

Attracting Tomorrow



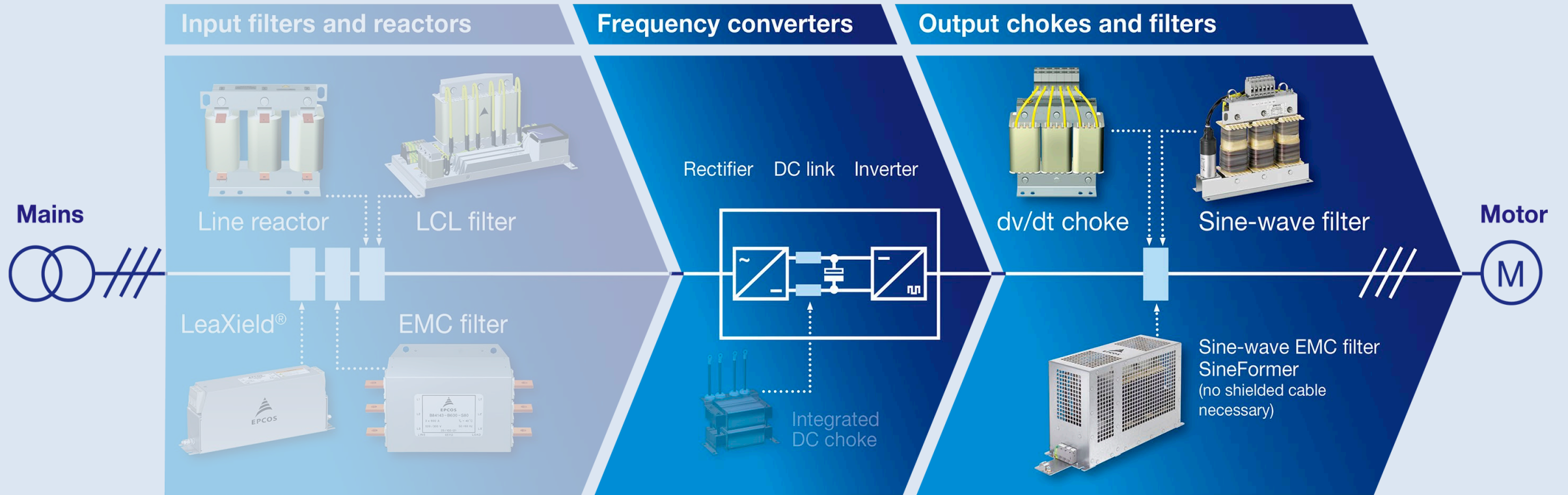
Output filter solutions

Output chokes and filters
for frequency converters



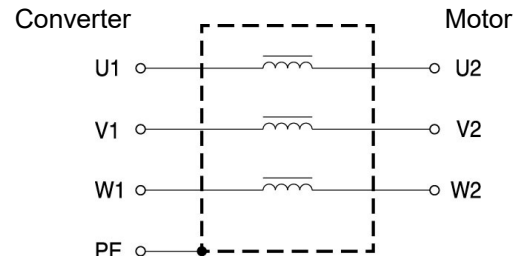
TDK Electronics AG
Magnetics Business Group
Munich, Germany
March 2022

EMC output filter solutions

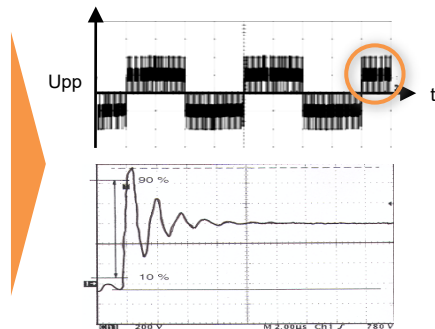


Output filter concepts

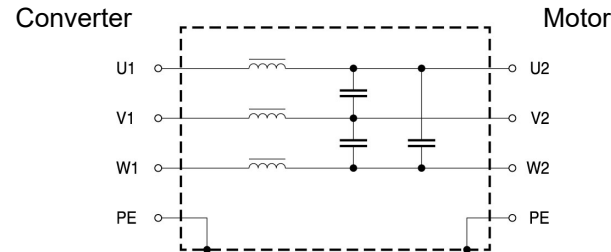
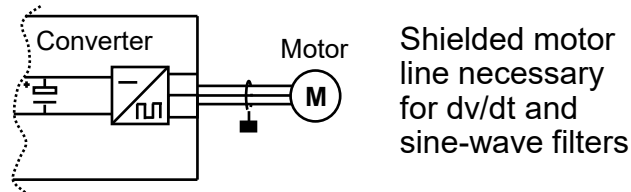
dv/dt chokes B86301U*R000/S000



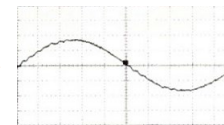
dv/dt of the output voltage drops and voltage spikes at the motor are reduced



Sine-wave filters B84143V*R227/*229/*230

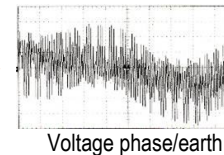


Forms sine wave between the phases



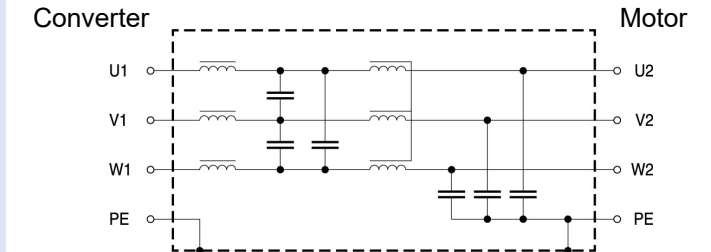
BUT

Common-mode interference is still present

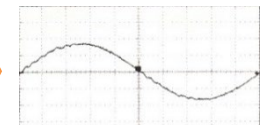


Sine-wave EMC filters B84143V*R127

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. 50 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

