



Traction systems for locomotives and high-speed applications

Partnering with ABB

Major benefits

High flexibility and innovation to realize your project vision

Large global corporation and technology leader with a long-term strategic commitment to the rail industry

ABB as a pure traction chain and electrical partner for train builders and operators

Competent local service and support wherever your project is

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ABB – your partner of choice

Unrivalled flexibility

Large series of trains and locomotives fitted with ABB traction equipment are in reliable and economic operation every day and in every climate.

ABB is the expert for traction converters, motors, transformers, and complete traction chain solutions. In deep and trustful partnerships with vehicle builders, refurbishers, and rail operators, we supply state-of-the-art traction systems. Among traction specialists, ABB excels with the broadest traction portfolio and engineering capabilities for tailor-made solutions.

We combine decades of rail experience and a world-leading position in areas such as traction transformers with a wealth of cross-industry know-how in power electronics, motion control and project management. ABB is not only the leader in industrial drives, but also the most innovative supplier of power semiconductors.

The following pages offer many ideas of how ABB could contribute to your next locomotive and high-speed project. We hope to inspire you as to what is possible today in the areas of power management and energy efficiency, hybrid and multi-system technology, compactness and energy-density, reliability and robustness, control and adaptability.

One of the greatest strengths of ABB is our flexibility to create real value-adding innovations. Given a sound business opportunity, ABB is ready to quickly embark with you on a partnership for game-changing new solutions.

“We care for every detail, because we know the impact on the lifetime of the traction system.”

Complete product portfolio

ABB traction solutions

BORDLINE® traction converters and ABB traction solutions stand for comprehensive, flexible solutions with high performance and rewarding cost and energy savings over the life cycle.

Traction chain partner

As a major supplier of traction systems, ABB works with most of the leading rolling stock manufacturers. We also support transport operators throughout the whole life cycle of the traction chain, i.e. in the areas of service, maintenance, upgrades, and retrofit projects.

Benefits of comprehensive traction chain responsibility

- Single partner for the entire traction chain
- Optimization of component dimensions and interfaces
- Fast commissioning and homologation
- TCMS integration and system optimization
- Higher total energy efficiency and reduced life cycle cost

ABB traction solutions for all rail applications

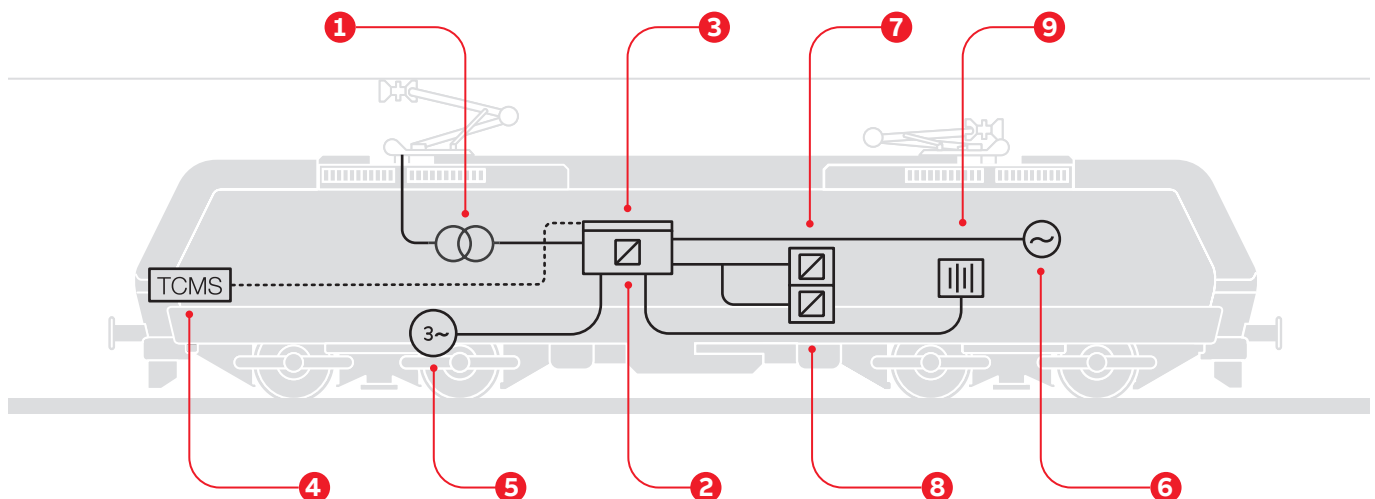
Complete portfolio of traction chain solutions from a few 100 kW to more than 7 MW and for all types of locomotives (e.g. passenger, freight, shunting), power heads, and distributed propulsion systems.

