Doepke

Miniature circuit-breakers

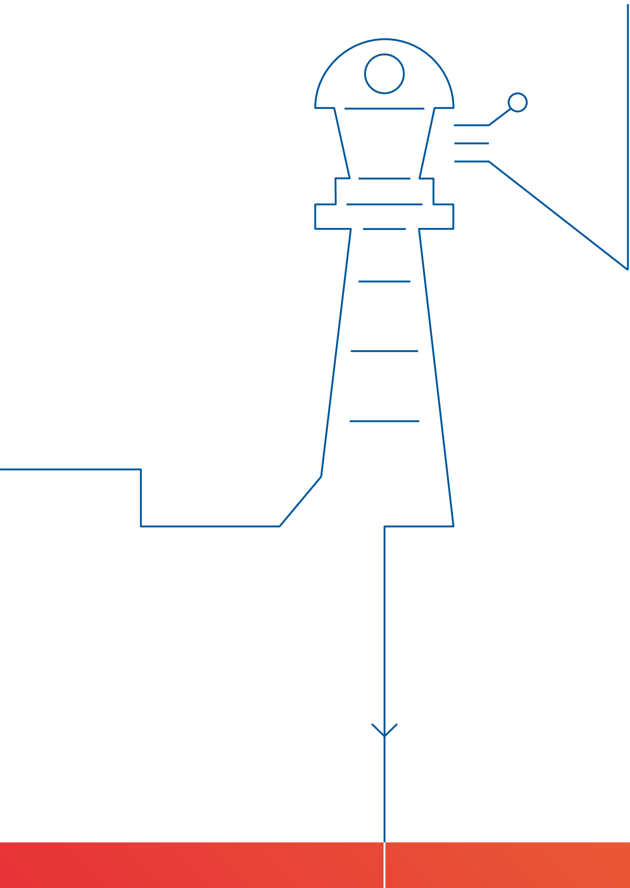
Application notes and technical information

The safest way to use electricity.

Liability

Technical Information

February 2024



1. About Doepke – The safest way to use electricity

For almost 70 years, Doepke Schaltgeräte GmbH has been synonymous with the highest levels of safety when working with electricity.

Our mission is to protect against electrical currents

We develop and produce residual current circuit-breakers, miniature circuit-breakers, residual current protection technology and special solutions. As the sought-after experts in this field, we help to define safety standards. With our extensive range of products, we provide the right solution for any requirements.

We are pioneers

Doepke was founded in 1956 by Franz Doepke and August-Wilhelm Engels in Norden, a town in Germany's historic East Frisia region. Together, the businessman and the technician made pioneering strides in the electrical installation industry through the development and production of residual current circuit-breakers, and by establishing their own distribution structure. Over a history spanning nearly seven decades, Doepke has relocated several times, and has opened a subsidiary plant in Thuringia and established three subsidiary companies overseas. But we have always remained true to our roots in Norden.

We are experts

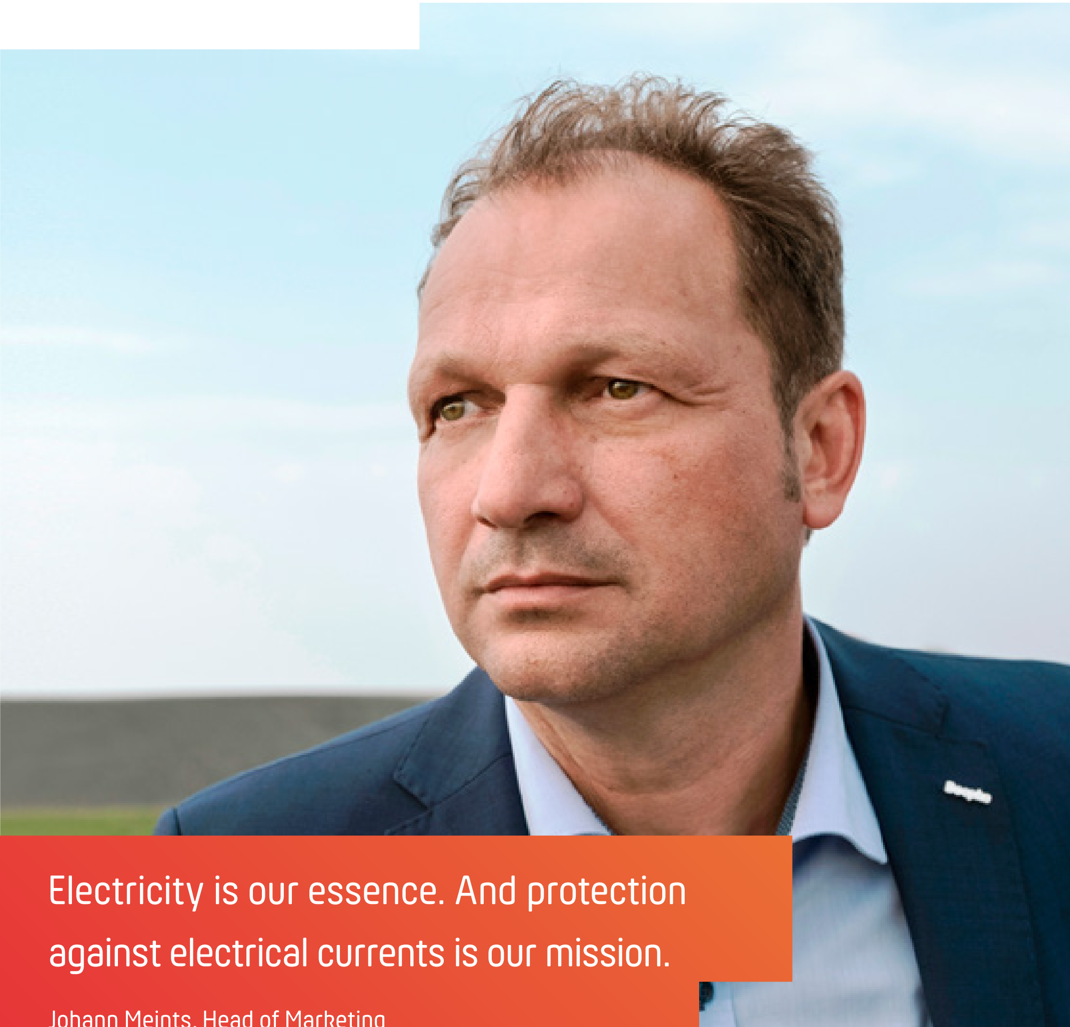
Technological progress continually throws up new challenges for the use of electricity. Knowing in advance what requirements will be placed on protective measures is essential for research and development projects. The Doepke name is now synonymous with protection technology that meets the very latest requirements and is at the forefront of technological progress. This is how we create the framework for safely using the technology of today – and tomorrow too.

We are growing

Doepke repositioned itself as a brand in 2018 and has since undergone rapid growth. By expanding its product range, increasing its workforce, opening new sites and buildings, and investing in modern production facilities and machines, the company has put itself in a strong position to meet future market demands.

We produce sustainable quality

Electricity is indispensable – when it flows properly. And when it doesn’t, our products spring into action to protect equipment and save lives. We guarantee top quality standards, with resource-friendly production, comprehensive advice, straightforward support solutions and piece-by-piece inspections. As a result, our products are valued for their quality, durability and reliability.



> Electricity is our essence. And protection against electrical currents is our mission.

Johann Meints, Head of Marketing

2. Introduction

This manual is aimed at electrical planners and installers, and anyone who works with miniature circuit-breakers.

These devices, which are also referred to as MCBs for short, protect lines and cables against overload and short-circuits. Miniature circuit-breakers are a standard feature in the final circuits of electrical systems used in residential, industrial and other purpose-built facilities.
Alongside residual current circuit-breakers, they can be found as a standard product in virtually every switching cabinet or sub-distribution board according to the latest standards.

The properties of miniature circuit-breakers

One of the key characteristics of miniature circuit-breakers is that they don't require any particular specialist training to use. Unlike the safety fuses that were common in the past, a miniature circuit-breaker can simply be switched back on after it has been triggered by an overload or a short-circuit, without the need to replace the entire switching device or individual fuse elements. Practically speaking, this means much greater safety during use, along with significant cost and time savings in the long term.

Miniature circuit-breakers from Doepke have a reduced installation height of 82.5 mm, making them one of the most compact on the market. With up to 7.5 mm of extra wiring space gained as a result, installers can benefit from much easier assembly.

Miniature circuit-breakers have fixed tripping characteristic curves that do not change over the service life of the switching device. And the range of applications can be expanded even further by adding auxiliary contacts, operating current releases and/or other auxiliary equipment.

Doepke offers a wide range of miniature circuit-breaker products with a variety of characteristics and rated currents, making it possible to find individual solutions for all customer requirements and systems.

Even the smallest series with special characteristic curves and special combinations can be realised precisely according to customer requirements. For instance, it is possible to provide a 3-pole miniature circuit-breaker with three different characteristics and/or current strengths:

Examples

- Current path 1: B16 A or B10 A
- Current path 2: C16 A or C13 A
- Current path 3: D16 A or D20 A

Customers can request further variants of miniature circuit-breakers with different rated currents or tripping characteristics.

Several standards stipulate the use of miniature circuit-breakers, such as the DIN VDE 0100 series of standards (Erection of low voltage installations).

Miniature circuit-breakers are available in a wide range of variants and combinations:

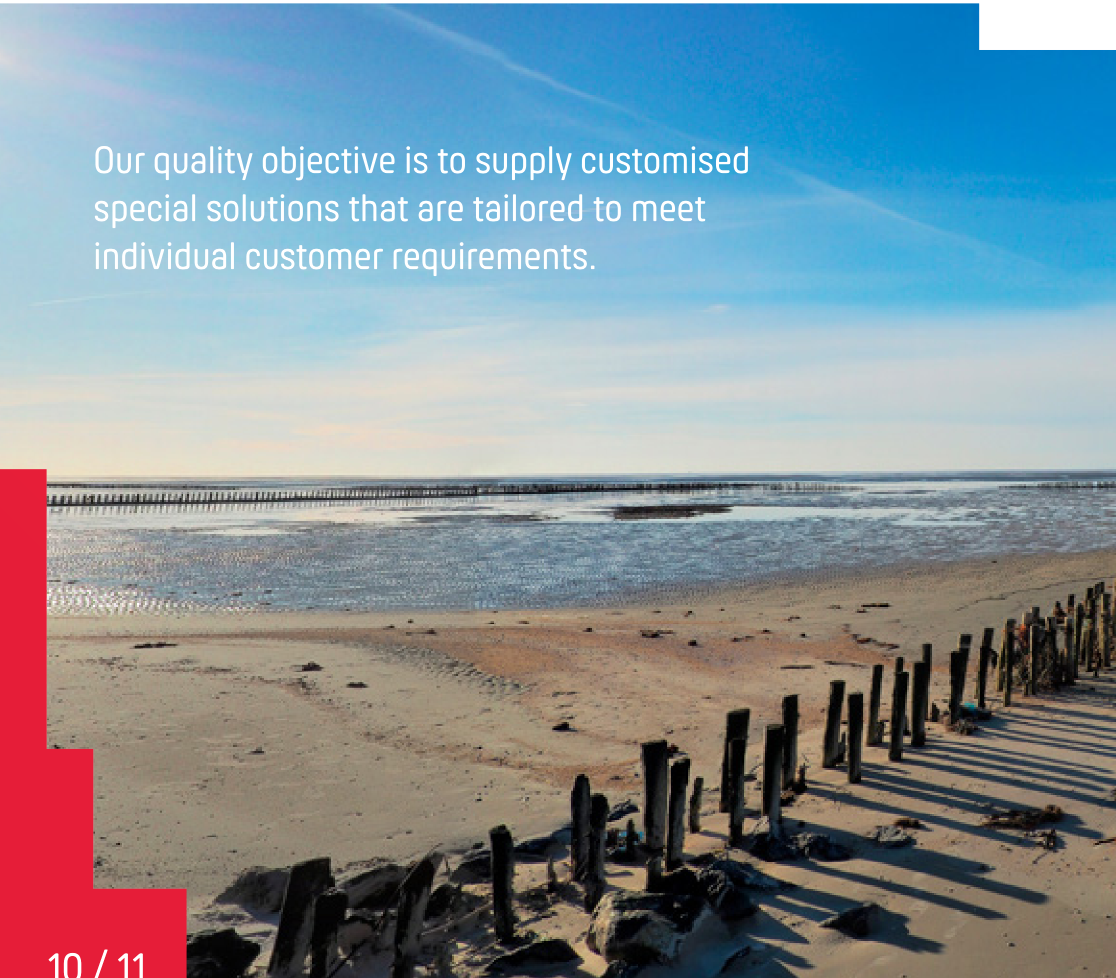
- single- or multi-pole
- with or without neutral conductor connection
- for rated currents up to 63 A

Miniature circuit-breakers have a variety of specific characteristics.

Overview of characteristics

- Can be operated without specialist training
- Switches off independently in the event of overload and/or short-circuit
- Once it has tripped, the miniature circuit-breaker can be switched back on without the need for maintenance or replacement of fuse elements
- Can be switched on and off manually for maintenance
- High switching capacity (6000 A – 10,000 A) despite very compact design
- Tripping characteristic curves remain consistent throughout the service life
- Compatible with auxiliary equipment such as operating current releases and auxiliary switches
- Clearance and creepage distances of at least 4 mm facilitate isolating functions and use for release
- The modular design and the use of multi-pole devices facilitate multi-phase switching

- The use of restart locks enables locking while the device is switched off and ensures compliance with number two of the five golden safety rules
- Labelled control element indicates the current switching status and makes it easier to identify faulty circuits.
- Trip-free mechanism ensures reliable tripping even if the control element is blocked
- Standardised tripping characteristic curves ensure perfect coordination between the miniature circuit-breaker and connected devices or lines



Our quality objective is to supply customised special solutions that are tailored to meet individual customer requirements.

3. The structure of a miniature circuit-breaker

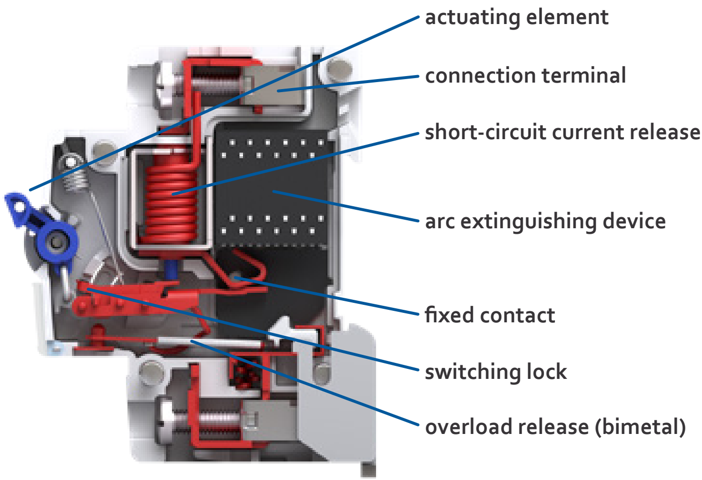


Fig. 1: Typical structure of a miniature circuit-breaker

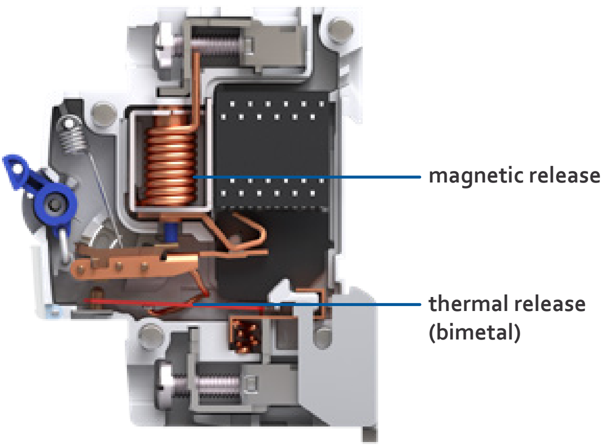


Fig. 2: Overcurrent and short-circuit release

Connection terminals

The terminals are used to establish a detachable connection of the conductors from the supply side and the load side. A distinction is made here between screw-type terminals and screwless terminals with a spring clamping mechanism. When using screw-type terminals, the maximum torque specified by the manufacturer for the clamping screw must be observed. Just like screw-type terminals, screwless terminals can only be used to connect conductors that satisfy the manufacturer's requirements.

Latch with control element

The purpose of the latch is to interrupt the contact system. The contact is closed manually via the control element. There are three ways that it can be opened: 1. manually via the control element; 2. via the short-circuit current release; or 3. via the overcurrent release. In the event of a fault (overload or short-circuit), deactivation also takes place via the integrated trip-free mechanism if the control element is blocked in the ON position.

Short-circuit current release

The short-circuit current release consists of a magnet system.
In the event of a short-circuit, this magnet system switches off the miniature circuit-breaker virtually instantaneously after a defined current limit is exceeded, based on the tripping characteristics.
If a fault occurs, the short-circuit current flows via the tripping coil of the short-circuit current release. If the tripping threshold is exceeded, the striker hits the latch, switching off the affected circuit.

Overcurrent release

The overcurrent release consists of a bimetal that is calibrated to the rated current of the miniature circuit-breaker.
If the current exceeds the specified tripping current, the release of the latch is initiated and the bimetal moves either quickly or slowly in the direction of the latch, depending on the current. Unlatching causes the contact system to open and thus interrupts the current flow.

Contact system

The contact system is responsible for opening and closing the current path. Thanks to their contact opening distance of at least 4 mm, all miniature circuit-breakers have an isolating function and are suitable for isolating.

Electric arc suppressor

Electric arcs that occur when switching the miniature circuit-breaker are guided from the contact system towards the electric arc suppressor due to the design of the miniature circuit-breaker.

The short-circuit current causes the magnetic release to trigger the latch. An electric arc is formed between the opening contacts. This arc remains at the contact point for a short time and becomes heated. The arc then moves away from the contact point due to the magnetic field and travels on metal guides towards the spark suppression chamber. The arc is widened in this process, and splits when it enters the spark suppression chamber. At this point, the electric arc voltage becomes higher than the driving mains voltage and the flowing short-circuit current no longer follows the prospective profile, but is effectively limited.

4. Overview and labelling

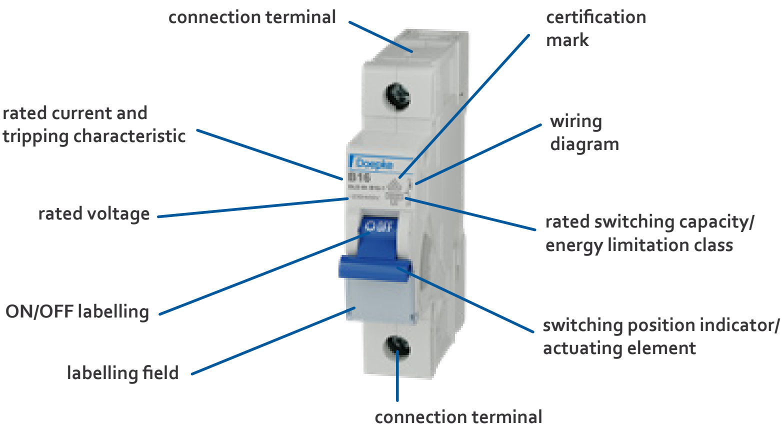


Fig. 3: Overview and labelling

5. Miniature circuit-breaker vocabulary

Overcurrent

A current that exceeds the rated current of a piece of equipment.

Overload current

An overcurrent that occurs in a circuit that is undamaged (fault-free) from an electrical standpoint. If an overload current occurs over a longer period of time, this can result in damage.

