

Active Seat Suspension

Team project within DaimlerChrysler AG

Active suppression of vibration in commercial vehicles

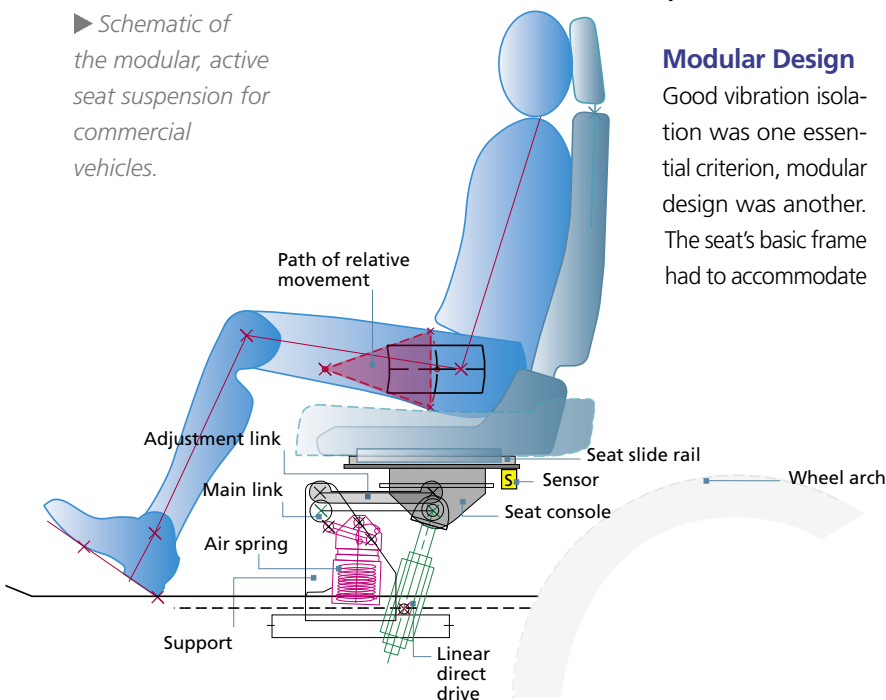
dSPACE prototyping system speeds up controller development

A joint project between DaimlerChrysler Research and Technology and the company's advanced engineering truck group developed a mechatronic truck seat system. The system aims to reduce the annoying vibration that truck drivers are subjected to while driving. A dSPACE prototyping system based on a DS1005 PPC Board provided fast results for developing and verifying a prototype of the controller. And since the seat system is modular in design, the basic seat model can be reused in multiple ways, which cuts down on the number of different parts.

Mechatronic Concept

Truck drivers' performance and condition behind the wheel greatly depend on their being in good physical and mental shape. The seat they sit on has a lot to do with this. Conventional, passive seat suspension systems for commercial vehicles use springs and dampers to isolate vibration. Since there is virtually no more room for improvement in these, the team developed an active seat suspension for commercial vehicles that uses actuators in addition to the spring-damper elements. Passive support of the seat is provided by an air spring integrated into the seat frame. The air spring compensates for vibration and is also used for seat height adjustment. This is supplemented by a compact electrical linear direct drive for active vibration isolation, which acts as an actuator and is supplied by the vehicle's electrical system.

Schematic of the modular, active seat suspension for commercial vehicles.



Modular Design

Good vibration isolation was one essential criterion, modular design was another. The seat's basic frame had to accommodate



