

The best preventive measure for very long motor cables: all-pole sine filter



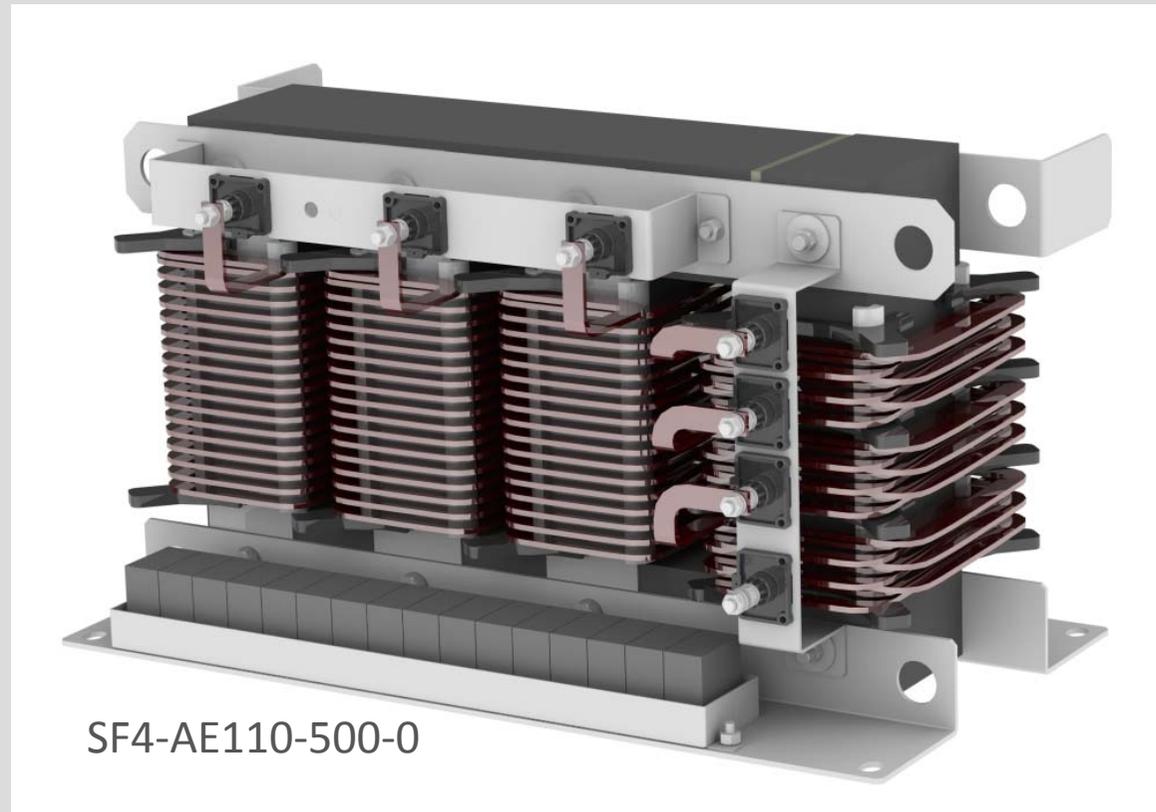
AGENDA

Functional principle

Application

Function properties

Future Winding



SF4-AE110-500-0

NEW ALL-POLE SINE FILTER SF4

Dipl.-Ing. (FH) Malte Heuermann
Productmanager EMC
malte.heuermann@block.eu

APPLICATION

NEW ALL-POLE SINE FILTER SF4

Customer Application



Drives for pump systems

Requirements

- Motor cable length up to 150m per Drive
- Use of unshielded motor cables
- Motor cable laid in the water
- Installation of RCD's 30 mA
- 3 Drives installed behind 1 RCD
- Conducted emissions EN 61800-3 C1

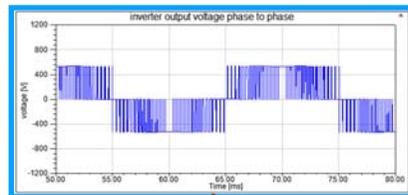


OVERVIEW

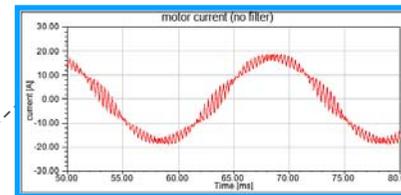
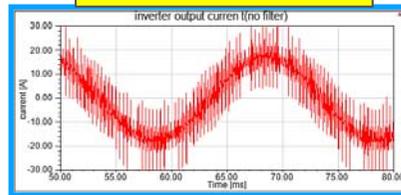
CURRENT AND VOLTAGE WAVEFORMS WITHOUT FILTER



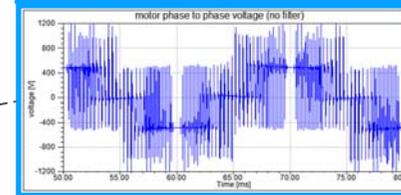
Differential Mode



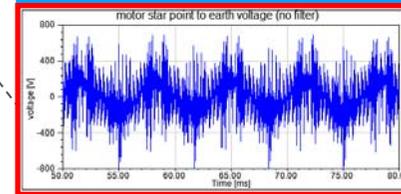
Add. Inverter losses



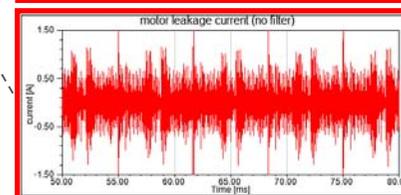
Motor noise & add. losses



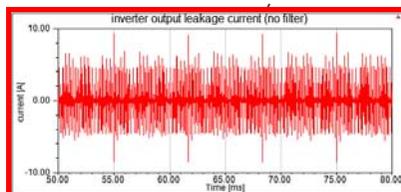
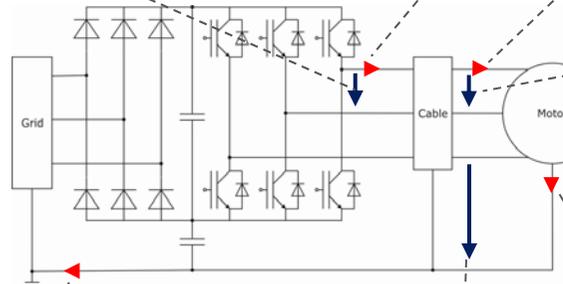
Motor insulation faults



