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dSPACE MAGAZINE

3/2010

Suzuki – Virtual Test Drives

Ford – Automated Test Processes

Liebherr – Optimization of Aircraft Electrical Systems

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dSPACE is helping to electrify vehicles. Electric actuators like steering systems and electromotoric drives are classic applications for our development tools and HIL simulators. The Mitsubishi iMiEV – a battery-driven four-seater that we recently exhibited at our User Conference in Paderborn – is just one innovation that was developed with our products. And we're no strangers to modern high-voltage batteries, especially when they need to be simulated in an HIL test system, as one article in this issue vividly demonstrates. Not surprisingly, our customers now include battery manufacturers like Johnson Controls-SAFT, Sanyo, and SB LiMotive.

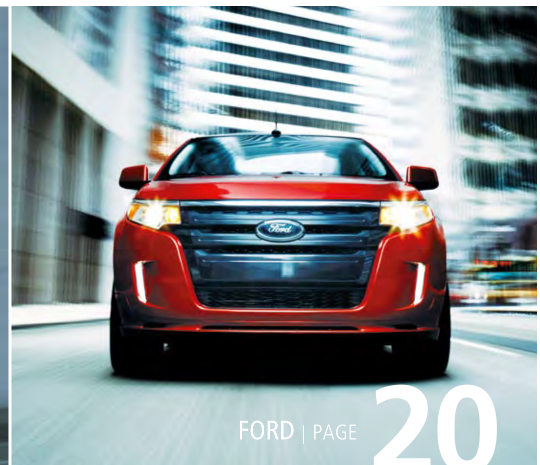
We see electromobility as an interesting business field in all its forms, from hybrids to completely battery-driven vehicles, and we are investing in it accordingly. Personally, though, I can't help but feel that the political and public pressure to create electric vehicles is overdone, and expectations are too high. This also comes out in the interview on page 65. The most frequently cited reason for electric vehicles is that they will save CO_2 emissions. Yet as long as the electricity still comes from conventional sources, the amount of CO_2 in the energy mix has to be taken into account.
This is one reason why Greenpeace Germany doesn't support electromobility yet. With Germany's mix of energy sources, one small battery-driven car currently causes 90 g CO_2 per driven kilometer. But that underestimates the real problem. Because as long as even just one coal-fired power plant is on the grid, you would be justified in saying that in reality, every additional kilowatt hour that goes into an electric vehicle has been paid for with CO_2 emissions of a kWh from a coal-fired plant. If the same journeys were made with a gasoline vehicle that didn't need the kilowatt hour then the output of the coal-fired plant could be reduced by that same kilowatt hour, while the more CO_2-neutral electricity generators continue running to capacity.
Approached this way, the actual figure is not 90 g/km, but 140 g/km. And that's more than the same small car would generate with a reasonably powerful combustion engine. If you take a larger vehicle, plus enough battery strength for a range comparable to that of a gasoline vehicle, you quickly reach the CO_2 emissions of two very sporty SUVs.

There are no doubt good reasons for electromobility, but a reduction in CO_2 is currently not really one of them – except in countries whose power stations really do not burn fossil fuels.

I wish you a very happy festive season and every success in 2011!

Dr. Herbert Hanselmann
President

Embedded Success dSPACE



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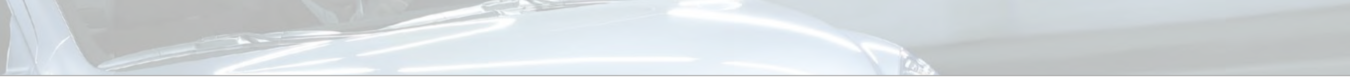

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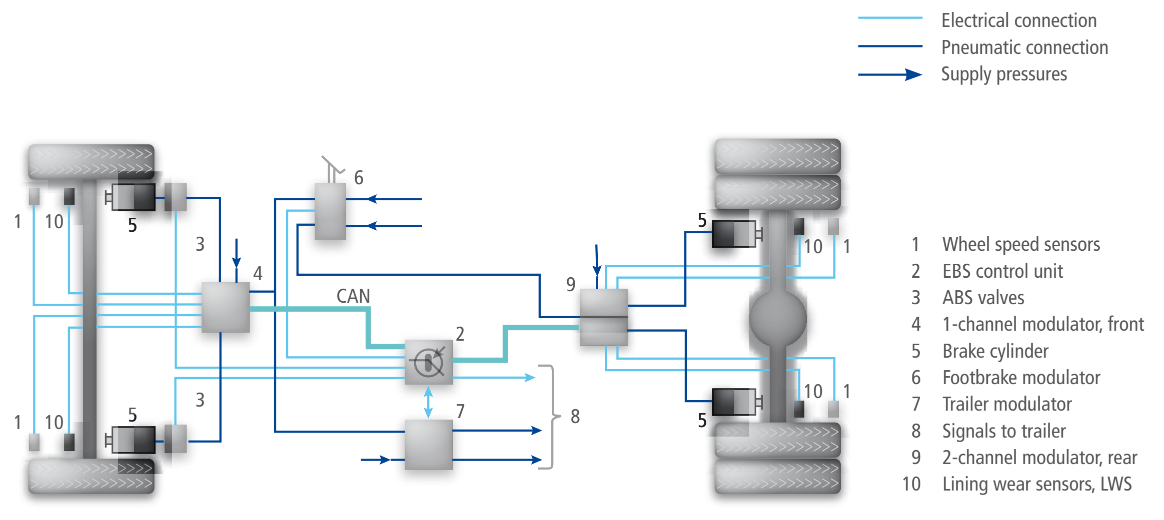
Big on Safety

Volvo 3P’s innovative product development include HIL simulations to test and verify brake system controllers

Back in the old days a truck carried next to nothing compared to the load that a modern heavy-duty truck hauls safely on the road today. Maintaining 100% reliable and safe operation under all road, load, and traffic conditions is a challenge for the brakes. Volvo 3P relies on HIL simulation to test and verify the controllers when developing brake systems.



Overview of the EBS on a truck with two axles.

> "Cars are driven by people. Therefore the guiding principle behind everything we make at Volvo is – and must remain – safety."
>
> *Assar Gabrielsson and Gustaf Larson, the founders of Volvo, 1927*

Braking by Air and Wire

In cars, the brake pressure and the brake force depend on the force applied to the brake pedal. The pressure is boosted by a vacuum taken from the engine's intake manifold and transferred to the brake by a hydraulics system. For large, heavy trucks and buses, this vacuum is not strong enough, and a hydraulic system is inconvenient when it comes to coupling and decoupling trailers. The brake systems of such vehicles therefore work with air pressure.

The force that press the brake pads against the brake disc is applied pneumatically and regulated by the brake pedal. These are electropneumatic brakes which are fully based on by-wire technologies. The compressed air for the pneumatic system is stored in reservoirs and passed to the brakes by electronically controlled modulators. To avoid overheating, fading, and excessive wear, trucks utilize auxiliary brakes such as retarders and engine brakes. The brake system has to coordinate the auxiliary brakes with the service brakes for the different brake system functions that control the speed, maintain vehicle stability and stop the vehicle.

All these brake actuator systems and functions have to work together efficiently and safely. A job for an electronic controller: the electronic brake system (EBS).

Truck Brake System Features

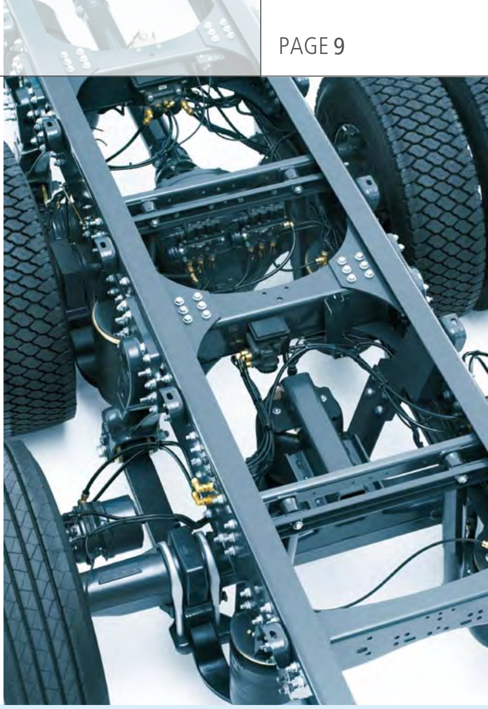
Numerous sensors provide information on a truck's dynamic behavior if it is equipped with an EBS and ESP function: wheel speed, yaw rate, lateral acceleration and steering angle. Moreover, the brake system has to be adaptive to meet the special requirements of trucks, such as coping with unbalanced loads, liftable axles, attached trailers, or service requirements like even wear on the brake pads. Thus, sensor signals such as the axle load and brake lining wear have to be taken into account to determine the best braking strategy. If the truck is equipped with any auxiliary brakes, the characteristics of these brake systems are transmitted to the EBS so that safe and comfortable brake blending control can be achieved.

Braking the Trailer

The brake system on the trailer is separate from the truck. It can be either a conventional pneumatically controlled system or an electronically controlled pneumatic system. The truck and the trailer can have different brake systems: pneumatically or electronically controlled. The trailer has its own energy storage (air pressure tanks) supplied from the truck. The brake control signal to the trailer brake system comes from the truck and can be either purely pneumatic or both electric and pneumatic. The trailer brake system is required to brake its own mass. The coupling force control (CFC) function in the EBS helps to achieve the brake balance between the truck and the trailer.

EBS and Modulators

All the brake functions, including the anti-lock braking system (ABS) and the electronic stability program (ESP), are integrated in the EBS. The



EBS communicates with up to four modulators that control the pneumatic pressure on the brakes. Each modulator interface on the EBS ECU can be connected to either a 1-channel or a 2-channel modulator; this makes the EBS system modular so it can be adapted for different truck variants. Each modulator controls the brake pressure in either one or two circuits depending on whether it is a 1- or 2-channel modulator. This is done in feedback control mode, as the modulator has a pressure sensor for each circuit. Under normal operation the modulators receive a brake pressure request from the EBS ECU on a CAN bus, but if the electronics fail, the modulator brake pressure will be controlled by a pneumatic control signal that comes from the foot brake modulator.

Truck Vehicle Dynamics

A fully loaded, heavy-duty truck can have almost three times the weight of the unloaded truck. Thus, the vehicle dynamics of the truck are heavily influenced by its cargo. With swap bodies, the same truck can be used for different types of transport, which the chassis systems have to adapt to. As the differences in vehicle weight are so large, some

Functions of an Electronic Brake System

Basic brake pressure calculation: Calculates brake pressure based on the brake pedal position and truck load.

Adhesion-optimized brake force distribution: Adapts brake pressure to the individual brake circuits according to axle load distribution and the driving situation.

Brake blending: Automatically distributes the retardation request between service brakes and auxiliary brakes to reduce the load on the service brakes.

Brake assistance: Increases the brake pressure automatically if the brake pedal depressing gradient is high (emergency brake assistance).

Coupling force control: Balances the longitudinal force between truck and trailer in order to equalize the wear on the brakes.

Tilt prevention: Prevents the vehicle tilting forward (important for solo tractors braking downhill).

Wear-optimized brake force distribution: Equalizes the wear on the brake pads on the different axles.

Antilock braking: A safety function (called ABS) that prevents the wheels from locking up.

Drag torque control: Controls engine drag torque if the driven wheels start locking due to the engine drag torque.

External brake demand: Interface used by other ECUs to request braking, for example, in adaptive cruise control.

Fading warning: Brake temperature warning.

Lining wear prediction and wear display: Estimates the mileage to the next brake pad replacement and displays the current pad wear status.

Traction control: Controls drive wheel slip due to engine propulsion in order to maintain traction.

ESP: Includes the yaw control function, which prevents the truck from skidding, and the rollover prevention function.

Differential lock control: Automatically synchronizes the left and right drive wheels during diff-lock engagement, including automatic diff-lock engagement.

trucks have rear axles that can be lifted to reduce tire wear and fuel consumption. It also optimizes traction on the driven axle if the truck is hauling only a light load or none at all. For maneuverability reasons, and to reduce tire wear, some trucks have one or two steerable rear axles. The steering angles on these axles are controlled according to the steering wheel angle and vehicle velocity by an ECU and a hydraulics actuator system. The rear axle steering (RAS) ECU is only active in low speed if the steered axle is the last axle, as otherwise it would affect vehicle stability. For the brake system functions that help the driver to keep the truck on track in demanding traffic and road conditions, the challenge is to handle different truck variants, different loads, and different operation mode conditions safely. The brake system functions have to adapt to different load distributions between the axles and different centers of gravity, which affect load distribution when braking or cornering. When braking hard, each axle needs to be braked against the axle load in the same proportion to utilize the same level of the available road friction on all axles.

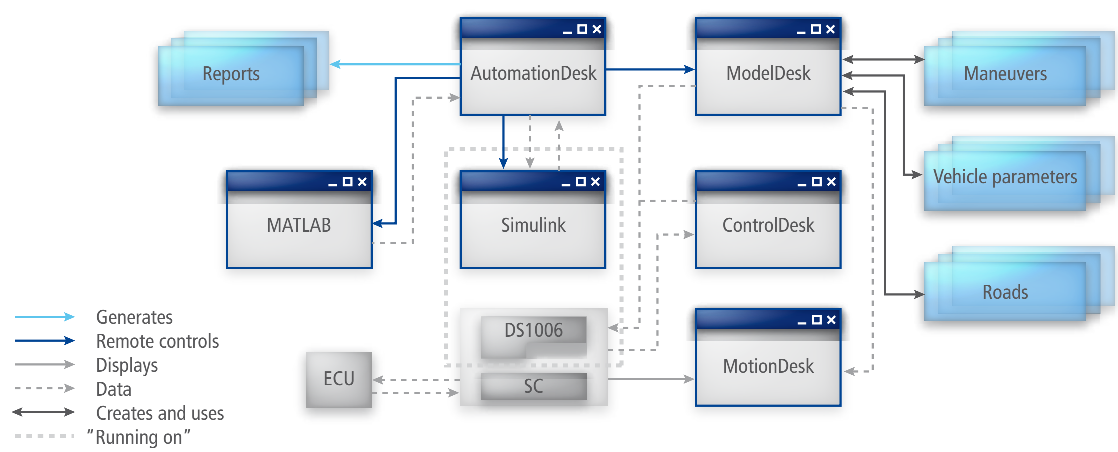
Challenges for the Test System

To test and verify the controllers for future truck brake systems and to ensure their functional safety Volvo 3P decided to install a hardware-in-the-loop (HIL) test system, that can perform manual and automated test runs. The test system has to meet the following challenges:

- Quick, convenient configuration of Volvo 3P's many brake system truck configurations
- Virtualization of the complex pneumatics system
- Testing different ECU generations
- Including the modulator electronics of the EBS
- Including models of auxiliary brakes
- Including a hydraulics model of the rear axle steering system

Thus the HIL simulator model had to represent different truck variants just by changing parameters in the real-time environment. The parameterization of the compiled HIL simulator model had to include the listed submodels that were developed by Volvo 3P, plus all the parameters used for switching either a 1-channel or a 2-channel modulator to the EBS ECU and to the I/O pins, since the I/O used for the 1-channel modulator on a specific modulator position had to be reused if a 2-channel modulator needed to be connected to test the right truck variant.

The dSPACE HIL simulator tool chain, from test case and vehicle parameters definition, to automated batch simulations, to test reports.



High Demands on Productivity

Other important requirements were easy-to-use graphics-based tools to support interactive simulations, create test cases conveniently, and handle all the variants efficiently. The goal was a system that runs with push-button ease, without requiring any engineering resources for development and maintenance. It was important to find a supplier that could deliver a complete HIL simulator tool chain that covered all the requirements, rather than integrate different tools from different suppliers to make a complete HIL simulator.

Basic Setup of the HIL System

dSPACE used Volvo 3P's specifications and the documentation on sensor and actuator characteristics to configure a HIL simulator. The system is based on two DS1006 processor boards for real-time processing, one for the truck and trailer models and the other for the I/O model. The truck's behavior and components are simulated with the Automotive Simulation Models (ASM) created in MATLAB®/Simulink® by dSPACE. Truck parameters, roads and maneuvers are used to configure and parameterize the models. The test cases are defined and performed in dSPACE AutomationDesk®. Each automated test run delivers a report.

Integration of Volvo 3P's Plant Models

To test the EBS and RAS control functions, the respective controlled systems need to be simulated. Volvo 3P's developed plant models of the wheel brake, the pneumatic pressure system and the steering system actuators therefore had to be included in the ASM truck model. The complete HIL simulator model also had to be supplemented by subsystems that could switch in the right modulator brake pressure to the right axle depending on truck variant, and switch the right model wheel speed to the right modulator depending on truck variant. Close integration was achieved thanks to the ASMs' open structure.

> "For truck vehicle dynamics simulation with this electronic brake system simulator we rely on the Automotive Simulation Models (ASM)."
>
> *Per Olsson, Volvo 3P*

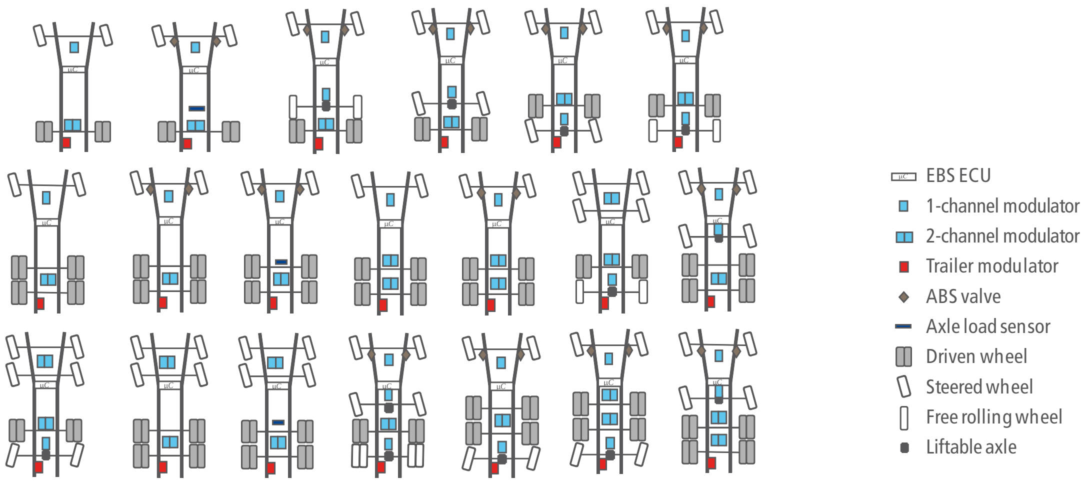
The Simulator's Truck-Specific Features

All the modulators where included as real loads. To save space, just the modulators' printed circuit boards (PCB) and solenoids were assembled in a load box. Two load boxes were built for the HIL simulator for different EBS generations. The I/O model was made generic for both EBS generations, so to change the HIL simulator setup from one EBS generation to the other, all that needs to be done is to change the load box and EBS ECU, and download a new parameter set defined in ModelDesk. It takes less than 5 minutes. Depending on the truck variant, different modulator configurations – either a 1-channel or a 2-channel modulator or none at all – need to be connected to the four modulator positions of the EBS ECU and to the dSPACE Simulator I/O. This was solved by using a dedicated board which Volvo 3P has specified for these applications and which is used in other test systems within the company. This board features load switching, short circuit fault injection and signal conditioning as well as a 1-bit ADC, which were used to obtain isolated differential measurements of the EBS solenoid activations. The boards' configuration is controlled by an RS232 protocol. Volvo 3P created a driver model based on this protocol that runs on the DS1006 board. With parameterizations for the different truck variants, this driver model selects the right modulator configuration.

