Optimised Converter for Solar and Wind

SEMISTACK® RE
450kVA up to 5MVA
4-Quadrant power converters for wind turbines with double-fed induction generator

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Rectifier</th>
<th>No. of Stacks in //</th>
<th>1.5 MW</th>
<th>2.0 MW</th>
<th>2.5 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>525A</td>
<td>740A</td>
<td>950A</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>470A</td>
<td>650A</td>
<td>820A</td>
</tr>
<tr>
<td>Inverter</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

\[ T_{\text{ambient}} = 40^\circ\text{C}, f_{\text{sw}} = 2\text{kHz}, V_{\text{bus}} = 1100\text{V}_{\text{DC}}, V_{\text{out}} = 690\text{V}_{\text{AC}}, f_{\text{out}} = 50\text{Hz}, \text{PF} = 0.95, \text{Overload 150\% 20s} \]

4-Quadrant power converters for wind turbines with synchronous generator

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Rectifier</th>
<th>No. of Stacks in //</th>
<th>2.5 MW</th>
<th>3.0 MW</th>
<th>5.0 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>2400A</td>
<td>2800A</td>
<td>4600A</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>2400A</td>
<td>2800A</td>
<td>4600A</td>
</tr>
<tr>
<td>Inverter</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

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Solar PV inverters

<table>
<thead>
<tr>
<th>Configuration</th>
<th>650kW</th>
<th>1.3 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200 V SKiiP</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1700 V SKiiP</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

\[ T_{\text{ambient}} = 40^\circ\text{C}, T_w = 45^\circ\text{C}, 3\text{kHz} / 50\text{Hz} / \cos \phi 1, 1200V : 600V_{\text{DC}} / 300V_{\text{AC}} 1700V : 1100V_{\text{DC}} / 600V_{\text{AC}} \]

- 2 sizes, water-cooled
- Embedding SKiiP 3 and SKiiP 4 technology for flexible power rating
- Designed for integration into 600 x 600 x 2000 mm cabinet
- Compliant with environmental standards (IEC 60721-3)
- Comprehensive dual-level production tests including SEMISTACK RE full functional test
- Optional burn-in tests for SKiiP and SEMISTACK RE
- Brake chopper available

Key features

450kVA up to 5MVA
- Water-cooled IGBT platform
- Power density up to 11.4 kW/litre
- Long lifetime
- SKiiP Technology

NOTE: All information is based on our present knowledge and is to be used for information purposes only. The specifications of our components may not be considered as an assurance of component characteristics.
2-Level but 1500V DC
With Intelligent Switching

SEMIKUBE®
Aircooled inverter up to 1500kVA
AC drive power converters

<table>
<thead>
<tr>
<th>Size 1/2</th>
<th>Size 1</th>
<th>Size 2</th>
<th>Size 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>400V, PF = 0.95</td>
<td>110kW</td>
<td>210kW</td>
<td>440kW</td>
</tr>
<tr>
<td>Overload 110 %, 60 s</td>
<td>180A</td>
<td>320A</td>
<td>670A</td>
</tr>
<tr>
<td>400V, PF = 0.95</td>
<td>90kW</td>
<td>170kW</td>
<td>340kW</td>
</tr>
<tr>
<td>Overload 150 %, 60 s</td>
<td>140A</td>
<td>260A</td>
<td>520A</td>
</tr>
</tbody>
</table>

- 3-phase diode/thyristor rectifier and 3-phase IGBT inverter
- Brake chopper optional

Solar PV inverters

<table>
<thead>
<tr>
<th>Size 1/2</th>
<th>Size 1</th>
<th>Size 2</th>
<th>Size 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>400Vac, PF=1 up to 1000Vac</td>
<td>140kW</td>
<td>240kW</td>
<td>520kW</td>
</tr>
<tr>
<td>No overload</td>
<td>200A</td>
<td>350A</td>
<td>750A</td>
</tr>
<tr>
<td>690Vac, PF=1 up to 1500Vac</td>
<td>-</td>
<td>-</td>
<td>1500kW</td>
</tr>
<tr>
<td>No overload</td>
<td>-</td>
<td>-</td>
<td>1300A</td>
</tr>
</tbody>
</table>