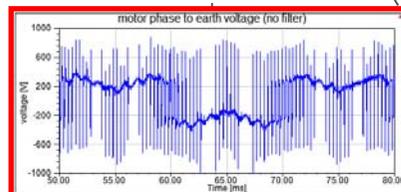
Bearing currents



Radiated EMI



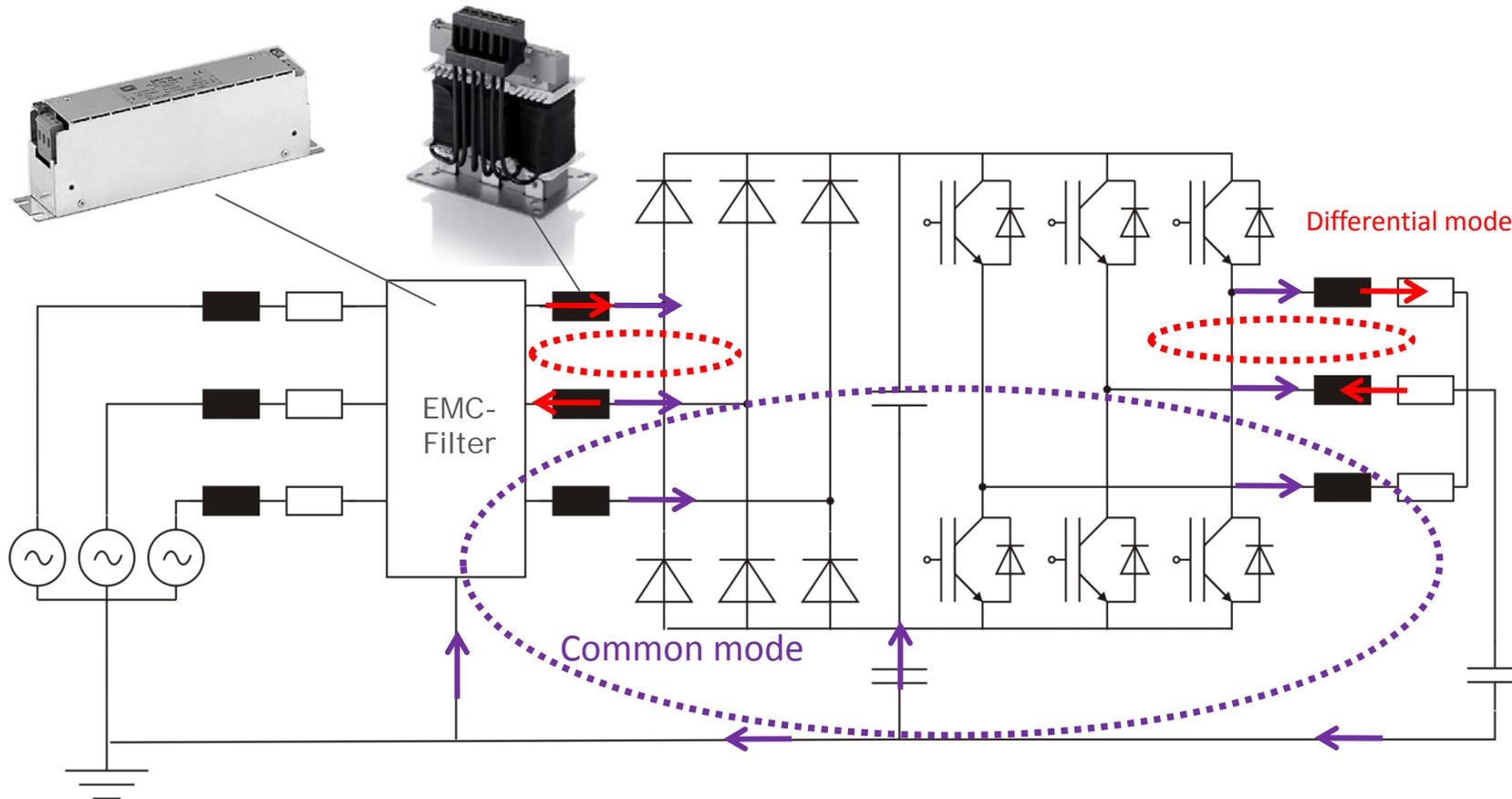
Tripping RCD & conducted emissions



Motor insulation faults

Common Mode

DISTRIBUTION OF DISTURBANCES CONDUCTED EMISSIONS >150KHZ

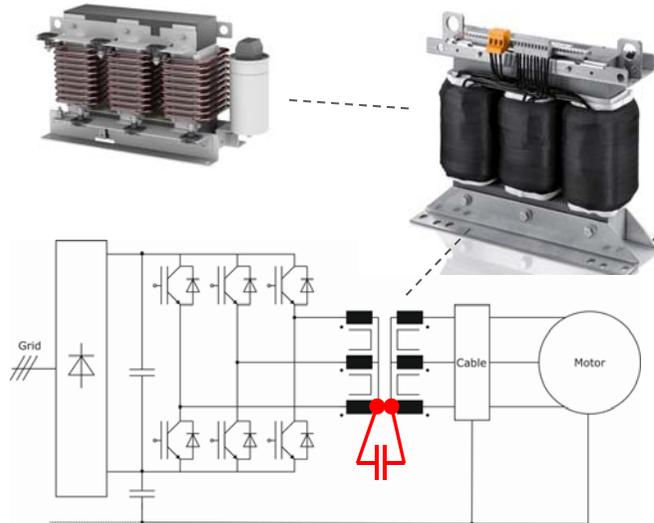


The grid can be safely protected against disturbances of all frequencies with a line inductor or a harmonic filter and in addition an EMI-Filter.

COMMON MODE MOTOR FILTERS ISOLATING TRANSFORMER TT3



Sine-wave filter must be installed in front of the isolation transformer to prevent overheating

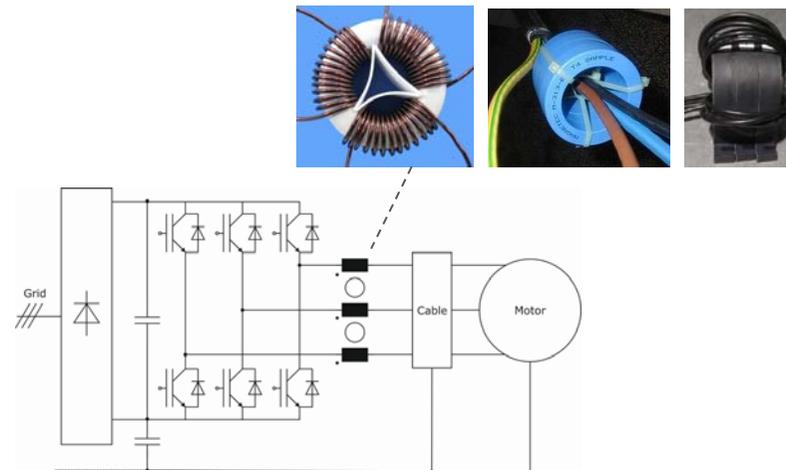


Galvanic isolation of transformer opens the common mode path for lower frequencies. Higher frequencies are not blocked because of the parasitic capacitance of the transformer.

