The Flexx Family: unlocking new functionalities with a SIL4 based architecture

This is the fourth instalment in The Flexx Family, our five-part series of white papers on our Metroflexx and Regioflexx brake control solutions.

● **Pushing boundaries with integrated solutions**

● **Achieving more through unrivaled modularity**

● **A maintenance break-through**

● **Unlocking new functionalities with a SIL4 based architecture**

● **Converging on the future of brake architecture**

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In the previous instalments of this series, we explained how the core architecture of our Flexx Family integrated brake control solutions offers unrivaled modularity at optimal cost.

We also showcased the game-changing improvements to train availability and maintenance that the Flexx Family offers customers compared to conventional solutions.

In this fourth white paper, we consider Flexx Family products as more than brake control systems in the conventional sense. Rather, we think of them as powerful computers. Much like those used in railway signaling, they are designed to control brake cylinder pressure at the highest level of safety (SIL4).

Highly integrated with the train's command and control system, Metroflexx and Regioflexx safely and autonomously perform all required braking functions. But they also go the extra mile reaching peak functionality with their SIL4-based architecture.

Full brake system performance monitoring

The SIL4 design enables the safe monitoring of the entire brake system performance, including electro-dynamic (ED) brake, and to activate corrective measures to guarantee the expected results.

Deceleration compensation

Deceleration compensation is part of our DistanceMaster adhesion management package under the name DistanceMaster Control+ (DM-Control+).

Each Regioflexx brake control unit receives brake demand signals from the TCMS, and autonomously calculates the deceleration achieved. This SIL4 function is performed based on the information transmitted by the speed sensors.

DM-Control+ comes in to play when there is a discrepancy between requested and actual, measured deceleration (e.g. due to low adhesion, slope, isolated bogies, etc.). In such cases, each Regioflexx unit, taking advantage of the locally available adhesion, can increase braking effort within predetermined limits, for example maximum brake cylinder pressure or maximum adhesion usage. This entirely local process does not require communication between the train's different brake control units and can be used for service and emergency brake alike.

As such, DM-Control+ enables brake systems to reconfigure and adapt to any degraded situation at the train level.

Safely monitoring electro-dynamic (ED) brake contribution

The use of ED brakes in service brake is no longer cause for question, but the same is not the case for emergency braking. Here too, Regioflexx stands out as a game-changer. Based on the requested braking effort and emergency brake input, Regioflexx can safely calculate the achieved deceleration and assess whether ED braking is providing the required amount. This is the case whether blending is performed by traction, the car builder or the Regioflexx unit itself. Any failure to reach the requested effort is compensated by the friction brake, within adhesion limits.

This helps optimize the design of the friction brake equipment, which can lead to using fewer or lighter discs, or even replacing discs with tread brake units. Ultimately, the benefits are most apparent in the reduction of both sprung and unsprung weight, and of initial and lifecycle costs. We will further develop this notion in the final instalment of our Flexx Family white papers, "Converging on the future of brake architecture".

requested deceleration

achieved deceleration

corrective action

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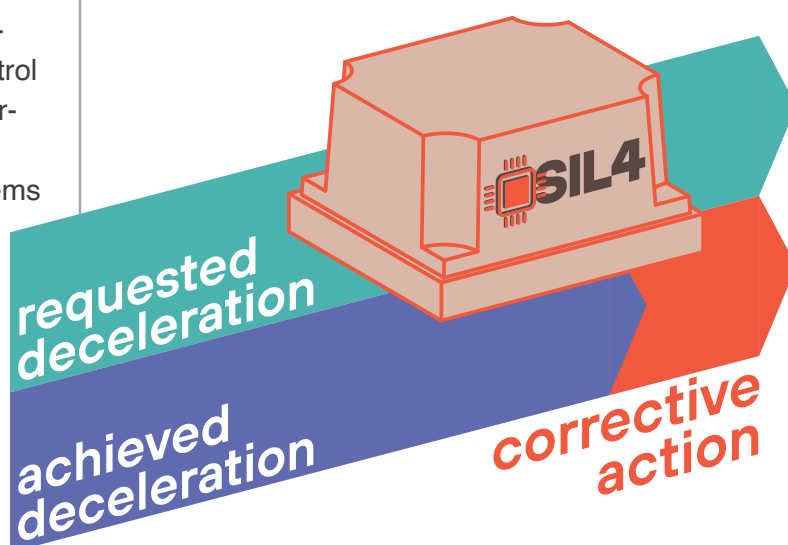
Smart adhesion management monitoring

Adhesion management is a critical topic, as some malfunctions could result in full brake release. As such, the Flexx Family safety features were designed with an initial focus on the core of the advanced brake control software, following exacting safety design standards.