SEMIKUBE at a glance
- 4 sizes
- Power assembly includes IGBTs, capacitor banks, drivers, current and temperature sensors

Pre-qualified platform
- Complies with environmental standards (IEC 60721-3)
- Automated electrical tests and 100% fully tested in production

Easy maintenance
- DC connection via fast-mount clamps
- Fast replacement time of 30mins
- Power assembly weighs less than 30kg

Key features
- 75kVA up to 1500kVA
- Power density up to 5.7kVA/litre
- Size 3 with new ASIC chipset
- Increased SOA with multi switch modes
- Driver and current sensors
- Forced air cooled platform
- UL recognised
- Flexible design

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www.semikron.com/contact

SEMIKUBE® SlimLine
IGBT inverter from 75kVA to 1300kVA

Motor Drives  Solar Energy
SEMIKUBE®SlimLine

Benefits from the SEMIKUBE experience and discover the new SEMIKRON SlimLine platform. Powerful, compact, precise, long lifetime – these are the attributes of the SEMIKUBE SlimLine.

Benefits
SEMIKUBE SlimLine platform has been designed to fit applications in severe environments. Suitable for outdoor cabinets, the platform can be placed in environments subject to high temperature fluctuations. Extremely slim, the platform can be mounted into 300mm deep cabinets. The platform design facilitates easy arrangement in the cabinet owing to the separation of the main cooling air flow through the heatsink and its IP54 rated mounting flange.

Extending the SEMIKUBE portfolio, the SEMIKUBE SlimLine platform is a family of pre-qualified power assemblies which follow the same rigorous SEMIKRON qualification and certifications. The platform integrates advanced technologies which maximize performance and power density.

Applications
Following the philosophy of the SEMIKUBE, the SEMIKUBE SlimLine is optimized for solar PV central inverters. Sized for the most commonly used central inverter ratings on the market, i.e. 500kW, 670kW up to 900kW, the SEMIKUBE SlimLine 3-phase inverter operates up to 1000VDC bus voltage. Designed in accordance with IEC 62109, the platform is poised to obtain UL 1000V recognition. SEMIKUBE SlimLine complies with most AC Drives application requirements, offering typical electrical topologies including controlled or uncontrolled rectifier, an IGBT inverter and a brake chopper. The new slimmer frame design, with front access for the power connections, simplifies integration of the electrical power distribution arrangement inside the cabinet. The current measurement precision of 1% (at 25°C) allows for premium motor control required for highly dynamic applications and motion control systems.

Product range
The SEMIKUBE SlimLine offers four frame sizes of continuous rated current from 150A to 1500A, using SEMITRANS 1200V IGBT Trench E4 modules. SEMIKUBE SlimLine design is optimized for the following electrical topologies; 3-phase inverter, diode/thyristor rectifier with 3-phase inverter and brake chopper, linked to a capacitor tank using either electrolytic or polypropylene capacitors.

The IGBTs are controlled by a SEMIKRON embedded driver, which provides TOPBOT gate signals, control and error management, and analogue outputs of current, DC voltage and heatsink temperature. A CAN interface is available for parameter configuration and diagnostics monitoring. Custom factory settings to meet specific application requirements can also be set via the CAN interface during manufacture. Air cooling for SEMIKUBE SlimLine is provided by highly efficient long life axial fans, realizing maximum power within a compact package.