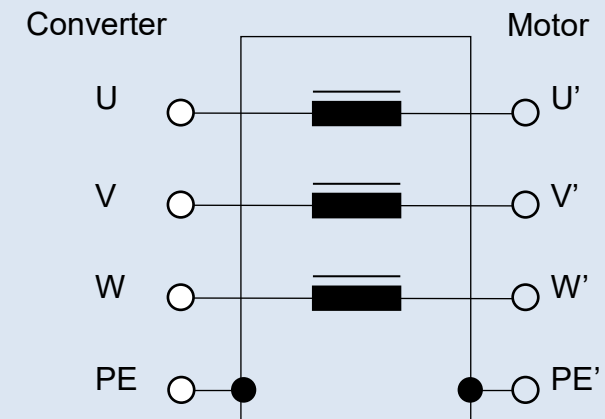
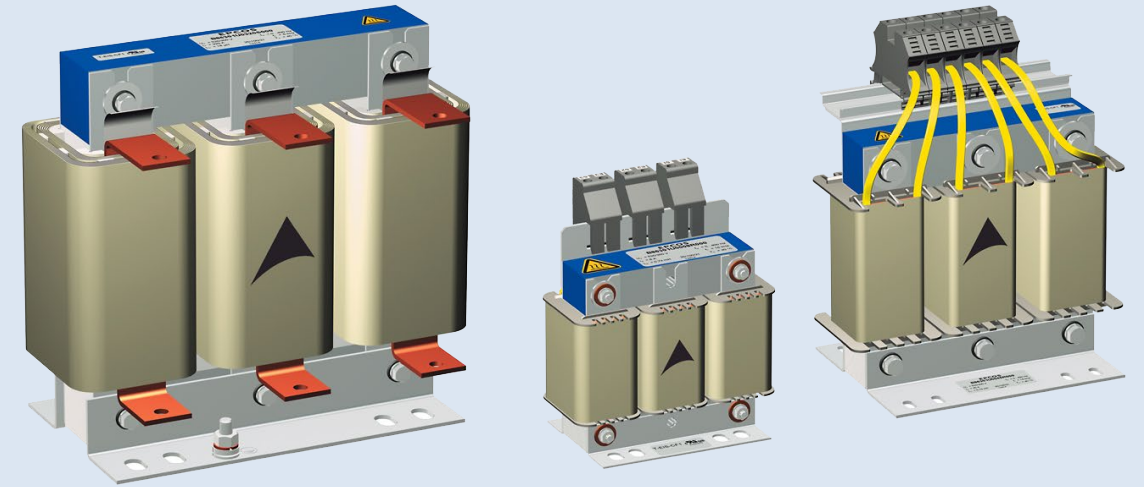
- ✓ Reduce dv/dt peaks significantly
- ✓ Forms sine wave between the phases
- ✓ Reduction of acoustic motor noise created by clock frequency
- ✓ Reduction of eddy current losses
- ✓ Shielded motor cables not necessary
- ✓ Minimization of motor bearing currents

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

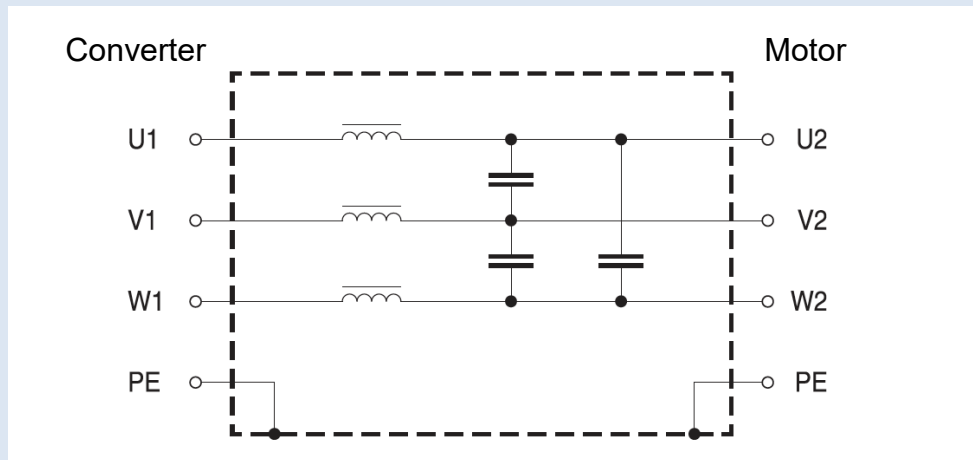
Features

- 8 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 \leq 24 A, IP10 45 A ... 112A), IP00 >180 A
- Optimized for motor cable lengths up to 50 m
- From stock delivery up to 950 A



Sine-wave output filter series B84143V*R227/*229/*230

- Current range from 4 A up to 390 A/520 V
- 690 V version: up to 320 A
- Designed for motor cables up to 1000 m
- IP21 housing available for *229/*230
- UL approved isolation system
- From stock delivery
- 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**

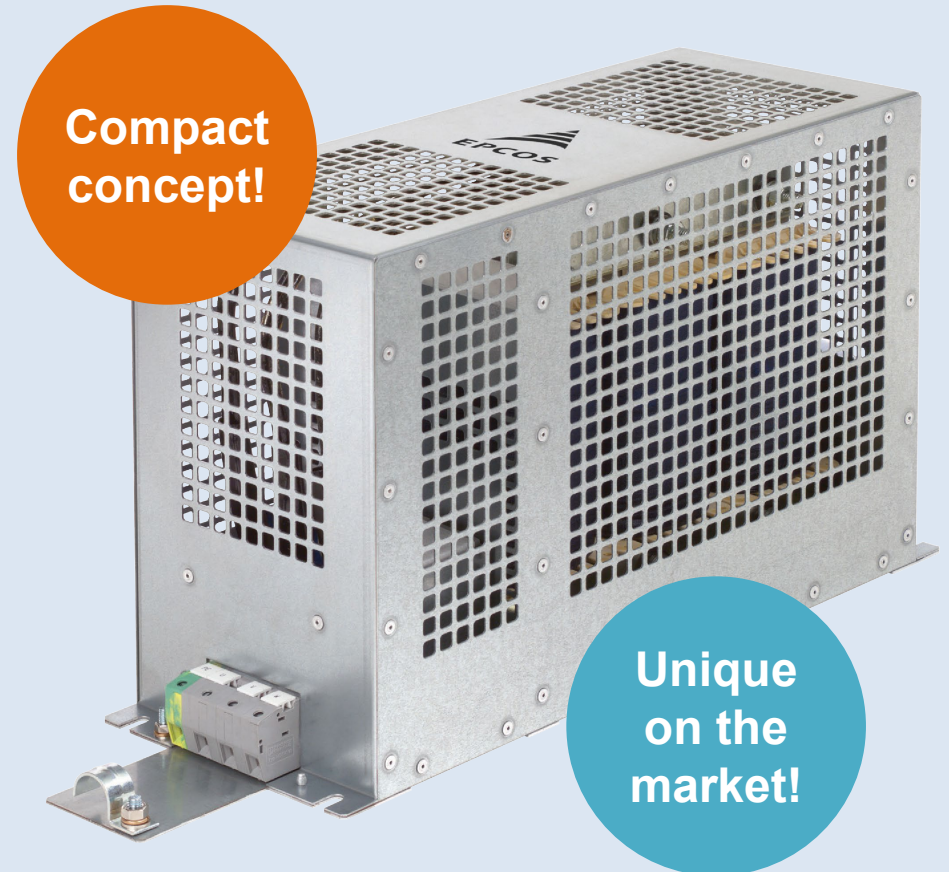
Longer life cycle of the motor, motor noise reduction, substantial compensation of bearing currents and eddy current losses, no forced ventilation necessary
 → Maintenance-free (fan would have a life cycle of 2 up to 4 years only), no feedback to the DC link needed
 → Reduction of all kinds of radiation 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