Variant Handling

Because customer-specific models can be added to the ASM models,

Real-time animation of the simulated truck.



Differences in the truck variants that have to be simulated for brake system controller development.

all the parameters for the standard ASMs and also the submodels added by Volvo 3P can be controlled from ModelDesk, where entire parameter sets can be defined for the HIL simulator configuration for the different truck variants and EBS generations. ModelDesk's graphical support for parameterization makes the whole process intuitive and convenient. It takes just a few mouse clicks to modify the truck geometry – its length, the number of axles, the tire model and so forth. An entire library with the parameters of all the variants can be created and managed in this way.

> "Without this HIL simulator, it would not have been possible to get the necessary test and verification coverage so quickly."
>
> *Per Olsson, Volvo 3P*

Per Olsson
Per Olsson is Technical Specialist for HIL simulations at Volvo 3P in Gothenburg, Sweden

Scope of Simulation

The HIL simulator simulates:

- Truck and trailer dynamics, such as suspension, wheels, tires, roll, pitch and yaw
- Dynamics of the brake system's pneumatic components
- Road and driver characteristics
- Dynamic communication between the EBS ECU and the rest of the truck electrical system
- Rear axle steering system hydraulics
- Manual and automated test runs
- Fault injection tests

The HIL simulator was delivered with a set of automated tests programmed in AutomationDesk:

- ABS, straight-line braking on high and low μ
- ABS, split μ braking
- Sine with dwell
- Closing curve

These automated tests are generic and automatically adapted to the tested truck variant. Volvo 3P will use AutomationDesk to program more test cases that eventually will cover all the EBS functions for all truck variants. With this HIL simulator, Volvo 3P is aiming for an automated test process for the EBS software and parameters releases covering all the truck variants.

Manual Testing

Initially, manual tests are used to define proper maneuvers and test conditions for the automated tests to be created. It is also used for special tests like follow-up tests and resolving problems reported from real test trucks. The configurability of the HIL simulator makes it easy to perform quick manual tests on the effects of EBS parameters on special truck variants that can be difficult to access. During manual tests, results can easily be monitored by 3-D animation.

Test Automation

Automated test runs are defined in AutomationDesk and are ideal for performing reproducible regression tests to verify a complete EBS software and parameter release. All the test cases have variables so that it is possible to execute them at different speeds and load situations, and with different tire or road friction. During batch simulation in AutomationDesk, parameters like the velocity of a maneuver or the weight of the load can change. The truck behavior for such parameters can be presented in tables and diagrams. The results of a complete simulation run are automatically collected in a global result list. With ModelDesk's tool automation interface, individual truck variants can be selected during automated test runs, so multiple variants can be tested overnight. Again, this process is very efficient since the plant model does not need to be recompiled for a new variant.

Ensuring Functional Safety

Since the EBS is safety-critical, it is important to ensure its functionality even if the system is subjected to various faults like sensor defects and functional degradation, and to make sure it performs safely in all operation modes. The HIL simulator gives engineers total control over all EBS sensors, actuators and related CAN signals, which makes it much easier and safer for them to perform these kinds of tests in the HIL simulator compared to tests in real trucks.

First Results

Since its installation, the HIL Simulator has run a lot of tests supporting several EBS software and parameter releases. Thanks to the HIL simulator tests, corrections to the software and parameters were made before they reached the test trucks. This alone has saved a lot of time and money by avoiding costly investigations on the prototype trucks.

Evaluation of dSPACE Products

The HIL simulator matches Volvo 3P's specifications and operates stably. It is a vital tool for the verification of the EBS functions. A lot of things need to work together perfectly for such a test system to deliver the desired results. This HIL simulator delivers, without engineers having to waste time fiddling around with the system. Without the HIL simulator, it would not have been possible to get the needed test and verification coverage of the EBS so quickly. Testing so many different variants reliably by automated means is enormously time-saving. The HIL simulator tool chain supports manual tests, automated tests, animation, and online model parameterization including customer-added submodels, and is a good platform to work with. ■

Per Olsson
Volvo 3P

Outlook

The next step is to automate the tests of all EBS functions according to Volvo 3P's requirements and test specifications. In a further step, the parameters of all truck variants will be included in the simulations and validated. The test cases in AutomationDesk will be extended to increase test depth until a fully automated release process for the EBS parameters and software for all truck variants is achieved. It is also planned to investigate the efforts required for homologation by simulation according to United Nations Economic Commission for Europe (UNECE) regulation 13-H.

Virtual Vehicle Test Drives

Efficient testing processes at Suzuki, featuring component testing and virtual vehicle testing

Since 2000, Suzuki Motor Corporation has been efficiently intensifying their use of dSPACE simulators for the safe development of electronic control units (ECUs). So far, Suzuki uses several simulators for individual ECUs, including body and air-conditioning, as well as engine, transmission and all-wheel drive ECUs. But for the models Kizashi and Swift, a dSPACE virtual vehicle simulator takes over the efficient verification of all vehicle control functions.

Electronic control technology is evolving with features such as adaptive cruise control (ACC), electronic stability programs (ESP), and pre-crash safety systems. At the same time, more functions are integrated into a single ECU to reduce the overall number of ECUs per vehicle. Complex functions are distributed on several networked ECUs. Across-the-board validation of distributed functions is not possible with component simulators for individual ECUs, and real test drives are not safe for testing such complex systems with all the connections and dependencies between functions. A virtual vehicle simulator is required to test the whole ECU network.

Requirements for the Virtual Vehicle

To efficiently validate all of a vehicle's distributed control functions the dSPACE virtual vehicle simulator has to meet the following preconditions:

- Information on each ECU and its functions has to be shared across the whole hardware-in-the-loop (HIL) system.
- Network tests must be possible, even if not all ECUs are available yet.

Component Simulator vs. Virtual Vehicle

To test a single ECU, e.g. for engine management, a component simulator is required. It comes with a dedicated setup for the ECU under test.
To test multiple ECUs or a complete ECU network including all communication aspects, a virtual vehicle simulator is required. Several simulators are closely integrated to represent a complete vehicle.
A virtual vehicle can be configured for different vehicle variants.

- Real loads must be includable and switching between load and model must be automated.
- Test execution must be easy, so that Suzuki's engineers can focus on function design, not test creation.
- Variant handling by switching between vehicle models or parameter sets must be easy to reduce HIL system downtime.
- Suzuki's inhouse tools, e.g., for diagnostics and RAM monitoring, have to be connected to the dSPACE virtual vehicle.

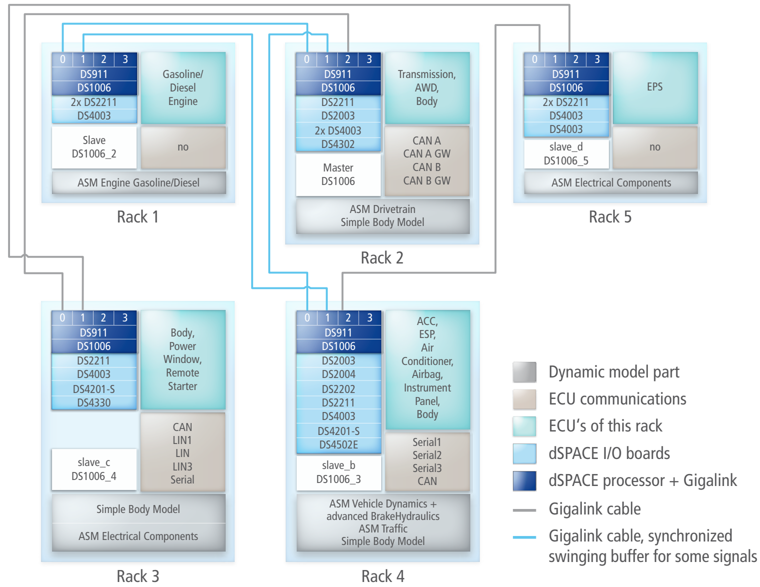
Virtual Vehicle Setup

The simulator consists of five integrated racks that are each configured for certain vehicle components, like engine, body electronics, driver assistance systems, etc. The controlled system models are all taken from dSPACE Automotive Simulation Models (ASM). Besides drivetrain and vehicle dynamics models, this setup also features models for the electrical system and the surrounding traffic to test ACC functionality. Test automation is performed by dSPACE AutomationDesk® together with the Real-Time Testing (RTT) extension. This virtual vehicle simulator can be configured and parameterized for the different variants of Suzuki Kizashi and Swift.

Flexibility of the Virtual Vehicle

The virtual vehicle simulator was designed to handle time-consuming tasks such as changing the target vehicle or vehicle configuration efficiently. For example, the test target engine can be switched from a gasoline engine ECU to a diesel engine ECU in just five minutes. The only manual tasks are releasing and attaching the ECU harnesses. Changing the optional vehicle features such as ACC or air-condition-

Configuration of the virtual vehicle: The dSPACE processor and I/O boards are installed in five racks.



ing, which vary according to the vehicle class, is simply a matter of changing settings in dSPACE ControlDesk®, the experiment software.

Test Process

Any problem detected by the virtual vehicle can be verified thoroughly and in great detail on a component simulator. For example, a closed-loop problem detected by automatic tests overnight can be investigated and corrected the next day

> "The biggest result of installing the dSPACE virtual vehicle simulator was that it enabled us to easily perform important tests that we couldn't even run before."
>
> *Katsuhiko Douhata, SUZUKI MOTOR CORPORATION*

on the component simulator. When the problem is solved the new, correct function can be restored to the virtual vehicle for further automatic testing. Unlike the component simulator, the virtual vehicle contains many parameters that are dynamic, which increases the depth of testing. As long as the tester uses the same test environment for the virtual vehicle simulator and the component simulator, it is possible to run common parameters, common environmental conditions, and common tests. By adding test cases on a daily basis, testers can thoroughly verify control functions with large numbers of conditions.

The Advantages of Restbus Simulation

ECU functions that will be available on future ECUs and ECUs that are not yet available can be implemented by using restbus simulation and CAN gateway functions. Restbus simulation is a method normally applied to ECUs that are only available in virtual form and cannot participate in CAN communication. The CAN gateway functions simulate abnormal states such as data corruption or wrong values on the bus to falsify and correct ECU messages if the available ECU was developed for a different vehicle platform. Combining these methods allowed Suzuki to develop new functions even without a complete ECU network. If an ECU was missing some functions, they were implemented using the two methods. The whole implementation was optimized and the behavior of the other ECUs was tested in this way. Problems that might occur for new functions and ECUs that could have an impact on the whole ECU network were eliminated.

Use of dSPACE Products

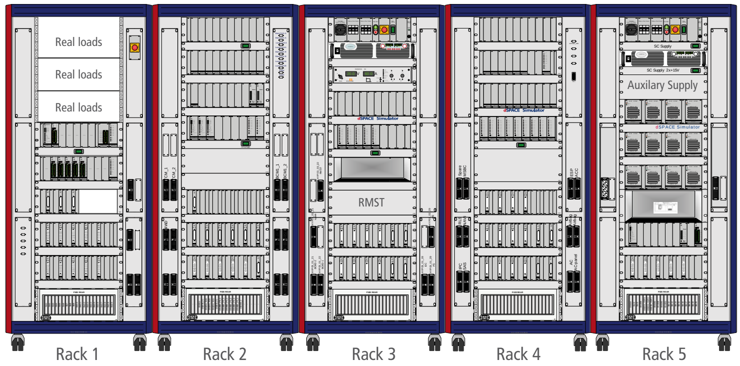
Suzuki had been using dSPACE products for some years, so it was possible to transfer existing test

Yasuhiro Hayashi (on the left)
Yasuhiro Hayashi is General Manager of the automobile electric design department at Suzuki in Shizuoka, Japan.

Katsuhiko Douhata (on the right)
Katsuhiko Douhata is a technical expert for automobile electric design at Suzuki in Shizuoka, Japan.

dSPACE as a Tool Supplier

Suzuki wanted to direct its efforts into developing the test target ECUs and network testing, but doing all the design work for the test equipment would have been very time-consuming. To save time, its virtual vehicle simulator was built up in cooperation with dSPACE engineers. Suzuki's engineers assembled the parameters and made the virtual vehicle compatible with Suzuki's existing simulators. These efforts paid off, and as soon as the new simulator was completed, full ECU function testing and network testing started. High rates of operation have been maintained right up to the present. Suzuki's workload was reduced because dSPACE is a one-stop supplier of simulator development tools, including turnkey engineering.



Setup of the virtual vehicle simulator for testing the complete ECU networks of the new Suzuki models Kizashi and Swift.

> "Compared with a real-world vehicle, verification on the dSPACE Simulator was easy and our benefits of being able to run automated and reproducible tests were huge."
>
> *Katsuhiko Douhata, SUZUKI MOTOR CORPORATION*

cases to the virtual vehicle. With the test automation software AutomationDesk, it was easy to program and extend the test sequences graphically, using high-level library functions. The test data is read from Microsoft Excel® files which were already used for test data handling. For time-critical operations, AutomationDesk also parameterizes and controls Python code, which runs in real time parallel to the Simulink® models.

By combining powertrain, vehicle dynamics, electrical system and environment models from the ASMs, an entire vehicle simulation system was constructed for the virtual vehicle. The ASMs provide the conditions needed for vehicle drive control, to develop functions such as ESP, traction control, and adaptive cruise control. dSPACE ModelDesk is the graphical user interface for intuitive parameterization and parameter set management for the ASMs. The many different variants involved can be handled fluently and easily by changing parameter sets in ModelDesk. Complete engine types, and parameters like engine displacement or distances for the ACC, were defined by graphical means and handled as parameter sets.

Suzuki's entire test track was replicated in ModelDesk to run virtual vehicle dynamics tests and compare them with results from real test drives. This was done for conditions like summer and winter, and for different types of road surfaces.

The state of the vehicle can be observed in 3-D animation MotionDesk, making verification simple and clear.

"We were able to handle variants more easily than we had imagined by changing virtual test tracks, engines, transmissions, and other parameters fluently with dSPACE ModelDesk."

Yasuhiro Hayashi, SUZUKI MOTOR CORPORATION

Future Development

To cope with the challenges of reducing fuel consumption, and electric current consumption, it's important to simulate the behavior of the respective systems early on. In addition to the ASMs already installed, Suzuki will use the ASM Electric Components simulation model to accurately calculate the power consumption of the electric devices that are planned for future developments.

Suzuki is promoting partnerships using HIL with other divisions – not only the electrical components division. The more tests that can be implemented across different divisions, the greater the data's usefulness and the higher its validity. ■

Katsuhiko Douhata
Yasuhiro Hayashi
SUZUKI MOTOR CORPORATION, Japan

"We appreciate the convenient test creation in AutomationDesk's graphical user interface."

Yasuhiro Hayashi, SUZUKI MOTOR CORPORATION

Conclusion

By using the dSPACE virtual vehicle for a large number of ECUs, the functions and loads were tested very efficiently. The virtual vehicle was well designed, with the relays operated via the PC, the replaceable parts arranged on tables in front of the simulators, and the parameters able to be processed via a database. For example, the accuracy of ACC simulation was confirmed. The distance and attenuation were compared with the values for an actual vehicle and found to be correct.

GO for Quality

Ford's electrical/electronics system validation group turns to 'lights out testing' to maximize test coverage

The North American Electrical & Electronics System Validation group at Ford Motor Company has nearly tripled its automated testing capability, adding momentum to the automaker's resolve to strengthen its global market position by producing the highest level of quality cars and trucks, while reducing its overall cost structure.

HIL Simulation Lab

Recently Ford's Electrical/Electronics System Validation Group acquired eight, full-size hardware-in-the-loop (HIL) simulators from dSPACE. The group's state-of-the-art testing lab is now equipped with a total of 13 full-size dSPACE HIL simulators all dedicated to developing and testing embedded systems associated with Ford's electric/electronic (E/E) architecture for future vehicle models. Similar dSPACE HIL systems are applied at Ford facilities in Cologne, Germany, and at its flagship technical center in Dunton, UK.

Automated Test Runs

With the addition of automated test scripts, written with dSPACE AutomationDesk® software, the Electrical Validation Group is now equipped to perform "lights out testing." This means the group has the capability to test E/E systems around the clock, running tests nights and weekends with minimal supervision.

"This capability enables the Electrical/Electronics System Validation Group to conduct more thorough and in-depth testing, while dramatically minimizing its manual testing costs," says Jace Allen, Manager HIL Engineering at dSPACE, Inc. "It will also improve the quality of the modules and electronic systems in the vehicle, which directly leads to better vehicle quality and greater customer satisfaction."

The Benefits of Automated Testing

"The number of distributed functionality across ECUs in vehicle electronics is rapidly growing. Automated testing at the subsystem and vehicle system level is absolutely essential and has become an integral part of the Ford development process," says EESE Global Embedded Software Manager, Florian Frischmuth. "Automated software testing including the real ECU real hardware gives us the ability to cover significantly more conditions and scenarios than manually ever possible."

Smart Power Testing

HIL simulation testing has long been a proven test method to the Electrical/

> "Our ability to automate and execute testing 24/7 has been a key contributor to the success and expansion of our HIL testing activity."
>
> *Florian Frischmuth, Ford*

Electronics System Validation Group. For the past several years, this progressive engineering team has been performing simulation testing for its "Smart Power Distribution Junction Box (SPDJB)" – an electronic control unit (ECU) that analyzes and disseminates many of the car's electronic functions, and thus serves as one of the core components to Ford's E/E architecture.

The smart junction box not only distributes electrical power throughout the vehicle, but it single-handedly manages and monitors loads of electronic functions for powertrain, safety, traction, security, consumer infotainment, remote keyless entry, and other features.

Over 4000 Test Runs

To ensure that this powerful ECU is functioning properly, the Electrical/Electronics System Validation Group put the smart junction box through a rigorous validation process. More than 4000 tests were performed on the ECU around-the-clock, 24/7, utilizing a full-size dSPACE HIL Simulator and dSPACE's AutomationDesk test automation and test management tool.

Flawless Execution and Launch

"The SPDJB is a highly complex module and is being used across numerous vehicle lines," says Wajiha Chahine, EE Validation Group Supervisor. "Our hardware-in-the-loop validation effort was extremely critical to its flawless execution and launch. We have worked very closely with our supplier to validate the ECU software and its functionality. Our response time to identifying, reporting and fixing issues was virtually instantaneous and very effective given the numerous software drops that we had to iterate through. We are extremely pleased with the results."

