Surge protection for frequency converters

White Paper

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A frequency converter typically consists of a rectifier, d.c. link, inverter and control electronics (**Figure 1**).
At the inverter input, a single-phase a.c. voltage or three-phase line-to-line a.c. voltage is converted into a pulsating d.c. voltage and is fed into the d.c. link which also serves as an energy storage system (buffer).
Capacitors in the d.c. link and earthed L-C sections in the mains filter can cause problems with upstream residual current protective devices (RCDs). These problems are often incorrectly associated with surge arresters. They are, however, caused by short-time fault currents of the frequency converter which are sufficiently high to trip sensitive RCDs. This can be prevented by using a surge-proof RCD circuit breaker which is available with a discharge capacity of 3 kA (8/20 µs) and higher for a tripping current $I_{\Delta n}$ = 30 mA.
The inverter provides a pulsed output voltage via the control electronics. The higher the pulse frequency of the control electronics for pulse width modulation, the more similar is the output voltage to a sinusoidal curve. However, with each pulse a voltage peak occurs that is superimposed on the fundamental wave. This voltage peak reaches values of more than 1200 V (depending on the frequency converter). The better the simulation of the sinusoidal curve, the better the run and control performance of the motor. This, however, means that voltage peaks occur more frequently at the output of the frequency converter.
In order to pick the correct surge arrester for your frequency converter, the maximum continuous operating voltage U_c must be taken into account which specifies the maximum permissible operating voltage a surge protective device may be connected to. Owing to the voltage peaks that occur during the operation of frequency converters, arresters with a high U_c value must be used to avoid "artificial ageing" due to the heating of the surge arrester under "normal" operation conditions and the associated voltage peaks.
Heating of surge arresters can lead to a shorter service life and a disconnection of the surge arrester from the installation it is supposed to protect.