SineFormer[®]: Test results and technical data



- 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 V AC (600 V AC)
Rated current (40 °C)	6 to 180 A (320 A)
Motor frequency	0 to 100 Hz
Clock frequency	4 to 8 kHz (2.5 to 8 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

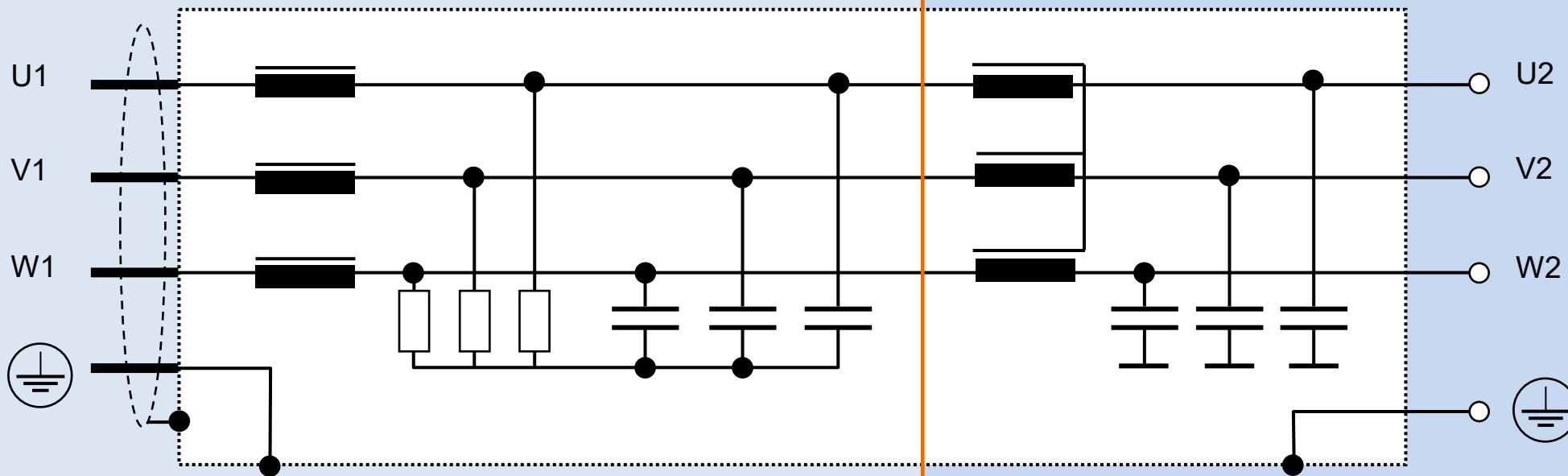
I_R^* A	Terminal cross section mm ²	ΔV %	PL W	R_{typ} m Ω	Approx. weight kg	Ordering code	Approvals  	
$V_R = 520 \text{ V AC}$								
6	4	7	45	290	9	B84143V0006R127	–	–
11	4	5	26	46	9	B84143V0011R127	x	x
16	6	7	38	32	11	B84143V0016R127	x	x
33	10	8	92	20	24	B84143V0033R127	x	x
45	10	8	82	17	28	B84143V0045R127	–	–
66	25	8	160	15	47	B84143V0066R127	x	x
95	50	10	210	8	99	B84143V0095R127	x	x
180	150	10	450	6	125	B84143V0180R127	x	x
$V_R = 600 \text{ V AC}$								
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

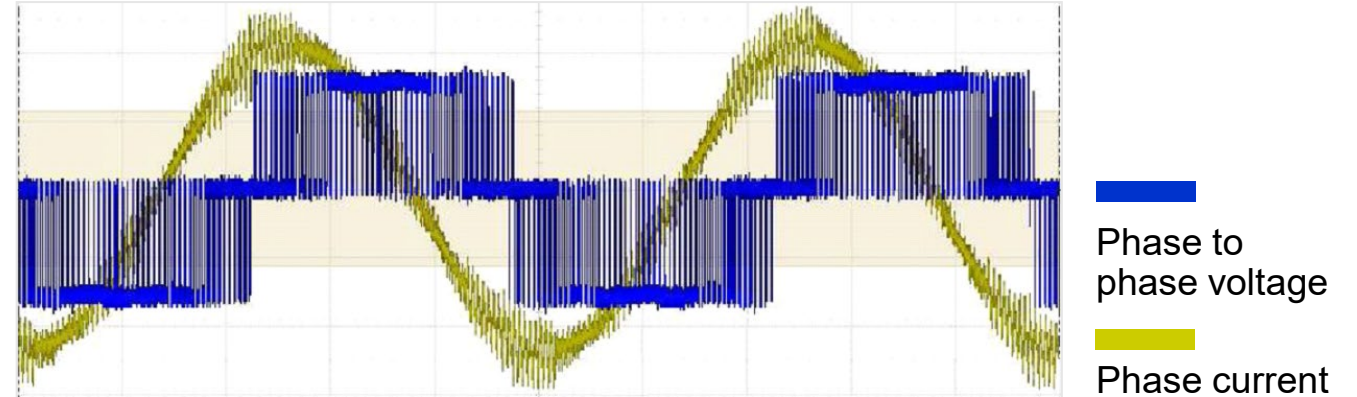
- Common-mode current reduction
- Field strength reduction
- Conducted emission reduction



SineFormer[®]: Measurements (1)

