Vehicle electronics validation

How Danlaw’s Mx-Suite is being used by Volvo Car Corporation for vehicle electronics system validation

With the increasing size and complexity of electronics in its vehicles, Volvo Car Corporation knows that vehicle product revisions during a program are more expensive than ever before, and that miscommunication of even a single requirement can have expensive consequences. Embedded software demands earlier testing and more thorough test coverage. In order to protect its brand, Volvo began embedded software virtual testing for electronic components years ago. The company is now taking verification and validation to the next level through a strategy of concurrent development and testing.

Volvo’s central electronic module (CEM) is a complex and feature-rich ECU that controls the majority of body, chassis, safety, and convenience features in the vehicle. It communicates with other sensors and components using a combination of hard-wired signals and CAN/LIN communications in order to control body, safety, and convenience features. These features require complex and highly interdependent software functions capable of monitoring and controlling more than 1,200 signals. Because of conflict between electrical components and features, developing a robust CEM is both challenging and time consuming.

Volvo required a single tool to support model-in-loop (MIL) validation of algorithm simulations, software-in-loop (SIL) verification tool of handwritten features, and hardware-in-loop (HIL) tests for the CEM electronics. They required the tool to produce portable test cases that could be reused across the MIL/SIL/HIL environments, and across different vendor’s HIL equipment. The tool had to be scalable from component level testing all the way through complete system testing.

Volvo chose Mx-Suite embedded software test environment in order to meet the need for test automation as a response to increased software content within key automotive function areas, primarily body control, infotainment, hybrid technology, and advanced driver assistance system. Mx-Suite provides the ability for Volvo to test the entire CEM software in a software representation of the electronics control unit (virtual ECU). The same black-box test cases are used with simulation models, virtual ECUs, components on the bench, and vehicle testing lab equipment. Mx-Suite test cases and simulation models can also be provided to development teams or suppliers as comprehensive executable specifications.

The new-generation CEM software is developed according to the AUTOSAR standard and most of the software application layer is developed internally at Volvo using a model-based approach. A number of commercial and customer tools are used to develop and test the CEM software in a prototype vehicle rig called a ‘box car’. The test environment must support unit testing and automated integration testing of the application layer software components. It must provide MIL testing using a PC workstation and Simulink. It has to allow software testing in a HIL environment (dSPACE Simulator). It must provide CAN/LIN simulation and other functions for testing in a vehicle network. The tool environment must also connect to both custom and commercial tools for...
There are two key requirements for the test environment. One is to provide the ability to create automatic, equipment-independent test cases for MIL, SIL, and HIL tests, and the other is to reduce the number of HIL equipment needed and domain knowledge required to execute HIL tests.

Volvo chose to evaluate a number of industry-leading tools that provided automation and the ability to test in MIL, SIL, and HIL environments. Tools from Danlaw, dSPACE, MathWorks, National Instruments, and Vector were chosen as potential solutions.

The set of data that is available for the creation of test cases and the evaluation of the tools comes from different environments, including model simulations and MATLAB data, bench measurements, CAN logs, in-vehicle data acquisitions, HIL simulation equipment, and hand-generated data.

During the requirements analysis and design phase, Volvo designers use Mx-Suite to import test cases, CAN data, and discrete bench data as signal sources in order to drive the simulation models. Mx-Suite recognizes the MathWorks signal database and builds its own software test harness. The automatic harnessing feature and intuitive behavior pass-fail thresholds enable Volvo to create experiments more quickly than with other tools. Additional tests are easily handcrafted using Mx-Suite’s graphical interface, which define test signals and test messages to inject into simulation models in order to verify behaviors of each feature of the CEM. Volvo reports that Mx-Suite is easier to use than other tools to create test cases for Simulink models. It is easy to learn and very useful for engineers with limited or no knowledge of programming. Volvo notes that delivering a comprehensive specification package to a supplier that includes test cases is the most effective form to communicate executable specifications.

Harnessing the CEM software to a virtual ECU for testing is straightforward. In the case where CEM features are implemented in handcrafted software, the regression testing capability of Mx-Suite is especially useful: it alerts the engineers when they ‘check-in’ code that breaks other software feature behaviors.

One of the highest payoffs that Volvo has achieved is the consolidation of its test benches. Most of the HIL tools come with software that has its own unique way of representing and executing tests, so there is little potential reuse or portability from one HIL setup to another. Mx-Suite provides the benefit of being able to reuse test cases throughout the lifecycle, i.e. model-based test cases from the design phase, and test cases from the software design verification phase, and test cases from CAN tools or other HIL tools. Mx-Suite is ‘HIL-agnostic’ and can connect with any third-party test tools and vehicle networks, so it is possible to reduce the number of different third-party tools used in the organization’s test framework. It provides a standard way to measure quality of the embedded control software. By having portable, reusable test cases, they create efficiency in their own organizations, as well as the suppliers’ organizations.

Using the Mx-Suite embedded software test environment, Volvo engineers are pleased with the reductions of the time and effort required to provide comprehensive testing. Mx-Suite provides executive summaries, requirements-traceability, code-coverage, and detailed test cases, to prove that software is fully tested.

With thanks to Martin Nilsson, manager electrical integration environments at Volvo.

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