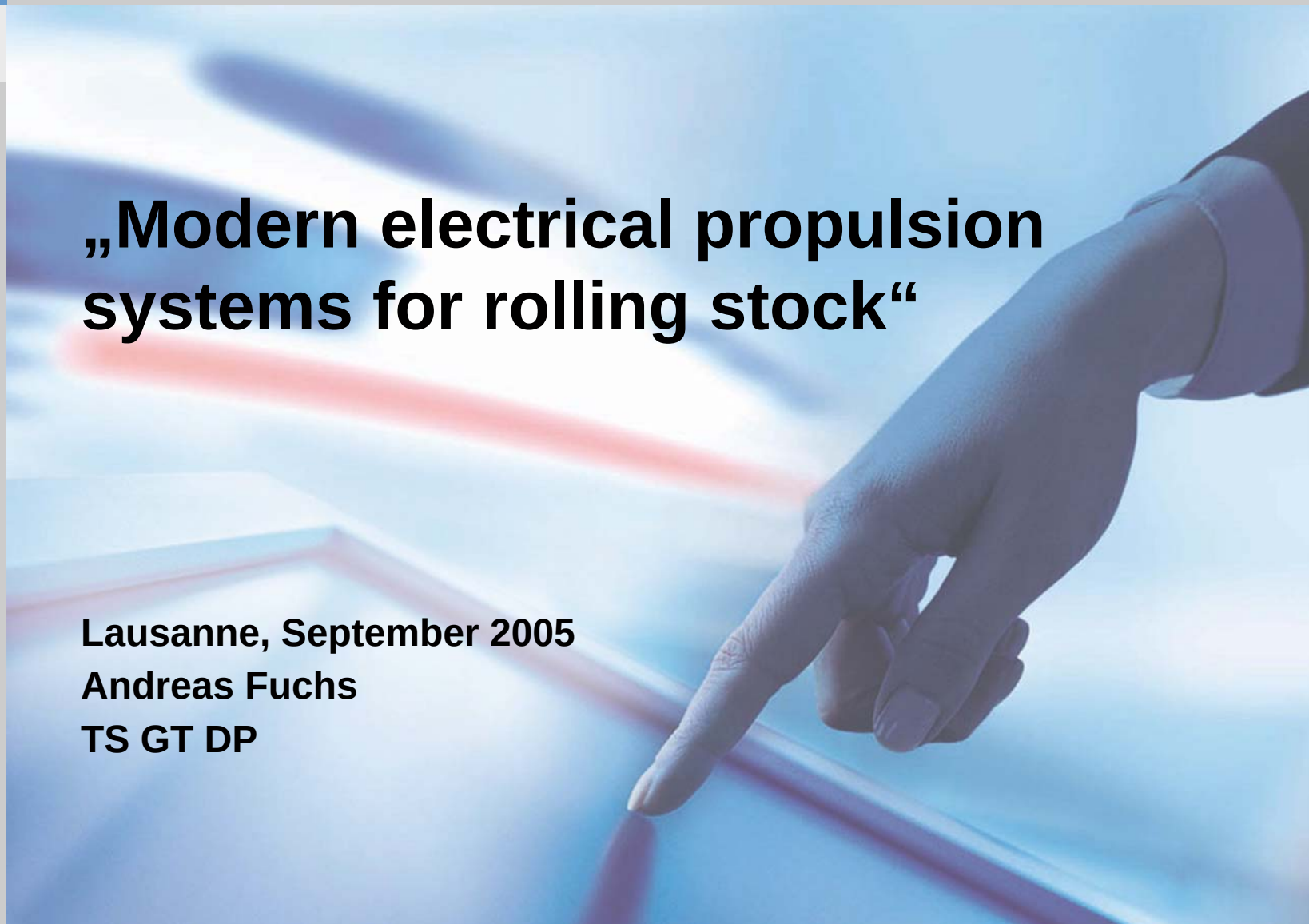
SIEMENS

Transportation Systems

Group Technology

„Modern electrical propulsion systems for rolling stock“



Lausanne, September 2005

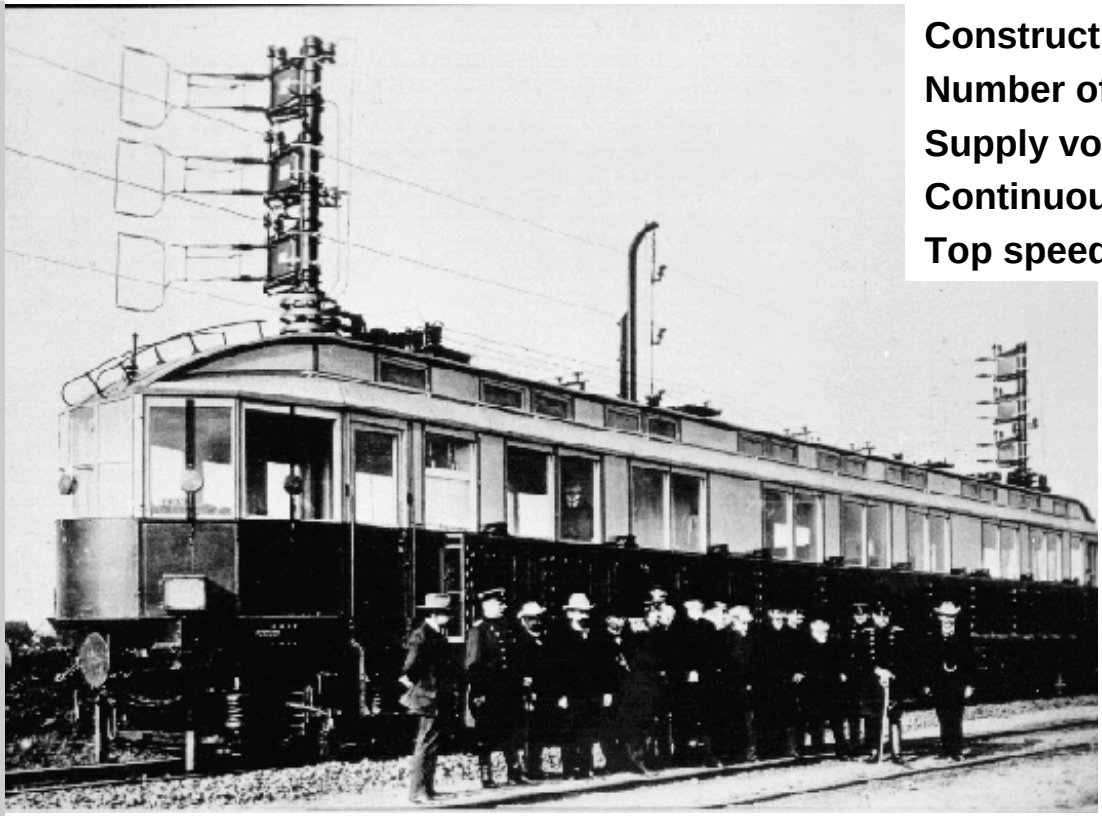
Andreas Fuchs

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
   - SITRAC® improved traction control system
   - Railway vehicles with IGBT-traction converters (examples)
5. Conclusion

