Cleverly Connected

Testing ECUs in a networked system

Software that is ever more connected is controlling vehicle functions that are ever more complex. To validate this software, developers need to have the option to connect Hardware-in-the-Loop (HiL) simulations of individual domains to form a network – and ideally to be able to switch back and forth between testing individual components and testing the connected system. ETAS has now developed a solution for flexible real-time networking of component HiLs, and it also offers an impressive open architecture.

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In connected vehicles, electronic control units (ECUs) act as neural nodes. Because safety, powertrain, and convenience functions are increasingly interacting with each other, the distributed ECU intelligence needs to be interconnected. This, in turn, requires that the software for the relevant ECUs function smoothly and be capable of interoperating.

Hardware-in-the-Loop (HiL) simulation has proven very effective for validating ECU software. Now it is important to test software functions in connected ECUs. This requires synchronous connectivity of the component HiLs used to validate individual software modules and functions, as well as guaranteed real-time data traffic.

ETAS Multi-Real-Time PC for network HiL

ETAS developed Multi-Real-Time PC (Multi-RTPC) as a solution for the ETAS LABCAR HiL system. It connects component HiL systems via Ethernet and incorporates new versions of both the ETAS LABCAR-OPERATOR HiL configuration and experiment environment and the ETAS LABCAR-RTPC simulation target.

The RTPC software turns normal PCs into high-performance real-time simulation targets that calculate models with cycle times of under 0.5 ms and satisfy even rigorous real-time requirements in simulating highly dynamic physical control processes. Developers can now integrate any number of RTPCs into a

LABCAR network HiL – in other words, they can scale it according to the complexity of the ECU network. This enables them to simulate connected, physically accurate complete-vehicle models with hybrid powertrain and many driver assistance systems in a network.

The LABCAR-RTPCs are linked via three separate networks (see figure). These networks are responsible for the following:

- Communication with the LABCAR-OPERATOR software on a host PC
- Time synchronization of the integrated simulation targets
- Exchange of data between the targets

The three channels – the component HiL connection, the multi-core PC technology based on the Intel Core i7 processor, and the standard interfaces and network protocols – ensure top performance. Every target can communicate with all other targets at transfer rates exceeding 80 MB/s. The domains are synchronized using the Precision Time Protocol (PTP) defined in IEEE 1588.

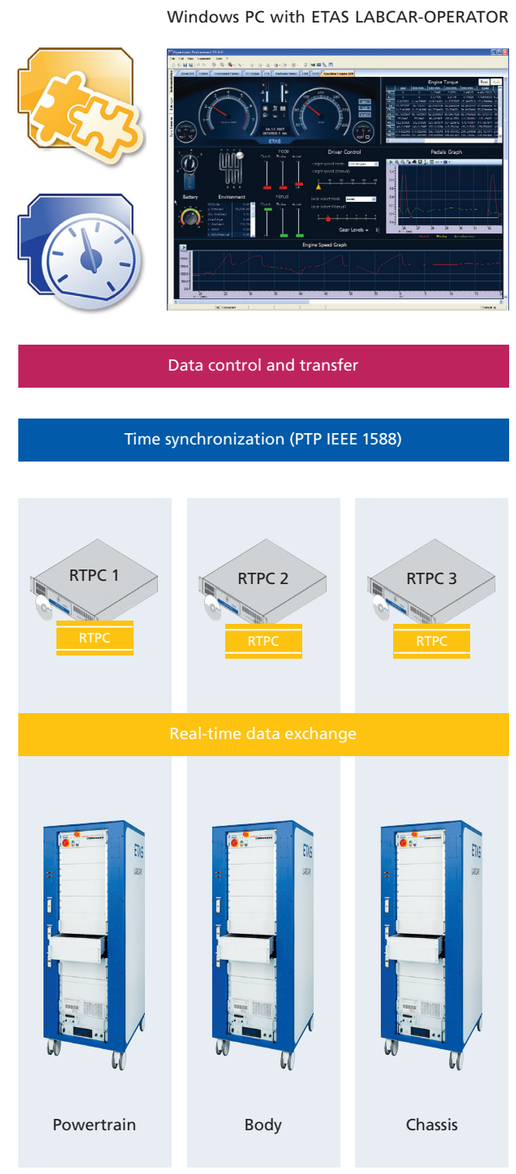
Modular design

The scalability of the network HiLs allows developers to test and validate ECU software individually at first, and then in a network. If connectivity and complexity continue their forward march, further component HiLs can easily be integrated. Thanks to standardized, tried-and-tested technology, it is easy to upgrade existing development environments to include Multi-RTPC. To keep costs down, ETAS paid special attention to the hardware, using Ethernet switches instead of expensive shared memory cards. The RTPCs incorporate PTP-capable network cards, which ensure synchronization of the simulation targets with deviations of <1 µs while costing barely more than conventional network adapters. Thanks to the progress that has been made in standardization, there is a broad array of manufacturers to choose from.

The component HiLs are connected to the network HiL via standard network communication, but they can also be operated separately, allowing developers from different areas to work in parallel. The LABCAR-OPERATOR software is useful for project configuration. Before creating the network HiLs, users set up one project for each of the individual component HiLs. When all interfaces and points of contact have been clearly established, the component HiLs can be merged using the new LABCAR-OPERATOR *Project Merger*, and then they can all be executed at the same time. Since the domain-specific HiLs are connected only by a network switch, users can continue to address the individual component HiLs without modifying the network wiring – so they can switch between the broad overview and the detailed view.

Outlook

Comprehensive environmental sensors and the trend toward partially automated driving are resulting in a rapid rise in system complexity and data traffic. That is why ETAS switched to a 64-bit Linux system for the latest version (V6.2.0) of the LABCAR-RTPC HiL simulation target – and why it continues to drive the performance and usability of its HiL solutions forward. After all, keeping the complexity manageable in the long term will only be possible with tools that provide optimum support for development processes.



Simplified structure of a complete-vehicle HiL system. Specialized PTP-capable network cards are required only for the PTP IEEE 1588 network. The other networks can function with standard network switches and cards.