Global presence

ABB is present in more than 100 countries and can provide strong local support to your project. With a truly global organization, we are committed to local competence and local service.

Electric			Hybrid			Diesel-Electric
AC	DC	MS	DE/AC	DE/DC	DE/MS	
✓	✓	✓	✓	✓	✓	✓

Overview of ABB's traction offerings



01 Traction transformer
02 Traction converter
03 Traction control

04 Train Control and Monitoring System
05 Traction motor
06 Diesel engine generator

07 Auxiliary converter
08 Battery charger
09 Energy storage

Proven traction components

Transformers, motors, generators

ABB traction transformers

- World market leader with unrivaled experience
- Minimum line harmonics and optimum total efficiency of the traction system
- State-of-the-art production technology as well as design and simulation software
- Tailor-made configurations for under-floor or machine-room installation
- Highly flexible design for compactness and optimized winding topology, being critical for multi-system (MS) vehicles to respect vehicle weight/axle restrictions

ABB traction motors

- Frameless induction traction motors designed to ensure reliable operation and high torque output
- Fully customizable motor concept to meet a broad range of requirements regarding e.g. output power, mounting arrangements and air duct position
- Broad design skills and experience to achieve a carefully calculated optimum solution for each application, whether tailor-made or based on a standard design

ABB traction generators

- Synchronous brushless generators designed for high-powered diesel-electric locomotives
- Single bearing design for two couplings to be combined with the diesel engine crankshaft decreasing the size and weight of the gensets
- ABB UNITROL 1020 automatic voltage regulator generator, designed for reliable excitation control in traction applications
- Complete family of induction (asynchronous) generators suitable for medium power range applications
- Main advantages: simple, compact and reliable design

Examples of ABB traction components



Traction transformer LOT 1100
1.5 MW for 16 2/3 Hz high-speed double-deck trains



Traction transformer LOT 6500/6700
4.5 MW for 50 Hz AC locomotives



Traction transformer
4.8 MW for 16 2/3 Hz and 5.2 MW for 50 Hz high-speed trains



Traction motor
1.2 MW for cargo locomotives



Traction motor
600 kW for high power applications



Traction generator
2.65 MW for high power applications

Proven traction components

BORDLINE® CC – Compact Converters

ABB traction converters

- BORDLINE® CC Compact Converters: the heart and the brain of the traction system
- Two-level and three-level topologies for optimal energy efficiency, economic retrofit, and fast homologation
- Integrated auxiliary converters, battery chargers, and head-end power (HEP) converters fed from the DC link
- Large portfolio of optimized durable housing solutions: from lightweight all-aluminum machine room cabinets to stainless steel underframe constructions
- Most compact and economic multi-system converters
- Tailor-made configurations for under-floor or machine-room installation
- Environmentally friendly and highly efficient water cooling
- Easy handling of low weight replacable power electronic modules