Testing the E/E System

As part of its expanded automated testing capability, the eight simulators are being used to test E/E components associated with 2011 vehicle model programs. This includes the following ECUs:

- Restraints Control Module / Occupant Classification System (RCM/OCS). With the use of electronic sensors placed around the vehicle, the RCM automatically detects crashes and deploys safety features, such as safety belt pretension and air bag deployment, to protect passengers. The OCS uses classification sensing to determine how to deploy or suppress airbags, depending on the size of passenger(s) in the front seat.
- Infotainment Cluster Module (ICM) fully integrates infotainment customer interaction, with devices such as stereo CD/radios, MP3 players, and DVD entertainment systems, into the vehicle.
- Driver Seat Module
- Remote Climate Control Module
- Smart Power Distribution Junction Box
- Anti-lock Brake System (ABS)
- Adaptive Cruise Control (ACC)
- Audio Control System / Smart Display Module
- Ford Sync™ – Ford's industry-exclusive, voice-activated hands-free in-car communications and entertainment system

The cross-functionality of these consumer-desired technologies poses a much larger challenge to auto companies today – the need to perform systems integration testing across the entire realm of the vehicle electrical and electronics (EE) system.

Understanding the Impacts of Converging Technologies

Most electronic devices are real-time in nature, and thus have to conform to strict timing requirements. Moreover, these devices are typically self-reliant in that they function on their own resources and power. When these devices are integrated into a vehicle, their functionality is dependent on communication and interaction with other technologies in the vehicle (e.g. data, communication and power).

The convergence of these technologies makes systems integration testing critical to ensure proper functionality at both the component level and across the greater E/E architecture.

System and Component Testing

With the use of an HIL simulator, a virtual real-time test environment is established. This environment is scalable. Each HIL simulator can be configured to act as an independent unit to test specific modules, or any number of them can be hooked together to work as a system tester.

"The complete CAN network and all of the power systems in the vehicle need to be managed properly – primarily to optimize power usage and to ensure effective ECU interaction," says Allen.

"These HIL systems provide accurate ECU power measurement, dynamic simulation and control of the CAN network to support system integration testing. Ford has been implementing this cutting-edge testing capability and is able to leverage this in future programs as well."

Automated Diagnostics Process

In addition to performing HIL simulation, the testing environment for the Systems Integration Group will also feature an automated diagnostics process. Using a CAN and Simulink® interface, test engineers will be able to read the ECUs to determine whether diagnostic trouble codes, programmed into the test process, are being detected.

Ford installed eight HIL simulators for automated ECU testing.

Vehicle Dynamics Testing

Additionally, the test environment includes a vehicle dynamics model from dSPACE Automotive Simulation Models (ASM) that will allow the group to perform full-vehicle dynamics simulation on virtual drive courses and test conditions.

"In combination, these tools will help the Ford Systems Integration Group deal more effectively with engineering resources by lowering testing resource costs and improving timing capabilities," says Allen.

"The increase in vehicle electrical content and complexity and the need to develop and validate faster, more robustly and efficiently have proven to be a strong driver for HIL testing," added Frischmuth. "Our ability to automate and execute testing 24/7, and to accurately simulate the vehicle and its operating environment, have been a key contributor to the success and expansion of our HIL testing activity."

> "Our HIL validation effort was extremely critical to the flawless execution and launch of the controllers. We are extremely pleased with the results."
>
> *Wajiha Chahine, Ford*

Wajiha Chahine
Wajiha Chahine is EE Validation Group Supervisor at Ford in Dearborn, USA.

Florian Frischmuth
Florian Frischmuth is Electrical/Electronic Systems Engineering (EESE) Global Embedded Software Manager at Ford in Dearborn, USA.

Computer illustration of the SHEFEX II heat shield experiment planned for early 2011. The navigation systems of the payload nose cone are undergoing intensive pre-launch testing with a dSPACE system.

Beating the Heat

Testing the navigation system for the SHEFEX II heat shield experiment

While developing a new space glider, the German Aerospace Center is investigating new heat shield technologies in their SHEFEX II program. A nose cone mounted on the tip of a high-altitude research rocket is scheduled for launch in early 2011 to test a new type of heat shield constructed from flat panels. This will be easier to maintain and much less expensive than the heat shields on current spacecraft. The navigation system for the reentry nose cone, which carries the payload, is undergoing thorough prior testing on a dSPACE system.

New Type of Heat Shield

The heat shield of the U.S. Space Shuttle has more than 20,000 differently shaped curved panels, each of them fitting just one specific location on the shuttle. This means high manufacturing costs for the panels and high maintenance costs for the heat shield. So the German Aerospace Center (DLR) is trying a completely different approach in SHEFEX II (Sharp Edge Flight Experiment).
All the panels are flat, and there are only a few basic shapes. This simplifies manufacture, and the heat shield also needs much less maintenance work. Moreover, the heat shield's facetted form, with its sharp corners and edges, has better aerodynamic properties. With the SHEFEX technology, the space glider is simple to assemble and therefore less expensive, and can touch down with the same precision as a space shuttle. The SHEFEX program aims to test the new heat shield technology with a high-altitude test rocket flight.

Navigation by IMU, GPS and the Stars

During its return to Earth, the payload nose cone will be guided by 4 small fins called canards. Its speed, position, and attitude (alignment of its longitudinal axis with the direction of flight) have to be known at every point in time. Three different navigation systems are used to measure these variables:

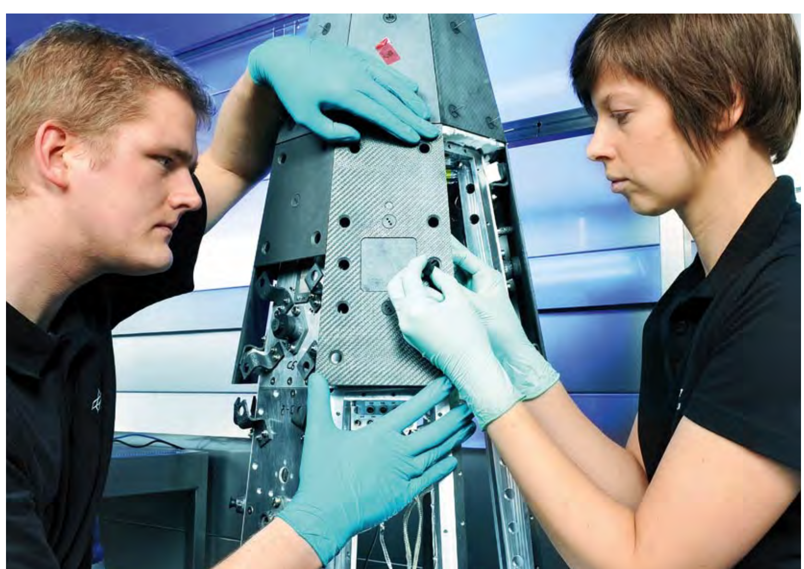
- Inertial measurement unit (IMU): Monitors the high dynamics of the payload nose cone and its attitude in relation to its trajectory (sampling rate 400 Hz)
- Global Positioning System (GPS): Measures the position and speed (sampling rate 1 Hz).
- Star tracker: Navigates by the stars with the aid of a camera (sampling rate 1 Hz).

This combination of three systems ensures high precision and reliability. The dSPACE system's task is to simulate the flight sequence, including navigation signals, in order to test the interaction between all the components before the actual flight.

dSPACE System for Flight Simulation

The dSPACE system for ground-based navigation system tests essentially consists of the DS1006 Processor Board (to calculate the trajectory and the navigation system signals according to the current flight attitude) and various I/O boards (to connect to the navigation systems).
There are several test steps. In the first, the experiment setup consists solely of the dSPACE system and the navigation computer. The actual navigation devices (IMU, GPS, star tracker) are not connected yet, so their signals are all simulated by the dSPACE system. This test phase validates and optimizes the basic functionality of the navigation software. The navigation devices are connected stepwise after the first phase has been completed.
In the second step, the GPS and a

Figure 1: Left: The payload nose cone is just over 2 m long and has flat thermal protection panels.
Right: Mounting the panels. Underneath the panels lie temperature sensors, pressure sensors and other devices for in-flight measurements.



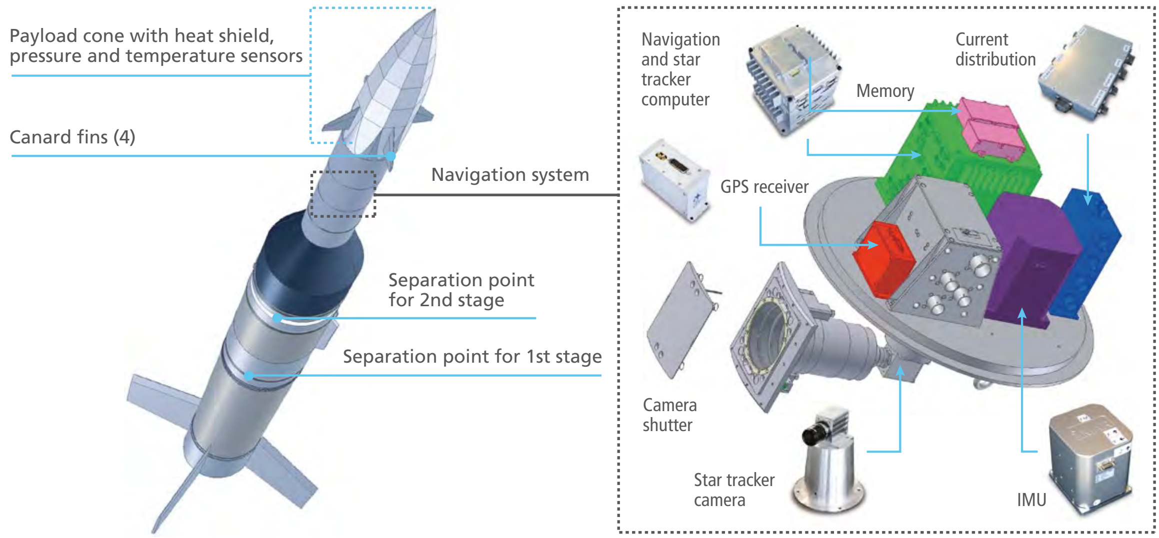


Figure 2: The Brazilian two-stage solid fuel VS-40 rocket is just over 12 m long. It carries the nose cone with the heat shield and the navigation system to an altitude of approx. 140 km.

GPS signal generator are connected so that GPS navigation can be tested. The third step then connects the IMU, which is mounted on an ACUTRONIC rotation table to simulate different craft movements (figure 3). In the final step, the star tracker is integrated into the setup. It receives a simulated map of the stars from a Jenoptik sky simulator. Because of the high velocities involved, time delays in GPS measurements seriously affect the navigation solution. Synchronizing the measurement signals with the navigation computer's internal clock is therefore a major focus. The control models are developed with MATLAB®/Simulink®. The signals and settings of each test are observed and visualized during run time by the experiment software dSPACE ControlDesk®.

Stephen Steffes
Stephen Steffes is a project engineer working on the SHEFEX navigation system at the German Aerospace Center in Bremen, Germany.

Falling at Mach 10 from an Altitude of 140 km

The rocket is due to be launched from the test site in Woomera, Australia, in 2011. It is expected to reach an altitude of 140 km in a flight lasting approx. 10 minutes. After the flight, the payload nose cone with the heat shield will be parachuted down for a soft landing in the desert approx. 830 km away. The IMU can be used for navigation throughout the entire flight, unlike the GPS, which is anticipated to fail for a short time during reentry into the Earth's atmosphere. This is because the payload nose cone will be split to bring it down abruptly from hypersonic to subsonic. It will go into a fast spin during this procedure, making it practically impossible for the GPS antennas to continue receiving signals. At the apogee, the star tracker will be activated to compare the positions of the stars with the stored star maps and to determine the relative attitude of the payload nose cone to the trajectory.

REX Free Flyer, the Reusable Space Glider

In the reentry phase, the approx. 160 sensors in the payload nose cone will collect a wealth of data on the pressure and temperature distribution on the heat shield. SHEFEX engineers are investigating several different thermal protection technologies, most of them the DLR's own fiber ceramic developments. One of them will be active cooling, in which a gas is ejected from pores in the thermal protection panels to form a heat-insulating layer. This will be the first time active cooling is used in the entire history of space travel.

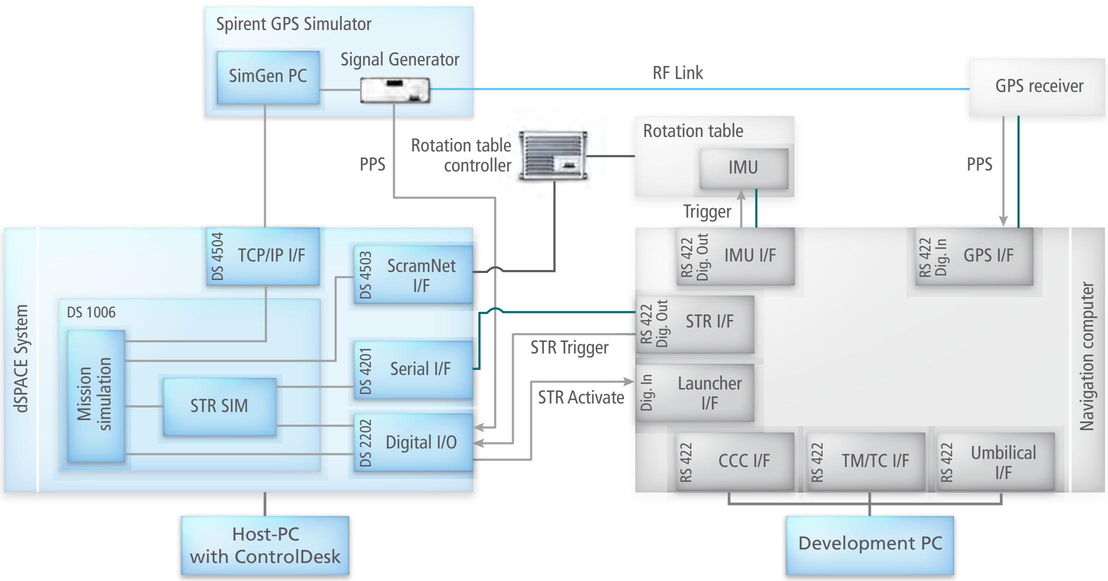


Figure 3: One of the test scenarios. The dSPACE system tests the navigation computer, to which the GPS and the inertial measurement unit (IMU) are connected as real components. The star tracker (STR SIM) is simulated by the dSPACE system.

> "The dSPACE system lets us simulate the entire mission on the ground and test every detail of our navigation system."
>
> *Stephen Steffes, DLR (German Aerospace Center)*

These tests on new heat shield technologies are part of a long-term development project. The ultimate goal is to create a completely new kind of space glider, called the REX Free Flyer, which could become available around 2020 to bring experiments back to earth from a zero-gravity environment. ■

Stephen Steffes
German Aerospace Center

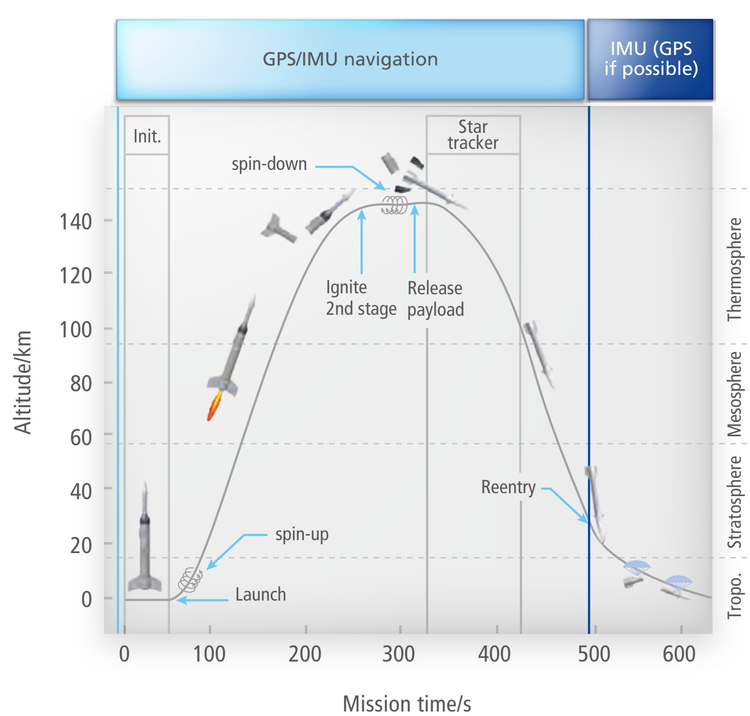


Figure 4: All the navigation systems will be used during the approx. 10-minute flight. During reentry, approx. 160 sensors will measure the temperature and pressure distribution on the heat shield.

Productivity is key when Ford engineers bring their new battery management system to production level

Fusion Hybrid Energized

The control software for the battery management system of the 2010 Ford Fusion Hybrid was developed completely using model-based design and automatic production code generation. Jim Swoish, who is in charge of this project, explains how the development was performed and what was achieved.

Jim Swoish is HEV HV Battery Controls & Software Supervisor at Ford in Dearborn, USA.

> "Using TargetLink, we have had no model-based autocode issues in the field."
>
> *Jim Swoish, Ford*

Could you briefly describe your battery software development project?
Our main goal was to develop an in-house battery control system for the 2010 Fusion Hybrid. We wanted to develop and retain the key intellectual property of the control system. This enabled us to source the battery cells and other components separately and gave Ford a significant strategic advantage. It also gave us the ability to optimize the battery control system with the vehicle control system in order to reduce energy consumption. This was one factor in the Fusion Hybrid achieving the official 41 miles-per-gallon rating (~5.75 l / 100 km), making it the most fuel-efficient mid-size sedan in America at that time.

What were the innovations in this project?
We had two Ford Motor Company firsts. These were the first in-house development of software for a Hybrid Battery Energy Control Module – where functional safety is crucial – and the first use of model-based development to autocode software for a production program.

What did the actual development process look like?
We completely relied on model-based design (MBD) and autocoding. This allowed the engineers to focus on developing and testing the correct behavior of the safety-critical system without laborious hours of handcoding. This, in turn, sped up the overall development and saved resources. We developed the code from the ground up, so all aspects of the battery control system had to be developed from scratch. There was no legacy code. Most of the code – about 80 to 85 % – was autocoded, with the exception of lower-level routines. Our target hardware utilized a 32-bit floating-point microprocessor that proved to be more than adequate for the task.

HEV HV Battery Controls & Software Supervisor Jim Swoish and his project team received the esteemed Henry Ford Award in recognition of the battery software they developed for the 2010 Ford Fusion.