This combination of SIL4 design and embedded technologies opened the door for advanced adhesion management monitoring and improved performance:
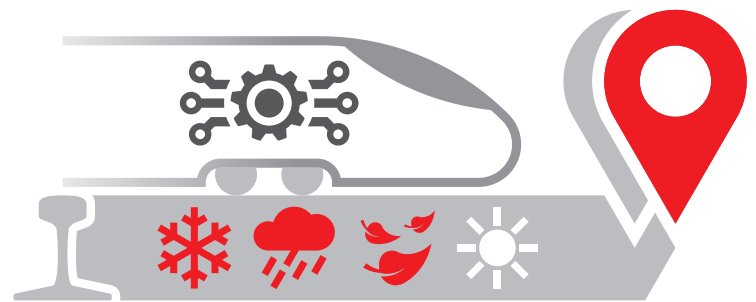
WSP monitoring

Flexx Family products include a hardware watchdog and a SIL4 WSP monitoring function.

Required under EN and UIC standards, the independent watchdog serves to restore the requested brake force in case WSP operation causes a sustained reduction or a release. Because some environments regularly experience very low adhesion conditions, Wabtec has designed a WSP monitoring, as a native feature of Regioflexx, to be activated or disabled depending on user requirements. This function improves train safety and availability, significantly reducing the risk of axle lock and/or wheel flat in very low adhesion conditions. The traditional watchdog function remains active, but WSP monitoring exerts fast, highly accurate control to prevent its activation while recovering axle speed after a slide.

Native wheel rotation monitoring (WRM)

Regioflexx includes a native, independent wheel rotation monitoring (WRM) function to ensure redundancy and independent wheel lock detection.

Implementing the WRM function only requires double speed sensors, eliminating the need for dual-WSP units per vehicle and the associated cabling complexity. This results in significant savings on operating and installation costs, as well as reduced weight, simplified maintenance, and improved reliability. Regioflexx also natively includes an optional, independent brake release (further to a WRM detection) for very high-speed applications

Increase safety in stations and on track

The SIL4 monitoring capabilities of the Flexx Family can also be used within other brake functions where such operational standards are becoming necessary.

Holding brake

Holding brake in station is safety-critical to fully automated operations. The architecture of Regioflexx systems enables them to automatically apply the holding brake below a predefined speed threshold. Likewise, the Regioflexx safety unit continuously monitors brake pressure and vehicle speed to automatically apply the emergency brake in the event of an abnormality as a SIL4 function.

Snow brake

A snow brake function is necessary in countries with very cold climates. The service brake is periodically applied at reduced effort for a limited time, which keeps the discs and pads (or brake blocks) at a baseline temperature, preventing ice from accumulating.

This function may also be used for vehicles equipped with tread brakes, when conditioning the tread is necessary to ensure the right shunting capability (compatibility with signaling system).
Whereas conventional brake systems require additional, dedicated hardware to do so, this is a native feature of the Regioflexx safety unit.

Replacing complex pneumatic valves by software emulation

As discussed previously in the "Flexx Family" series, these solutions feature simple pneumatic components that are managed by software to offer the most advanced functions. When it comes to ensuring optimal performance, our powerful safety monitoring capabilities offer an alternative to costly and maintenance-intensive complex valves.

Here are some applications of this design concept with SIL4 functions:

Emulated multi-stage relay valve

On very high-speed applications, brake cylinder pressure must be reduced above certain pre-determined speed thresholds to ensure required adhesion does not exceed available adhesion. Conventional brake control systems require multi-stage pneumatic relay valves, plus the train's associated control valves and logic, to perform this function.

By contrast, Regioflexx natively includes SIL4 vehicle speed, which means brake cylinder pressure can be modulated upon vehicle speed, in any number of stages. Features that cannot be achieved with traditional relay valves could also be implemented, e.g. continuous ratio variation, and smooth transition between stages to avoid power peaks at the friction pair.

Emulated EN 15355 brake distributor

For double pipe brake systems, Regioflexx features a software-emulated EN 15355 brake distributor. The Regioflexx unit receives brake request signals from the brake pipe pressure and acts as a pneumatic distributor valve (with much better accuracy than a physical distributor).