Examples of ABB traction components



Compact Converter
2.3 MW for electric locomotives



Compact Converter
3 MW for electric locomotives



Compact Converter
1.6 MW for electric multi-system high-speed trains



Compact Converter
1.8 MW for diesel-electric locomotives

Proven traction components

BORDLINE® M – Auxiliary converters

Auxiliary converters and battery chargers

- Complete portfolio of auxiliary converters, converting power from 2 kW up to 1.2 MW, ranging from converters for individual loads or batteries, to full onboard power supply for a train
- BORDLINE® M: all **stand-alone** auxiliary converter types, battery chargers and head end power (HEP) converters
- BORDLINE® CC: Compact Converters for the traction chain with **integrated** auxiliary converters (and battery chargers) connected to the DC link



Auxiliary converter
210 kVA



Battery charger
10 kW



Auxiliary converter
130/260 kVA



Head end power converter
1200 kW

Powerful converter modules

Full flexibility for customized solutions

High-performance control module

- Key advantage of ABB traction solutions: the AC 800PEC control platform, probably the most powerful modular controller for high-speed performance on the market
- AC 800PEC control platform also used in ABB wind converters, high-power industrial drives, plant automation, high-power rectifiers and many other applications
- High volume and wide application diversity → high reliability
- Excellent range of control and communication functionality in cycle times extending from the sub-microsecond to the millisecond level
- Fast reaction times crucial to protect the traction system
- Complemented by a variety of input/output modules as well as engineering and service tools
- Tested under the most stringent environmental conditions
- Admired for the workmanship of the control wiring

Robust, reliable, service-friendly power modules

- All BORDLINE® converters, offered in a multitude of configurations and designs, are built on a platform of a few optimized PEBBs (Power Electronic Building Blocks) with 1.7 kV, 3.3 kV, 4.5 kV, and 6.5 kV IGBTs (Insulated Gate Bipolar Transistor)
- High production quantity of standardized PEBBs:
 - Excellent reliability and field experience
 - Technical optimization (lifetime, switching behavior, power density)
 - Multiple sources for all PEBB components
 - High spare part availability at reasonable cost
- PEBBs also optimized for service aspects: easy to handle (small and lightweight) and to exchange
- Liquid-cooled PEBBs for high power converters (highest compactness and long lifetime)
- Air-cooled PEBBs for many types of auxiliary converters



Three-level power module



Two-level power module

Cutting-edge control technology

High-performance control software

State-of-the-art adhesion control

- Key for the quantitative performance of the locomotive or the train and for reducing maintenance cost due to less mechanical wear
- Superior determination of actual vehicle speed and perfect wheel-slip/slide control for all types of driven axle configurations (single axle or bogie control)
- Exceptional adhesion performance, see references on page 12 and 14

Reduced mechanical wear of the vehicle

- Reduced wear of motors, gears, wheels, and the bogies
- Minimization of harmonics in the motor current for all speed-torque regimes
- Reduced vibrational oscillations
- Suppression of torsional oscillations of the driven axles in a bogie

