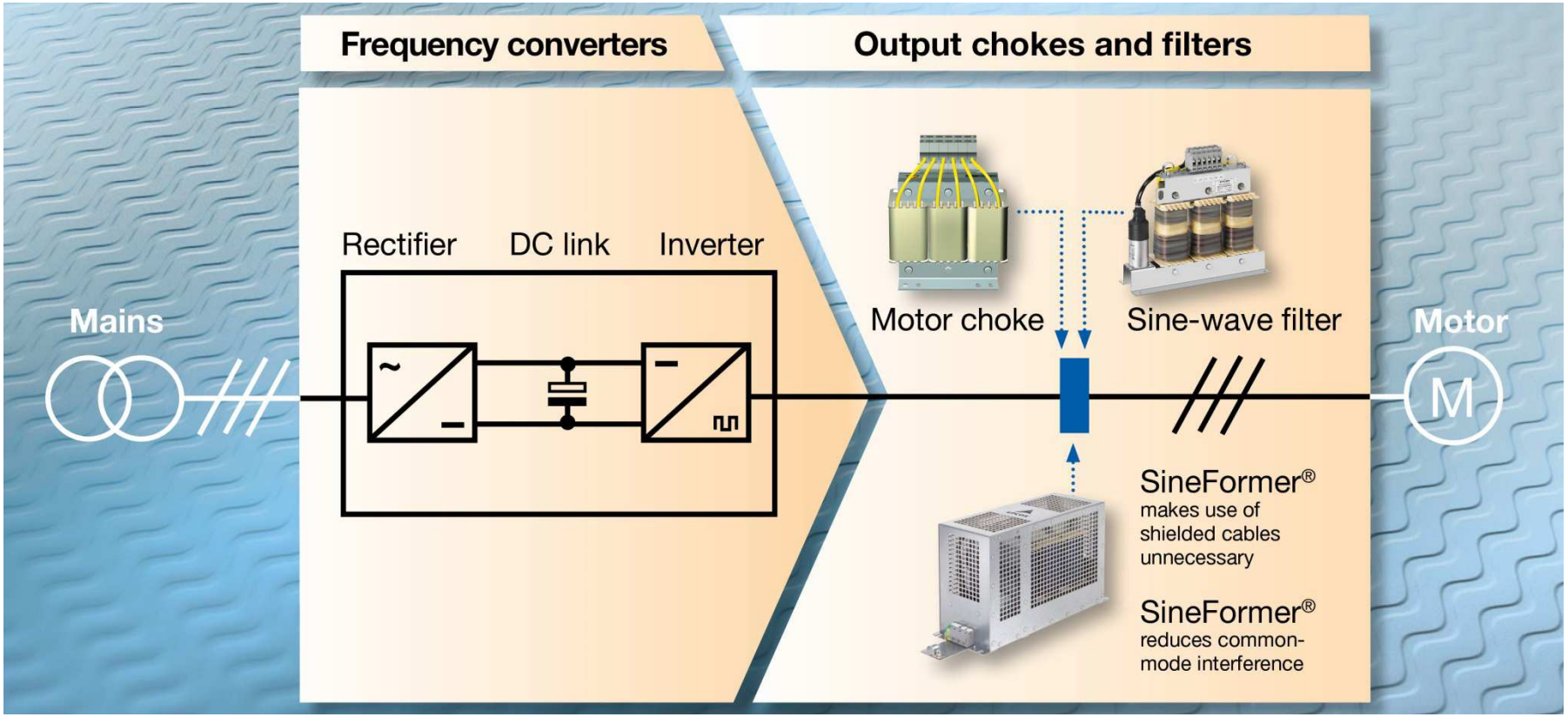
EMC Output Filter Solutions

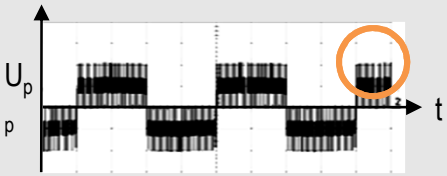


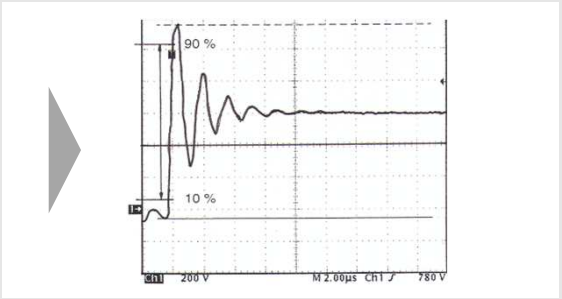
EPCOS AG
A TDK Group Company
Magnetics Business Group • Power EMC Filters
Munich, Germany
April 2016

