# Roll and control

## The AC 800PEC control platform in a broad range of applications

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**The great reliability, speed and precision required of power converters and drives call for high performance controllers. ABB's AC 800PEC controller is integrated into the company's successful and widely adopted 800xA control system. The AC 800PEC is suitable for a wide range of applications – not limited strictly to power electronics control, but including fields such as rolling plants in the metals industry where it is has a part in controlling the complete process. The following two examples illustrate the successful integration of the AC 800PEC[1] in locomotive drives and rolling plants.**


## Fast control in a traction application

**To lower operating costs while raising attractivity, modern trains are becoming increasingly light and agile. The on-board power converters must follow suite by delivering greater speed, responsiveness and reliability while fitting into a smaller footprint. Enter ABB's CC750® power converter!**

The CC750® low-voltage IGBT converter is at the heart of the power circuit of the FLIRT 1 type[2] [1] of Swiss Federal Railways (SBB) as well as of GTW-type vehicles for the operators THURBO (*Thurgau-Bodensee Bahn*) and RM (*Regionalverkehr Mittelland*). All these trains are manufactured by Stadler Rail AG. Since their first commercial operation in December 2003, a total of about 250 vehicles have been commissioned. Their power converters are all controlled by AC 800PEC units from ABB.

### System Configuration

The CC750® was developed as a trac-

1 ABB's CC750® power converters are an integral part of the FLIRT-type modern lightweight trains.

tion converter for use in regional and suburban electrical multiple unit trains. The CC750® has an integrated auxiliary supply and is suitable for several catenary voltage supplies including 15 kV / 16.7 Hz and 25 kV / 50 Hz. It uses IGBT (Insulated Gate Bipolar Transistor) modules with 1200 V blocking voltage in both its traction supply circuit and in the auxiliary converter.

The two converter systems are fully redundant – the vehicle can continue to operate at reduced power should one of them fail.

The main system configuration is shown in 2. Two identical CC750® converter systems (2d and 2e) are connected to the catenary 2a via a common oil-cooled high voltage transformer 2c. The two converter systems are fully redundant – the vehicle can continue to operate at reduced power should one of them fail.

**Embedded Control System**

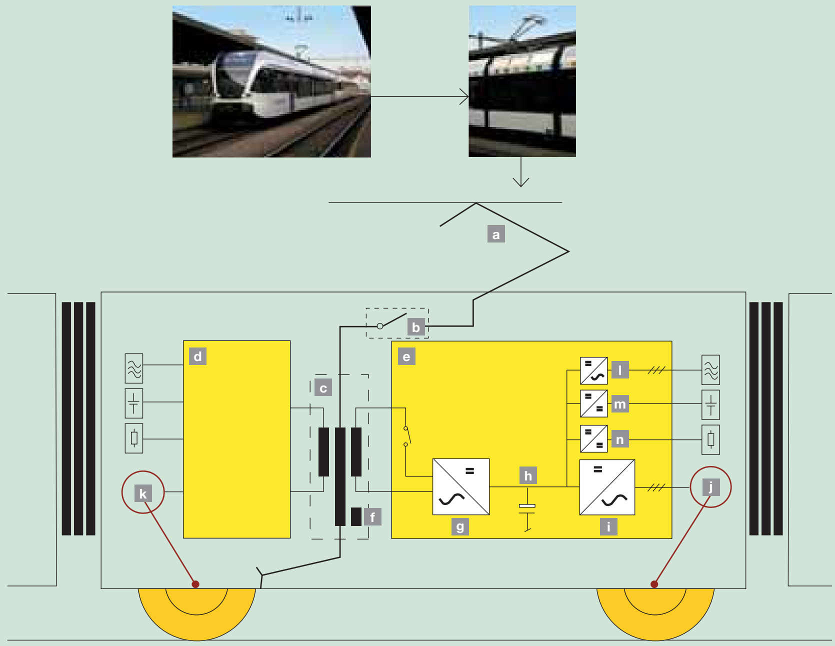
A decentralized concept was chosen for the control hardware 3 consisting of the following units:

- *AC 800PEC Controller* 3e, ABB's high-end process control system. This can be programmed using MATLAB®/Simulink® and Real-Time Workshop®.
- The *PEBB* 3b (Power Electronics Building Block) interface board, used as a universal remote I/O device. This board controls and protects the IGBT converters. The links to the IGBT drivers are bidirectional.
- *Combi I/O board* 3c, a universal remote I/O device for high-speed traction applications.
- *Auxiliary modules* 3a 3d, comprising power supplies and intermediate current and voltage transducers and the control of the switch and disconnector devices.

Furthermore, the hardware arrangement includes AC current and DC voltage measurement (synchronous sampling), overcurrent protection and modulation and firing interlocking.