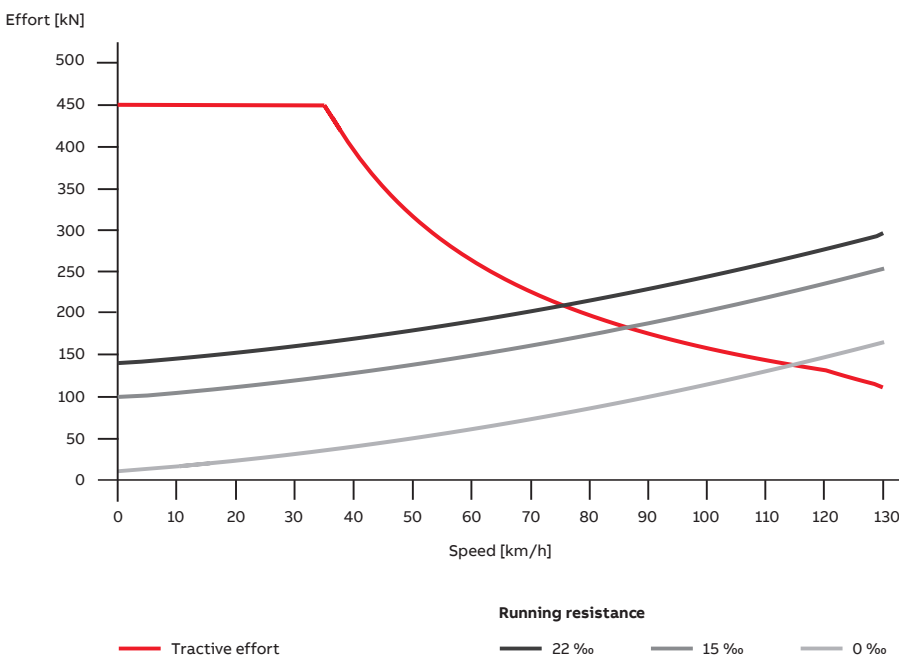
Optimized line voltage impact

- Minimization of line harmonics
- Faster homologation
- Stabilization of the line voltage by active damping under weak line conditions, resulting in higher availability of vehicles with ABB traction

Examples of other innovative ABB software functions

- Various system control functions for reducing energy consumption in cooling, auxiliaries, and diesel engines
- Converter emergency operation mode to clear track even when TCMS is fault
- De-icing function for the catenary
- Integration of energy storage control

Traction diagram



Cutting-edge control technology

Excellence in software development

Control code consistency and traceability

- Simple, transparent and intuitive code, programmed in a modular and visual function block language
- Used consistently from the design phase through to detailed implementation, in real-time simulation tests and finally during fine-tuning under commissioning and homologation
- Perfect traceability of requirements and specifications to the operative version of the traction system software

Speeding up of commissioning and homologation

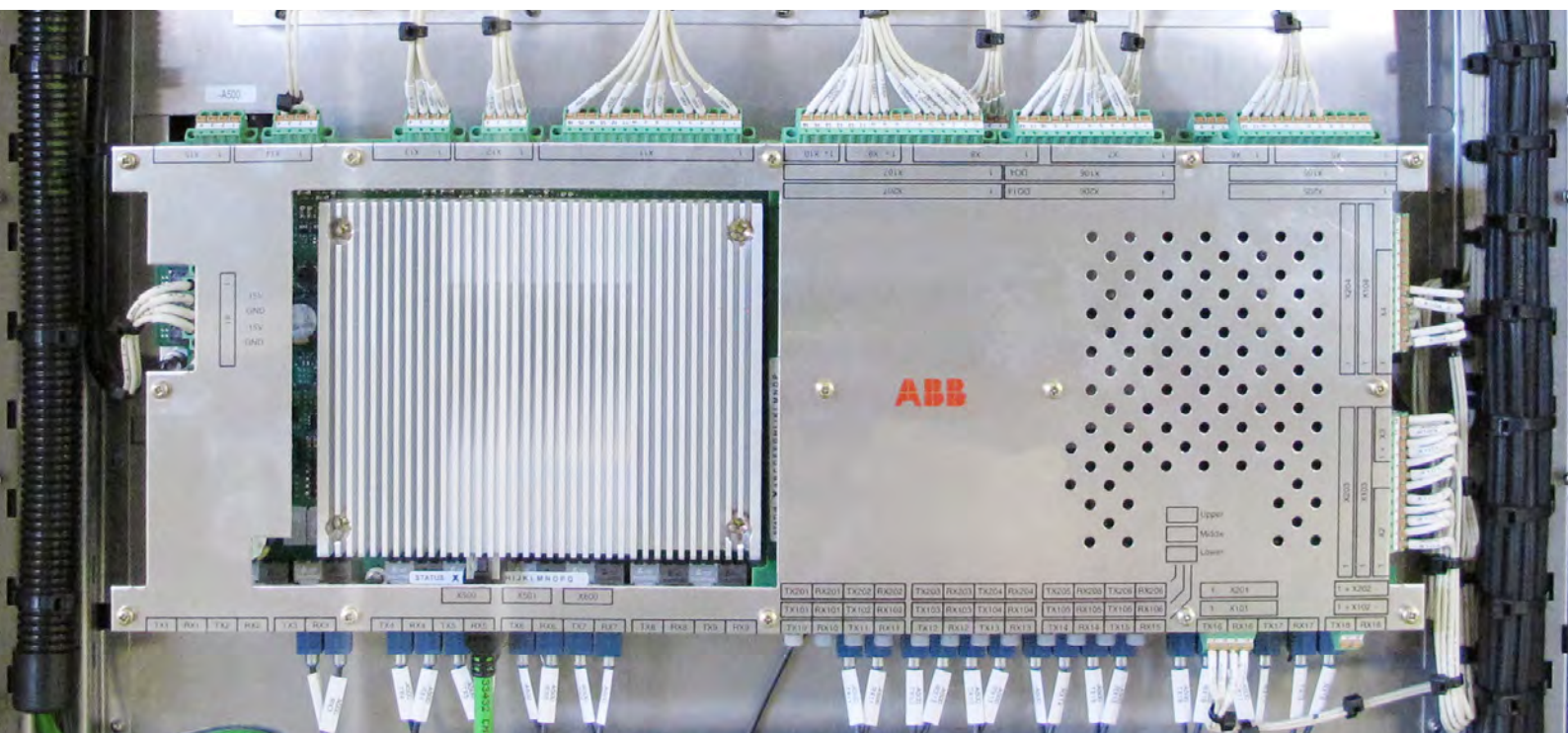
- Fast commissioning and homologation due to:
 - Quality and transparency of the software development
 - Simple adjustment of parameters during commissioning and homologation
 - Minimization of line harmonics
 - Rigorous and automated testing of the control software in a real-time simulation environment
- Reduced lead time between commissioning and first roll-out
- Faster project delivery and substantial cost savings as a result of shortened vehicle commissioning and homologation