> "We chose model-based design and autocoding with TargetLink to do more development in less time. Mission accomplished!"
>
> *Jim Swoish, Ford*

What size team did you have, and how long did the development take?
On average we had 4 people doing model-based design and 10 other team members working on requirements, handcoding, and hardware-in-the-loop (HIL) systems, and on developing model-based processes and best practices.
The project started in early 2006 and went into production on the 2010 Ford Fusion Hybrid in early 2009. The Fusion was named Motor Trend's 2010 Car of The Year and has received dozens of other awards. Our project team received the Henry Ford Excellence Award.

This was all with TargetLink?
Yes, the battery team used TargetLink for the whole process from function design to software implementation. One of the advantages of model-based development was that we could use simulation for early verification. TargetLink also greatly simplified our testing process by providing a seamless simulation environment for both model-in-the-loop (MIL) and software-in-the-loop (SIL) testing. Especially switching between the modes and comparing results is very convenient and helps to understand if the generated code behaves as desired.

What modeling guidelines did you use?
We used some early guideline documents to start off with, but then continued to develop our own. This helps the modelers maintain common structures for similar functionality. It also drives the organization and structure of even unique features to the point that it is difficult to tell that different people worked on the various parts.

Did you utilize the capabilities of the dSPACE Data Dictionary?
Yes, a lot! Maintaining the data dictionary and practicing proper check-out and check-in procedures is critical. We also established strict naming conventions and a formal change control process.

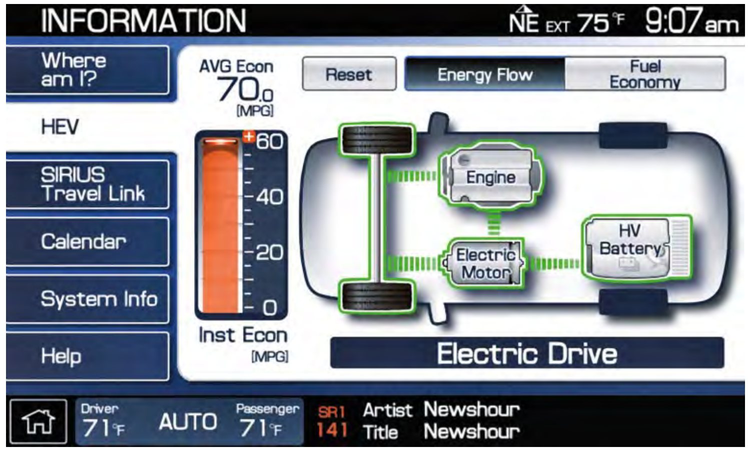
What major challenges did you face?
Some of the biggest challenges were in software management and archive database applications. Most such tools are designed for text file merging and branching. Using the model as the master presented some challenges initially. After that, it was a challenge to develop an automated build tool that would handle all the steps involved in autocoding, compiling, linking, etc. We now can go from a complete set of models to a hex file in 30 minutes just by pressing one button.

What was your experience with TargetLink?
Very good. We did have only a few minor issues with the tool during

With TargetLink, Ford employee Michael Schamber stays on top of things.

Profile of Ford Fusion Hybrid

- 2.5 L /152 hp gasoline engine
- Permanent magnet AC synchronous motor, 106 hp
- 275-volt sealed nickel-metal-hydride (NiMH) battery
- Full hybrid
- Regenerative braking



Instrument panel with energy flow display in the Ford Fusion Hybrid.

development, but none of them were job stoppers. The support we received was very good and the issues were resolved quickly. Thanks to a proper model structure and variable naming, the code is highly readable and well structured. Code efficiency is good, and with attention to best practices we have been able to continue increasing it.
The main reason we chose model-based development with autocoding was to do more development in less time. Mission accomplished! To date we have had no model-based autocode issues in the field.

Do you have plans to use TargetLink in any future projects?
Yes, our next generation of batteries and control systems are already well along – all done with TargetLink. We continue to work toward more automation and test coverage as far ahead in the process as possible. We have efforts in progress to further develop MIL and SIL testing capability. Our goal is to reduce the defects found at the HIL level to zero early on. A high bar to set, but we have seen tremendous improvement over the last 4 years.

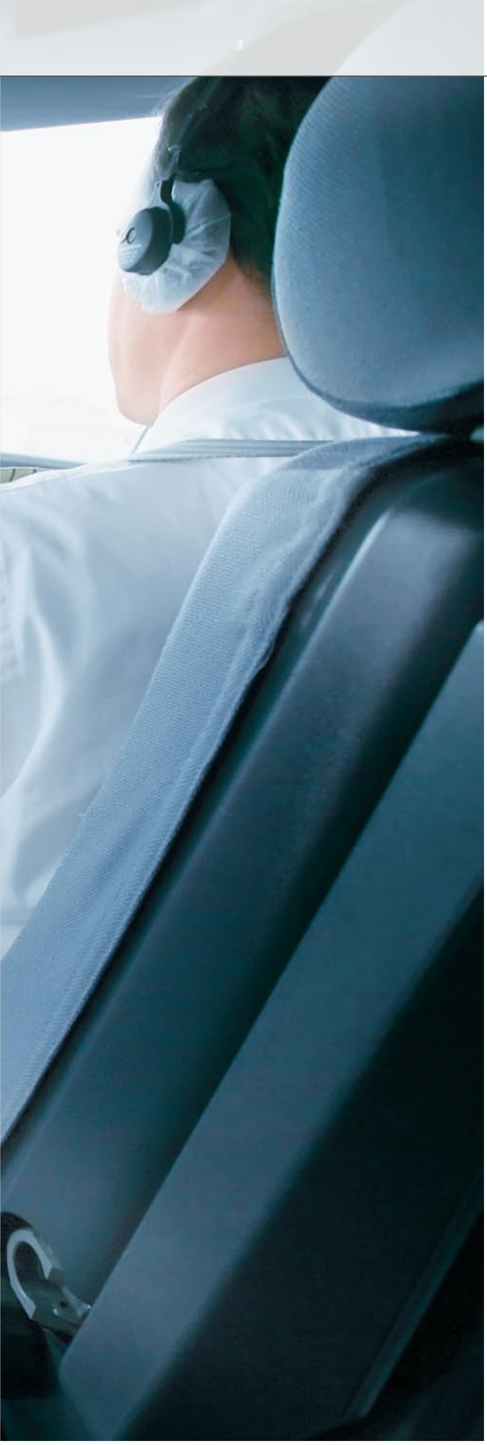
Many thanks for talking to us, Mr. Swoish!

The Ford Fusion is based on second-generation hybrid technology.

Using active mains filters as a new approach to suppressing interference in aircraft electrical systems

Onboard Power

Reducing aircraft weight decreases kerosene consumption and protects the environment. One method is to use lightweight electrical components instead of heavy hydraulic and pneumatic systems. This means that a high-quality power supply is absolutely essential, and also requires powerful interference suppression. Liebherr-Elektronik GmbH used dSPACE tools to develop a prototype of an active mains filter.



Active mains filters will be used in the future, for example, in the Airbus A380 Electrical-Back Up Hydraulic Actuator.

The Challenge: High-Quality Power Supply on Board

Everyone knows the noises a cell phone causes when it is near a loudspeaker and receives a text message. This interference is audible, but there is also inaudible interference such as that caused by phone battery chargers. These draw nonsinusoidal current from the mains and distort the voltage (figure 1). The fundamental frequency is overlaid by harmonics that negatively affect the entire supply network. They lead to higher losses in transformers, generators and lines; interfere with sensitive devices; and can even cause mains overload. In household appliances this is usually harmless, but in aircraft the resulting malfunctions can have serious consequences. This can be avoided by using an active mains filter that prevents such distortions from getting into the onboard power supply in the first place.

Filters Suppress Interference

In aircraft, electric energy is generated by three-phase generators driven by the turbines. Each electric consumer must first generate direct

The Airbus A380 Electrical-Back Up Hydraulic Actuator

is an electrical, hydrostatic actuator used as a backup system. In normal operation, the pump is switched off, and the actuator is moved by the aircraft's internal hydraulic pressure. If both of the aircraft's hydraulic circuits fail, the electrical pump springs into action to generate the necessary oil pressure directly on the actuator. Liebherr-Elektronik GmbH develops and produces parts for these control and power electronics jointly with dSPACE.
In the future, the active mains filter will be a component in these electronics, where it will rectify the three-phase variable-frequency electrical system (360 - 800 Hz), ensuring that the interference generated in the rectification does not get into the aircraft's power supply. The main aim in using the active filter is to reduce the masses and volumes of the power electronics, which in turn will reduce kerosene consumption.

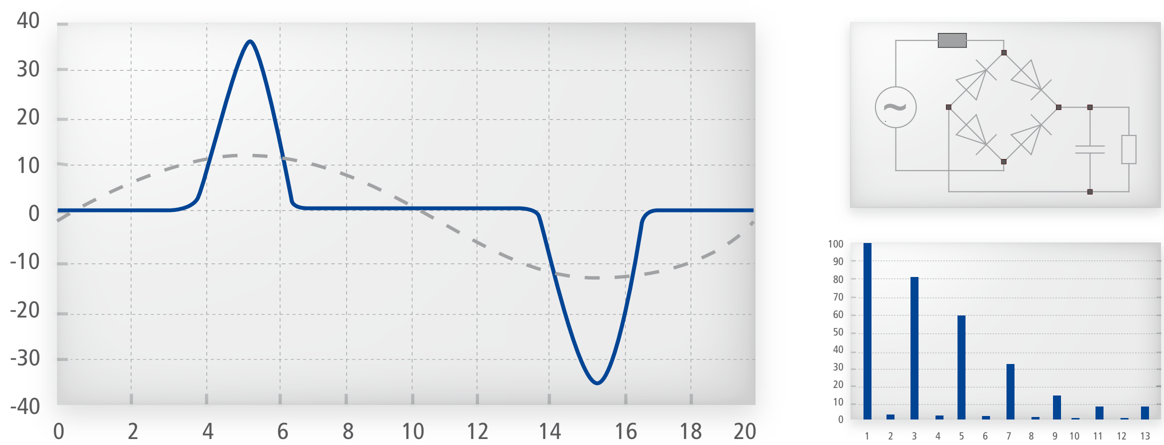


Figure 1: The rectifier shown here draws nonsinusoidal current from the supply mains (upper right). This causes additional losses in transformers and "dents" in the phase voltage. The ideal current is shown as a dotted line (left). The total range indicates the large harmonics content (lower right).

> "With the dSPACE prototyping system, we were able to develop a fully functioning active mains filter for aircraft in just a few months."
>
> *Sebastian Liebig, Liebherr-Elektronik GmbH*

current from the three-phase variable-frequency network (360 to 800 Hz). Up to now, this was done by 12-pulse rectifiers (special rectifiers with a 12-pulse transformer) or by active power factor correction (PFC). An active mains filter is a superior alternative to PFC because it can compensate for single harmonics, reactive power, asymmetrical voltages or even overvoltages, depending on how it is designed.

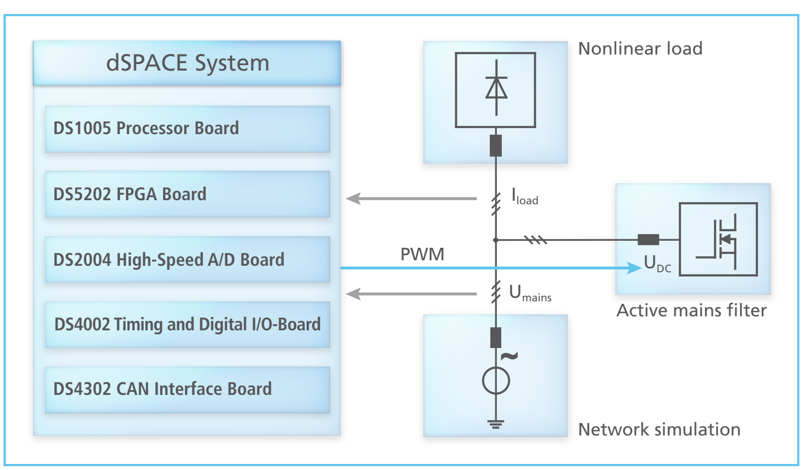
Active Mains Filters Improve Network Quality

Active mains filters have not been used in aircraft yet because the high frequency of the aircraft electrical system (800 Hz, relevant harmonics up to 10 kHz) requires extremely quick control. But now new, fast-switching semiconductors are making active mains filters a viable proposition. The ability to suppress interference in several devices simultaneously by means of one active mains filter is particularly attractive. This is much more economical than installing a separate filter for each device. Moreover, the active mains filter only has to be designed for the currents that need correcting, so its dimensions and weight are much lower than in an active PFC, which is designed for all currents. In addition, the high switching frequencies make it possible to use compact semiconductor switches.

Prototype Development with a dSPACE Processor Board

The primary requirement for implementing an active mains filter is powerful hardware, needed to achieve high switching frequencies of up to 100 kHz and compute the complex control algorithms in real time. The dSPACE system (figure 2) consists of a DS1005 Processor Board and several I/O boards. These include the new DS5202 FPGA Base Board with the EV1048 piggyback module, which enables pulse width modulation (PWM) with center-aligned sampling of clocked currents

Figure 2: The laboratory setup consists of a three-phase network simulation, a nonlinear consumer (rectifier with ohmic load), the active mains filter and the dSPACE Expansion Box, which is operated from ControlDesk on a laptop.



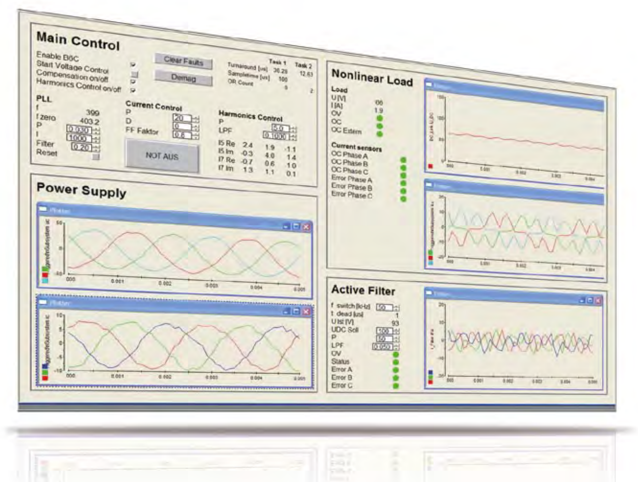


Figure 3: ControlDesk layout showing the measured voltages and currents and the correction signals.

and voltages. Further analog signals such as load currents I_{Load} or temperature sensors are read in via the DS2004 High-Speed A/D Board. The system currently achieves a switching frequency of 50 kHz with ease, so the entire control algorithm is computed in less than 20 µs. Thanks to multitasking, the computing power can be distributed flexibly, meaning that less important digital I/Os and temperature signals can be evaluated at considerably lower speeds, allowing additional resources to be assigned to more important tasks. After controller design is completed in MATLAB®, all the sensor signals and arbitrary virtual variables can be observed during run time by means of dSPACE ControlDesk®, which is an extremely convenient way to perform error detection and parameter optimization (figure 3).

Result

With the aid of the dSPACE rapid prototyping system, it was shown that an active mains filter can be used reliably despite a variable electrical system frequency. The harmonics are successfully compensated for. Measurements confirmed that a device with an active mains filter fulfills the relevant standards. This is a major step along the long road to aviation approval.

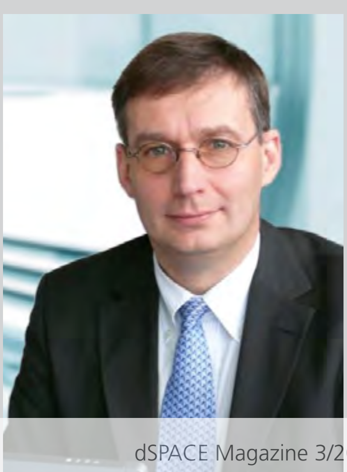
Outlook

The next task will be to optimize the algorithm in order to increase the 50 kHz switching frequency. This is important for downsizing passive components such as inductivities and intermediate circuit capacitors and for enhancing operational safety. The more frequently the model is computed, the better unexpected events such as voltage transients or phase failures can be detected and compensated for. The high safety levels required in aviation make such robustness an absolute necessity.

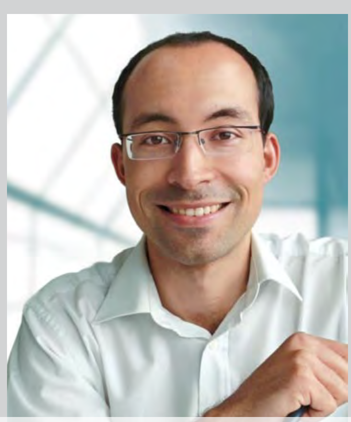
The active filter is put into series production with a digital signal processor (DSP) from Texas Instruments. The developed algorithms are turned into production code for this DSP by means of dSPACE TargetLink®. ■

Alfred Engler, Sebastian Liebig
Liebherr-Elektronik GmbH

Alfred Engler
is Head of Advance Development (EV) at Liebherr-Elektronik GmbH in Lindau, Germany.



Sebastian Liebig
is an engineer working in Advance Development at Liebherr-Elektronik GmbH in Lindau, Germany.



Conclusion

- The electrification of aircraft makes new measures for high-quality electrical systems essential.
- An active mains filter can be included in the architecture of an aircraft's electrical system, and complies with the mandatory limits.
- The go-ahead has been given to use TargetLink to develop the system up to production level.

Welcome to the Future!

MicroAutoBox II: Flexible, powerful, and ready for future applications

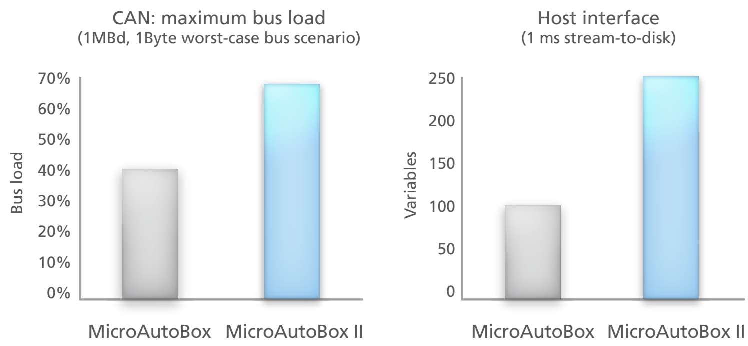
dSPACE proudly presents MicroAutoBox II, the advanced version of our long-running success story, MicroAutoBox. This flexible, open prototyping system combines Ethernet interfaces providing versatile connection options, an integrated FPGA board for application-specific extensions, and I/O interfaces that are faster and more powerful than ever. This new generation is raising performance standards.

The Future Challenges for Prototyping Systems

New driver assistance systems, electric and hybrid drive concepts, combustion engine optimization: The trends in automotive electronics are making increasingly tough demands on development tools. Flexible networking is essential. Automotive bus systems need to be supported, and standard PC interfaces are also becoming more important. The prototyping systems have to be extendable and configurable to meet the needs of specific applications. For example: In the development of electric drive concepts, specific I/O such as resolver interfaces must be added as and when required, but they do not have to be supplied with every system.

