1,600
	Internal subdivision	Form 1, 2b, 3b, 4a, 4b
	Busbar position	At the top

	Fixed–mounted design with cubicle door / front cover	
	Mounting design	Withdrawable unit, fixed–mounted, socket with front covers
	Functions	Cable outlets
	Rated current I_n	max. 1,600 A
	Connection type	Front and rear side
	Cubicle width [mm]	1,200 / 1,600
	Internal subdivision	Form 1, 2b, 3b, 4a, 4b
	Busbar position	At the top

	In–line design for horizontal in–line type switch disconnectors	
	Mounting design	Plug–in design
	Functions	Cable outlets
	Rated current I_n	max. 630 A
	Connection type	Front side
	Cubicle width [mm]	1,000 / 1,200
	Internal subdivision	Form 1, 3b, 4b
	Busbar position	At the top

	In–line design for vertical in–line type fuse switch disconnectors	
	Mounting design	Fixed mounting
	Functions	Cable outlets
	Rated current I_n	max. 630 A
	Connection type	Front side
	Cubicle width [mm]	600 / 800
	Internal subdivision	Form 1, 2b, 3b, 4a, 4b
	Busbar position	At the top

	Modular devices	
	Mounting design	Fixed mounting
	Functions	Modular devices
	Rated current I_n	max. 200A
	Connection type	Front side
	Cubicle width [mm]	600 / 800
	Internal subdivision	Form 1, 2b
	Busbar position	Top/without

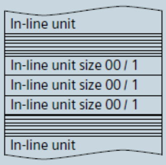
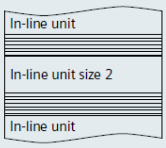
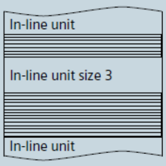
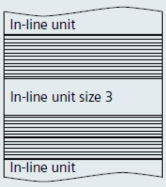
	Special cubicles	
	Mounting design	Mounting plate, 19“ guide frame
	Functions	Any design
	Cubicle width [mm]	400 / 600 / 800 /1,000 / 1,200 (mounting plate) 600 / 800 (19“ guide frame)
	Internal subdivision	Form 1, 2b
	Busbar position	Top/without (mounting plate) Without (19“ guide frame)

3.12.2 Cable Connection

Please check the cable connection options at the cubicles!

3.12.3 Component Mounting Rules for Vented Cubicles with 3- or 4-pole In-line Switch Disconnectors

- Component mounting in the cubicle from bottom to top and decreasing from size 3 to size 00
- Recommended maximum component density per cubicle incl. reserve approx. 2/3
- Distribute in–line switch disconnectors of size 2 and 3 to different cubicles, if possible
- Total operating current per cubicle max. 2,000 A
- Rated currents of component sizes = $\mathbf{0,8} \cdot I_n$ of the largest fuse–link
- Rated currents of smaller fuse–links in same size = $\mathbf{0,8} \cdot I_n$ of the fuse–link

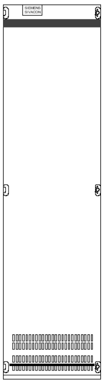
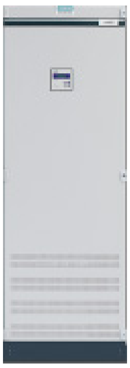
Size	Grouping	Blanking covers with vent slots	Example		
00 1	Summation current of the group ≤ 400 A	100 mm blanking cover below [1] the group		Nominal current fuse: 80 A 125 A 250 A Total:	Operating current: 64 A 100 A 200 A 364 A
2	Not permissible	50 mm blanking cover below [1] the in-line unit		Nominal current fuse: 400 A	Operating current: 320 A
3	Not permissible Operating current < 440 A	50 mm blanking cover above and 100 mm blanking cover below [1] the in-line unit		Nominal current fuse: 500 A	Operating current: 400 A
	Not permissible Operating current from 440 A to 500 A	100 mm blanking cover each above and below [1] the in-line unit		Nominal current fuse: 630 A	Operating current: 500 A

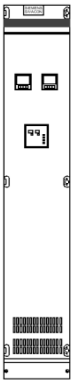
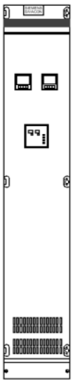
[1] Below the bottommost in-line unit, only 50 mm blanking cover instead of 100 mm blanking cover or no blanking cover instead of 50 mm blanking cover required

3.13 Technical Data of SIVACON S8 Low-voltage Switchgear

3.13.1 Cubicles

	Circuit–breaker design	
	Mounting technique	Fixed–mounted or withdrawable unit design
	Functions	System infeed, feeder, coupling
	Rated current I_n	max. 6,300 A
	Connection type	Front or rear side cables/ busbar trunking systems
	Cubicle width (mm)	400 / 600 / 800 / 1,000 / 1,400
	Internal separation:	Form 1, 2b, 3a, 4b, 4 Type 7 (BS)
	Busbar position:	Rear / top
	Universal mounting design	
	Mounting technique	Withdrawable unit design, fixed mounted with compartment doors, plug–in design
	Functions	Cable feeders, motor feeders (MCC)
	Rated current I_n	max. 630 A / max. 250 kW
	Connection type	Front and rear side
	Cubicle width (mm)	600 / 1,000 / 1,200
	Internal separation	Form 2b, 3b, 4a, 4b, 4 Type 7 (BS)
	Busbar position	Rear / top
	Fixed–mounted design	
	Mounting technique	Fixed–mounted design with front cover
	Functions	Cable feeders
	Rated current I_n	max. 630 A
	Connection type	Front–mounted
	Cubicle width (mm)	1,000 / 1,200
	Internal separation	Form 1, 2b, 3b, 4a, 4b
	Busbar position	Rear / top

	Frequency converters	
	Mounting technique	Fixed–mounted design with front cover
	Functions	Motor feeders with frequency converter
	Rated current I_n	max. 630 A / up to 250 kW
	Connection type	–
	Cubicle width (mm)	400 / 600 / 800 / 1,000
	Internal separation	Form 1, 2b
	Busbar position	Rear / none
	In–line design for switch disconnectors mounted horizontally in–line	
	Mounting technique	Plug–in design
	Functions	Cable feeders
	Rated current I_n	max. 630 A
	Connection type	Front–mounted
	Cubicle width (mm)	1,000 / 1,200
	Internal separation	Form 1, 3b, 4b
	Busbar position	rear / top
	In–line design for fuse switch disconnectors mounted vertically in–line	
	Mounting technique	Fixed–mounted devices
	Functions	Cable feeders
	Rated current I_n	max. 630 A
	Connection type	front–mounted
	Cubicle width (mm)	600 / 800 / 1,000
	Internal separation	Form 1, 2b
	Busbar position	Rear
	Reactive power compensation	
	Mounting technique	Fixed–mounted devices
	Functions	Central compensation of reactive power
	Rated current I_n	Non–choked up to 600 kvar / choked up to 500 kvar
	Connection type	Front–mounted
	Cubicle width (mm)	800
	Internal separation	Form 1, 2b
	Busbar position	Rear / top / none

	Network switching	
	Mounting technique	Fixed–mounted devices
	Functions	Completely equipped network switching cubicle for control of 2 ACB / MCCB for automatic / manual switchover between mains and equivalent power supply network
	Rated current I_n	–
	Connection type	–
	Cubicle width (mm)	400
	Internal separation	Form 2b
	Busbar position	Rear / top / none
	Central earthing point	
	Mounting technique	Fixed–mounted devices
	Functions	Central earthing point, usable for busbar systems L1, L3, PEN (insulated), PE
	Rated current I_n	–
	Connection type	–
	Cubicle width (mm)	200 / 600 / 1,000
	Internal separation	Form 2b
	Busbar position	Rear / top / none

3.13.2 Cable connection

Please check the cable connection options of the cables at the panels/cubicles!
Information can also be found in the section “Parallel cables in incoming and outgoing feeders in the SIVACON S8 system (low–voltage power distribution board)” of this manual.

3.13.3 Busbar Trunking Size for Connection Type "busbar trunking system for circuit-breaker design"

	Busbar trunking system – connection pieces for LD busbars with aluminium conductors – busbar amperage			
		IP34, horizontal	**IP34, vertical**	**IP54**
LDA<n>	LDA1	max. 1,100 A	max. 950 A	max. 900 A
	LDA2	max. 1,250 A	max. 1,100 A	max. 1,000 A
	LDA3	max. 1,600 A	max. 1,250 A	max. 1,200 A
	LDA4	max. 2,000 A	max. 1,700 A	max. 1,500 A
	LDA5	max. 2,500 A	max. 2,100 A	max. 1,800 A
	LDA6	max. 3,000 A	max. 2,300 A	max. 2,000 A
	LDA7	max. 3,700 A	max. 2,800 A	max. 2,400 A
	LDA8	max. 4,000 A	max. 3,400 A	max. 2,700 A

	Busbar trunking system – connection pieces for LD busbars with copper conductors – busbar amperage			
		IP34, horizontal	**IP34, vertical**	**IP54**
LDC<n>	LDC2	max. 2,000 A	max. 1,650 A	max. 1,600 A
	LDC3	max. 2,600 A	max. 2,100 A	max. 2,000 A
	LDC6	max. 3,400 A	max. 2,700 A	max. 2,600 A
	LDC7	max. 4,400 A	max. 3,500 A	max. 3,200 A
	LDC8	max. 5,000 A	max. 4,250 A	max. 3,600 A

	Busbar trunking system – connection pieces for LX busbars with aluminium conductors – busbar amperage	
LXA<n>	LXA01...	max. 800 A
	LXA02...	max. 1,000 A
	LXA04...	max. 1,250 A
	LXA05	max. 1,600 A
	LXA06	max. 2,000 A
	LXA07	max. 2,500 A
	LXA08...	max. 3,200 A
	LXA09...	max. 4,000 A
	LXA10...	max. 4,500 A

	Busbar trunking system – connection pieces for LX busbars with copper conductors – busbar amperage	
LXC<n>	LXC01...	max. 1,000 A
	LXA02...	max. 1,250 A
	LXA04...	max. 1,600 A
	LXA05	max. 2,000 A
	LXA06	max. 2,500 A
	LXA07	max. 3,200 A
	LXA08...	max. 4,000 A
	LXA09...	max. 5,000 A

	Busbar trunking system – connection pieces for LI busbars with aluminium conductors – busbar amperage	
LIA<n>	LIA1600	max. 1,600 A
	LIA2000	max. 2,000 A
	LIA2500	max. 2,500 A
	LIA3200	max. 3,200 A
	LIA4000	max. 4,000 A
	LIA5000	max. 5,000 A