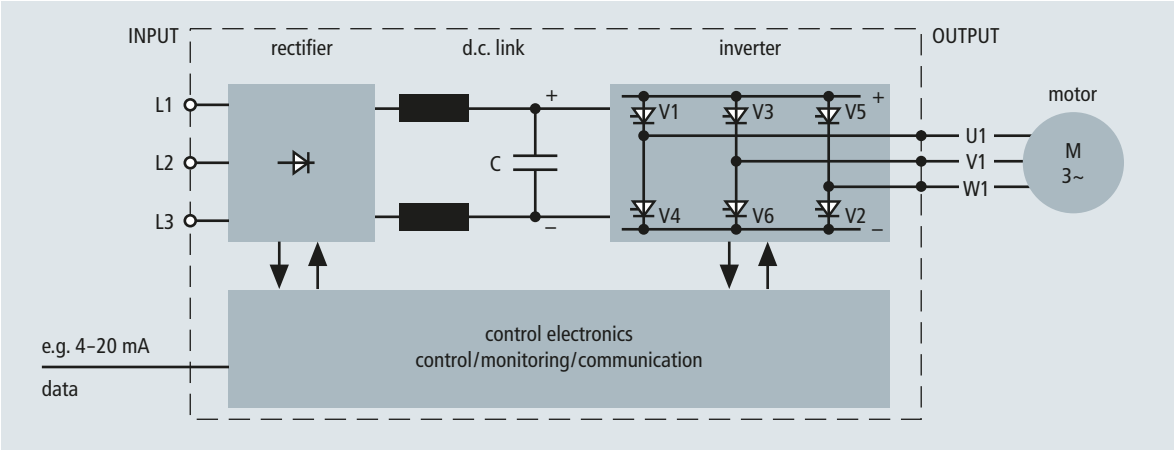

Figure 1 Basic principle of a frequency converter

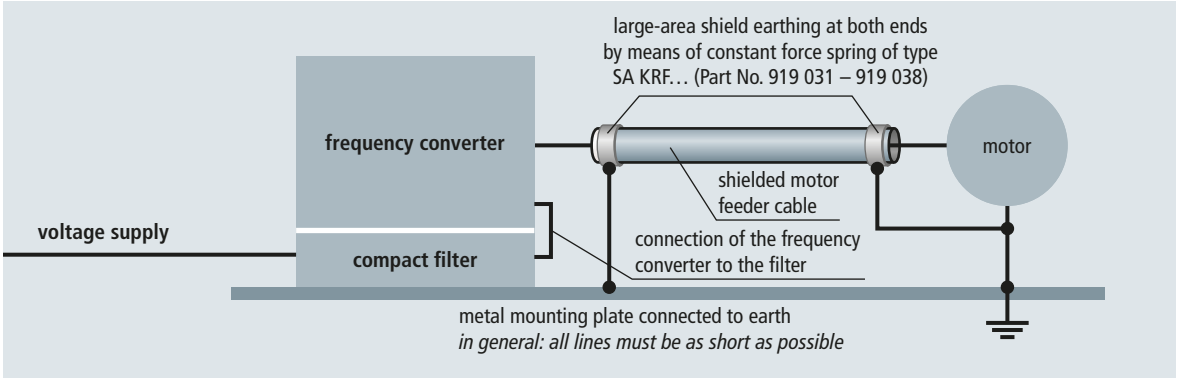

Figure 2 EMC-compatible shield connection of the motor feeder cable

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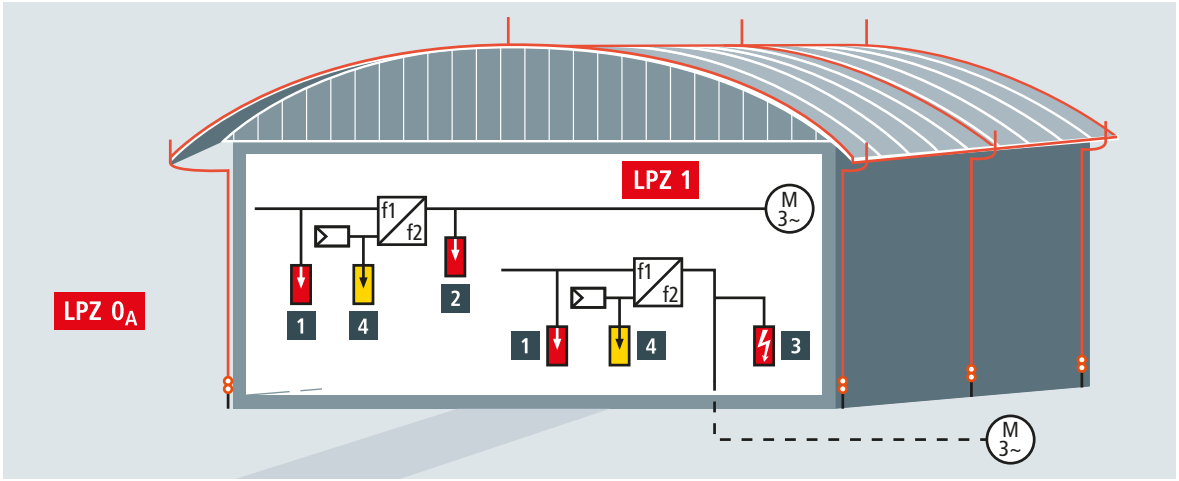


No.	Surge protective device		Part No.
1	DEHNguard modular	DG M TNS 275 (TN-S system)	952 400
	DEHNguard modular	DG M TT 275 (TT system)	952 310
2	DEHNguard S	DG S WE 600 (3 items)	952 077
3	DEHNbloc Maxi + DEHNguard S	DBM 1 760 FM (3 items) DG S WE 600 (3 items)	961 175 + 952 077
4	BLITZDUCTOR XT + BLITZDUCTOR XT base part	BXT ML2 BE S 24 (e.g. 4–20 mA) BXT BAS	920 224 + 920 300

Figure 3 Frequency converter with drives in LPZ 0_A and LPZ 1

The high pulse frequency at the output of the frequency converter causes field-based interference. To avoid that other systems are interfered with, the motor feeder cable must be shielded. The shield of the motor feeder cable must be earthed on both ends, namely at the frequency converter and at the motor. To this end, large-area contact with the shield must be provided, preferably by constant force springs (**Figure 2**), to fulfil EMC requirements. Intermeshed earth-termination systems, namely the connection of the earth-termination system of the frequency converter to that of the drive motor, reduce potential differences between the different parts of the installation, thus preventing equalising currents from flowing through the shield.