Ready for the Future

One answer to the challenges of constant change is to use flexible, open tools that future-proof investments in the long term. So dSPACE has revamped its tried and tested MicroAutoBox, giving it a new, flexible, open architecture.



The performance of the MicroAutoBox II communication interfaces has been further improved (as the CAN and host interfaces show).

The result: MicroAutoBox II. New Ethernet and USB interfaces ensure openness, and modern FPGA technology provides the necessary flexibility. With its powerful 900-MHz processor, it is currently the fastest fanless prototyping compact system for developing automotive embedded applications.

Keeping the Best

The MicroAutoBox's proven strength such as its compact size and passive cooling live on in the new model. The permitted operating temperature is still -40°C to +85°C (-40 ... 185 °F) – a true benchmark! Its mechanical robustness is better than ever. Users can operate the MicroAutoBox II via a convenient RTI blockset just as they always did to test new control functions quickly in the vehicle.

Ethernet Interfaces for Openness

MicroAutoBox II has an Ethernet interface for direct connection to a host PC, for tasks such as loading models and reading or adjusting parameters in ControlDesk®. It also uses the Ethernet I/O interface to communicate with devices like embedded PCs and measurement systems, to process their data and signals in the controller model. There is a new RTI blockset for configuring the Ethernet I/O interface.

All-New Powerful I/O Interfaces

The I/O interfaces on the MicroAutoBox II are completely new. They provide powerful digital I/O

Modern FPGA Technology and Ethernet Interfaces for Greater Flexibility and Openness

(with 40 inputs and 40 outputs) for all kinds of applications. There are also sixteen fast 16-bit analog inputs with a sampling rate of 1 MSample/s, ideal for precisely capturing dynamic signals. And there's no need to worry about growing volumes of bus traffic: The FlexRay, CAN and LIN channels have been given a significant performance boost by new controllers and a new interface implementation, respectively.

Maximum Flexibility with FPGA

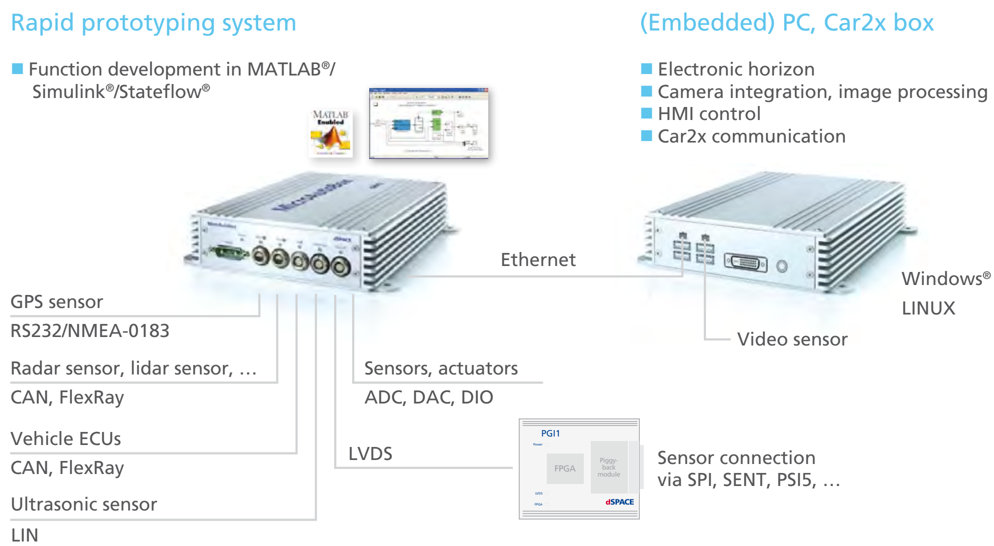
The integrated FPGA technology (Xilinx® SPARTAN-6 FPGA) opens up completely new potential. With the new architecture, computing-intensive data preprocessing can run on the FPGA, so engineers can implement very fast control loops. Initially, the programming will be done by dSPACE's Engineering Service, but users will soon be able to create their own FPGA designs with a Simulink® blockset. The I/O interfaces can be extended to meet the needs of specific applications, using additional modules that are currently under development. The modules will be completely integrated into the MicroAutoBox by mounting them on the FPGA carrier board. One module due for launch very soon will be used to control electric motors in support of current developments in drivetrain electrification.

Other Enhancements

One of MicroAutoBox's special strengths, its fast boot-up behavior, is now even quicker: Similar to a real ECU, it can now perform immediate boot-up in ECU networks. A USB interface has been integrated for data logging to external hard drives or USB sticks.

Summary

The new MicroAutoBox II's compact, robust design is as impressive as ever – and when it comes to performance, openness and flexibility, it sets new standards. In short, it's ready for the future. The transition to MicroAutoBox II is easy for customers who already use MicroAutoBoxes. They can continue using their familiar tool environment such as ControlDesk – or ControlDesk Next Generation – plus Real-Time Interface. All they need is a current dSPACE software release. ■



The wide range of connection options on the MicroAutoBox II is ideal for developing intelligent driver assistance systems.

Application Examples

Developing Cylinder Pressure-Based Controllers

For the latest adaptive engine control developments, the cylinder pressures need to be captured angle-synchronously and with high precision for several cylinders at once. The characteristics calculated from the pressures have to be used for parameterizing the subsequent injections cycle. Such applications have several hundred thousand measurement values per second, and the new A/D interfaces are ideally suited to this. Being able to also use external, angle-synchronous hardware triggering of the AD converters and burst data transmission greatly reduces the load on the real-time processor during measurement. This means that sufficient capacity is available for model computation. The optimized I/O connection means that cylinder pressures for up to 16 cylinders can be processed with a resolution of 0.1° at a corresponding engine speed.

Electrifying the Powertrain

Using electric motors in hybrid vehicles and electric vehicles, and also for the electrification of auxiliary units of conventional vehicles, currently promises the greatest potential for reducing fuel consumption and emissions. A wide range of different electric motors can be used depending on the application – brushless direct current motors, synchronous and asynchronous motors. Rapid control prototyping systems have to support the different position capture and control methods used with these motors. For this type of application, MicroAutoBox II users will soon be able to use an additional module that is tailor-made for controlling electric motors. This will be plugged onto the FPGA-based carrier board, which is designed for different I/O extensions, and will be completely integrated into MicroAutoBox II.

Profile

- Compact, robust prototyping system for in-vehicle use
- Powerful I/O including CAN, LIN, K/L-line, FlexRay, and Ethernet interfaces, plus an LVDS/bypass interface
- High processing power with passive cooling and a small footprint
- Integrated FPGA board for application-specific extensions
- Live data recording (flight recorder) on USB mass storage device

High-precision cell voltage emulation with a dSPACE HIL simulator

Electrifying

The task of battery management systems is to create optimum conditions for all the operating points of high-voltage batteries. These systems are classified as safety-critical, and their functions and in-vehicle communication require comprehensive testing. dSPACE now presents new hardware and software for performing these tests.

The Function of a Battery Management System

Batteries for hybrid vehicles and electric vehicles frequently consist of single cells connected in series. Li-ion cells are the ones generally used, with a nominal voltage of approx. 3.6 V and a charging voltage of 4.2 V. Voltages of more than 600 V are achieved by series connection. When single cells are connected in series, the whole battery stack is affected if one of them fails or weakens. Thus, the main function of battery management systems (BMS) in modern hybrid or electrical vehicles is to optimize the longevity of individual cells by protecting them against overload, deep discharge and thermal overload. They do this by cell balancing, which ensures that all cells constantly have the same charge state. A BMS also estimates the remaining mileage from the available parameters and provides it to the higher-level hybrid ECU. Communication usually runs via the vehicle's CAN bus.

The Structure of a BMS

A BMS is divided into two parts, the BMS ECU itself and the cell module (CM). They are connected to one another via an isolated CAN (figure 1). Each CM is assigned to a cell stack – a subset of all the single battery cells.The CM is responsible for measuring cell voltages and initiating discharge in specific single cells. To do so, it has a switch (transistor) for each cell. When the transistor is switched on, it connects the cell to a load via a resistance. If some cells have a higher voltage than the others, the ECU discharges them by activating their associated switches. This mechanism keeps all the battery's cells at the same charge level, leveling out differences in cell behavior.

HIL Tests for BMS

If only the control strategy for the BMS has to be tested, it is only necessary to test the BMS ECU on its own. The cell modules are then simulated by restbus simulation via

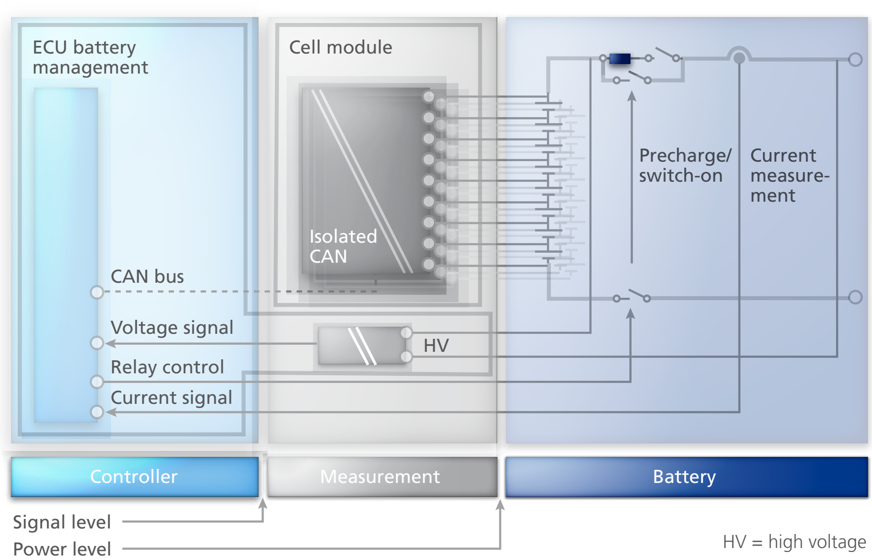


Figure 1: Interfaces in the HIL testing of battery management systems.

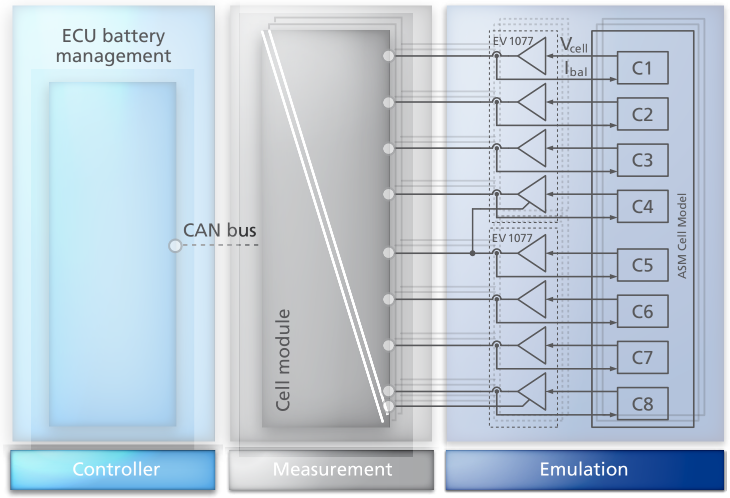


Figure 2: Instead of the real battery cells, the EV1077 cell emulation modules are connected to the cell modules. The EV1077s are controlled by the ASM Cell Model.

CAN. To test the entire battery management system, all the CMs, or at least one of them, have to be integrated into the HIL system. This requires a controlled system consisting of a real-time-capable battery simulation model and a cell voltage emulator that outputs the analog terminal voltage. dSPACE offers the cell model from the Automotive Simulation Models (ASM) and the EV1077 Battery Cell Emulation Module for this (figure 2).

Real-Time-Capable Battery Models

Unlike conventional battery models such as the ones used for simulating vehicle electrical systems, models for battery management systems have to simulate a battery's behavior as a number of connected single cells. The cell model represents the cell voltage and charge state of one battery cell. It has to include the typical cell behaviors of different cell technologies such as Li-ions, NiMH and lead. This includes differences in charging and discharging, and also dynamic behavior during load variations and leakage currents (for example, due to gassing effects). The model of the battery is made up of individual cell models. It needs to support the series connection of cells so that the necessary voltage level can be reached, and also parallel connection with the resulting currents. It must be possible to adjust cell parameters and states (such as the internal resistance or the initial charge state) individually, and also to make the resulting cell voltages available to the BMS individually. The cell balancing currents that the BMS outputs must also be included.

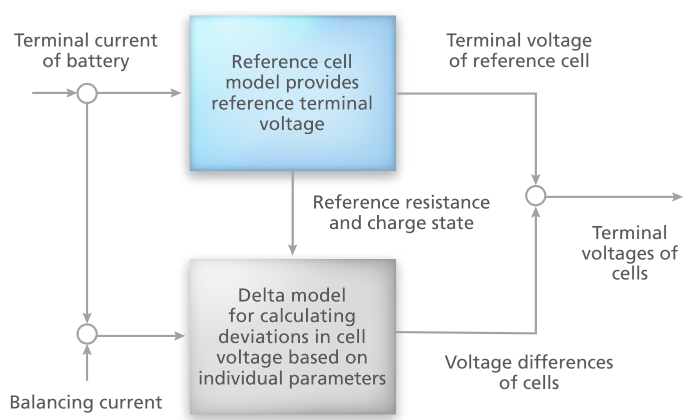
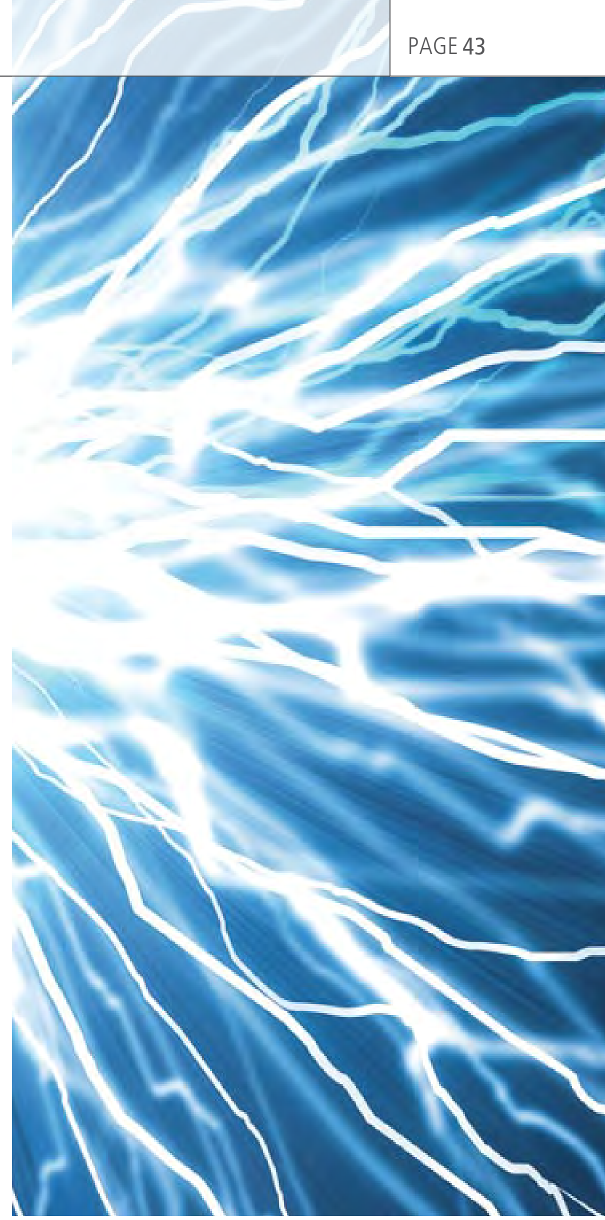


Figure 3: The input values to the cell network are the input current to the reference cell. The delta model calculates the n-th cell's deviation from the terminal voltage. The terminal voltage of the n-th cell can then be computed from the reference cell's terminal voltage and the calculated deviation.



ASM Cell Model

The ASM cell model consists of a cell voltage model and a charge state model. With the cell voltage model, individual physical effects such as internal resistance, diffusion and double-layer capacity can be parameterized. The charge state model deals with the cell's charge and discharge currents, and also with leakage currents such as those caused by gassing effects in the charging of NiMH cells.
With this single cell model as a starting point, a series string of n cells can be created by connecting n single models. However, if there are a large number of cells, this type of model becomes difficult to handle and may not be real-time-capable. Another method is to simulate only single cells and to scale the output variables by multiplying them by the number of cells. This is of little use in testing a BMS, however, because it is not possible to represent the parameter spreads and different charge states of individual cells.

Reference and Delta Models

The approach used in the ASMs is to connect single cells of identical design to create a series string of cells. This consists of a reference cell model that describes the basic behavior of the cell type used, and a delta model that computes the deviation of each individual cell's voltage from the reference voltage. The capacity, initial charge state and deviation from the reference value of the internal resistance can be specified for each cell.
This new approach to describing a cell string has a very positive effect on the computing effort for simulation. In real-time simulation on a DS1006, the execution time needed by the reference-and-delta-model approach is lower by a factor of 12 than a series connection of 100 single cell models. Even more time is saved in offline simulation. Moreover, if vector calculations are used, the complexity of the delta model is independent of the number of cells (figure 3).

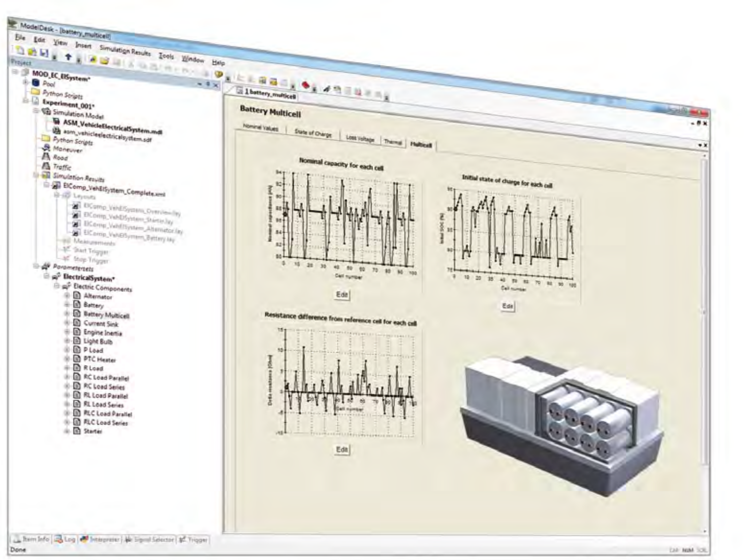


Figure 4: User interface in ModelDesk for configuring and parameterizing the cell model.

The model description for the cell level has even greater parameterization requirements than that for the battery level. However, even multicell simulation for a battery management system is manageable with the intuitive access provided by ModelDesk (figure 4).