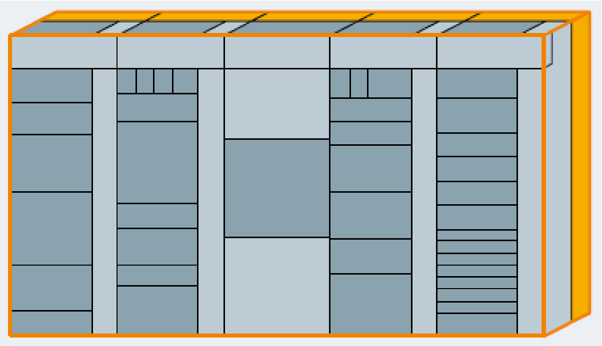
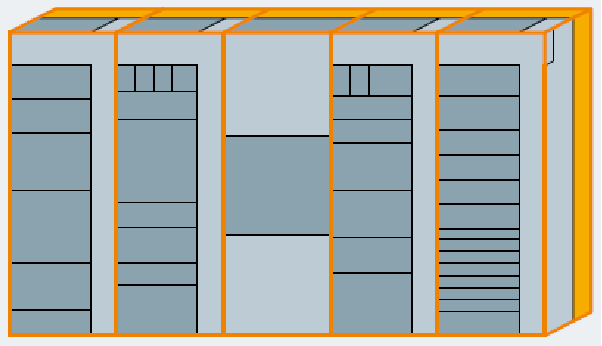
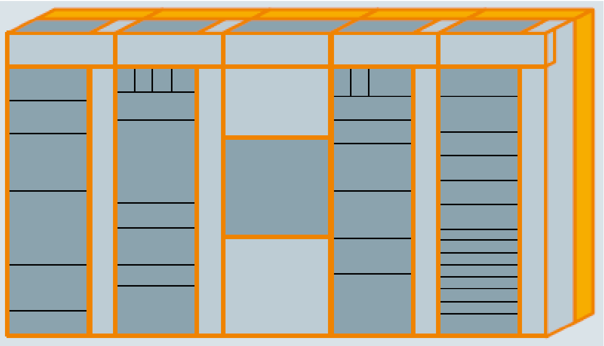
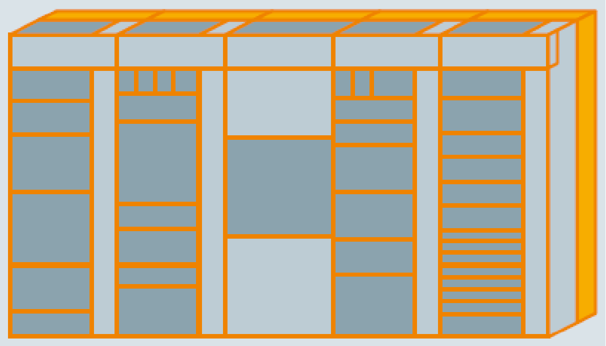
	Busbar trunking system – connection pieces for LI busbars with copper conductors – busbar amperage	
LIC<n>	LIC1600	max. 1,600 A
	LIC2000	max. 2,000 A
	LIC2500	max. 2,500 A
	LIC2000	max. 2,000 A
	LIC3200	max. 3,200 A
	LIC4000	max. 4,000 A
	LIC5000	max. 5,000 A
	LIC6300	max. 6,300 A

For SIVACON S8 low–voltage switchgear there are special busbar trunking connectors available. These busbar trunking connectors allow the connection of 3WL air circuit–breakers with the busbar trunking system. Therefore however it is necessary to have them installed as withdrawable unit in the switchgear.

3.13.4 Arcing Fault Levels

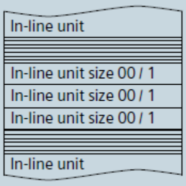
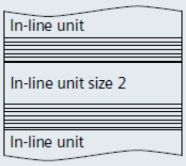
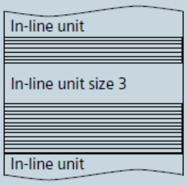
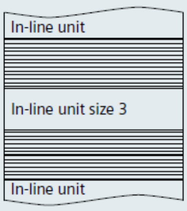
Arcing fault levels describe a classification based on the equipment properties under arcing fault conditions and the limitation of the effects of an arcing fault on the installation or parts thereof.

Testing of low–voltage switchgear under arcing fault conditions is a special test in compliance with IEC 61641 or VDE 0660 Part 500–2.

	**Level 1** Personal safety without limiting the effects of an internal arc within the switchgear as far as possible.
	**Level 2** Personal safety and limiting the effects of the internal arc to one panel/cubicle or one double–front unit.
	**Level 3** Personal safety and limiting the effects to the main busbar compartment in a panel/cubicle or double–front unit and the device or cable connection compartment.
	**Level 4** Personal safety and limiting the effects of the internal arc to the place of fault origin.

3.13.5 Equipment Rules for Ventilated Cubicles with 3- or 4-pole In-line Units

- Equipment in the cubicle from bottom to top, decreasing from size 3 to size 00
- Recommended maximum equipment per cubicle approximately 2/3 including reserve
- Distribute size 2 and 3 in–line units on different cubicles to the extent possible.
- Summation operational current per cubicle max. 2,000 A
- Rated currents of the devices sizes = $\mathbf{0.8} \cdot \boldsymbol{I_n}$ of the largest fuse link
- Rated currents of smaller fuse links of one size = $\mathbf{0.8} \cdot \boldsymbol{I_n}$ of the fuse link

Size	Grouping	Blanking covers with vent slots	Example		
00 1	Summation current of the group ≤ 400 A	100 mm blanking cover below [1] the group		Nominal current fuse: 80 A 125 A 250 A Total:	Operating current: 64 A 100 A 200 A 364 A
2	Not permissible	50 mm blanking cover below [1] the in-line unit		Nominal current fuse: 400 A	Operating current: 320 A
3	Not permissible Operating current < 440 A	50 mm blanking cover above and 100 mm blanking cover below [1] the in-line unit		Nominal current fuse: 500 A	Operating current: 400 A
	Not permissible Operating current from 440 A to 500 A	100 mm blanking cover each above and below [1] the in-line unit		Nominal current fuse: 630 A	Operating current: 500 A

[1] Below the bottommost in-line unit, only 50 mm blanking cover instead of 100 mm blanking cover or no blanking cover instead of 50 mm blanking cover required

3.13.6 Derating tables

3.13.6.1 Rated current for 3WL air circuit breakers (ACB)

Degree of protection		IP54 (Non–venti–lated)	IP3X, IP4X (Venti–lated)	IP54 (Non–venti–lated)	IP3X, IP4X (Venti–lated)	IP54 (Non–venti–lated)	IP3X, IP4X (Venti–lated)	IP54 (Non–venti–lated)	IP3X, IP4X (Venti–lated)
Busbar position		Rear							
Function		Incoming, outgoing feeder							
Cable/Busbar entry		Bottom				Top			
Type of connection		Cable, busbar		Cable		LD busbar		LX busbar	
Nominal current [A]	**Size**	Rated current at 35° [A]							
630	I	630	630	630	630				
800	I	800	800	800	800				
1000	I	1000	1000	1000	1000				
1250	I	1170	1250	1020	1190				
1600	I	1410	1600	1200	1360	1440	1550	1250	1410
2000	I	1500	1840	1480	1710	1590	1740	1310	1570
2000	II	1630	1920	1880	2000	1630	1920	1660	1970
2500	II	1950	2320	1830	2380	2130	2330	1940	2230
3200	II	2470	2920	1990	2480	2440	2660	2160	2530
4000	III	2700	3700	2430	3040	2750	3120	2700	3110
5000	III	3590	4440			3590	4440	3580	4490
6300	III	3710	4780					3710	4780

Degree of protection		IP54 (Non–ventilat-ed)	IP3X, IP4X (Ventilat-ed)	IP54 (Non–ventilat-ed)	IP3X, IP4X (Ventilat-ed)
Busbar position		Rear			
Function		Bus coupler, longitu-dinal		Bus coupler, trans-verse	
Nominal current [A]	**Size**	Rated current at 35° [A]			
630	I	630	630	630	630
800	I	800	800	800	800
1000	I	1000	1000	1000	1000
1250	I	1140	1250	1170	1250
1600	I	1360	1600	1410	1600
2000	I	1630	1910	1500	1840
2000	II	1710	2000	1630	1920
2500	II	1930	2440	1950	2320
3200	II	2410	2700	2470	2920
4000	III	2650	3510	2700	3700
5000	III	3310	4460		
6300	III	3300	5060		

Degree of protection		IP54 (Non–ventilat-ed)	IP3X, IP4X (Ventilat-ed)	IP54 (Non–ventilat-ed)	IP3X, IP4X (Ventilat-ed)	IP54 (Non–ventilat-ed)	IP3X, IP4X (Ventilat-ed)
Busbar position		**Top**					
Function		**Incoming, outgoing feeder**					
Cable/ Busbar entry		Bottom		Top			
Type of connection		Cable, busbar		LD busbar		X busbar	
Nominal current [A]	**Size**	**Rated current at 35° [A]**					
630	I	630	630				
800	I	800	800				
1000	I	930	1000				
1250	I	1160	1250				
1600	I	1200	1500	1420	1580	1360	1600
2000	I	1550	1780	1600	1790	1360	1630
2000	II	1630	2000	1630	2000	1630	2000
2500	II	1960	2360	2030	2330	1820	2310
3200	II	2240	2680	2420	2720	2090	2640
4000	III	2600	3660	2980	3570	3480	3820
5000	III	3830	4450	3860	4460	3830	4450
6300	III	4060	4890			4530	5440

Degree of protection		IP54 (Non–ventilated)	IP3X, IP4X (Ven-tilated)
Busbar position		Rear	
Function		Bus coupler, longitudinal	
Nominal current [A]	**Size**	Rated current at 35° [A]	
630	I	630	630
800	I	800	800
1000	I	930	1000
1250	I	1160	1250
1600	I	1390	1600
2000	I	1500	1850
2000	II	1630	1930
2500	II	1960	2360
3200	II	2200	2700
4000	III	2840	3670
5000	III	3660	4720
6300	III	3920	5180

3.13.6.2 Rated current for 3WT air circuit breakers (ACB)

Degree of protection		IP54 (Non–ventilat-ed)	IP3X, IP4X (Ventilat-ed)	IP54 (Non–ventilat-ed)	IP3X, IP4X (Ventilat-ed)
Busbar position		Rear			
Function		Incoming, outgoing feeder			
Cable/ Busbar entry		Bottom		Top	
Type of connection		Cable, busbar			
Nominal current [A]	**Size**	Rated current at 35° [A]			
630	I	630	630	630	630
800	I	800	800	800	800
1000	I	1000	1000	915	1000
1250	I	1160	1250	1060	1250
1600	I	1500	1600	1220	1370
2000	II	1710	1980	1710	1980
2500	II	2030	2400	1930	2210
3200	II	2290	2690	2020	2340