Short-circuit current

An overcurrent that occurs as a result of a fault without significant impedance between different potentials during normal operation. A short-circuit current can be caused by a fault or by incorrect connection of different potentials.

Rated insulation voltage

A value specified by the manufacturer to which the clearance and creepage distances and the insulation test voltages refer. Unless otherwise specified, the rated insulation voltage is the value of the highest rated voltage of the miniature circuit-breaker.

Number of poles

Indicates how many current paths the respective protective device has; pole numbers between one and four are possible. Two- and four-pole devices are also available with an unprotected pole (neutral conductor, mounted on the right).

Time/current characteristic curve range

Miniature circuit-breakers must ensure that circuits are adequately protected without tripping prematurely. Thermal overload release: For the characteristics B, C and D, the thermal test currents are defined as 1.13 x In and 1.45 x In. For the characteristics K and Z, 1.05 x In and 1.2 x In are specified.

Magnetic overload release

This involves determining the multiple of the rated current at which the electromagnetic tripping of the miniature circuit-breaker may occur at the earliest and must occur at the latest. The short-circuit release must not trip below the first value and must trip by the second value at the latest. The following factors apply to the respective characteristics:

- B = 3-5 x In
- C = 5-10 x In
- D = 10-20 x In
- Z = 2-3 x In
- K = 8-12 x In

Rated voltage (U_n)

In the field of switching devices, this is defined as "the effective value of the highest line-to-line voltage that corresponds to the highest mains voltage for which a piece of equipment is rated."
This means that the equipment may only be operated in networks whose mains voltage does not exceed the value of the rated voltage of the switching device. The operating and performance characteristics of the switching devices also relate to the rated voltage.

Rated current (I_n)

The electrical current that is assigned to electrical equipment by a switching device manufacturer for precisely defined operating conditions.

For miniature circuit-breakers with the B/C/D characteristic, a reference calibration temperature (30°C) for the thermal release is specified in the device standard. A reference calibration temperature of 20°C is assigned to the K and Z characteristics in the relevant standard. Factors or derating curves are provided by the manufacturer for ambient temperatures that deviate from the reference calibration temperature.

Rated switching capacity (I_{cn})

The limit value of the current in the event of a short-circuit that a switching device can safely switch off at the rated voltage and rated frequency without damage or destruction. It is specified as an effective value. Miniature circuit-breakers must be designed for at least the following rated switching capacities in accordance with the technical connection conditions of the grid operators and the VDE user rule (VDE-AR-N 4100):

- 25 kA when installed in the main power supply system (upstream of the measuring device)
- 10 kA for distribution circuits in the system-side connection space of a meter point
- 6 kA for final circuits (minimum requirement for energy supply companies in Germany is 6 kA)

Rated frequency

The frequency assigned by the switching device manufacturer for specified operating conditions.

Miniature circuit-breakers conforming to DIN EN 60898-1 (VDE 0641-11) are designed for both 50 Hz and 60 Hz (if no frequency is specified on the product). If the manufacturer specifies a frequency, the miniature circuit-breaker is only designed and suitable for this frequency. Use at other frequencies is only possible with the express approval of the manufacturer in its documentation.

Current heat loss

This occurs in conductor rails, cables, overhead lines and in all device current paths. The electrical power loss is completely converted into thermal energy. The current heat loss depends on the current, the current displacement factor and the temperature-dependent electrical resistance (DC resistance) of the conductor material.

Short-circuit protection device (SCPD)

One of these must be provided if there is a possibility that the rated short-circuit current could be exceeded. They are also referred to as back-up fuses. Fuses with a maximum rated current of 125 A and a characteristic curve of type gL (gG) can be used for this purpose.

Isolating function

A function for switching off the power supply and disconnecting from any electrical power source. The device standard for miniature circuit-breakers requires an isolating distance between the open contacts of a switching device to ensure safe isolation. The minimum isolating distance for miniature circuit-breakers is 4 mm in accordance with EN 60898.

Tripping characteristics (current-time behaviour)

This describes the behaviour of the miniature circuit-breaker in the event of an overcurrent. In the case of miniature circuit-breakers, it is visibly printed on the device immediately before the rated current. The characteristic curves always describe the tripping behaviour as a function of current and time. The tripping characteristics of miniature circuit-breakers are selected on the basis of the following factors:

- Short-circuit protection
- Fault protection
- Inrush currents of consumables.

The tripping characteristics are defined in the device standards EN 60898-1 (VDE 0641-11). Customer-specific characteristic curves can also be implemented.

Power limitation category

Miniature circuit-breakers with characteristics B and C according to DIN EN 60898-1 (VDE 0641-11) are categorised into power limitation categories. The technical connection conditions of the grid operators and the VDE user rule VDE-AR-N 4100 state that miniature circuit-breakers in the circuit distribution board must fulfil the requirements of power limitation category 3. This classification may not be used for the D characteristic and for miniature circuit-breakers with a rated current of over 63 A.

The limitation of the let-through energy (I^2t) is an important factor in the resistance of the conductor insulation in the event of a short-circuit and the coordination with upstream or downstream protective switching devices for selectivity analysis.

The device standard stipulates that power limitation category 3 must be visibly marked on the miniature circuit-breaker in a square together with an indication of the rated switching capacity before installation. The information on our miniature circuit-breakers is also legible once the device is installed.

Overvoltage category

Miniature circuit-breakers are devices that are intended to be incorporated into electrical installations. For these cases, DIN EN 60664-1 stipulates that miniature circuit-breakers should be placed in overvoltage category III. The device standard for miniature circuit-breakers adopts this requirement and defines the test requirement for the proof of insulation resistance. DIN EN 60898-1 requires a rated impulse withstand voltage of at least 4 kV.

Over-voltage category	Description	Rated impulse voltage	Typical devices
I	Devices with an external transformer or plug adaptor.	1500 volts	- Computers - Programmable household appliances - etc.
II	Devices that are connected with a safety plug/ IEC connector, for example.	2500 volts	- Household appliances - Domestic-type appliances - etc.
III	Devices that are connected directly.	4000 volts	- Distribution boards - Circuit-breakers - Miniature circuit-breakers - Busbars - etc.
IV	Devices that are operated very close to the feed point of the electrical installation.	6000 volts	- Electricity meters - Primary overcurrent protective devices - Ripple control devices - etc.

Tab. 1: Overvoltage categories I–IV

Pollution degree

A parameter for dimensioning the clearance and creepage distances of electrical equipment. The standard DIN EN IEC 60664-1 (VDE 0110) distinguishes between four degrees of pollution. Miniature circuit-breakers are intended for use in an environment with pollution degree 2.

Pollution degree	Meaning
Pollution degree 1	No pollution or only dry, non-conductive pollution occurs. The pollution has no impact.
Pollution degree 2	Only non-conductive pollution occurs. Occasionally, however, temporary conductivity due to condensation must be expected. This condensation can occur during the on/off load cycles of the equipment.
Pollution degree 3	Conductive pollution occurs or dry, non-conductive pollution that becomes conductive because condensation is to be expected.
Pollution degree 4	Permanent conductivity occurs due to conductive dust, rain or moisture.

Tab. 2: Pollution degrees 1–4

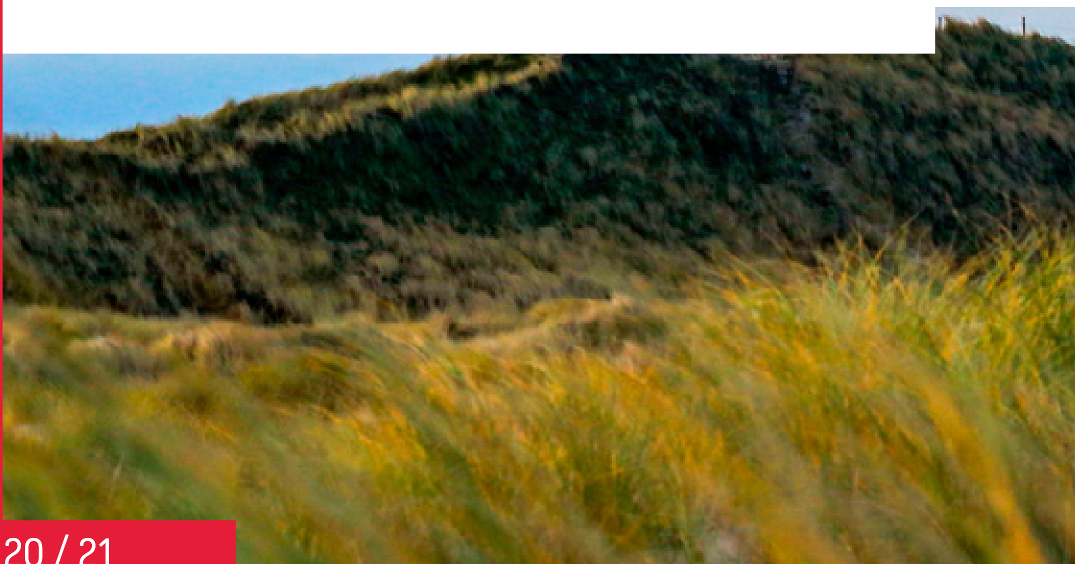
6. Selecting electrical equipment

Electrical equipment that performs tasks relating to protection, switching, control or monitoring must be selected and installed taking into account the expected operating conditions.
All external influences must also be taken into account for the precise and correct selection of equipment.
In Germany, the requirements for the installation of low-voltage systems are generally set out in the DIN VDE 0100 series of standards 'Erection of low voltage installations'. This is based on the international series of standards 'IEC 60364' in conjunction with the common European amendments 'HD 60364' and additional national requirements.

European Directive

Electrical equipment with a rated voltage between 50 V and 1000 V AC (75 V and 1500 V DC) must comply with the safety criteria of the European Low Voltage Directive 2014/35/EU (LVD) in the European Economic Area. The aim of this directive is to ensure a high level of protection for electrical equipment with free movement of goods within the European Union. The directive has been transposed into national law in Germany and is enshrined in the German Product Safety Act.

The manufacturer confirms compliance with the applicable directives and regulations in the declaration of conformity.
The CE marking is affixed to the products.



Standards

Products that are selected and installed in accordance with the VDE 0100 series of standards must fulfil the relevant device standards. In the case of 'Miniature circuit-breakers for household and similar uses – Miniature circuit-breakers for alternating current (AC)', this is DIN EN 60898-1 (VDE 0641-11).
Compliance with the standard is documented in the declaration of conformity.

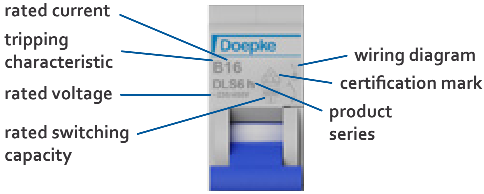
Conformity with the device standard can be tested by an in-house laboratory or by an independent certification body such as the VDE Testing and Certification Institute.
The test mark (e.g. VDE mark) then confirms that the requirements of the device standard have been met.

We make it possible to use electricity with confidence.

DECISIVE ADVANTAGES
OF OUR MINIATURE CIRCUIT-BREAKERS

1 FUNCTIONAL FORM

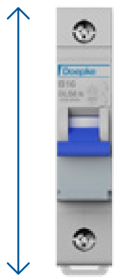
— user-friendly ergonomics
— comprehensible product name
— clearly recognisable on/off labelling



2 COMPACT DESIGN

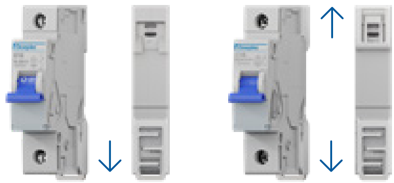
— one of the smallest miniature circuit-breakers on the market
— maximum space saving for convenient wiring

H and I series
height only 82,5 mm



3 SIMPLIFIED BUSBAR REMOVAL

— innovative fastening slider for easy removal from a busbar system even with power supply from the top



4 CONSISTENT DESIGN

5

COMPREHENSIVE APPLICATION POSSIBILITIES

Three separate product series for various applications in industrial and domestic installation in AC and DC versions.
With a large selection of tripping characteristics and 22 different rated currents between 0.3 A and 63 A.
Internationally certified: VDE, CCC

h SERIES
6 kA according to IEC 60898
6 A-32 A, in B and C characteristics
one-pole and three-pole

hsl SERIES
6 kA according to IEC 60898
16 kA, in B characteristic
one-pole

i SERIES
10 kA according to IEC 60898 and IEC 60947
0,3 A-63 A, in B, C, D, K, Z characteristics
one-pole, 1+N, two-pole, three-pole, 3+N, four-pole

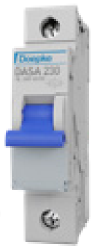
hdc SERIES
6 kA according to IEC 60898
0,5 A-63 A, in B und C characteristics, one-pole 125 V and two-pole 250 V DC for continuous connection

6

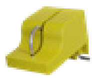
ENTIRE PRODUCT RANGE

— complete range of attachements and accessories
— a uxiliary switch available for both left-hand as well as for right-hand mounting
— standardised accessories for all product series

auxiliary switch



operating current trip



restart locks

7

PROFESSIONAL LABELLING SYSTEM

— pre-printed labelling sheet
— pre-punched blank labelling sheet available

7. Basic principles

This section deals with the basic principles for the use of miniature circuit-breakers in practice and in accordance with standards.
It is intended to support the planning and implementation of projects.

We make the use of electricity safe and provide exciting innovations and developments.

Gerold Roolfs, Head of Development and Construction

7.1. Standards and guidelines for miniature circuit-breakers DIN VDE 0100-410 Erection of low voltage installations

Standards	Content/topic
DIN EN 60898-1 VDE 0641-11	Product standard for miniature circuit-breakers in domestic installations and similar purposes (Classification of tripping characteristics B, C, D)
DIN EN 60947-2 VDE 0660-101	Product standard for circuit-breakers (Classification of tripping characteristics Z, K)
DGUV V2 VDE 0660-514	Topics relating to contact protection: such as finger and back-of-hand safety
DIN VDE 0100-430	Erection of low voltage installations – Part 4-43: Protective measures – Overcurrent protection
DIN 43880	This standard regulates the envelope dimensions and associated installation dimensions, e.g. the width of the MCB, i.e. the module width
DIN EN 60068-2-59 DIN EN 60068-2-78 DIN EN 60068-2-30	These standards describe the environmental tests, test procedures and test conditions
DIN EN IEC 60664	Insulation coordination for electrical equipment in low-voltage systems (including definition of pollution degree)
DIN EN 60204-1 VDE 0113-1	Safety of machinery – Electrical equipment of machines
DIN VDE 0100-560	Equipment for safety purposes (labelling of final circuits for safety applications)
DIN 18015	Instructions for the installation of electrical systems in residential buildings (e.g. division of circuits in residential buildings)
RoHS Directive 2011/65/EU RoHS Directive 2015/863/EU	Directive of the European Parliament and of the Council on the restriction of the use of hazardous substances in electrical and electronic equipment and on compliance with the maximum permitted concentration in homogeneous materials

REACH Regulation (EC) 1907/2006	REACH is the European Chemicals Regulation for the Registration, Evaluation, Authorisation and Restriction of Chemicals
Directive 2014/35/EU (Low Voltage Directive)	The Low Voltage Directive of the European Parliament and of the Council of 26 February 2014 serves to harmonise legislation on the provision of electrical equipment for use within certain voltage limits. The Low Voltage Directive is therefore one of the most important regulatory instruments for the safety of electrical appliances.

Tab. 3: Standards and guidelines

7.2. Current characteristics

Charac-teristic	Use
B	For circuits with loads without high inrush current spikes, i.e. resistive loads such as heating appliances.
C	For circuits with predominantly inductive loads that can generate current peaks, such as TV sets or socket outlet circuits where the subsequently connected loads are alternating.
D	For circuits with machines, transformers or capacitors in which extreme current peaks can occur at the moment of switching on.
K	For circuits in which loads with a requirement for more sensitive overcurrent tripping are installed; this is used in three-phase circuits (motor and transformer load circuits).
Z	For circuits with electronic loads (semiconductor elements) and circuits with high impedances.

Tab. 4: Table: Current characteristics

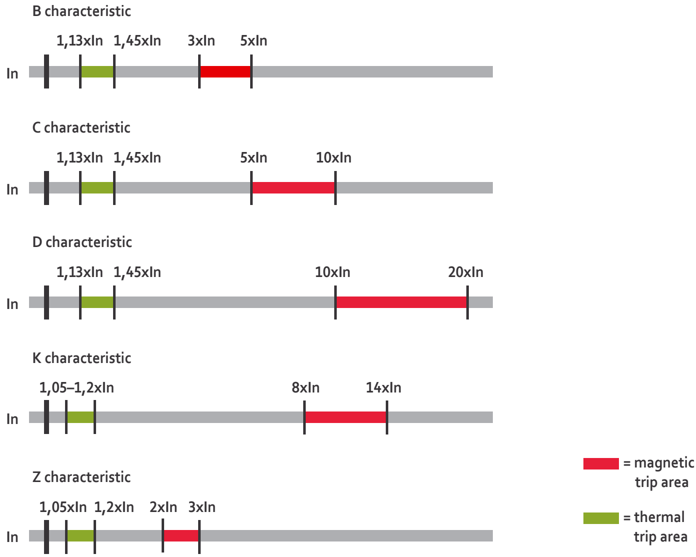


Fig. 4: Overview of the current characteristics

	Overload						Short-circuit											
	B, C, D		K		Z		B		C		D		K		Z	
	I1	I2	I1	I2	I1	I2	I4	I5	I4	I5	I4	I5	I4	I5	I4	I5
In (A)	1,13	1,45	1,05	1,2	1,05	1,35	3	5	5	10	10	20	8	12	2	3
0,3	0,339	0,435	0,315	0,360	0,315	0,405	-	1,5	1,5	3	3	6	2,4	3,6	0,6	0,9
0,5	0,565	0,725	0,525	0,600	0,525	0,675	-	2,5	2,5	5	5	10	4	6	1	1,5
0,75	0,848	1,088	0,788	0,900	0,788	1,013	-	3,75	3,75	7,5	7,5	15	6	9	1,5	2,25
1	1,13	1,45	1,05	1,20	1,05	1,35	3	5	5	10	10	20	8	12	2	3
1,6	1,81	2,32	1,68	1,92	1,68	2,16	-	8	8	16	16	32	12,8	19,2	3,2	4,8
2	2,26	2,90	2,10	2,40	2,10	2,70	6	10	10	20	20	40	16	24	4	6
2,5	2,83	3,63	2,63	3,00	2,63	3,38	-	12,5	12,5	25	25	50	20	30	5	7,5
3	3,39	4,35	3,15	3,60	3,15	4,05	9	15	15	30	30	60	24	36	6	9
3,5	3,96	5,08	3,68	4,20	3,68	4,73	-	17,5	17,5	35	35	70	28	42	7	10,5
4	4,52	5,80	4,20	4,80	4,20	5,40	12	20	20	40	40	80	32	48	8	12
5	5,65	7,25	5,25	6,00	5,25	6,75	15	25	25	50	50	100	40	60	10	15
6	6,78	8,70	6,30	7,20	6,30	8,10	18	30	30	60	60	120	48	72	12	18

	Overload						Short-circuit											
	B, C, D		K		Z		B		C		D		K		Z	
	I1	I2	I1	I2	I1	I2	I4	I5	I4	I5	I4	I5	I4	I5	I4	I5
16	18,1	23,2	16,8	19,2	16,8	21,6	48	80	80	160	160	320	128	192	32	48
20	22,6	29,0	21,0	24,0	21,0	27,0	60	100	100	200	200	400	160	240	40	60
25	28,3	36,3	26,3	30,0	26,3	33,8	75	125	125	250	250	500	200	300	50	75
32	36,2	46,4	33,6	38,4	33,6	43,2	96	160	160	320	320	640	256	384	64	96
40	45,2	58,0	42,0	48,0	-	-	120	200	200	400	400	800	320	480	-	-
50	56,5	72,5	52,5	60,0	-	-	150	250	250	500	500	1000	400	600	-	-
63	71,2	91,4	66,2	75,6	-	-	189	315	315	600	600	1260	504	756	-	-

Tab. 5: Overload and short-circuit currents

7.3. Obsolete characteristics

Charac-teristic	Use
A	Semiconductor protection; with high system impedance similar to Z characteristic.
R	Characteristic comparable to Z characteristic.
H	Old characteristic for 'household', B characteristic can be used as a replacement.
G	Characteristic for 'device protection', C characteristic can be used as a replacement.
L	Characteristic for 'line protection', B characteristic can be used as a replacement.
U	Characteristic similar to the also obsolete characteristic G.
V	Characteristic, C characteristic can be used as a replacement.

