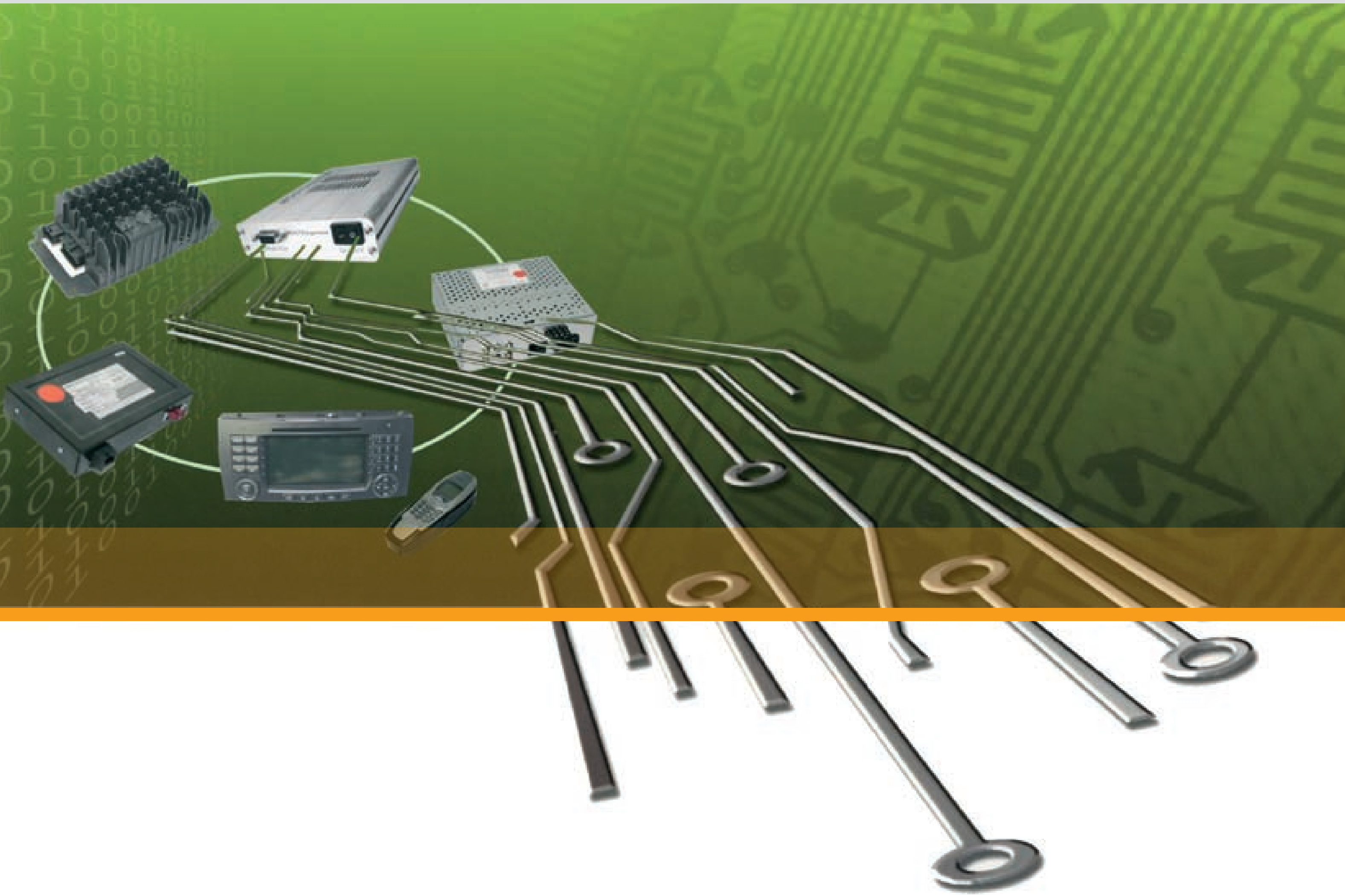

Using Hardware-in-the-Loop Technology for Testing Telematics Components

Telematics systems are considered state of the art in vehicle development today and are no longer limted to premium models. Latest-generation telematics systems are characterized by compact design and integrate many of the functions listed above in a single control unit, the head unit (HU). This article describes how Daimler AG expanded the HiL simulator used in the comfort and drivetrain department to include telematics.

