New generation of converters for rail vehicle auxiliary power supplies

The BORDLINE™-S series of static converters for onboard power supplies features a wide input voltage range, advanced IGBT technology and electrically isolated outputs for smoothed DC and sinusoidal three-phase AC. Total efficiency is better than 90 percent. The converters are compact, rugged and easy to maintain, while their modular design provides the flexibility needed to meet the widest range of customer requirements.

The demands made on the onboard power supplies of mass transit rail vehicles have undergone a dramatic change in recent years, and railway operators today put a high premium on their reliability and availability. Thanks to modern technology, train travel offers a much higher level of comfort than in the past. Controlled ventilation or air-conditioning in the coaches and an air-conditioned cab make train travel more comfortable for passengers and driver alike, while a smooth journey is ensured by electronically controlled, stepless acceleration.

Low-floor technology has also enhanced passenger comfort by allowing easier entry and exit, which is especially important for older or handicapped people. However, a lower floor also means less space for the systems and apparatus that have been installed underfloor in the past. Since it now has to be mounted on the roof and modern vehicles tend to be lightweight constructions, this equipment has to be designed for maximum compactness and lowest weight.

All of these gains in passenger comfort come at a cost: an increase in the demand for energy, plus a high-power three-phase AC output for the motors that drive the blowers and compressors. Often, operators also specify a 230-V output for cleaning equipment and ticket vending machines, etc.

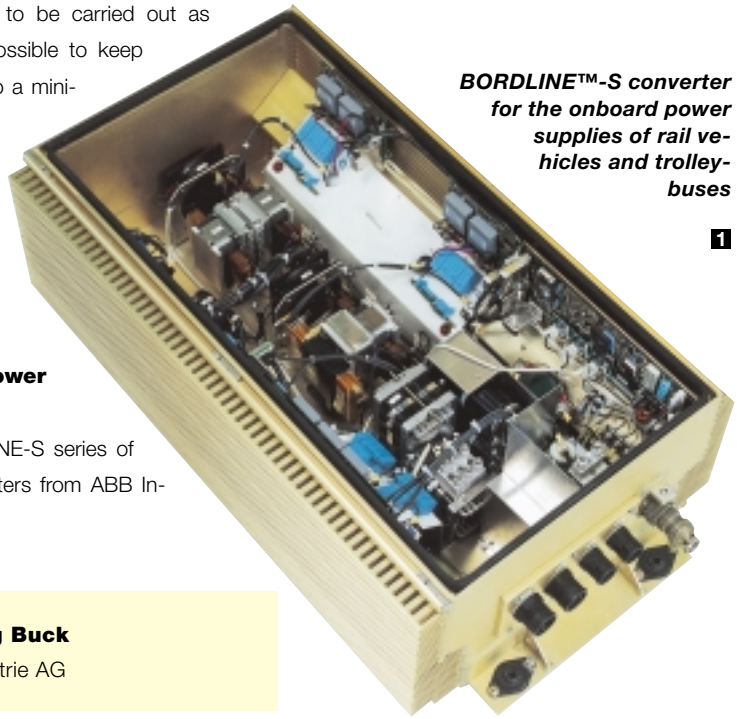
The reliability and availability of the onboard power supply converter are given a high priority because cooling of the traction equipment and battery charging are vital for operation of the vehicle. Also, necessary repairs have to be carried out as quickly as possible to keep downtimes to a minimum.

BORDLINE-S – a new generation of auxiliary power converters

The BORDLINE-S series of static converters from ABB Industrie AG **1** is designed to meet all of the mentioned requirements. The compact, rugged units were developed especially for onboard power supplies for rail vehicles and trolleybuses with ratings of up to 28 kW (*Table 1*). Of modular design, they can be adapted precisely to customers' needs and specific service conditions. Their wide input voltage range makes them suitable for use with traction power networks operating with catenary voltages ranging from 600 VDC to 750 VDC.

Models designed for higher DC input voltages as well as for AC input voltages are also available. The complete family of BORDLINE converters, including the BORDLINE-M and BORDLINE-L series, which are not described here, covers the power range up to 200 kW.

The BORDLINE-S converter generates an electrically isolated, smoothed direct voltage for charging the battery and supplying power to the vehicle control electronics and other equipment attatched to the battery, plus a sinusoidal three-phase voltage for AC motors. AC at 230 V can, of course, also be taken from it. A sine wave filter provides sufficient filtering of the alternating voltage to allow standard AC motors and equipment to be used.



