

Intelligent Wedge Brake

- **Siemens VDO Automotive develops electronic wedge brake**
- **By-wire control system developed using FlexRay tools from dSPACE**
- **Passed test drives with excellent results**

Test drives have shown the new electronic wedge brake from Siemens VDO Automotive to have excellent braking performance. Experts rate the dynamics and deceleration particularly highly. This is sophisticated technology, and handling it requires powerful control systems. Among the tools that Siemens VDO Automotive is using to develop the systems and test them in a real vehicle is a modular dSPACE prototyping system, which controls the brakes. dSPACE's FlexRay tools are used to develop the FlexRay network for the entire brake system.

At Siemens VDO Automotive, we are currently developing a new generation of brakes, which will go into production by 2010. The idea behind brake-by-wire technology, which was first presented in 2005, is to do without any hydraulic brake components whatsoever. This will enable future driver assistance systems to access the brakes faster and more accurately, so automobile manufacturers will be able to implement shorter braking distances, even on ice and snow.

How the Brake Works

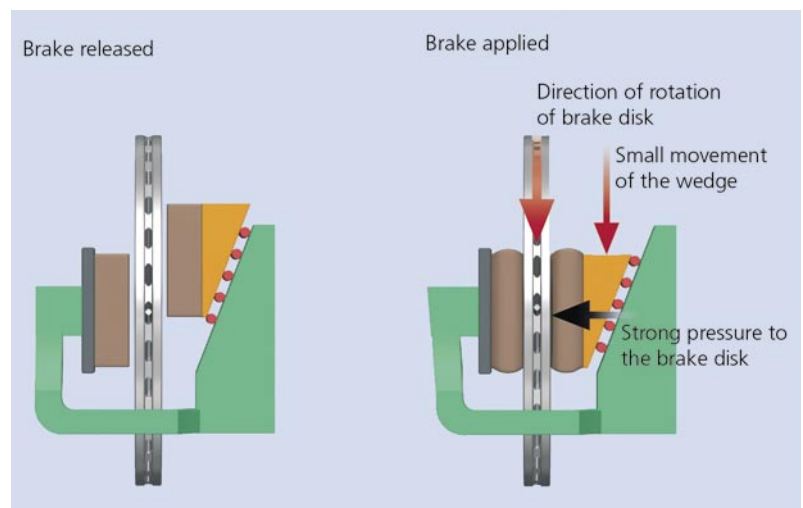
The basic idea behind the electronic wedge brake (EWB) is to convert the vehicle's own kinetic energy into a braking force. During braking, a brake pad connected to a wedge is pressed between the brake caliper and the brake disk. The rotation of the wheel, which is driven by the vehicle's kinetic energy, automatically amplifies the wedging effect. Thus, a very

large braking force can be generated with very little effort. An intelligent control system prevents the brake wedge from jamming. The EWB's particular advantages are its fast responses, especially in ABS mode, and constant braking pressure at low energy consumption.

Cascaded Control System with FlexRay Network

Every brake module in the vehicle is equipped with intelligent electronics that control the actuators. A central electronic control unit (ECU) executes the higher-level control strategy. The brake modules are connected in a FlexRay network. In the prototyping phase, a dSPACE prototyping system acts as the central ECU. This executes the four brake controllers and an ABS/ESP controller, while the motor controllers for the wedge motors run on the brake modules. The

► *The principle: When the wedge brake is open, the brake disc rotates freely, and the wheel is unbraked. When the wedge brake is applied, it utilizes the wheel's own motion. A slight change in wedge position therefore effects a high braking pressure on the brake disk.*



highly dynamic brake controllers are implemented on the dSPACE prototyping system with a cycle time

“The dSPACE development system was not only hard-worked with regard to data throughput and flexibility, but also tested successfully for reliability under extreme mechanical conditions in test drives.”

Bernd Gombert

of 700 μ s, producing a correspondingly high data transmission rate between the dSPACE prototyping system and the brake modules with the wedge motor controllers.

Efficient Function Prototyping with FlexRay

We use the RTI FlexRay Blockset to extend the function model of the brake controller that we developed. This allowed the model to be mapped to the controller topology quickly and reliably. The computation-intensive controller model calculation and FlexRay communication both have to be performed within the short cycle time of 700 μ s. This is achieved by a DS1005 multiprocessor system, whose high processing power and low I/O latencies ensure both complete controller computation and deterministic transmission of FlexRay data. The processor boards are installed in a Tandem-AutoBox together with DS4501 FlexRay Interface Boards and DS4302 CAN Interface Boards. This allows it to be used in the actual test vehicle. The DS1005 system is connected with the vehicle’s CAN bus via the CAN

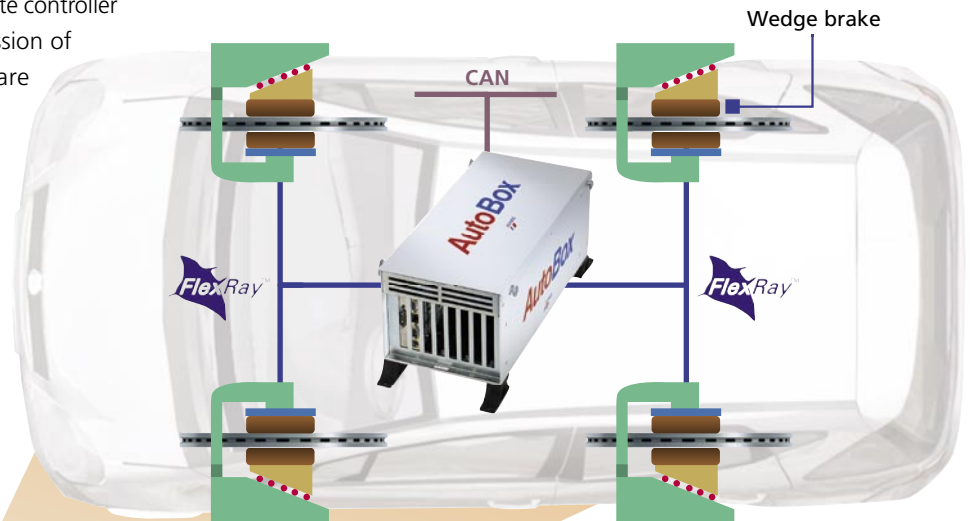
► *Design of the real test vehicle with FlexRay bus: All four wheels have electronic wedge brakes that are controlled via a central prototyping ECU installed in the AutoBox.*

Interface Board, for example, to use sensor data (such as lateral acceleration) or to send ESP requests for torque reduction to the engine ECU.

Successful Test Drives

When the braking force is applied and removed at sufficient speed, using a hydraulic pressure gradient of max. 5800 bar/s for pressure build-up and max. 2000 bar/s for pressure release, with precision control of the braking force, the wedge brake is able to perform ABS and ESP interventions very effectively. The first test drive period put the brake’s performance and stability to the test, including extreme climatic conditions and difficult ground. The ABS/ESP functionalities tested successfully on road surfaces with both high and low friction, and the robustness of the brake under high mechanical and thermal stress was investigated. The dSPACE system also passed this test under high mechanical stresses, without any failures.

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◀ *Test drives with the wedge brake prove that the innovative by-wire system was implemented successfully. A dSPACE prototyping system is installed in the test vehicle and proves to be a robust, high-performance system.*