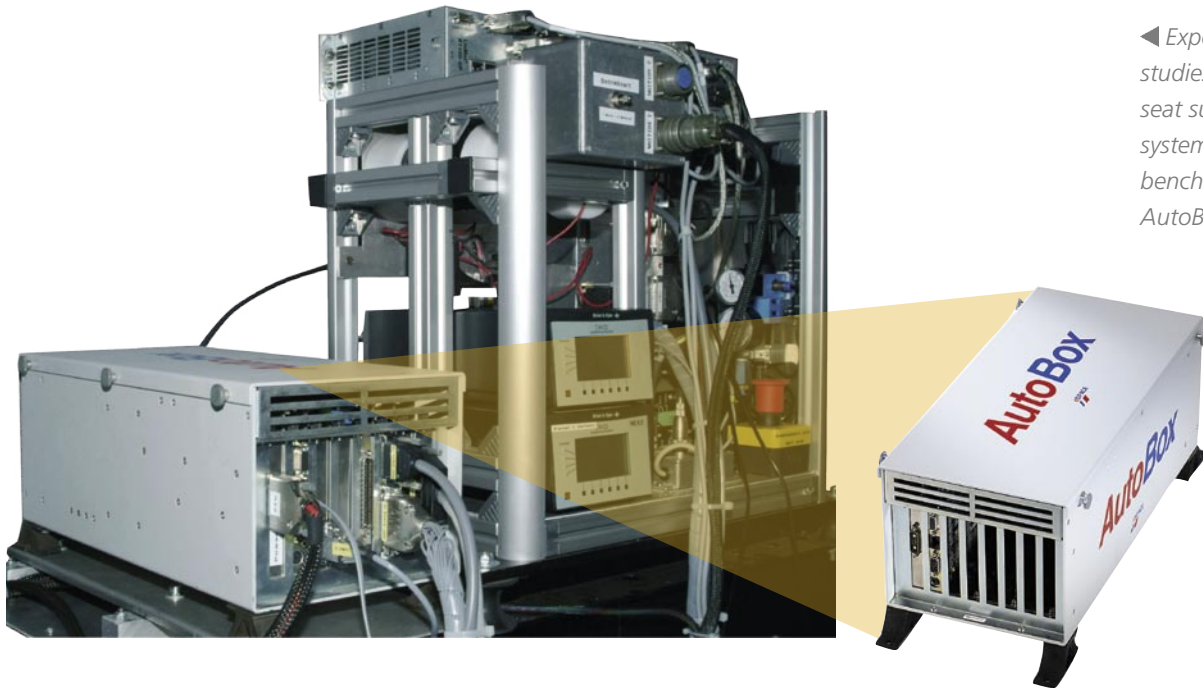
The prototype of the active seat suspension, integrated into a driver's cab.

two seat suspension systems: the conventional passive one and the new active one. The modular seat system also had to be installed in various truck series with different floor structures and wheel arches.

Model-Based Control Design

The seat control considerably improves the vibration isolation compared with passive seat suspension systems. It was designed completely on a model basis. The control was optimized with reference to essential requirements such as minimizing the vibration stress for the seated person, while keeping the relative motion between

◀ Experimental studies of the active seat suspension system on the test bench with dSPACE AutoBox.



the seat and the cab floor within reasonable bounds. The control requires only the acceleration and the relative seat motion as measurement data, and proved to

“The dSPACE system enabled us to implement various controller concepts quickly and simply. We used ControlDesk to fine-tune the controller parameters and to capture relevant variables during operation.”
Simon Kern

be extremely robust in handling vehicle occupants of different weights and in varying sitting positions. An acceleration sensor provides information on the status of seat motion.

Fast Results with dSPACE

The controller structure was designed graphically using MATLAB®/Simulink® and first simulated offline using the model of the controlled system. Next the controller structure was replaced by dSPACE hardware. The DS1005 PPC Board supplied the computing power for our real-time system and was also the interface to the I/O board. The DS2201 Multi-I/O Board measured the required input and output signals, and provided the output value for the actuator signal. Finally, relative motion given by the electrical actuator was captured via the DS3002 Incremental Encoder Interface Board.

Validating the Controller Design in Tests

To initially test for compliance with the design specifications without using a real vehicle environment, the design results were validated online on DaimlerChrysler’s vibration comfort test bench in Sindelfingen, which included a real driver’s seat, sensors, and actuators. Measurements made on the test bench and in later test drives proved that the active seat suspension considerably reduces physical stress for the truck driver. However, the improved vibration isolation also results in greater relative motion between the seat and the cab floor. This takes some getting used to and as a first impression impairs the subjective comfort level.

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