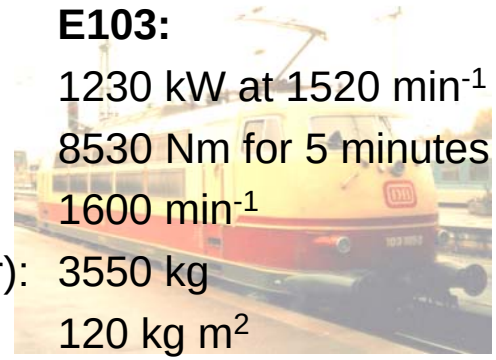
Motorcar Marienfelde-Zossen

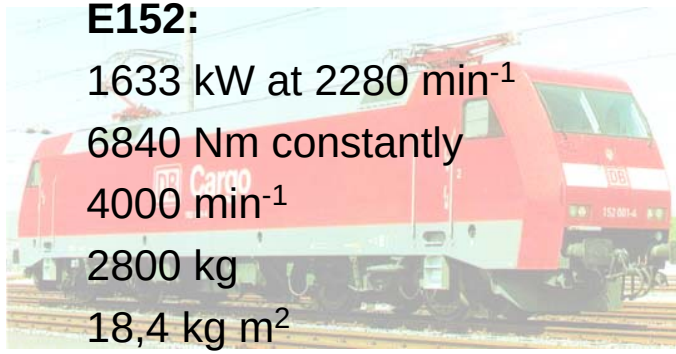


Construction year	1903
Number of units	1
Supply voltage	AC Three phase
Continuous power	2.2 MW
Top speed	210 km/h

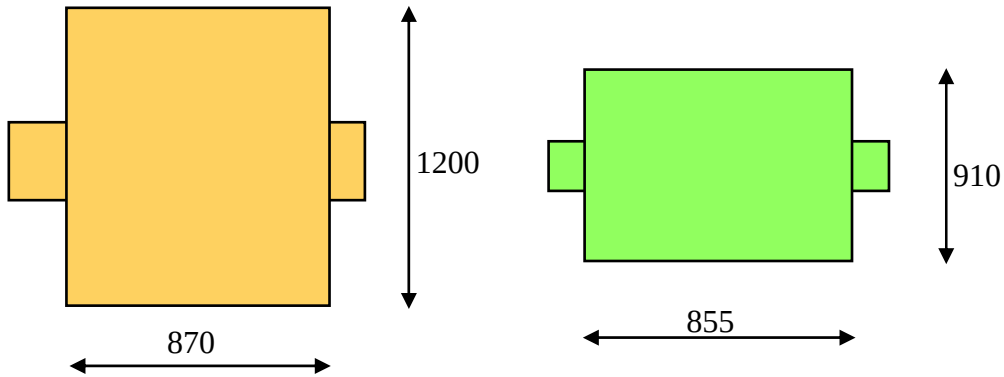
Comparison of DC- and AC-Traction Motor

Traction drive of:	**E103:**	**E152:**
rated power:	1230 kW at 1520 min^{-1}	1633 kW at 2280 min^{-1}
maximum torque:	8530 Nm for 5 minutes	6840 Nm constantly
maximum speed:	1600 min^{-1}	4000 min^{-1}
mass (without gear):	3550 kg	2800 kg
moment of inertia:	120 kg m^2	18,4 kg m^2

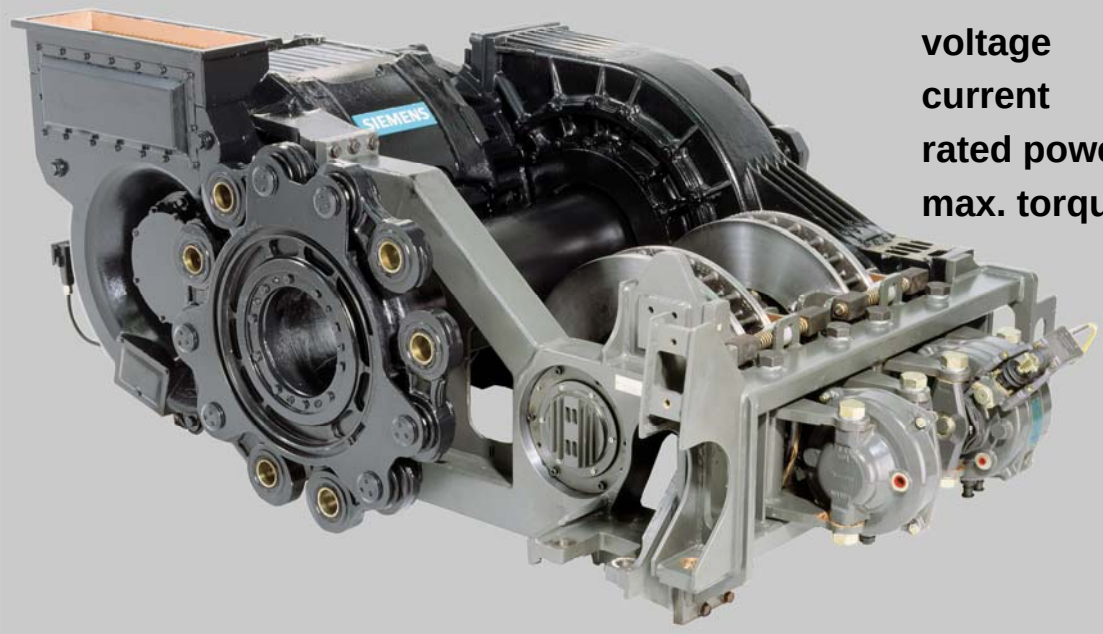




Dimensions:



High performance hollow shaft drive



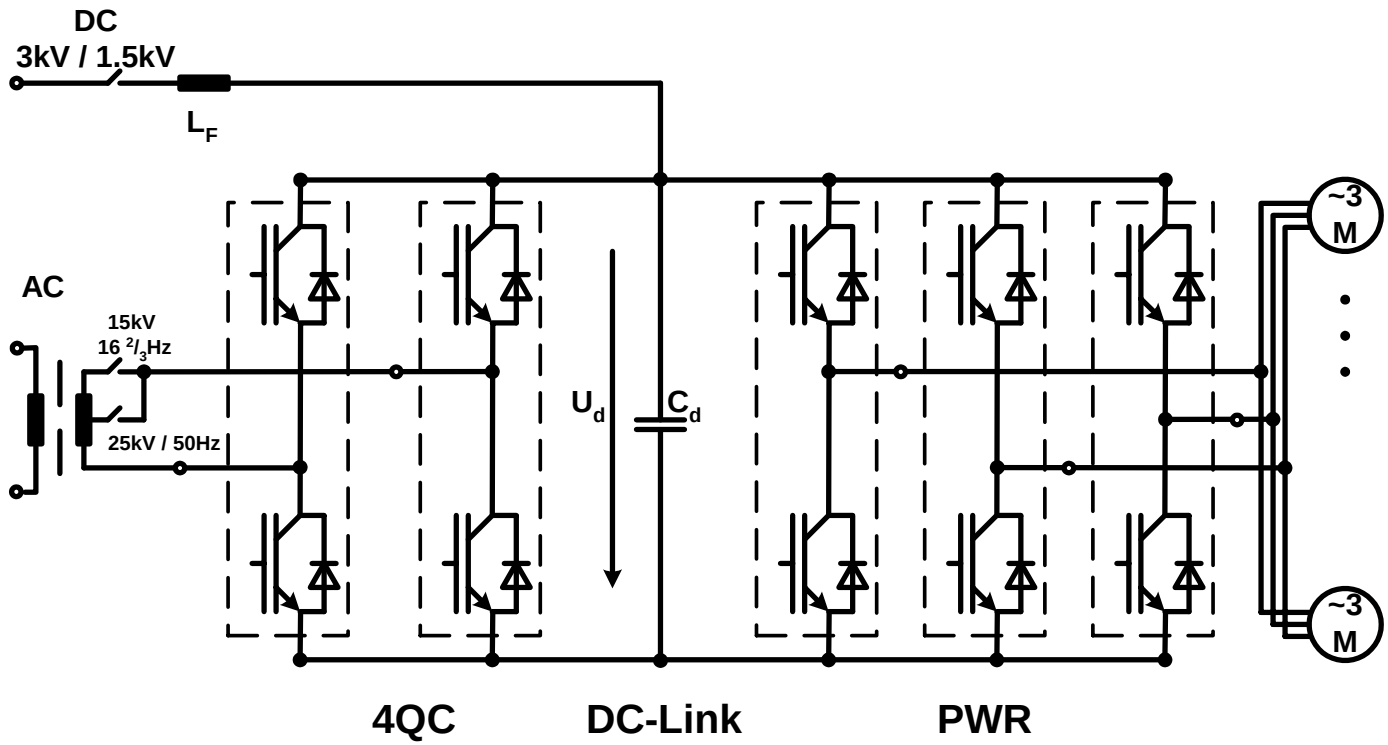
Motor 1TB2824

voltage	= 1840	V
current	= 590	A
rated power	= 1630	kW at 1485/min
max. torque	= 10500	Nm

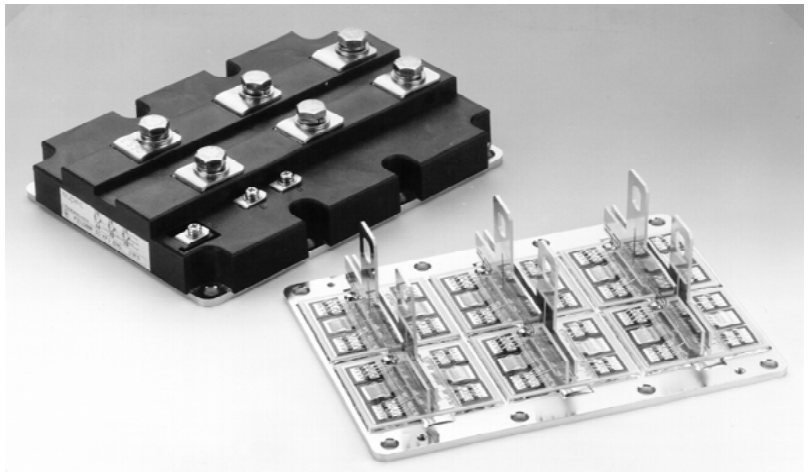
Traction converters have to work at various catenary voltages and have to cope with a wide output power range

Characteristic, Parameter	Typical range
• Catenary voltage	DC 750 V ... 3000 V AC 15 kV ... 25 kV
• Power of the propulsion system	0,5 ... 2.0 (3,5) MW
• Reliability	1000 Fit / IGBT + driver (1 Fit: 1 failure / 10^9 h)
• Failure behaviour	Restricted to converter module
• Mechanical construction	• Flat underfloor converter cubicle for EMU and Metro • Switchgear cubicle or locomotives

Chopperless multi system converter with 6,5 kV IGBTs



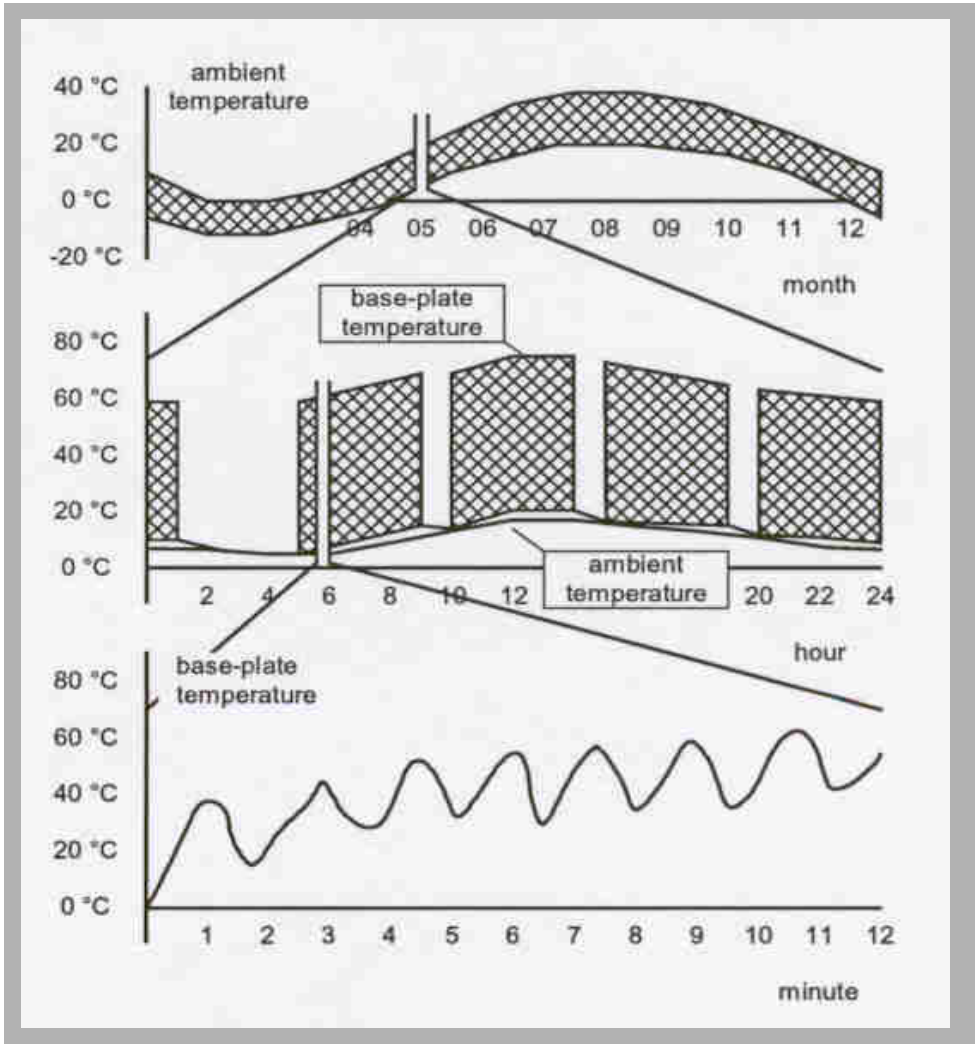
IGBTs with different blocking voltages are offered by several semiconductor suppliers in a housing with the same footprint



