„Modern electrical propulsion systems for rolling stock“

Athen, January 2006
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TS GT DP
Modern electrical propulsion systems for rolling stock

1. Comparison of DC and AC traction machines

2. System aspects and general requirements for traction converters

3. State of the art IGBT-technology, an overview

4. The traction converter family SIBAC®
   - Modular Building Blocks
   - Railway vehicles with IGBT-traction converters (examples)

5. Conclusion
Motorcar Marienfelde-Zossen

Construction year: 1903
Number of units: 1
Supply voltage: AC Three phase
Continuous power: 2.2 MW
Top speed: 210 km/h
Comparison of DC- and AC-Traction Motor

**Traction drive of:** E103:
- rated power: 1230 kW at 1520 min⁻¹
- maximum torque: 8530 Nm for 5 minutes
- maximum speed: 1600 min⁻¹
- mass (without gear): 3550 kg
- moment of inertia: 120 kg m²

**E152:**
- rated power: 1633 kW at 2280 min⁻¹
- maximum torque: 6840 Nm constantly
- maximum speed: 4000 min⁻¹
- mass (without gear): 2800 kg
- moment of inertia: 18.4 kg m²

**Dimensions:**
- E103: 870 mm x 1200 mm
- E152: 855 mm x 910 mm
Traction converters have to work at various catenary voltages and have to cope with a wide output power range.

### Characteristic, Parameter

- **Catenary voltage**
- **Power of the propulsion system**
- **Ambient temperature range**
- **Failure behaviour**
- **Mechanical construction**

### Typical range

- DC 750 V ... 3000 V
- AC 15 kV ... 25 kV
- 0,5 ... 2.0 (3,5) MW
- -40 ... 50 °C
- Restricted to converter module

- Flat underfloor converter cubicle for EMU and Metro
- Switchgear cubicle for locomotives
Chopperless multi system converter with 6,5 kV IGBTs

DC
3kV / 1.5kV

AC
15kV
16 2/3Hz

25kV / 50Hz

4QC
DC-Link
PWR

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IGBT Development, Innovation
Device Availability and Projects

IGBT-Pilot Application
Frankfurt R
1200 V-Device
Renfe-Circuit

Experimental samples
Series Devices


IGBT 1200 V / 300 A

IGBT 1700 V / 300 A

IGBT 3300 V / 1200 A

IGBT 1700 V / 2400 A

IGBT 6.5 kV / 600 A

Strab Würzburg
BVG U-Bahn HK
La Chaud de Fonds
Strab Portland
Heathrow (AC)
Combino
Üstra 2000
Metro Prag
Frankfurt R2
BTS Bangkok
Puerto Rico
ISAP Athen
Calgary
Salt Lake City

Metro Vienna
Metro Munich
Amsterdam
Desiro UK

Bursa
Desiro OSE
OSE
FEVE
Melbourne

Series Locos
Class 189
Preseries Locos
Class 189
EMU 3 kV
IGBTs with different blocking voltages are offered by several semiconductor suppliers in a housing with the same footprint.

Module design of a 3.3 kV – 1200 A IGBT

Module design of a 6.5 kV – 600 A IGBT
Typical variation of the base plate temperature during the lifetime of an IGBT in a traction converter (EMU operation)

Power semiconductor devices, due to the operation of railway vehicles, have to withstand a high number of load cycles during lifetime.
Thermal cycling capability of the base plate and the bondwires (traction IGBT)

 Introduced technologies:
• Al SiC-base plate
• Polyimide passivation on the chip surface
The traction converter family SIBAC®

- Compact inverter
- Up to 3 kV line voltage
- Air cooled or water cooled

IGBT Building Block SIBAC® BB
- Up to 3 kV line voltage
- Air cooled or water cooled
Typical output power limits of SIBAC® IGBT traction converters

![Graph showing power capability of IGBT converter modules.](image)

- 3-parallel-IGBTs
- 2-parallel-IGBTs
- Single-IGBT

Key:
- **BB** - forced air
  - BB 750 F, BB 1500 F
- **BB** - water
  - BB 1500 W, BB 3000 W
- **CC** - forced air
  - CC 750 F, CC 1500 F
- **CC** - water
  - CC 1500 W, CC 3000 W

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Desiro OSE, Greece
picture: vehicle concept

- Second class chairs throughout the train in all of the 5 cars
- Wheelchair accessible toilet in 2 intermediate cars with additional multi purpose room; floor height: 800 mm
- Low floor entrance on 800 mm above rail
- Full air conditioning in passenger compartment and driver cabins according UIC
- Coupling of 2 trains possible (double traction)
- Redundant traction (8 three-phase motors), auxiliary power supply (2 converters) and redundant control system (SIBAS 32)
## Desiro OSE Technical data

### Technical data

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
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<tr>
<td>Gauge</td>
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<tr>
<td>Cars per train</td>
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<tr>
<td>Seats</td>
<td>313</td>
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<tr>
<td>Weight, empty</td>
<td>163 t</td>
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<tr>
<td>Length over coupler</td>
<td>89340 mm</td>
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<tr>
<td>Length of cars</td>
<td>End/Mittel 20895/15840 mm</td>
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<tr>
<td>Line voltage</td>
<td>25 kV/50 Hz</td>
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<tr>
<td>Max. Power at wheel</td>
<td>3000 kW</td>
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<tr>
<td>Traction effort</td>
<td>210 kN</td>
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<tr>
<td>Max. acceleration</td>
<td>1.0 m/s²</td>
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<tr>
<td>Max. speed</td>
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<td>Order quantity</td>
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<td>Entry height</td>
<td>800 mm</td>
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<tr>
<td>Axle arrangement</td>
<td>Bo(2)Bo′Bo′(2)Bo′</td>
</tr>
</tbody>
</table>

### Traction- and braking effort diagram

- Zugkraft (red)
- Bremskraft (blue)
- Fahrradierstand bei Steigung = 0.4%
Desiro OSE
Traction and auxiliary power supply

The train is prepared for a further development of a 7-car unit
Desiro OSE
Traction Components

Bogie

Transformer

Traction-Converter
Thank you