BORDLINE™-S converter for the onboard power supplies of rail vehicles and trolleybuses

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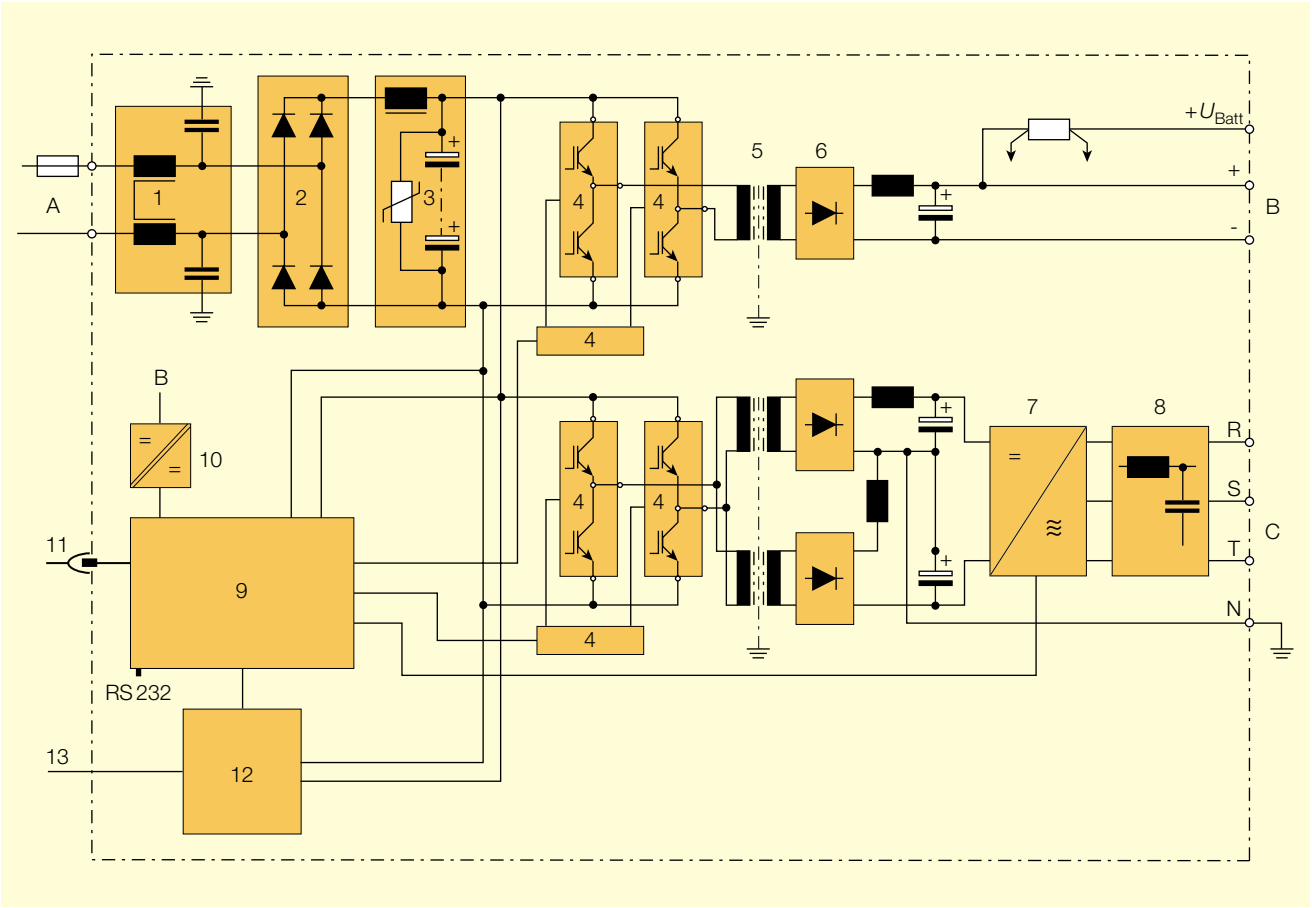


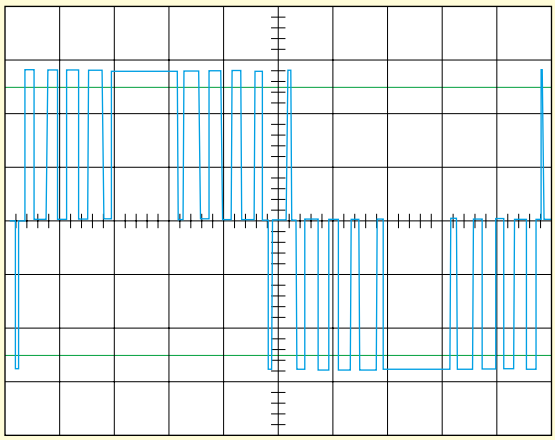
Basic circuit of the BORDLINE-S converter model for AC input voltage **2**

A	*Input voltage*
B	*DC output voltage*
C	*AC output voltage*
N	*Star point (optional)*
U_{Batt}	*Battery connection*