Tab. 6: Obsolete characteristics

7.4. Switch-off times (AC)

The following switch-off times in accordance with IEC 60364-4-41 (VDE 0100-410) must be observed for automatic switch-off in the event of a fault (fault protection):

TN system (120 V < U_0 ≤ 230 V)

- In socket outlet circuits ≤ 63 A, the switch-off time is < 0.4 seconds.
- In fixed connection circuits ≤ 32 A, the switch-off time is < 0.4 seconds.
- In fixed connection circuits > 32 A and distribution circuits, the maximum switch-off time is 5 seconds.

TT system (120 V < U_0 ≤ 230 V)

- In socket outlet circuits ≤ 63 A, the disconnection time is < 0.2 seconds.
- In fixed connection circuits ≤ 32 A, the disconnection time is < 0.2 seconds.
- In fixed connection circuits > 32 A and distribution circuits, the maximum switch-off time is 1 second.

If disconnection in the TT system is achieved by an overcurrent protective device and all external conductive parts of the system are connected to the protective equipotential bonding via the main earthing busbar, the disconnection time applicable to TN systems may be used.

IT system (120 V < U_0 ≤ 230 V)

- In the IT system, automatic switch-off and compliance with the switch-off times is not mandatory when a fault occurs for the first time. If the bodies are connected to each other by protective conductors and earthed together via the same earthing system, the conditions of the TN system apply and the following switch-off times must be observed:
- In fixed connection circuits ≤ 32 A, the switch-off time is < 0.4 seconds.
- In fixed connection circuits > 32 A and distribution circuits, the maximum switch-off time is 5 seconds.

Note — *U_0 is the rated AC voltage when considering the line conductor to earth.*

7.5. The time/current characteristic curve explained

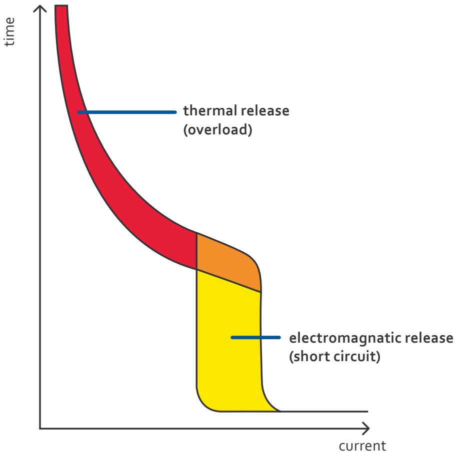


Fig. 5: Time/current tripping ranges of an MCB

Miniature circuit-breakers have two independent releases.

Thermal release (delayed release)

This takes the form of a thermobimetal.

Magnetic release (instantaneous release)

This takes the form of an electromagnet.

Tripping in the delayed overload range takes place via a bimetal that is deflected by the current flowing through the miniature circuit-breaker. The time interval until tripping occurs depends on the actual overcurrent that is flowing. If this current remains below the rated current of the MCB, no tripping occurs. If the value of the tripping current is exceeded, delayed tripping occurs.

The operating current flowing through the MCB generates a permanent magnetic field in the coil (electromagnet). The release is adjusted by means of an iron core that is retained by a spring. In the event of a short-circuit, tripping via the bimetal is too slow. For this reason, the electromagnetic release acts in this case. When a short-circuit occurs, a large magnetic field is created in the coil due to the high current flow through the MCB. As a result, the iron core overcomes the counteracting spring force and is pulled into the coil at high speed. This movement causes the latch to be triggered. The impact energy is used to accelerate the moving contact during opening. Due to the rapid tripping, electromagnetic release is also referred to as instantaneous release.

Tripping ranges of the characteristic curve

A double logarithmic division is generally used to display the tripping characteristic curves. The multiple of the rated current is plotted on the x-axis. The y-axis shows the tripping time in seconds/minutes. All MCB manufacturers display this information in this way. This means that tripping times can be compared directly across manufacturers.

Thermal and magnetic tripping for miniature circuit-breakers is defined in EN 60898-1. Manufacturers of miniature circuit-breakers are obliged to comply with the specified benchmark values.

Tripping curve

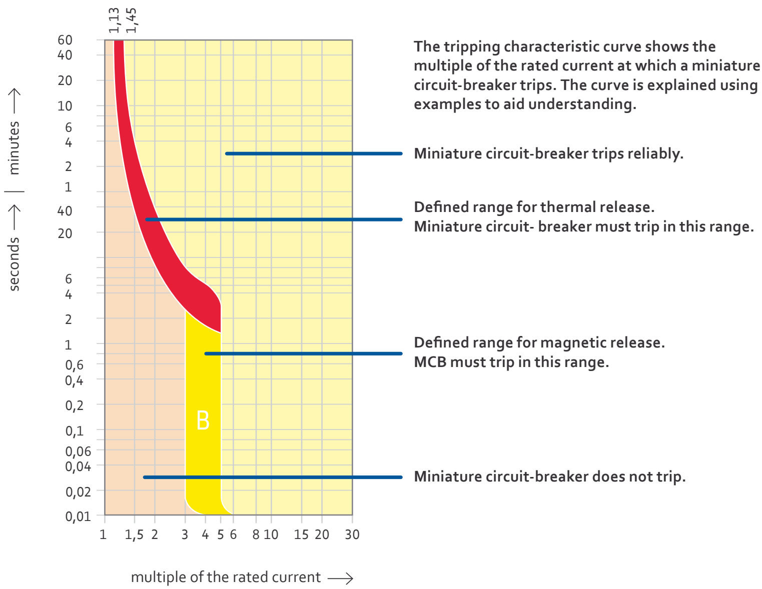


Fig. 6: Tripping curve for B characteristic

7.6. Tripping times

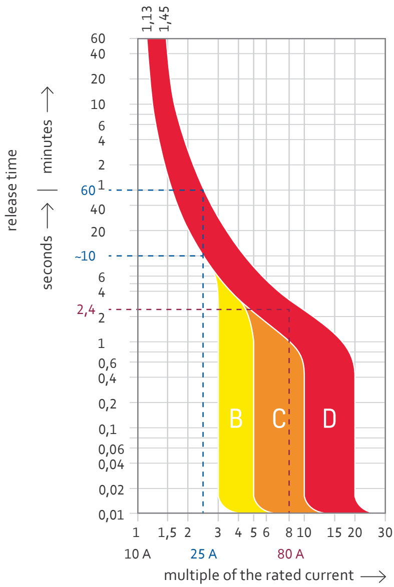


Fig. 7: Tripping curves for B, C, D characteristic

Example 1

A current of 25 A (2.5x In) flows through a miniature circuit-breaker with characteristic B (In = 10 A). If the duration of the current flow is limited to a few seconds (t < 10 seconds), the MCB does not trip due to the inertia of the bimetal release.

If the current of 25 A flows for a longer period (t > 10 seconds), the MCB trips within 10 to 60 seconds.

Example 2

For a miniature circuit-breaker with characteristic B (In = 10 A), there is an inrush current of 8x In (80 A) on the circuit.
The MCB trips within 100 milliseconds because the inrush current is higher than the defined magnetic tripping value (50 A).

By contrast, for a miniature circuit-breaker with characteristic C, thermal tripping occurs after a maximum of 2.4 seconds. However, the electromagnetic release can also respond and cause tripping within 100 ms. At 8x rated current, we are already in the magnetic (instantaneous) tripping range.

Practical example

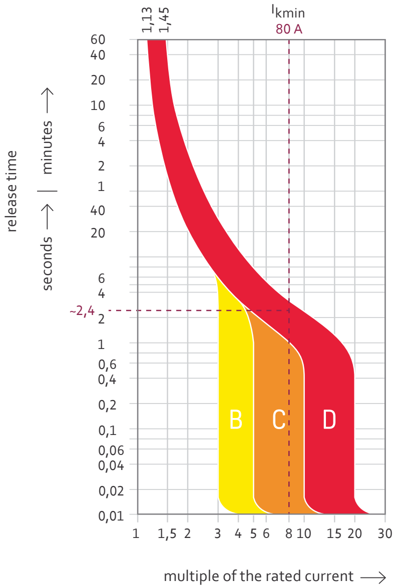


Fig. 8: Tripping curve with practical example

In a circuit with a very long supply line, a small short-circuit current I_k of 80 A is expected.

In order for the miniature circuit-breaker to trip within 0.4 seconds (instantaneous tripping), tripping characteristic B must be used. In the case of MCB B10 A, safe instantaneous tripping occurs at a short-circuit current of 50 A at the latest. In the case of characteristic C, the tripping time could be up to approx. 2.4 seconds if the magnetic release still does not respond.

If a type C nonetheless needs to be used,
there are the **following options:**

- Distribute loads across multiple circuits to reduce the rated current.
- Increase the conductor cross-section to reduce the system impedance. This causes an increase in the possible short-circuit current I_k and instantaneous tripping is achieved with a C characteristic MCB.

Note — *A miniature circuit-breaker protects the line, but not personnel or equipment. The protection of personnel and equipment must always be considered separately.*

7.7. The influence of harmonics

Harmonics are frequency components that are an integer multiple higher than the fundamental component. They can occur when the electrical voltage is distorted due to various influencing factors. The European grid has a fundamental frequency of 50 Hz, and the harmonics occurring here include the 2nd harmonic (100 Hz), 3rd harmonic (150 Hz), 5th harmonic (250 Hz), etc.

Harmonics can cause false tripping in the area of the miniature circuit-breaker, as the operating current that occurs in the system due to the harmonics is greater than can be determined by simple calculations and measurements prior to commissioning.

The increased currents cannot usually be determined by simple measurements, as most measuring instruments do not measure true root mean square (TRMS) values. For this reason, the value given for non-sinusoidal currents is often up to 40% too low.

It is therefore essential to use a TRMS measuring device to measure the real operating currents and thus ensure that the system is designed correctly.

Due to the harmonics that occur and the resulting changes in operating currents, the currents of the line conductors may not cancel each other out as usual, but instead occur as increased operating current on the neutral conductor. This can result in the load on the neutral conductor exceeding the load on the line conductors.

In this case, the cross-section of the neutral conductor must be adapted to the neutral conductor current that occurs, or the neutral conductor must be protected by an overcurrent protective device, for example a 4-pole miniature circuit-breaker.

Examples of single-phase loads include:

- Switching power supplies
- Electronic ballasts for fluorescent lamps
- Small uninterruptible power supply systems (UPS systems)

Examples of three-phase loads include:

- Variable-speed motors (frequency inverters)
- Large UPS systems

8. Dimensioning and planning

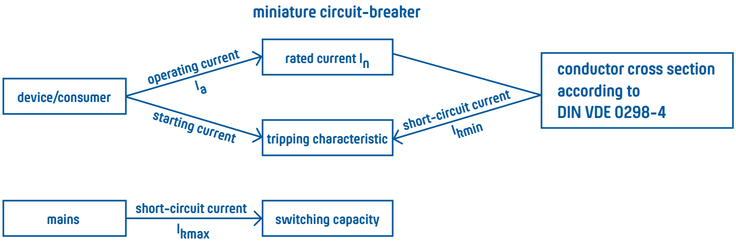


Fig. 9: Flow chart – Dimensioning and planning

If there are no special conditions that need to be taken into account during planning, it is sufficient to consider the operating currents and the starting currents when designing the miniature circuit-breaker. The operating current of the system must be below the rated current of the miniature circuit-breaker. It also needs to be ensured that the starting current/inrush current is below the electromagnetic tripping range. The rated current of the selected protective device can then be used to dimension the conductor cross-section.

Conditions that require more specific planning:

- Low impedances
- High impedances
- Special frequencies
- Special voltages
- Harmonic components
- Specific ambient temperature characteristics
- Particular requirements for system availability
- Derating due to series-connected switching devices
- Current type (AC or DC application)

8.1. Protection against overload currents in accordance with DIN VDE 0100-430

Protection against overload due to high heating is provided if the following conditions are met:

Rated current rule: $I_B \leq I_n \leq I_Z$

Tripping rule: $I_2 \leq 1.45 * I_Z$

For miniature circuit-breakers: $I_2 = 1.45 * I_n$

This gives a simplified check: $I_n \leq I_Z$

It is important for the operating current (I_B) to be lower than the rated current (I_n) of the circuit-breaker; it must also be lower than the maximum current-carrying capacity of the line (I_Z).

I_B Operating current of the circuit

I_n Rated current of the protective device

I_Z Permitted continuous current-carrying capacity of the line

I_2 Large test current that ensures effective disconnection within the time specified for the protective device

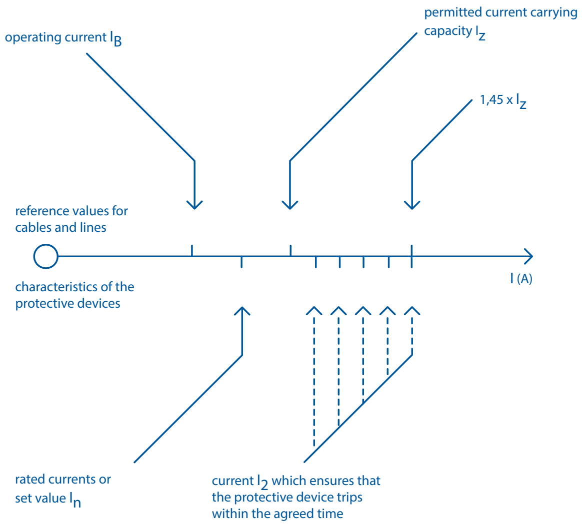


Fig. 10: Protection against overload currents

8.2. Dissipation power

Our miniature circuit-breakers are usually installed in power distributors, switching installations and control systems, meter cabinets, and so on. When creating these 'distributors', safety requirements for electrical equipment and protection objectives for people and systems must be taken into account. Furthermore, compliance with the legal requirements, in particular the German Product Safety Act (ProdSG) and the German Electromagnetic Compatibility Act, as well as the associated declaration of conformity, including CE labelling, must be observed.

In order to establish a standardised benchmark for this evaluation, the DIN EN 61439 series of standards was created as the basis for conformity assessment. Section 10.10 of this standard (heating) lists three possible methods for determining the dissipation power:

a) Testing (Section 10.10.2);
b) Comparison with a reference construction (10.10.3);
c) Assessment (calculation) (10.10.4).

Assessment (c) is the most common method and is used the most frequently. Data on dissipation power and internal resistance for Doepke miniature circuit-breakers can be found in the following table.

Note —— *The dissipation power specifications of the miniature circuit-breakers are important values that are required for the optimum design of a switching cabinet. The sum of the dissipation power of all switching devices can be used to determine the size of the power distribution and/or the required cooling.*

Elevated temperatures in the energy distribution system can have serious consequences:

- They can lead to thermal false tripping.
- The conductor insulation can age prematurely and/or become damaged
- Insulation faults may occur.

Internal resistances in mΩ and dissipation power in watts per pole (for In)

	B characteristic		C characteristic		D characteristic		K characteristic		Z characteristic	
Rated current in (A)	Internal resist-ance in mΩ	Dissi-pation power in watts	Internal resist-ance in mΩ	Dissi-pation power in watts	Internal resist-ance in mΩ	Dissi-pation power in watts	Internal resist-ance in mΩ	Dissi-pation power in watts	Internal resist-ance in mΩ	Dissi-pation power in watts
0,3	-	-	16600	1,5	16600	1,5	16860,0	1,5	31500	2,8
0,5	-	-	6850	1,7	6850	1,7	6850,0	1,7	10250	2,6
0,8	-	-	3050	2,0	3050	2,0	3050,0	2,0	5150	3,3
1	1950	2,0	1750	1,8	1750	1,8	1750,0	1,8	1690	2,7
1,6	720	1,8	590	1,5	590	1,5	590,0	1,5	940	2,4
2	510	2,0	420	1,7	420	1,7	420,0	1,7	690	2,8
2,5	325	2,0	295	1,8	295	1,8	295,0	1,8	430	2,7
3	211	1,9	200	1,8	173	1,8	200,0	1,8	345	3,1
3,5	159	1,9	125	1,5	125	1,5	125,0	1,5	225	2,8
4	131	2,1	109	1,7	105	1,7	109,0	1,7	225	3,6
5	85	2,1	61,6	1,5	61,6	1,5	65,4	1,6	105	2,6
6	52,9	1,9	49,1	1,8	45,9	1,7	49,1	1,8	82,3	3,0
8	26	1,7	24	1,5	20,7	1,3	44,0	2,8	37,1	2,4
10	13,4	1,3	13,4	1,3	13,4	1,3	31,5	3,1	27,8	2,8
13	11,3	1,9	8,04	1,4	8,1	1,4	8,8	1,5	15,1	2,6
16	8,04	2,1	8,04	2,1	8,1	2,1	7,5	1,9	11,3	2,9
20	7,1	2,8	7,45	3,0	6,4	2,5	6,3	2,5	7,4	3,0
25	5	3,1	5	3,1	4,1	2,5	4,7	2,9	508	3,7
32	3,6	3,7	3,6	3,7	2,7	2,8	2,8	2,9	3,6	3,7
40	2,2	3,5	2,2	3,5	2,2	3,5	2,2	3,5	-	-
50	1,95	4,9	1,9	4,8	1,8	4,6	2,0	4,9	-	-
63	1,77	7,0	1,77	7,0	1,7	6,8	1,8	7,0	-	-

Tab. 7: Internal resistance and dissipation power DLS 6

8.3. Switching capacity

Miniature circuit-breakers in accordance with EN 60898-1 have a rated switching capacity of between 3 kA and 10 kA. Miniature circuit-breakers with a rated switching capacity of 3 kA and 4.5 kA are not authorised by the energy supply companies in Germany. These companies require a rated switching capacity of at least 6 kA.

The switching capacity must be taken into account for the application so that a miniature circuit-breaker can switch off the maximum expected short-circuit current without damage occurring; this requires knowledge of the short-circuit current at the installation location.

If the expected short-circuit current is greater than the maximum switching capacity of the miniature circuit-breaker, the short-circuit current must be limited by backup protection at the installation site.

Possible options for implementing backup protection include fuses or selective circuit-breakers.

If there are high short-circuit currents at the installation location, the switching capacity must be determined using the coordination tables associated with the switching device. See also the section of this document on backup protection.

Type	Application	Switching capacity
DLS 6i	Industry	6/10 kA
DLS 6h	Skilled trade/household	6 kA
DLS 6hsl	Screwless	6 kA
DLS 6hdc	Skilled trade/household	6 kA

Tab. 8: Switching capacity of the DLS 6 series

8.4. Power limitation category

Two power limitation categories are defined in the device standard for miniature circuit-breakers. The standard category of power limitation is power limitation category 3 in accordance with EN 60898-1. This category 3 is the only category authorised by energy supply companies. Category 1 has no relevance. In the event of a short-circuit, MCBs of power limitation category 3 have a very high short-circuit limitation.