2 Traction converter arrangement on THURBO GTW with two CC750® units delivering a total of 1.1 MW of traction power.

a pantograph (15kV, 16 2/3 Hz cantenary)
b main circuit breaker
c transformer
d and e CC750® power converter units
f auxiliary transformer winding for train heating supply
g grid inverter (390V input)
h DC-link (750V)
i traction inverter (480V / 0 – 170 Hz, 750 kVA traction power)
j and k asynchronous traction motor
l three-phase auxiliary supply (50 kVA / 3 x 400 Vac)
m battery charger (12 kW / 36 Vdc)
n brake chopper



In order to ensure high tolerance to electromagnetic interference, communication between the AC 800PEC Controller, the PEBB interface board and the Combi I/O board is assured by optical fibers. An additional optical link connects the converter control system to the higher level vehicle control system via a CANopen bus. The connection to a host computer for programming and monitoring purposes is provided by an Ethernet link.

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**Control Software of the AC 800PEC**

High-speed digital control systems represent the state of the art in power

3 Control hardware panel of CC750®

a auxiliary module
b PEBB interface board
c Combi I/O board
d auxiliary module
e AC 800PEC

## Embedded system technologies

electronics. Typically, FPGAs (Field-Programmable Gate Arrays) using advanced VHDL (VHSIC Hardware Description Language) programming tools are used for highly time-critical functions in the microsecond-range and below. In the intermediate speed range (100 µs to millisecond-range) AC 800PEC provides a software layer based on MATLAB®/Simulink® with Real-Time Workshop® [2]. This environment allows high-level graphical programming on the conceptual abstraction level favored by control and system engineers. All coding, downloading and monitoring functions are integrated into the platform. The engineer is spared time-consuming and error-prone low level coding.

Table 1 Software tasks and their cycle times

| | | tasks (examples) | cycle time |
|---|---|---|---|
| Vehicle Control via CANopen | | speed and torque instructions | 50 ms |
| AC 800PEC, MATLAB®/ Simulink® with Real-Time Workshop® | Task C | state machine, slow protection flux controller | 1 ms |
| | Task B | current controllers, pantograph bounce detection | 250 µs |
| | Task A | very fast current controllers | 50 µs |
| FPGA, VHDL | | modulators, very fast protection | ns-range |

Control systems typically consist of components with different time constants. The software therefore has sub-tasks that are executed at different intervals. In the control software for the CC750®, three software cycles have been implemented running at cycle times of 1ms, 250 ms and 50 ms Table 1.

# Rolling mill in the metal industry

**In the metals industry, demands on product quality and on plant productivity and flexibility are steadily increasing. ABB's new generation of rolling mill automation system includes an integrated and advanced solution suite that meets the customers' needs for product quality and throughput. The use of ABB's 800xA Automation Platform with the powerful AC 800PEC controller permits mill-wide uniform automation, seamlessly integrating advanced solutions into the process control system.**

In hot and cold rolling mills 4, the demands on mill profitability, productivity and product quality are on the rise. At the same time, mill flexibility has to match the growing variety of products. Strip quality and mill throughput are influenced by various factors such as mechanical design, electrical equipment, auxiliary supplies and control strategy, and the very many associated variables have to be tightly controlled to meet product quality targets.

An impression of key data of a cold rolling mill is given by Table 2. To be able to control such a large and complex plant and meet the high demands on process speed and product quality, a powerful controller is needed to handle all required functions from low level binary control up to advanced and sophisticated control solutions. The AC 800PEC is outstandingly well suited to meet these requirements. Beside the full integration into the 800xA Automation platform with communication to I/Os, Drives, various fieldbus systems and the Human Machine Interface, its strengths lie in its powerful programming capability (based on IEC 61131-3) and the CPU performance provided 5.

The customer's benefit is an improvement of the thickness deviation of up to 50 percent (product dependent).

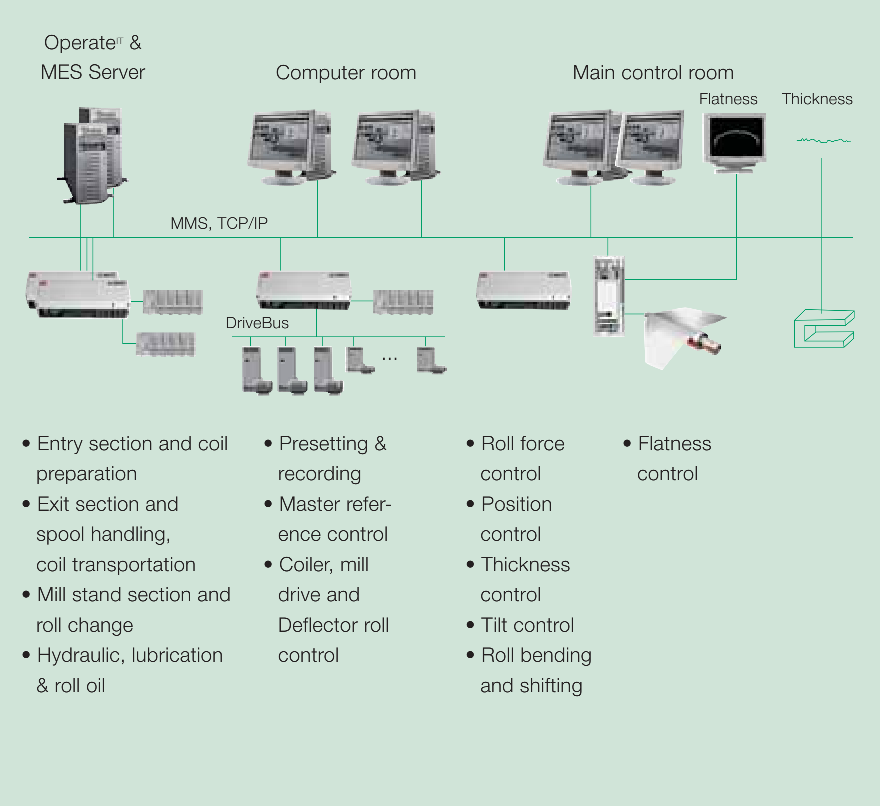
4 Everything under control at the rolling mill


