Bugatti: Powerful Cars Need Powerful Tests

- ◢ Powertrain simulator for Bugatti

- ◢ Simulation models from Volkswagen

- ◢ ECUs network-tested using dSPACE Simulator

At 1001 HP, the Bugatti EB 16.4 Veyron seems set to become the fastest and most expensive production vehicle ever built. And for active safety at speeds of over 400 km/h, a whole range of electronic control units (ECUs) are needed. Bugatti first performed intensive validation work on the ECUs in the laboratory, using dSPACE Simulator. This allowed functions to be tested efficiently, both in individual tests and in a network, with no danger at all to driver or vehicle.

The figures speak for themselves: from zero to 300 km/h in less than 14 seconds, a top speed of over 400 km/h and a buying price of 1,160,000 euros. With figures like these, it is easy to see why it is not possible to test the entire ECU behavior on the road. On top of this, there are only a very few prototype vehicles available, and the technical requirements are extremely high. The only reasonable alternative is to test the ECUs thoroughly in the laboratory first.

▲ *The tests are run from the realistic instrument panel of the ControlDesk user interface.*

We Used Our Own Models

At Bugatti, we used a dSPACE Simulator Full-Size to test the ECUs for the powertrain: 2 engine ECUs, one ECU for the 7-gear dual clutch transmission, and one each for the all-wheel and ESP components. So that the ECUs could be integrated into a virtual world, mathematical models of the components to be controlled were needed. Our parent company, Volkswagen, developed models for the W16 engine and the 7-gear dual clutch transmission. We were able to put the models on the Simulator and use them for real-time simulation with a minimum of adaptation work.

▲ *The Bugatti's powertrain ECUs were tested in virtual test drives in hardware-in-the-loop simulation.*

The models for the all-wheel transmission and the ESP component were outsourced. dSPACE developed the I/O connection for integrating the models into the simulator environment. The telephone support given by dSPACE project engineers was very productive for our Simulator staff, who had not formerly had any experience with dSPACE.

Testing Diagnostic Functions

The main focus of investigations was on hardware-in-the-loop tests for diagnostic functions. We tested the ECUs by systematically applying faults to them. With its powerful processor hardware and flexible I/O hardware, dSPACE Simulator had no problem coping with the tough demands made on signal generation and the simulation of faulty sensors. dSPACE's experiment software, ControlDesk, was used for graphical instrumentation and interactive operation

of the Simulator. MotionDesk performed 3-D visualization. A test automation system developed by Volkswagen was used for the management and automation of the tests. Some tests that had already been created were efficiently imported onto the dSPACE Simulator.

Network Testing

The functions for controlling the powertrain are distributed across several ECUs, so network testing of these is vital. dSPACE Simulator provided the following support for this:

▰ Parallel and
   constant monitoring of all CAN channels: drive CAN, ESP sensor cluster CAN, and private CAN between engine master and engine slave with ControlDesk
▰ Arbitrary switching of individual ECUs,
   and their simulation in the network, on and off using CAN restbus simulation (for isolated testing of individual ECUs without interactions)
▰ CAN signal manipulation for all messages and
   signals from all participating ECUs, for example, the corruption of CAN messages and their contents, failure of senders, failure of individual messages

Project Ran Smoothly

The project was highly dynamic, as the vehicle had to be developed according to an extremely tight schedule. This necessitated a variety of modifications to the specifications, which the dSPACE project engineers at Paderborn had to incorporate and implement quickly during the project planning phase. dSPACE delivered the system to us in February 2003, and we started using it immediately after installation.

▲ *MotionDesk, software for visualizing real-time simulations, displays the simulation results in a 3-D on-screen world.*

Current Project Status and Outlook

We have been productively using the system for ECU testing for some months now. During this period, we have set up the Simulator several times, whenever the software and hardware versions of the ECUs to be tested changed. In parallel to this, further tests automated by Volkswagen's own test automation system are being put into operation on the Simulator. HIL-based laboratory testing with dSPACE Simulator has proven a great success.

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