ABS on the Rails

Knorr-Bremse relies on ETAS ASCET

High-speed trains are an essential part of efficient transport infrastructure in any modern industrialized country. But the trains' travel speeds – of up to 250 km/h and more – place enormous demands on brake system mechanical components and control electronics. For the last 15 years, ETAS tools have helped Knorr-Bremse AG to develop the software for managing and controlling these crucial safety-related systems.

Wheel-rail system:
The brake system's anti-skid/anti-slip protection prevents braking-induced flat spots.

For high-speed trains, the brake concept is a key element of the safety plan. It encompasses brake force management, comprising the optimum distribution of the brake force over the various brake systems throughout the entire train, specific actuation of the friction brakes, anti-skid/anti-slip protection, and rolling monitoring, as well as the recovery of electrical energy during braking.

The current generation of ICE trains has three complementary braking systems. Actuation of just the disk brakes suffices at lower speeds; at higher speeds the electrodynamic brakes also engage. These in turn are backed up by the eddy current brakes when traveling certain stretches. One thing is clear: no intelligent braking concept can be implemented without electronics.

Electronics instead of mechanical components

Rail vehicle brakes were constructed and actuated almost exclusively on a mechanical and pneumatic basis well into the 1970s. The impetus to introduce electronically controlled antilock braking systems (ABS) stemmed from the desire to reliably prevent annoying and dangerous vibrations or operational instability caused by braking-induced flat spots on the wheelsets. Today's anti-skid/anti-slip protection, comparable with automotive ABS, also controls axle slippage in order to optimize the stiction between wheels and rails when braking and consequently reduce the braking distance.

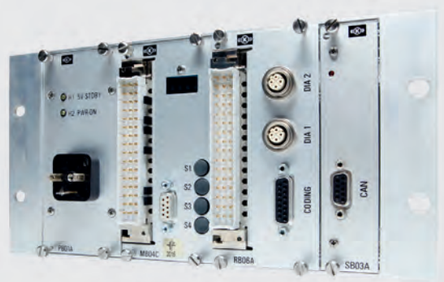
ASCET software – safe, proven, and automatically generated

To develop open-loop and closed-loop algorithms requires reliable and professional tools. Engineers at Knorr-Bremse have relied on ASCET for model-based software development since 1999.

Previously, the engineers had to laboriously specify the system functions, which were then programmed in the computer language C by software developers. Back then, block diagrams of open-loop/closed-loop control systems were drafted on the computer with the help of MicroGrafX Designer, the first graphics program available for Windows PCs. When ASCET was introduced, its key advantage was how production-ready C code could be automatically generated from block diagrams

Knorr-Bremse

is the world's leading manufacturer of braking systems for rail and commercial vehicles. Founded in Berlin in 1905, the company is now incorporated as an AG (Aktiengesellschaft; publicly traded corporation) and headquartered in Munich, Germany. The first important milestones in the company's history were the K1 pneumatic brake for passenger trains, and more importantly the Kunze-Knorr compressed-air brake – introduced in 1918 for freight trains – which made it possible to increase the top speed for freight from 30 km/h to 65 km/h.
In 1972 Knorr-Bremse caused a sensation with the first ABS for commercial vehicles. Twenty years later the Munich-based company presented the first pneumatically operated disk brake for commercial vehicles. Today, in addition to braking systems, the corporation – with more than 20,000 associates – offers a variety of other technical systems for rail vehicles: from air conditioning and door systems to torsional vibration dampers for diesel engines.



The flagship of Deutsche Bahn – ICE 3.

Left:
Electronic brake control system (ESRA).

Right:
Brake module containing the control system.

that had been created in ASCET. In fact, using certified versions of the tool meant it was no longer even necessary to check the generated C code. But that's not all: ASCET fulfills DIN EN 50128 requirements and is therefore suitable for use in developing safety-critical SIL2 applications.
Given that braking systems are designed for a service life of between 30 and 40 years, are regularly overhauled, and are continually improved while still in operation, what truly matters to Knorr-Bremse – in addition to ASCET's special product features – is the fact that ETAS performs long-term maintenance support on this development tool.

Complex systems

Current brake control devices feature an extremely complex design. They have 19" ESRA plug-in boards with a CAN bus interface. The backplanes of the control unit hardware are a proprietary development by Knorr and have been specifically adapted to CAN.
A Freescale PowerPC MPC5554 microcontroller, with a 132 MHz clock rate and a PC104 interface, serves as a CPU. In operational deployment, a system consists of one or more mainboards plus additional boards with I/O expansion modules and bus coupler boards.

Application software with high safety margins

The development and specification of the modules, tasks, and processes of the current application software for the control units is carried out exclusively with ASCET. It is easy to integrate and call up any existing manually coded standard functions. The software architecture is supported by templates. These establish both the definition of the input and output signals of individual functions as well as their treatment for further processing. When creating variants, individual open-loop and closed-loop functions can be configured out of the ASCET model during code generation.

Part of an elaborate safety concept

After the calibration parameter values have been determined through comprehensive simulations and tests, the software is then "hard-wired". Furthermore, the control unit is exactly monitored during runtime: the relative amount of diagnostic and safety functions in the various systems lies between 50 and 80 percent.
At the moment, Knorr-Bremse engineers are working with ASCET version 6.2. For software configuration management they use ASCET-SCM together with the JIRA tool, which tracks errors and requirements.

European urban centers are growing closer together – thanks to ASCET: Paris, Brussels, and Amsterdam are connected at speeds of up to 320 km/h by ICE 3, the flagship of Deutsche Bahn (Germany's national railway). Based on Siemens' "Velaro D" platform, ICE 3 employs state-of-the-art Knorr eddy current brakes, the software for which was developed with ASCET.

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