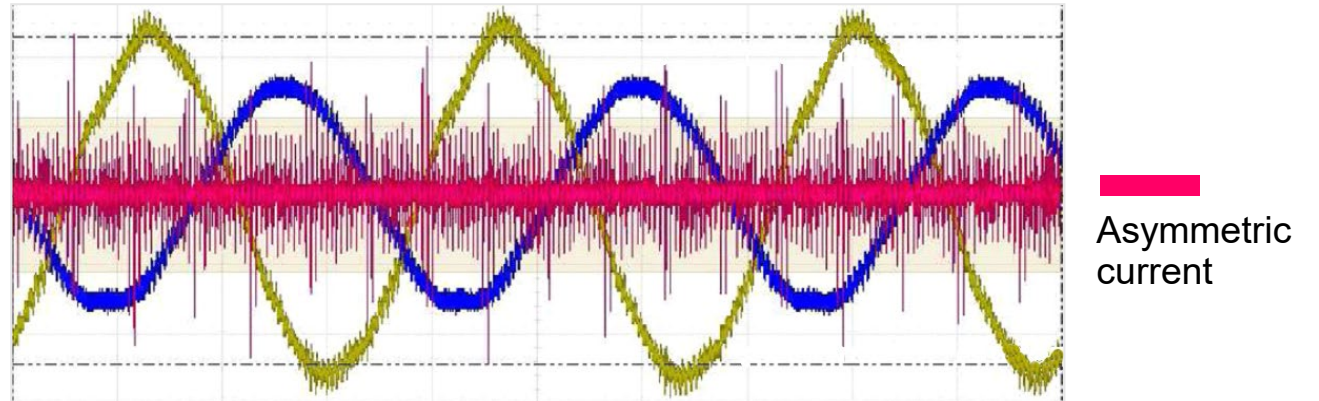
Measurements of the converter output

- 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

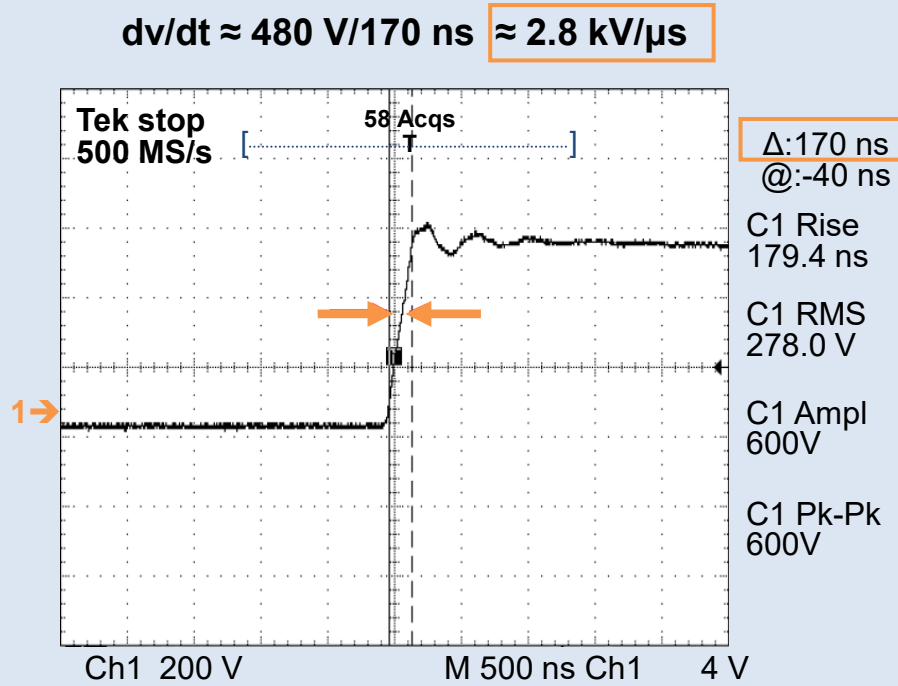


No shielded motor cable required, bearing currents minimized!

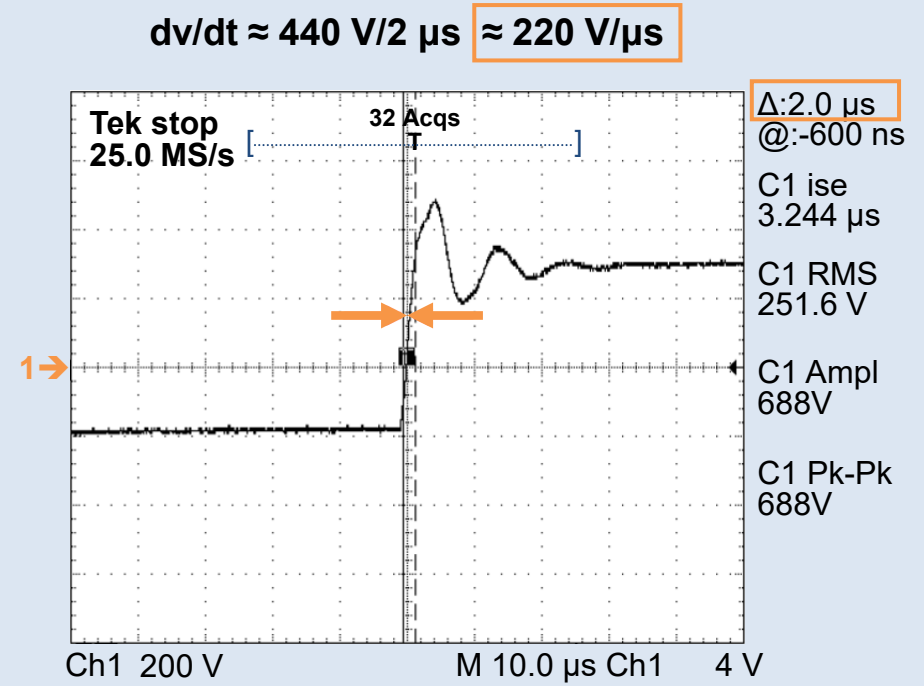
SineFormer[®]: Measurements (2)

Typical value for 4 kHz switching and 50 Hz motor frequency

Without output filter



With SineFormer[®]