Hardware Requirements for Cell Voltage Emulation

In emulation, cell voltages must be connected in series in the same way as in a real battery, because the measurements for cell voltage on the CM side run via one line only. This is connected to the cell connector. The emulation therefore has to consist of galvanically isolated voltage sources. Li-ion cells have a very flat discharge characteristic (figure 5). The ECU therefore performs voltage measure-

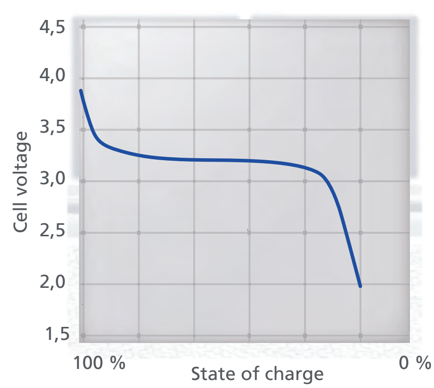


Figure 5: The charge state of Li-ion battery cells is read off from the very flat voltage/charge characteristic. This means that to test battery management systems (BMS), a cell voltage has to be emulated with high precision.

ment with high precision, meaning that high precision is also required in the cell voltage emulation. Deviations of more than 2 mV are usually not to be tolerated. The cell balancing function puts a load of several hundred mA on the emulated voltage source. The precision of the voltage must be preserved under load, and any voltage drop on the lines from the emulation to the ECU must be compensated for. The measured balancing current is included to ensure correct simulation of a cell's charge state.

Fault simulation

A complete HIL simulation also covers faulty battery states. This can involve simulating defective cells with modified parameters, for example, for internal resistance or capacity, and simulating a broken wire or a short circuit. A broken wire can be simulated for the measurement line to the CM, and also for the cell connector, which electrically separates the entire cell network if it is interrupted.

High Dynamics Requirements

When the load on the battery changes quickly, the voltage changes on all the cells almost simultaneously. Thus, one requirement is that all the individually simulated cells must be able to change their voltage

Technical Data for EV1077* Emulation Electronics:

Hardware structure	36/40 cells per 19" 3-HE module
Output voltage	0...6 V
Resolution	120 µV
Precision (across working temperature range)	+/-1.5 mV
Working temperature (environment)	10…50 °C
Maximum current (sink/source)	1 A, switchable in parallel
Isolation	60 V between the cells of a module 1000 V between cell and environment
Connection	dSPACE LVDS link (copper cable or optic cable)
Maximum update rate for all cells	1 kHz
Fault simulation	Broken wire between ECU and battery

*) *Modifications possible.*

within one model clock cycle. Fast transmission of reference values and a high control speed for the output voltage are also essential. Other typical requirements are short-circuit protection, overload protection, easy extendability to the required number of cells, and high insulation strength because series connection can cause dangerous voltages.

Emulation Electronics Setup

Cell voltage emulation is performed with controllable buffer amplifier modules, the number of which is configured to match the battery type (figure 6). The modules supply an adjustable voltage from 0 to 6 volt. This relatively wide range means that damaged cells can be emulated. For example, a short-circuited cell can be emulated by outputting 0 V, and a voltage higher than the nominal voltage simulates a cell's increased internal resistance during charging.

The voltage is output with a precision of +/-1.5 mV across the entire working temperature range. The voltage is galvanically isolated, allowing the modules to be connected in series up to a voltage of 800 V.

A reference value step is corrected completely in less than 500 µs.

Fast data transmission means that a change to all the cell's voltages takes less than 1 ms.

The maximum current that can be supplied or sunk is 1 A, which is sufficient for the usual balancing currents. For special requirements, up to four modules can be connected in parallel to quadruple the maximum current.

HIL Integration of the Emulation Unit

In view of the high precision and galvanic isolation required, the obvious solution is control via a digital interface. This makes it easier to transmit digital signals in isolated form, and also to transmit reference values with less interference than with an analog interface. The requirement for fast voltage changes necessitates fast data transmission. This can be achieved by the dSPACE LVDS interface, which connects the real-time processor with the cell emulation. Transmission can run via copper cable or an optic cable across a distance of up to 100 m.

A control board receives the reference values for the individual cells from the real-time processor and transmits the galvanically isolated data to the individual modules for cell voltage emulation (figure 4). One control board can communicate with up to 128 cells. It receives not only the reference values, but also the control commands that switch the relays. In the other direction, the real-time processor receives information on the current flowing in each cell and on the temperature of a module. If the output stage of a module is overloaded, an error message is also output by this route.

The relays on a module set up the connection to the ECU and also disconnect it for the purposes of failure simulation. An external relay can disconnect the line to the next channel to simulate a break in the cell connector. A special relay switch ensures that no unrealistic voltage peaks occur during disconnection and reconnection. ■

Highly Precise Voltage Sources and Scalable Cell Model for Emulating High-Voltage Batteries

Conclusion

For HIL tests on battery management systems (BMS), high-voltage batteries have to be simulated at cell level. To make this possible, dSPACE provides a scalable, real-time-capable cell model and a high-precision emulation unit to output the cell terminal voltage. The two are combined to set up an HIL simulator that runs tests reproducibly under automatic control. The system can handle component testing on an individual ECU and also integration testing on an ECU network.

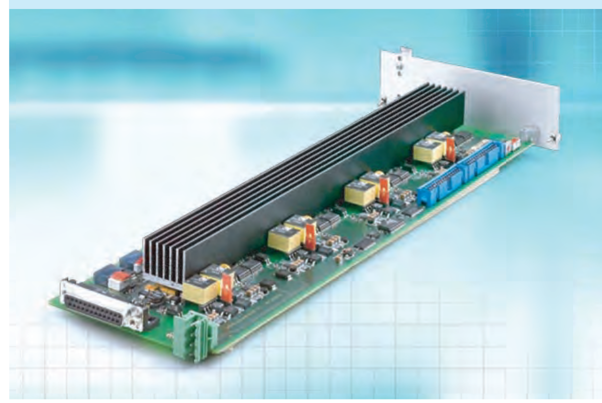


Figure 6: The new EV1077 Battery Cell Voltage Emulation Module emulates a controllable, highly precise terminal voltage for single battery cells.

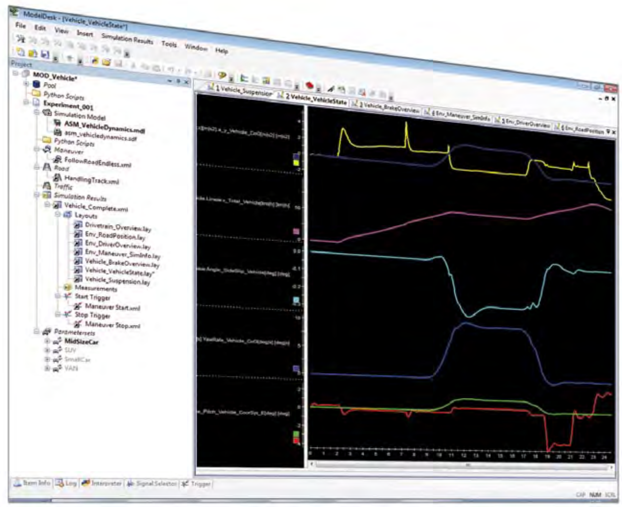
Integrated simulation process in ModelDesk

Straight Through from MIL to HIL

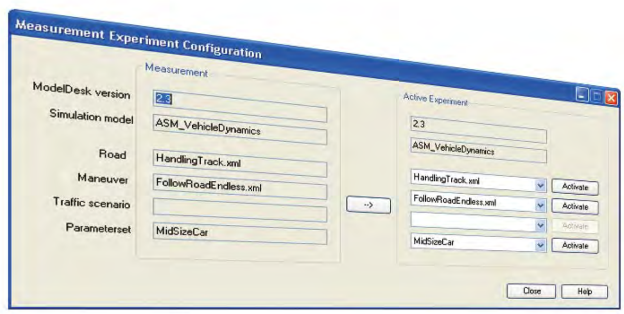
Up to now, ModelDesk has mainly been used as the central parameterization software for the Automotive Simulation Models. Now it's taking on an additional role in the development process: simulation management based on its integrated plotter and simulation management feature. ModelDesk can be used seamlessly from parameterization to offline and online simulation, right up to parameter and result management.

Simulation Models with Graphical Front End

The Automotive Simulation Models (ASMs) are MATLAB®/Simulink® models for simulating essential automotive components and properties. They include combustion engines, electric motors, vehicle dynamics, electrical systems, and traffic for passenger vehicles as well as commercial vehicles. The models are open down to Simulink block level. You can view the modeled functions and modify them any way you want. ModelDesk is the graphical front end for calibration and parameterization.



ModelDesk's new plotter displaying various vehicle dynamics signals.



Configuration of a simulation experiment consisting of a vehicle model, road, maneuver and vehicle parameters.

Profile of ModelDesk 2.3

Central user interface for offline and online simulations

- Integrated simulation control
- Plotters
- Simulation data management

Consistent workflow for offline and online simulations

New Simulation Management

The new version of ModelDesk includes powerful functions for directly executing and displaying simulations, and managing their results:

- Starting and stopping a simulation
- Plotters for visualization
- Saving, comparing and managing simulation and measurement data
- Saving simulation experiments (driving maneuvers, roads, traffic, etc.)

To help you use new functions efficiently from the word go, there are ready-made plotters that provide the signals of individual models – giving you direct access to important vehicle dynamics characteristics. You also have complete freedom to display further stimulus signals, for example, via additional plotters. Signals can be selected quickly and easily with the well-organized structure of the ASM signal bus.

Many Tasks – One Tool

With its integrated simulation functions, ModelDesk is the main user interface, bringing together all the tasks that are essential before, during, and after simulation. ModelDesk is equally well suited to model-in-the-loop (MIL) simulations or Simulink simulations (offline) and hardware-in-the-loop (HIL) simulations (online), so it supports an integrated process from function development to ECU testing. During simulation experiments, ModelDesk stores parameters such as roads, driving maneuvers, traffic, and vehicle configurations together with the simulation results and any measurement data to ensure that simulations are easy to reproduce. Offline and online simulations can also be compared just as easily. ■

Think AUTOSAR, Think SystemDesk

Modeling and Simulating Production ECU Software

The AUTOSAR standard is becoming increasingly important, and electronic control units (ECUs) based on it are now going into production. As Version 3.0 of the SystemDesk architecture software shows, dSPACE is committed to complying with this standard.

Thinking in Systems

The enhanced handling and performance of the new SystemDesk® version make it ideal for large-scale production projects. SystemDesk 3.0 is clearly separated into a library level and a system level to give users a new, well-structured workflow. The library level contains reusable AUTOSAR elements. The system level contains the software architecture, the hardware topology, and the network communication. The software components and compositions modeled in the library can be directly integrated into a system and edited within it. This helps users keep track of everything, even in complex projects. Also included are extended modeling functionality for the communication on CAN, LIN and FlexRay buses, and features for complete configuration of the run-time environment (RTE) and the operating system (OS). Another plus: SystemDesk 3.0 builds on AUTOSAR Release 3.1 – the version currently in focus in the automotive industry.

Interacting with TargetLink®

To fully benefit from AUTOSAR throughout the entire development process, users need coordinated tools that can exchange AUTOSAR files (ARXML) and supplementary documents. This is what dSPACE offers, providing closely coupled structural and behavioral modeling with SystemDesk and TargetLink.
The system architects export a software component (SWC) container from SystemDesk. The container holds all the files belonging to a modeled software component (ARXML and any other specification documents). TargetLink users import the SWC container and use the defined interfaces to automatically create an AUTOSAR frame model for the components. Then they develop the actual functionality and generate AUTOSAR-compliant code. This code is transferred back to SystemDesk in the SWC container together with any ASAP2 files that were generated, plus the ARXML files with additional implementation information. The SWCs now contain implementation information that can be used to simulate and test the ECU's behavior offline.
The SWC containers are handled in the Container Manager, a specialized tool with a graphical user interface.

Finding Errors Sooner

The earlier errors are found in the development process, the easier and less expensive it is to correct them. SystemDesk 3.0 not only offers software-in-the-loop (SIL) simulation, but also the ability to execute AUTOSAR applications in the form of virtual ECUs on evaluation boards, for example, by means of TargetLink. Thus, ECU code can be simulated on the target processor at a very early stage.
In addition to direct simulation in SystemDesk, the virtual ECUs that are created can also be connected to Simulink models of the controlled system and tested as an overall system with ControlDesk® Next Generation, dSPACE's experiment software. ■

Profile of SystemDesk 3.0

Modeling

- Enhanced interaction between SystemDesk and TargetLink
- Extended modeling of AUTOSAR 3.1 system templates
- New editor for mapping software components and ECUs
- Improved signal mapping editor
- Multiple instantiation of software components

RTE Generation

- Complete RTE and OS configuration
- Enhanced interaction with third-party RTEs and basic software

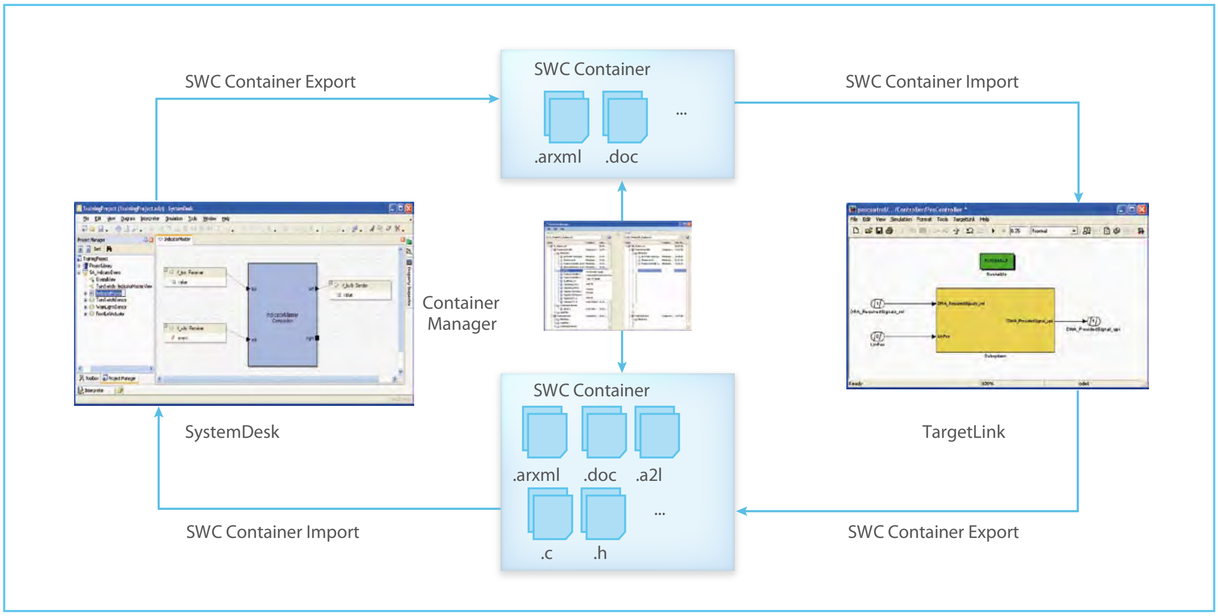
Simulation

- Processor-in-the-loop (PIL) simulation
- Direct connection of virtual ECUs

Handling

- Structured workflow with the library system concept
- Greater performance
- Filter mechanisms in selection lists
- Improved search

Exchanging SWC containers between SystemDesk (the architecture and integration tool) and TargetLink (the behavior modeling tool) in an AUTOSAR-compliant development process.



One Tool Does It All

ControlDesk Next Generation: The new universal experiment tool for efficient ECU development

Rapid control prototyping, hardware-in-the-loop simulation, bus system access, ECU calibration and diagnostics – once completely separate, now converging more and more. Requirements are changing, and development tools have to change with them. ControlDesk Next Generation is dSPACE's answer to this challenge.

No More Strict Dividing Lines

Numerous specialized tools have evolved to meet the needs of different phases of developing and testing ECU software – rapid control prototyping (RCP), hardware-in-the-loop (HIL), calibration and diagnostics, and so on. Each tool is tailored to its own application context, and each requires expert knowledge for productive work. But that is no longer completely in tune with the realities of ECU development. The dividing lines between different areas are disappearing, as these examples of real-world situations show:

- For a component test, several internal ECU variables, bus signals and variables from the HIL simulation model have to be measured on a HIL simulator, under automatic control and time-synchronously. The test also requires access to the ECU's fault memory and the simulator's electrical failure simulation (figure 1).
- An RCP system is being put into operation, and CAN bus monitoring has to be performed to evaluate correct communication with the real ECUs involved. Internal ECU variables also need to be measured time-synchronously for plausibility checks.
- To test an ESP ECU, measurement data (e.g., from wheel speed sensors) has to be replayed by a HIL system precisely and in real time.

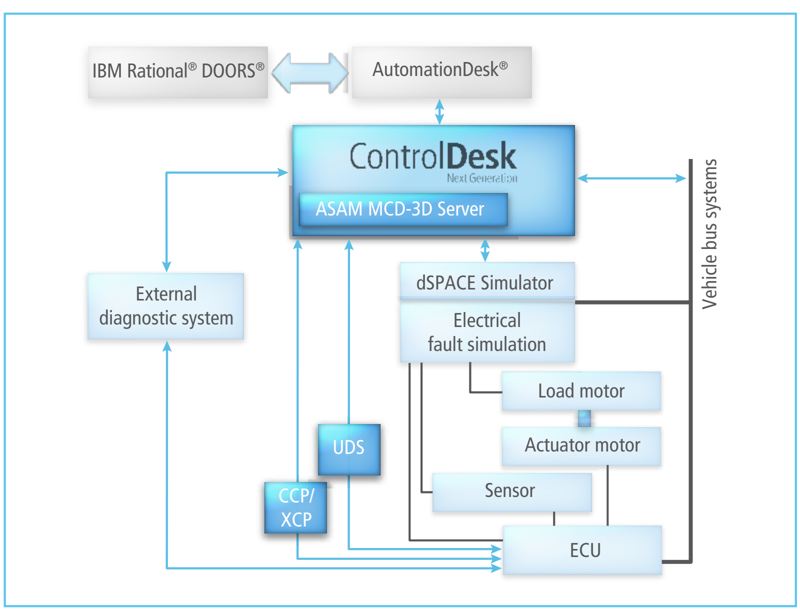


Figure 1: Example scenario for using ControlDesk® Next Generation.

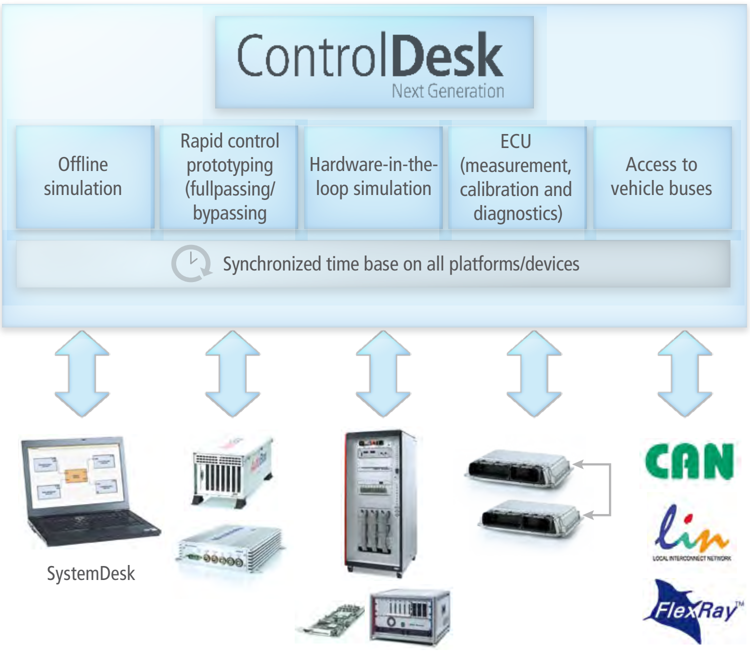


Figure 2: ControlDesk Next Generation, the new universal, scalable experiment tool for ECU development.