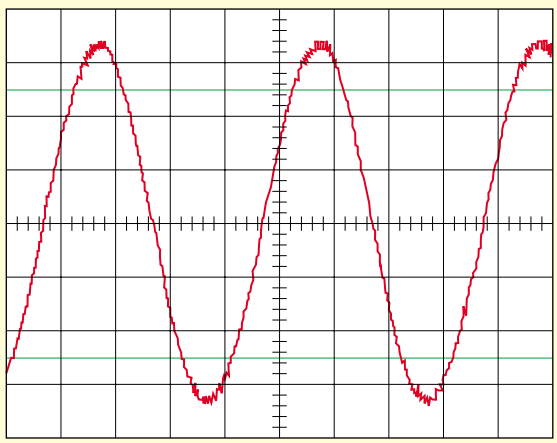
1	*EMC filter*
2	*Input rectifier*
3	*Input filter*
4	*Power section with control*
5	*Transformer*
6	*Rectifier*
7	*Inverter*

8	*Sine wave filter*
9	*Control electronics*
10	*Electrics power supply*
11	*Signal connector*
12	*Emergency starting unit (optional)*
13	*Emergency starting control signal*

Output voltage of the series B 800 converter (a) and the new BORDLINE series (b). The new equipment generates an almost pure sinusoidal voltage. **3**



a



b

IGBT technology

The static converters of the BORDLINE-S series are equipped with an input EMI filter for direct connection of the catenary voltage. The power sections that generate the voltage for battery charging and the three-phase AC voltage are completely separate and operate autonomously 2. On their supply side they have a full-wave bridge in IGBT* technology. The generated AC voltage at 20 kHz is isolated electrically by a transformer and rectified. Due to the high working frequency there is no audible noise; also the transformers can be built small and light. The IGBT-based inverter is operated with a pulse frequency of 9.6 kHz and, due to the output filter, produces an almost pure sinusoidal voltage 3. Because of this, shielding does not usually have to be provided for the motor supply leads. The IGBT technology allows a high total efficiency in excess of 90 percent.

Table 1:
Main technical data of the three standard classes of BORDLINE-S series converters

Power output	12 kW	16 kW	28 kW
Catenary voltage range		420–950 VDC	
Battery charging			
• Output voltage		28/42 V ± 1%	
• Output current	150/100 A	300/200 A	250/165 A
AC output			
• Nominal voltage	3 × 230 V, 50 Hz	3 × 230 V, 50 Hz	3 × 400 V, 50 Hz
• Power output	8 kW/10 kVA	8 kW/10 kVA	20 kW/23 kVA
Test voltages (as per IEC 77/146/411)			
• Input to chassis ground and ouputs		5.5 kV_{DC}/1 min	
• Battery output to chassis ground		2.1 kV_{DC}/1 min	
• AC output to chassis ground		3.6 kV_{DC}/1 min	
Efficiency, typ		90 %	
Weight, approx	165 kg	195 kg	260 kg
Size, incl fixing (L×B×H in mm)	1150 × 620 × 350	1450 × 620 × 350	1850 × 620 × 350
Ambient temperature		–25 °C to + 40 °C	
Protection class (casing)		IP 65	

Comprehensive protection

The protection concept was designed with the rigorous requirements of traction applications in mind. It includes monitoring of the input voltage and protection against transient voltage peaks, etc, as well as power outputs designed to withstand sustained short circuits. The central control electronics includes a microcontroller that monitors all of the operating statuses and the temperature of the power semiconductors. A diagnostics system featuring Windows software is available as an option. Detailed diagnostics data can be transferred via an RS232 interface from the converter's supervisory electronics to a personal computer.

Providing it has not been deactivated by a 'stop' signal at the input, the converter is ready to begin operating as soon as the input voltage lies within the working range. If the motor being started is a large AC unit, the frequency and voltage of the inverter will be reduced and the motor run up to rated power in 'soft start' mode.

Heat sink, developed especially for the BORDLINE power semiconductor devices 4

Compact construction

During the development of the converters special attention was paid to the cooling of the power semiconductors, which are mounted direct on a specially designed heat sink 4 for maximum cooling efficiency. By reducing the temperature inside the modules a longer lifetime is achieved for the power semiconductor devices. The combination of a rugged, simple design and service-friendly mounting of the devices also makes maintenance appreciably easier. An integrated diagnostics facility supports trouble-shooting by allowing fast identification and replacement of defective components.

The BORDLINE-S converter's casing is splashproof and dustproof. Due to its low height it is suitable for either underfloor or roof mounting. The basic model is designed to be cooled by the vehicle's slipstream, but other types of cooling (eg, water) are possible. Recyclable aluminium is used for the casing and heat sinks. The units are delivered in a standard dark powder coated finish.

The mechanical and electrical design of the converters incorporates all measures necessary for full EMC. Conformance to EU directives regarding EMC was ensured at all stages of the BORDLINE-S converter's development.

*IGBT = Insulated gate bipolar transistor

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