Module design of a
1.7 kV – 1200 A IGBT

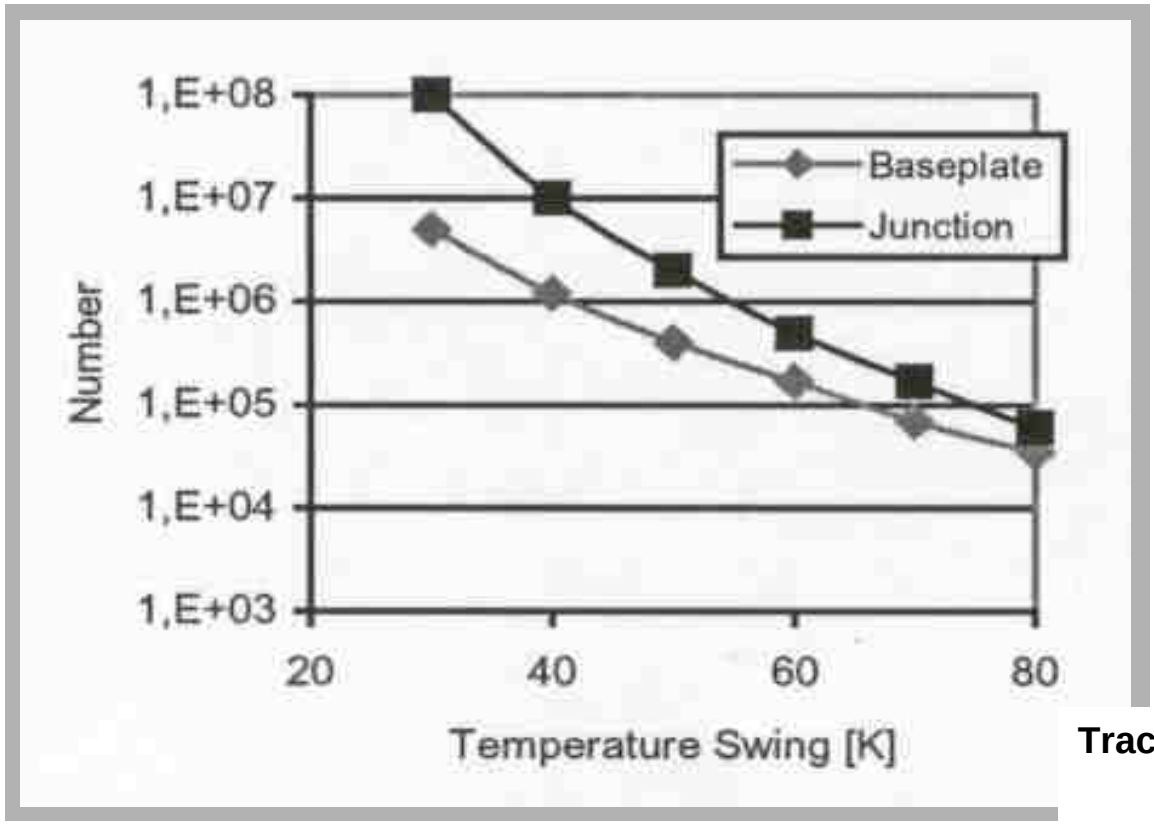
Module design of a
6.5 kV – 600 A IGBT

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)



Traction IGBT

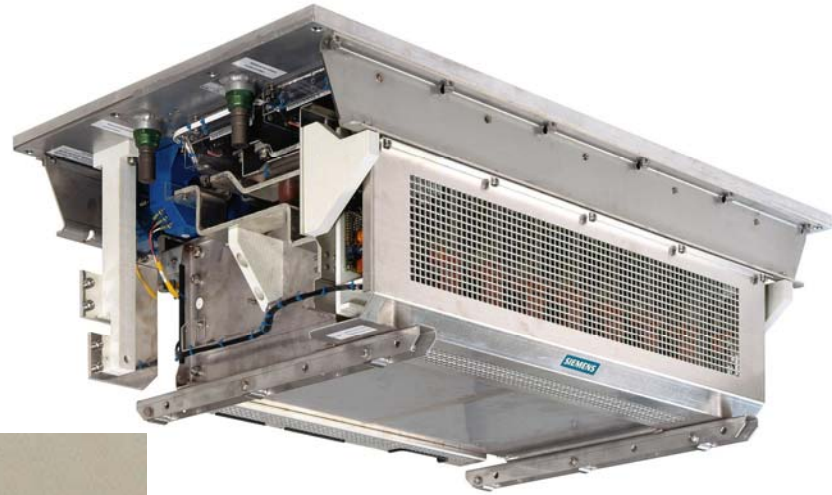
Introduced technologies:

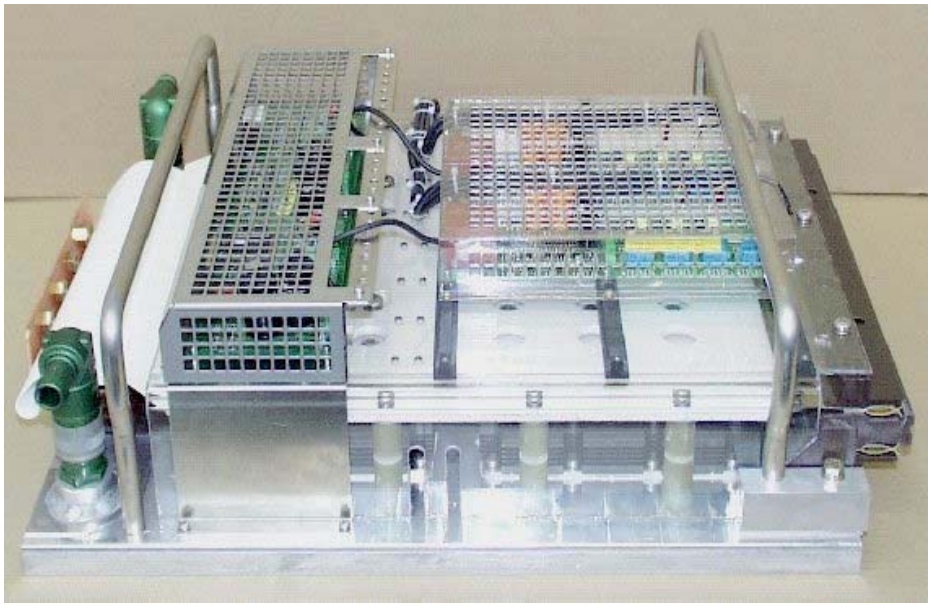
- **Al SiC-base plate**
- **Polyimid passiviation on the chip surface**