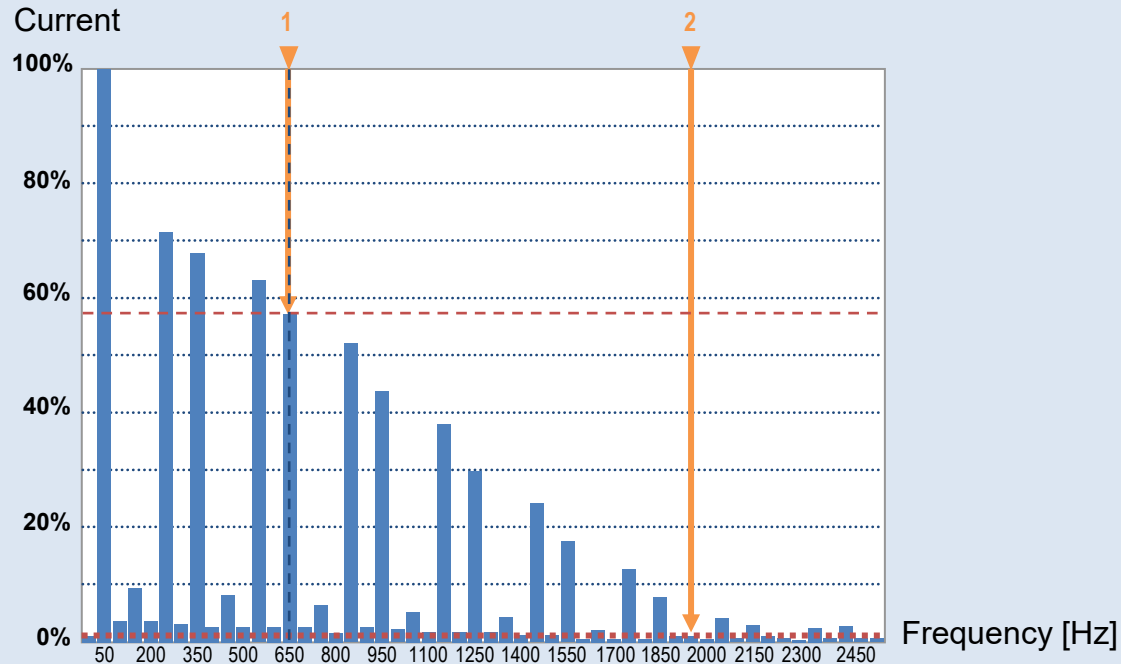


dv/dt peaks reduced significantly to uncritical values

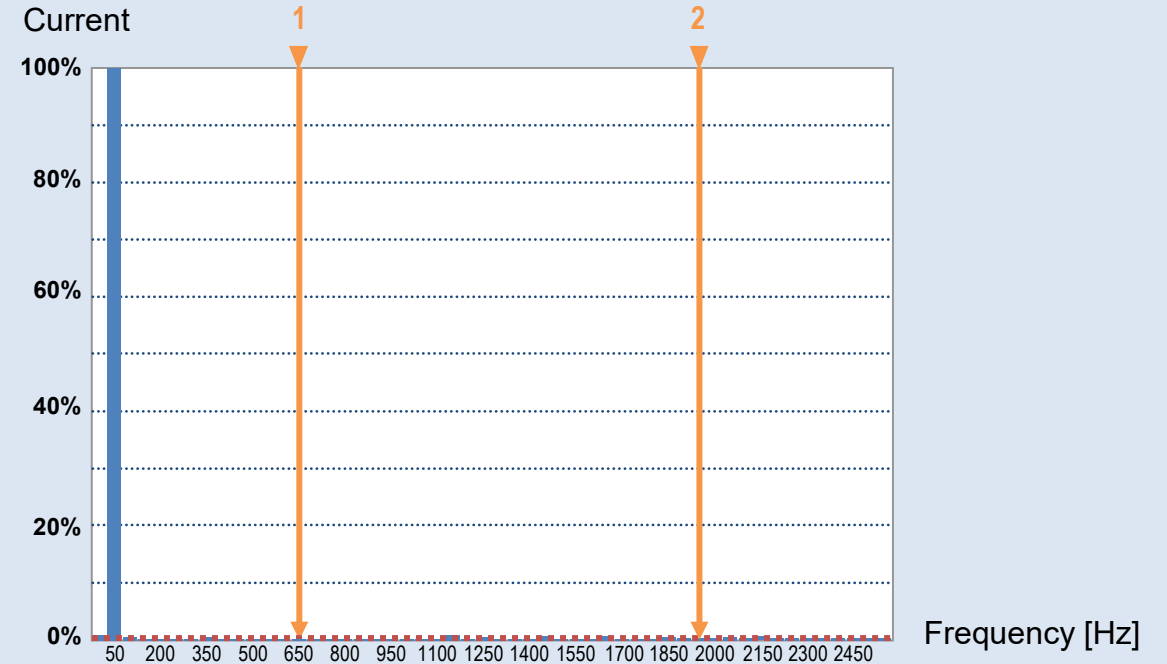
SineFormer[®]: Measurements (3)