Key features
- Air cooled IGBT power assembly
- Power density up to 7.5kVA/L
- Four frame sizes ranging from 75kVA up to 1300kVA
- Maximum output current from 150A up to 1500A
- Switching frequency up to 15kHz
- AC output voltage up to 500VAC
- DC bus voltage up to 1000VDC
- Current measurement accuracy <1%
- \( V_{\text{BUS}} \), \( V_{\text{OUT}} \), \( I_{\text{OUT}} \) : analogue measurement or CAN monitoring
- Operating temperature range: -30°C to +60°C
- Integration into 300mm deep cabinet
- IP54 mounting
- UL1741 1000V ready
- 100% tested in production

Solar PV inverter application

**Solar Energy**

<table>
<thead>
<tr>
<th>Frame SL20</th>
<th>Frame SL40</th>
<th>Frame SL80</th>
<th>Frame SL50</th>
</tr>
</thead>
<tbody>
<tr>
<td>600kW</td>
<td>1000kW</td>
<td>1500kW</td>
<td>2000kW</td>
</tr>
<tr>
<td>PF = 1</td>
<td>No overload</td>
<td>( f_{\text{SW}} = 3,\text{kHz} ), ( f_{\text{OUT}} = 50,\text{kHz} ), ( T_{\text{AMBIENT}} = 40 ,^\circ \text{C} ), ( V_{\text{BUS\ MAX}} = 1000,\text{VDC} )</td>
<td></td>
</tr>
</tbody>
</table>

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- Switching frequency up to 15kHz
- AC output voltage up to 500VAC
- DC bus voltage up to 1000VDC
- Current measurement accuracy <1%
- \( V_{\text{BUS}} \), \( V_{\text{OUT}} \), \( I_{\text{OUT}} \) : analogue measurement or CAN monitoring
- Operating temperature range: -30°C to +60°C
- Integration into 300mm deep cabinet
- IP54 mounting
- UL1741 1000V ready
- 100% tested in production

**Slim profile, easier cabinet integration**
- All frames <260mm deep
- DC and AC power connection at front
- Heat sink cooling separate from component side
- Option IP 20 protection for electronics

**High accuracy measurement, premium current control**
- <1% current accuracy at 25°C, from \( I_{\text{OUT}} \) (phase) to driver \( I_{\text{OUT}} \) current analogue output
- Current sensor accuracy temperature drift reduced
- <3% current accuracy over the operating temperature range -30°C to +60°C

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**Solar PV inverter application**

<table>
<thead>
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<th>Frame SL80</th>
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<td></td>
</tr>
</tbody>
</table>
Versatile High Power Inverter Platform

SKiiPRACK®
150kVA up to 5MVA
Modular phase cell assembly
- 1200V or 1700V SKiiP IPM modules mounted on cooling plate
- Electrolytic or polypropylene capacitor bank
- Rack with sliding mechanism for easy access
- Front or rear AC connections
- Available configurations - half bridge, single phase bridge and full 3-phase bridge
- SKiiP can be connected in parallel for higher output power

SKiiPRACK platform
- Available converter topologies: inverters, 6- or 12-pulse rectifiers and inverters, 4Q converters, brake choppers
- High power density > 12kVA/litre in 3 MVA configuration
- Flexible converter mechanics: cell arrangement horizontal and/or vertical
- Long service life thanks to SKiiP thermal cycling capability and capacitor lifetime at 100,000 hours at 40°C
- Easy maintenance: semiconductor and capacitor subassembly dismountable from front, less than 30kg

SKiiPRACK quality and reliability
- Rigorous design and qualification process
- Compliant with environmental standards (IEC 60721-3)
- Comprehensive dual-level production tests for SKiiP and SKiiPRACK
- Optional burn-in test for SKiiP and SKiiPRACK
- REACH/RoHS

Key features
<table>
<thead>
<tr>
<th>150kVA up to 5MVA</th>
<th>Long lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td>High power density &gt; 12 kVA/litre</td>
<td></td>
</tr>
<tr>
<td>With SKiiP 1200V and 1700V water-cooled</td>
<td></td>
</tr>
<tr>
<td>Configurable individual phase assemblies</td>
<td></td>
</tr>
</tbody>
</table>