By contrast, power limitation category 1 means that there is no limitation of the short-circuit current (only for so-called 'zero point suppression without current limiting').

1. No arc voltage occurs when the contacts are closed.

2. When the contacts are opened, an electric arc is generated between the contacts, resulting in an arc voltage. The arc voltage increases on the way to the arc suppression device (suppression chamber) and reaches its highest value when it enters the spark suppression chamber. If the arc voltage reaches a value above the driving mains voltage (A), the short-circuit current (B) drops to a value of 0. At the end, the electric arc is extinguished and the current is interrupted.

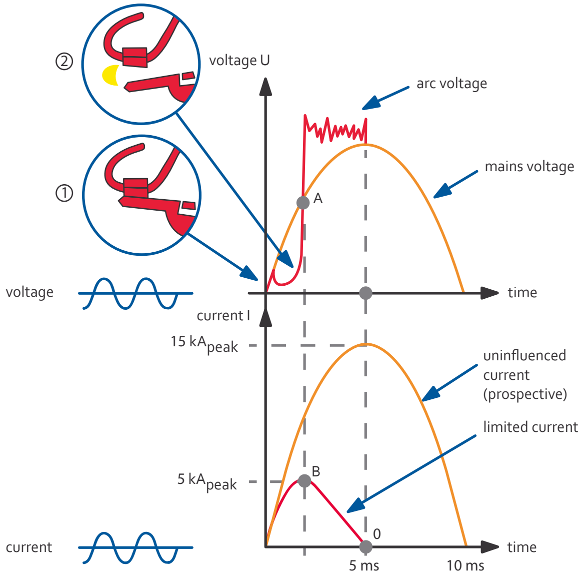


Fig. 11: Visualisation of the energy limitation

These physical processes result in the following advantages:

- Very high short-circuit current limitation from e.g. 10 kA prospective short-circuit current to 5 kA let-through current.
- Switch-off time reduced to approx. 5 milliseconds.

8.5. Direct voltage/special frequency

Our miniature circuit-breakers are switching devices for alternating current (AC). These switching devices can also be used for direct current applications up to a voltage of 60 VDC (1-pole) and 125 VDC (2-pole).

For voltages up to 250 VDC, the DLS 6hdc version is recommended for DC networks. The rated switching capacity of this device series is 6 kA for distribution circuits and final circuits.

The miniature circuit-breakers for AC applications in the 'Skilled trade' and 'Industrial applications' series can also be used at frequencies higher than 50 Hz. It should be noted that the electromagnetic release is influenced by the frequency. The correction factors are listed in the table below. The magnetic hold tripping value of the respective characteristic can be calculated by multiplying the factor for the frequency or DC.

Magnetic release	Frequency	I4	I5
	[Hz]		
B characteristic	16,67 - 50	3 x I_n	5 x I_n
	DC	4,5 x I_n	7,5 x I_n
	100	3,3 x I_n	5,5 x I_n
	200	3,6 x I_n	6 x I_n
	400	4,5 x I_n	7,5 x I_n
C characteristic	16,67 - 50	5 x I_n	10 x I_n
	DC	7,5 x I_n	15 x I_n
	100	5,5 x I_n	11 x I_n
	200	6 x I_n	12 x I_n
	400	7,5 x I_n	15 x I_n
D characteristic	16,67 - 50	10 x I_n	20 x I_n
	DC	15 x I_n	30 x I_n
	100	11 x I_n	22 x I_n
	200	12 x I_n	24 x I_n
	400	15 x I_n	30 x I_n

Tab. 9: Tripping factors for DC voltage and special frequency

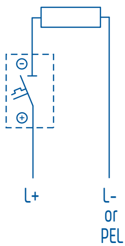
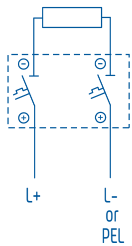
I4 magnetic holding current: The electromagnetic release must not trip before this value is reached.

I5 magnetic tripping current: The electromagnetic release must trip virtually instantaneously within 0.1 s (e.g. in the event of a short-circuit).

Minimum/maximum values for the operating voltage:

- AC: 12 V to 230 V/400 V, DLS 6i and DLS 6h series
- DC: 12 V to 60 V/125 V, 125 V with a series connection of two poles, DLS 6i and DLS 6h
- DC: 12 V to 125/250 VDC, 250 V with a series connection of two poles, DLS 6hdc series

Preferential values for the rated voltage and the corresponding supply systems for miniature circuit-breakers in DC voltage applications.

Miniature circuit-breakers	Single-pole with DLS 6h	Single-pole with DLS 6hdc	Two-pole with DLS 6h	Two-pole with DLS 6hdc
Rated voltage	60 VDC	125 VDC	125 VDC	250 VDC
	TN-S: L+ to L- (125 VDC) TN-C: L+ to PEL (125 VDC) TT: L+ to L- (125 VDC)	TN-S: L+ to L- (125 VDC) TN-C: L+ to PEL (125 VDC) TT: L+ to L- (125 VDC)	TN-S: L+ to L- (125 VDC) TN-C: L+ to PEL (125 VDC) TT: L+ to L- (125 VDC)	TN-S: L+ to L- (250 VDC) TN-C: L+ to PEL (250 VDC) TT: L+ to L- (250 VDC)
Maximum voltage between the line conductors	60 VDC	125 VDC	125 VDC	250 VDC
Maximum voltage between the line conductor and M	60 VDC	125 VDC	125 VDC	250 VDC
Installation examples for DC miniature circuit-breakers				

Tab. 10: Wiring for DC voltage

8.6. Calculating the cross-section

The cross-section of lines and cables is calculated in five steps, with several key factors to take into account.

Following the five steps for determining the cross-section, the largest calculated conductor cross-section is selected.

5. Steps of calculating the cross-section

By mechanical strength	By voltage drop	By fault protection	By current-carrying capacity	By overload and short-circuit protection
DIN VDE 0100-520	DIN 18015-1 DIN VDE0 100-520 DIN VDE 0100 Sheet 5 DIN VDE 0100 520 Sheet 2 TAB	DIN VDE 0100 Sheet 5 DIN VDE 0100-410	DIN VDE 0100-520 Sheet 2 DIN VDE 0298-4 DIN VDE 0276-603 DIN VDE 0276-1000	DIN VDE 0100 Suppl. 5 DIN VDE 0100-430

Tab. 11: Overview of standards for steps of calculating the cross-section

1. Determination of cross-section based on mechanical strength (0100-520)

Table of mechanical strength (DIN VDE 0100-520)

Application	Conductor material	Minimum cross-section
Cables, sheathed cables and core wires permanently installed	Copper	1.5 mm²
Bare conductor materials for power circuits	Copper	10 mm²
Cables, sheathed cables and core wires, permanently installed, for signalling and control circuits	Copper	0.5 mm² *
Mobile connection with insulated conductors, general	Copper	0.75 mm²

Mobile connection for protection and functional extra-low voltage	Copper	0.75 mm²
* A lower minimum cross-section of 0.1 mm² is permissible in signalling and control circuits of electronic equipment		

Tab. 12: Extract from Table 52J of the DIN VDE 0100-520 standard for industrial machinery: VDE 0113-1

2. Determination of the cross-section based on the voltage drop

DIN 18015-1 specifies a permissible voltage drop of 3% for lines and cables from the measuring device to the consumer.
By contrast, DIN VDE 0100-520 specifies 4% for the entire voltage drop between the transfer point of the supply network operator (possibly the domestic junction box) and the consumer (final circuits).
The following formulae can be used to determine the conductor cross-section, taking the selected maximum voltage drop into account:

Cross-section according to voltage drop

Calculation via current		Calculation via power	
Alternating current/three-phase alternating current			
Alternating current	Three-phase current	Alternating current	Three-phase current
$A = \frac{2 * l * I * \cos\varphi}{\Delta u * \varkappa}$	$A = \frac{2 * l * P}{\Delta u * \varkappa * U}$	$A = \frac{2 * l * P}{\Delta u * \varkappa * U}$	$A = \frac{l * \sqrt{3} * I * \cos\varphi}{\Delta u * \varkappa}$

l = Line length in m
I = Rated current in A
$\varkappa$ = Electrical conductivity of the conductor material

P = Rated power in W
U = Rated voltage in V
Δu = Voltage drop in V

Tab. 13: Formulae for calculating the conductor cross-section based on the voltage drop

Determination of the cross-section based on the selected protective measure

For fault protection by means of automatic disconnection using overcurrent protective devices in TN networks, the following switch-off times must be observed:

- 0.4 s for socket outlet circuits up to 63 A and for permanently connected, portable equipment that is carried by hand.
- 5 s for permanently connected, stationary equipment greater than 32 A and socket outlet circuits over 63 A

To comply with these switch-off times, the loop impedances must not exceed certain maximum values depending on the protective measure selected. If a residual current device is installed, it is not necessary to determine the cross-section according to the protective measure selected, as the switch-off times can usually be adhered to.

Condition

$$Z_S \leq \frac{2}{3} \times \frac{U_0}{I_a}$$

U_0 = Line conductor voltage to earth

I_a = Switch-off current of the overcurrent protective device

Switch-off factors (DIN VDE 0100-600, Table NA.1)

Overcurrent protective device	Permitted switch-off time tA ≤ 0.4 s	≤ 5 s
Fuses Characteristic gL	≤ 50 A = 8 x In	≤ 40 A = 5 x In
Fuses Characteristic gG	≤ 50 A = 10 x In	≤ 40 A = 6 x In
Miniature circuit-breakers B characteristic	5 x In	5 x In
Miniature circuit-breakers C characteristic	10 x In	10 x In

Tab. 14: Switch-off factors based on DIN VDE 0100-600, Table NA. 1

The line impedances used for the loop impedance are only partially taken into account on the load side; the impedances of the network must also be taken into account when determining the cross-section. The values of the network can be measured on site or requested from the relevant supply network operator.

Calculation example

An earthing contact socket is to be installed at a distance of **42 m** and protected by a **B16 A** miniature circuit-breaker. A value of **0.9 Ω** is calculated for the system impedance. What cross-section is suitable for compliance with the switch-off conditions?

$$I_A = 5 * I_N = 5 * 16\,A = 80\,A$$

$$Z_{loop} \leq \frac{2}{3} \times \frac{U_0}{I_A} \leq \frac{230\,V}{80\,A} = 1{,}92\,\Omega$$

$$R_{line} = Z_{loop} - Z_{mains} = 1{,}92\,\Omega - 0{,}9\,\Omega = 1{,}02\,\Omega$$

$$A = \frac{2 * l}{\varrho * R_{line}} = \frac{2 * 42\,m}{56 \frac{m}{\Omega * mm^2} * 1{,}02\,\Omega} = 1{,}47\,mm^2 \Rightarrow \mathbf{1{,}5\,mm^2}$$

Fault loop impedance (for rated voltage 230 V. At 240 V, Zs * 1.04)

	B characteristic		C characteristic		D characteristic	
Trip time	**0.4 s***	**5 s''**	**0.4 s***	**5 s''**	**0.4 s***	**5 s''**
Rated current	**Zs (Ω)**	**R (Ω)**	**Zs (Ω)**	**R (Ω)**	**Zs (Ω)**	**R (Ω)**
0,3	153,33	153,33	76,67	76,67	38,33	40,35
0,5	92,00	92,00	46,00	46,00	23,00	24,21
1	46,00	46,00	23,00	23,00	11,50	12,11
1,6	28,75	28,75	14,38	14,38	7,19	7,57
2	23,00	23,00	11,50	11,50	5,75	6,05
2,5	18,40	18,40	9,20	9,20	4,60	4,84
3	15,33	15,33	7,67	7,67	3,83	4,04
4	11,50	11,50	5,75	5,75	2,88	3,03
5	9,20	9,20	4,60	4,60	2,30	2,42
6	7,67	7,67	3,83	3,83	1,92	2,02
8	5,75	5,75	2,88	2,88	1,44	1,51
10	4,60	4,60	2,30	3,05	1,15	3,05
13	3,54	3,54	1,77	2,34	0,88	2,34
16	2,88	2,88	1,44	1,90	0,72	1,90
20	2,30	2,30	1,15	1,52	0,58	1,52
25	1,84	1,84	0,92	1,22	0,46	1,22
32	1,44	1,44	0,72	0,95	0,36	0,95
40	1,15	1,15	0,58	0,76	0,29	0,76
50	0,92	0,92	0,46	0,61	0,23	0,61
63	0,73	0,73	0,37	0,48	0,18	0,48

Tab. 15: * from Table 41.1 of DIN VDE 0100 Part 410

'' from Section 411.3.2.3 of DIN VDE 0100 Part 410

$Z_S = R_{LS} + R_{conductor}$ (data from time-current characteristic curves)

4. Determination of the cross-section based on the current-carrying capacity

The current-carrying capacity of lines and cables depends on the following factors:

- Type of conductor material
- Type of insulating material
- Installation type
- Ambient temperature
- Clustering

The table according to DIN VDE 0298-4 refers to an ambient temperature of 30°C. The following maximum operating temperatures are specified for the conductor insulation:

- 60°C (rubber insulation)
- 70°C (PVC insulation)
- 90°C (cross-linked polyethylene)

Installation type	Description of the installation conditions
A1	**Installation in thermally insulated walls** - Core lines in the conduit
A2	**Installation in thermally insulated walls** - Multi-core lines and cables in the conduit - Multi-core lines and cables in the wall
B1	**Installation in conduits or ducts** - Core lines in the conduit or in the duct on the wall - Core lines, single or multi-core lines and cables in the conduit in the wall or under plaster
B2	**Installation in conduits or ducts** - Multi-core lines and cables in the conduit or in the duct on the wall or on the floor
C	**Direct installation** - Single- or multi-core lines and cables on the wall or on the floor - Multi-core lines and cables in the wall or under plaster - Webbed cable in plaster - Single- or multi-core cable or sheathed installation line laid in multiple layers on a perforated cable tray

E	**Installation clear in the air** - Multi-core lines and cables with distance from wall a ≥ 0.3 d (line diameter) and distance a ≥ 2 d from other lines or cables

('Conduit' means electrical conduit and 'Duct' means electrical installation duct)

Tab. 16: Description of installation types

Design	Selection based on current-carrying capacity PVC-insulated cables, sheathed cables, webbed cables and core lines for fixed installation											
Installation type	A1		A2		B1		B2		C		E	
Number of loaded cores	2	3	2	3	2	3	2	3	2	3	2	3
Cross-section (Cu) in mm²	Load capacity in amps (A)											
1,5	15,5	13,5	15,5	13	17,5	15,5	16,5	15	19,5	17,5	22	18,5
2,5	19,5	18	18,5	17,5	24	21	23	20	27	24	30	25
4	26	24	25	23	32	28	30	27	36	32	40	34
6	34	31	32	29	41	36	38	34	46	41	51	43
10	46	42	43	39	57	50	52	46	63	57	70	60
16	61	56	57	52	76	68	69	62	85	76	94	80
35	99	89	92	83	125	110	111	99	138	119	148	126
50	119	108	110	99	151	134	133	118	168	144	180	153
70	151	136	139	125	192	171	168	149	213	184	232	238
95	182	164	167	150	232	207	201	179	258	223	282	238
120	210	188	192	172	269	239	232	206	299	259	328	276
150	240	216	219	196	-	-	-	-	344	299	379	319
185	273	245	248	223	-	-	-	-	392	341	434	364
240	320	286	291	261	-	-	-	-	461	403	514	430
300	367	328	334	298	-	-	-	-	530	464	593	497

Tab. 17: Current-carrying capacity of lines and cables (extract from DIN VDE 0298-4, Table 3)

The current-carrying capacity values (see table) are values that can be achieved under optimum conditions. In the case of less favourable influences, such as an increased ambient temperature, corresponding reduction factors must be taken into account.

5. Determination of the cross-section based on the short-circuit protection

The cross-section and the corresponding maximum line length can be determined from tables on the basis of the system impedance, the rated current of the protective device and the type of protective device. These tables are based on DIN VDE 0100-410 and DIN VDE 0100-430.

Tables are available for the following applications:

- Fuses for circuits with 0.4 s switch-off time
- Fuses for circuits with 5 s
- Type B miniature circuit-breakers
- Type C miniature circuit-breakers

Example

Internal system resistance: 300 milliohms
Cross-section: 4 mm²
Rated current: 16 A
Switch-off time: 0.4 s

The known values yield a maximum line length of up to 156 metres (shown in green).

This method can be used to determine the appropriate cross-section and maximum line length for any combination.

Cross-section	Rated current	Required short-circuit current	Cut-off time	Internal system resistance up to the fuse in milliohms								
				10	50	100	200	300	400	500	600	700
S mm²	In A	Ik erf A	ta s	l_{max} in m								
1,5	6	47	0,4	159	157	156	153	150	147	144	141	137
1,5	10	82	0,4	89	88	86	83	80	77	74	71	68
1,5	16	109	0,4	66	64	63	60	57	54	51	48	45
1,5	20	148	0,4	46	45	44	41	38	35	32	29	26
2,5	10	82	0,4	148	146	144	139	134	129	123	118	113
2,5	16	109	0,4	110	109	106	101	96	91	86	80	75
2,5	20	148	0,4	80	78	76	71	66	61	55	50	45
2,5	25	180	0,4	65	63	60	56	50	45	40	35	29
4	16	109	0,4	180	176	172	164	**156**	148	139	131	122
4	20	148	0,4	131	128	124	116	108	99	91	82	73
4	25	180	0,4	107	104	100	92	83	75	66	58	49
4	35	270	0,4	70	66	62	54	46	37	29	20	10
4	40	315	0,4	59	56	52	44	35	27	18	9	-
6	20	148	0,4	198	193	187	175	162	149	137	124	110
6	25	180	0,4	162	157	151	139	126	113	100	87	74
6	35	270	0,4	106	102	96	83	70	57	44	30	16
6	40	315	0,4	90	86	80	67	54	41	28	14	-
10	25	315	0,4	274	266	256	235	213	192	170	147	124
10	35	270	0,4	181	173	163	142	120	98	57	51	27
10	40	315	0,4	155	147	136	115	93	70	47	23	-
10	50	470	0,4	102	94	83	62	39	16	-	-	-
10	63	550	0,4	86	78	68	46	23	-	-	-	-
10	80	850	0,4	53	45	35	13	-	-	-	-	-
16	35	270	0,4	289	276	260	226	191	155	119	82	44
16	40	315	0,4	247	234	217	183	148	112	75	37	-
16	50	470	0,4	164	151	134	99	63	26	-	-	-
16	63	550	0,4	139	126	109	74	38	-	-	-	-
16	80	850	0,4	88	74	57	22	-	-	-	-	-
16	100	1020	0,4	72	59	42	5	-	-	-	-	-
16	125	1500	0,4	46	33	16	-	-	-	-	-	-

Tab. 18: Permissible limit lengths for fuses (DIN VDE 0636-1)

8.7. Planning example 1

The graphical overview of all known currents helps you to check your own planning and design of a system. The diagrams below show the relationships between a 16 A miniature circuit-breaker with characteristic B in combination with a copper line with a cross-section of 1.5 mm² and two loaded cores.

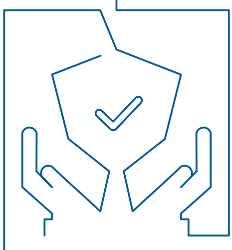
The characteristic curve of the permissible load capacity of the line refers to a line with PVC insulation at an ambient temperature of 30°C and with installation conditions of installation type C.

