Hardware-in-the-Loop (HIL) Simulation with Modelica – A Design Tool for Thermal Management Systems

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Due to the higher complexity of electrified vehicles the requirements for vehicle components and vehicle design augment and new development tools are desirable. The following paper describes the design of a hardware-in-the-loop (HIL) test bench along with its structure using Modelica and a Remote Process Communication library. The aim is to support the development of components and operational strategies under realistic boundary conditions. The test bench is planned and built up within the scope of the public founded project qOpt at the Institute for Automotive Engineering (RWTH Aachen University) in cooperation with the Forschungsgesellschaft Kraftfahrwesen mbH Aachen and the Institute of Automatic Control (RWTH Aachen University). An overview of the participated applications currently in use at the HIL is shown in Fig. 1.

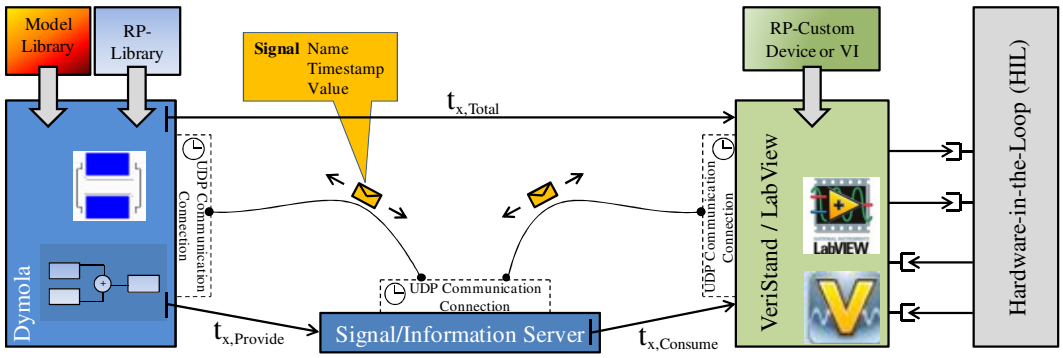

Fig. 1: Software structure of the HIL system. Multiple applications are joined for operation.

An application example is given in which a thermal storage unit is integrated into a Plug-In-Hybrid Electric Vehicle, to enhance the combined heat and power (CHP) usage of the internal combustion engine (ICE). In order to measure the usable amount of waste heat of the ICE the vehicle is placed on a dynamic chassis dynamometer and the cooling circuit of the ICE is connected to the HIL. All heat sinks, like the passenger cabin as well as the thermal storage are simulated in Dymola and the respective physical values are transferred to the thermo-hydraulic test bench. The results show that a reasonable amount of waste heat could be recovered in a thermal storage. Therefore, the electric driving range can be enhanced by providing the heat demand of the passenger cabin in form of the storage unit.