The objective: to reproduce a test drive in the laboratory as many times as required.
As these cases show, developers increasingly have to work with different data sources, without necessarily having a specialized knowledge of the overall system or of all its subdomains.

Status Quo: Heterogeneous Tool Chains

Today's users work with several development tools at once – usually from different providers. The tools have to be adapted to one another and integrated into the development process to fit the overall scenario. Users themselves have to ensure that all the tools function satisfactorily when combined in a complex scenario. If there is a problem, any one of the tools could be the source. Tool couplings add to the difficulty. Validating and maintaining the tool chain involves intensive work, especially if an error occurs, and wastes time that could be spent working productively.

> ControlDesk Next Generation is a complete package, containing everything developers need for efficient work.

A Seamless Process

Seamlessness is another major goal. Ideally, tasks such as setting up user interfaces, or generating and managing measurement data and parameter sets, should be performed only once. Getting rid of unnecessary data management is the only way to make transitions easy, such as from an RCP system to the real ECU.

ControlDesk Next Generation: dSPACE's Central Experiment Tool

ControlDesk Next Generation is dSPACE's new tool for use throughout the entire ECU development and testing process, optimally covering all application scenarios (figure 2). It unites the functionalities of ControlDesk and CalDesk®, two of dSPACE's well-established tools (available since 1999 and 2003 respectively). ControlDesk is primarily used for HIL, RCP (fullpassing) and offline simulation; CalDesk for ECU calibration and diagnostics, in-vehicle scenarios and RCP (bypassing). Now the strengths of the two tools have been combined in their successor, ControlDesk Next Generation. The result: fewer tools, less time spent working on user interfaces and administration, and no more data exchange between different tools. The long-awaited seamless process has arrived.

Synchronous access to all data sources, including ECUs and bus interfaces, is another major benefit. On top of that, ControlDesk Next Generation has numerous enhanced details and entirely new features. Now that ECU access and diagnostics are integrated, and bus systems can be accessed flexibly, third-party tools are no longer needed. ControlDesk Next Generation's modules ensure scalability, and it can be configured optimally for specific application cases. Whenever users require additional functionality, such as ECU access, they can simply buy it at a later date (figure 3). ■

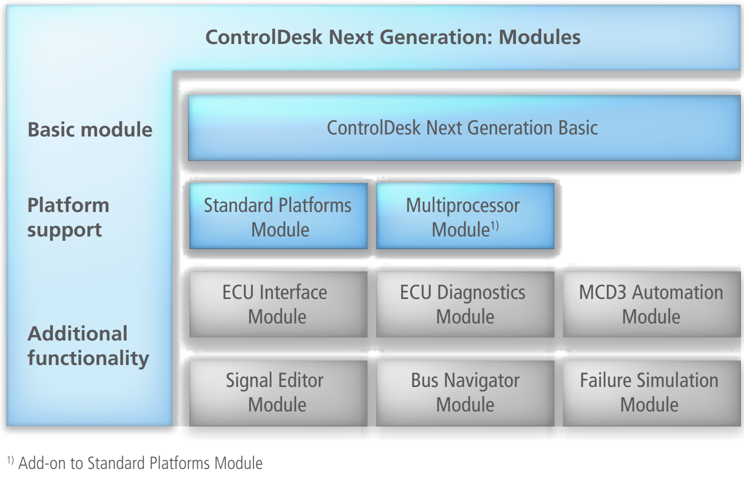


Figure 3: ControlDesk Next Generation's modular design.

Migration

Thanks to its new installation concept, ControlDesk Next Generation can easily be installed in parallel to existing dSPACE releases, instead of being placed in the dSPACE folder structure. This makes it easier to evaluate the new tool and to migrate ControlDesk 3.x and CalDesk experiments.
Customers with valid Software Maintenance Service contracts for ControlDesk 3.x and CalDesk will automatically receive the new ControlDesk Next Generation with dSPACE Release 7.0.

Interview

with Holger Krisp,
Product Manager for
ControlDesk Next Generation

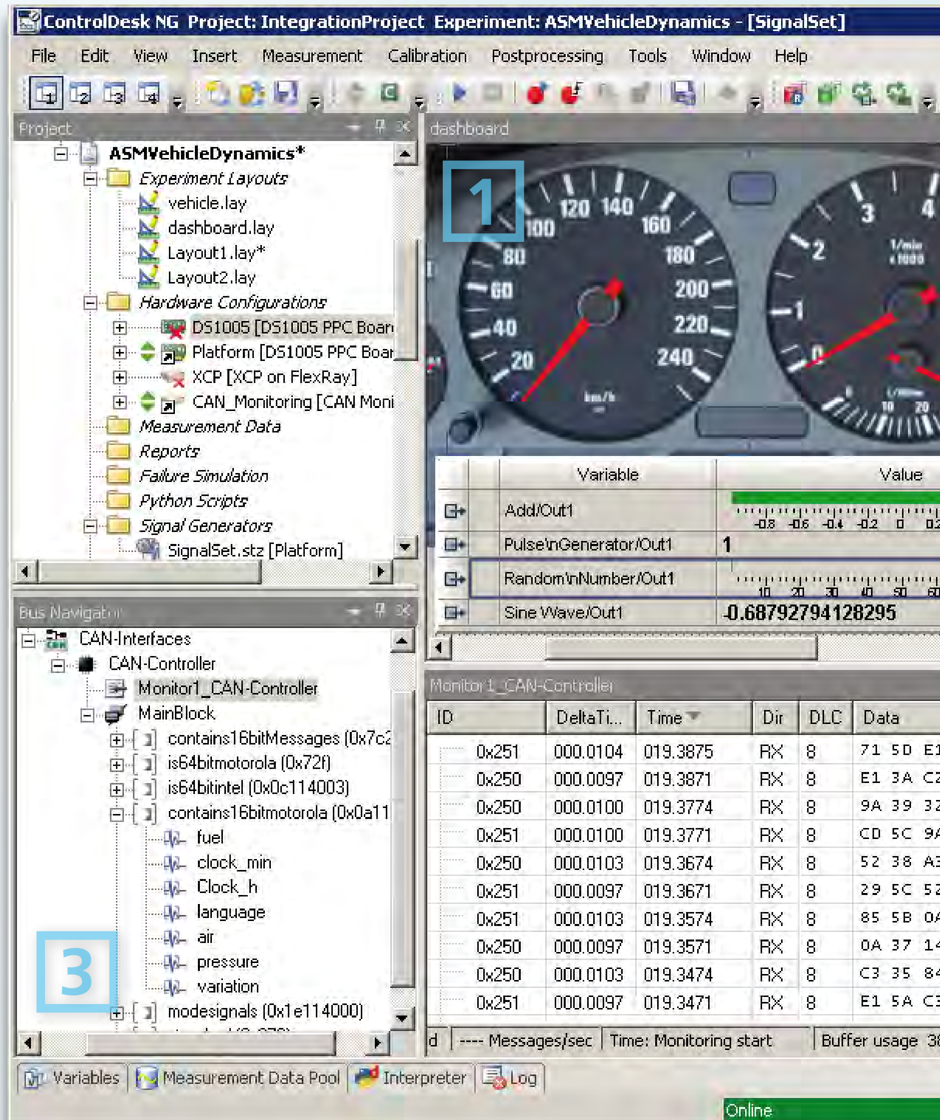
Mr. Krisp, why did dSPACE decide to develop ControlDesk Next Generation?
We are in close touch with many of our users, so we have first-hand knowledge of how they use our products. For some time now, we've been seeing that classic work practices are changing – and the trend is gaining momentum. So we created ControlDesk Next Generation to bring together different application scenarios, with the aim of making daily work easier and also of creating new application potential. ControlDesk and CalDesk were powerful, well-established tools, each in its own domain. Their successor ControlDesk Next Generation harnesses synergies and extensions, so it is in an even stronger position.

Why should customers choose ControlDesk Next Generation?
Because it's the current all-rounder, precisely geared to the needs of the market. As a strong partner, dSPACE makes sure that the new tool focuses on efficient development work, eliminating the stress of problems like malfunctioning tool couplings. If something ever doesn't function as desired, we see it as our duty to analyze the problem and work with the customer to find the right solution.

Do you already have market feedback?
Discussions with our customers on ideas for combining ControlDesk and CalDesk have been going on for a long time now. Their response to our vision is unanimously positive. As one customer statement put it: "At long last ControlDesk and CalDesk have been united. Just what we were waiting for." The waiting will finally be over, when ControlDesk Next Generation launches in dSPACE Release 7.0.

Thank you for talking to us, Mr. Krisp.

The Functionalities of ControlDesk Next Generation



So Many Interfaces
ControlDesk Next Generation provides access to all dSPACE RCP and HIL platforms (such as the multicore DS1006 Processor Board and the new MicroAutoBox II). For ECU access, it supports ASAM MCD-1 MC (CCP and XCP, more specifically XCP on CAN/Ethernet/FlexRay) and different types of on-chip debug interfaces. To integrate ECU diagnostics, CAN- and K-line-based access via ASAM MCD-2 D (ODX) is available, with diagnostic protocols such as KWP2000, UDS, TP2.0 and GM LAN.
External measurement equipment can also be connected (for example, for measuring temperatures). Vehicle buses (CAN, LIN and FlexRay) can be accessed directly via PC interface boards and dSPACE bus interfaces (such as the DS4302).

All Data Sources Measured Synchronously
ControlDesk Next Generation ensures the precise synchronization of measurement data from different sources (RCP and HIL platforms, ECUs, bus interfaces and external measurement devices). This opens up entirely new possibilities, especially for HIL users. For example, the temporal relationship between the HIL simulator's setting an overvoltage and the change this provokes in one of the ECU's internal variables can be measured directly in the tool. The collected measurement data can be placed in the Measurement Data Manager and exported for further evaluations in standard formats such as MAT or ASAM MDF.

Instrumentation
ControlDesk Next Generation has numerous innovations for creating layouts easily and flexibly. Several simulation, ECU and bus variables can be quickly dragged all at once to a multi-row instrument (the Variable Array) for display. The Instrument Selector has been completely reworked for easier handling. Instruments are generated automatically when variables are dragged from the variable description, so there is no need to create an instrument beforehand. And there are a whole lot of little improvements that when added together really speed up the user's work.

Plotting and Postprocessing
Ongoing measurements can be observed and compared with previous recordings in Plotter instruments, with a time cursor for going straight to any desired point in time within the data. Several Plotters can be scrolled in synchrony. The Plotter can be switched to a triggered display like an oscilloscope, making it easier to perform tasks such as analyzing high-frequency signals (for example, to evaluate a system's step response).

Figure 4:
User interface of the new ControlDesk Next Generation.

Legend:

1 Instrumenting
2 Plotting und Postprocessing
3 Bus Navigator
4 Signal Editor

Bus Navigator
For access to bus systems such as CAN, LIN and FlexRay, the bus interfaces to the connected HIL and RCP platforms, and PC interface boards, can be integrated. The Bus Navigator gives a clear picture of the current communication matrix, which is defined according to DBC, LDF and ASAM MCD-2 NET (FIBEX). Layouts for transmitting and receiving bus messages can be generated at the push of a button, and automatically contain all the defined signals. Signals can be connected to display and parameterization instruments from within the Bus Navigator. A bus monitor is available to display and record CAN and LIN traffic with the message contents (for example, for during system setup). Recorded CAN traffic can also be replayed in real time.

Signal Editor
In the new Signal Editor, time-synchronous stimulus signals such as sine, ramp or noise can be defined graphically. Changes in signal form can be coupled to conditions (such as "Generate a sine signal as long as the vehicle speed is lower than 50 km/h."). Recorded signals from the Measurement Data Manager can be easily dragged across for stimulation. The Signal Editor saves the signal behaviors in accordance with the ASAM AE HIL API 1.0 standard.

Automation
With its comprehensive automation options, ControlDesk Next Generation can be given application-specific extensions, and it also integrates optimally into existing development and test processes. Tool events can be received from external tools and processed (for example, to control a test sequence in AutomationDesk). The automation interface is implemented as a COM object model, so that external applications (implemented in C#, C++, Visual Basic, etc.) can be integrated, and automation scripts can be written in various programming languages (such as Python, C# and Visual Basic). An automation module that complies with the ASAM MCD-3 standard is also available.

Innovations in Model-Based Development

Japan User Conference 2010

The Tokyo Conference Center was the venue for this year's dSPACE User Conference in Japan. Over 300 attendees took up the invitation, breaking all previous records. The main topics were the increasingly difficult tasks involved in reducing emissions and the high development standards for quality assurance, traceability and safety. Impressive user presentations showed new technical approaches and efficient methods, and also reflected the growing need for development progress. One particular highlight was the special project presented by Masa Hirvonen (Honda Aircraft Company) in his keynote speech: the Advanced Systems Integration Test Facility (ASITF). One of the most modern facilities for system integration in commercial aviation, ASITF was founded to support system integration for the highly advanced HondaJet plane and functional tests on its subsystems. dSPACE provided a complete testing framework for integrating networked electronics, with support for a wide range of aircraft configurations.

Masa Hirvonen, Honda Aircraft Company, presented the Advanced Systems Integration Test Facility in his keynote speech (on the left).

1. The lecture by Yoshiharu Sudani, Honda R&D, described an innovative testing environment for complex automotive systems utilizing dSPACE's Virtual Vehicle.

2. Ryo Kitabatake, Isuzu Advanced Engineering Center, Ltd., explained performance improvements on a six-cylinder, heavy-duty diesel engine equipped with a camless system.

3. Mitsubishi Motors designed a HIL simulation testing/model verification method. Masahiro Kaneda, Mitsubishi Motors Corporation, summarized the process up to vehicle production.

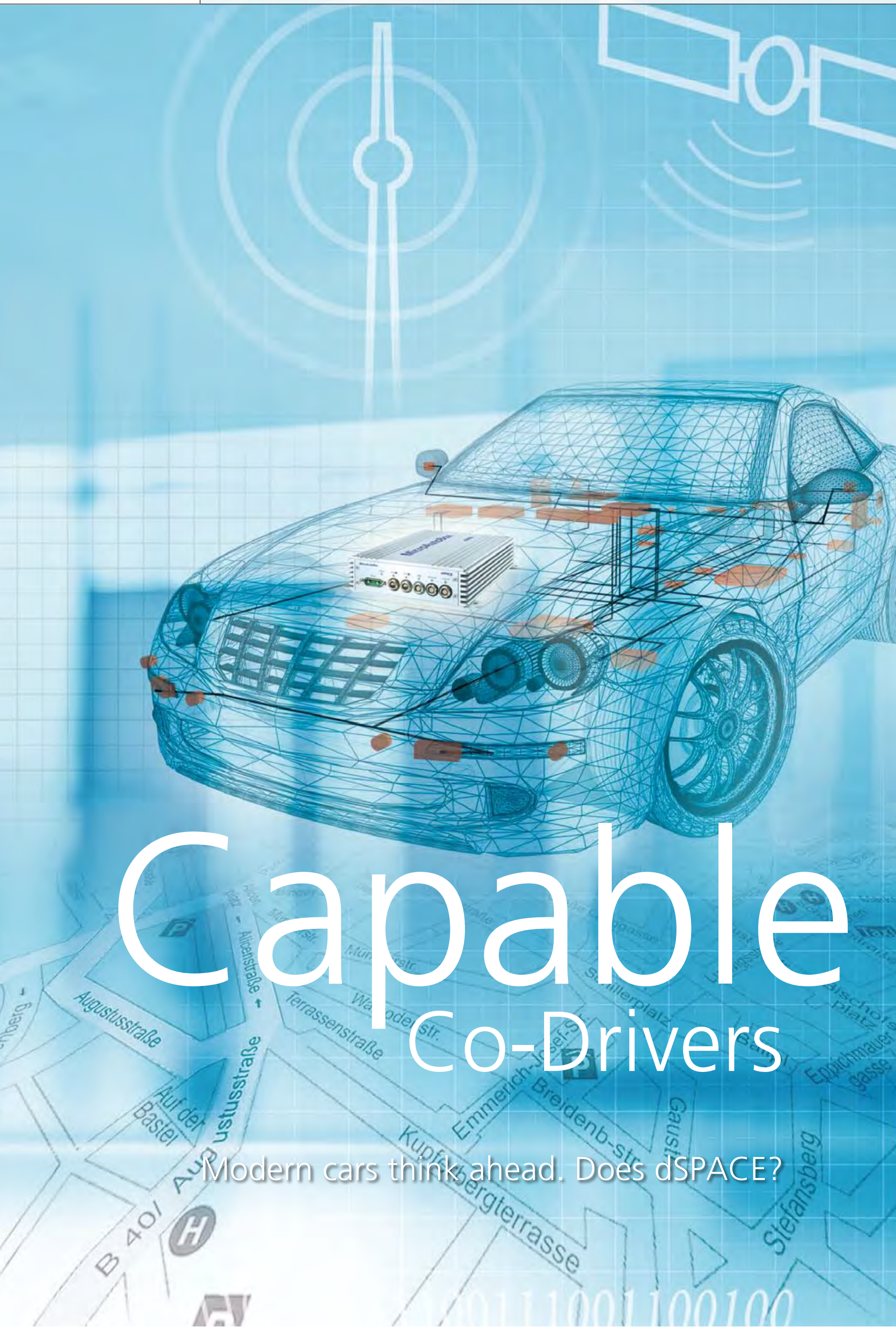
4. Hiroya Murao, Sanyo Electric Co. Ltd, explained a system adopted from dSPACE for the development of battery control software: Battery-in-the-Loop Simulation.

5. The paper given by Taku Senoo, Tokyo University, described an ultra-high-speed manipulation system for new robot skills.

6. Yoshimichi Nakamura, SmartEnergy Laboratory, talked about the characteristics of power supply systems.

Our Thanks

dSPACE Japan K.K. would like to thank everyone who participated in this year's Japanese User Conference. Special thanks go to the speakers, who presented groundbreaking innovations and important findings from practical development work. The conference made a valuable contribution to advancing the development of modern controller software. ■



Capable Co-Drivers

Modern cars think ahead. Does dSPACE?

Intelligent driver assistance systems are a prime issue in the automobile industry. Product Manager André Rolfsmeier explains why, and how dSPACE stays on top of this trend.

