Integrating a SiL into a HiL Test Platform

I. Matheis, T. Dörsam and W. Hoffmann

Abstract At Daimler, a HiL for the high power net of an electrical vehicle was built. The rest-bus simulation was planned to be implemented as a script that simply pushed constant values to the bus. Later on, the script was to be extended by further logic to become more realistic. At the same time for another team of Daimler, a SiL was developed to carry out pretesting of code and data changes of some ECUs. The SiL contained three virtual ECUs that used the real in-house software, a plant model and of course some rest-bus simulation. By chance an engineer of the HiL team met and discussed about their current work. A synergy was detected: when the SiL would be put into HiL context, it would be a perfect rest-bus simulation since the original ECU code could be used to calculate all signals needed. Also the rest-bus simulation was coming almost for free because the SiL was ready to use. The virtual ECU tool Silver was then integrated into the HiL and further synergy effects were found. For the price of a powerful desktop PC, the plant model of the SiL, which was more detailed than needed, could be reused for the HiL. At last, the Silver could be extended to remotely control the hardware of the HiL. Thus, the SiL could even drive test scripts on the HiL. Integrating the SiL into the HiL improved its quality and sped up its build. Last but not least, the SiL helped to reduce costs because the three virtual ECUs replaced the three real ones for which special HiL hardware would have been required as well.

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1 Planning Targets of the High Voltage Vehicle Power Net HiL

Due to high voltages and power, the high voltage power net of a hybrid or electric vehicle needs to meet special safety requirement. Apart from the usual functionalities like boost charging of the battery or running strong electric motors, safety has to be guaranteed. To examine how the components of the high voltage power net fulfill their specification, manifold tests with the target hardware must be carried out.

The HiL of the high voltage power net was used for:

- Testing prototypes during development of the hybrid drive,
- Verifying component tests,
- Administering specific standardized component tests,
- Analyzing sensitivity: what affects the system reaction the most,
- Simulating incidents measured in the vehicle and
- Developing system tests for the high voltage power net of the vehicle.

The design of the HiL was such that it was as close as possible to the vehicle layout (Fig. 1).

The HiL was modularized so that single components as well as subsets of the setup above could be tested. E.g. the high voltage battery could be replaced by a programmable power supply unit.

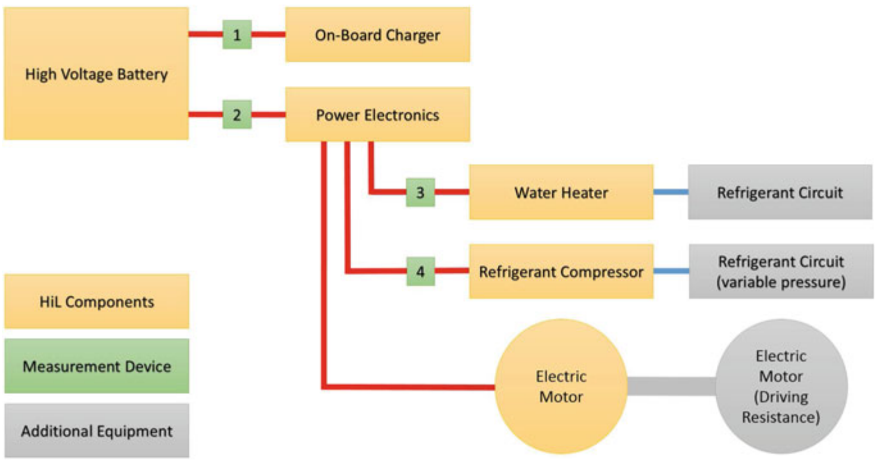

Fig. 1 The HiL setup

2 Powertrain-SiLs at Daimler

Since many years Daimler relies on virtual development solutions by QTronic [1–4]. Development and application engineers are able to test their changes within minutes on a standard Windows PC. This fast development cycle improves the quality of the code and the data before it is passed on to the build process of the real ECU. Thus, the quality of the product improves and costs can be reduced. At Daimler there are also highly accurate plant models available. Putting this together results in closed-loop simulations that are well accepted by the engineers.

The SiLs used in this project was a hybrid drive containing three virtual ECUs: the engine control unit (ECU), the transmission control unit (TCU) and the central powertrain coordinator (CPC). The virtual ECUs were built out of original C-code and original data. Any change could be applied and tested in less than 5 min.

The components of the SiL were integrated using Silver by QTronic. Because Silver provides an emulation layer for XCP and CAN, the engineers could reuse their application and measurement software (e.g. CANape or INCA) which they normally use for the car or the HiL. In particular, Silver was also able to control real hardware [5] running in a real-time mode, which turned out to be useful for integrating the SiL into the HiL. The SiLs were updated on a daily basis.

3 Reutilization of the Existing SiL in the HiL

Like any HiL test platform, the HiL for the high voltage power net needed a plant model and a rest-bus simulation. The initial plan for the rest-bus was to send constant values to the CAN bus. Later on, this was planned to grow in complexity in order to get closer to the performance of the real vehicle. The plant model of the HiL was planned to be implemented in Simulink starting with a simple model and enhancing the quality with every iteration.

Because the SiL was validated already and used by many engineers, it could provide the features of the rest-bus simulation. Since the SiL contained the real code and real data of the vehicle, the rest-bus was very realistic from the start. The amount of work to connect the SiL with a CAN bus of the HiL was a matter of less than one day's work. Furthermore it was not necessary to implement a plant model because the SiL already contained one.

At the beginning of the project the Modelica based plant model was too slow in some situations. This problem was solved by running the SiL on a high-end computer with a water cooling system. Silver then was set to slow down the SiL so that it followed real time.

However, further enhancement opportunities were detected. Using python scripts in Silver and the package PyVISA, Silver could control the HiL hardware. In order to connect to the HiL hardware connections such as RS232, GPIB (via GPIB bus or Ethernet), FTP, CAN (CANopen and Automotive CAN) and USB-IO were implemented.

One challenge was that the HiL hardware did not always accurately respond to the python programs. There were delays and sometimes the hardware simply failed to reach the target state. The problem of the delays was solved by moving any control code to python threads that ran in the background while Silver continued to act as the rest-vehicle. Retry-counters covered the case when the hardware returned with some error code. In the end, the python test scripts running in Silver became so robust that they could run several hours without a human in the loop.

Silver became one of the central components of the HiL.

4 Conclusion

The integration of the SiL into the HiL influenced the progress of the project in three ways:

1. Fast set-up of the HiL: using a high-end computer the SiL could run in real time. Integrating it into the HiL was done in less than a day. The SiLs were updated on a daily basis and the SiL covered the needs for a rest-bus and a plant model. Furthermore, at the time the HiL was setup, there were no real ECUs available. Integrating the virtual ECUs was the only way to start the project this early.
2. Improved quality of the HiL: because the rest-bus was based on three virtual ECUs made of original code and data, the rest-bus was nearly perfect. Furthermore, the well tested and highly accurate plant model was much better than needed.
3. Reducing the costs of the HiL: integrating three ECU in the HiL would have needed several HiL racks. Instead, the SiL needed a single high-end computer with a water cooling system. Furthermore the human resources for maintaining the HiL, programming the rest-bus and the plant model could be saved.

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