I_B Operating current
I_n Rated current
I_z Permissible current-carrying capacity of the line

Miniature circuit-breaker I_n = 16 A
B characteristic
6 kA switching capacity
Power limitation category 3

50 Hz
230/400 V
30°C ambient temperature
Installation type: C

Conductor cross-section: 1.5 mm²



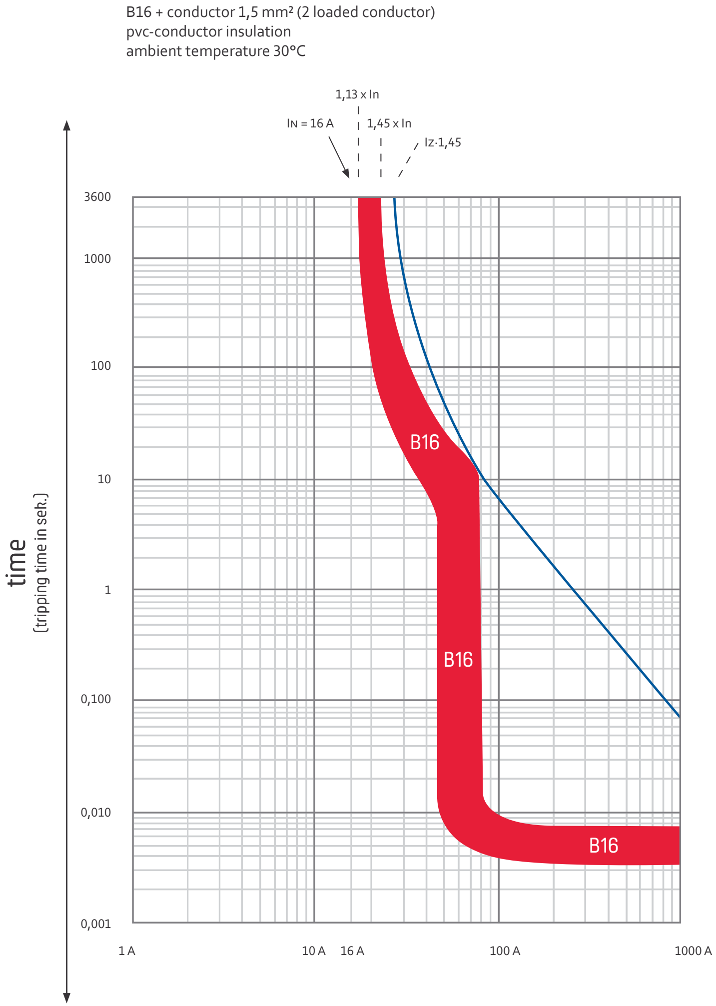


Fig. 12: Characteristic curve for planning example 1

8.8. Planning example 2

The diagrams below show the relationships between a 16 A miniature circuit-breaker with characteristic B in combination with a copper line with a cross-section of 2.5 mm² and two loaded cores.

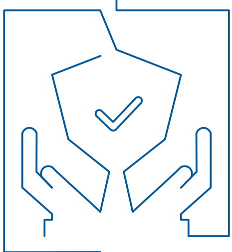
The characteristic curve of the permissible load capacity of the line refers to a line with PVC insulation at an ambient temperature of 30°C and with installation conditions of installation type C.

I_B Operating current
I_n Rated current
I_z Permissible current-carrying capacity of the line

Miniature circuit-breaker I_n = 16 A
B characteristic
6 kA switching capacity
Power limitation category 3

50 Hz
230/400 V
30°C ambient temperature
Installation type: C

Conductor cross-section: 2.5 mm²



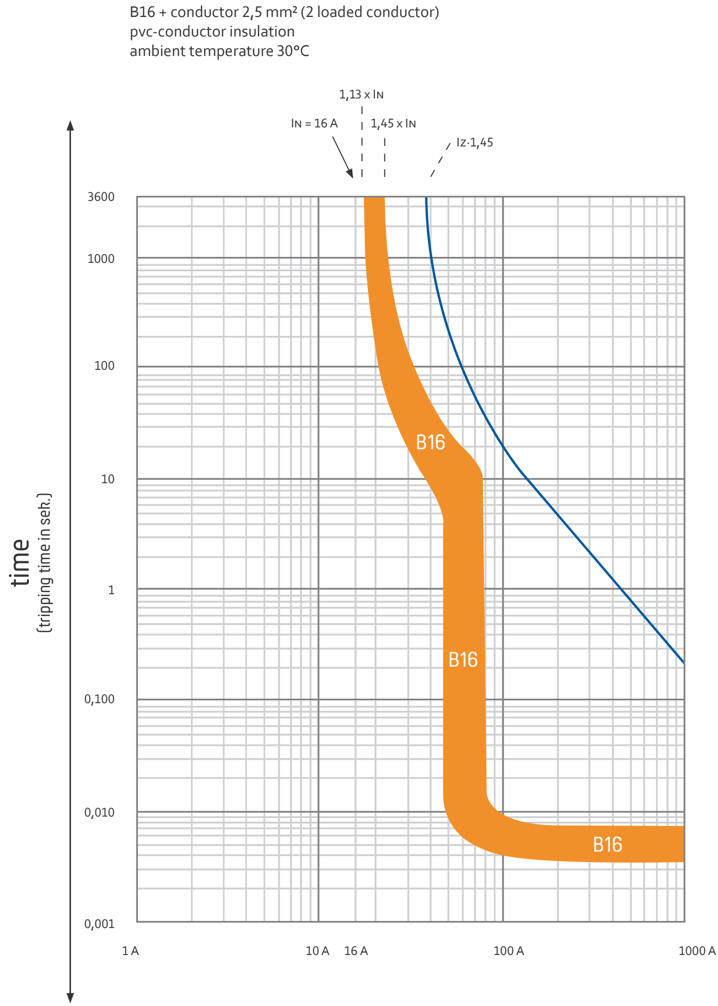


Fig. 13: Characteristic curve for planning example 2

8.9. Planning example 3

The diagrams below show the relationships between a 16 A miniature circuit-breaker with characteristic B in combination with a copper line with a cross-section of 2.5 mm² and three loaded cores.

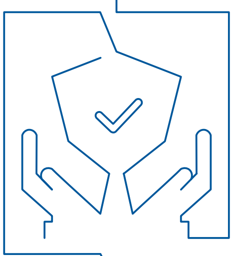
The characteristic curve of the permissible load capacity of the line refers to a line with PVC insulation at an ambient temperature of 30°C and with installation conditions of installation type C.

I_B Operating current
I_n Rated current
I_z Permissible current-carrying capacity of the line

Miniature circuit-breaker I_n = 16 A
B characteristic
6 kA switching capacity
Power limitation category 3

50 Hz
230/400 V
30°C ambient temperature
Installation type: C

Conductor cross-section: 2.5 mm²



B16 + conductor 2,5 mm² (3 loaded conductor)
pvc-conductor insulation
ambient temperature 30°C

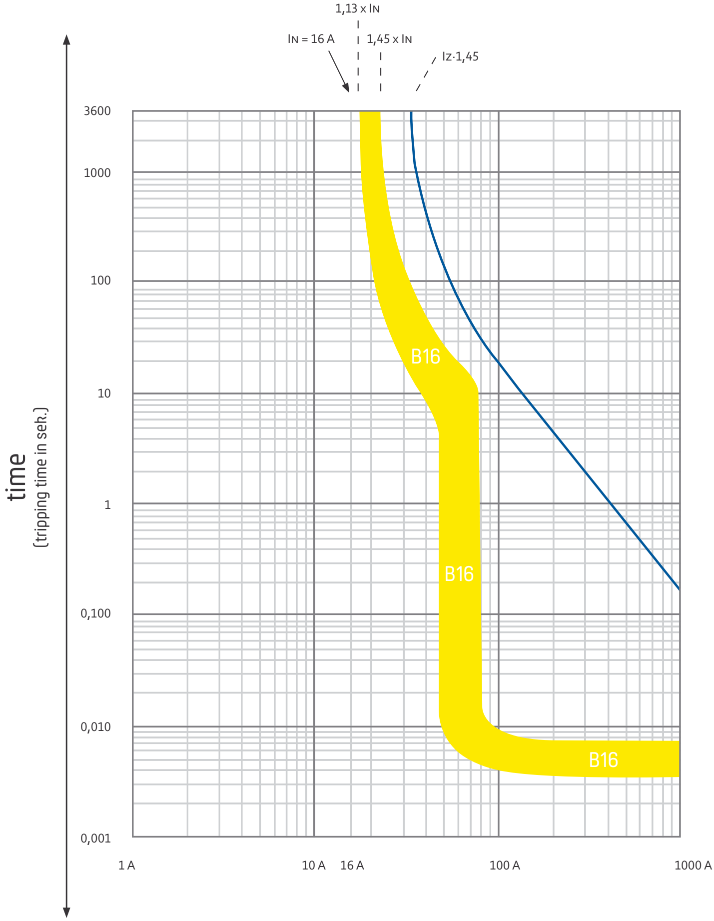


Fig. 14: Characteristic curve for planning example 3

8.10. Backup protection/selectivity

Backup protection
Miniature circuit-breakers only have a limited capacity for cutting off short-circuits. If the uninfluenced short-circuit current exceeds the value that the miniature circuit-breaker itself can switch off or withstand without damage, a fuse is required as backup to protect the miniature circuit-breaker. The upstream protective device thus protects the downstream miniature circuit-breaker against excessive short-circuit currents and is referred to as backup protection.

This backup protection can be achieved with fuses, main circuit-breakers and circuit-breakers in conjunction with a downstream miniature circuit-breaker. The switching capacity of the combination under consideration is decisive for the limit of the backup protection. Corresponding information (tables or characteristic curves) is provided by the manufacturers.

Selectivity
The selectivity between protective devices is an important characteristic that must be taken into account when designing electrical installations. The aim of selectivity is to minimise the consequences of errors. Only the faulty circuit should be switched off, while the others remain in operation. Overcurrent selectivity of two overcurrent protective devices in series exists if the protective device on the load side takes over the protection without the protective device on the supply side responding.

In a distribution system, there are two types of overcurrent faults that may occur:

- overload,
- short-circuit.

Generally, overcurrents between 1.1 and 10 times the operating current are referred to as overload.
These are short-circuits that must be switched off within the shortest possible time.

To determine the selectivity, both the current-time characteristic curves and the I^2t characteristic curves are considered. As long as the characteristic curve of the downstream overcurrent protective device is below that of the upstream one, selectivity is present. If this condition is met over the entire characteristic curve range (no intersection of the characteristic curves), this is referred to as full selectivity.

Otherwise, partial selectivity exists up to the intersection point. If the intersection point is above the maximum possible short-circuit current in the system, selectivity is guaranteed for this system.

Current selectivity

The response values of downstream protective devices are staggered consistently. Depending on certain conditions, full selectivity or partial selectivity exists. For full selectivity, the switch-off behaviour of less than and greater than 0.1 seconds must be considered separately. In the case of high short-circuit currents, the let-through energy (I^2t) is decisive for the selectivity analysis, whereas the tripping characteristic curves can be compared for smaller short-circuit currents.

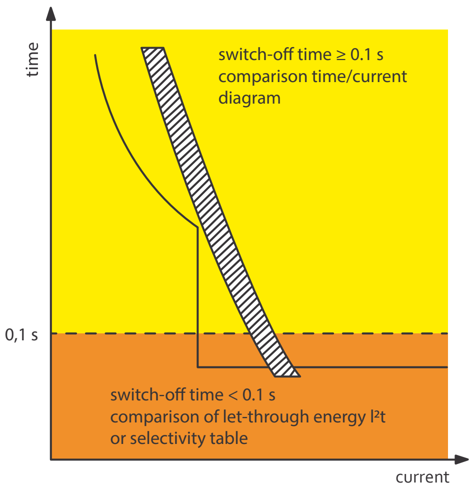


Fig. 15: Current selectivity

Switch-off time ≥ 0.1 seconds

The selectivity is analysed on the basis of the characteristic curve comparison in the current/time diagram. It must be ensured that the characteristic curves do not overlap and that there is a sufficiently large distance between them (for the tolerance).

Switch-off time < 0.1 seconds

The let-through, response or melting energy is decisive for large short-circuit currents. The values are determined by means of extensive tests, and various coordination tables are available to the planner to simplify the process.

Fuse-to-fuse selectivity
Selectivity of fuses with characteristic gG in relation to one another is relatively easy to achieve. All that needs to be ensured is that the rated currents are graded in a ratio of 1:1.6 (two rated current stages).

Example

Backup fuse: gG 63 A

Downstream fuse: gG 35 A

This combination behaves selectively.

Limitation of the let-through energy [I^2t] and selectivity when using miniature circuit-breakers in series with fuses

Characteristic curve 1 shows the let-through energy of a full, unaffected half-wave in the event of a short-circuit. This very high let-through energy means that, if a short-circuit occurs, the conductor cross-sections 1.5 mm^2 (characteristic curve 3) and 2.5 mm^2 (characteristic curve 4) are destroyed. Characteristic curve 2 (our B16 miniature circuit-breaker) shows a let-through value of 21,500 A^2s for miniature circuit-breakers with a short-circuit switch-off capacity of 6 kA. A let-through value of 35,000 A^2s is permissible.

For the miniature circuit-breaker series with 10 kA short-circuit switch-off capacity, we achieve a let-through value of approx. 35,000 A^2s. However, the device standard allows for a value of 70,000 A^2s. Thanks to the high limitation of the let-through energy, conductor cross-sections of 1.5 mm^2 and 2.5 mm^2 are provided with effective protection. At the intersection points, the characteristic curves for 25 A and 35 A fuses (frequently used as meter fuses) show the short-circuit current up to which the MCBs and the fuses behave selectively. The fuse with a rated current of 63 A is usually used by energy supply companies in domestic junction boxes.
The maximum permissible backup fuse has a rated current of 125 A. This characteristic curve is also shown.

**Note: For the characteristic curves, the lower characteristic curve of the fuse is shown. The actual selectivity is higher.
The upward spread is approx. 10%.**

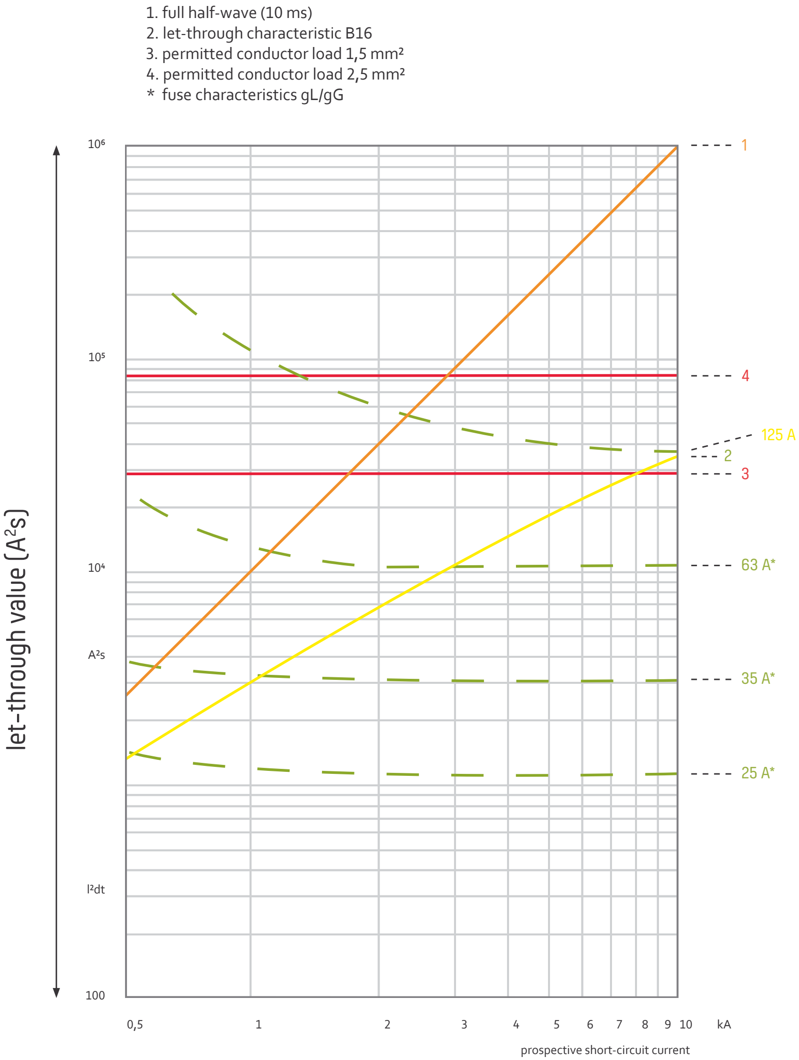


Fig. 16: Let-through energy

Selectivity to fuses (upstream/downstream)

When analysing the selectivity of miniature circuit-breakers in relation to upstream fuses, the tables provided by us must be taken into account.

miniature circuit-breaker 10 kA version DLS 6i: short-circuit selectivity to fuses in kA

NH fuse characteristic gL/gG according to DIN VDE 0636	rated current In (A)									
tripping characteristic B / C / D	6 / 6/8 / 6/8	10 / 10 / 10	13 / 13 / 13	16 / 16 / 16	20 / 20 / 20	25 / 25 / 25	32 / 32 / 32	40 / 40 / 40	50 / 50 / 50	63 / 63 / 63
In (A) 25	0,85 / 0,7 / 0,7	0,8 / 0,7 / 0,6	0,8 / 0,7 / 0,6	0,75 / 0,65 / 0,6	0,7 / 0,6 / 0,55					1.)
35	1,6 / 1,3 / 1,2	1,6 / 1,3 / 1,15	1,5 / 1,25 / 1,1	1,5 / 1,2 / 1,1	1,4 / 1,2 / 1,0	1,2 / 1,1 / 0,9	1,1 / 1,0 / 0,9	0,8 / 0,7 / 0,5		
50	2,4 / 2,1 / 1,9	2,35 / 2,1 / 1,8	2,3 / 2,0 / 1,7	2,3 / 2,0 / 1,7	2,2 / 1,9 / 1,6	1,6 / 1,5 / 1,3	1,5 / 1,4 / 1,2	1,3 / 1,2 / 1,1	1,2 / 1,1 / 1,0	
63	3,5 / 2,9 / 2,5	3,3 / 2,8 / 2,4	3,2 / 2,7 / 2,4	3,2 / 2,7 / 2,3	3,0 / 2,6 / 2,3	2,5 / 2,1 / 1,8	2,4 / 2,0 / 1,8	1,8 / 1,6 / 1,4	1,7 / 1,5 / 1,3	1,6 / 1,4 / 1,2
80	5,0 / 4,1 / 3,5	4,8 / 4,0 / 3,4	4,7 / 3,9 / 3,3	4,6 / 3,9 / 3,2	4,3 / 3,6 / 3,1	3,4 / 2,8 / 2,5	3,3 / 2,8 / 2,4	2,5 / 2,1 / 1,9	2,4 / 2,0 / 1,8	2,3 / 1,9 / 1,7
100	7,6 / 6,3 / 5,2	7,3 / 6,1 / 4,9	7,1 / 5,9 / 4,8	7,0 / 5,7 / 4,7	6,5 / 5,0 / 4,4	5,1 / 4,0 / 3,5	5,0 / 3,9 / 3,4	3,5 / 2,9 / 2,5	3,3 / 2,8 / 2,4	3,1 / 2,6 / 2,3
125	10 / 10 / 8,8	10 / 10 / 8,8	10 / 10 / 7,7	10 / 10 / 7,6	10 / 8,7 / 7,1	8,8 / 6,9 / 5,7	8,5 / 6,8 / 5,6	5,4 / 2,9 / 2,5	3,3 / 4,5 / 3,8	4,9 / 4,1 / 3,5

1.) Above the step line, overload selectivity is no longer given.