Output filter concepts

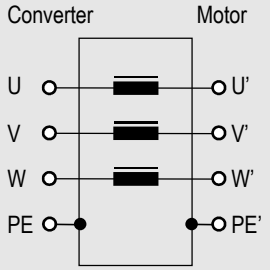
dv/dt chokes

B86301U*R000/S000



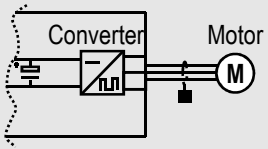


Strong reduction of dv/dt

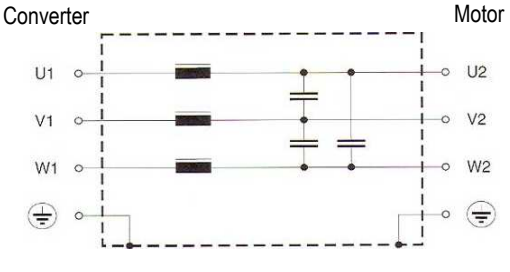


Sine-wave filters

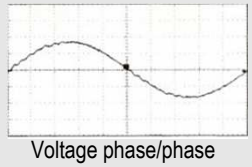
B84143V*R227/R229/R230



Shielded motor line necessary for dv/dt and sine-wave filters

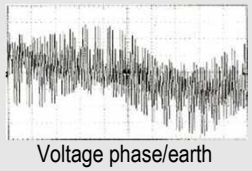


Forms sine wave between the phases



BUT

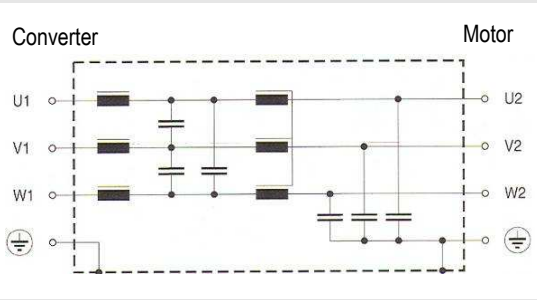
Common-mode Interference is still present



Sine-wave EMC filters

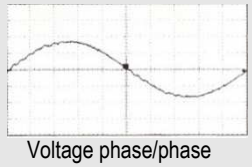
B84143V*R127

SineFormer®



Forms sine wave between the phases

Reduces common-mode interference



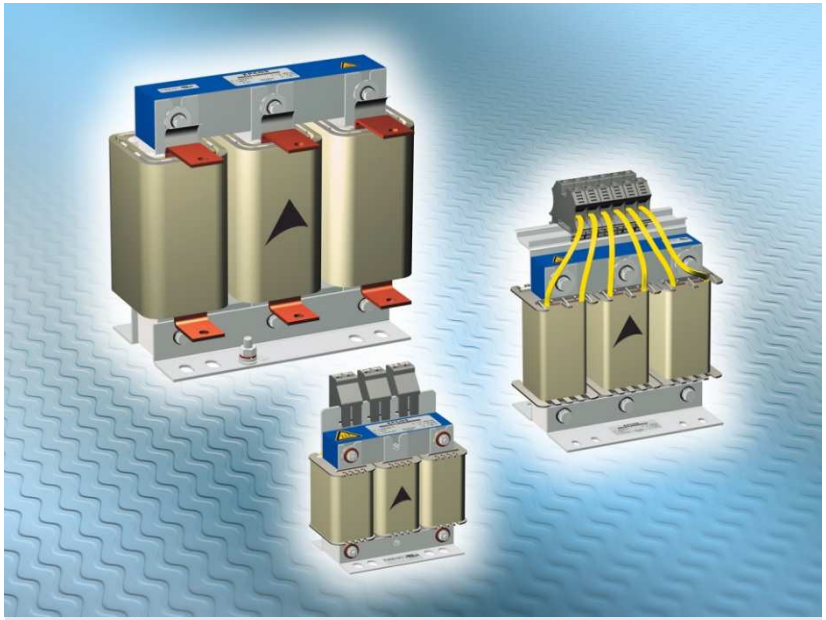
Eliminates need for shielded motor cables and reduces motor bearing currents!

Output filter concepts: Advantages & disadvantages

dv/dt chokes	✓ Reduce dv/dt peaks significantly ✓ Low-cost solution – Motor line is limited to approx. 100 m – No reduction of acoustic noise – Shielded motor cables necessary
Sine-wave filters	✓ Reduce dv/dt peaks significantly ✓ Forms sine wave between the phases ✓ Reduction of acoustic motor noise created by clock frequency ✓ Reduction of eddy current losses – Shielded motor cables necessary
SineFormer® Sine-wave EMC filters	✓ Reduce dv/dt peaks significantly ✓ Forms sine wave between the phases ✓ Reduction of acoustic motor noise created by clock frequency ✓ Reduction of eddy current losses ✓ Shielded motor cables not necessary ✓ Minimization of motor bearing currents

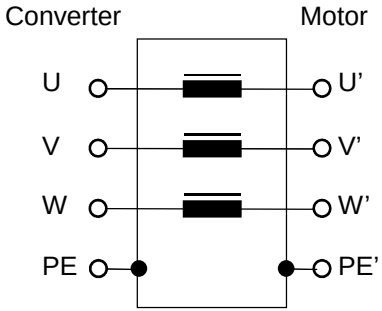
3-phase motor chokes for drives B86301U*R000/S000

Motor chokes reduce the voltage stress at the motor and the dv/dt increase at the frequency converter output



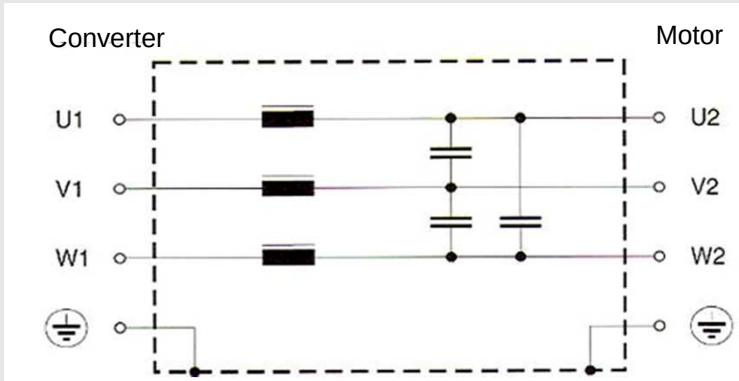
Features

- 4 to 1500 A/ 520 V
- 1% impedance reactor
- Easy to install
- Low weight
- Compact design
- Design complies to IEC 60076-6
- UL approved isolation system class F (155 °C)
- IP protection degree IP20 ≤20 A, 24 A ≤IP 10 ≤112 A, IP 00 >112 A
- Optimized for motor cable lengths up to 100 m
- From stock delivery up to 950 A