The traction converter family SIBAC®

Compact inverter

Up to 3 kV line voltage
Air cooled or water cooled

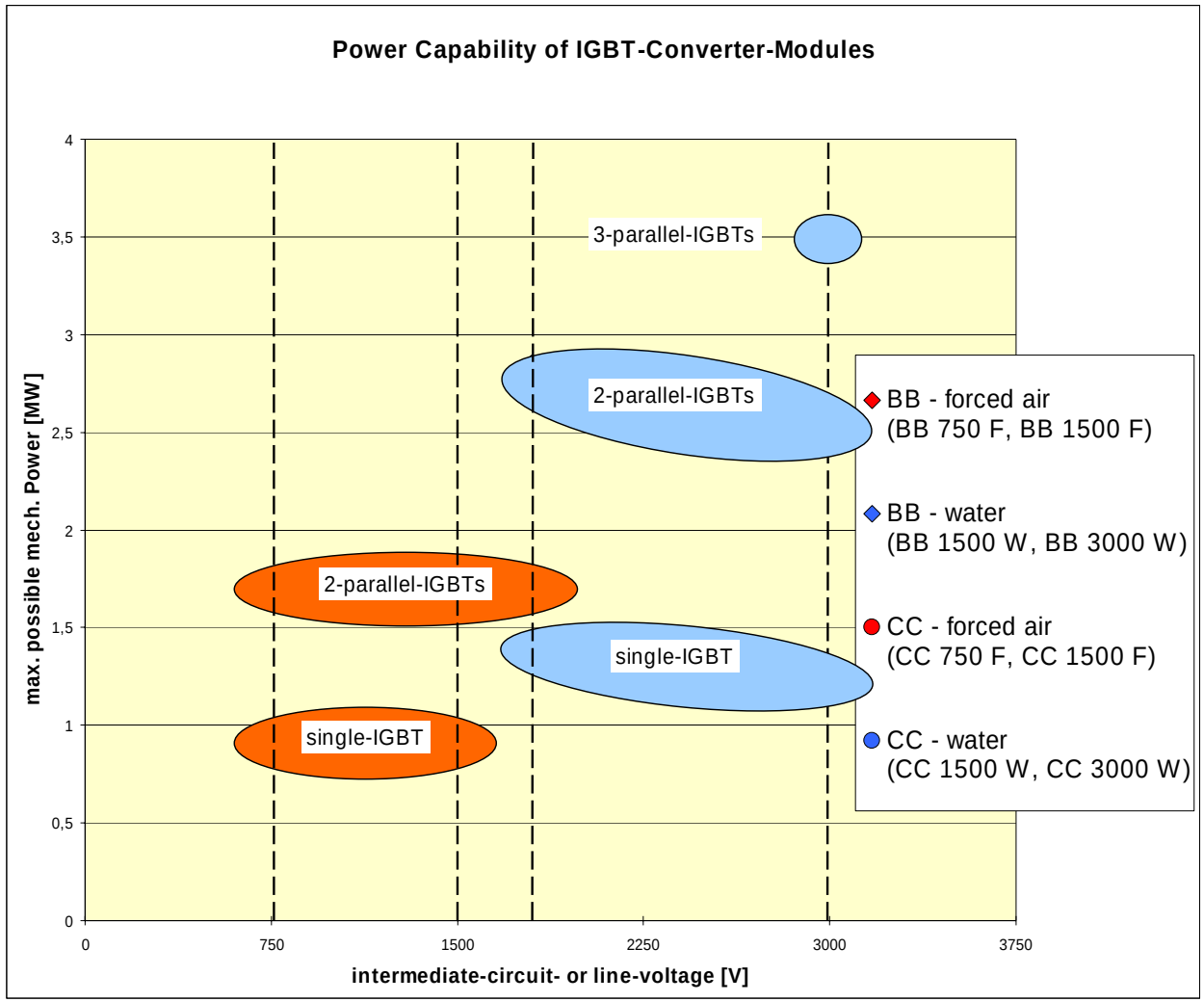




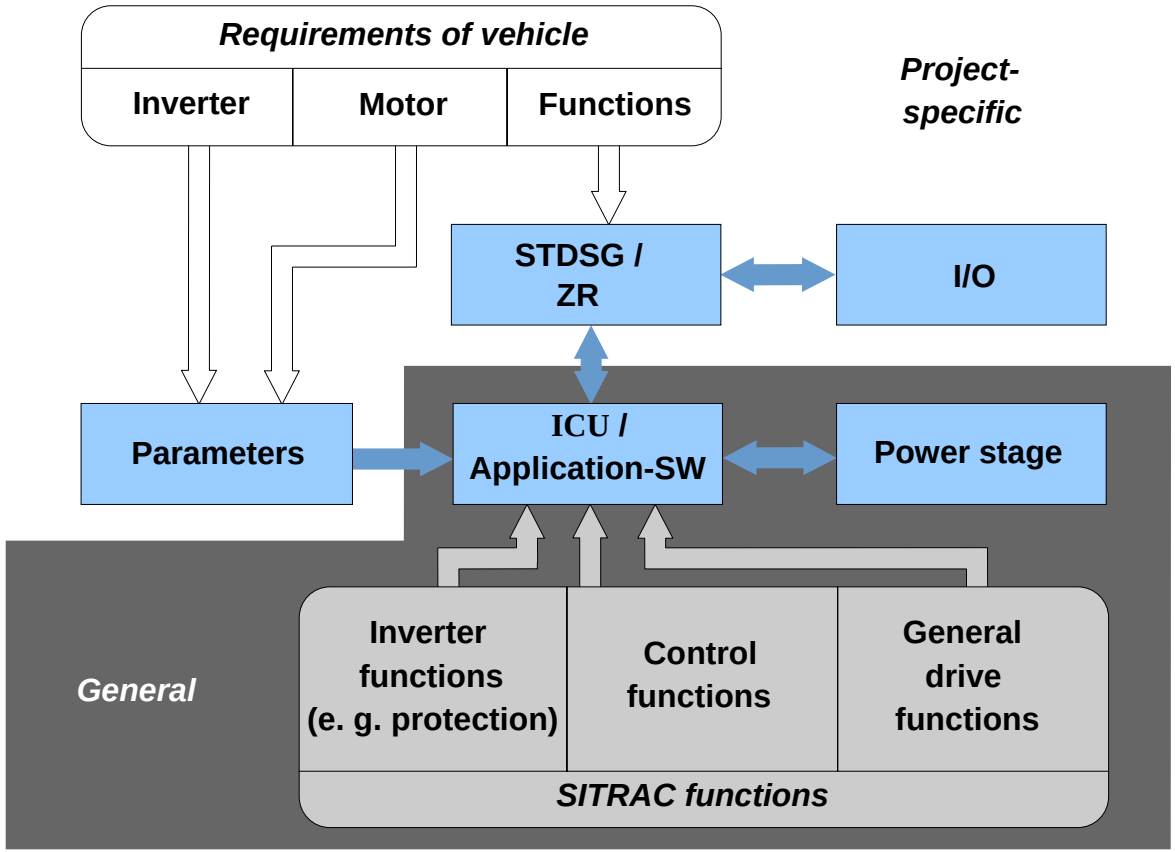