- Effective against leakage currents <1kHz
- heavy solution, no bearing current filter

COMMON MODE MOTOR FILTERS

COMMON MODE CHOKE



- No switching frequency reduction, nearly no influence on voltage waveform at the motor
- Effective damping of very high frequency common mode disturbances. Improvement on conducted emissions >150kHz.
- No reduction of switching frequency leakage currents
- Very good bearing reduction, if amount and type of cores are probably design to the drive system.
- If wrong designed, resonances could lead to opposite effects*

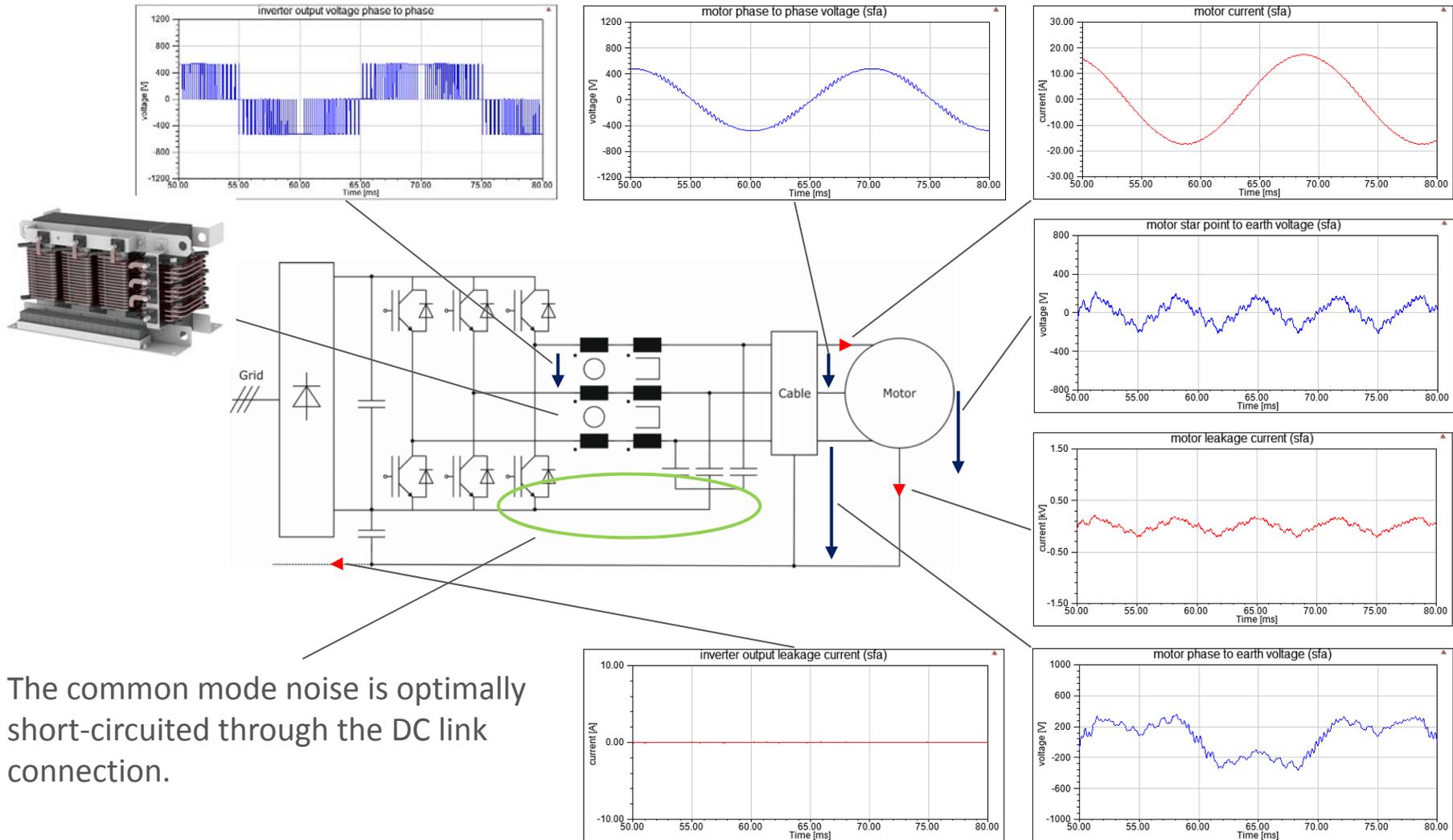
* SPS/IPC/DRIVES 2009, 24. – 26. November 2009 in Nürnberg Dr.-Ing. Benno Weis, Siemens AG, Erlangen, I DT SD R&D 3

Erhöhte Spannungsbelastung von Motoren durch Umrichter-Ausgangsfilter

FUNCTIONAL PRINCIPLE

ALL-POLE SINE FILTER

EXAMPLE RUNS ON A DRIVE WITH SF4



The common mode noise is optimally short-circuited through the DC link connection.