Sine-wave output filter series B84143V*R227/ R229/R230

- Complete design from 4 A
  up to 720 A/ 520 V (R227/R230)
- 690 V version: R230 up to 204 A
- Designed for motor cables up to 1000 m
- Slim design unique in the market
- UL approved isolation system
- From stock delivery up to 250 A
- >720 A in development



SineFormer®: Best output filter solution

- **Commercial advantages**
  System-cost savings due to the use of unshielded cables
  ➔ Automatic cost savings from a motor-cable length of approx. 100 m
- **Technical benefits**
  Longer life cycle of the motor, motor noise reduction, substantial compensation of bearing currents and eddy current losses, no forced ventilation necessary
  ➔ Maintenance-free (fan would have a life cycle of 2 to 4 years only), no feedback to the DC link needed
  ➔ Reduction of all kinds of radiation sources by easy installation
- **Installation advantage**
  Unshielded cables are lighter and more flexible
  ➔ Cost savings during installation
- **Logistics advantage**
  Shielded cables are used in small volumes which is cost intensive ➔ Unshielded cables are standard products

Compact concept!

Unique on the market!

SineFormer®: Data sheet

- **Functional tests up to 1000 m unshielded cable passed**
- **EMC tests with 300 m unshielded cable passed (radiated emissions)**

Ordering code	B84143V****R127
Rated voltage	520 VAC (600 V)
Rated current (40 °C)	6 to 180 A (320 A)
Motor frequency	0 to 100 Hz
Clock frequency	4 to 8 kHz (2.5 kHz/ 320 A)
Protection degree	IP20
Approval	UL/CSA (up to 180 Amps, except 6 A and 45 A version)

SineFormer® B84143V*R127: Technical data

Characteristics and ordering codes

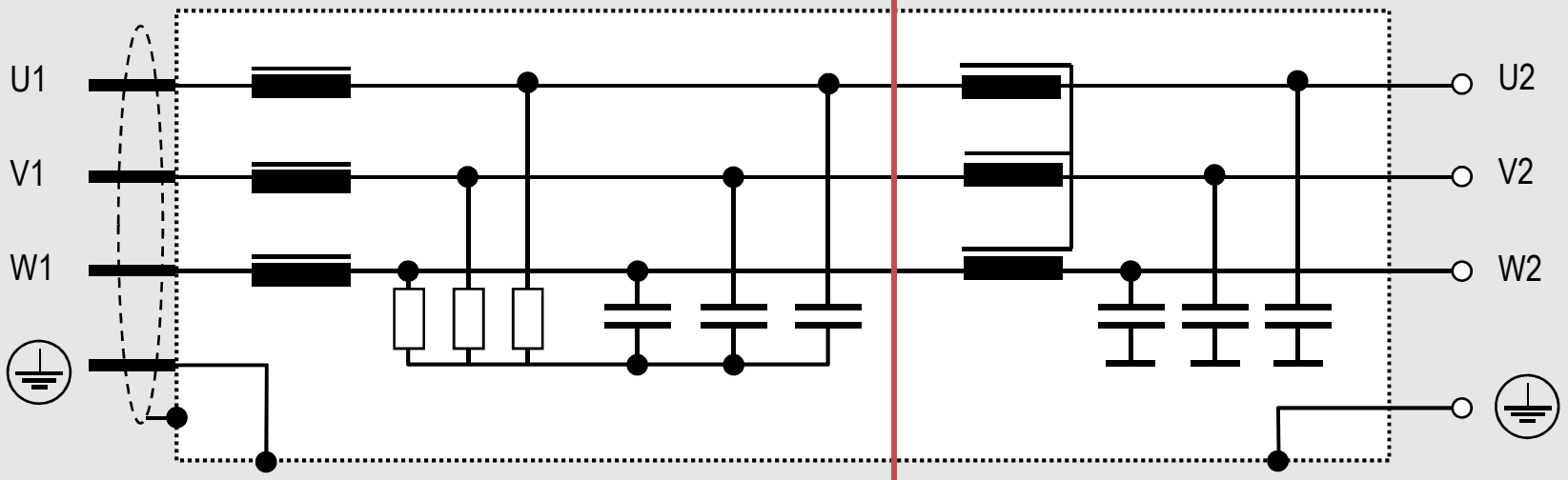
I_R* A	Terminal cross section mm²	ΔV %	P_L W	R_{typ} mΩ	Approx. weight kg	Ordering code	Approvals	
V_R = 520 V AC								
6	4	7	45	290	9	B84143V0006R127	–	–
11	4	5	26	46	9	B84143V0011R127	×	×
16	6	7	38	32	11	B84143V0016R127	×	×
33	10	8	92	20	24	B84143V0033R127	×	×
45	10	8	82	17	28	B84143V0045R127	–	–
66	25	8	160	15	47	B84143V0066R127	×	×
95	50	10	210	8	99	B84143V0095R127	×	×
180	150	10	450	6	125	B84143V0180R127	×	×
V_R = 600 V AC								
320	see dimensional drawing	10	475	4	195	B84143V0320R127	–	–

SineFormer®: Circuit diagram

- dv/dt reduction
- Sine-wave signal phase to phase
- Current peak reduction

SineFormer® features

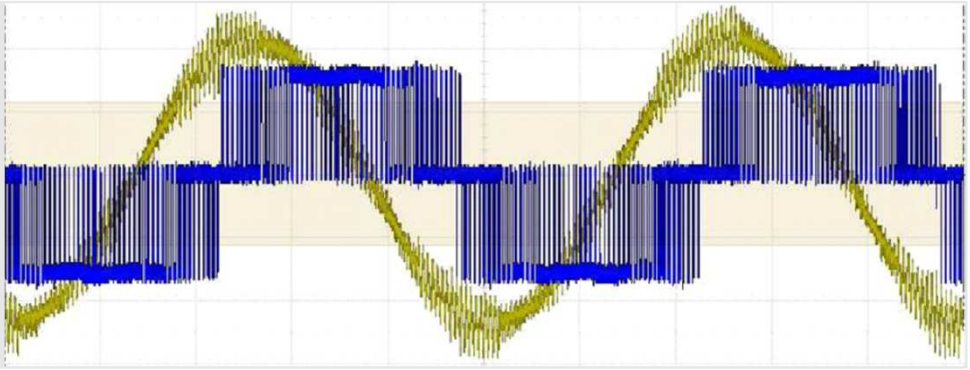
- Common-mode current reduction
- Field strength reduction
- Conducted emission reduction