We are close to our customers
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SEMIKRON INTERNATIONAL GmbH
P.O. Box 820251 / 90253 Nuremberg, Germany
Phone +49 911 6559 234 / Fax +49 911 6559 262
sales.skd@semikron.com / www.semikron.com

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The Benchmark for Wind Turbine Availability Under Tough Conditions

SKiiP® X
3-phase inverter from 1MW up to 6MW
Increased power ratings combined with a demand for highest reliability and robustness are the driver for new inverters in the wind power industry. With the SKiiPX SEMIKRON is setting a new standard regarding power density, robustness and reliability.

Benefits
Under harsh climatic conditions, secondary damages caused by moisture rank among the most common causes of power modules failures. Generally, the requirements increase in terms of robustness and reliability. The new IGBT module SKiiPX is designed for extreme climatic conditions and allows condensation during operation. Furthermore, an integrated gate driver and closed cooling system combine as a fully tested system, reducing the design and integration effort.

Applications
SKiiPX meets the requirements specifically for wind turbines in a power range of 1 to 6 MW in an outstanding way. Besides wind power applications, SKiiPX fits in every high power application where the focus is on reliability and robustness such as industrial drives and solar.

Product range

3-phase IPM
6-blades
$P_{\text{max}} = 1100\,\text{kW}$
$I_{\text{RMS}} = 1080\,\text{A}$
SKiiP 121XGD17E4-6DW
SKiN 180A

3-phase IPM
9-blades
$P_{\text{max}} = 1650\,\text{kW}$
$I_{\text{RMS}} = 1620\,\text{A}$
SKiiP 181XGD17E4-9DW
SKiN 180A

Key features
- 3-phase inverter from 1MW to 6MW
- 50% less volume
- 50% fewer parts
- SKiN Technology
- Maximum environmental protection
- Scalable building blocks for all power ranges
- 3.3MW 4-Q inverter in a single cabinet
- Absolute benchmark in FIT
- 1 million load cycles @ $\Delta T$ 70K
- Condensation allowed
3.3 MW 4-Q Inverter in a Single Cabinet

The latest in performance standards
- Complete cabinet incl. cabling, cooling and current sensors
- 3.3 MW converter, inverter in one 600mm x 800mm x 2000mm cabinet
- Absolute benchmark in FIT, 50% less compared to today’s solutions
- Fully assembled and tested IPM compact and low inductive DC link assembly supported
- Climatic conditions 3K4 / pollution degree III condensation and pollution allowed during operation, less effort for climatic control inside cabinet

First-rate components in a first-rate product
- More than 13.2kVA/litre, only 125 litre for 1.65MW 3-phase inverter incl. DC-link
- Stack plug-in 1.65MW 3-phase converter
- Suitable for 600mm x 800mm x 2000mm cabinet size
- Safely galvanically separated primary output, no need for controller-side isolation

Robustness is our maxim
- Three assembled 180A SKiN units for extended lifetime and high power density
- Each blade is fully galvanically isolated including temperature detection
- No bond wires, no solder – ten times higher load cycle capability
- Integrated and closed cooling system
- Constant operation up to 70°C ambient temperature, requires less cooling effort

SKiN® Technology – wire bond-free
In 2011 SEMIKRON presented the SKiN technology which comprises the consistent application of the sintering technology on all material combinations influenced by load-cycling in a power module: All soldering and bond connections are replaced by sintered compositions. A single SKiN units provides a half bridge configuration with an output current of 180A_RMS including a temperature sensor.
- One phase 1700V 180A_RMS
- 200,000 power cycles at delta T 110°C
- 100% solder-free thanks to SKINTER technology
- 100% free of bond wires thanks to flex foil and top side sintering
Modular High Current Rectifier