Typical value for 4 kHz switching and 50 Hz motor frequency

Converter output



SineFormer[®] output

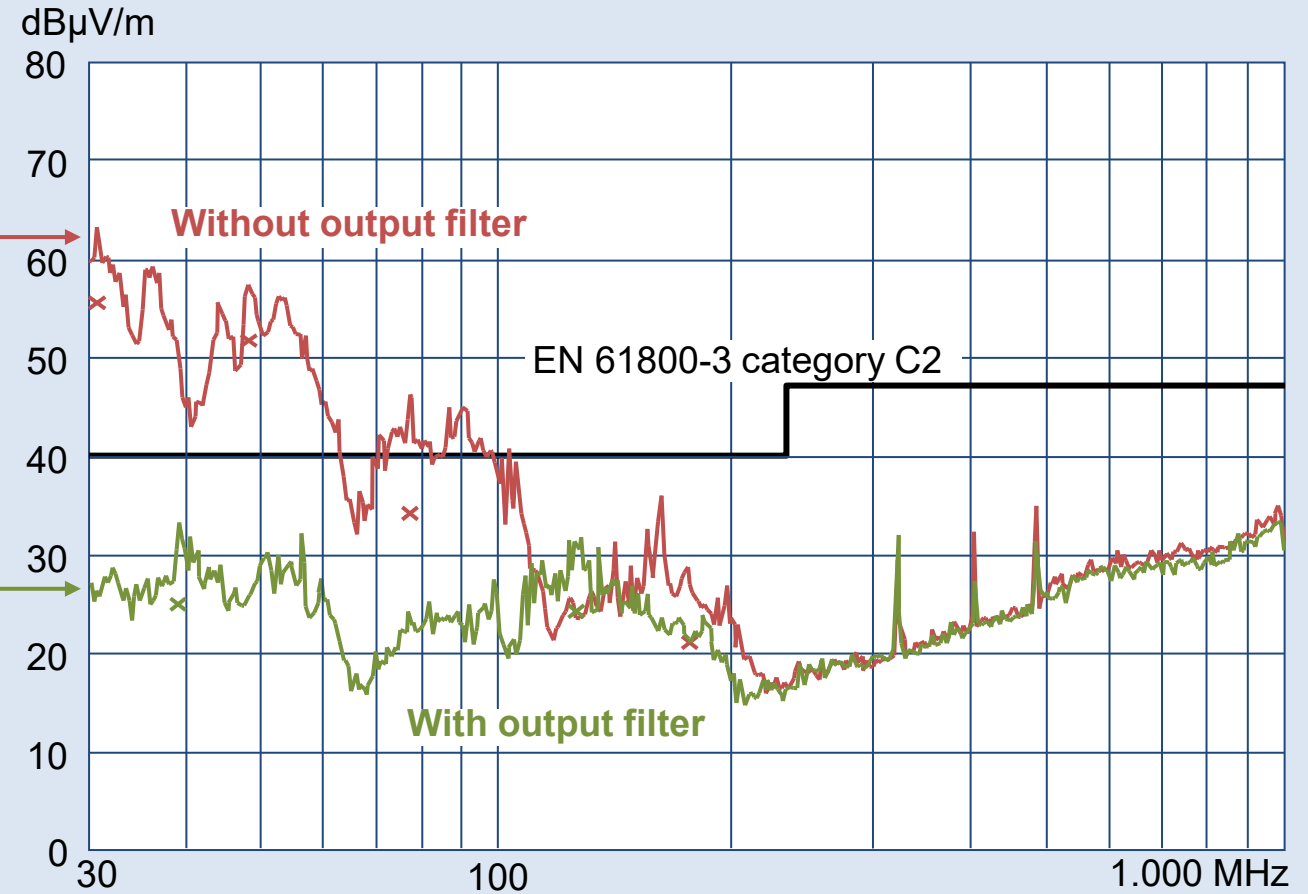


Elimination of harmonics on the output side!

SineFormer[®]: Measurements (4)

Limits exceeded
 Converter and unshielded cable
 (**without** SineFormer[®])

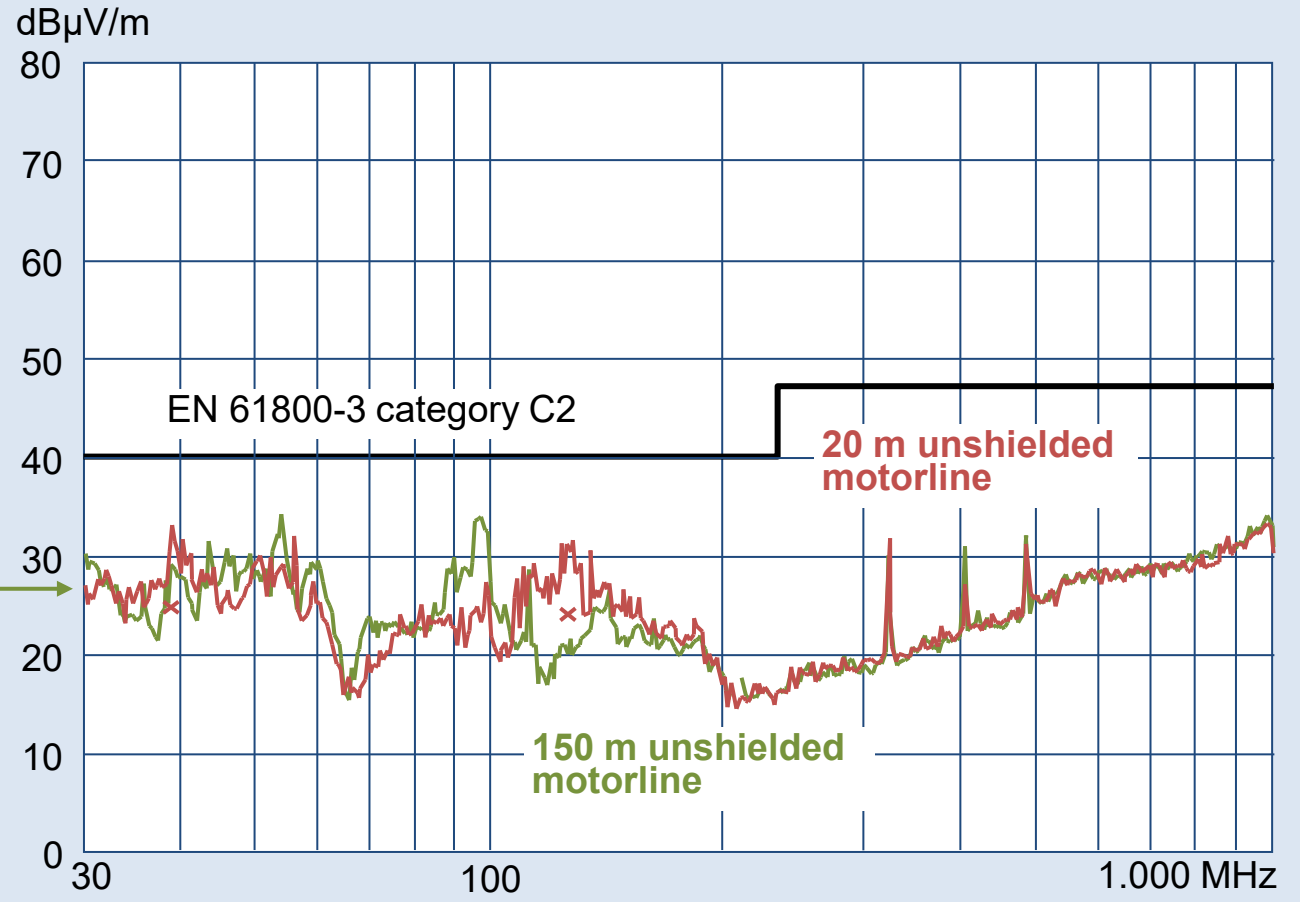
Limits kept
 Converter and unshielded cable
 (**with** SineFormer[®])



Field strength: Goodbye shielded cables!

SineFormer[®]: Measurements (5)