SineFormer®: Measurements /1

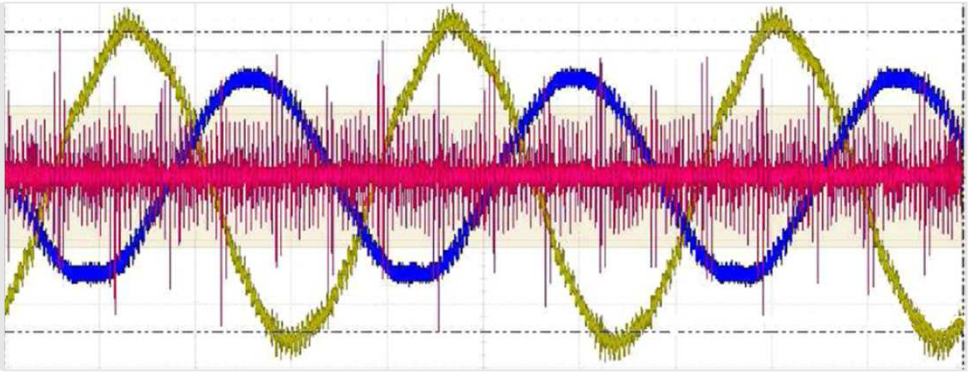
Measurements of the converter output

- Phase-to-phase voltage is not sinusoidal
  ➔ Creation of interferences and bearing currents



Measurements of the filter output (300 m motor line)

- Phase-to-phase voltage is sinusoidal
- Asymmetric (common-mode) current significantly reduced



Phase current
Asymmetric current
Phase to phase voltage

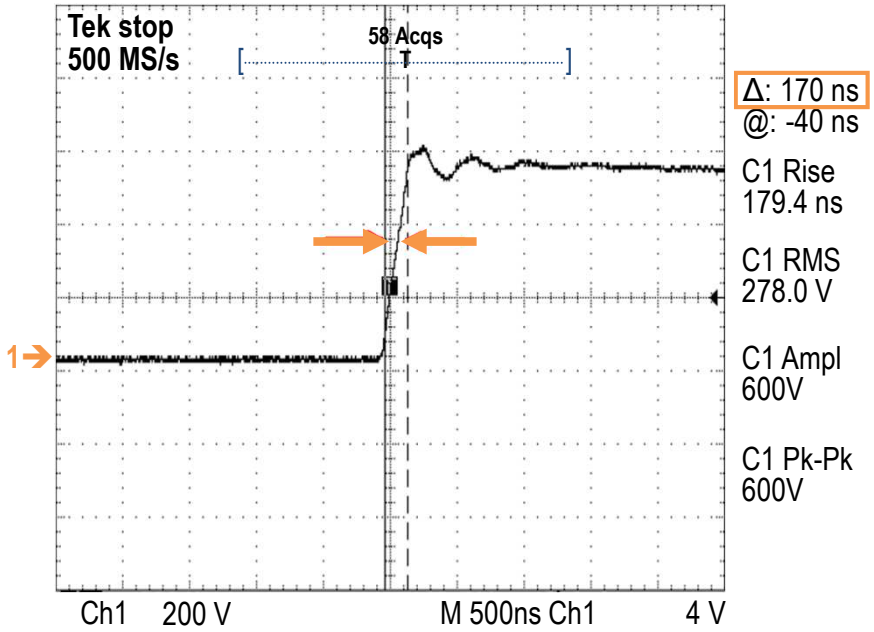
No shielded motor cable required, bearing currents minimized!