Degree of protection		IP54 (Non–ventilat-ed)	IP3X, IP4X (Ventilat-ed)	IP54 (Non–ventilat-ed)	IP3X, IP4X (Ventilat-ed)
Busbar position		Rear			
Function		Bus coupler, longitu-dinal		Bus coupler, trans-verse	
Nominal current [A]	**Size**	Rated current at 35° [A]			
630	I	630	630	630	630
800	I	800	800	800	800
1000	I	1000	1000	1000	1000
1250	I	1230	1250	1160	1250
1600	I	1430	1640	1500	1600
2000	II	1660	1950	1710	1980
2500	II	2180	2460	2030	2400
3200	II	2290	2690	2290	2690

Degree of protection		IP54 (Non–ventilated)	IP3X, IP4X (Ventilated)
Busbar position		Top	
Function		Incoming, outgoing feeder	
Cable/ Busbar entry		Bottom	
Type of connection		Cable, busbar	
Nominal current [A]	**Size**	Rated current at 35° [A]	
630	I	630	630
800	I	800	800
1000	I	860	1000
1250	I	995	1250
1600	I	1350	1590
2000	II	1440	1810
2500	II	1760	2200
3200	II	2000	2390

Degree of protection		IP54 (Non–ventilated)	IP3X, IP4X (Ventilated)
Busbar position		Rear	
Function		Bus coupler, longitudinal	
Nominal current [A]	**Size**	Rated current at 35° [A]	
630	I	630	630
800	I	800	800
1000	I	860	1000
1250	I	995	1250
1600	I	1420	1600
2000	II	1440	1810
2500	II	1760	2200
3200	II	1980	2380

3.13.6.3 Rated current for 3VL moulded-case circuit breakers (MCCB) (single cubicle)

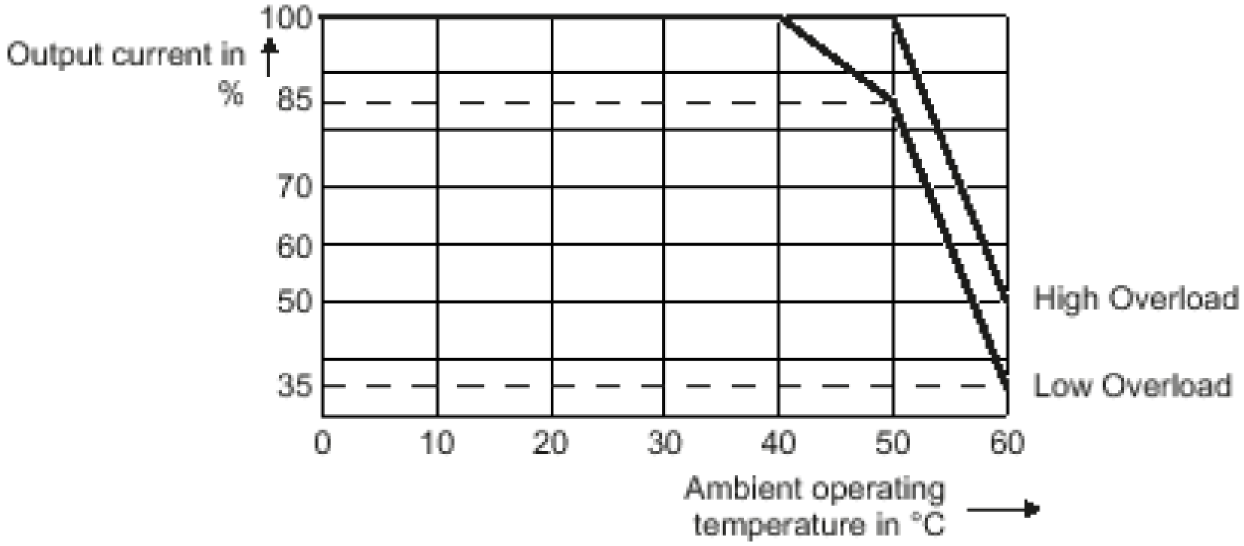
Degree of protection	IP54 (Non–ventilated)	IP3X, IP4X (Ventilated)	IP54 (Non–ventilated)	IP3X, IP4X (Ventilated)
Busbar position	Rear			
Function	Incoming, outgoing feeder			
Cable/ Busbar entry	Bottom		Top	
Type of connection	Cable		Cable	
Nominal current [A]	Rated current at 35° [A]			
630	515	570	475	520
800	655	720	605	660
1250	890	1100	775	980
1600	1050	1200	915	1070

Degree of protection	IP54 (Non–ventilated)	IP3X, IP4X (Ventilated)
Busbar position	Top	
Function	Incoming, outgoing feeder	
Cable/ Busbar entry	Bottom	
Type of connection	Cable	
Nominal current [A]	Rated current at 35° [A]	
630	540	570
800	685	720
1250	890	1100
1600	900	1100

3.13.7 Frequency converters

3.13.7.1 Built-in units

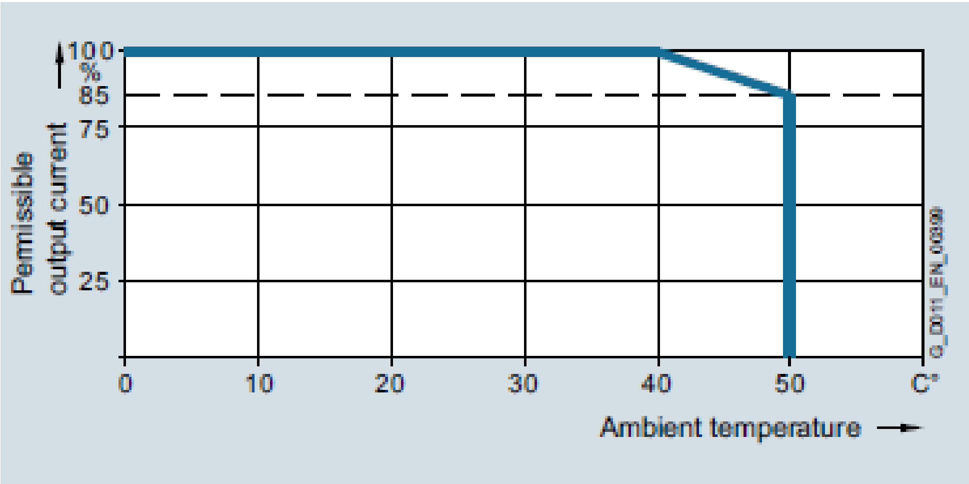
Allowed output current depending on the ambient operation temperature of the converter (valid until 1000m above NN):



Ambient operating temperature = temperature within the cubicle

3.13.7.2 Frequency converter (Cabinet units for application "pumping, ventilating, compressing")

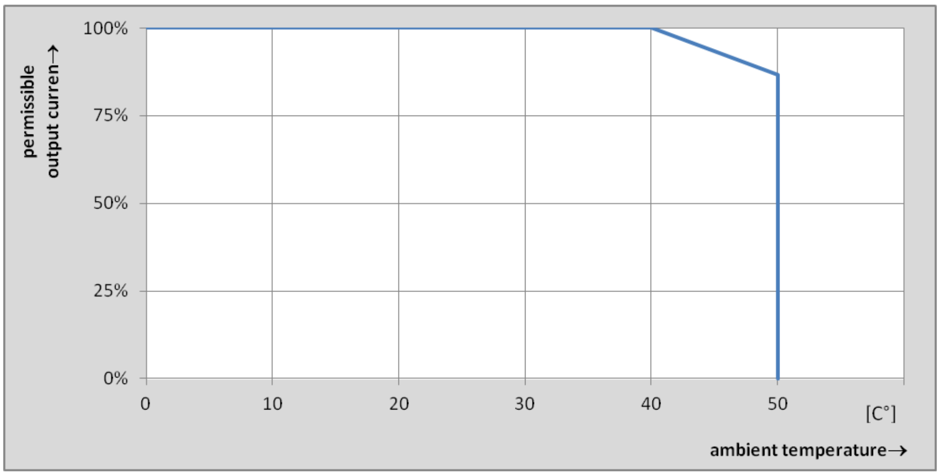
Permissible output current depending on the ambient operation temperature of the converter (valid until 1000m above NN):



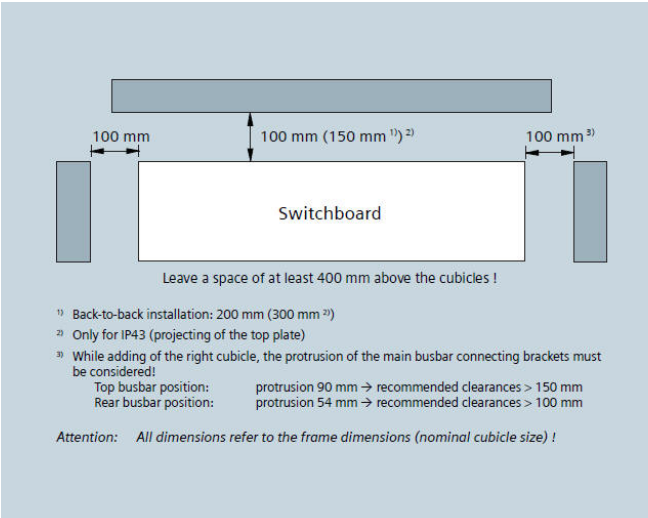
Ambient temperature = temperature within the cubicle

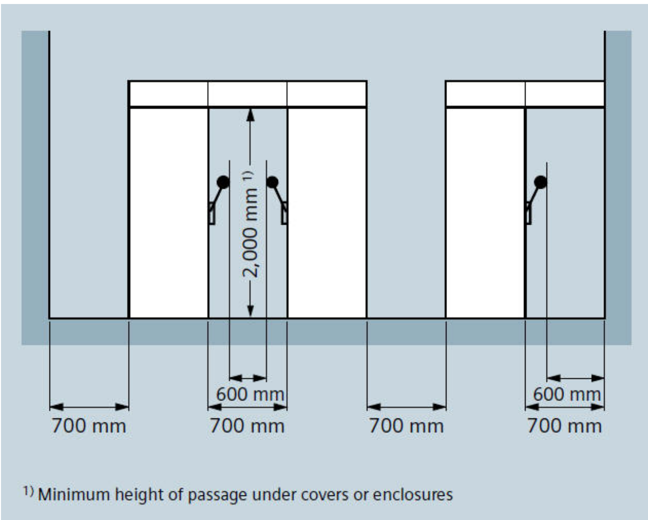
3.13.7.3 Frequency converter (Cabinet units for application "moving" and "processing")