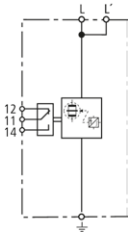
When integrating a frequency converter in the building automation, all evaluation and communication interfaces must be protected by surge protective devices to prevent surge-related system failure. **Figure 3** shows an example of the controller interface 4–20 mA.

DEHNbloc

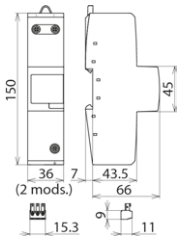
DBM 1 760 FM (961 175)

- Encapsulated non-exhausting spark gap
- High follow current extinction and limitation due to RADAX Flow technology
- Directly coordinated with DEHNguard surge protective devices without additional cable length

Figure without obligation



Basic circuit diagram DBM 1 760 FM



Dimension drawing DBM 1 760 FM

Coordinated single-pole lightning current arrester with high follow current limitation for U_C = 760 V

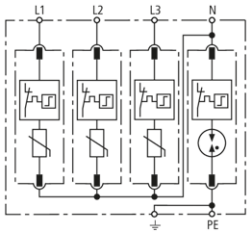
Type Part No.	DBM 1 760 FM 961 175
SPD according to EN 61643-11	Type 1
SPD according to IEC 61643-1/-11	Class I
Max. continuous operating a.c. voltage (U_C)	760 V
Lightning impulse current (10/350 µs) (I_{imp})	25 kA
Specific energy (W/R)	156.25 kJ/ohms
Nominal discharge current (8/20 µs) (I_n)	25 kA
Voltage protection level (U_P)	≤ 4 kV
Follow current extinguishing capability a.c. (I_{fi})	25 kA_{rms}
Follow current limitation / Selectivity	no tripping of a 32 A gL/gG fuse up to 25 kA_{rms} (prosp.)
Response time (t_A)	≤ 100 ns
Max. backup fuse (L) up to I_K = 25 kA_{rms} (t_a ≤ 5 s)	250 A gL/gG
Max. backup fuse (L) up to I_K > 25 kA_{rms}	100 A gL/gG
Max. backup fuse (L-L')	125 A gL/gG
Temporary overvoltage (TOV) (U_T)	1000 V / 5 sec.
TOV characteristic	withstand
Operating temperature range (parallel connection) (T_{UP})	-40°C...+80°C
Operating temperature range (series connection) (T_{US})	-40°C...+60°C
Operating state/fault indication	green / red
Number of ports	1
Cross-sectional area (L, L', ⏚) (min.)	10 mm^2 solid/flexible
Cross-sectional area (L, ⏚) (max.)	50 mm^2 stranded/35 mm^2 flexible
Cross-sectional area (L') (max.)	35 mm^2 stranded/25 mm^2 flexible
For mounting on	35 mm DIN rails acc. to EN 60715
Enclosure material	thermoplastic, red, UL 94 V-0
Place of installation	indoor installation
Degree of protection	IP 20
Capacity	2 module(s), DIN 43880
Approvals	UL, CSA
Type of remote signalling contact	changeover contact
a.c. switching capacity	250 V/0.5 A
d.c. switching capacity	250 V/0.1 A; 125 V/0.2 A; 75 V/0.5 A
Cross-sectional area for remote signalling terminals	max. 1.5 mm^2 solid/flexible
Weight	508 g
Customs tariff number	85363030
GTIN	4013364116283
PU	1 pc(s)

DEHNguard

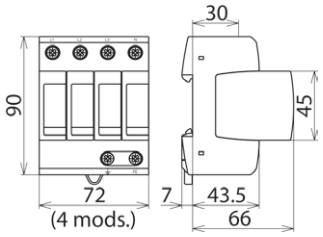
DG M TT 275 (952 310)

- Prewired complete unit consisting of a base part and plug-in protection modules
- High discharge capacity due to heavy-duty zinc oxide varistors / spark gaps
- High reliability due to "Thermo Dynamic Control" SPD monitoring device

Figure without obligation



Basic circuit diagram DG M TT 275



Dimension drawing DG M TT 275

Modular surge arrester for use in TT and TN-S systems ("3+1" circuit).

