Audi: Complete Powertrain Simulation

CUSTOMERS

- Networked HIL simulators
- Simulation of complete powertrain
- Operation like a real car
- Simulink-based simulation with TESIS DYNAware models

Audi is to apply dSPACE Simulators to the task of developing powertrain electronics for an increasingly complex networked vehicle. SPEA (German: Simulationsprüfstand vernetzter Elektroniksysteme im Antriebsstrang) is the first simulation rig to provide a complete powertrain simulation in real time.

The rapid growth of networks in vehicle electronics has led to an increase in the cost and complexity of experimental vehicles. Consequently, the use of development rigs has risen and is already the established practice for interior electronics at Audi. For powertrain electronics, however, the introduction of hardware-in-the-loop simulators (HIL simulators) is essential; the electronic control units (ECUs) contain complex control algorithms with sensitive fault recognition and cannot be operated realistically without an HIL environment. In addition, a given vehicle can include numerous powertrain variants (engines, transmission types, etc.), which multiply the cost of building a rig unless simulation is applied.

HIL at Audi

Individual powertrain ECUs have been developed and tested successfully at Audi with HIL simulators from dSPACE for several years. However, such simulators are tailored to the needs of each specific ECU; that is, their behavior in a network is given a low priority, and partnering ECUs are either absent entirely or at best simulated only crudely. The challenge presented by SPEA was to improve and apply HIL technology to the development and testing of distributed powertrain functions.

User Requirements

The requirements for SPEA were produced in close cooperation with the intended users. The priorities were maximum configurability and operation as close as possible to that of a real vehicle. Further specifications were maximum reusability of HIL components, minimum downtimes for reconfiguration and upgrades, and extensive features for monitoring and manipulating CAN messages. Displays had to be set up, and the chosen vehicle configured, from a single PC.

Operation from the PC – and soon from a real vehicle.

Chosen Architecture

The baseline architecture incorporates engine management (twin ECUs for some variants), transmission control and chassis control (ESP, air suspension). Physically, the architecture comprises one dSPACE Simulator (central unit) as the master controlling three further dSPACE Simulators (I/O Units for engine, transmission and chassis control) via high-speed optical links. Each I/O Unit contains all the necessary signal conditioning hardware and electrical loads (partly simulated, partly real components) for its ECU(s). The central unit generates the exterior view using the RealMotion 3-D tool, shortly to be replaced by its successor, MotionDesk.

The existing Simulink models from TESIS (engine, transmission and running gear) were integrated into a single powertrain model. This runs completely in the central unit. The excellent performance of the multiprocessor system with three processor boards made it possible for the simulation to run at speeds exceeding those of stand-alone HIL simulators.

This architecture has several major advantages:

- The interfaces between model components (for example, between engine and transmission) exist purely in software. This avoids problems with timing due to hardware protocols and feedback delays and simplifies the hardware interfaces between the SPEA units.
- Reconfiguring SPEA to behave as a different model variant (for example, conventional automatic

transmission instead of CVT, V8 engine instead of V6) only requires the model on the central unit to be reconfigured, and not each simulator individually.

- The commissioning process is simplified; missing I/O Units can be replaced by ECUs simulated in the central unit (SoftECUs), without rebuilding any code. This also allows SPEA to be used while components are upgraded or disconnected.

Operation Like a Real Car

In the SPEA cockpit, all the driver controls relevant to powertrain systems are installed as in a real vehicle. These components are connected to the central unit and wired to the appropriate ECUs, for example, the accelerator pedal sensor to the engine ECU via discrete wiring, or the steering angle sensor to the ESP electronic control unit via the powertrain CAN bus. Parallel to these, additional sensors provide independent information about pedal positions, steering angle, etc. The sensors also transmit this information to the central unit via a dedicated Simulation CAN bus.