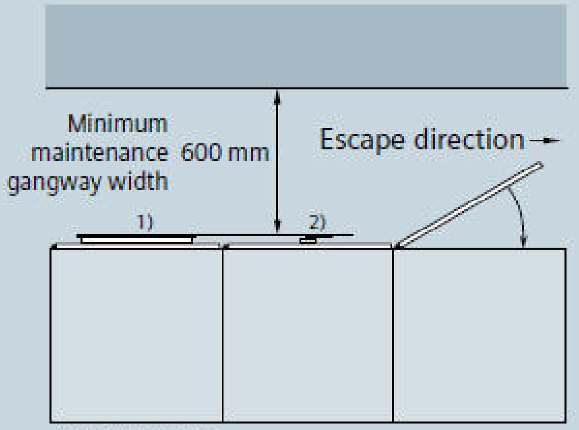
Permissible output current depending on the ambient operation temperature of the converter (valid until 2000m above NN):



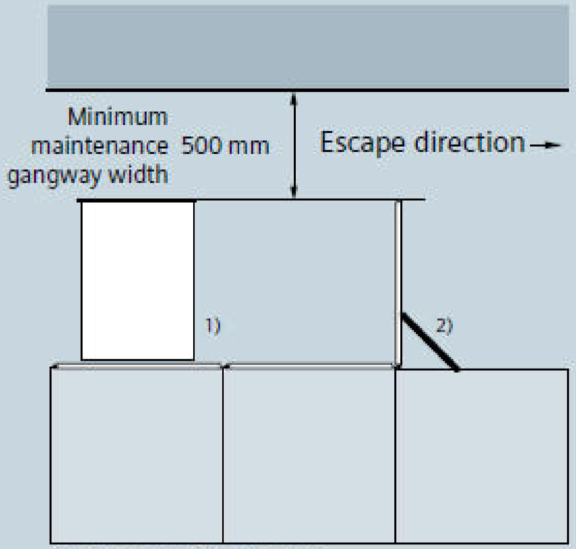
3.13.8 Installation – clearances and gangway width



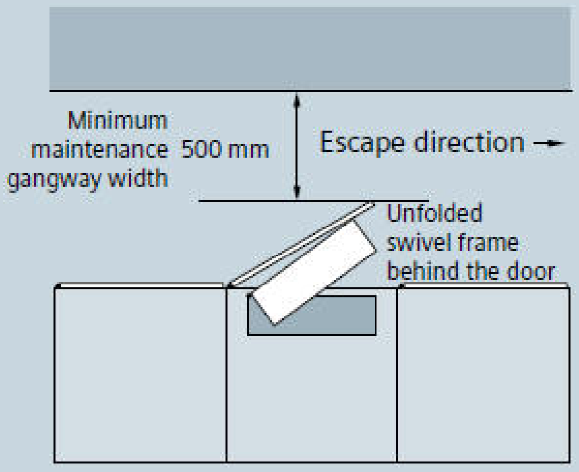




[1] Circuit-breaker in the "completely extracted and isolated" position
[2] Handles (e.g. for controls or equipment)

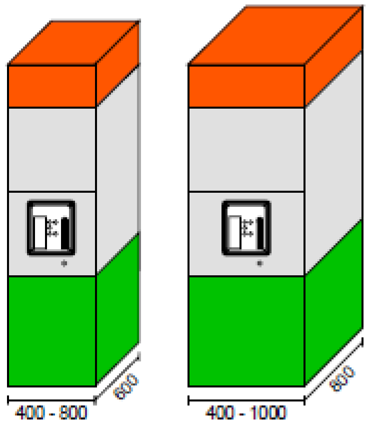


[1] Circuit breaker fully withdrawn
[2] Door fixed in open position

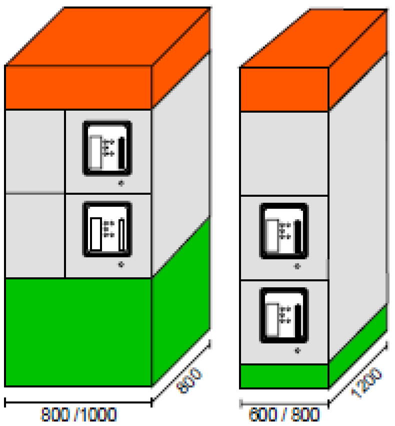


3.14 Technical Data of SIVACON 8PT Low-voltage Switchgear (only for China)

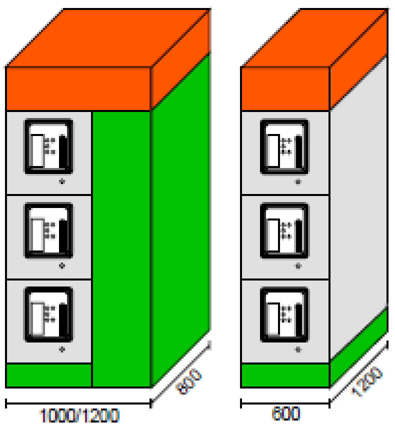
3.14.1 Cubicles



	Circuit breaker system for 1 circuit breaker
Installation systems:	Fixed–mounted design, Withdrawable design
Functions:	Supply, Feeder, Coupling
Rated current I_n:	up to 6,300 A
Connection position:	front or rear Cable / busbar trunking system
Section width (mm):	400 / 600 / 800 / 1,000
Internal separation:	Form 1, 2b, 3a, 4b
Busbar position:	top

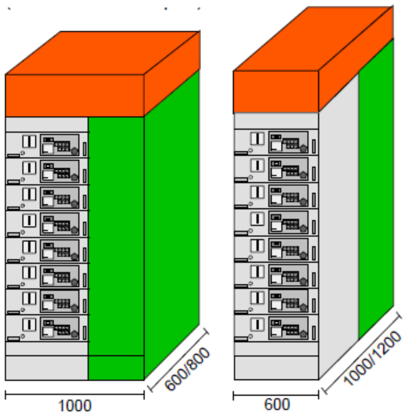


	Circuit breaker system for 2 circuit breaker
Installation systems:	Fixed–mounted design, Withdrawable design
Functions:	Supply, Feeder, Coupling
Rated current I_n:	2,000 / 2,500 A
Connection position:	front or rear Cable / busbar trunking system
Section width (mm):	600 / 800 / 1,000
Internal separation:	Form 1, 3a
Busbar position:	top



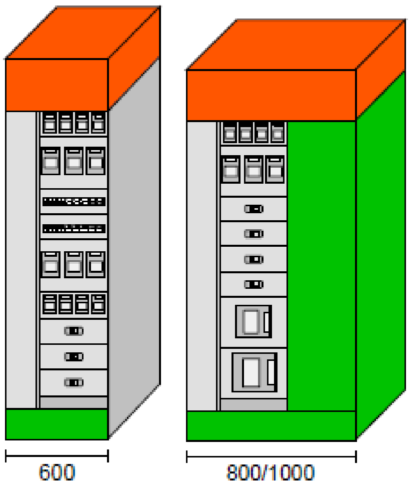
	Circuit breaker system for 3 circuit breaker
Installation systems:	Fixed–mounted design, Withdrawable design
Functions:	Supply, Feeder
Rated current I_n:	up to 1,600 A
Connection position:	front or rear Cable / busbar trunking system
Section width (mm):	600 /1,000 / 1,200
Internal separation:	Form 1, 3a
Busbar position:	top

Withdrawable unit design with front doors



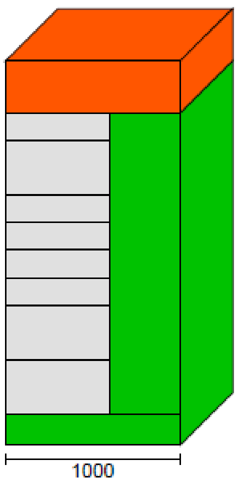
Installation systems:	Withdrawable unit design with front doors
Functions:	Cable feeders, Motor feeders (MCC)
Rated current I_n:	up to 630 A
Connection position:	front or side right
Section width (mm):	600 / 1,000
Internal separation:	Form 3b, 4b
Busbar position:	top

Fixed–mounted design with front covers OFF1



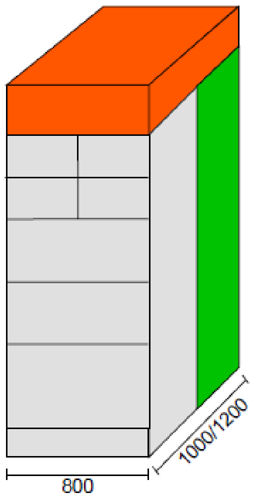
Installation systems:	Fixed–mounted or plug–in design with front covers
Functions:	Cable feeders
Rated current I_n:	up to 630 A
Connection position:	front or side right
Section width (mm):	600 / 800 / 1,000
Internal separation:	Form 1, 2b
Busbar position:	top

Fixed–mounted design with front doors, connection right, OFF2



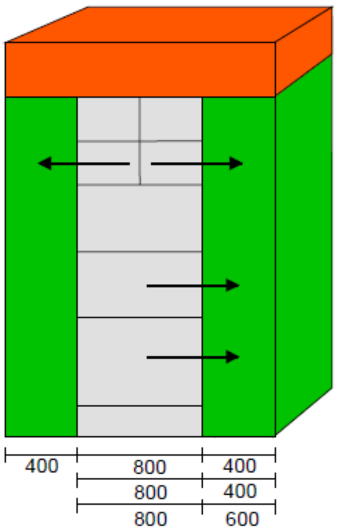
Installation systems:	Fixed–mounted or plug–in design with front doors
Functions:	Cable feeders
Rated current I_n:	up to 630 A
Connection position:	side right
Section width (mm):	1,000
Internal separation:	Form 4a
Busbar position:	top

Fixed–mounted design with front doors, connection rear, OFF3



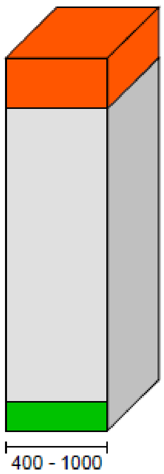
Installation systems:	Fixed–mounted or plug–in design with front doors
Functions:	Cable feeders
Rated current I_n:	up to 630 A
Connection position:	rear
Section width (mm):	800
Internal separation:	Form 3b, 4b (type 5 and 7 acc. BS EN 60439 possible
Busbar position:	top

Fixed–mounted design with front doors, connection right/right and left, OFF4



Installation systems:	Fixed–mounted or plug–in design with front doors
Functions:	Cable feeders
Rated current I_n:	up to 630 A
Connection position:	right or right and left
Section width (mm):	1,200 / 1,400 / 1,600
Internal separation:	Form 3b, 4b (type 5 and 7 acc. BS EN 60439 possible
Busbar position:	top

Cubicles for customised solutions



Installation systems:	Fixed–mounted design
Functions:	Mounting plates and devices for control task
Rated current I_n:	up to 1,200 A (for busbar)
Connection position:	front
Section width (mm):	400 / 600 / 800 / 1000
Internal separation:	Form 1, 2b
Cubicle bus system:	without, rear
Busbar position:	top

Cable connection
Please check the connection of cables to the fields!