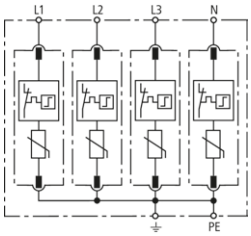
Type Part No.	DG M TT 275 952 310
SPD according to EN 61643-11 / IEC 61643-11	type 2 / class II
Nominal a.c. voltage (U_N)	230 / 400 V (50 / 60 Hz)
Max. continuous operating a.c. voltage [L-N] (U_C)	275 V (50 / 60 Hz)
Max. continuous operating a.c. voltage [N-PE] (U_C)	255 V (50 / 60 Hz)
Nominal discharge current (8/20 µs) (I_n)	20 kA
Max. discharge current (8/20 µs) (I_{max})	40 kA
Lightning impulse current (10/350 µs) [N-PE] (I_{imp})	12 kA
Voltage protection level [L-N] (U_P)	≤ 1.5 kV
Voltage protection level [L-N] at 5 kA (U_P)	≤ 1 kV
Voltage protection level [N-PE] (U_P)	≤ 1.5 kV
Follow current extinguishing capability [N-PE] (I_{fi})	100 A_{rms}
Response time [L-N] (t_A)	≤ 25 ns
Response time [N-PE] (t_A)	≤ 100 ns
Max. mains-side overcurrent protection	125 A gG
Short-circuit withstand capability for max. mains-side overcurrent protection (I_{SCCR})	50 kA_{rms}
Temporary overvoltage (TOV) [L-N] (U_T) – Characteristic	335 V / 5 sec. – withstand
Temporary overvoltage (TOV) [L-N] (U_T) – Characteristic	440 V / 120 min. – safe failure
Temporary overvoltage (TOV) [N-PE] (U_T) – Characteristic	1200 V / 200 ms – withstand
Operating temperature range (T_U)	-40 °C ... +80 °C
Operating state / fault indication	green / red
Number of ports	1
Cross-sectional area (min.)	1.5 mm^2 solid / flexible
Cross-sectional area (max.)	35 mm^2 stranded / 25 mm^2 flexible
For mounting on	35 mm DIN rails acc. to EN 60715
Enclosure material	thermoplastic, red, UL 94 V-0
Place of installation	indoor installation
Degree of protection	IP 20
Capacity	4 module(s), DIN 43880
Approvals	KEMA, VDE, UL, VdS
Weight	450 g
Customs tariff number	85363030
GTIN	4013364108479
PU	1 pc(s)

DEHNguard

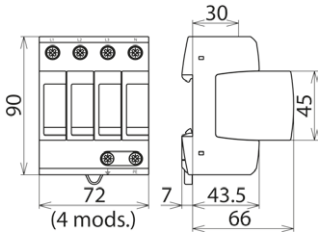
DG M TNS 275 (952 400)

- Prewired complete unit consisting of a base part and plug-in protection modules
- High discharge capacity due to heavy-duty zinc oxide varistors / spark gaps
- High reliability due to "Thermo Dynamic Control" SPD monitoring device

Figure without obligation



Basic circuit diagram DG M TNS 275



Dimension drawing DG M TNS 275

Modular surge arrester for use in TN-S systems.

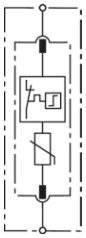
Type Part No.	DG M TNS 275 952 400
SPD according to EN 61643-11 / IEC 61643-11	type 2 / class II
Nominal a.c. voltage (U_N)	230 / 400 V (50 / 60 Hz)
Max. continuous operating a.c. voltage (U_C)	275 V (50 / 60 Hz)
Nominal discharge current (8/20 µs) (I_n)	20 kA
Max. discharge current (8/20 µs) (I_{max})	40 kA
Voltage protection level (U_P)	≤ 1.5 kV
Voltage protection level at 5 kA (U_P)	≤ 1 kV
Response time (t_A)	≤ 25 ns
Max. mains-side overcurrent protection	125 A gG
Short-circuit withstand capability for max. mains-side overcurrent protection (I_{SCCR})	50 kA_{rms}
Temporary overvoltage (TOV) (U_T) – Characteristic	335 V / 5 sec. – withstand
Temporary overvoltage (TOV) (U_T) – Characteristic	440 V / 120 min. – safe failure
Operating temperature range (T_U)	-40 °C ... +80 °C
Operating state / fault indication	green / red
Number of ports	1
Cross-sectional area (min.)	1.5 mm^2 solid / flexible
Cross-sectional area (max.)	35 mm^2 stranded / 25 mm^2 flexible
For mounting on	35 mm DIN rails acc. to EN 60715
Enclosure material	thermoplastic, red, UL 94 V-0
Place of installation	indoor installation
Degree of protection	IP 20
Capacity	4 module(s), DIN 43880
Approvals	KEMA, VDE, UL, VdS
Weight	443 g
Customs tariff number	85363030
GTIN	4013364108455
PU	1 pc(s)