Coherent results at different motor cable lengths



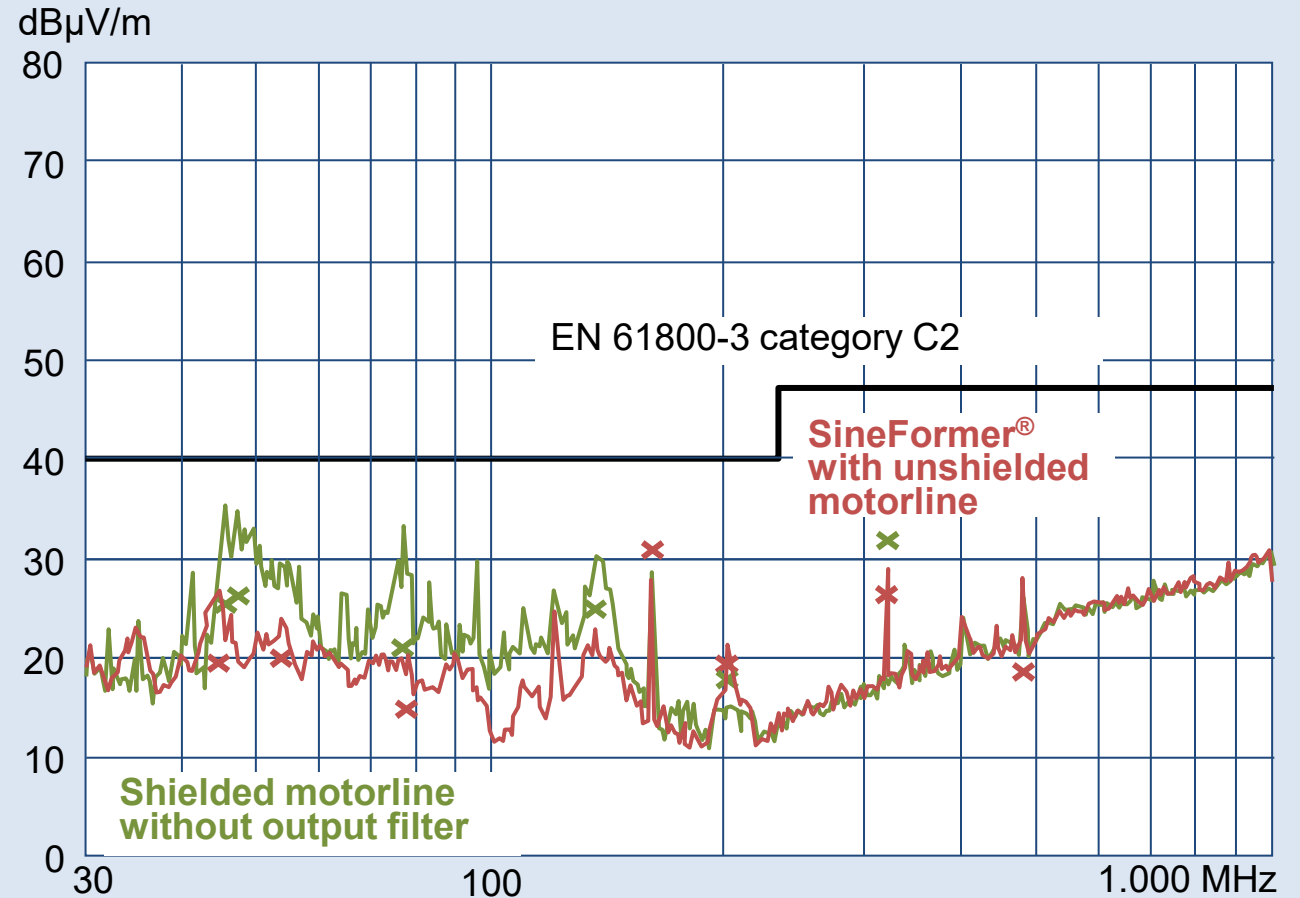
Field strength performance is not dependent on cable length!

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.

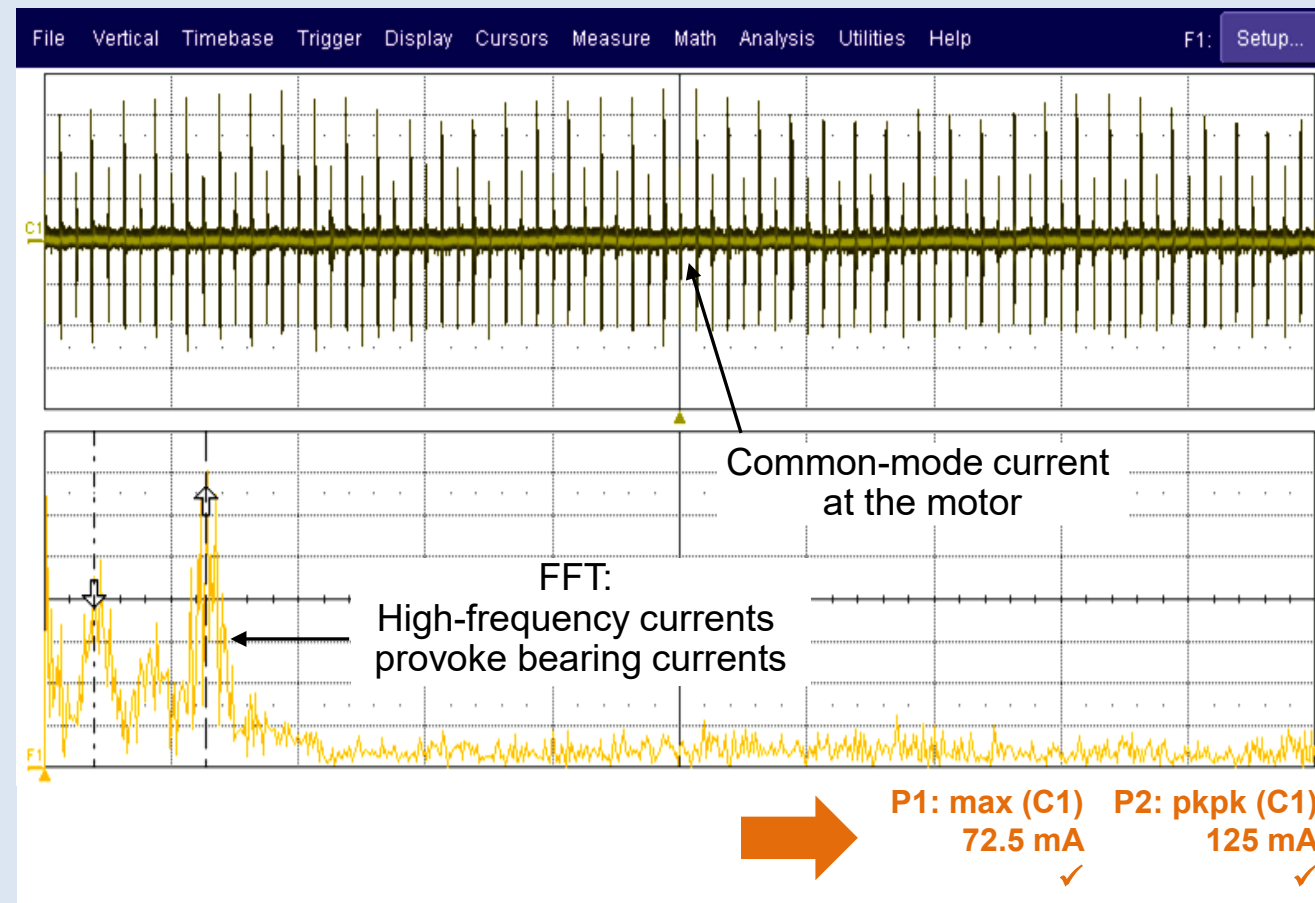
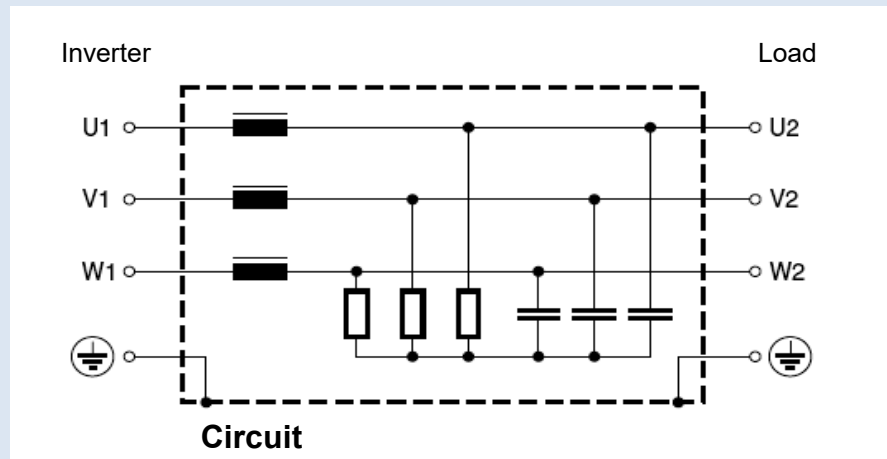