3.14.2 Derating tables

3.14.2.1 Rated Currents for 1 Circuit-breaker/Cubicle with 3WT

Rated currents I_n as a function of ambient temperature														3WT	
Incoming feeder or outgoing feeder function															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	35° [A]	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	35° [A]	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
630	630	630	630	630	630	630	630	630	630	630	630	630	630	3WT806	630
800	800	800	800	800	800	800	800	800	800	800	800	800	800	3WT808	800
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	3WT810	1000
1250	1250	1250	1250	1250	1220	1180	1250	1250	1250	1250	1250	1250	1250	3WT812	1250
1600	1600	1580	1540	1500	1450	1410	1600	1600	1600	1600	1600	1600	1590	3WT816	1600
2000	2000	2000	2000	2000	1950	1890	2000	2000	2000	2000	2000	2000	2000	3WT820	2000
2500	2500	2450	2390	2330	2260	2190	2500	2500	2500	2500	2500	2500	2490	3WT825	2500
2750	2690	2620	2560	2490	2420	2340	3150	3070	3000	2920	2850	2770	2680	3WT832	3200

Rated currents I_n as a function of ambient temperature														3WT	
Coupling function Non–ventilated															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
630	630	630	630	630	630	630	630	630	630	630	630	630	630	3WT806	630
800	800	800	800	800	800	800	800	800	800	800	800	800	800	3WT808	800
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	3WT810	1000
1250	1250	1250	1250	1220	1190	1150	1250	1250	1250	1250	1250	1250	1250	3WT812	1250
1590	1540	1490	1440	1390	1340	1280	1600	1600	1600	1600	1600	1580	1520	3WT816	1600
2000	2000	2000	2000	2000	1950	1890	2000	2000	2000	2000	2000	2000	2000	3WT820	2000
2500	2500	2480	2420	2350	2290	2220	2500	2500	2500	2500	2500	2500	2460	3WT825	2500
2590	2530	2470	2400	2340	2270	2210	3000	2930	2860	2790	2710	2640	2560	3WT832	3200

3.14.2.2 Rated Currents for 2 Circuit-breakers/Cubicle with 3WT

With cubicle type 2 ACB/cubicle the rated currents are specified according the installation position of the circuit–breaker.

Rated currents I_n as a function of ambient temperature														3WT	
Incoming feeder or outgoing feeder or coupling function															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
Installation position top															
1790	1750	1710	**1660**	1620	1570	1530	2000	2000	2000	**2000**	1990	1940	1880	3WT820	2000
2060	2010	1960	**1910**	1860	1810	1750	2470	2410	2350	**2290**	2230	2170	2100	3WT825	2500
Installation position below															
1910	1870	1820	**1770**	1730	1680	1630	2000	2000	2000	**2000**	1970	1920	1860	3WT820	2000
2280	2220	2170	**2120**	2060	2000	1940	2500	2500	2500	**2500**	2490	2420	2350	3WT825	2500

3.14.2.3 Rated Currents for 3 Circuit-breakers/Cubicle with 3WT

With cubicle type 3 ACB/cubicle the rated currents are specified according the installation position of the circuit–breaker.

ATTENTION: Consider the rated current of the vertical busbars while projecting the cubicle!

Rated currents I_n with **vertical busbars** as a function of ambient temperature														Installation position
Non–ventilated							Ventilated							
20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	
3175	3100	3025	**2950**	2870	2790	2705	4090	3995	3900	**3800**	3700	3595	3485	Σ below, middle, top
2260	2210	2155	**2100**	2045	1985	1925	2905	2840	2770	**2700**	2630	2555	2480	Σ below, middle

Rated currents I_n as a function of ambient temperature														**3WT**	
Installation position optional															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
630	630	630	**630**	630	630	600	630	630	630	**630**	630	630	630	3WT806	630
800	800	800	**800**	800	780	750	800	800	800	**800**	800	795	765	3WT808	800
1000	1000	1000	**1000**	1000	1000	1000	1000	1000	1000	**1000**	1000	1000	1000	3WT810	1000
Installation position top															
1160	1135	1110	**1080**	1050	1020	990	1250	1250	1250	**1250**	1215	1180	1145	3WT812	1250
1160	1135	1110	**1080**	1050	1020	990	1345	1315	1280	**1250**	1215	1180	1145	3WT816	1600
Installation position middle															
1185	1155	1130	**1100**	1070	1040	1010	1250	1250	1250	**1250**	1250	1250	1250	3WT812	1250
1185	1155	1130	**1100**	1070	1040	1010	1455	1420	1385	**1350**	1315	1275	1240	3WT816	1600
Installation position below															
1345	1315	1280	**1250**	1215	1180	1145	1345	1315	1280	**1250**	1215	1180	1145	3WT812	1250
1505	1470	1435	**1400**	1365	1325	1285	1600	1600	1600	**1600**	1555	1515	1470	3WT816	1600

3.14.2.4 Rated Currents for 1 Circuit-breaker/Cubicle with 3WL

Rated currents I_n depending on ambient temperature														3WL	
Function incoming supply or outgoing feeder															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
630	630	630	**630**	630	630	630	630	630	630	**630**	630	630	630	3WL1106	630
800	800	800	**800**	800	800	800	800	800	800	**800**	800	800	800	3WL1108	800
1000	1000	980	**955**	930	900	875	1000	1000	1000	**1000**	1000	1000	1000	3WL1110	1000
1250	1220	1190	**1160**	1130	1100	1060	1250	1250	1250	**1250**	1250	1250	1240	3WL1112	1250
1580	1550	1510	**1470**	1430	1390	1350	1600	1600	1600	**1600**	1600	1600	1600	3WL1116	1600
1910	1870	1830	**1780**	1730	1680	1630	2000	2000	2000	**2000**	2000	1950	1890	3WL1220	2000
1250	1220	1190	**1160**	1130	1100	1060	1250	1250	1250	**1250**	1250	1250	1240	3WL1112	1250
1580	1550	1510	**1470**	1430	1390	1350	1600	1600	1600	**1600**	1600	1600	1600	3WL1116	1600
1910	1870	1830	**1780**	1730	1680	1630	2000	2000	2000	**2000**	2000	1950	1890	3WL1220	2000
2210	2160	2100	**2050**	2000	1940	1880	2500	2500	2500	**2440**	2380	2310	2240	3WL1225	2500
2530	2470	2410	**2350**	2290	2220	2160	3010	2940	2870	**2800**	2720	2650	2570	3WL1232	3200
3760	3680	3590	**3500**	3400	3310	3210	4000	4000	4000	**4000**	4000	3930	3810	3WL1340	4000
3860	3770	3680	**3590**	3490	3400	3290	4740	4630	4520	**4400**	4280	4160	4040	3WL1350	5000
4860	4750	4630	**4520**	4390	4270	4140	5720	5610	5500	**5390**	5280	5160	5040	3WL1363	6300

Rated currents I_n depending on ambient temperature														3WL	
Function longitudinal coupler															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
630	630	630	**630**	630	630	630	630	630	630	**630**	630	630	630	3WL1106	630
800	800	800	**800**	800	785	760	800	800	800	**800**	800	800	800	3WL1108	800
895	875	850	**830**	810	785	760	1000	1000	1000	**1000**	1000	1000	995	3WL1110	1000
1180	1160	1130	**1100**	1070	1040	1010	1250	1250	1250	**1250**	1250	1250	1250	3WL1112	1250
1540	1510	1470	**1430**	1390	1360	1310	1600	1600	1600	**1600**	1600	1600	1590	3WL1116	1600
2000	1980	1920	**1850**	1780	1710	1640	2000	2000	2000	**2000**	2000	2000	1970	3WL1220	2000
2280	2210	2140	**2070**	1990	1910	1830	2500	2500	2500	**2480**	2390	2300	2200	3WL1225	2500
2470	2400	2320	**2240**	2160	2080	1990	3140	3050	2950	**2850**	2750	2640	2530	3WL1232	3200
3510	3430	3350	**3270**	3180	3090	3000	4200	4100	4000	**3900**	3800	3690	3580	3WL1340	4000
3790	3700	3610	**3520**	3430	3330	3230	4980	4870	4750	**4630**	4510	4380	4250	3WL1350	5000
4570	4460	4350	**4240**	4130	4010	3890	5570	5440	5310	**5180**	5040	4900	4750	3WL1363	6300

3.14.2.5 Rated currents for 2 Circuit-breakers/Cubicle with 3WL, Rear Connection

With cubicle type 2 ACB/cubicle the rated currents are specified according to the installation position of the circuit–breaker.

ATTENTION: max. $I_{cw} = 65\ kA$, 1s at cable connection rear

Rated currents I_n depending on ambient temperature														**3WL**	
Function incoming feeder or outgoing feeder															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
Installation position top															
1870	1830	1790	**1740**	1690	1650	1600	1960	1910	1870	**1820**	1770	1720	1670	3WL1220	2000
1930	1870	1810	**1750**	1690	1620	1550	2270	2200	2130	**2060**	1990	1910	1830	3WL1225	2500
Installation position below															
1760	1760	1760	**1760**	1710	1660	1620	1840	1840	1840	**1840**	1790	1740	1690	3WL1220	2000
2200	2200	2200	**2200**	2140	2080	2020	2310	2310	2310	**2310**	2250	2190	2120	3WL1225	2500

Rated currents I_n depending on ambient temperature														**3WL**	
Function incoming feeder or outgoing feeder and coupler															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35°** [A]	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
Installation position top (coupler)															
1780	1740	1700	**1650**	1610	1570	1520	1860	1810	1780	**1730**	1680	1630	1590	3WL1220	2000
1830	1780	1720	**1660**	1610	1540	1470	2160	2090	2020	**1960**	1890	1810	1740	3WL1225	2500
Installation position below (incoming feeder or outgoing feeder)															
1670	1670	1670	**1670**	1620	1580	1540	1750	1750	1750	**1750**	1700	1650	1610	3WL1220	2000
2090	2090	2090	**2090**	2030	1980	1920	2190	2190	2190	**2190**	2140	2080	2010	3WL1225	2500

3.14.2.6 Rated Currents for 2 Circuit-breakers/Cubicle with 3WL, Front Connection

With cubicle type 2 ACB/cubicle the rated currents are specified according to the installation position of the circuit–breaker.