DEHNguard

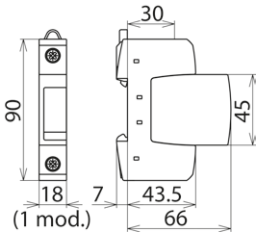
DG S WE 600 (952 077)

- Multi-purpose surge arrester consisting of a base element and plug-in protection module
- High discharge capacity due to heavy-duty zinc oxide varistor
- High reliability due to "Thermo Dynamic Control" SPD monitoring device

Figure without obligation



Basic circuit diagram DG S WE 600



Dimension drawing DG S WE 600

Pluggable single-pole surge arrester with a rated varistor voltage U_{mov} = 750 V a.c., consisting of base part and plug-in protection module; FM version with floating remote signalling contact.

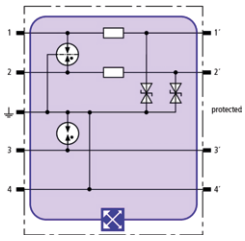
Type Part No.	DG S WE 600 952 077
SPD according to EN 61643-11 / IEC 61643-11	type 2 / class II
Nominal a.c. voltage (U_N)	480 V (50 / 60 Hz)
Max. continuous operating a.c. voltage (U_C)	600V (50 / 60 Hz)
Rated varistor voltage a.c. (U_{mov})	750 V
Nominal discharge current (8/20 µs) (I_n)	15 kA
Max. discharge current (8/20 µs) (I_{max})	25 kA
Voltage protection level (U_P)	≤ 3 kV
Voltage protection level at 5 kA (U_P)	≤ 2.5 kV
Response time (t_A)	≤ 25 ns
Max. mains-side overcurrent protection	100 A gG
Short-circuit withstand capability for max. mains-side overcurrent protection (I_{SCCR})	25 kA_{rms}
Temporary overvoltage (TOV) (U_T) – Characteristic	900 V / 5 sec. – withstand
Temporary overvoltage (TOV) (U_T) – Characteristic	915 V / 120 min. – safe failure
Operating temperature range (T_U)	-40 °C ... +80 °C
Operating state / fault indication	green / red
Number of ports	1
Cross-sectional area (min.)	1.5 mm^2 solid / flexible
Cross-sectional area (max.)	35 mm^2 stranded / 25 mm^2 flexible
For mounting on	35 mm DIN rails acc. to EN 60715
Enclosure material	thermoplastic, red, UL 94 V-0
Place of installation	indoor installation
Degree of protection	IP 20
Capacity	1 module(s), DIN 43880
Approvals	KEMA, UL, CSA, VdS
Weight	137 g
Customs tariff number	85363030
GTIN	4013364119680
PU	1 pc(s)

BLITZDUCTOR XT

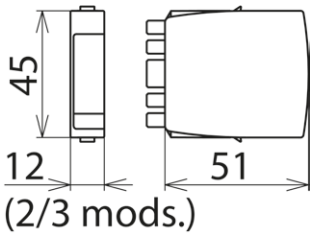
BXT ML2 BE S 24 (920 224)

- LifeCheck SPD monitoring function
- Optimal protection of two single lines and the cable shield
- For use in conformity with the lightning protection zone concept at the boundaries from 0_A –2 and higher

Figure without obligation



Basic circuit diagram BXT ML2 BE S 24



Dimension drawing BXT ML2 BE S 24

Space-saving combined lightning current and surge arrester module with LifeCheck feature for protecting two single lines sharing a common reference potential as well as unbalanced interfaces, with direct or indirect shield earthing. If LifeCheck detects thermal or electrical overload, the arrester has to be replaced. This status is indicated contactlessly by the DEHNrecord LC / SCM / MCM reader.