IGBT Building Block SIBAC® BB

Up to 3 kV line voltage
Air cooled or water cooled

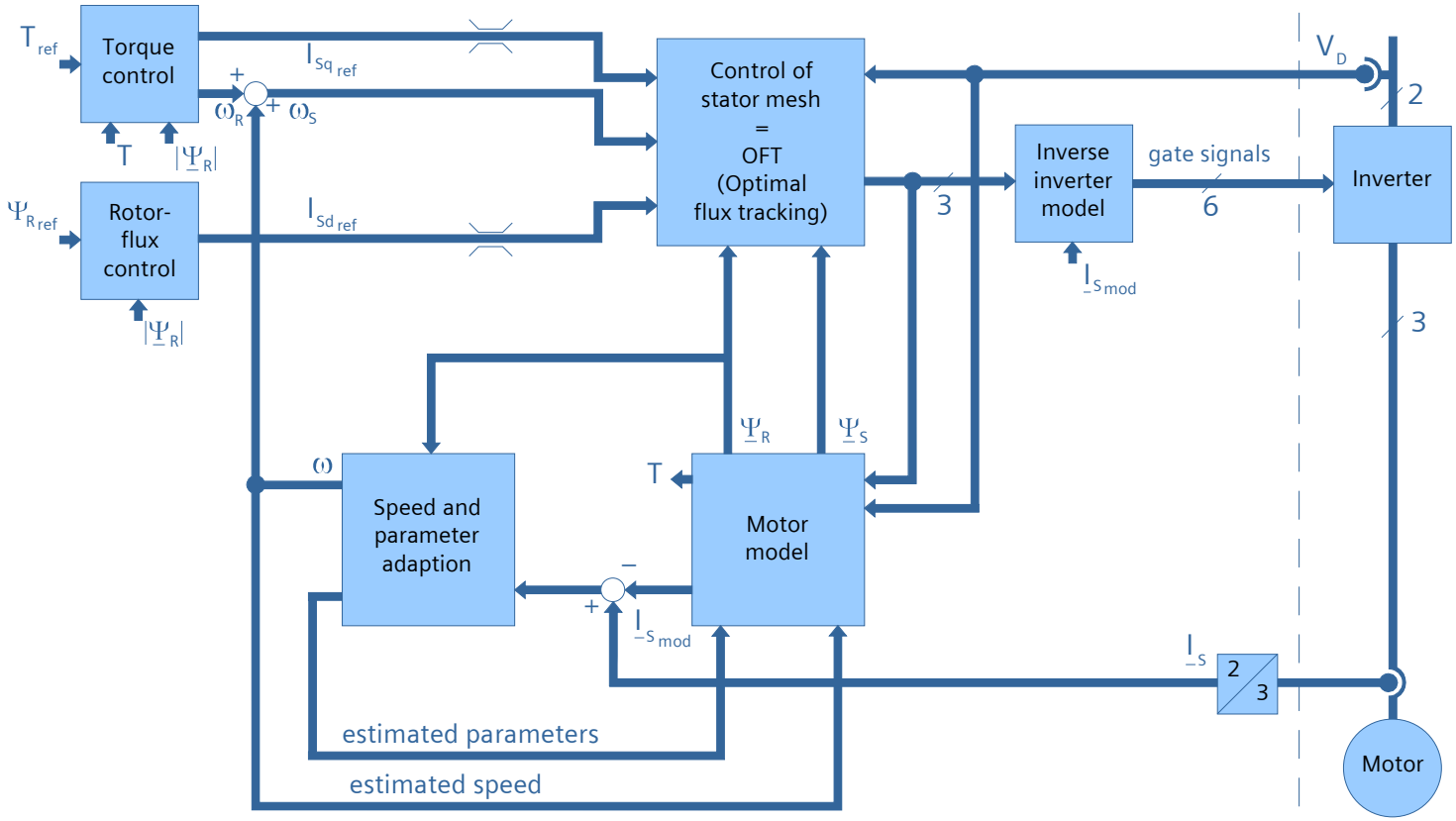
Typical output power limits of SIBAC® IGBT traction converters