Rated currents I_n depending on ambient temperature														3WL	
Function incoming feeder or outgoing feeder															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
Installation position top															
1380	1340	1310	**1270**	1240	1210	1170	1890	1840	1800	**1760**	1710	1660	1610	3WL1220	2000
1380	1340	1310	**1270**	1240	1210	1170	2090	2040	2000	**1940**	1890	1830	1790	3WL1225	2500
Installation position below															
1380	1380	1380	**1380**	1340	1300	1260	1770	1770	1770	**1770**	1720	1670	1620	3WL1220	2000
1720	1720	1720	**1720**	1670	1620	1580	2210	2210	2210	**2210**	2160	2090	2030	3WL1225	2500

Rated currents I_n depending on ambient temperature														3WL	
Function incoming feeder or outgoing feeder and coupler															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
Installation position top (coupler)															
1450	1410	1380	**1340**	1310	1270	1230	1990	1940	1890	**1850**	1800	1750	1690	3WL1220	2000
1450	1410	1380	**1340**	1310	1270	1230	2200	2150	2100	**2040**	1990	1930	1880	3WL1225	2500
Installation position below (incoming feeder or outgoing feeder)															
1450	1450	1450	**1450**	1410	1370	1330	1860	1860	1860	**1860**	1810	1760	1710	3WL1220	2000
1810	1810	1810	**1810**	1760	1710	1660	2330	2330	2330	**2330**	2270	2200	2140	3WL1225	2500

3WL1220 operated alone:
I_n = 2000 A, applies for incoming feeder, outgoing feeder and coupling, ventilated and non–ventilated

3WL1225 operated alone:
I_n = 2500 A, applies for incoming feeder, outgoing feeder and coupling, ventilated

3.14.2.7 Rated Currents for 3 Circuit-breakers/Cubicle with 3WL

No test results are available for 3WL yet; the rated currents were taken over from 3WN

With cubicle type 3 ACB/cubicle the rated currents are specified according the installation position of the circuit–breaker.

ATTENTION: Consider the rated current of the vertical busbars while projecting the cubicle!

Rated currents I_n with **vertical busbars** as a function of ambient temperature														Installation position
Non–ventilated							Ventilated							
20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	
3175	3100	3025	**2950**	2870	2790	2705	4090	3995	3900	**3800**	3700	3595	3485	Σ below, middle, top
2260	2210	2155	**2100**	2045	1985	1925	2905	2840	2770	**2700**	2630	2555	2480	Σ below, middle

Rated currents I_n as a function of ambient temperature														**3WL**	
Installation position optional															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
630	630	630	**630**	630	630	600	630	630	630	**630**	630	630	630	3WL1106	630
800	800	800	**800**	800	780	750	800	800	800	**800**	800	795	765	3WL1108	800
1000	1000	1000	**1000**	1000	1000	1000	1000	1000	1000	**1000**	1000	1000	1000	3WL1110	1000
Installation position top															
1160	1135	1110	**1080**	1050	1020	990	1250	1250	1250	**1250**	1215	1180	1145	3WL1112	1250
1160	1135	1110	**1080**	1050	1020	990	1345	1315	1280	**1250**	1215	1180	1145	3WL1116	1600
Installation position middle															
1185	1155	1130	**1100**	1070	1040	1010	1250	1250	1250	**1250**	1250	1250	1250	3WL1112	1250
1185	1155	1130	**1100**	1070	1040	1010	1455	1420	1385	**1350**	1315	1275	1240	3WN1116	1600
Installation position below															
1345	1315	1280	**1250**	1215	1180	1145	1345	1315	1280	**1250**	1215	1180	1145	3WL1112	1250
1505	1470	1435	**1400**	1365	1325	1285	1600	1600	1600	**1600**	1555	1515	1470	3WL1116	1600

3.14.2.8 Rated Currents for 1 Circuit-breaker/Cubicle with 3VL

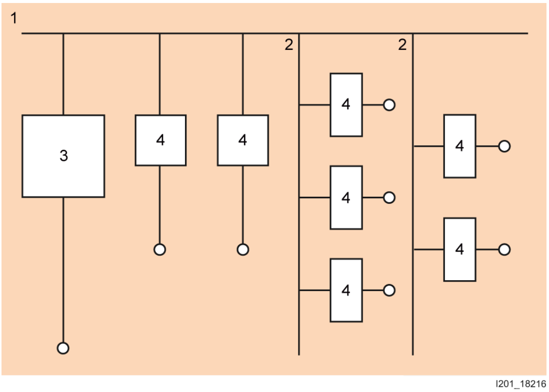
Rated currents I_n depending on ambient temperature														**3VL**	
Function incoming feeder or outgoing feeder															
Non–ventilated							Ventilated								
20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	20° [A]	25° [A]	30° [A]	**35° [A]**	40° [A]	45° [A]	50° [A]	Type	Rated current [A]
560	545	525	**510**	490	470	450	630	630	610	**590**	570	545	525	3VL5763	630
690	670	650	**630**	605	580	555	800	800	780	**755**	730	700	670	3VL6780	800
1190	1150	1120	**1080**	1040	1000	955	1220	1180	1140	**1100**	1060	1020	980	3VL7712	1250
1260	1220	1180	**1140**	1100	1060	1010	1380	1340	1300	**1260**	1210	1160	1110	3VL8716	1600

3.15 Forms of Internal Separation in Low-voltage Switchgear Cabinets (Forms 1–4)

Protection Targets acc. to 61 439–1

- Protection against contact with live parts in the adjacent functional units. The degree of protection must be at least IPXXB.
- Protection against ingress of foreign bodies from one functional unit of the switchgear and controlgear assembly into an adjacent one. The degree of protection must be at least IP2X.

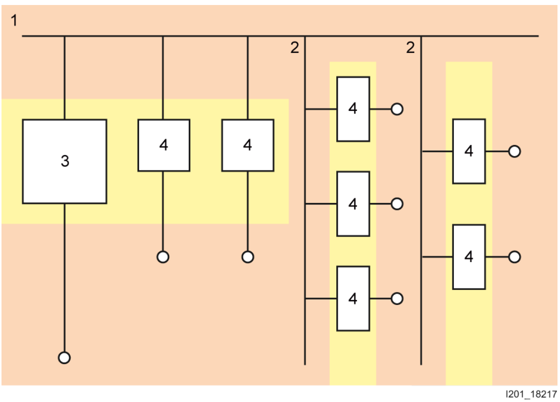
Form 1 | **No Internal separation**



Form 2 | **Compartmentalisation between busbars and functional units**

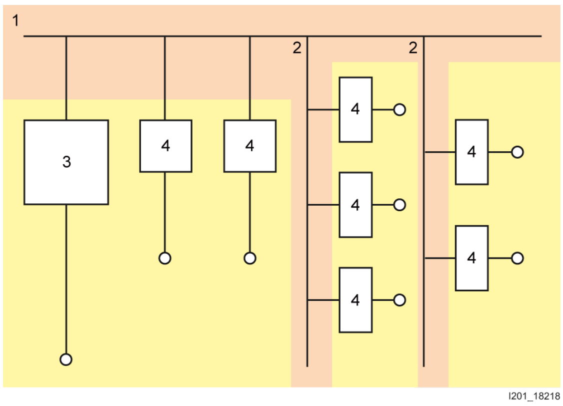
Form 2a

- No compartmentalisation between terminals and busbars



Form 2b

- Compartmentalisation between terminals and busbars

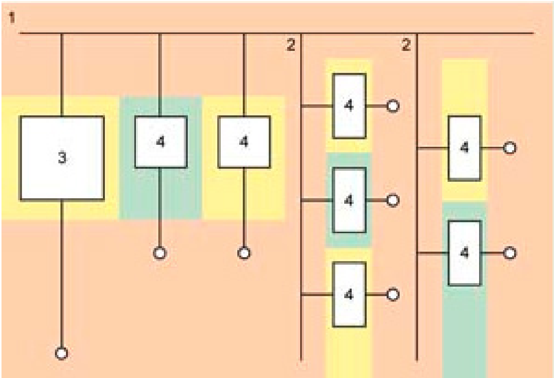


Form 3

Compartmentalisation between busbars and functional units
+ compartmentalisation between functional units
+ compartmentalisation between terminals and functional units

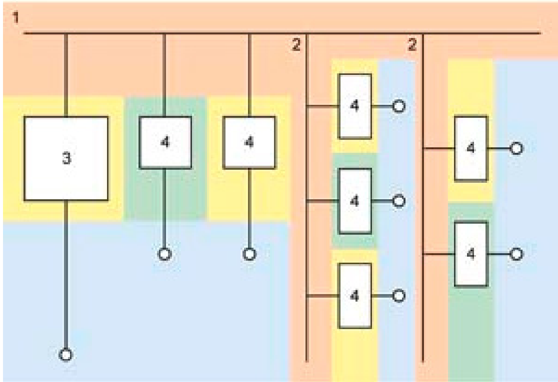
Form 3a

- No compartmentalisation between terminals and busbars



Form 3b

- Compartmentalisation between terminals and busbars

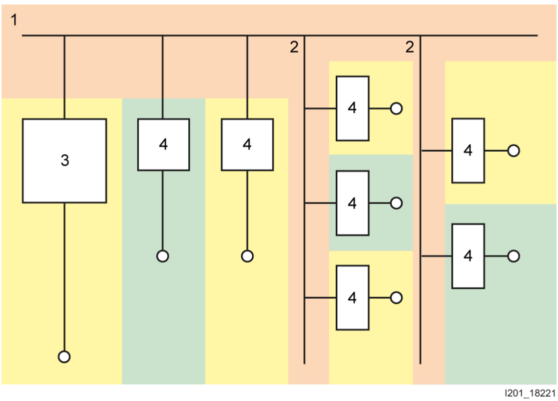


Form 4

Compartment between busbars and functional units
+ compartmentalisation between functional units
+ compartmentalisation between terminals of functional units