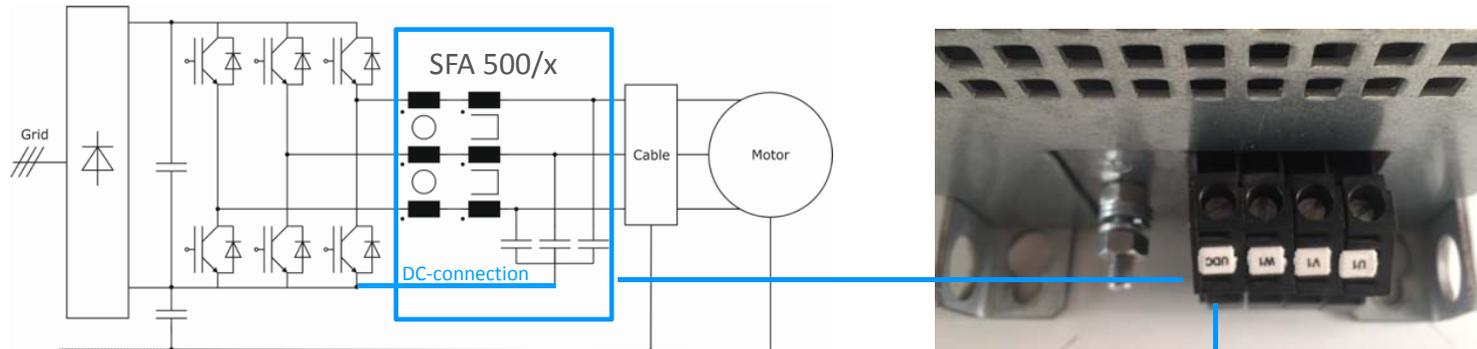
FIELD OF APPLICATION

NEW ALL-POLE SINE FILTER SF4

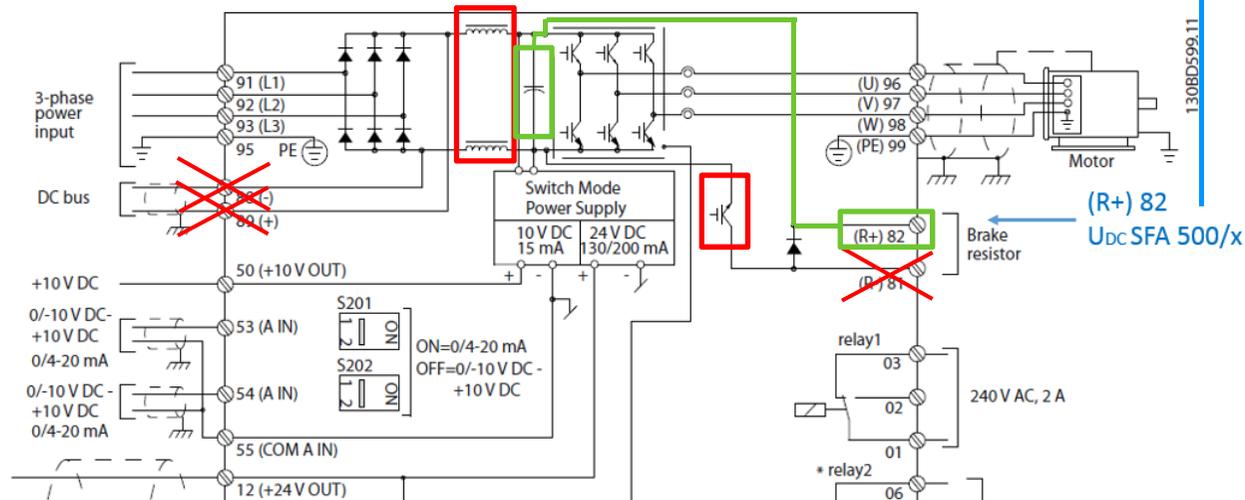
Installation



SF4 needs a direct contact to the DC-circuit of the Drive



For example: Circuit diagram Danfoss FC 302



APPLICATION

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- Conducted emissions EN 61800-3 C1

TESTS:

- Measurement of conducted emissions
- Measurement of leakage currents
- False Tripping Test RCD



APPLICATION

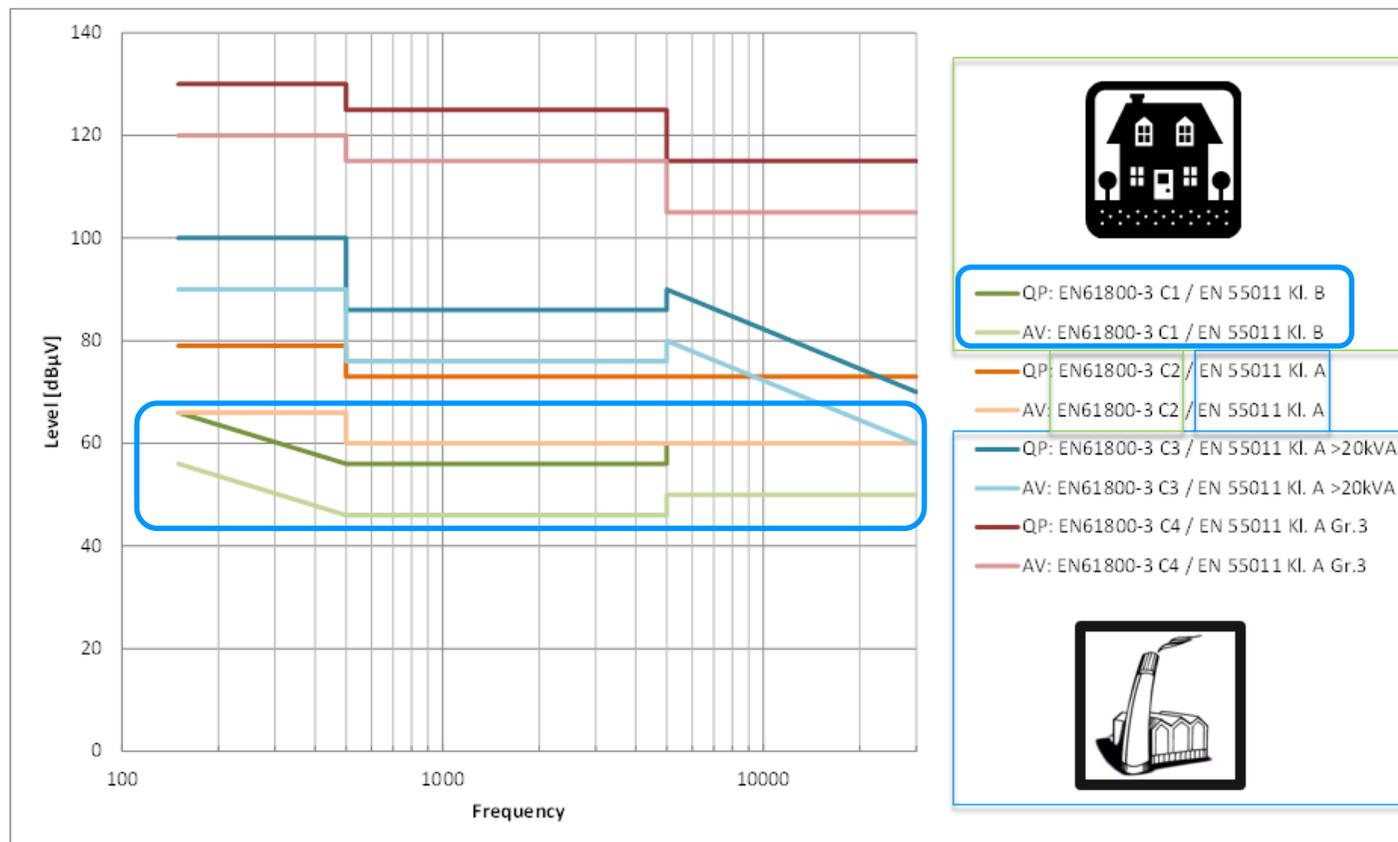
NEW ALL-POLE SINE FILTER SF4

Customer Application



Test description

| | | | | | |
|-------------|---------------------------------------|----|----|----|------|
| IEC 61800-3 | Conducted emissions 150kHz - 30MHz | C1 | C2 | C3 | > C3 |
|-------------|---------------------------------------|----|----|----|------|