Safe testing of non-standard operational modes

- Real-time simulator extending the software validation to situations inaccessible on the test track (e.g. speed limitations, very unlikely system failures)
- Faster project delivery

Flexible adaptation of the control software

- Control software change requests facilitated by leading-edge software development environment
- Sustainable quality of traction system control over the lifetime of the vehicle



Retrofit and modernizations

Cooperation with operators

Interesting business cases for retrofit

- Need to replace converters or other traction chain components while the major part of the locomotive or high-speed train are fit for another 20 years of operation:
 - Availability and cost of spare parts
 - Unsatisfactory reliability and performance
- Additional benefits ('mid life crisis as a chance'):
 - Energy savings
 - Easy maintenance concepts
 - Lifetime extension for retained components, e.g. motors
 - Reduced heat and noise generation
 - Higher compactness and lower weight of new traction chain components
 - Optional change of fleet mission, e.g. hybrid or multi-system operation, higher speed or tractive effort, higher on-board power
- Return on investment scales with the size of the modernized fleet

ABB support for assessment

- Which traction chain components to keep, to upgrade or to replace
- Performance potential of the complete traction chain for new duty profiles
- RAMS (reliability, availability, maintainability, safety) potential

Demanding tailor-made engineering

- Traction chain retrofit engineering for an existing vehicle by far more challenging than for new designs
- ABB with a wealth of experience in engineering and project management