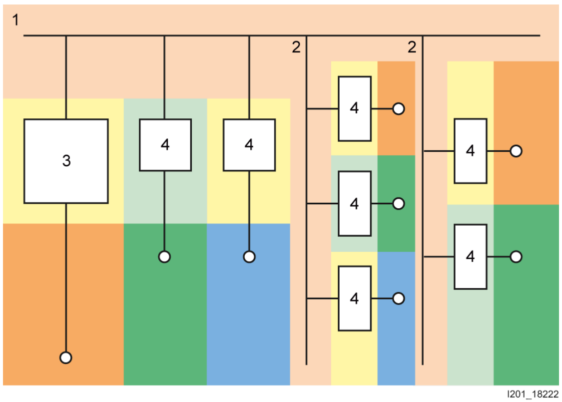
Form 4a

- Terminals in the same compartment like the connected functional unit

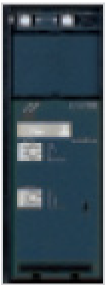
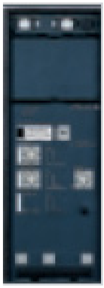
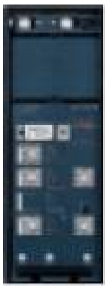
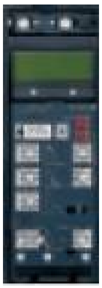


Form 4b

- Terminals not in the same compartment like the connected functional unit



3.16 Electronic Overcurrent Trip Units (ETU) for 3WL Circuit-breakers

	Accessories for 3WL circuit–breakers, (ETU = Electronic Trip Unit)	
	**ETU 15B** Functions	■ ETU Characteristic LI ■ Adjustable protection ■ Without rated current ID module ■ Overload protection ■ Instantaneous short–circuit protection
	**ETU 25B** Functions	■ ETU Characteristic LSI ■ Adjustable protection ■ Without rated current ID module ■ Overload protection ■ Short–time delayed short–circuit protection ■ Instantaneous short–circuit protection
	**ETU 27B** Functions	■ ETU Characteristic LSING ■ Adjustable protection ■ Without rated current ID module ■ Overload protection ■ Short–time delayed short–circuit protection ■ Instantaneous short–circuit protection ■ Neutral conductor protection ■ Earth fault protection
	**ETU 45B** Functions	■ ETU Characteristic LSIN ■ Adjustable protection ■ Overload protection ■ Short–time delayed short–circuit protection ■ Instantaneous short–circuit protection ■ Neutral conductor protection ■ Earth fault protection (optional) ■ Zone–selective interlocking ZSI (optional) ■ 4–line LCD (optional) ■ Communication via PROFIBUS–DP (optional) ■ Measuring function U, I, P, W, Q, F, ***cos μ***, harmonics and THD (optional)
	**ETU 76B** Functions	■ ETU Characteristic LSIN, adjustable protection ■ Overload protection ■ Short–time delayed short–circuit protection ■ Instantaneous short–circuit protection ■ Neutral conductor protection ■ Earth fault protection (optional) ■ Zone–selective interlocking ZSI (optional) ■ LCD graphics display ■ Communication via PROFIBUS–DP (optional) ■ Measuring function U, I, P, W, Q, F, ***cos μ***, harmonics and THD (optional) ■ Toggling between parameter sets possible ■ User–defined programming of parameters

3.17 Protection against arcing faults by arc fault detection devices and their consideration in SIMARIS project

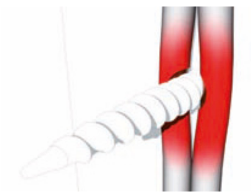
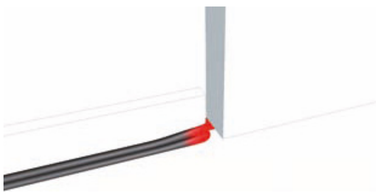
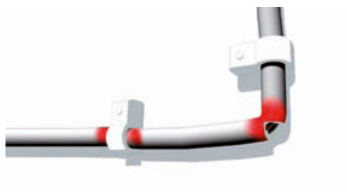
About 30% of all fires caused by electricity develop owing to fault reasons in electrical installations. Since such fires can cause tremendous damage, it is reasonable to take protective measures in the electrical installation in those cases where preventive action is possible.

3.17.1 Arcing faults in final circuits

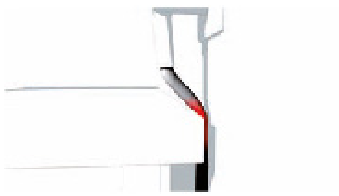
3.17.1.1 Causes

Arcing faults in final circuits can occur as parallel arcing faults between phase and neutral conductor / earth or as serial arcing faults in the phase or neutral conductor. Please find possible causes of arcing faults in the information below.

- **Causes of parallel arcing faults between phase and neutral conductor / earth**

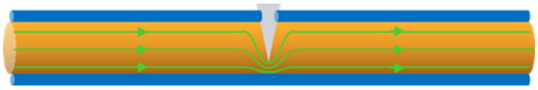
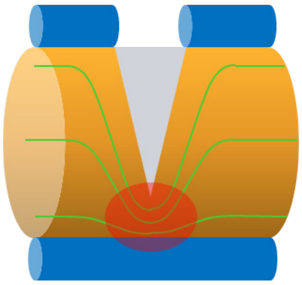
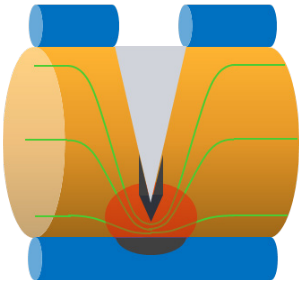
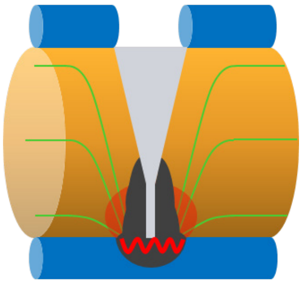
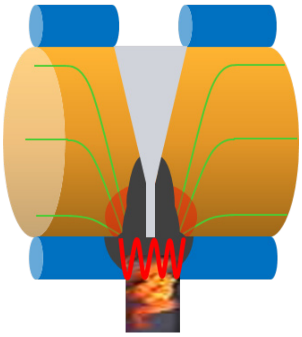
Damage by nails and screws	Squeezed cables	Bending radius too small
		

- **Causes for serial arcing faults in the phase or neutral conductor**

Loose contacts and connections	UV radiation, rodents	Kinked plugs, cables
		

The high temperature in the arc in conjunction with flammable material may then cause a fire.

3.17.1.2 Development of an arc as a result of a faulty point in the cable

Phase	Description	
Phase 1	Current flows through a damaged cable	
Phase 2	Bottle neck in the cable and the insulation are getting hot	
Phase 3	Up to approx. 1,250 °C Hot copper oxidizes to copper oxide, the insulation is carbonized	
Phase 4	Up to approx. 6,000 °C Copper melts and gasifies for a short moment (e.g. in the sine peak) ■ Air gap ■ Occasional arcing faults across the insulation	
Phase 5	Approx. 6,000 °C Stable arcing fault across the carbonized insulation	

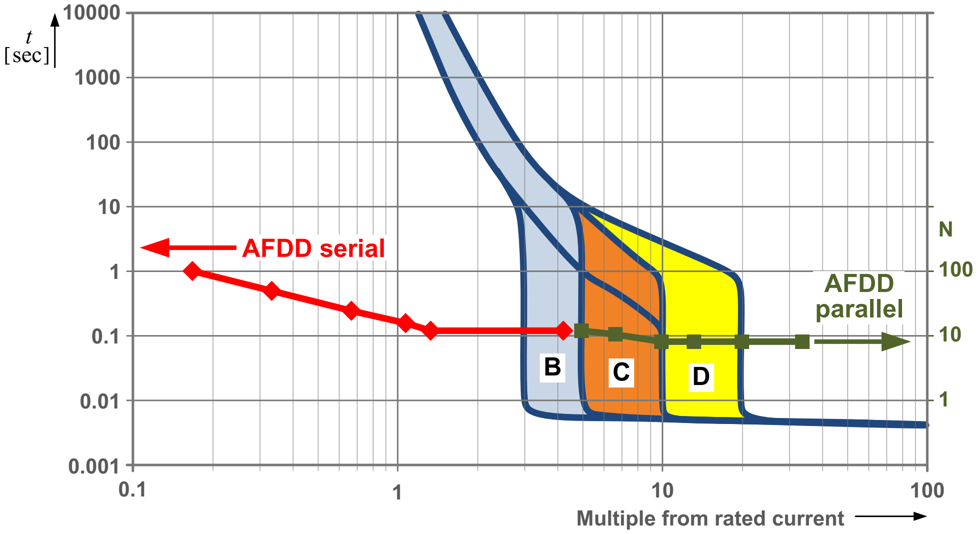
3.17.2 Closing the protection gap for serial and parallel arcing faults

As a rule, overcurrent protection devices can only be effective if the current flow time at a given amperage is above the tripping characteristic of the respective overcurrent protection device.

Arc fault detection devices may provide additional protection against serial or parallel arcing faults in cases where miniature circuit–breakers would not trip and fuses would not melt. This means that existing gaps in protection can be closed by arc fault detection devices (AFDD).

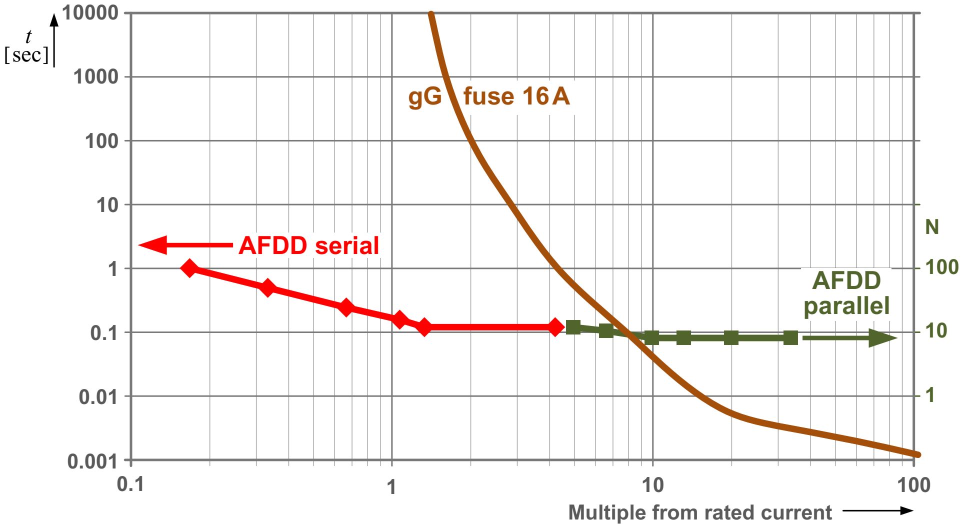
Protection by miniature circuit–breakers

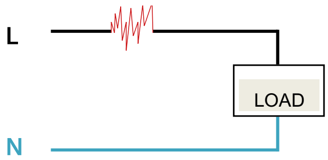
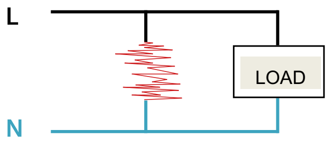
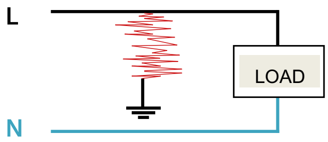
The following diagram shows characteristic tripping curves of miniature circuit–breakers with characteristics B, C and D, as well as the tripping characteristic of the 5SM6 AFDD. In events of parallel arcing faults, the tripping times of AFDDs provide complementary and improved protection in some transitional zones. As explained above, only AFDDs protect against serial arc faults. Miniature circuit–breakers are not suitable in these cases.