APPLICATION

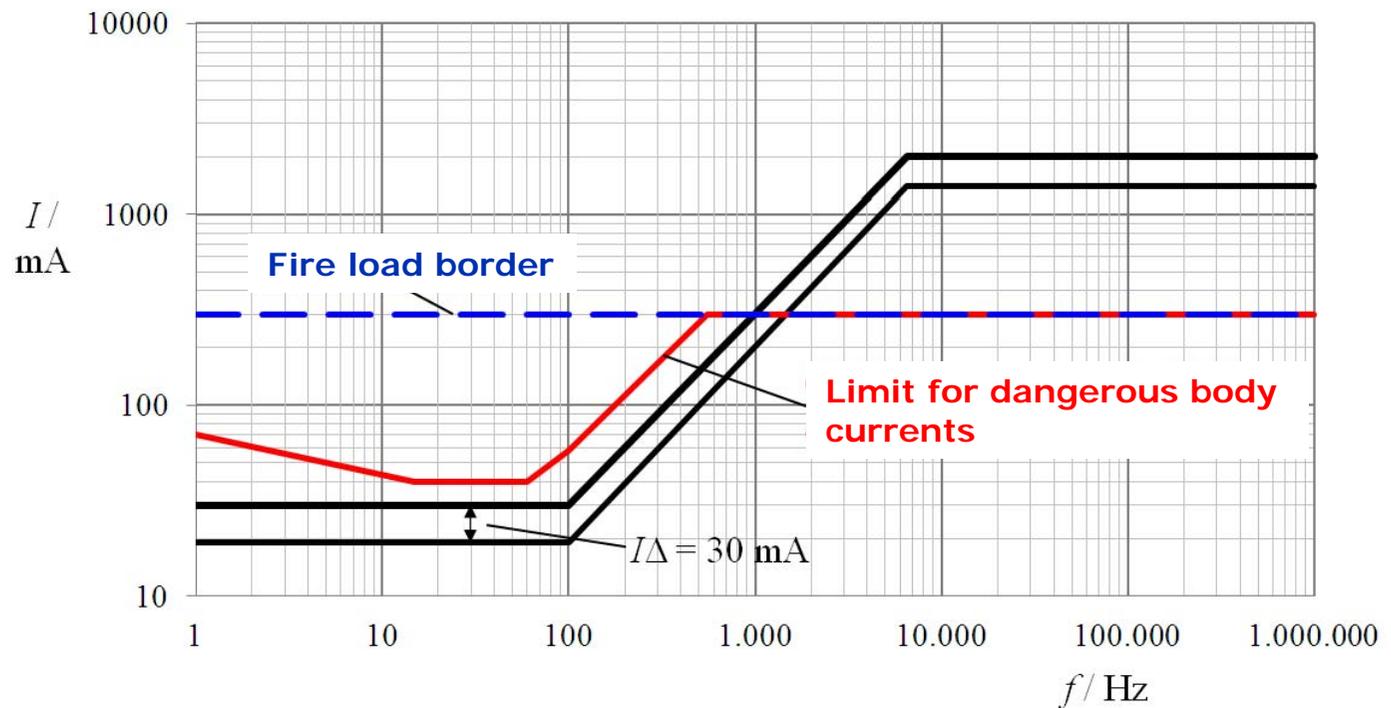
NEW ALL-POLE SINE FILTER SF4

Customer Application



Test description

| | | | | |
|-----|--|---|--|---|
| RCD | Differential current measurement / RCD utilization in% | <30% | 30-50% | >50% |
|-----|--|---|--|---|



Type B RCCBs are optimized for systems with frequency converters. In the event of a fault, they also detect DC-currents and monitor a frequency range up to 100kHz.

APPLICATION

NEW ALL-POLE SINE FILTER SF4

Customer Application



Test description

| | | | | |
|-----|--|---|--|--------------------------------------|
| FTT | False-Tripping Test RCD -> 10x on / off the system | Direct on / off switching on the RCD without false tripping | Direct on / off switching only possible via main switch with snap-action function. Connecting via RCD can lead to false tripping | RCD triggers when switching on / off |
|-----|--|---|--|--------------------------------------|

10 times on/off



Due to the charging current of the system capacitances, a multiple of the nominal leakage current can flow in the moment of switch on/off .