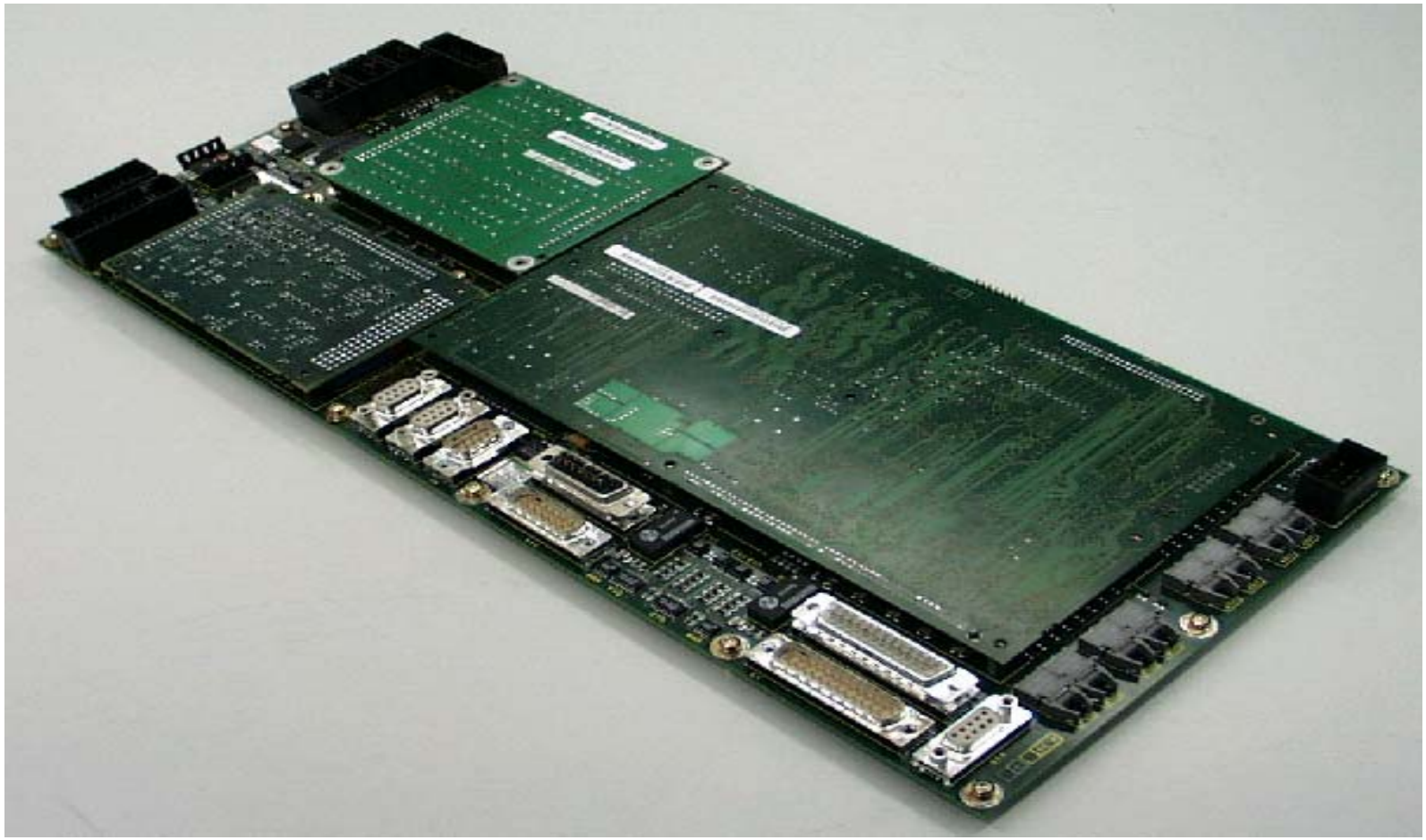
Overview SITRAC: Siemens Traction Control



SITRAC PWR block diagram of the control structure without speed encoder



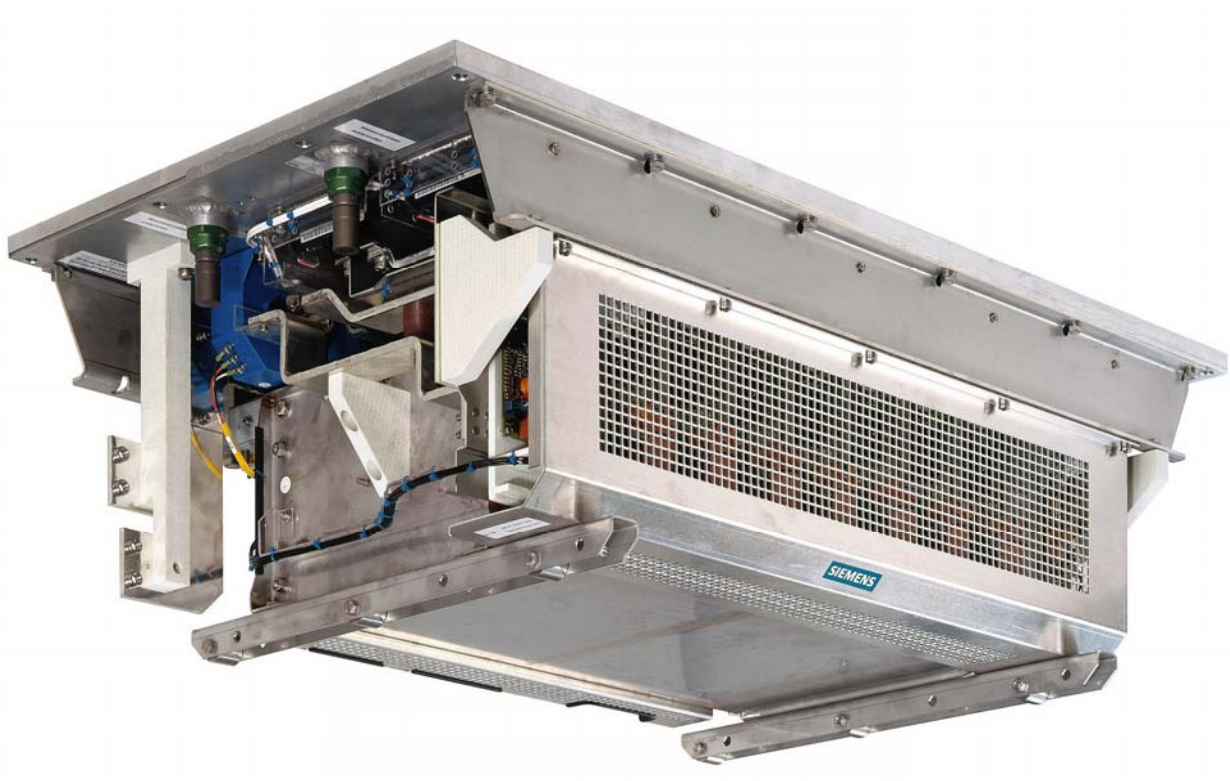
Sitrac – Hardware
Inverter control unit for the compact inverter



Electric Multiple Unit RENFE TREN 2000

Supply system:	**DC 3 kV**
Train configuration:	**2 ... 5 sections, 50 % ... 60 % driven axles**
Rated power:	**0.6 MW / converter, 1C2M**
Traction converter:	**IGBT compact converter CC 3000 W**

