EMC Output Filter Solutions
Output filter concepts

**dv/dt chokes**
B86301U*R000/S000

- Strong reduction of dv/dt

**Sine-wave filters**
B84143V*R227/R229/R230

- Forms sine wave between the phases
- BUT
- Common-mode interference is still present

**Sine-wave EMC filters**
B84143V*R127

- 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

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<thead>
<tr>
<th>dv/dt chokes</th>
<th>Sine-wave filters</th>
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<td>Reduce dv/dt peaks significantly</td>
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</tr>
<tr>
<td>Low-cost solution</td>
<td>Forms sine wave between the phases</td>
</tr>
<tr>
<td>Motor line is limited to approx. 100 m</td>
<td>Reduction of acoustic motor noise created by clock frequency</td>
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<tr>
<td>No reduction of acoustic noise</td>
<td>Reduction of eddy current losses</td>
</tr>
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<td>Shielded motor cables necessary</td>
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<td>Minimization of motor bearing currents</td>
<td>Reduction of eddy current losses</td>
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</tbody>
</table>
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!](image)
SineFormer®: Data sheet

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

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>Ordering code</td>
<td>B84143V****R127</td>
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<tr>
<td>Rated voltage</td>
<td>520 VAC (600 V)</td>
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<tr>
<td>Rated current (40 °C)</td>
<td>6 to 180 A (320 A)</td>
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<tr>
<td>Motor frequency</td>
<td>0 to 100 Hz</td>
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<tr>
<td>Clock frequency</td>
<td>4 to 8 kHz (2.5 kHz/320 A)</td>
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<tr>
<td>Protection degree</td>
<td>IP20</td>
</tr>
<tr>
<td>Approval</td>
<td>UL/CSA (up to 180 Amps, except 6 A and 45 A version)</td>
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### SineFormer® B84143V*R127: Technical data

#### Characteristics and ordering codes

<table>
<thead>
<tr>
<th>$I_R$</th>
<th>Terminal cross section mm²</th>
<th>$\Delta V$%</th>
<th>$P_L$ W</th>
<th>$R_{typ}$ mΩ</th>
<th>Approx. weight kg</th>
<th>Ordering code</th>
<th>Approvals</th>
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<tbody>
<tr>
<td>6</td>
<td>4</td>
<td>7</td>
<td>45</td>
<td>290</td>
<td>9</td>
<td>B84143V0006R127</td>
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<tr>
<td>11</td>
<td>4</td>
<td>5</td>
<td>26</td>
<td>46</td>
<td>9</td>
<td>B84143V0011R127</td>
<td>×</td>
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<tr>
<td>16</td>
<td>6</td>
<td>7</td>
<td>38</td>
<td>32</td>
<td>11</td>
<td>B84143V0016R127</td>
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<tr>
<td>33</td>
<td>10</td>
<td>8</td>
<td>92</td>
<td>20</td>
<td>24</td>
<td>B84143V0033R127</td>
<td>×</td>
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<tr>
<td>45</td>
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<td>8</td>
<td>82</td>
<td>17</td>
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<tr>
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<td>10</td>
<td>210</td>
<td>8</td>
<td>99</td>
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<td>×</td>
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<td>180</td>
<td>150</td>
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<td>450</td>
<td>6</td>
<td>125</td>
<td>B84143V0180R127</td>
<td>×</td>
</tr>
</tbody>
</table>

**$V_R = 520$ V AC**

**$V_R = 600$ V AC**

- see dimensional drawing
- $10$ (for dimensional drawing)
- $475$
- $4$
- $195$
- B84143V0320R127
- —
- —

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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® circuit diagram
SineFormer®: Measurements

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**

\[ \text{dv/dt} \approx 480 \text{ V/170 ns} \approx 2.8 \text{ kV/µs} \]

**With SineFormer®**

\[ \text{dv/dt} \approx 440 \text{ V/2 µs} \approx 220 \text{ V/µs} \]

**dv/dt peaks reduced significantly to uncritical values**

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EMC Output Filter Solutions
SineFormer®: Measurements /3

Typical value for 4 kHz switching and 50 Hz motor frequency

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

Only SineFormer® filters reduce bearing currents significantly!