The most demanding function in a rolling mill is the thickness control. Keeping the strip thickness within a narrow tolerance band is one of the

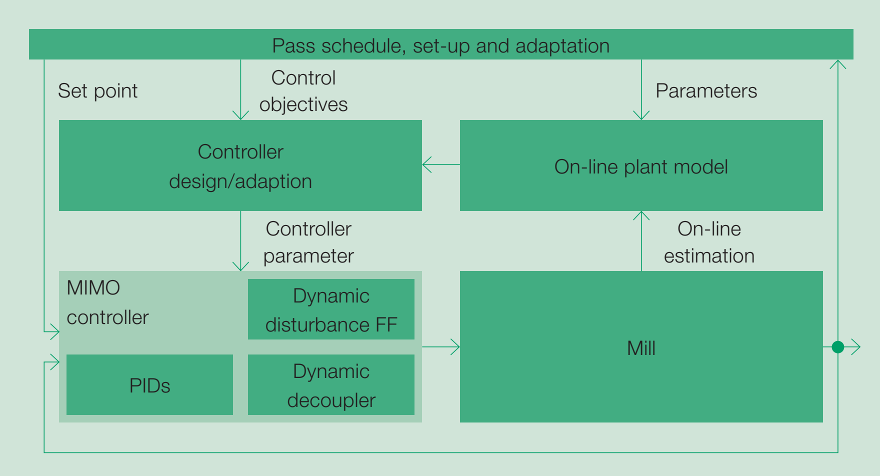
Table 2 An impression of key data of a cold rolling mill

- Maximum roll force = 30 MN
- Maximum mass of rolls in a stand = 40 tons
- Maximum mill acceleration = 2 m/s$^2$
- Maximum mill speed = 150 km/h
- Minimum strip thickness = 6 µm
- Thickness tolerance = 0.5 ... 1.0 %

5 Typical system configuration of the rolling mill application




6 MIMO control concept with dynamic online parameter adaptation




mill's most crucial requirements. The benchmark is set by the deep drawing[3] of aluminum and steel sheets for cans or car body parts. The more the variation of thickness can be reduced, the smaller the minimum permissible thickness the mill can be operated at. This permits improvements through lower material usage, weight saving and overall cost-efficiency. To achieve effective control of the rolling process, mechanical, electrical and hydraulic systems, instrumentation, as well as the lubrication and the control strategy must all fit together seamlessly 6.

State-of-the-art thickness control algorithms are composed of single feedforward control loops. These algorithms are limited in their achievable thickness performance because they do not fully take into account the connection between thickness, roll position and tension [3].

By using the powerful AC 800PEC controller and its possibility of implementing C-Code beside the standard IEC 61131-3 program level, a new thickness control solution for cold rolling mills has been developed based on a MIMO (Multi-Input Multi-Output) control concept. The customer's benefit is an improvement of the thickness deviation of up to 50 percent (product dependent).

Mill flexibility has to match the growing variety of products.

### A powerful all-rounder

Thanks to the different programming levels of the AC 800PEC, this controller is well suited for a broad range of applications – from fast control algorithms in power electronics to process-wide control applications.

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**References**

[1] Peter Bruderer Stadler Rail Bussnang, Description of FLIRT train, Railvolution 4/04 pages 58–72
[2] The Mathworks, User Manual Release 12.1, In particular Matlab, Simulink, Real Time Workshop, Stateflow, Stateflow Coder
[3] ABB in metals, http://www.abb.com

**Footnotes**

1) For more background on the AC 800PEC, see also "Design patterns" on page 62.

2) FLIRT: "Flinker Leichter Innovativer Regional Triebzug" or "Fast, Lightweight Innovative Regional Train"

3) *Drawing* is the process of forming metal sheet into cylindrical or box-shaped parts using a punch. In *deep drawing* the depth of the part is greater than its diameter.