Tab. 19: Selectivity DLS 6i to gl/gG

miniature circuit-breaker 6 kA, versions DLS 6h and DLS 6hsl: short-circuit selectivity to fuses in kA

NH fuse characteristic gL/gG according to DIN VDE 0636	rated current In (A)						
tripping characteristic B / C	3,3 / 2,4	10 / 10	13 / 13	16 / 16	20 / 20	25 / 25	32 / 32
In (A) 25	0,85 / 0,7	0,8 / 0,7	0,8 / 0,7	0,75 / 0,65	0,7 / 0,6	0,6 / 0,55	1.)
35	1,6 / 1,3	1,6 / 1,3	1,5 / 1,25	1,5 / 1,2	1,4 / 1,2	1,2 / 1,1	1,1 / 1,0
50	2,4 / 2,1	2,35 / 2,1	2,3 / 2,0	2,3 / 2,0	2,2 / 1,9	16 / 1,5	1,5 / 1,4
63	3,5 / 2,9	3,3 / 2,8	3,2 / 2,7	3,2 / 2,7	3,0 / 2,6	2,5 / 2,1	2,4 / 2,0
80	5,0 / 4,1	4,8 / 4,0	4,7 / 3,9	4,6 / 3,9	4,3 / 3,6	3,4 / 2,8	3,3 / 2,8
100					6,0 / 5,0	5,1 / 4,0	5,0 / 3,9

1.) Above the step line, overload selectivity is no longer given.

Tab. 20: Selectivity DLS 6 h/DLS 6 hsl to gl/gG

Selectivity to other miniature circuit-breakers

In the case of two miniature circuit-breakers connected in series, selectivity generally exists up to the lower limit of the instantaneous tripping range of the upstream miniature circuit-breaker. This limit is well below the short-circuit currents possible in the systems. Therefore, using MCB switches for selectivity design is not recommended.

short-circuit selectivity MCB and MCB in A

miniature circuit-breaker D characteristic In (A) feed-in switch	rated current in (A)							
tripping characteristic In (A) B C D	6 6 6	10 10 10	13 13 13	16 16 16	20 20 20	25 25 25	32 32 32	40 40 40
20	250 250 250	250 250 250	250 250 250					
25	300 300 300	300 300 300	300 300 300	300 300 300				
32	400 400 400	400 400 400	400 400 400	400 400 400	400 400 400			
40	500 500 500	500 500 500	500 500 500	500 500 500	500 500 500	500 500 500		
50	630 630 630	630 630 630	630 630 630	630 630 630	630 630 630	630 630 630	630 630 630	
63	800 800 800	800 800 800	800 800 800	800 800 800	800 800 800	800 800 800	800 800 800	800 800 800

Tab. 21: MCB to MCB selectivity

Downstream miniature circuit-breaker 10 kA	Rated current	Upstream MCB feed switch NZMN-2 100 (DFL 8 100 A)	NZMN-2 125 (DFL 8 125 A)	NZMN-2 160 (DFL 8 160 A)	NZMN-2 200 (DFL 8 200 A)	NZMN-2 250 (DFL 8 250 A)
B characteristic	6	T	T	T	T	T
	10	10	10	10	10	10
	16	10	10	10	10	10
	20	10	10	10	10	10
	25	10	10	10	10	10
	32	8	8	8	8	10
	40	7	7	7	7	10
	50	6	6	6	6	10
	63	6	6	6	6	10
C characteristic	6	T	T	T	T	T
	10	10	10	10	10	10
	16	10	10	10	10	10
	20	10	10	10	10	10
	25	10	10	10	10	10
	32	8	8	8	8	10
	40	7	7	7	7	10
	50	6	6	6	6	10
	63	6	6	6	6	10
D characteristic	6	T	T	T	T	T
	10	10	10	10	10	10
	16	10	10	10	10	10
	20	10	10	10	10	10
	25	10	9	9	9	10
	32	8	8	8	8	9
	40	7	7	7	7	8
	50	6	6	6	6	7
	63	6	6	6	6	7

10 = Selectivity up to a short-circuit current of 10 kA in accordance with IEC 60947
Ue = 400–415V AC

Tab. 22: Selectivity MCB to circuit-breaker NZMN-2

Examples of selectivity

total selectivity

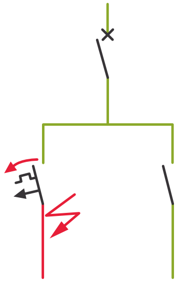


Fig. 17: Overload selectivity

Illustration of overload selectivity of two overcurrent protective devices connected in series; only the protective device closest to the fault on the load side trips.

Partial selectivity

This designates the overcurrent selectivity of two overcurrent protective devices connected in series.
In this case, the protective device on the load side takes over the protection up to a certain overcurrent value without the upstream protective device taking effect.

In the event of small short-circuit currents, only the protective device closest to the fault location trips. Only when the short-circuit current is above the selectivity limit does the upstream protective device also trip in parallel. If the short-circuit currents exceed the switching capacity of the protective device, this ensures that the upstream protective device takes over the backup protection.

If the short-circuit is at the load, selectivity exists due to low short-circuit currents.

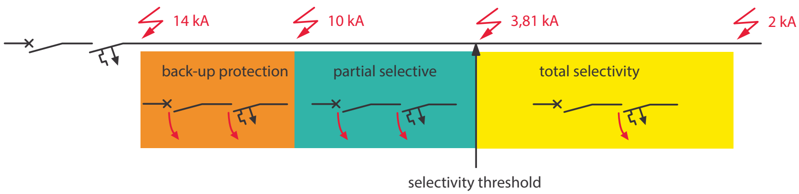


Fig. 18: Partial selectivity

Example of backup protection

Illustration of the backup protection if the magnitude of a short-circuit current exceeds the switching capacity of the protective device. The upstream protective element limits the short-circuit current to ensure safe disconnection. In the event of a fault in the form of a short-circuit, both protective elements usually trip.

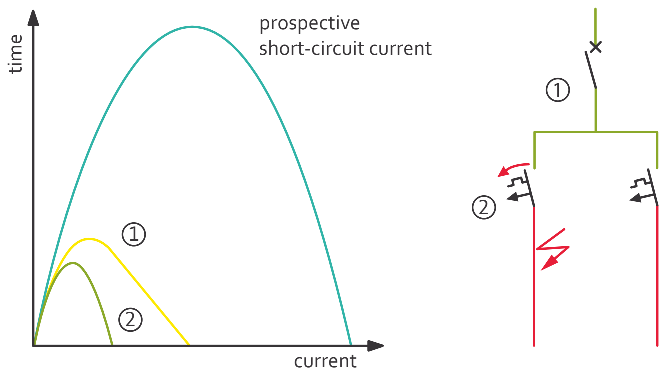


Fig. 19: Backup protection

Tip

Backup protection often already exists, for example in the form of the backup fuse for the sub-distribution board or a group backup fuse for the RCD, but this should still be checked on a case-by-case basis.

Let-through characteristic curves for B characteristic

1. B63
2. B50
3. B40
4. B32
5. B25
6. B20
7. B16
8. B13
9. B10
10. B8
11. B6
12. B5
13. B4
14. B3
15. B2
16. B1

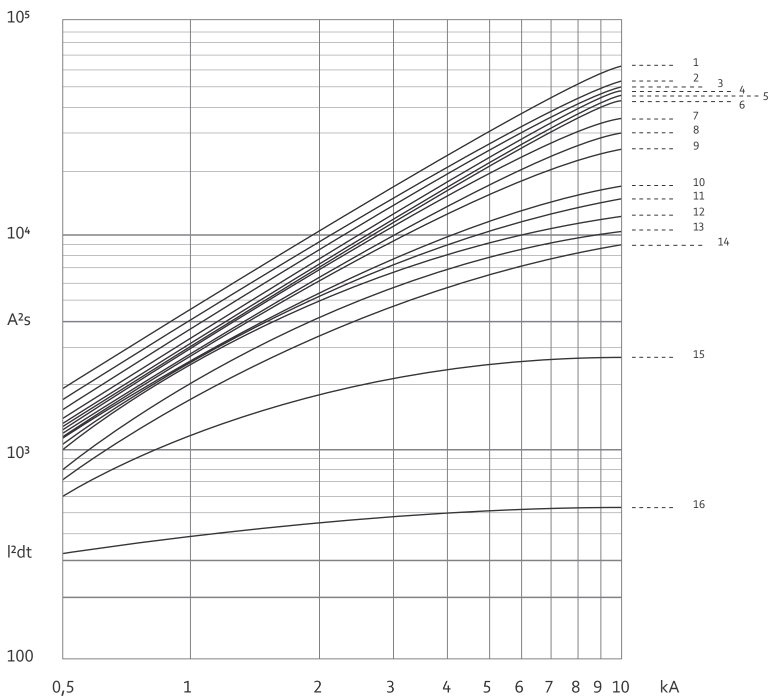


Fig. 20: Let-through characteristic curves for B characteristic

Let-through characteristic curves for C characteristic

1. C63
2. C50
3. C40
4. C32
5. C25
6. C20
7. C16
8. C13
9. C10
10. C8
11. C6
12. C5
13. C4
14. C3
15. C2
16. C1

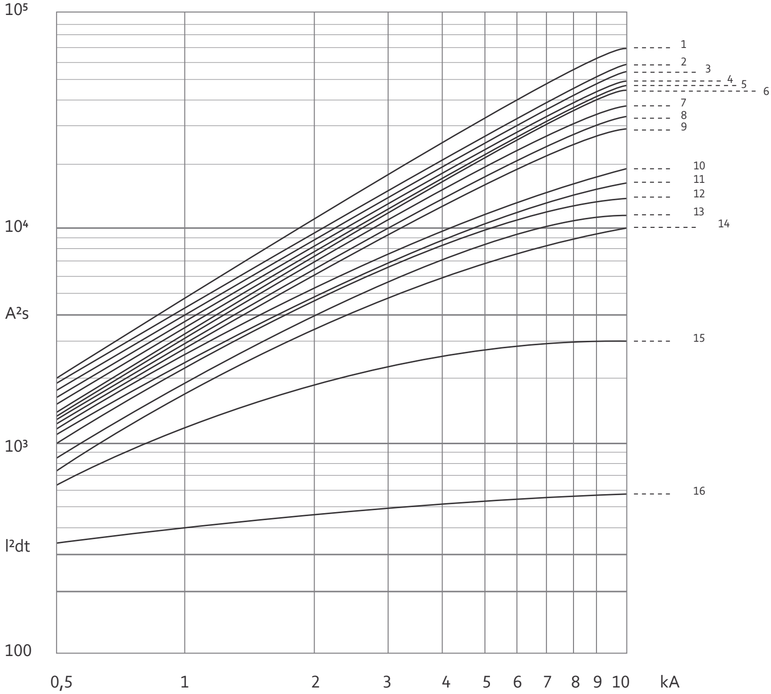


Fig. 21: Let-through characteristic curves for C characteristic

8.11. Elevated ambient temperature/derating

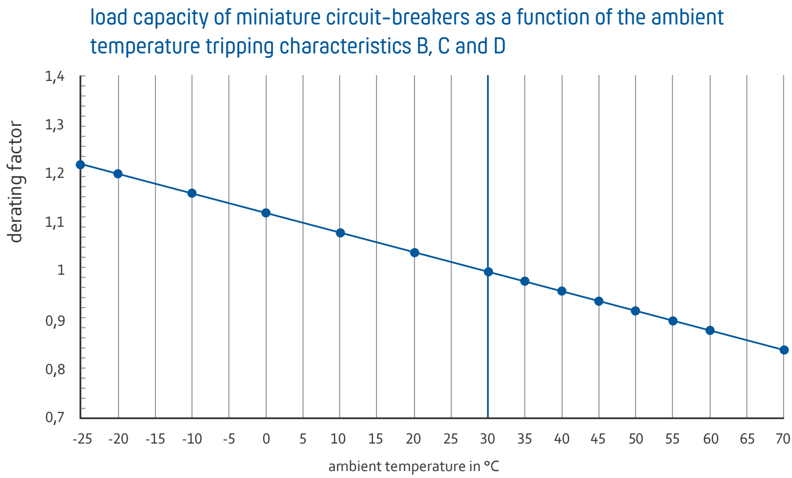


Fig. 22: Derating for B, C, D characteristic

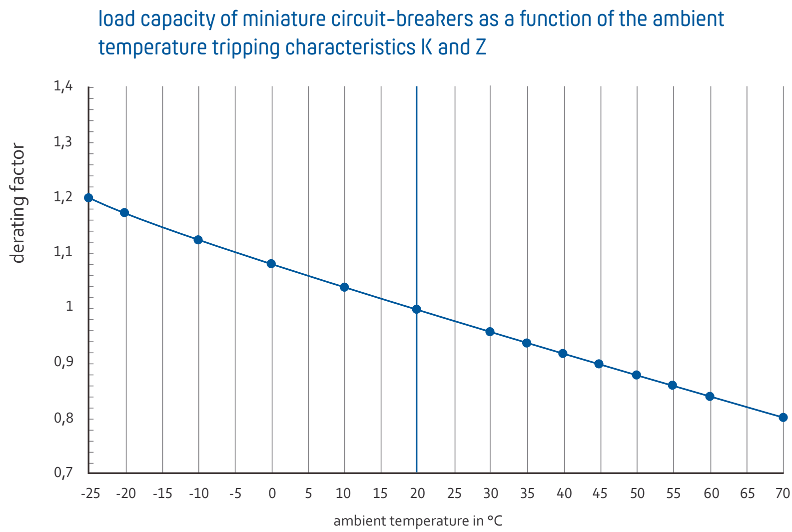


Fig. 23: Derating for K, Z characteristic

Load capacity (corrected values) for characteristics B, C and D.

I_n [A]	Ambient Temperature T [°C] -25	-20	-10	0	10	20	30	35	40	45	50	55	60	70
0,3	0,37	0,36	0,35	0,35	0,32	0,31	0,3	0,29	0,29	0,29	0,28	0,27	0,26	0,25
0,5	0,61	0,60	0,58	0,58	0,54	0,52	0,5	0,49	0,48	0,48	0,46	0,45	0,44	0,42
0,8	0,98	0,96	0,93	0,93	0,86	0,83	0,8	0,78	0,77	0,77	0,74	0,72	0,70	0,67
1,0	1,2	1,2	1,2	1,2	1,1	1,0	1,0	1,0	1,0	1,0	0,9	0,9	0,9	0,8
1,6	2,0	1,9	1,9	1,9	1,7	1,7	1,6	1,6	1,5	1,5	1,5	1,4	1,4	1,3
2,0	2,4	2,4	2,3	2,3	2,2	2,1	2,0	2,0	1,9	1,9	1,8	1,8	1,8	1,7
2,5	3,1	3,0	2,9	2,9	2,7	2,6	2,5	2,5	2,4	2,4	2,3	2,3	2,2	2,1
3,0	3,7	3,6	3,5	3,5	3,2	3,1	3,0	2,9	2,9	2,9	2,8	2,7	2,6	2,5
3,5	4,3	4,2	4,1	4,1	3,8	3,6	3,5	3,4	3,4	3,4	3,2	3,2	3,1	2,9
4	4,9	4,8	4,6	4,6	4,3	4,2	4	3,9	3,8	3,8	3,7	3,6	3,5	3,4
5	6,1	6,0	5,8	5,8	5,4	5,2	5	4,9	4,8	4,8	4,6	4,5	4,4	4,2
6	7,3	7,2	7,0	7,0	6,5	6,2	6	5,9	5,8	5,8	5,5	5,4	5,3	5,0
8	9,8	9,6	9,3	9,3	8,6	8,3	8	7,8	7,7	7,7	7,4	7,2	7,0	6,7
10	12	12	12	12	11	10	10	9,8	9,6	9,6	9,2	9,0	8,8	8,4
13	16	16	15	15	14	14	13	13	12	12	12	12	11	11
16	20	19	19	19	17	17	16	16	15	15	15	14	14	13
20	24	24	23	23	22	21	20	20	19	19	18	18	18	17
25	31	30	29	29	27	26	25	25	24	24	23	23	22	21
32	39	38	37	37	35	33	32	31	31	31	29	29	28	27
40	49	48	46	46	43	42	40	39	38	38	37	36	35	34
50	61	60	58	58	54	52	50	49	48	48	46	45	44	42
63	77	76	73	73	68	66	63	62	60,5	60	58	57	55,4	53

Tab. 23: Corrected values for B, C, D characteristic

Load capacity (corrected values) for characteristics K, Z.

	Ambient Temperature T [°C]														
	-25	-20	-10	0	10	20	25	30	35	40	45	50	55	60	70
I_n [A]															
0,30	0,36	0,35	0,34	0,32	0,31	0,300	0,29	0,28	0,28	0,28	0,27	0,26	0,26	0,25	0,24
0,50	0,60	0,58	0,56	0,54	0,52	0,50	0,49	0,47	0,47	0,46	0,45	0,44	0,43	0,42	0,40
0,80	0,96	0,93	0,90	0,86	0,83	0,80	0,78	0,77	0,75	0,74	0,72	0,70	0,69	0,67	0,64
1,00	1,2	1,2	1,1	1,1	1,0	1,0	1,0	1,0	0,9	0,9	0,9	0,9	0,9	0,8	0,8
1,60	1,9	1,9	1,8	1,7	1,7	1,6	1,6	1,5	1,5	1,5	1,4	1,4	1,4	1,3	1,3
2,00	2,4	2,3	2,2	2,2	2,1	2,0	2,0	1,9	1,9	1,8	1,8	1,8	1,7	1,7	1,6
2,50	3,0	2,9	2,8	2,7	2,6	2,5	2,5	2,4	2,4	2,3	2,3	2,2	2,2	2,1	2,0
3,00	3,6	3,5	3,4	3,2	3,1	3,0	2,9	2,9	2,8	2,8	2,7	2,6	2,6	2,5	2,4
3,50	4,2	4,1	3,9	3,8	3,6	3,5	3,4	3,4	3,3	3,2	3,2	3,1	3,0	2,9	2,8
4	4,8	4,6	4,5	4,3	4,2	4	3,9	3,8	3,8	3,7	3,6	3,5	3,4	3,4	3,2
5	6,0	5,8	5,6	5,4	5,2	5	4,9	4,8	4,7	4,6	4,5	4,4	4,3	4,2	4,0
6	7,2	7,0	6,7	6,5	6,2	6	5,9	5,8	5,6	5,5	5,4	5,3	5,2	5,0	4,8
8	9,6	9,3	9,0	8,6	8,3	8	7,8	7,7	7,5	7,4	7,2	7,0	6,9	6,7	6,4
10	12	12	11	11	10	10	9,8	9,6	9,4	9,2	9,0	8,8	8,6	8,4	8,0
13	16	15	15	14	14	13	13	12	12	12	12	11	11	11	10
16	19	19	18	17	17	16	16	15	15	15	14	14	14	13	13
20	24	23	22	22	21	20	20	19	19	18	18	18	17	17	16
25	30	29	28	27	26	25	25	24	24	23	23	22	22	21	20
32	38	37	36	35	33	32	31	31	30	29	29	28	28	27	26
40	48	46	45	43	42	40	39	38	38	37	36	35	34	34	32
50	60	58	56	54	52	50	49	48	47	46	45	44	43	42	40
63	76	73	71	68	66	63	62	60	59	58	57	55	54	53	50

Tab. 24: Corrected values for K, Z characteristic

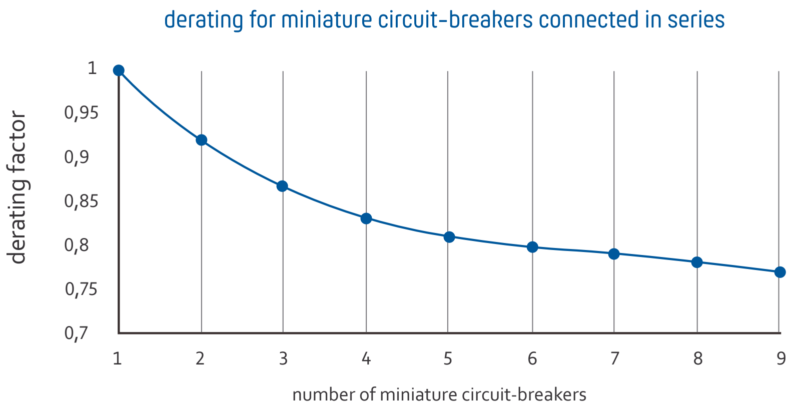


Fig. 24: Derating of MCBs connected in series

Load capacity for miniature circuit-breakers connected in series

The table below shows the correction factor (K) for mutual thermal interference between miniature circuit-breakers installed next to each other at rated power.