SineFormer®: Measurements /2

Typical value for 4 kHz switching and 50 Hz motor frequency

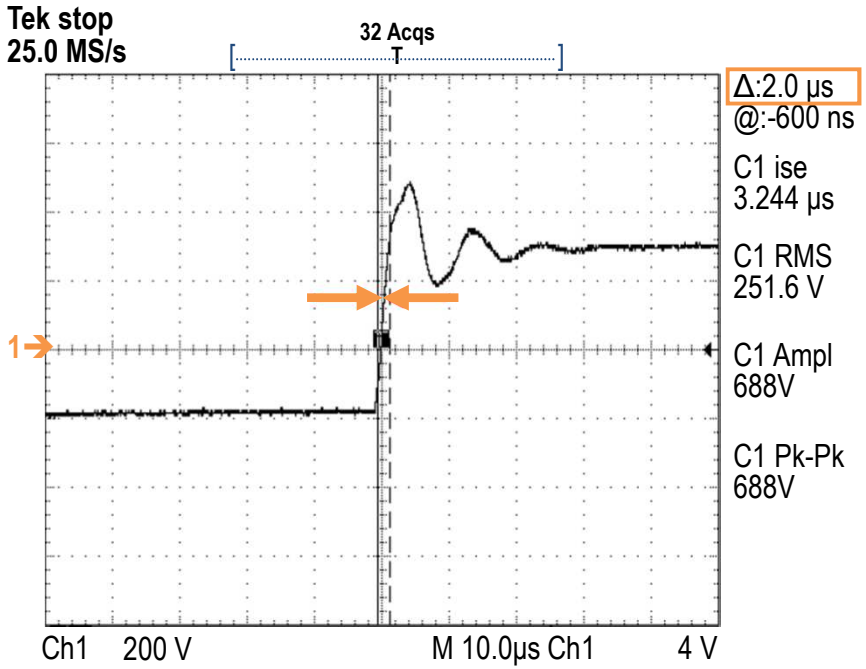
Without output filter

dv/dt ≈ 480 V/ 170 ns **≈ 2.8 kV/µs**



With SineFormer®

dv/dt ≈ 440 V/ 2 µs **≈ 220 V/µs**

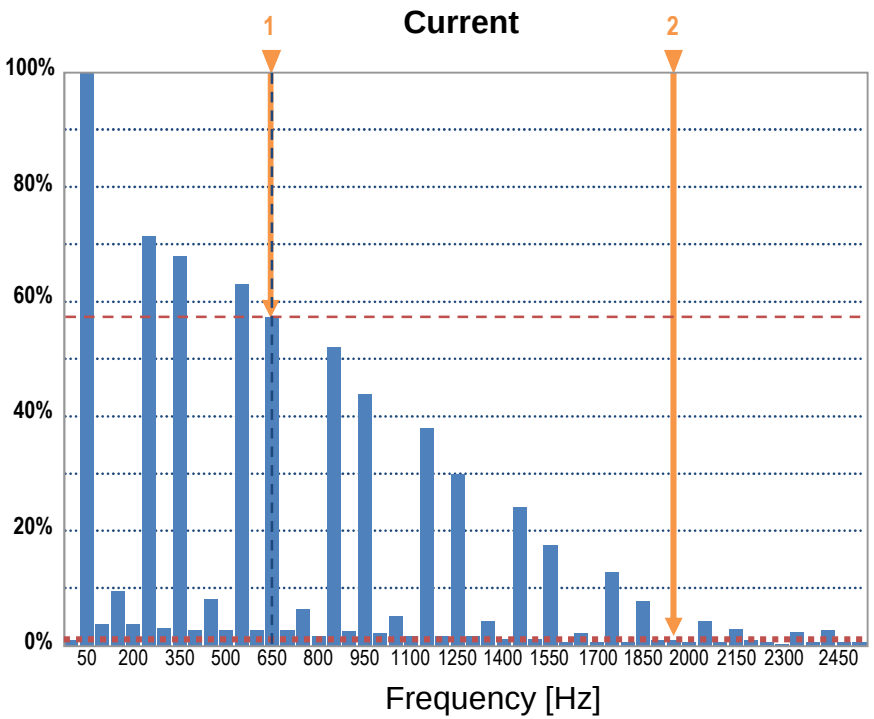


dv/dt peaks reduced significantly to uncritical values

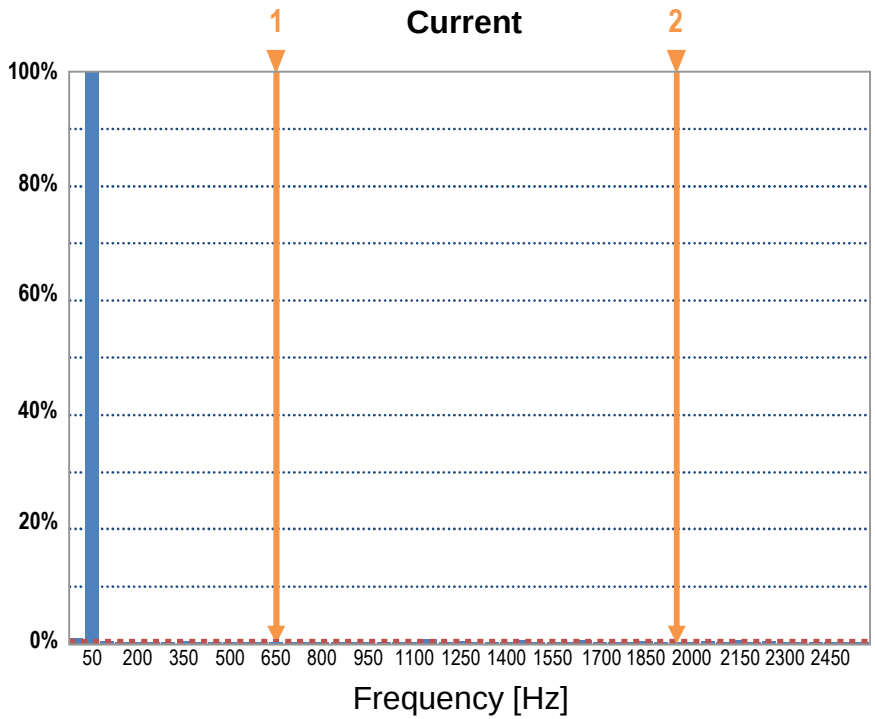
SineFormer®: Measurements /3

Typical value for 4 kHz switching and 50 Hz motor frequency

Converter output



SineFormer® output



Elimination of harmonics on the output side!