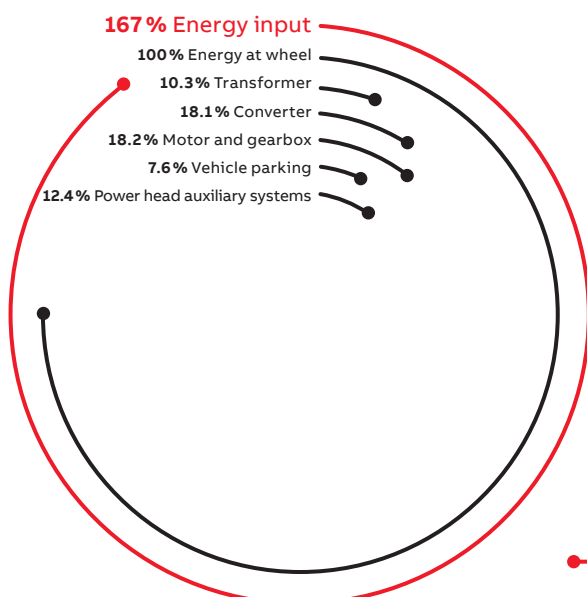
Deep partnership with the customer

- Flexible to utilize the customer's workshop capacities for the retrofit project
- Training and empowerment of the customer's operations and maintenance staff

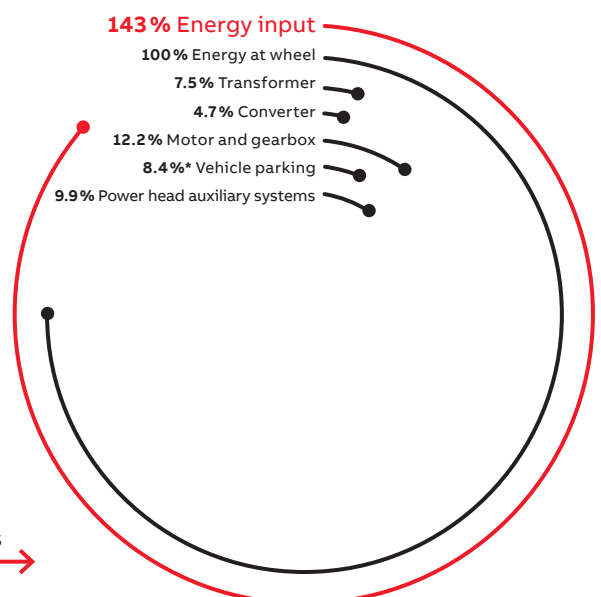


Project example for energy savings through retrofit

Old traction chain



New traction chain



15% lower losses →

*Higher percentage value due to reduced total losses

Service and support

New era of industry partnership

Empowering the customer

- Pragmatic maintenance concept for efficient adoption of on-site maintenance by customer's service personnel:
 - Customized trainings
 - Strong diagnostic tools
 - Modular repair
 - Commissioning support
 - Product maintenance
 - Upgrades
- Commitment to customer support with flexible ABB service contracts spanning multi-year periods:
 - Clever spare part logistics
 - Repairs, on-site service
 - Field operating statistics and analysis
 - Support line and expert support
- The BORDLINE® Service philosophy:
 - Deep partnership with the customer's service organization, providing focused services in areas of the industrial partner's expertise
 - Smooth commissioning and early operation phase
 - Guaranteeing high converter availability after the warranty period and through the entire life cycle

Reinventing spare parts logistics

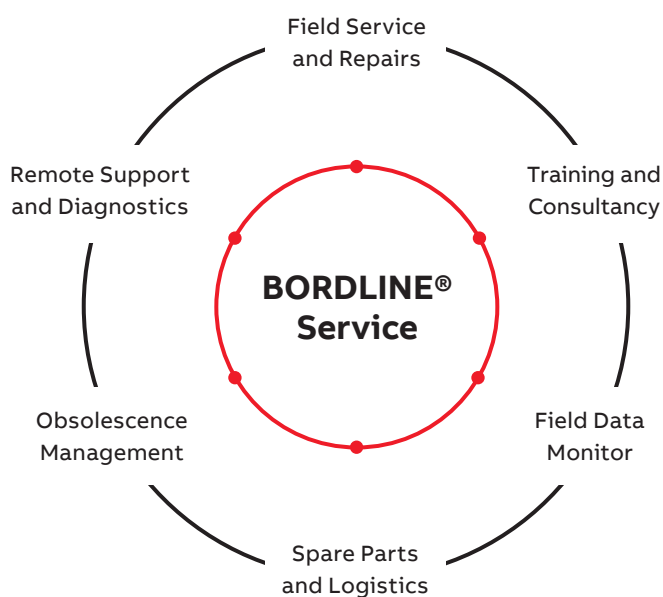
- No more stocking of obsolete spare parts, no more waiting for spares
- BORDLINE® Service concept: The right spare parts – at the right site – at the required time
- Containerized consignment stocks with automatic replenishment, optimized to suit the fleet requirements