Expandability and Reusability

In addition to signal conditioning hardware, each I/O Unit contains adequate processing power to allow it to be reconfigured per software and used as a standalone HIL simulator. Because the SPEA powertrain model incorporates the same models used in existing single-ECU HIL simulators, it profits from every improvement and modification to engine, transmission or chassis models made during the development of new ECUs. The Simulation CAN bus can be used to exchange information between the standard SPEA components and any additional simulators which are not equipped with dSPACE optical links. These features guarantee that SPEA can be extended to meet future demands.

Conclusion

dSPACE has demonstrated a willingness to extend its product family to meet the challenges posed by Audi's requirements and succeeded in resolving the conflict between the need for maximum flexibility and the simplest possible operation. SPEA provides Audi engineers with an environment in which powertrain systems for all vehicle variants can be tested and functional prototypes can be developed and proven. It will become an irreplaceable tool for the development and testing of powertrain control systems for all future Audi models.

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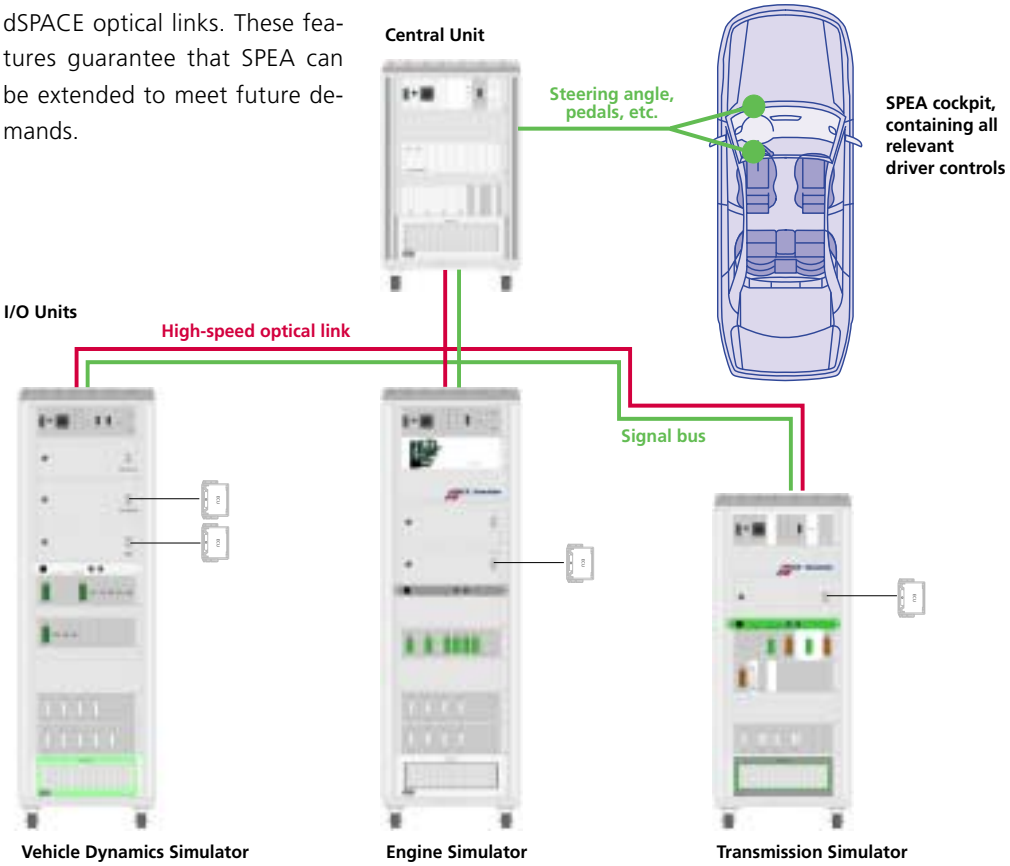

HIL test of distributed powertrain functions: each dSPACE Simulator can be used in a network or as a standalone system.

Job Opportunities

Are you an engineer who is just graduating? Or are you looking for new professional challenges? Then come and join our team in Paderborn, Germany or Northville, MI, USA!

Due to our continuous growth, dSPACE is looking for engineers in

- Software Development
- Applications
- Technical Sales
- Product Management
- Technical Documentation

Please visit our website **www.dspace.de** for further details.