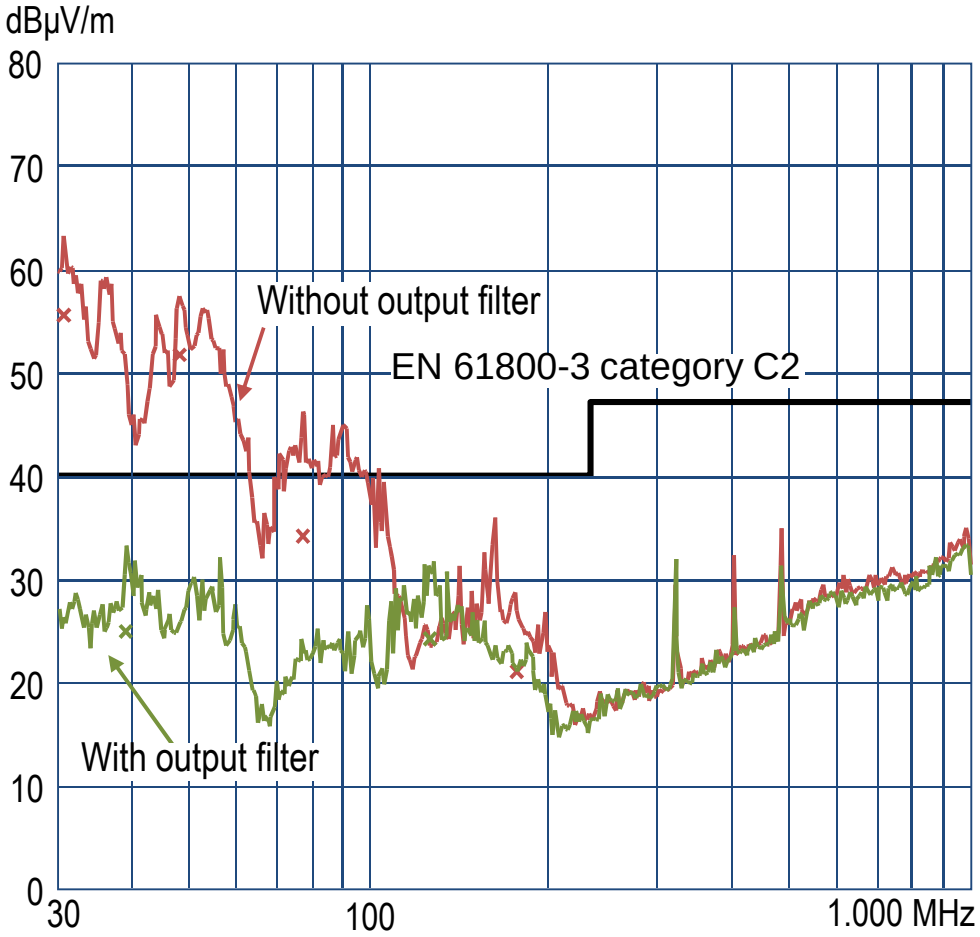
SineFormer®: Measurements /4

Converter and unshielded cable
(**without** SineFormer®)

Limits exceeded

Limits kept

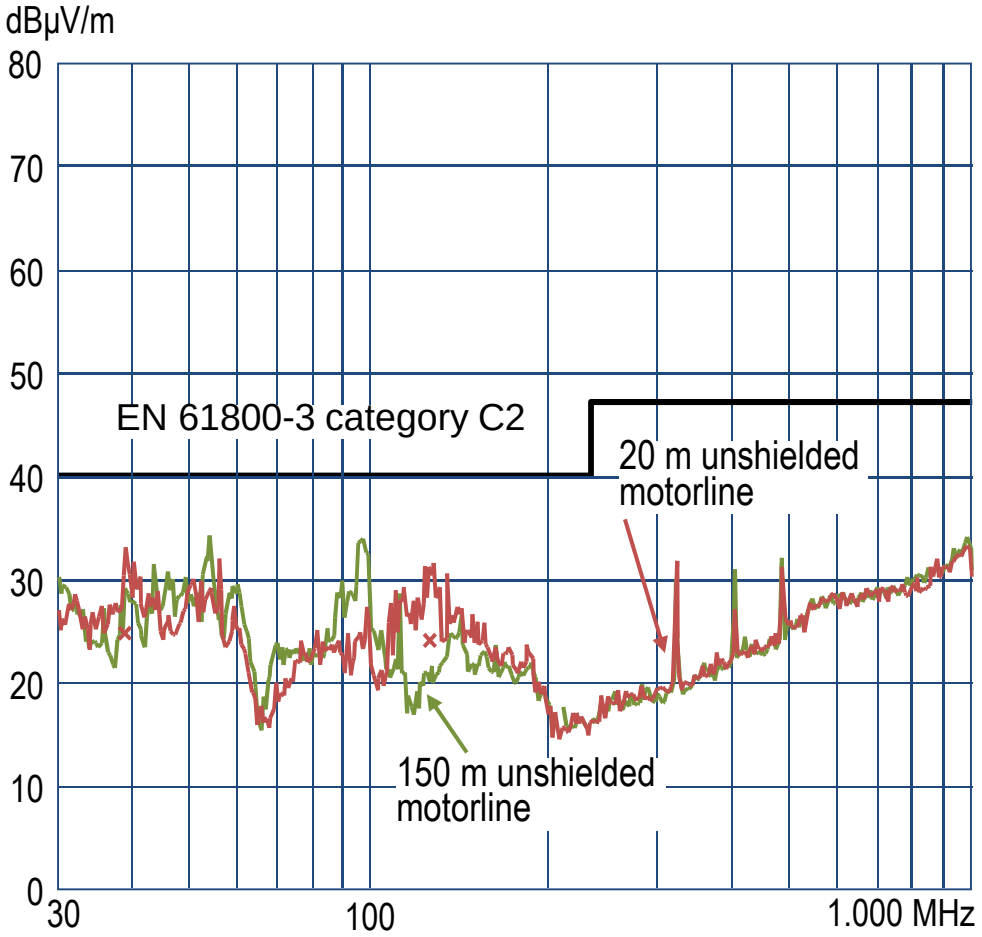
Converter and unshielded cable
(with SineFormer®)



Field strength: Goodbye shielded cables!