Service program for motors, generators, and transformers

- Please refer to service brochures TransForLife Solutions™ and motor/generator service

Unique service network

- Global network of skilled experts and service sites for converters, motors, generators, and transformers



INDIAN RAILWAYS | CLASS WAG 9/WAP 7/WAP 5

New IGBT converters for electric locomotives

BORDLINE® CC1500 AC, LOT 6500/6700, BORDLINE® M130/260 AC

Customer need

- Replacement of GTO (Gate Turn-Off thyristor) converters without any modification to mechanical loco design, interfaces, control, transformer, and traction motor
- Conversion from bogie control to single axle control
- Design suitable for old as well as new locomotives
- Resistant to high temperatures
- Service-friendly solution

ABB solution

- Design of new tailor-made IGBT-based (Insulated Gate Bipolar Transistor) converters
- High energy efficiency by reducing losses in the transformer and motors
- New generation adhesion control embedded in converter control
- Conversion from bogie control to single axle control



Customer benefits

- IGBT converters fully interchangeable with GTO converter series
- Significantly improved tractive effort under all conditions
- Haulage increased by 9 per cent to 5'500 tons
- Better energy-efficiency and less heat generation
- Higher availability in case of motor failure due to axle control
- Easy maintenance and reduction of operating cost

DIRECT RAIL SERVICES (DRS) | EUROLIGHT

Traction package for Diesel-electric locomotives

BORDLINE® CC1500 DE, traction motor, traction generator

Customer need

- Reliable traction chain partner
- Minimum weight of traction chain for diesel-electric propulsion

ABB solution

- Optimized system of generator, compact converters, and traction motors
- New traction chain platform, configurable for Bo-Bo locomotive with head end power/Co-Co locomotive



Customer benefits

- High adhesion coefficient utilization reducing sand consumption and mechanical wear significantly
- The EUROLIGHT is currently the only diesel-electric locomotive available on the market that combines a low axle-load (< 20 t) with a high power rating, resulting in high operational flexibility and low operating cost

HAVELLÄNDISCHE EISENBAHN (HVLE) | EURODUAL

Versatile traction chain for dual-mode locomotive platform

BORDLINE® CC1500 MS, traction transformer, auxiliary converter, traction motor

Customer need

- High tractive effort for heavy-haul freight operation
- High power electric and high power diesel propulsion
- Highly compact traction chain solution

ABB solution

- Traction system solution for 15kVac and 25 kVac electric lines and diesel operation
- Optimized system of traction transformer, traction converters and motors
- All traction components are engineered for optimum overall performance



Customer benefits

- High tractive effort and high power locomotive
- Compact and lightweight solution to stay within axle load limits
- Versatile traction platform for dual-mode locomotive platform for all standard line voltages and multi-system solutions
- High energy efficiency

DEUTSCHE BAHN (DB) | ICE 1 (CLASS 401)

Traction converter replacement for high-speed trains

BORDLINE® CC1500 AC

Customer need

- Replacement of old thyristor converters without any modification to mechanical power head design, interfaces, control, transformer, and traction motors
- Significant increase in energy efficiency and availability

ABB solution

- Development and production of new IGBT-based propulsion converter for 4.8 MW power head within 13 months
- Innovative three-level converter technology
- Service concept for easy maintenance
- Reliable delivery of one power head retrofit kit per week