Type Part No.	BXT ML2 BE S 24 920 224
SPD monitoring system	LifeCheck
SPD class	TYPE 1 P1
Nominal voltage (U_N)	24 V
Max. continuous operating d.c. voltage (U_C)	33 V
Max. continuous operating a.c. voltage (U_C)	23.3 V
Nominal current at 45 °C (I_L)	0.75 A
D1 Total lightning impulse current (10/350 µs) (I_{imp})	9 kA
D1 Lightning impulse current (10/350 µs) per line (I_{imp})	2.5 kA
C2 Total nominal discharge current (8/20 µs) (I_n)	20 kA
C2 Nominal discharge current (8/20 µs) per line (I_n)	10 kA
Voltage protection level line-line for I_{imp} D1 (U_p)	≤ 102 V
Voltage protection level line-PG for I_{imp} D1 (U_p)	≤ 66 V
Voltage protection level line-line at 1 kV/µs C3 (U_p)	≤ 90 V
Voltage protection level line-PG at 1 kV/µs C3 (U_p)	≤ 45 V
Series resistance per line	1.8 ohm(s)
Cut-off frequency line-PG (f_G)	6.8 MHz
Capacitance line-line (C)	≤ 0.5 nF
Capacitance line-PG (C)	≤ 1.0 nF
Operating temperature range (T_U)	-40 °C ... +80 °C
Degree of protection (plugged-in)	IP 20
Pluggable into	BXT BAS / BSP BAS 4 base part
Earthing via	BXT BAS / BSP BAS 4 base part
Enclosure material	polyamide PA 6.6
Colour	yellow
Test standards	IEC 61643-21 / EN 61643-21, UL 497B
SIL classification	up to SIL3 *)
ATEX approvals	DEKRA 11ATEX0089 X: II 3 G Ex nA IIC T4 Gc
IECEx approvals	DEK 11.0032X: Ex nA IIC T4 Gc
CSA & USA Hazloc approvals (1)	2516389: Class I Div. 2 GP A, B, C, D T4
CSA & USA Hazloc approvals (2)	2516389: Class I Zone 2, AEx nA IIC T4
Approvals	CSA, GOST, VdS
Weight	37 g
Customs tariff number	85363010
GTIN	4013364117785
PU	1 pc(s)

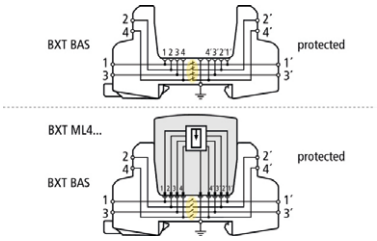
*)For more detailed information, please visit www.dehn-international.com.

BLITZDUCTOR XT

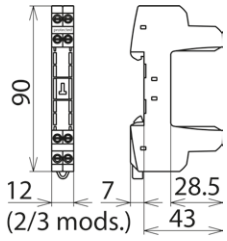
BXT BAS (920 300)

- Four-pole version for universal use with all types of BSP and BXT / BXTU protection modules
- No signal interruption if the protection module is removed
- Universal design without protection elements

Figure without obligation



Basic circuit diagram with and without plugged-in module



Dimension drawing BXT BAS

The BLITZDUCTOR XT base part is a very space-saving and universal four-pole feed-through terminal for the insertion of a protection module without signal interruption if the protection module is removed. The snap-in mechanism at the supporting foot of the base part allows the protection module to be safely earthed via the DIN rail. Since no components of the protective circuit are situated in the base part, only the protection modules must be maintained.