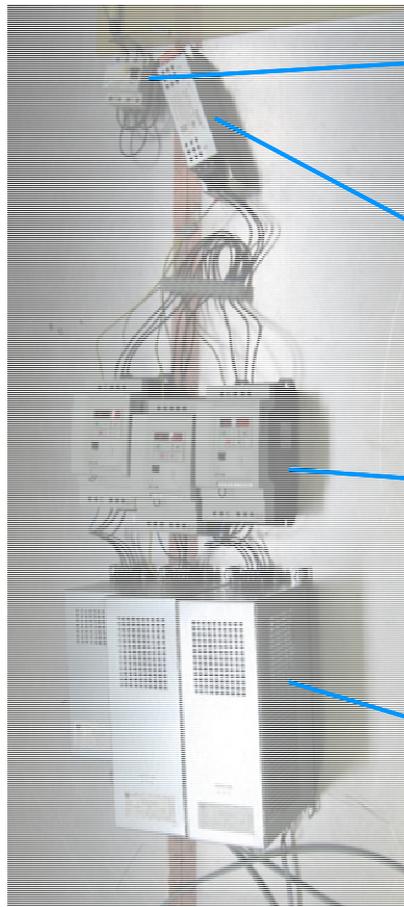
APPLICATION

NEW ALL-POLE SINE FILTER SF4 Customer Application

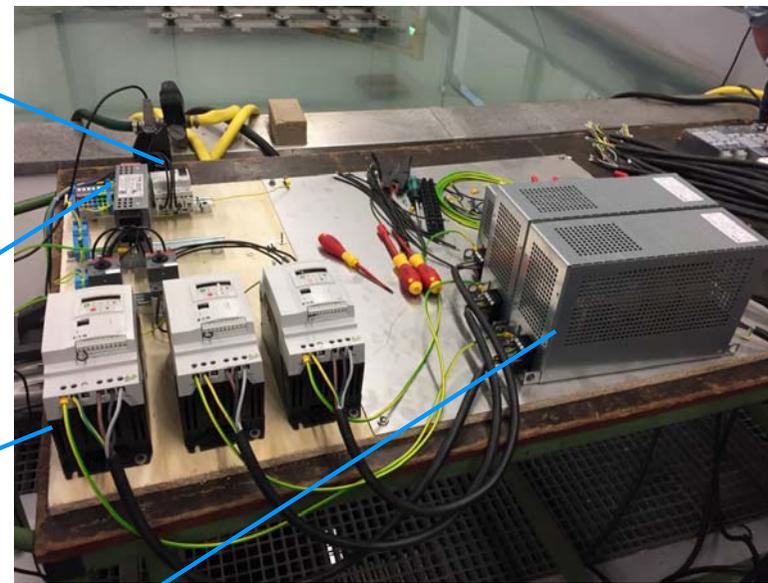


Measurements

Test BLOCKLab



Test Customer Side



RCD 30 mA

Ext. EMI-Filter
HLD 310-500/30
Low leakage < 0,4 mA

Drives

Allpole
Sinefilter
SF4

Pumps



APPLICATION

NEW ALL-POLE SINE FILTER SF4

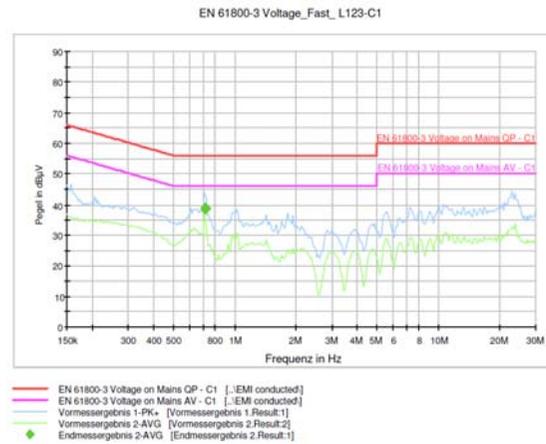
Customer Application



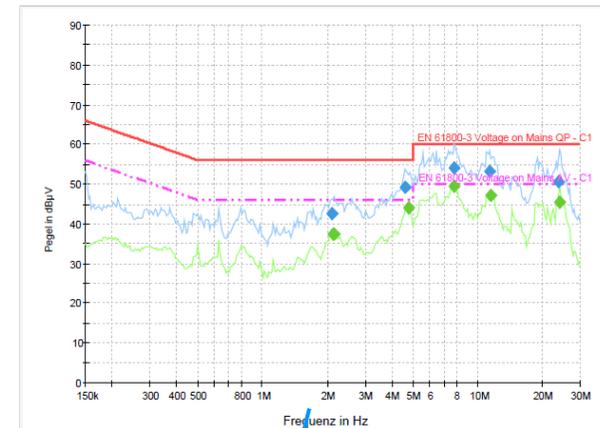
Test results BLOCK Lab

| Drive Power [kW] | fs [kHz] | fmot [Hz] | cable length | Cy int. EMI-Filter | ext. EMI-Filter | Motorfilter | IEC 61800-3 | RCD | FTT |
|------------------|----------|-----------|--------------|--------------------|-----------------|-------------|-------------|------|-----|
| 2x 4,0 / 1x 2,7 | 4 | 10 | 150 | No | HLD 310-500/30 | SF4-CD006 | C1 | 17 % | |

DC_E1_alle FU_o. int. EMI_4kHz_10Hz_150m ungesch_HLD 310_SFA 13 DCP



EN 61800-3 log C1_L123N



Test results Customer side

| Drive Power [kW] | fs [kHz] | fmot [Hz] | cable length | Cy int. EMI-Filter | ext. EMI-Filter | Motorfilter | IEC 61800-3 | RCD | FTT |
|------------------|----------|-----------|--------------|--------------------|-----------------|-------------|-------------|------|-----|
| 2x 4,0 / 1x 2,7 | 4 | 10 | 150m | No | HLD 310-500/30 | SF4-CD006 | C1 | 27 % | |

Requirement IEC 61800-3 C1 fulfilled!

APPLICATION

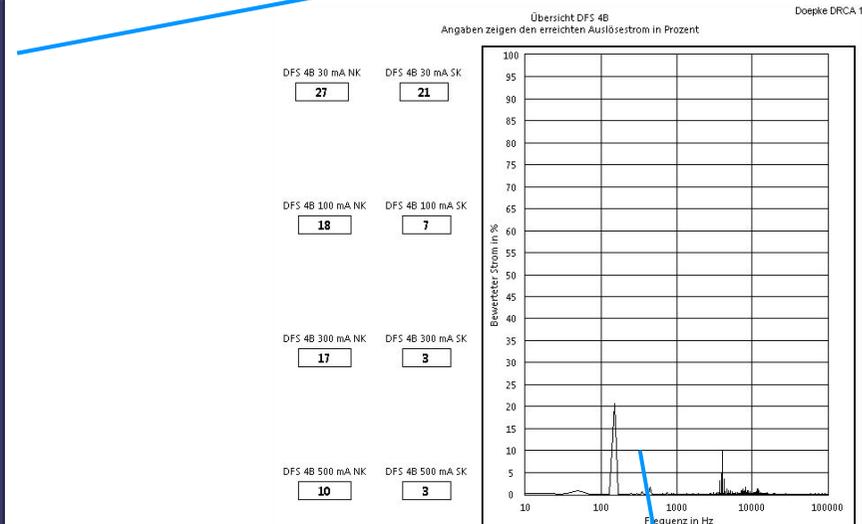
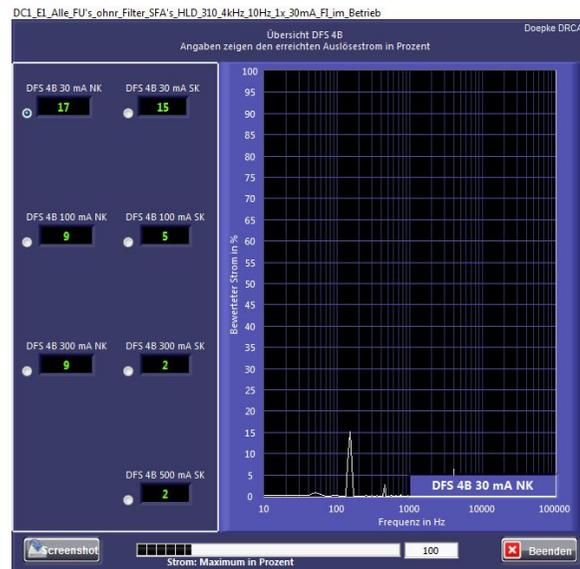
NEW ALL-POLE SINE FILTER SF4

Customer Application



Test results BLOCK Lab

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Test results Customer side

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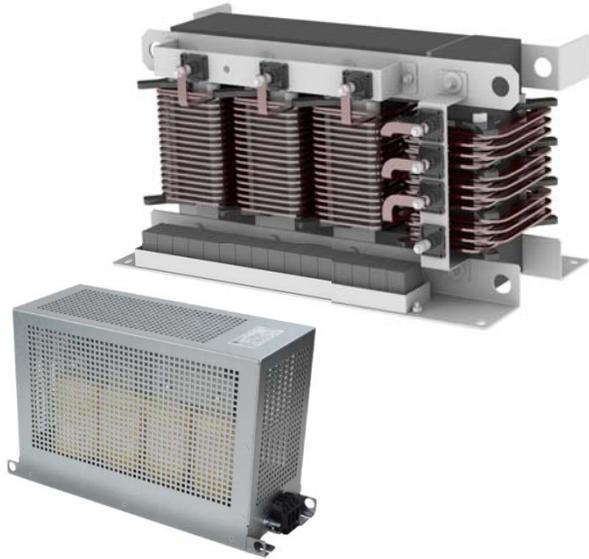
Requirement RCD 30mA fulfilled!

PROPERTIES

NEW ALL-POLE SINE FILTER SF4



- New topology based on 4-limb technology for a compact design
- Reduction of bearing currents to an absolute minimum



No filter

With CM-choke motor side

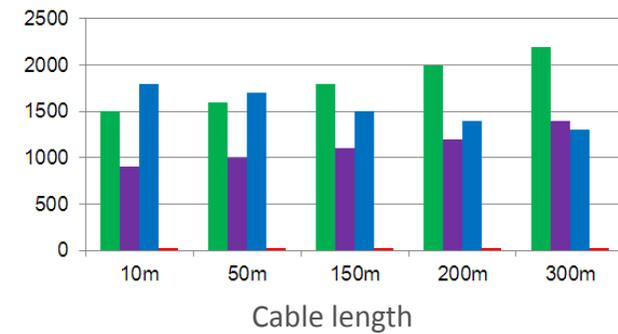
With CM-choke inverter side

With SF4 allpole sine filter

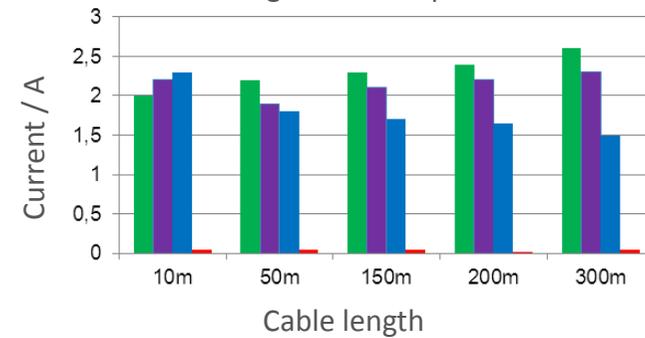


Only all-pole sine filters fully eliminate Drive-related bearing currents!