Customer benefits

- Reliable partnership for quick refurbishment of 38 power heads in the workshop of DB
- Energy consumption cut by at least 15 per cent
- Massive reduction in operating cost
- Massive gain in reliability and availability

SWISS FEDERAL RAILWAYS (SBB) | EEM 923

Traction package for hybrid locomotives

BORDLINE® CC750 MS, traction transformer

Customer need

- Hybrid system: 11/15/25 kV_{AC} and diesel-electric for 'last mile' operation
- High energy-efficiency

ABB solution

- Very compact and lightweight tailor-made traction transformer and two independent traction converters
- Superb adhesion control system
- Low noise emission



Customer benefits

- CO₂ emissions will be reduced by more than 4'000 tons per year with a first order of 30 shunters for SBB Cargo
- Significant reduction of operating costs

MRS LOGÍSTICA | HE 4/4

Traction converters for most powerful rack and adhesion locomotives

BORDLINE® CC750 DC

Customer need

- High-power $3kV_{DC}$ traction equipment controlling individually six motors
- 5 MW locomotive power
- Recuperation at full load (downhill)
- Easy maintenance

ABB solution

- Highly redundant traction system (six converters per locomotive)
- Well proven three-level medium voltage technology



Customer benefits

- Massive energy savings due to energy recuperation capability
- 780 kN tractive effort on ramps up to 104 ‰
- Remote diagnosis system for easier service

SWISS FEDERAL RAILWAYS (SBB) | EC250

Traction package for low-floor electric high-speed trains

BORDLINE® CC1500 MS, LOT 3000, BORDLINE® BC

Customer need

- Traction solution for diverse market requirements (multi-system)
- Compact solution for low-floor train with maximum seating capacity
- High energy efficiency

ABB solution

- Multi-system traction concept for various supply systems: 25 kVac, 15 kVac, 3 kVdc, 1.5 kVdc
- Compact low-floor traction converter and traction transformer
- Traction converter with a height of only 400 mm
- Power circuit of ABB three-level technology
- Compact battery charger built with silicon carbide (SiC) power semiconductors



Customer benefits

- High energy efficiency and availability
- Maximum space and comfort for passengers

SWISS FEDERAL RAILWAYS (SBB) | RE 460

Traction converter replacement for electric locomotives

BORDLINE® CC1500 AC

Customer need

- Replacement of GTO converters
- State-of-the-art IGBT technical solution
- Improved reliability and availability for next 25 years

ABB solution

- IGBT based 3-level propulsion converter
- Improved energy efficiency
- Existing transformer and motors retained
- Compatible with legacy vehicle control unit



Customer benefits

- Significantly lower energy consumption
- Easy maintenance
- Lower total cost of ownership

STK, LOTOS KOLEJ, FREIGHTLINER | E6ACT DRAGON

Powerful traction package for electric freight locomotives

BORDLINE® CC1500 DC, auxiliary filter package, traction motor

Customer need

- High power traction equipment for 3kV DC locomotive
- Single axle control
- Configurable for six-axle and four-axle variants
- Reliable and service-friendly traction package

ABB solution

- Highly standardized ABB traction system comprising DC line filter, traction converter with integrated auxiliary converter and battery charger, auxiliary filter package and traction motors



Customer benefits

- Powerful traction chain with standard modules and high service level

TRANSNET FREIGHT RAIL (TFR)

Traction package for Diesel-electric freight locomotive

BORDLINE® CC1500 DE, battery charger, traction motor, GenSet

Customer need

- Customized traction chain solution
- Short time to market

ABB solution

- Complete solution from one supplier
- All-in-one converter for traction and auxiliary including integrated cooling
- Well-proven standardized power electronic building blocks (PEBB) and control unit
- Standardized software modules for motor, brake chopper and auxiliary converter control



Customer benefits

- One partner for the entire traction chain
- Energy efficient traction chain
- Excellent maintainability



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