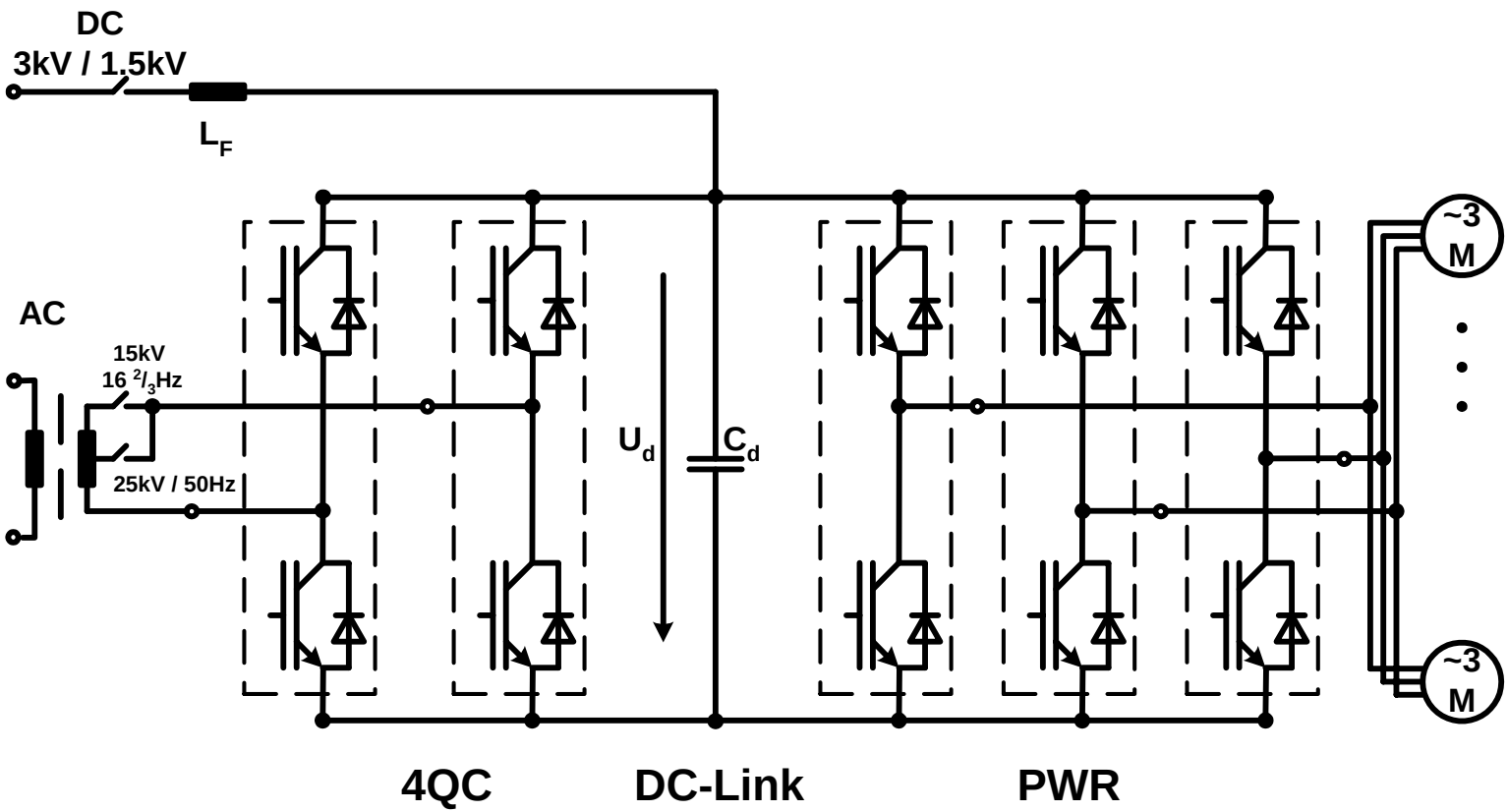
Electric Multiple Unit RENFE TREN 2000



Compact inverter SIBAC®

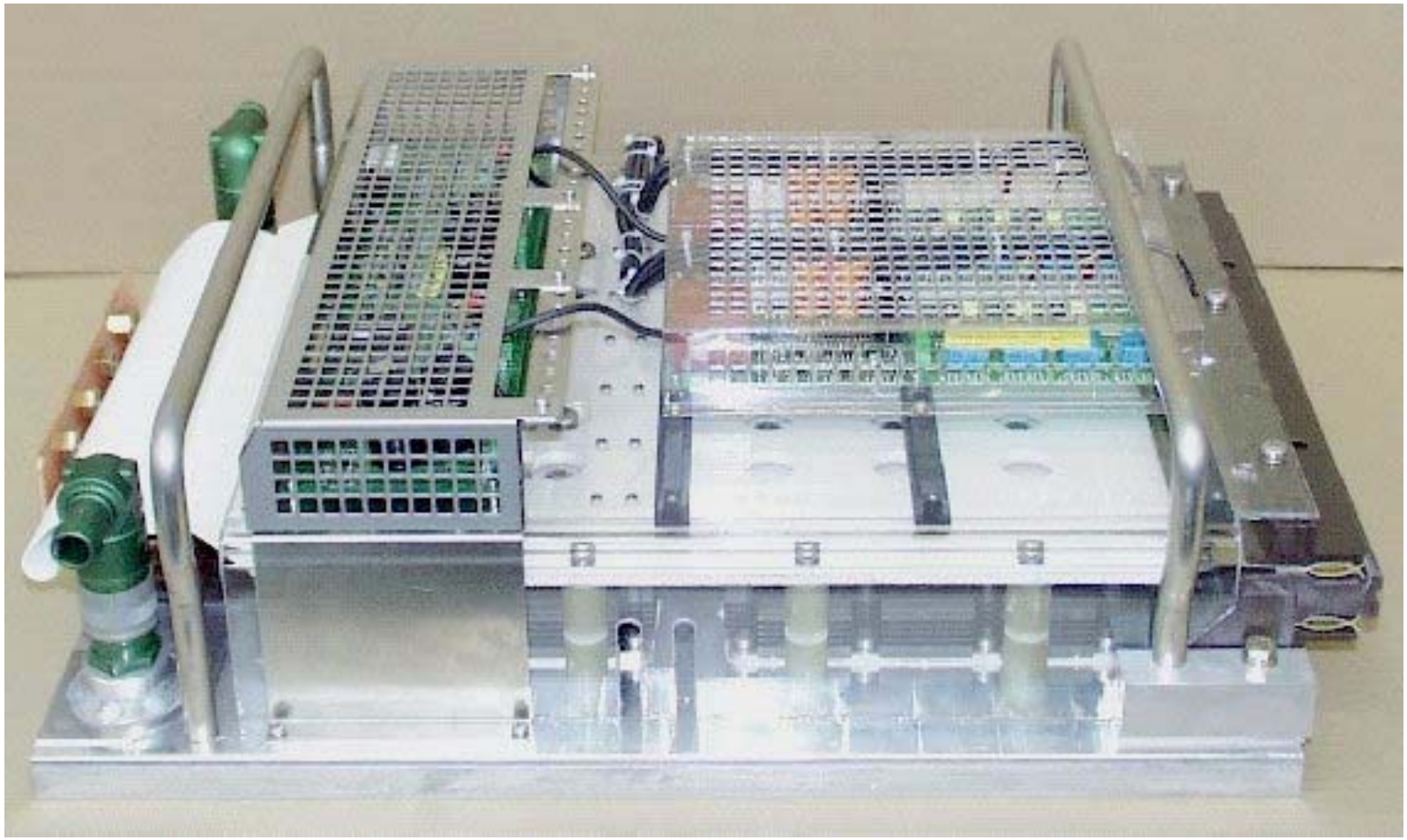
EuroSprinter Class 189 four-system locomotive for German Rail

Chopperless multi system converter with 6,5 kV IGBTs



EuroSprinter Class 189 four-system locomotive for German Rail

SIBAC® Building Block



EuroSprinter Class 189 four-system locomotive for German Rail

Traction converter of the class 189 locomotive