Type Part No.	BXT BAS 920 300
Operating temperature range (T_U)	-40 °C ... +80 °C
Degree of protection	IP 20
For mounting on	35 mm DIN rails acc. to EN 60715
Connection (input / output)	screw / screw
Signal disconnection	no
Cross-sectional area, solid	0.08-4 mm^2
Cross-sectional area, flexible	0.08-2.5 mm^2
Tightening torque (terminals)	0.4 Nm
Earthing via	35 mm DIN rails acc. to EN 60715
Enclosure material	polyamide PA 6.6
Colour	yellow
ATEX approvals	DEKRA 11ATEX0089 X: II 3 G Ex nA IIC T4 Gc *)
IECEx approvals	DEK 11.0032X: Ex nA IIC T4 Gc *)
Approvals	CSA, VdS, UL, GOST
Weight	34 g
Customs tariff number	85369010
GTIN	4013364109179
PU	1 pc(s)

*) only in connection with an approved protection module

Shield Connection / Constant Force Spring

Figure without obligation

Type Part No.	SA KRF 10 V2A 919 031
Lightning impulse current carrying capability (10/350 µs)	10 kA
Clamping range (Rd)	4-10 mm
Material	StSt
Colour	bare surface
For mounting on	cable shields
Approvals	T12-04-ETL 003
Weight	2 g
Customs tariff number	73209090
GTIN	4013364103511
PU	20 pc(s)

Type Part No.	SA KRF 15 V2A 919 032
Lightning impulse current carrying capability (10/350 µs)	10 kA
Clamping range (Rd)	9-15 mm
Material	StSt
Colour	bare surface
For mounting on	cable shields
Approvals	T12-04-ETL003
Weight	2 g
Customs tariff number	73209090
GTIN	4013364103528
PU	20 pc(s)

Type Part No.	SA KRF 22 V2A 919 033
Lightning impulse current carrying capability (10/350 µs)	10 kA
Clamping range (Rd)	14-22 mm
Material	StSt
Colour	bare surface
For mounting on	cable shields
Approvals	T12-04-ETL003
Weight	5 g
Customs tariff number	73209090
GTIN	4013364103535
PU	20 pc(s)

Type Part No.	SA KRF 29 V2A 919 034
Lightning impulse current carrying capability (10/350 µs)	10 kA
Clamping range (Rd)	18.5-29 mm
Material	StSt
Colour	bare surface
For mounting on	cable shields
Approvals	T12-04-ETL003
Weight	7 g
Customs tariff number	73209090
GTIN	4013364103542
PU	10 pc(s)

Shield Connection / Constant Force Spring

- For solderless connection of a conductor to the shield
- For use with all plastic and lead-sheathed cables
- Also suitable for steel-reinforced lead-sheathed cables

Constant force springs allow solderless shield connections for equipotential bonding or lightning equipotential bonding. They can be installed subsequently without interrupting the cable shield or requiring tools for installation. Approved for nuclear plants according to TÜV Certificate No. T12-04-ETL003 (TÜV = German Technical Inspectorate).

Type Part No.	SA KRF 37 V2A 919 035
Lightning impulse current carrying capability (10/350 µs)	10 kA
Clamping range (Rd)	23.5-37 mm
Material	StSt
Colour	bare surface
For mounting on	cable shields
Approvals	T12-04-ETL003
Weight	1 g
Customs tariff number	73209090
GTIN	4013364103559
PU	10 pc(s)

Type Part No.	SA KRF 50 V2A 919 036
Lightning impulse current carrying capability (10/350 µs)	10 kA
Clamping range (Rd)	31-50 mm
Material	StSt
Colour	bare surface
For mounting on	cable shields
Approvals	T12-04-ETL003
Weight	23 g
Customs tariff number	73209090
GTIN	4013364103566
PU	25 pc(s)

Type Part No.	SA KRF 70 V2A 919 037
Lightning impulse current carrying capability (10/350 µs)	10 kA
Clamping range (Rd)	44-70 mm
Material	StSt
Colour	bare surface
For mounting on	cable shields
Approvals	T12-04-ETL003
Weight	50 g
Customs tariff number	73209090
GTIN	4013364103573
PU	20 pc(s)

Type Part No.	SA KRF 94 V2A 919 038
Lightning impulse current carrying capability (10/350 µs)	10 kA
Clamping range (Rd)	58-94 mm
Material	StSt
Colour	bare surface
For mounting on	cable shields
Approvals	T12-04-ETL003
Weight	82 g
Customs tariff number	73209090
GTIN	4013364103580
PU	10 pc(s)

www.dehn-international.com/partners

Surge Protection
Lightning Protection
Safety Equipment
DEHN protects.

DEHN + SÖHNE
GmbH + Co.KG.

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