Amount of bearing current break downs

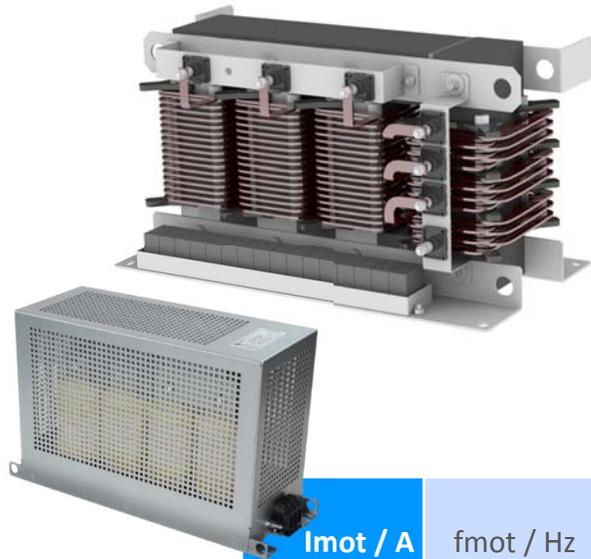


Bearing current amplitude



PROPERTIES

NEW ALL-POLE SINE FILTER SF4



- New topology based on 4-limb technology for a compact design
- Reduction of bearing currents to an absolute minimum
- Enables the use of extremely long motor cable lengths (> 500 m)
- Use of unshielded motor cables possible
- Increased Motor Lifetime
- Less motor noise
- Improvement in system efficiency

| Imot / A | fmot / Hz | fs / kHz | Shielded motor cable/m | Frequency inverter | Efficiency improvements with SF4-CD024-500-0 | | |
|----------|-----------|----------|------------------------|--------------------|--|--------|---------------|
| | | | | | Motor cable | Motor | Entire system |
| 7 | 5 | 8 | 10 | 4.76% | 24.14% | 40.00% | 3.66% |
| 7 | 5 | 8 | 50 | 37.04% | 52.78% | 38.59% | 23.59% |
| 22 | 50 | 4 | 10 | 5.56% | 2.21% | 1.71% | -3.50% |
| 22 | 50 | 8 | 10 | 13.73% | 3.04% | 2.33% | -2.02% |
| 22 | 50 | 4 | 50 | 6.59% | 1.46% | 2.06% | -1.00% |
| 22 | 50 | 8 | 50 | 12.72% | 3.64% | 2.67% | -0.19% |
| 22 | 50 | 8 | 100 | 21.64% | 9.46% | 3.01% | 3.55% |
| 22 | 50 | 8 | 150 | 23.20% | 11.17% | 3.70% | 4.85% |

Imot = Motor power

fmot = Motor revolving frequency

fs = Drive switching frequency

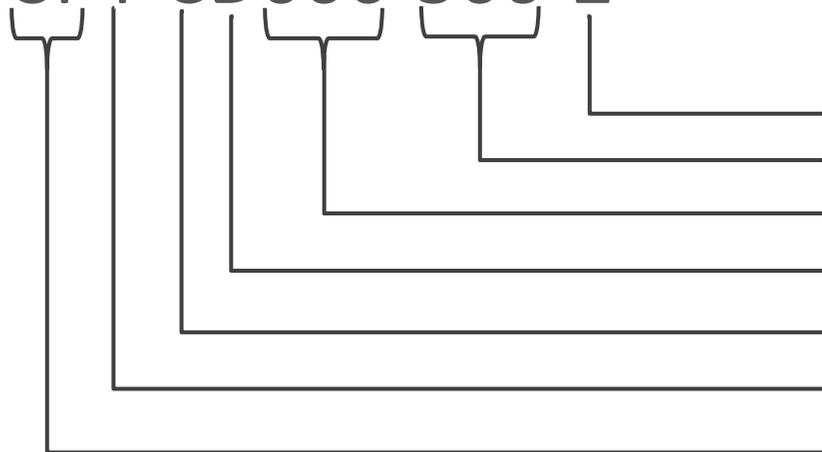
ALL-POLE SINE FILTER

Nomenclature SF4



| SF4-Types New nomenclature | Voltage | Protection class | Current @ 400 Vac | Derating @ 500 Vac | ta | Old nomenclature | Comment |
|-------------------------------|---------|------------------|-------------------|--------------------|------|------------------|--------------------------|
| SF4-CD006-500-2 | 500Vac | IP 20 | 6 | 5,5 | 45°C | SFA 500/6 | Available |
| SF4-CD013-500-2 | 500Vac | IP20 | 13 | 12 | 45°C | SFA 500/13 | Available |
| SF4-CD024-500-2 | 500Vac | IP 20 | 24 | 23 | 45°C | SFA 500/24 | Available |
| SF4-CE046-500-2 | 500Vac | IP 20 | 46 | 43,5 | 45°C | SFA 500/46 | Available |
| SF4-CD006-500-0 | 500Vac | IP 00 | 6 | 5,5 | 50°C | | Available from Q4 / 2018 |
| SF4-CD013-500-0 | 500Vac | IP 00 | 13 | 12 | 50°C | | Available from Q4 / 2018 |
| SF4-CD024-500-0 | 500Vac | IP 00 | 24 | 23 | 50°C | | Available from Q4 / 2018 |
| SF4-CE046-500-0 | 500Vac | IP 00 | 46 | 43,5 | 50°C | | Available from Q4 / 2018 |
| SF4-CE065-500-0 | 500Vac | IP 00 | 65 | 60 | 45°C | SFA 500/65 | Available from Q4 / 2018 |
| SF4-CE110-500-0 | 500Vac | IP 00 | 110 | 102 | 45°C | SFA 500/110 | Available from Q4 / 2018 |

SF4-CD006-500-2



- Protection class (0=IP00; 2=IP20)
- Voltage (Vac)
- Current (A)
- Winding technology
- Winding material (C=CU; A=Alu)
- Phases (4=4-pole → All-pole)
- Sine filter