CLASSIC SKSE
800kVA to 1700kVA
Modular and flexible high power rectifier

- Capsule diodes and thyristors up to 80mm diameter
- Phase leg modularity allows for easy maintenance and repair
- IP54 electronic cooling fans simplify cabinet integration and air control
- 15% size reduction and 30% weight reduction
- Multiple DC connection for flexible wiring

Modularity and maintenance

- Various topologies:
- Thermal protection
- Fan tachometer feedback signal for air flow monitoring
- Fuses optional
- Heatsink visual check (clogging)
- Multiple DC connection

Flexibility

- Redundant fan easy implementation
- Fan voltage option (24V)
- Customisation possible above 500V<sub>a</sub> on request
- Higher isolation possible on request

Key features

<table>
<thead>
<tr>
<th>Power (kW)</th>
<th>805</th>
<th>1005</th>
<th>1305</th>
<th>1265</th>
<th>1540</th>
<th>1730</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC current (A)</td>
<td>1200</td>
<td>1500</td>
<td>1950</td>
<td>1890</td>
<td>2580</td>
<td>2580</td>
</tr>
<tr>
<td>V&lt;sub&gt;d&lt;/sub&gt; (V)</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>

800kVA to 1700kVA rectifier
Modular and flexible design
15% size reduction
30% weight reduction

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High in Output – Low in Cost

MiniSKiiP® Stack
Compact 50kW inverter in PCB technology
Up to 20% better price-to-power ratio than conventional solutions

MiniSKiiP Stack Benefits
The MiniSKiiP Stack is a compact power stack which enables fast time to market in a challenging market environment.

In this power range the direct connection between power module and printed circuit board results in a 40% reduction in volume as well as a 20% lower price-to-power ratio.

The MiniSKiiP Stack meets today's solar and energy storage requirements with regard to costs, efficiency and time to market.

MiniSKiiP Dual solution PCB integrated
MiniSKiiP Dual solution only requires 6 screws compared to a conventional solution with up to 39 screws. This improves reliability and decreases costs significantly.

Conventional solution vs. MiniSKiiP Dual solution

Cost of conventional solution with busbar
Cost of MiniSKiiP Stack

20% lower price-to-power ratio
- Less material required
- Reduced assembly time

Power density
- No DC or AC busbars
- New MiniSKiiP Dual concept
- PCB based technology

Safety
- Integrated current sensing
- Over-temperature protection
- Short circuit detection with SoftOff

Reliability
- 100% tested in power and thermal cycling tests
- Better fit rate thanks to component count reduction

Maximum performance in 40% less volume

<table>
<thead>
<tr>
<th>Specification</th>
<th>Conventional solution with busbars</th>
<th>MiniSKiiP Dual solution PCB integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stack Size (WxHxD in mm)</td>
<td>369 x 639 x 272</td>
<td>300 x 433 x 220</td>
</tr>
<tr>
<td>Weight in kg</td>
<td>27</td>
<td>15</td>
</tr>
</tbody>
</table>

PCB integrated inverter for up to 50kW

<table>
<thead>
<tr>
<th>Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated output power</td>
<td>50kW</td>
</tr>
<tr>
<td>Input voltage</td>
<td>400~820V&lt;sub&gt;AC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Max input voltage</td>
<td>1000V&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Output voltage</td>
<td>290V&lt;sub&gt;AC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Output current</td>
<td>105A&lt;sub&gt;AC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Over load</td>
<td>110%</td>
</tr>
<tr>
<td>Over load duration</td>
<td>60sec</td>
</tr>
<tr>
<td>Switching frequency</td>
<td>2~8kHz</td>
</tr>
</tbody>
</table>
Speed up Your Time to Market

100kW Evaluation Box
Back to Back Converter
Controller powered by NATIONAL INSTRUMENTS
General Purpose Inverter Controller Platform
Power Electronic Stacks

SEMIKRON is the global market leader in power electronic stacks with over 200,000 assemblies in the field. We offer the full range from simple module on heatsink up to fully integrated cabinets. Five global stack centers provide optimized, pre-qualified and field-tested stack assemblies. Our stacks feature short lead times while still easy to customize for your needs.