Number of miniature circuit-breakers (1)	Correction factor (K)
1	1.0
2	0.92
3	0.87
4	0.84
5	0.81
6	0.80
7	0.79
8	0.78
9	0.77

(1) applies to 1-, 2-, 3-, 4-, 1+N, 3+N-pole devices

Tab. 25: Derating of MCBs connected in series

8.12. Trip-free mechanism

Miniature circuit-breakers cannot be blocked by the user. They are designed with a mechanical trip-free mechanism. A 'trip-free' mechanism is a mechanism, or more precisely a protective function, which ensures that a miniature circuit-breaker can be tripped without external influence or blocking. The trip-free mechanism enables tripping even if the switch mechanism is held in the switch-on position by hand. It is a common misconception that a trip-free mechanism prevents the operator from reactivating the miniature circuit-breaker while the cause is still present. This is clearly incorrect, as the miniature circuit-breaker would have to be able to determine whether the fault is still present while it is switched off.
This is not the case with miniature circuit-breakers.

Rather, the following sequence occurs:
Upon switching on, the circuit is closed; if the fault is still present, it is recognised again and the miniature circuit-breaker trips, even if the switch is still held in the on position.

Likewise, if the bimetal has not yet cooled down sufficiently after the last fault and is therefore still in the tripping range, the circuit-breaker trips immediately, regardless of whether the fault is still present or not.

8.13. Bimetal release (delayed release)

Thermobimetals consist of two or more layers of metals (components) that have different coefficients of thermal expansion and are inseparably bonded together by pressure welding.
When a thermobimetal is heated, the metal component with the greater thermal expansion (active component) tries to expand more than the other component (passive component).
The difference between the different expansions causes a curvature of the thermobimetal.

Fig. 1

Fig. 2

Fig. 25: Bimetal

Figure 1 shows two metals with different thermal expansion.

Figure 2 shows the two metals above, which are inseparably bonded together when exposed to heat. Due to the difference in thermal expansion, the material combination is deformed into a round shape.

Bimetals can be heated in various ways:

- Convection radiation
- Direct current flow
- Indirect heating (heat conductor).

By pairing corresponding components, it is possible to obtain bimetals with different specific thermal deflection (different deflection at the same temperature).

In electrical switching devices (miniature circuit-breakers), the bimetals are usually heated by the direct current flow. This applies to MCBs with a rated current of approx. 10–63 A. The smaller rated currents are mainly heated indirectly by means of applied heat conductors. In miniature circuit-breakers, these thermobimetals are almost always used in ‘strip’ form. The bimetals are secured on one side. The free end is used directly to trigger the release mechanism.

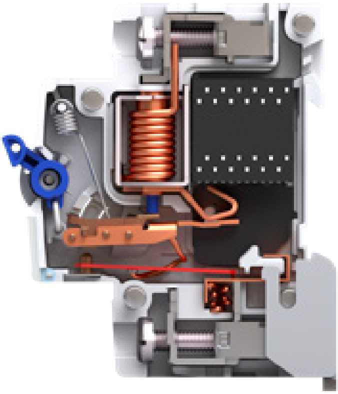


Fig. 26: Position of bimetal in MCB

Characteristic	Thermal release	Use
B, C, D	1.13...1.45 * rated current	Line protection: - Circuits with loads without high inrush current spikes, i.e. resistive loads such as heating appliances - Circuits with predominantly inductive loads that can generate current peaks, such as TV sets or socket outlet circuits where the subsequently connected loads are alternating. - Circuits with transformers or capacitors in which extreme current peaks can occur at the moment of switching on.
K	1.05...1.3 * rated current	For circuits in which loads with a requirement for more sensitive overload tripping are installed; this is used in three-phase circuits (motor and transformer load circuits).
Z	1.05...1.2 * rated current	For circuits with electronic loads (semiconductor elements) or with high impedances.

Tab. 26: Thermal release

8.14. Electromagnetic release

The electromagnetic release in the miniature circuit-breaker enables practically instantaneous tripping in the event of a short-circuit. The current carried by the miniature circuit-breaker flows through a coil inside the protective device. If the current of a short-circuit increases sharply, the magnetic field also increases instantaneously, whereupon a striker hits the switching mechanism and thus disconnects the contacts of the miniature circuit-breaker.

Characteristic	Short-circuit tripping	Use
B	3...5 * rated current	Line protection: Circuits with loads without high inrush current spikes, i.e. resistive loads such as heating appliances.
C	5...10 * rated current	Line protection: Circuits with predominantly inductive loads that can generate current peaks, such as TV sets or socket outlet circuits where the subsequently connected loads are alternating.
D	10...20 * rated current	Line protection: Circuits with transformers or capacitors in which extreme current peaks can occur at the moment of switching on.
K	8...14 * rated current	For circuits in which loads with high inrush currents are installed; this is used in three-phase circuits (motor and transformer load circuits).
Z	2...3 * rated current	For circuits with electronic loads (semiconductor elements) or with high impedances.

Tab. 27: Magnetic release

8.15. Labelling software

Simple-to-use programs, easy-to-read documents and other tools make it easier to use our products. The labelling software means that line and residual current circuit-breakers can be labelled in a standardised and easy-to-read way. It is compatible with Microsoft Windows operating systems, is simple to use and provides the option of producing your own designs on a standard A4 sheet. The labelling software can be downloaded from www.doepke.de.

For DLS and DFS

- 1–4 module widths possible
- Icons (symbols) or lettering can be inserted
- Direct printing from the preview level of labels and distribution lists

Options in the distribution list:

- Number the PE and N terminals
- Save company and address details
- Insert comments

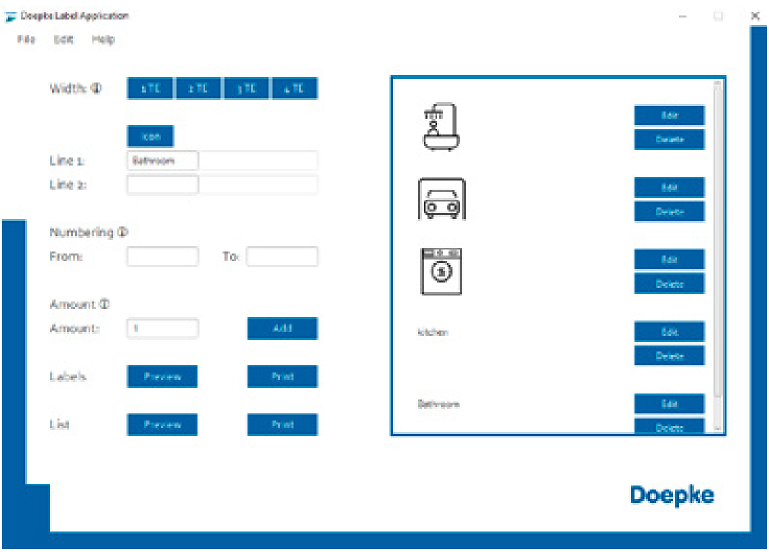


Fig. 27: Display labelling software

9. Switching devices for the whole world

Switching devices are used all over the world – and that includes the products from Doepke Schaltgeräte. There are various directives, standards and regulations that apply around the world.

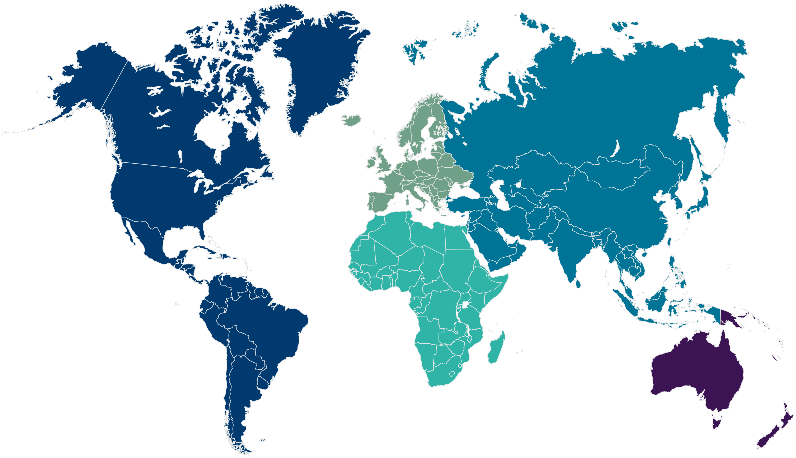


Fig. 28: Areas of standardisation

Product range

DLS 6h
The DLS 6h design for skilled trade applications and conventional residential buildings features a rated switching capacity of 6 kA, making it ideal for distributor and final circuits.

DLS 6hsl
The DLS 6hsl screwless design for industrial/commercial applications features a rated switching capacity of 6 kA, making it ideal for distributor and final circuits. It is particularly easy to handle thanks to the screwless plug-in terminals at the top.

DLS 6hdc
The DLS 6hdc design features a rated switching capacity of 6 kA, making it ideal for applications in DC networks of up to 250 V DC.

DLS 6i
The DLS 6i design features a high rated switching capacity of 10 kA, making it perfect for industrial and mechanical engineering applications.

Comparison of the different variants

	DLS 6h	DLS 6hsl	DLS 6hdc	DLS 6i
Switching capacity	6 kA	6 kA	6 kA	10 kA
Detachable from the combination	only from the bottom	only from the bottom	only from the bottom	top and bottom
Eurovario from RCD to circuit-breaker	only from the bottom	only from the bottom	only from the bottom	only from the bottom
Contact protection	yes	yes	yes	yes
Tripping characteristic	B, C	B, C	B, C	B, C, D, K, Z

Tab. 28: Comparison of the different variants

Characteristics and current strengths

	DLS 6h				DLS 6hsl		DLS 6hdc		DLS 6i					
Amperages/currents	6 – 32 A				6 – 20 A		B 1 – 63 A C 0,5 – 63 A		B 1 – 63 A C/D/K 0,3 – 63 A Z 0,3 – 32 A (ony 1- and 3-pole)					
Pole number	1	2	3	4	1	3	1	2	1	2	3	4	1+N	3+N
B characteristic	■	■	■	■	■	■	■	■	■	■	■	■	■	■
C characteristic	■	■	■	■	■	■	■	■	■	■	■	■	■	■
D characteristic									■	■	■	■	■	■
K characteristic									■	■	■	■	■	■
Z characteristic									■	■	■			

Tab. 29: Overview of characteristics and current strengths

Tripping characteristic curves of different characteristics

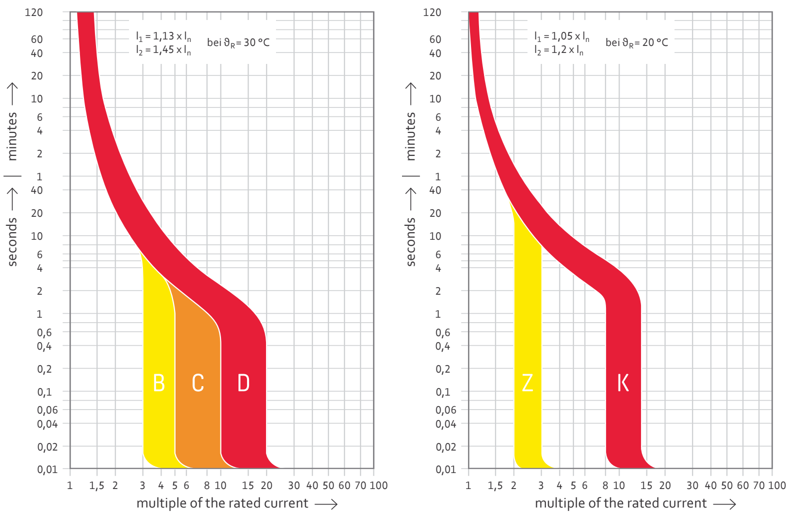


Fig. 29: Tripping characteristic curves

Miniature circuit-breakers of the product series DLS 6 h, DLS 6 hsl and DLS 6 i – Technical data

	B	C	D	K	Z
Application	Line protection	Line protection Device protection	Line protection for high inrush currents (trans- formers, motors)	Line protection with more sensitive overload tripping	Line protection at high impedances (semiconductor elements)
Number of poles					
Product series DLS 6 h	1 and 3		-	-	-
Product series DLS 6 hsl	1 and 3		-	-	-
Product series DLS 6 i	1-4; 1+N; 3+N				1-3
Regulations, rated switching capacity	IEC 60898-1, DIN EN 60898-1, VDE 0641-11			IEC 60947-2, DIN EN 60947-2, VDE 0660-101	
Product series DLS 6 h	6 kA	6 kA	-	-	-
Product series DLS 6 hsl	6 kA	-	-	-	-
Product series DLS 6 i	6 kA/10 kA	6 kA/10 kA	6 kA/10 kA	10 kA	10 kA
Current limitation class up to 63 A	3	3			
Rated AC voltage	1-pole: 230 V/400 V; 1-pole+N: 230; 2-/3-/3-pole+N/4 pole: 400 V				
Rated voltage DC L/R = 4 ms	1-pole: 60 V 2-pole 125 V with both poles connected in series				
Rated current range In					
Product series DLS 6 h	6-32 A	6-32 A	-	-	-
Product series DLS 6 hsl	6-20 A		-	-	-
Product series DLS 6 i	1-63 A	0.3-63 A	0.3-40 A	0.3-63 A	0.3-32 A
Test currents: Thermal hold I1 (A) > 1 h	1.13 x In	1.13 x In	1.13 x In	1.05 x In	1.05 x In
Test currents: Thermal release I2 (A) < 1 h	1.45 x In	1.45 x In	1.45 x In	1.2 x In	1.2 x In
Test currents: Electromagnetic hold I4 (A) > 0.1 s	3 x In	5 x In	10 x In	8 x In	2 x In
Test currents: Electromagnetic release I5 (A) < 0.1 s	5 x In	10 x In	20 x In	14 x In	3 x In
Reference temperature of the thermal release	Influence of the ambient temperature on thermal release: Current values are reduced at higher ambient temperatures and increased at lower temperatures by approx. 5% per 10°C temperature difference				
Frequency range of the electromagnetic release	16.667 to 60 Hz At higher frequencies, the electromagnetic release values increase by a factor of approx. factor 1.1 at 100 Hz; 1.2 at 200 Hz; 1.3 at 300 Hz; 1.4 at 400 Hz; 1.5 at DC				
Ambient temperature	-25°C to +70°C				
Storage temperature	-40°C to +70°C				
Device depth acc. to DIN 43880	68 mm				
Mechanical service life	20,000 switching cycles (20,000 switch-ons and 20,000 switch-offs)				
Contact protection	Finger and back-of-hand proof acc. to DIN EN 50274/VDE 0660-51, DGUV regulation 3				
Insulation group acc. to DIN DVE 0100	C at 250 V AC B at 400 V AC				
Protection class acc. to EN 60529/IEC 60529	IP 20				
Installation position	any				
Assembly	on mounting rail in accordance with DIN EN 60715 35 mm				
Sealing	The rocker arm can be sealed in the on and off position, i.e. secured against manual switching				
Resistance to climatic changes	Damp heat constant as per DIN IEC 60068-2-78; damp heat cyclical as per DIN IEC 60068-2-30				
Shake resistance	> 15 g DIN EN 60068-2-59				
Shock resistance	25 g 11 ms				

Tab. 30: Technical data (DLS 6h; DLS 6 hsl; DLS 6 i)

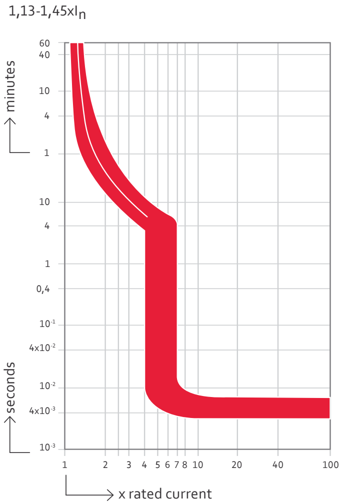
Miniature circuit-breakers of the product series DLS 6 hdc – Technical data

Tripping characteristic		B	C
Application		Line protection	Line protection Device protection
Number of poles		1 and 2	
Rated switching capacity		IEC 60898-3, DIN VDE 0641-13 (VDE 0641-13)	
Rated switching capacity DC DC L/R = 4 ms		6 kA	6 kA
Max. backup fuse		Fuse as per DIN VDE 0636 100 A utilisation category gL/gG	
Rated voltage DC L/R = 15 ms		1-pole 215 V 2-pole 250 V with both poles connected in series	
Rated current range In			
Product series 'hdc'		0.3 - 63 A	
Test currents	Thermal hold I1 (A) > 1 h	1.13 x In	1.13 x In
Test currents	Thermal release I2 (A) < 1 h	1.45 x In	1.45 x In
Test currents	Electromagnetic hold I4 (A) > 0.1 s	4 x In	7 x In
Test currents	Electromagnetic release I5 (A) < 0.1 s	7 x In	15 x In
Reference temperature of the thermal release		30°C+ 5°C Influence of the ambient temperature on thermal release: Current values are reduced at higher ambient temperatures and increased at lower temperatures by approx. 5% per 10°C temperature difference	
Ambient temperature		-25°C to +70°C	
Storage temperature		-40°C to +70°C	
Device depth acc. to DIN 43880		68 mm	
Mechanical service life		20,000 switching cycles (20,000 switch-ons and 20,000 switch-offs)	
Contact protection		Finger and back-of-hand proof acc. to DIN EN 50274/VDE 0660-51, DGUV regulation 3	
Protection class acc. to EN 60529/IEC 60529		IP 20	
Installation position		any	
Assembly		on mounting rail in accordance with DIN EN 60715 35 mm	
Sealing		The rocker arm can be sealed in the on and off position, i.e. secured against manual switching	
Resistance to climatic changes		Damp heat constant as per DIN IEC 60068-2-78; damp heat cyclical as per DIN IEC 60068-2-30	
Shake resistance		> 15 g DIN EN 60068-2-59	
Shock resistance		25 g 11 ms	

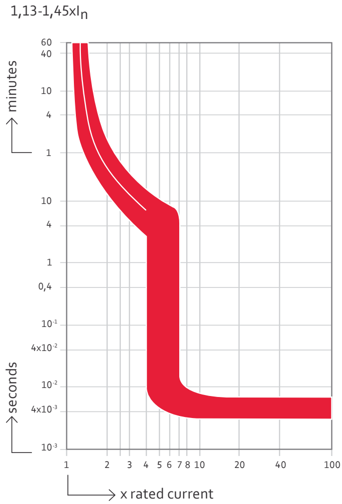
Tab. 31: Technical data (DLS 6hdc)

Miniature circuit-breakers of the product series DC

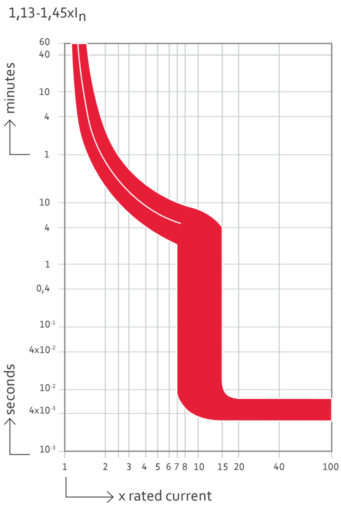
Tripping characteristic curves according to IEC 60898-3, DIN EN 60898-3 and VDE 0641-12.