1 Introduction

For years now, use of HiL test systems has been an established practice in the automobile industry for testing comfort-control and drivetrain systems. To date, the telematics-HiL has been characterized by providing the high degree of flexibility demanded for testing the systems. This includes vehicle-related testing of the various models with numerous combinations of standard and optional equipment as well as the strong influence of environmental conditions such as transmission scenarios and their different technologies (such as digital radio stations, which differ according to the individual markets and in their features).

The combinations of standard and optional equipment are addressed by using a MOST switch matrix to configure the MOST ring (MOST on-board network for telematics control units). This switch matrix allows computer-assisted design of various configurations of control unit combinations. This provides maximum flexibility in handling the many variants of control units. Simulators and defined environmental models meet the very different requirements of radio, TV and mobile radio telephone. External events such as SMS transmissions, incoming telephone calls and setting RDS signals can also be stimulated.

To date, vehicle-related testing was carried out by playing recorded traces from a real vehicle or by using simulation models. Expanding the comfort and drivetrain HiL will allow that part to be replaced by using real control units in order to provide even more realistic vehicle conditions. In addition, error level conditions will be reproduced and real on/off scenarios tested.

Not just the technology of the HiL test system, but also the test process itself is highly significant in that they allow equally effective and efficient testing. What is of special significance here is the ability to manage the many control unit variants and possible vehicle configurations.

2 Goals and Challenges

The goal and the challenge in verifying a system lie in testing the overall configuration as it will later be installed in the vehicle. Thus, attention must be paid not only to control units such as head unit, sound, television, and so on, but also to CAN control units, particularly the gateway, comfort and drivetrain components.

Efficient testing is characterized, amongst other things, by two elements: Use of test systems with a very high degree of automation, and the adaptation of existing test programs with a minimum of cost and effort. Since various models of test systems already existed, the aim was to install a test system based on the same hardware and software in order to obtain a standardized family of test systems. The hardware and software used in a comfort and drivetrain HiL simulator as well as the expansions necessary for testing telematics control units with these test systems are described in detail in the following section.

3 Test Environment

The performance spectrum of the hardware and software components to be employed was established on the basis of the scope of testing described in Chapter 5. Before hardware and software of the test system were specified, the test program was coordinated in detail with all the departments and test groups affected.

3.1 The Comfort and Drivetrain HiL Test System

As shown in **Figure 1**, control units were adapted to the test system essentially by means of signal conditioning (SC) and I/O cards. These components support the measurement of outputs and the stimulation of inputs at the control units. Other components used are so-called power switches. Power switches are used to selectively switch on and off the two voltage supplies for the individual control units. In addition to voltage switchover, they also include a current measurement with μA resolution to determine quiescent and operating currents.

For testing the different variants in the complete-vehicle HiL, the HiL integrates another standard component: the CAN switch matrix. It allows the creation of variable bus topologies by means of a dynamic and user-defined switching of CAN signal leads to different rails.

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As a precondition for automated testing of error level conditions, fault simulation is applied to all the essential control unit pins. This makes it possible to separate leads, apply offset voltages or cause short-circuits.

To support interactive and automated access to all available signal values and the control of all test stand peripherals, one common operating software is used for all integration test systems. In this setting, all HiL integration test systems are linked to a central database allowing tests to be performed not just at the test stand but from the workplace as well. To create a familiar test environment for developers and suppliers alike, current programs like CANoe and Optolyzer are available at the test stand. However, these tools play no role in the test automation.

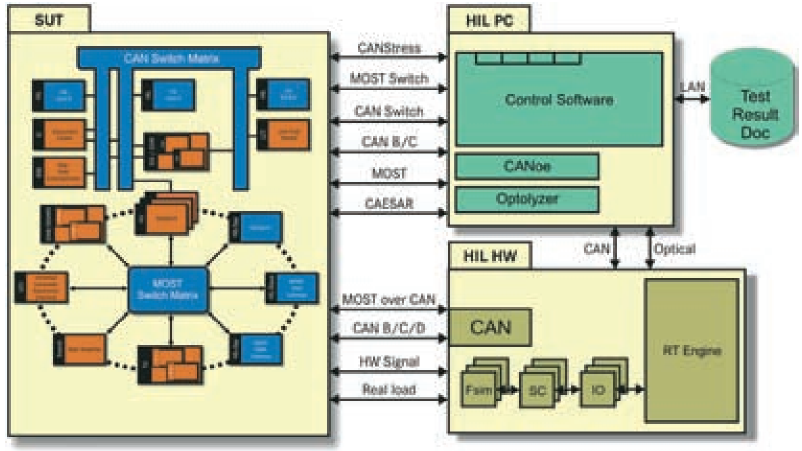

Figure 1: Test environment

3.2 Expansion of the Comfort and Drivetrain HiL Test System

The existing scope of the HiL test system has been supplemented with a MOST link and a MOST switch matrix. Current comfort and drivetrain HiL test systems required no linkage of the MOST bus to the real-time computer, since until now this technology has only been used in these test systems. For testing telematics components, however, linking the MOST bus is an absolute necessity. To meet test requirements, real-time capability of the MOST-link is just as important as the synchronous evaluation of MOST, CAN and hardware signals based on a global time stamp during the test run.