SineFormer[®] + unshielded motor cable have better performance than shielded motor cables!

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

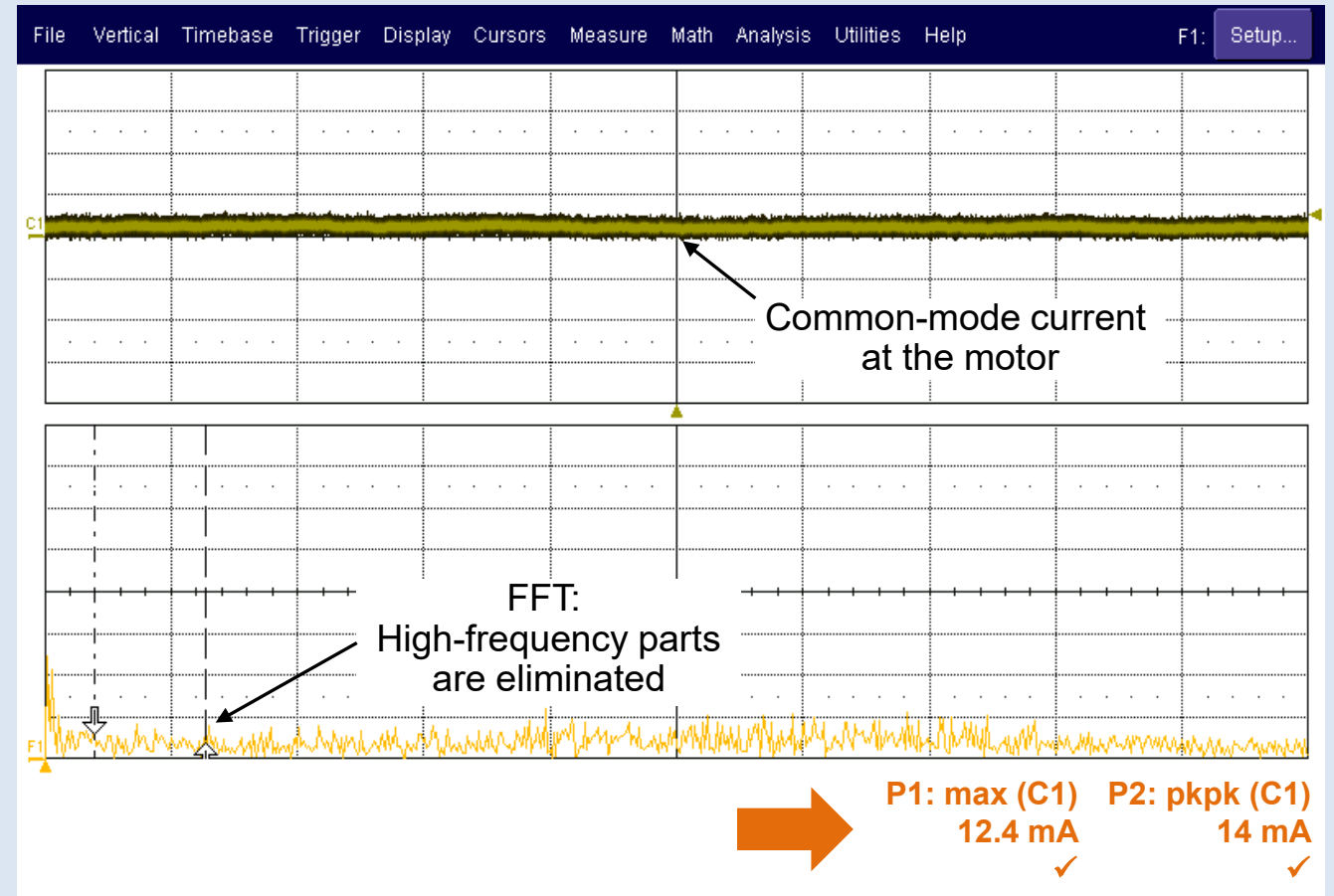
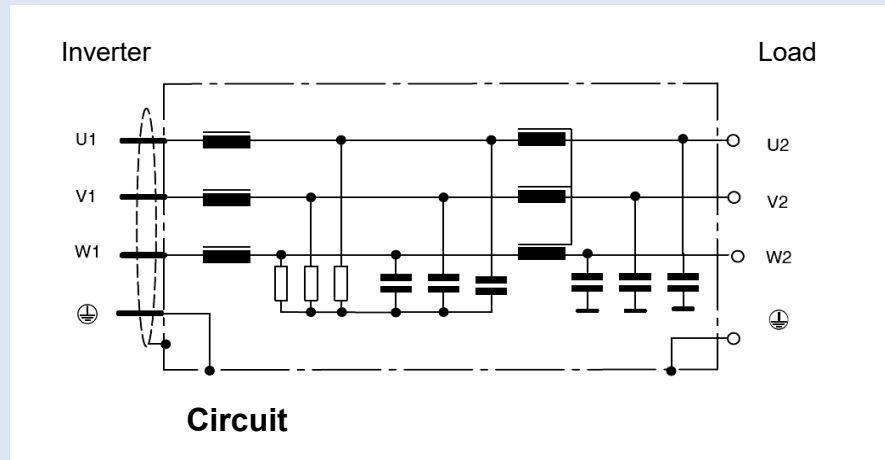


Sine-wave filters only partially reduce bearing currents in the motor!

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



Only SineFormer® filters reduce bearing currents significantly!



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