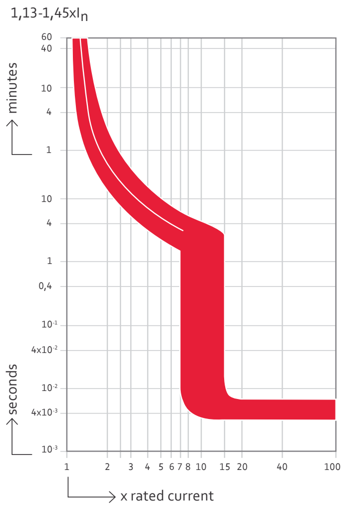
tripping characteristic B I_n = 1-6 A



tripping characteristic B I_n = 10-63 A



tripping characteristic C I_n = 0,5-6 A



tripping characteristic C I_n = 10-63 A

Fig. 30: DLS 6 hdc tripping characteristic curves

Connectable conductor cross-sections (DLS 6h, DLS 6 hdc and DLS 6 i)	Lower screw terminal with strain-relief clamp		Upper screw terminal with strain-relief clamp	
Type of conductor *)	max.	min.	max.	min.
solid	35 mm²	0.5 mm²	25 mm²	0.5 mm²
stranded	35 mm²	1.5 mm²	25 mm²	1.5 mm²
finely stranded	25 mm²	1 mm²	16 mm²	1 mm²
finely stranded with ferrule	16 mm²	0.5 mm²	16 mm²	0.5 mm²
Busbar/cable lug	max. 3 mm thick		max. 3 mm thick	
Combination (conductor and busbar or cable lug)	up to 35 mm² and up to 2 mm thick		up to 35 mm² and up to 2 mm thick	
Tightening torque	max. 2.5 Nm			
*) Stripping length 12–14 mm				

Tab. 32: Conductor cross-sections DLS 6 h/hdc/i

Connectable conductor cross-sections (DLS 6hsl)	Lower screw terminal with strain-relief clamp		Upper spring-loaded terminal	
Type of conductor *)	max.	min.	max.	min.
solid	35 mm²	0.5 mm²	4 mm²	1 mm²
stranded	35 mm²	1.5 mm²	4 mm²	1.5 mm²
finely stranded	25 mm²	1 mm²	4 mm²	1 mm²
Busbar/cable lug	max. 3 mm thick		-	
Combination (conductor and busbar or cable lug)	up to 35 mm² and up to 2 mm thick		-	
Tightening torque	max. 2.5 Nm		-	
*) Stripping length 12–14 mm				

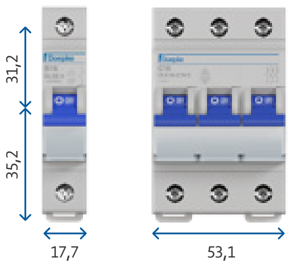
Tab. 33: Conductor cross-sections DLS 6 hsl

Note — *A maximum of 2 conductors of the same type and cross-section may be connected per screw terminal with strain-relief clamp.*

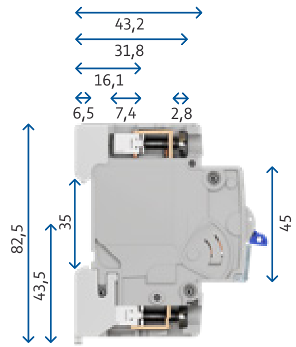
MINIATURE CIRCUIT-BREAKER PRODUCT SERIES h,hsl,i

Miniature circuit-breaker product series DLS 6h

with screw terminals
detachable from the BOTTOM of the busbar system

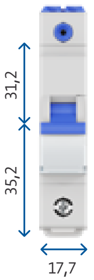


one-pole three-pole

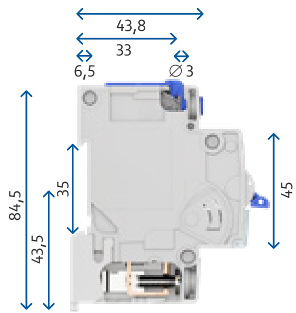


Miniature circuit-breaker product series DLS 6hsl

with screwless terminals
detachable from the BOTTOM of the busbar system

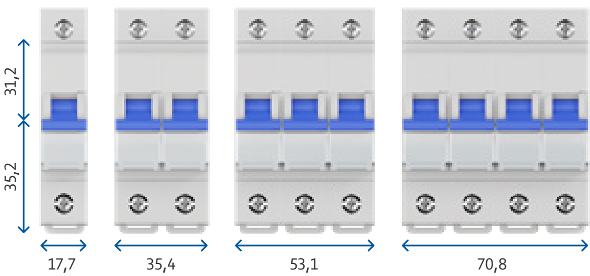


one-pole

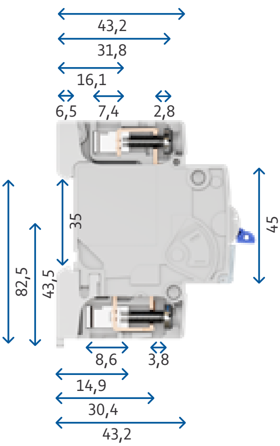


Miniature circuit-breaker product series DLS 6i

with screw terminals
detachable from the BOTTOM of the busbar system



one-pole | two-pole or three-pole with switched neutral conductor | three-pole | four-pole or three-pole with switched neutral conductor



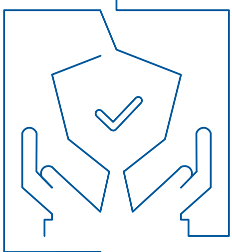
9.1. How to strip and connect correctly

Stripping length 10–12 mm

Due to the material structure, copper can break off in damaged areas or become very hot.

The available cross-section then no longer allows an unhindered flow of current. This can result in severe heating and even cable fires, which can occur within a few hours or even years later. To counteract this, conductors should be stripped properly. Stripping involves removing part of the insulating sheath of the electrical conductor over a certain length required for the connection. The illustrations below show the most frequently occurring fault patterns and apply to both solid and flexible conductors.

Stripping result OK

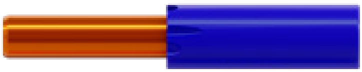


Severe deformation of the core insulation that reduces the insulation thickness by more than 20% is not permitted. In the worst case, touching the tapered area can lead to sparkover, or creepage currents can occur and trigger faults.

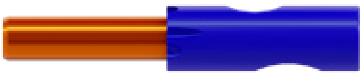
Insulation cut untidily

Insulation remnants on the individual wires

Insulation damaged



Insulation not cut properly, frayed



Insulation was severely damaged by tool

9.2. Special features of the red miniature circuit-breaker

Doepke's answer to the DIN VDE 0100-560 standard (equipment for safety purposes), which requires clear labelling of the switching devices of corresponding safety-relevant circuits, is the DLS 6 series as a special variant with a red housing.

In practice, installers often colour circuit-breakers with a red permanent marker. There is a possibility that such colouring may change the properties of the plastic and thus impair safety in the event of a fault. With circuit-breakers from the DLS 6 series with a red housing, there is no need for manual colouring.

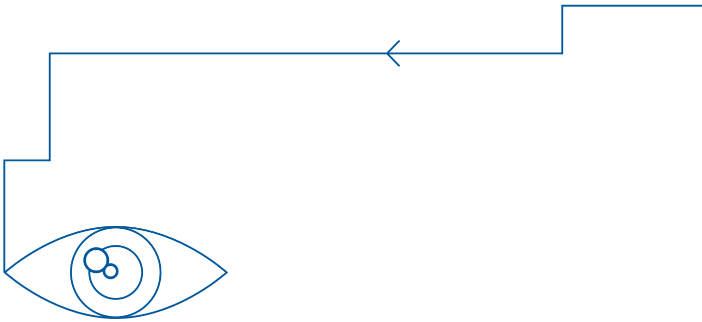
This standard is applicable to the following areas, among others:

- safety lighting systems
- fire alarms
- smoke and heat ventilation systems

The following products are currently available in this special variant:

- DLS 6i B10-1 RT 6kA (Art. no.: 09860100)
- DLS 6i B16-1 RT 6kA (Art. no.: 09860101)
- DLS 6i C16-1 RT 6kA (Art. no.: 09860102)

The miniature circuit-breakers in the red series naturally have the same high quality and the typical features of the DLS 6 series. This means that the installer does not have to get used to any new products and can continue working as usual.



Our solutions:
DLS 6i RT

Expert line protection to keep you safe at all times

Quick overview — Our 'red' miniature circuit-breakers:
According to DIN VDE 0100-560 (Equipment for safety purposes) switchgear and control gear must be learly labelled.

- safety lighting
- fire alarms
- smoke and heat ventilation systems.

Operating current release
The operating current release enables remote tripping of circuit-breakers. Operating current releases for remote tripping of miniature circuit-breakers of series DLS 6. The operating current release does not affect the protective function of the miniature circuit-breaker.

DASA 12 (09917992)
Rated voltage: 12 V UC

DASA 24 (09917993)
Rated voltage: 24 V UC

DASA 48 (09917994)
Rated voltage: 48 V UC .... 74 V UC

DASA 230 (09917995)
Rated voltage: 110 V UC .... 230 V UC

Example image

Trip-indicating auxiliary contact
Auxiliary switch function for DLS 6, different contact designs available, compact design (0.5 module width units), complies with IEC 60947-5-1, EN 60947-5-1 and VDE 0660-200

DHi-S11 (09917991)
Contact assignment: 2 changeover contacts
Rated current (AC): max. 4.8 A
Rated power: min. 0.1 VA

DHi-S10 (09917990)
Contact assignment: 1 changeover contact
Rated current (AC): max. 4.8 A
Rated power: min. 0.1 VA


Example image

Auxiliary switch

Auxiliary switches report the status of the main devices to which they are fitted.
The auxiliary switches DHi 3 to DHi 8 are suitable for the DLS 6 h, hsl and i series of miniature circuit-breakers. They trip in parallel to the miniature circuit-breaker when switched off by hand or because of overload or short-circuit.

Example image

DHi 8 (09917989)
Contact assignment: 2 changeover contacts
Rated voltage (AC): 230 V
Rated current (AC): max. 4.8 A
Rated power: min. 0.1 VA

DHi 7 (09917988)
Contact assignment: 1 changeover contact
Rated voltage (AC): 230 V
Rated current (AC): max. 4.8 A
Rated power: min. 0.1 VA

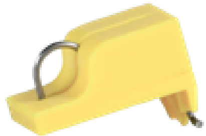
DHi 6 (09917987)
Contact assignment: 1 NC contact/2 NO contacts
Rated voltage (AC): 230 V
Rated current (AC): max. 10 A
Rated power: min. 0.1 VA

Auxiliary switch DHi 5 (09917986)
Contact assignment: 2 NC contacts/1 NO contact
Rated voltage (AC): 230 V
Rated current (AC): max. 10 A
Rated power: min. 0.1 VA

Auxiliary switch DHi 4 (09917985)
Contact assignment: 1 NC contact/1 NO contact
Rated voltage (AC): 230 V
Rated current (AC): max. 10 A
Rated power: min. 0.1 VA

Auxiliary switch DHi 3 (09917984)
Contact assignment: 1 NO contact
Rated voltage (AC): 230 V
Rated current (AC): max. 10 A
Rated power: min. 0.1 VA

DEASS restart lock (09917983)
The DEASS restart lock prevents miniature circuit-breakers of the DLS 6 series from being switched on or off. It provides protection during maintenance work and prevents sensitive circuits such as those in IT systems from being switched off accidentally. The protective function of the circuit-breaker is not affected.


Example image

KA-DLS/RH terminal covers (09913997)
Terminal covers for integrated distribution devices provide additional protection against electric shock due to contact. The KA-DLS/RH terminal covers are suitable for both the single-pole and multi-pole versions of the DLS 6 miniature circuit-breakers and for the RH main switches.


Example image

Various busbars
These components for the wiring of circuit-breakers in industrial, commercial and privately used electrical distribution units significantly reduce the amount of installation work required. The cut-to-length busbars of the Eurovario system are suitable for the supply-side connection of residual current circuit-breakers, miniature circuit-breakers (MCBs) and residual current operated circuit-breakers with integral overcurrent protection (RCBOs) on the bottom of the devices. The busbars are fork-shaped and available in a wide range of versions with one to four poles (some with space for auxiliary switches). The EV-S BS contact protector does not cover connections used.


Example image

Series connection bar
The connection bars are suitable for the supply-side three-pole connection between distribution board series.
They are available for mounting rail distances of 125 mm and 150 mm.

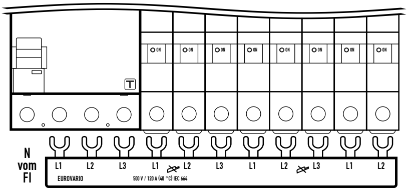

Example image

TECHNICAL INFORMATION

Overview of busbars

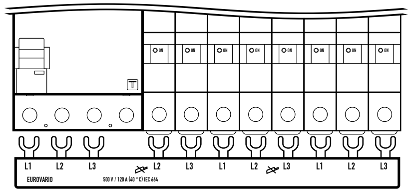
DFS 4, four-pole, N left with 8 × DLS 6

09920190 EV-S G 3.11.120 fork, three-pole, 11 module widths



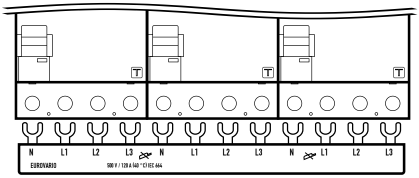
DFS 4, four-pole, N right with 8 × DLS 6

09920185 EV-S G 3/N.8.120 fork, three-pole, 12 module widths



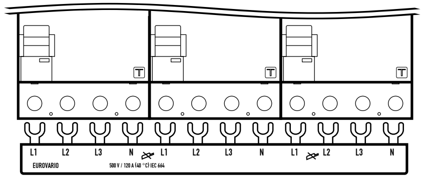
3 × DFS 4, four-pole, N left

09920125 EV-S G 4.12.120 L fork, four-pole, 12 module widths



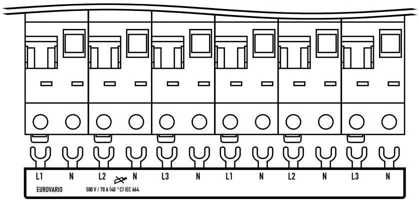
3 × DFS 4, four-pole, N right

09920123 EV-S G 4.12.120 fork, four-pole, 12 module widths



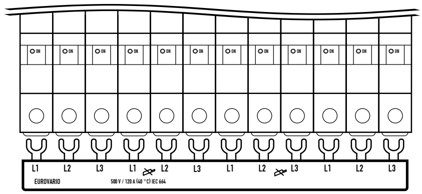
6 × DRCBO 3, 1+N, Type A

09920182 EV-S G 3.1+N.12.120 fork, four-pole, 12 module widths



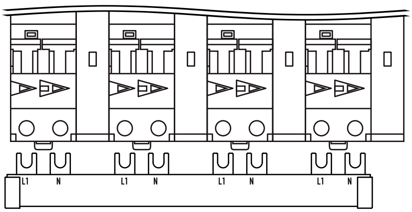
12 × DLS 6

09920119 EV-S G 3.12.120 fork, three-pole, 12 module widths



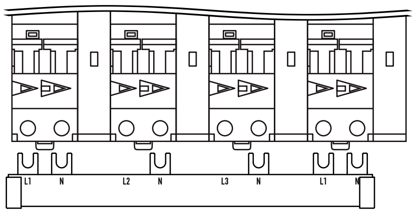
4 × DAFDD 1, two-pole, Type A

09920130 B G12TE-1/N/S-10 fork, two-pole 12 module widths



4 × DAFDD 1, two-pole, Type A

09920132 B G12TE-3/N/S-10 fork, four-pole, 12 module widths



DLS 6 H B 16 - 3

pole number
- 1
- 2
- 1+N
- 3
- 3+N
- 4

hyphen

rated current in amperes

- 0,3 A
- 0,5 A
- 0,8 A
- 1,0 A
- 1,6 A
- 2,0 A
- 2,5 A
- 3,0 A
- 3,5 A
- 4,0 A
- 5,0 A
- 6,0 A
- 8,0 A
- 10 A
- 13 A
- 16 A
- 20 A
- 25 A
- 32 A
- 40 A
- 50 A
- 63 A

characteristic
(B, C, D, K, Z)

blank space

„H“ (household) 6 kA
„HSL“ (screwless) 6 kA
„HDC“ (DC variant) 6 kA
„I“ (industry) 10 kA

type „6“ IEC switch

blank space

„DLS“ Doepke
miniature circuit breaker

10. Appendix

10.1. List of abbreviations

Abbreviation	Meaning
A	Unit symbol for amperes
Fig.	Figure
AC	Alternating voltage
CE	European Conformity
cosϕ	Power factor
Cu	Copper
DC	Direct voltage
Δu	Voltage drop in volts
DGUV	German Social Accident Insurance (Deutsche Gesetzliche Unfallversicherung)
DIN	German Institute for Standardisation (Deutsches Institut für Normung)
DLS	Doepke miniature circuit-breaker
h	Skilled trades
hdc	Skilled trades for DC circuits
hsl	Skilled trades, screwless
i	Industry
EMC	Electromagnetic compatibility
EN	European Standard
EU	European Union
EVU	Energy supply company
HES	Main earthing busbar
Hz	Hertz: unit of frequency
I	Current in amperes
I1	Test current for thermal hold in amperes
I2	Test current for thermal release in amperes
I^2t	Let-through energy
I4	Test current in amperes for electromagnetic hold
I5	Test current in amperes for electromagnetic release
I_A	Tripping current
I_B	Operating current
I_{cn}	Rated switching capacity
IEC	International Electrotechnical Commission

Abbreviation	Meaning
I_k	Short-circuit current
I_{kmax}	Maximum short-circuit current
I_{kmin}	Minimum short-circuit current
I_n	Rated current of the protective device
I_Z	Permitted continuous current-carrying capacity of the line
K	Correction factor
kA	Kiloamperes
ϰ	Kappa
kV	Kilovolts
l	Length of line in metres
LS	Circuit-breaker
LVD	Low Voltage Directive
mA	Milliamperes
MCB	Miniature circuit-breaker
ms	Milliseconds
P	Power in watts
PE	Protective earth
peak	Peak value
R_{line}	Resistance of the line in ohms
RWA	Smoke and heat ventilation systems
Sec.	Seconds
t	Time
MW	Module width (width: 18 mm)
U	Voltage in volts
U_0	Line conductor voltage to earth
UC	Universal control voltage
U_n	Rated voltage
V	Volts
VA	Apparent power in volt-amperes
VDE	Association for Electrical, Electronic & Information Technologies
$\sqrt{3}$	Square root of 3
Z_{system}	System impedance
$Z_{(S(loop))}$	Loop impedance

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