That is why a MOST CAN gateway is used, integrated in the MOST ring with three freely configurable nodes. The MOST CAN gateway is directly linked to the real-time computer via a CAN card and converts the messages received at the MOST bus into four defined CAN messages. The model in the test system receives these CAN messages and then converts the information back into the original MOST message. This allows the tester to access all MOST messages with a consistent latency time. This solution ensures the system's real-time capability and there is no need for an explicit synchronization of MOST, CAN and hardware signals.

A MOST switch matrix as described above is used to set up different ring topologies during testing. All control units, measuring equipment and other bus participants are connected to one of the twelve MOST channels on the switch matrix and during test initialisation are connected via RS232 to form a specific ring configuration. In addition to the MOST ring configuration, the switch matrix is also a prerequisite for testing error level conditions and diagnosing ring failures.

3.3 Test Concept

As a rule, telematics control units are designed to be used in several model series. Consequently, test programs are designed to be applicable across all model series and to be configurable. That is the basis upon which the current HiL test system for telematics and its associated test programs are built, **Figure 2**.

By selecting an equipment variant, the tester can generate a pre-defined test bench configuration with MOST and CAN topology. When the CAN and MOST switch matrices are started up, the associated residual bus simulation is automatically activated and the necessary hardware is connected.

Each of the over 3000 test programs is independently enabled by means of defined key words for special equipment variants and configured further through the actual variant. With this highly variable test framework, with a reasonable amount of time and effort it is possible to cover all the equipment variants to be tested. The limiting factor in testing variants and configurations, however, is the time available for conducting tests.

4 Test Scheduling

All control units tested on the HiL simulator must first undergo a component test. The purpose of the integration test is to check the interaction of all MOST and selected CAN control units. A full test run for the described scopes for a release comprises 3000 tests. All the scopes also include results verification, error analysis and error communication. Owing to the large number of releases and the time it takes to test them, a full test run is performed only when there is a change of head unit. Accordingly, test scheduling is very much affected by the release schedule for head-unit variants. To keep test redundancy to a minimum, test cases are performed only once per control unit platform. Here, a platform is defined in terms of standardized hardware and basic software.

5 Test Scope

A central scope of testing in the expanded HiL test system is the verification of error level conditions. The error patterns generated by the test system are entered at the control unit interfaces and then queried via diagnosis at the control unit. A key role is played by the simulation of hardware defects and by residual bus simulation on CAN and MOST. A defined error level condition test process extending across all domains and control units leads to test results that are comparable and consistent in their presentation.

Voltage fluctuations that can occur under extreme conditions in the vehicle (empty battery, cold weather and others) should not cause control units to malfunction. This is ensured by testing control unit functions both during and after application of real-life voltage fluctuations to individual control units or the overall system.

The head unit acts as a gateway between CAN and MOST and in this function forwards information for the control units to the respective other bus. The hardware and software of the MOST link used in the HiL allow real-time testing of the information transmitted. Relevant test scopes include reaction and routing times as well as value requests and notification.

Another major test area concerns On/Off behaviour. Here, the test focuses on the powering up and powering down of individual MOST nodes and, particularly, of the head unit in its function as network master.

6 Summary

The productive application of a Hardware-in-the-Loop simulator shows that the technology of a comfort and drivetrain HiL test system, combined with the expansions described, has outstanding relevance for the needs of telematics. The technical features of the HiL test system used are essentially the high degree of automation, the dynamic configuration of CAN and MOST, the electrical fault simulation and the individual measurement and manipulation of control unit signals.

The common test system hardware and software were expanded to include the telematics interfaces. This expansion allows testing of real-time-capable function sequences requiring the synchronization of hardware signals and CAN and MOST messages. In addition, the transfer of process and implementation expertise from interior and engine compartment HiL and telematics test stands allows the creation of a basis for the easy transfer and expansion of existing test programs. Within a very short period of time, this achieved a high degree of relevant test coverage.

Figure 2: Telematics HiL test bench