The controller is powered by the rugged and reliable NATIONAL INSTRUMENTS General Purpose Inverter Controller (GPiC) design and deployment platform. This platform includes a complete design suite covering circuit design, simulation, graphical control code development using LabVIEW, test and a complete validated and verified runtime software stack.

With that approach, SEMIKRON & NATIONAL INSTRUMENTS enable companies to enter markets worldwide, when time to market counts.

**System Component**

1. NI General Purpose Inverter Controller (Xilinx Zynq 7020 SoC Dual ARM Cortex-A9 with FPGA/DSP & IO)
2. Power supplies
3. Grid voltage sensors (line-neutral)
4. Precharge circuit
5. Main contactor
6. SEMIKRON SKiiP stacks (back-to-back)
   - 2 x SKiiP613GD123
7. Grid current sensors
8. EMI filter
9. Line filter
10. Fuses and terminal blocks

**Key features**

Start software development from day ONE

Our evaluation kits (>100KW) allow to:
- get controller running in few hours
- get system running in few hours
4 x Faster to the Market

Slow development => Traditional approach

<table>
<thead>
<tr>
<th>DESIGN &amp; DEVELOPMENT</th>
<th>QUALIFICATION</th>
<th>MANUFACTURING</th>
<th>ENDTEST</th>
<th>SYSTEM &amp; SOFTWARE ENGINEERING</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Simulation</td>
<td>- Standard tests</td>
<td>- Material Procurement</td>
<td>- 100% Test</td>
<td>- ~1 Mio lines of code</td>
</tr>
<tr>
<td>- Design</td>
<td>- Specific tests</td>
<td>- PCB Manufacture</td>
<td>- Burn-In test</td>
<td></td>
</tr>
<tr>
<td>- Verification</td>
<td>- Country requirements</td>
<td>- Assembly</td>
<td></td>
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<td>- Prototype</td>
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Fast development => SEMIKRON & NATIONAL INSTRUMENTS

Power Stack | SYSTEM & SOFTWARE ENGINEERING | 4 x faster to the market than traditional approach!

Products Power Electronic Stacks

- SEMIKUBE
- SEMIKUBE Slimline
- SKiiP Stack

Evaluation Kits

- Covers topologies like
  - Energy Storage /2 Stage
  - Wind Energy/DFIG
  - Solar Energy
  - Motor Drives

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC link voltage</td>
<td>800VDC</td>
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</tr>
<tr>
<td><strong>Active Rectifier</strong></td>
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</tr>
<tr>
<td>Grid voltage</td>
<td>480V rms</td>
<td>3 phase, 60Hz</td>
</tr>
<tr>
<td>Switching frequency</td>
<td>10kHz</td>
<td>Fixed due to line filter</td>
</tr>
<tr>
<td>Phase current</td>
<td>102A</td>
<td>Maximum continuous, no overload</td>
</tr>
<tr>
<td><strong>Motor Inverter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase current</td>
<td>144A, 96A</td>
<td>f_{sw} = 6kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f_{sw} = 10kHz</td>
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<tr>
<td></td>
<td></td>
<td>No overload considered</td>
</tr>
<tr>
<td>Motor voltage</td>
<td>460V rms</td>
<td></td>
</tr>
<tr>
<td>Motor power</td>
<td>40HP</td>
<td>(Reference Only)</td>
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<tr>
<td><strong>Environmental</strong></td>
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</tr>
<tr>
<td>Installation</td>
<td>Pollution degree 2, laboratory conditions only</td>
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</tr>
<tr>
<td>Temperature</td>
<td>40°C</td>
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</tbody>
</table>

Contact us:
power-stack@semikron.com

Further information:
www.semikron.com/power-stacks