Protection by fuses

The following diagram shows the melting characteristic of a fuse in utilisation category gL and the tripping characteristic of the 5SM6 AFDD. Here it is also demonstrated that the tripping times of AFDDs in case of parallel arcing faults provide complementary and improved protection in transitional zones. As explained above, only arc fault detection devices can protect effectively in case of serial arc faults.



Fault condition	Protection acc. to IEC standard	Protection acc. to UL standard
Serial 	AFDD	AFCI
Parallel Phase–Neutral/Phase–Phase 	MCB AFDD	MCB AFCI
Parallel Phase–Protective Conductor 	RCD AFDD	RCD AFCI
	AFDD Arc fault detection device **MCB** Miniature circuit–breaker **RCD** Residual current device (FI, fault interrupter)	**AFCI** Arc fault circuit interrupter; combination of MCB/ fire protection switch **MCB** Miniature circuit–breaker **RCD** Residual current device

In the United States (UL standard, UL1699) such AFCIs have already been a mandatory part of electrical installations for some years, within the IEC/EN standards it is currently being discussed whether to make such devices compulsory in order to minimize the possible fire risk caused by electrical installations.

Relevant standards are IEC/EN 62606, IEC 60364–4–42, IEC 60364–5–53.

3.17.3 Application areas of AFDDs for final circuits up to 16 A

Arc fault detection devices can be used in areas

- where a fire would not be detected immediately, thus causing a hazard for human beings
  - residential dwellings
  - bedrooms, children's bedrooms
  - high–power equipment is operated unattendedly, e.g. washing machine, dish washer run overnight
  - old people's homes
  - hospitals
- where valuable goods or works of art are stored
  - libraries
  - museums
  - galleries
- with / made of easily ignitable materials
  - wooden structures and panelling, ecological building material, attic conversions
- where easily flammable materials are processed
  - carpenter's workshops
  - bakeries
  - cattle sheds, barns

3.17.4 Consideration of AFDDs in project planning with SIMARIS project

In order to integrate fire protection into project planning, AFDDs can be added in several ways when planning distribution boards in SIMARIS project in the program step 'System planning'

- either by adding them to the component list, so that they will be automatically placed in the distribution boards during the 'Automatic placement' step
- or selected directly in the front view and placed graphically.

3.18 Standards in SIMARIS project

3.18.1 Standards for Project Planning in SIMARIS project

Title	IEC / EN	Local Norm
Medium voltage switchboards		
Common destinations for norms of high voltage switch devices	IEC / EN 62271–1	DIN VDE 0671–1 (0670–1000)
Metal–cladded alternating current switch boards for rated voltages beyond 1 kV up to and including 52 kV	IEC / EN 62271–200	DIN VDE 0671–200
High voltage current with nominal alternating voltage beyond 1 kV	IEC / EN 61936–1	DIN VDE 0101
Electrical plants in operation	EN 50 110	DIN VDE 0105–100
Instruction for sulphur hexalflouride (SF6) of technical purity grade for using in electrical manufacturing resources for new SF_6	IEC / EN 60376	DIN VDE 0373–1
Protection classes by casing (IP–Code)	IEC / EN 60529	DIN VDE 0470–1
Insulation coordination	IEC / EN 60071	DIN VDE 0111
Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts	IEC 62262	DIN VDE 0470–100
Medium voltage switching devices and monitoring installations		
High voltage alternating current switch devices	IEC / EN 62271–100	DIN VDE 0671–100
High voltage alternating current gate and motor starters with gates	IEC / EN 60470	DIN VDE 0670–501
High voltage alternating current circuit–breaker and –earthing switch	IEC / EN 62271–102	DIN VDE 0671–102
High voltage circuit breaker for rated voltages beyond 1 kV and lower than 52 kV	IEC / EN 62271–105	DIN VDE 62271–105
Protecting combinations of high voltage circuit breaker	IEC / EN 62271–105	DIN VDE 0671–105
High voltage fuses – current limiting fuses	IEC / EN 60282	DIN VDE 0670–4
Alternating current switch devices for voltages of more than 1 kV – Selection of current limiting fuse insertions for transformer circuit	IEC / EN 60787	DIN VDE 0670–402
Over–voltage protection	IEC / EN 60099	DIN VDE 0675
Transducers – current transformers	IEC / EN 60044–1	DIN VDE 0414–44–1
Transducers – inductive voltage transformers	IEC / EN 60044–2	DIN VDE 0414–44–2
Transducers – combinded transformers	IEC / EN 60044–3	DIN VDE 0414–44–3
Voltage diagnostic systems (VDS)	IEC / EN 61243–5	DIN VDE 0682–415

Title	IEC / EN	Local Norm
Transformers		
Dry–type transformer	IEC / EN 60076–11:2004	DIN VDE 42523
Dry–type transformer	IEC / EN 60076–11:2004	NBR 10295/11
Oil transformer	IEC / EN 60076/50464	DIN VDE 60076/0532
Low voltage switchgear		
Low voltage combinations of switch devices – Part 2: type–tested combinations	IEC / EN 61439–2 (60439–1)	DIN VDE 0660–600–2 (0660–500)
Establishing of low voltage plants	IEC / EN 60364	DIN VDE 0100
Classification of environmental conditions	IEC / EN 60721–3–3	DIN EN 60721–3–3
Protection classes by casing (IP–Code)	IEC / EN 60529	DIN VDE 0470–1
Electrical plants in operations	EN 50 110	DIN VDE 0105
Busbar Trunking Systems		
Low voltage combinations of switch devices – Part 2: Special busbar distribution requirements	IEC / EN 60439–2	DIN VDE 0660–502
Low voltage switching devices		
Insulating coordination for electrical manufacturing resources in low voltage plants	IEC / EN 60664	DIN VDE 0110–1
Low voltage switch devices – Part 1: Common definitions	IEC / EN 60947–1	DIN VDE 0660–100
Low voltage switch devices – Part 2: circuit breaker	IEC / EN 60947–2	DIN VDE 0660–101
Low voltage switch devices – Part 4–1: gate and motor starters – electromechanic gate and motorstarters	IEC / EN 60947–4–1	DIN VDE 0660–102
Low voltage switch devices – Part 3: circuit breaker, disconnectors, switch disconnector and switch – protecting– units	IEC / EN 60947–3	DIN VDE 0660–107
Low voltage fuses	IEC / EN 60269	DIN VDE 0636
Surge protection devices for low voltage – Part 11: Surge protection devices for using in low voltage plants – requirements and tests	IEC / EN 61643–11	DIN VDE 0675–6–11
Transducers – current transformers	IEC / EN 60044–1	DIN VDE 0414–44–1
Charging units		
Low voltage electrical installations: Requirements for special installations or locations – Supply of Electrical Vehicle	EN 60364–7–722	DIN VDE 0100–722
@Siemens: translation missing	IEC 62196	DIN IEC 62196
Electric vehicle conductive charging system	IEC 61851	

3.18.2 Explanations for the Standard for Medium-voltage Switchgear (IEC 62271–200)

Siemens offers the entire product range of air– and gas–insulated switchgear type–tested in accordance with IEC 62271–200.

Safety, availability, and easy maintenance are important qualifications which can be easily specified using standardized classifications.

- For example, the **category of operational availability** describes to which extent the switchgear will remain operable if a compartment is opened for maintenance works.
- The **type of accessibility of compartments** is also classified.
- In addition, the standard defines more classifications, such as service life and other characteristics of the switching devices.
- Medium–voltage switchgear is intended for use in rooms which are solely accessible to authorised personnel (locked electrical operating area). The switchgear installations are IAC–qualified, i.e. the metal encapsulation will protect the operating personnel in the (very rare) case of an internal arcing fault against its harmful effects. **The IAC qualification** describes the accessibility level, the possibilities of how to be installed in the room, as well as the test current and the testing time.

3.18.2.1 Operational Availability Category

Operational availability category	When an accessible compartment of the switchgear is opened ...	Type of construction
LSC 1	then the busbar and therefore the complete switchgear must be isolated.	No partition plates within the panel, no panel partitions to the adjacent panels.
LSC 2		
LSC 2A	only the supply cable must be isolated. The busbar and the adjacent panels can remain in operation.	Panel partitions and isolating distance with compartmentalisation to the busbar.
LSC 2B	the supply cable, the busbar and the adjacent panels can remain in operation.	Panel partitions and isolating distance with compartmentalisation to the busbar and the cable.

3.18.2.2 Type of Access to Compartments

Compartment accessibility	Access features	
Interlock–controlled	Opening for normal operation and maintenance, e.g. fuse change.	Access is controlled by the construction of the switchgear, i.e. integrated interlocks prevent unauthorized opening.
Procedure–dependent access	Opening for normal operation and maintenance, e.g. fuse change.	Access control via a suitable procedure (working instruction of the owner) combined with a locking device (lock).
Tool–dependent	Opening not for normal operation or maintenance, e.g. cable check.	Access only with opening tool, special access procedure (instruction of the owner).
Not accessible	**Opening can destroy the compartment** This generally applies to gas–filled compartments of gas–insulated switchgear. As the switchgear requires no maintenance and operates independent of climatic conditions, access is neither required nor possible.	

3.18.2.3 Internal Arc Classification IAC

The notation IAC A FLR, I and t is composed of the abbreviations for the following values:	
IAC	Internal Arc Classification
A	Distance between the indicators 300 mm, i.e. installation in rooms with access for authorised personnel, locked electrical operating area.
FLR	Access from the front (F = Front) from the sides (L = Lateral) from behind (R = Rear)
I	Test current = rated short–circuit breaking current (in kA)
t	Accidental arc duration (in seconds)

Note: Siemens thanks Alperen Gök from Pamukkale University for further optimization of our planning tool.

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