SineFormer®: Measurements /5

Coherent results at different motor cable lengths



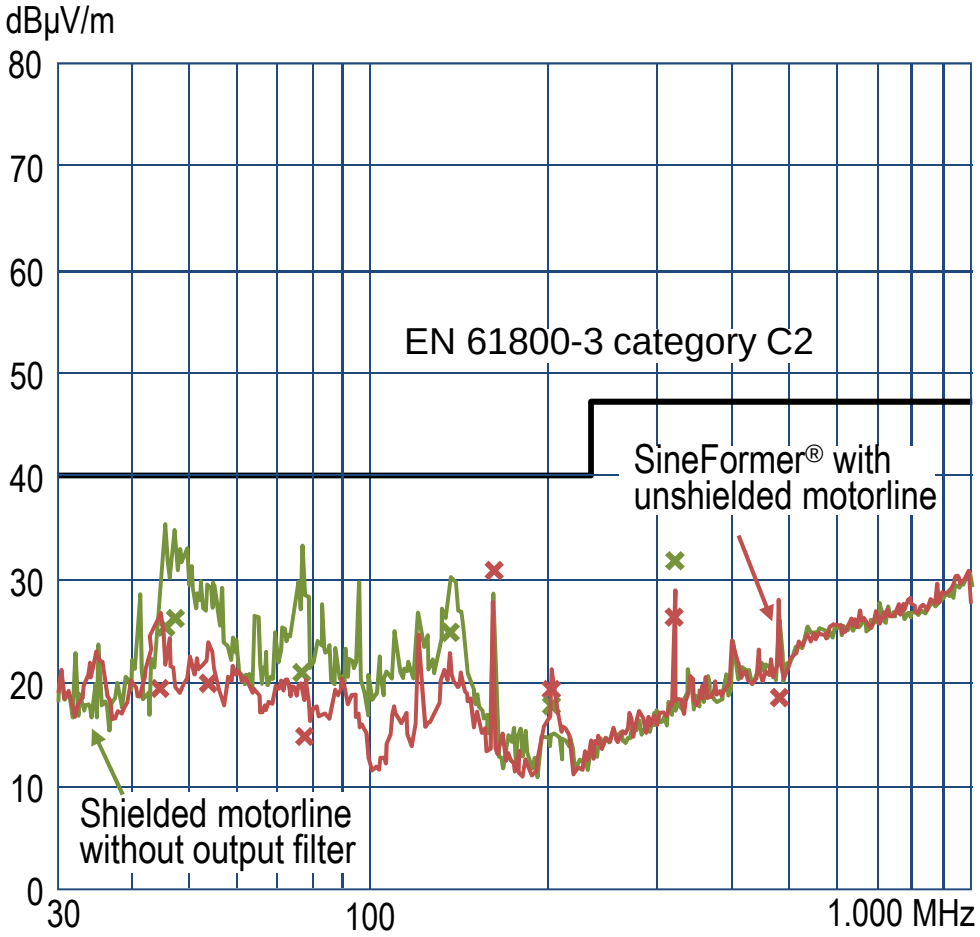
Field strength performance is not dependent on cable length!

SineFormer®: Measurements /6

Radiation measurement vertical antenna (worst case)

- Converter 2.2 kW/ 400 V
- Filter 11 A
- 300 m motor cable
- 8 kHz clock frequency

With an increase of the cable cross section, this effect will be even higher because the shielding will be more coarsely meshed.

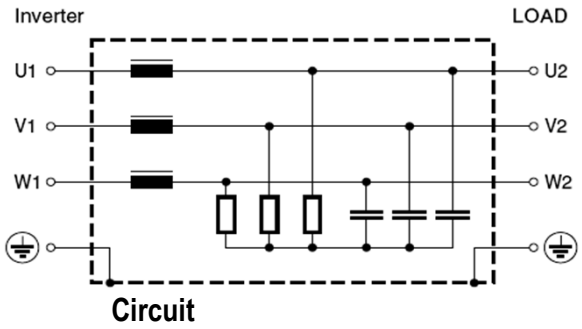


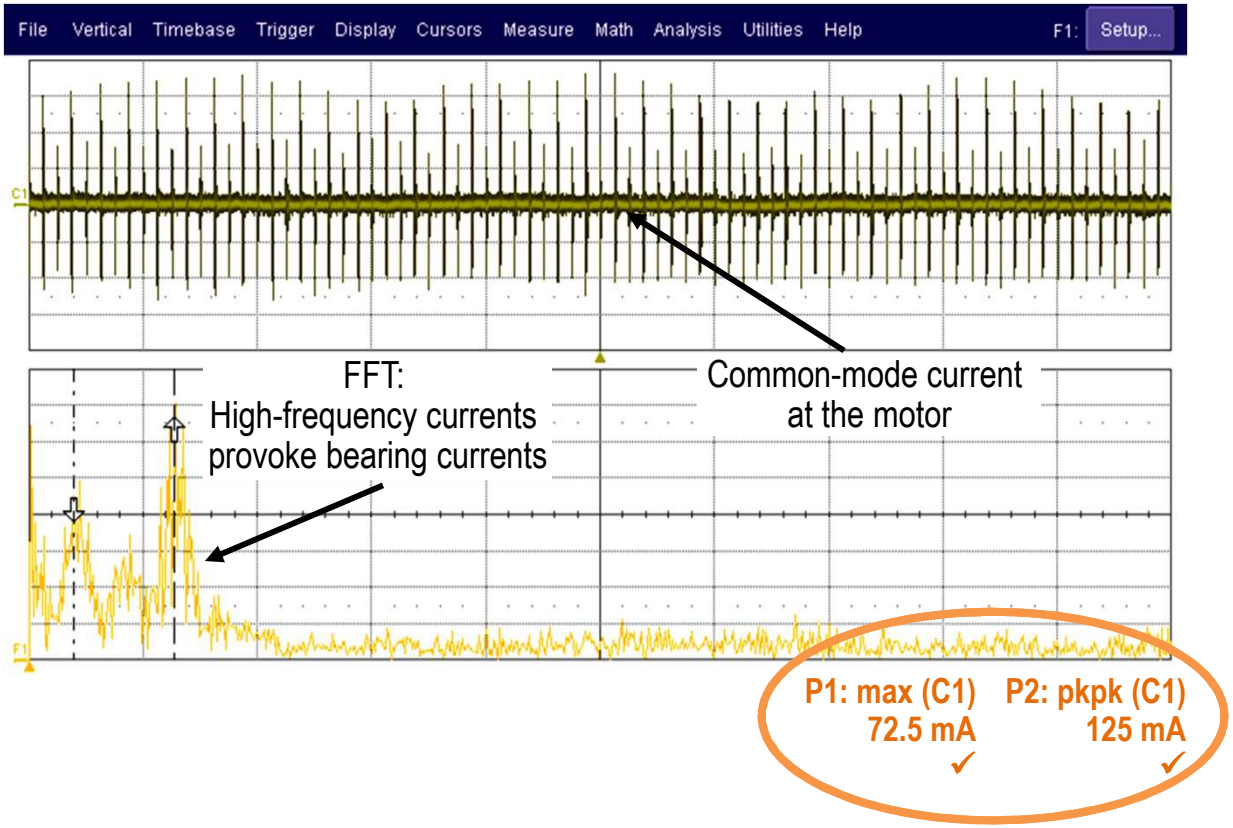
SineFormer® + unshielded motor cable have better performance than shielded motor cables!