Future Winding New Winding Technology



Future Winding
for next power generation

- ❄️ COOLING
- η⁺ LOW LOSSES
- ∞ LONG LIFE
- △□○ FREESTYLE
- ⌚ POTENTIAL CONTROL
- ⊗ HIGH CURRENT DENSITY

NETZDROSSELN
LINE REACTORS



SINUSFILTER
SINE FILTERS

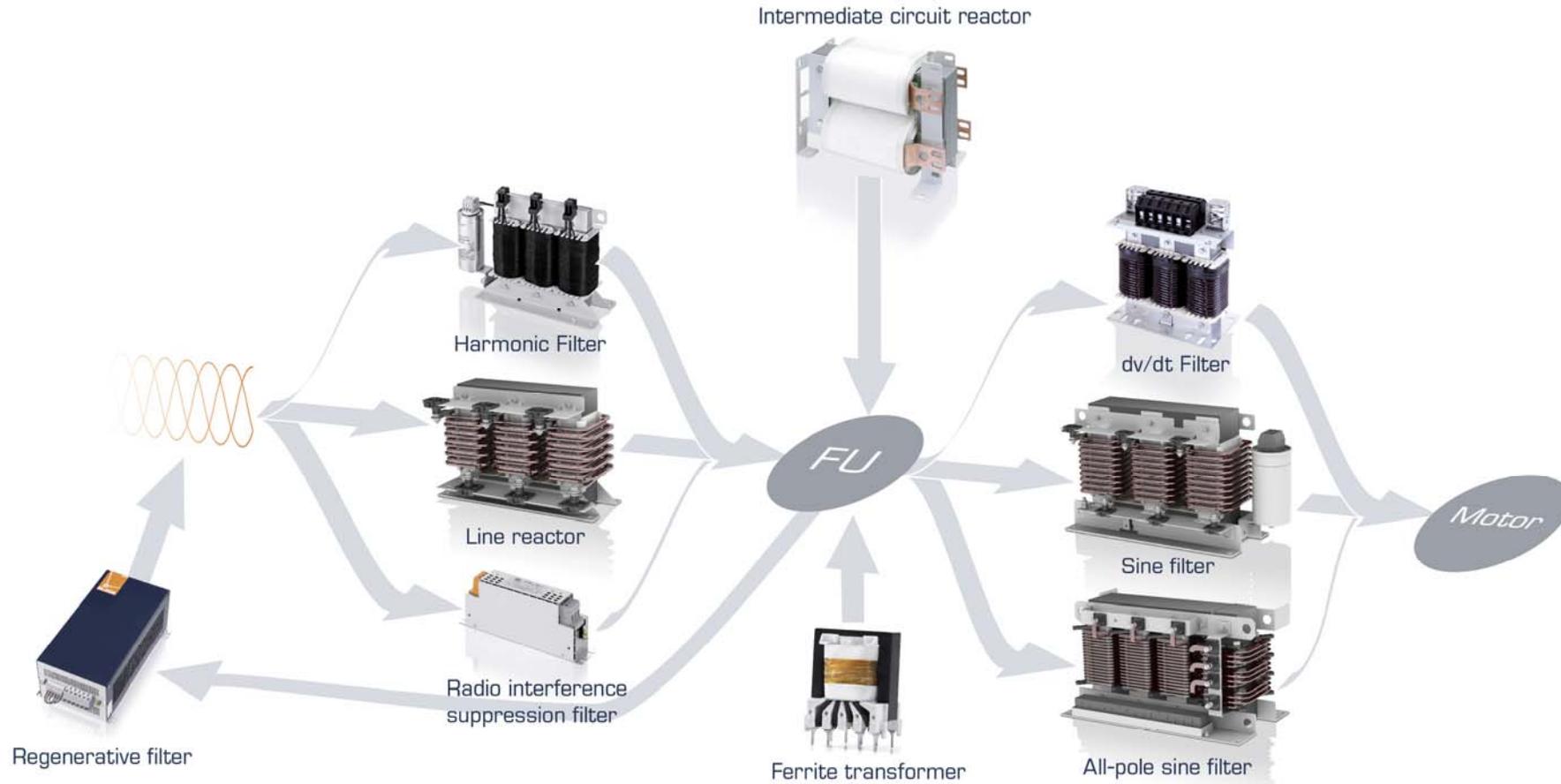


ALLPOLIGES SINUSFILTER
ALL-POLE SINE FILTERS

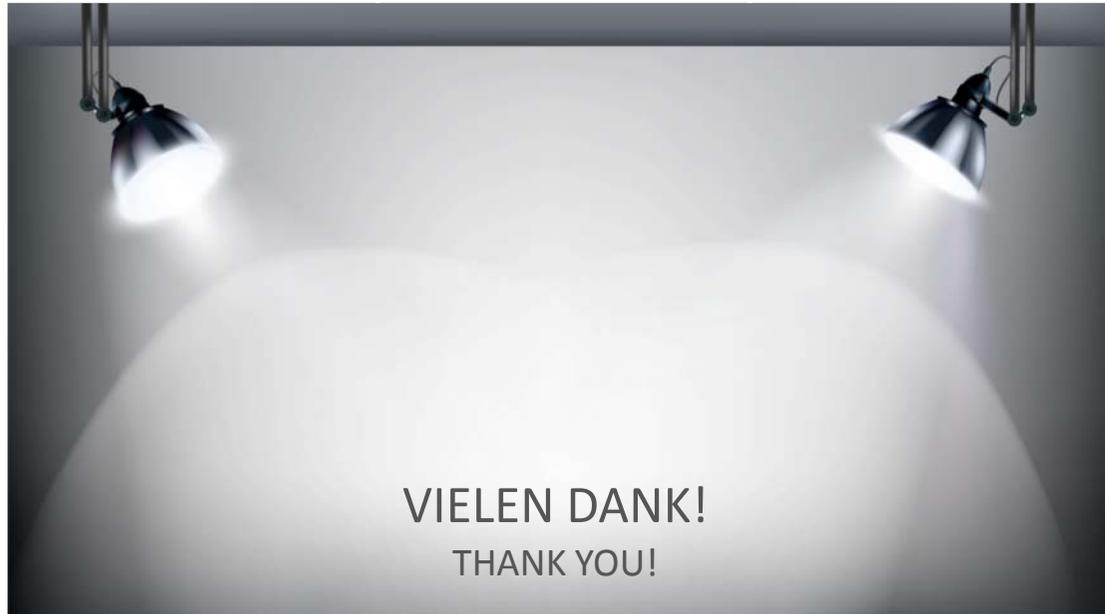


OVERVIEW

PASSIVE FILTER IN INVERTER SYSTEMS



The best preventive measure for very long motor cables:
all-pole sine filter



VIELEN DANK!
THANK YOU!

HABEN SIE FRAGEN?
DO YOU HAVE QUESTIONS?

BLOCK TRANSFORMATOREN-ELEKTRONIK GMBH
MAX-PLANCK-STRASSE 36-46
27283 VERDEN

TELEFON 04231 678-0
TELEFAX 04231 678-255
WWW.BLOCK.EU



Dipl.-Ing. (FH)
Malte Heuermann
Productmanager EMC
Malte.heuermann@block.eu
Telefon 04231 678-253
Telefax 04231 678-277