Should a train be specified for being towed without onboard electric power, via the brake pipe by a vehicle with a pneumatic-only connection, a traditional distributor can be installed to provide input to the Regioflexx EP units.

Emulated average load valve

Our Flexx Family also features a software-emulated average load valve, which receives pressure from two suspension bellows and calculates the average load.
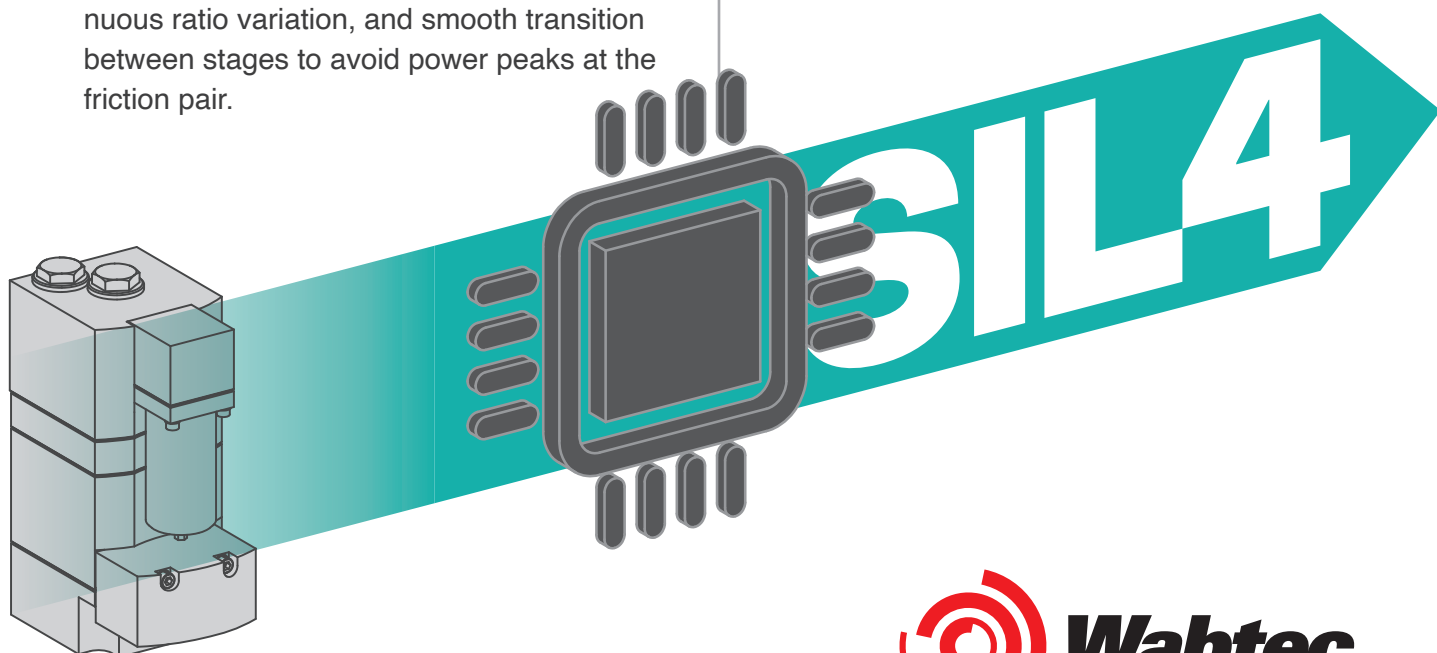
Takeaway: the Flexx Family's SIL4-based design raises the bar of safety and performance alike

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«Integrating SIL4 architecture makes the Flexx Family of products a game-changer for car builders and operators. Fundamentally, what it enables us to do is to provide brake control solutions that can offer so much more in terms of both safety and performance. Going beyond what is available with conventional systems, this is a fully integrated, autonomous solution operating at peak functionality.".

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Matteo Frea
Research & Development
Director
WABTEC

At a glance: The Flexx Family's SIL4-based design goes above and beyond conventional systems:

- Comprehensive, smart adhesion management monitoring that natively covers WSP and WRM.
- Full brake system performance monitoring, including deceleration compensation and electro-dynamic brake contributions.
- Enabler for most stringent automated train safety requirement
- Software emulation providing an alternative to complex safety pneumatic components, at same SIL level.

Read the final instalment in the Flexx Family series to find out how the features described so far can help manufacturers and train operators to revisit the margins that are now built into braking systems to guarantee braking performance, without of course compromising on safety.

Wabtec