Bearing current measurements with sine-wave filters

Measurement bearing current **with sine-wave filter**

- Drive 2.2 kW/ 400 V
- 25 m motor line
- 4 kHz clock frequency
- 5 Hz motor frequency



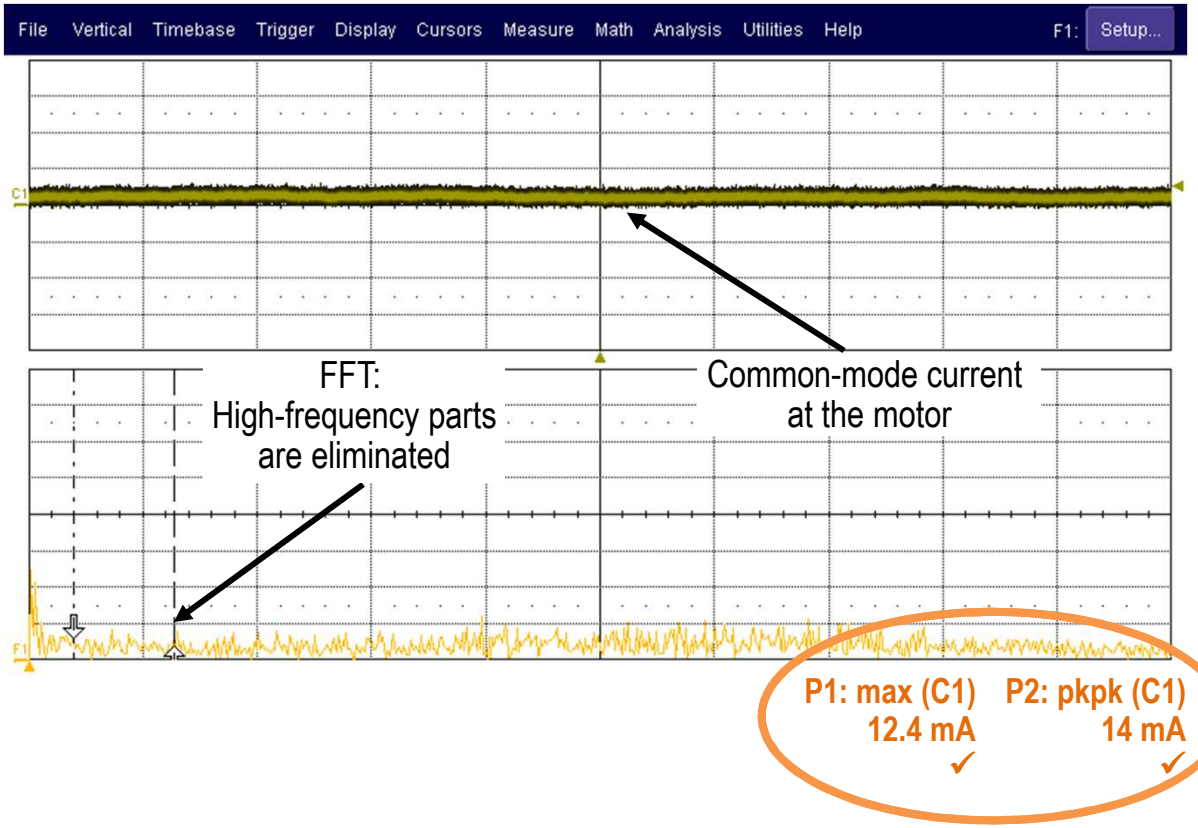


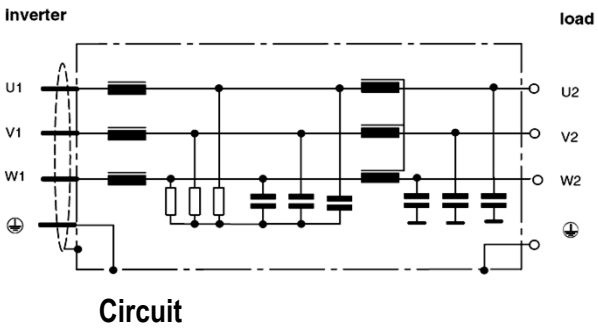
Sine-wave filters only partially reduce bearing currents in the motor!

Bearing current measurements with SineFormer®

Measurement bearing current **with SineFormer®**

- Drive 2.2 kW/ 400 V
- 25 m motor line
- 4 kHz clock frequency
- 5 Hz motor frequency





Circuit

Only SineFormer® filters reduce bearing currents significantly!

www.SineFormer.com