Why are advanced driver assistance systems attracting so much attention?
In Europe, tens of thousands of people die in road accidents every year. More than 90% of these accidents are due to human error. The number of accidents could be dramatically reduced by driver assistance systems. Assistance systems can also help solve problems caused by other challenges, such as global warming, demographic change, and increasing traffic density.

Which intelligent systems are playing a pioneering role in development?
Advanced driver assistance systems are intervening more autonomously in driving procedures such as braking and steering. The aim of future innovations will be above all to avoid accidents such as collisions with pedestrians, cyclists or other vehicles. In concrete terms, work is being performed on emergency brake assistants, intersection assistants, overtaking assistants and emergency steer assistants.
Other development focuses are reducing fuel consumption by means of predictive data and networking with other vehicles and the traffic infrastructure. Driver assistance systems optimize the energy and fuel management of modern drive concepts, for example, by evaluating the topography of the road ahead. Our customers are also working on systems to monitor the driver's attention and to stop the vehicle safely and call for help if the driver has a medical emergency.

What requirements arise for function development and testing these systems?
Video sensors will be a major component in the driver assistance systems of the future. Integrating video sensors and fusing video data with data from other sensors makes new demands on current rapid control prototyping systems. The same

André Rolfsmeier is Senior Product Manager at dSPACE GmbH in Paderborn, Germany, with responsibility for driver assistance systems.

> "Integrating video sensors makes new demands on established development tools."
>
> *André Rolfsmeier, dSPACE GmbH*

applies to the coupling of digital maps for predictive evaluation of the road ahead, and wirelessly networking the vehicle with its environment. It is important to support the relevant standards in this context. Testing driver assistance systems for production requires the ability to simulate complex traffic scenarios and run virtual test drives reproducibly in the laboratory. Simulation based on real roads and the auto-

matic generation of test scenarios are two issues that are becoming more important.

How is dSPACE meeting these challenges?

For several years now, dSPACE systems have been used successfully for developing and testing driver assistance systems. We already took the knowledge and experience gained from previous customer projects and put them back into product development, and product extensions incorporating this know-how will arrive soon. We are also actively engaged in partnerships for advancing strategies and solutions that unite different fields.

How is the new knowledge being turned into product extensions, for example in rapid prototyping systems?

In the development of video-based systems, there is a basic distinction between image processing, which is typically implemented in C/C++ on PC architectures, and the driver assistance function itself, which is implemented in MATLAB®/Simulink® on rapid prototyping systems. What we have done is create a connection between various embedded solutions and the dSPACE systems, for example, by providing powerful Ethernet interfaces and dedicated blocksets for coupling development tools such as ADAS RP from NAVTEQ and EB Assist ADTF. Our AutoBox and MicroAutoBox systems are making a fundamental contribution to the fast, iterative development of driver assistance functions.

What is the situation regarding hardware-in-the-loop simulation?

The dSPACE Simulator also provides an interface to EB Assist ADTF to connect to corresponding simulation environments in order to perform virtual test drives. In addition, there are various interfaces available like SPI for emulating sensors that are directly installed in an electronic control unit. Our Automotive Simulation Models (ASMs) already support the simulation of various driver assistance applications such as adaptive cruise control, brake assistants, and predictive drive controls. The ASMs are open Simulink models for modeling the vehicle, its sensors, the road, and the surrounding traffic. They can be coupled with ADAS RP, for example, to run simulations on real roads. What's attractive is that the models can be used for early concept development on PCs as well, so that algorithms can be tested by model-in-the-loop or software-in-the-loop simulation. Our customers benefit immensely from this when developing their innovative driver assistance functions in a shorter period of time and verifying production maturity with the aid of hardware-in-the-loop simulation.

What other innovations can dSPACE customers look forward to?

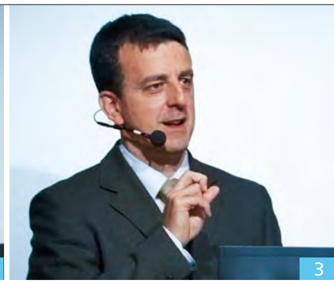
In the future, dSPACE will focus on simulating and visualizing complex traffic scenarios in virtual test drives. In doing so, we will continue the further development of our tools ASM, ModelDesk and MotionDesk. To make it even easier to connect EB Assist ADTF to the HIL real-time environment, our roadmap includes implementing GigaBit Ethernet and a comprehensive protocol stack on one core of the quad-core DS1006 Processor Board. In addition, we are planning to add an integrated

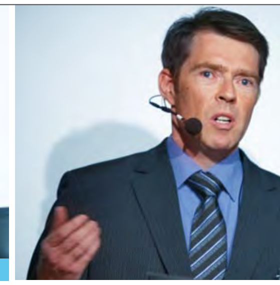
embedded PC platform to MicroAutoBox II so that digital maps, EB Assist ADTF, and Car2x software frameworks can be implemented on the MicroAutoBox directly. Support for the ADASIS V2 standard for transmitting predictive road data is also planned.
As you can see, dSPACE tool users are already one step closer to the vehicles of tomorrow – because dSPACE thinks ahead.

Open Dialogs

The hottest application trends presented at the 6th dSPACE German User Conference

From November 9 to 11, 2010, dSPACE welcomed nearly 200 visitors to the dSPACE user conference at the new company headquarters in Paderborn. Experts from the automotive field presented their current development projects and described how dSPACE systems are being used to ensure their success.





Two major challenges are currently being discussed in the car industry: the automotive electronics of the future and electromobility. The first two conference days opened with keynote speeches on these topics by Dr. Willibert Schleuter and Prof. Dr. Willi Diez. The conference then revolved around guest lectures given by major OEMs, suppliers and engineering service providers from the vehicle industry. The speakers described how they were using dSPACE products to make decisive progress in their projects.

Green Success – Electromobility and Hybrid Drives

The presentations of current development projects on alternative drives attracted intense interest. Various companies covered the entire range of energy efficiency techniques, from battery management systems to optimized combustion processes.

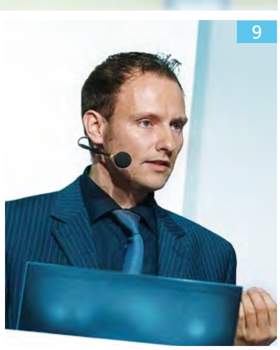
Test and Quality Assurance in ECU Development

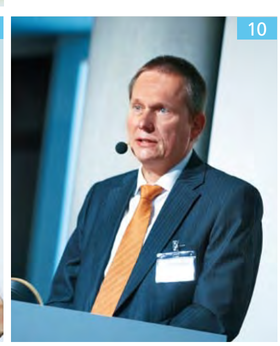
The speakers on the topic of testing described their experience with the automated testing of components and ECU networks, and presented processes and methods for verifying software maturity efficiently and reliably.

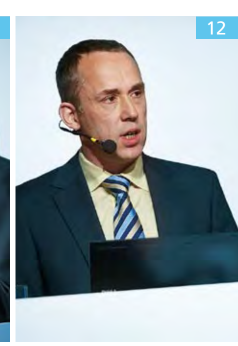
dSPACE Products Used for Driver Assistance Systems

Another topic was the development and production start of driver assistance systems, including the challenges of testing them.
The demand for personal comfort, the vision of accident-free traffic in today's aging society, and the


desire to reduce fuel consumption with vehicles that look ahead and communicate with each other were identified as being vital factors.







AUTOSAR – Moving Towards a Worldwide Standard

Current software development projects show that AUTOSAR is on its way to worldwide implementation. The papers in this field reported on preparations for AUTOSAR in projects and the benefits promised by AUTOSAR-compliant development, as well as the challenges still to be met.

Developing Safety-Critical Applications

One major issue in software development is how to handle safety-

relevant systems. Examples of innovative steering and braking systems demonstrated their growing importance.

Speakers:

1. *Dr. Brem-Kumar Saravanan, SB LiMotive Germany GmbH*
2. *Jakob Andert, FEV Motorentechnik GmbH / RWTH Aachen*
3. *Gianni Padroni, Schaeffler Technologies GmbH & Co.KG*
4. *Dr. Moritz Schulé, Daimler AG*
5. *Erich Scheiben, ABB Switzerland Ltd.*
6. *Knut Schwarz, Lemförder Electronic GmbH*
7. *Martin Fischer, Daimler AG*
8. *Ralf Belke, Audi Electronics Venture GmbH*
9. *Andreas Kern, Audi Electronics Venture GmbH*
10. *Christian Ress, Ford Forschungszentrum Aachen GmbH*
11. *Matthias Kohlweyer, Daimler AG*
12. *Dr. Karsten Schmidt, Audi Electronics Venture GmbH*
13. *Dr. Werner Bauer-Kugelmann, Audi Electronics Venture GmbH*
14. *Gisela Josko, Delphi Deutschland GmbH*
15. *Matthias Sendzik, Volkswagen AG*
16. *Christian Köglsperger, LSP Innovative Automotive Systems GmbH*
17. *Bernd Radgen, Continental Automotive GmbH*

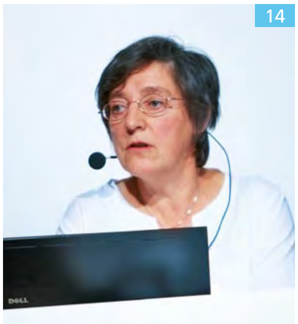
Networking

The conference provided plenty of opportunity for informal contact. Product innovations and development trends were the topic of numerous conversations. For the first time, the dSPACE User Conference was held at the new company headquarters in Paderborn, Germany, giving participants an inside view of the development world at dSPACE. Advanced seminars on selected topics were on the schedule for the third day of the conference.

We at dSPACE extend our sincere thanks to all of the speakers and participants for their fascinating topics and thought-provoking conversations throughout the user conference. ■

Shift into Gear and Step on the Gas

An evening racing event with Formula Student on an automobile association test track rounded off the first day of the conference. Bringing their latest race cars, Paderborn's UPBracing team and the Green Team Stuttgart showed the visitors exactly what they're made of. Despite the rainy weather, some guests jumped at the opportunity to get behind the wheel and experience the thrills of the race track for themselves.



Interview

with Dr. Willibert Schleuter,
former head of electrics/electronics development at Audi and module manager at the VW Group

The Future Challenges for Automobile Electronics

Dr. Schleuter, what megatrends will decide the innovations of the future?
Several areas are shaping developments. One is drivetrain electrification in various forms. Systems for accident-free driving, and networking vehicles with one another and with the infrastructure, are other important issues. These are not only changing our way of driving, but also opening up new opportunities.
Another trend is the further individualization of vehicles. There will basically be more vehicle derivates made up of different components. As globalization progresses, this will also lead to a shift in development tasks.

The balancing act between complexity and development time is getting tougher. What sort of development times will engineers have to face?
Development times strongly depend on the complexity of the systems under development. However, automobile manufacturers wanting to introduce new systems are coming under increasing pressure. Anything that is not ready in time for market launch is difficult to market later, which means that systems stay too expensive for too long.

What are the magic screws for adjusting processes to increasing complexity and development speeds?
The competence and efficiency of people are decisive. In Germany, our natural resources are what we have in our minds. We'll become more efficient if we succeed in networking our activities.
We can do it, but we need the courage to build confidence in closer cooperation. In the long run, the successful companies will be the ones who work together in network clusters, each contributing different skills to large-scale tasks that they could not solve or bring to market maturity on their own.
One enormously important task for everyone is to increase the proportion of women in engineering professions.

What new feature in the vehicles of the future are you looking forward to the most?
Traffic sign recognition! If you drive a lot and use a headset to phone, you're a much more relaxed driver if you have constant information on speed limits.
One future task that will bring great economic benefits is to improve traffic jam reporting via Car2Car, to give all road users the information they need. This will make driving more efficient, which will benefit everyone, whether they're directly affected by road congestion or not. The plans for traffic jam detection and reporting systems are already on the table, we just have to take them one step further.

Thank you for talking with us, Dr. Schleuter.

> "In Germany, our natural resources are what we have in our minds. We'll become more efficient if we succeed in networking our activities."
>
> *Dr. Willibert Schleuter*

Interview

with Prof. Dr. Willi Diez,
Director of the German Institute
for Automobile Economics (IFA)

Electromobility – The Road to the Future or a Dead End?

What is the state of play on electric cars, Prof. Diez?
Right now, we're seeing a lot of hype. Everyone is expecting to be able to drive an electric vehicle tomorrow, or at least the day after. But we have to remember that the range and costs of these vehicles still pose extreme challenges. Automotive manufacturers are still working on developing real-world solutions.

> "If you master battery technology, you will master the industry."
>
> *Prof. Dr. Willi Diez*

What role is battery technology playing?
It's the key technology. Batteries are to an electric vehicle what a combustion engine is to a conventional vehicle. Powerful, high-capacity batteries determine the vehicle's range and speed. And we mustn't forget current consumers such as the lights, climate control and numerous comfort functions – without powerful batteries, electric vehicles are not fit for general use.

What factors determine the viability of fossil-fuel and electric drive systems?
There are two basic cost factors, the purchase price and the running costs, which are essentially consumption costs.
At the moment, electric cars cost € 15,000 to € 18,000 more to buy than comparable combustion engine vehicles. Mainly because of the expensive battery. But with regard to energy consumption, electric cars are extremely cost-efficient. Right now, it takes about € 2 to drive approximately 100 km.

And what will this look like in a few years?
That's difficult to forecast. The batteries will certainly be cheaper. Unfortunately, though, the price of electricity is likely to increase. Environmentally aware motorists who want to use an electric car want to do so with a clear conscience. To do that, they need to use energy from regenerative sources, which in the foreseeable future will be much more expensive than electricity from coal-fired or atomic power plants. So initially, there are two conflicting trends. But in the long run, the costs of vehicles with combustion engines and ones with electric motors will converge.

How can electromobility contribute to reducing CO_2 emissions?
How much CO_2 is reduced depends on the energy mix. Electricity from coal-fired plants does not bring any advantages. The electricity must come from CO_2-free sources. Atomic energy is controversial in Germany, so we will need a larger supply of regenerative energy sources.

What potential does drivetrain electrification have for the global industry?
It's the second revolution in automotive technology. Completely new vehicles are needed, with completely new concepts and materials. If you master battery technology, you will master the industry.

Would you drive such a car?
I'd love to, as a second car, at the price of a second car. When the leasing rate is € 199, I'll be the first customer.

Thank you for talking to us, Prof. Diez.

dSPACE ADTF Blockset for Driver Assistance Systems

Advanced driver assistance systems (ADAS) capture the vehicle's environment using sensors such as video, radar and lidar. When ADAS control strategies are developed in the vehicle by means of rapid control prototyping (RCP) systems, data from these sensors has to be preprocessed, fused and recorded time-synchronously with other measurement variables. In addition, when ADAS electronic control units (ECUs) are tested with hardware-in-the-loop (HIL) simulators, previously recorded real sensor data often needs to be integrated, and virtual test drives have to be carried out in the laboratory.

EB Assist ADTF (Automotive Data and Time Triggered Framework), developed by Audi Electronics Venture GmbH, is an established tool in this field. It provides a neat way to couple several systems via the User Datagram Protocol/Internet Protocol (UDP/IP)-based ADTF Message Bus. The new ADTF Blockset from dSPACE is used to implement bidirectional, low-latency communication between dSPACE real-time systems and EB Assist ADTF via the ADTF Message Bus.

To use the dSPACE ADTF Blockset, the appropriate hardware and software from dSPACE Release 6.5 is needed for Ethernet connection, plus EB Assist ADTF Version 2.4 or higher. ■

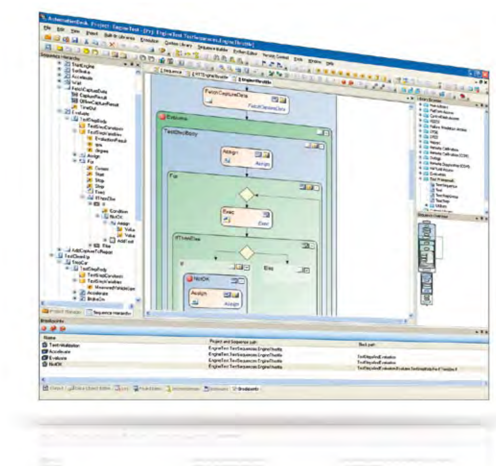
Sensor Simulation for Battery Management Systems

In battery management systems, the sensors for cell voltage, current and temperature are often connected to the microcontroller via SPI or I2C. These buses are typically used in the electronic control unit (ECU), or the sensors are installed close to the ECU. Emulating sensors in a hardware-in-the-loop (HIL) system requires a decentralized, flexible solution that can be installed in a HIL system near the ECU for easy modeling of sensor-specific interfaces. The **Programmable Generic Interface (PGI)** from dSPACE is an ideal FPGA-based platform for emulating interfaces such as SPI or I2C Slave and substituting the real sensors. If a project requires signal conditioning, this can be implemented by an integrated plug-on module. The resulting decentralized I/O interface can be galvanically isolated and connected to a HIL simulator or MicroAutoBox up to 5 m away by LVDS, and can be addressed from Simulink®. ■

Formula Student Electric

15 teams went to the starting line at the Hockenheimring in August for the world's first ever Formula Student Electric race, held in parallel to the Formula Student Germany competition. In tune with the trend for clean energy, the young engineers construct race cars that run solely on electricity. Since dSPACE is always eager to support sustainable innovations, it is sponsoring seven of the teams, for example, by donating MicroAutoBoxes. These control the vehicle's chassis, body, electric motor, and so on. The winners of the Formula Student Electric were the GreenTeam from Universität Stuttgart (Germany), closely followed by the team from the University of Eindhoven (Netherlands), with Graz University of Applied Sciences (Austria) in third place. ■

Comprehensive Signal Processing



Version 3.2 of **AutomationDesk®** offers users greater flexibility for using signals such as sine, ramp or noise in automated test sequences. Provided they comply with the HIL API standard, signals can be imported from a variety of sources, such as the Signal Editor in ControlDesk Next Generation (see page 50). Then they are integrated into a test sequence as stimuli. This has two clear advantages:

The first is that each signal can be varied for different test runs. There is no need to describe each and every signal separately, because once a signal is created, it can be changed under automatic control. For example, the frequency or amplitude can be increased stepwise for each new test run.

The second advantage is about evaluating the signals, like comparing a measured signal with a reference signal or checking whether a signal is inside or outside specific bounds. The bounds or reference signals can be described in ControlDesk Next Generation's new Signal Editor and are quickly and easily available in AutomationDesk for use with the Evaluation library. ■

TargetLink AUTOSAR Utilities Now Available!

With TargetLink® AUTOSAR Utilities, it is now even easier to develop AUTOSAR-compliant software. The utilities provide user interfaces and scripts that boost productivity in day-to-day work with TargetLink's AUTOSAR Module. They also contain demo models that visualize selected AUTOSAR features and how they are modeled in TargetLink.

TargetLink AUTOSAR Utilities support TargetLink 3.1 and higher. You can download them from: www.dspace.com/goto?tl_ar_utilities ■

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