EFFICIENT BATTERY FUNCTION DEVELOPMENT BY APPLICATION OF BATTERY-AS-A-SERVICE CONCEPTS

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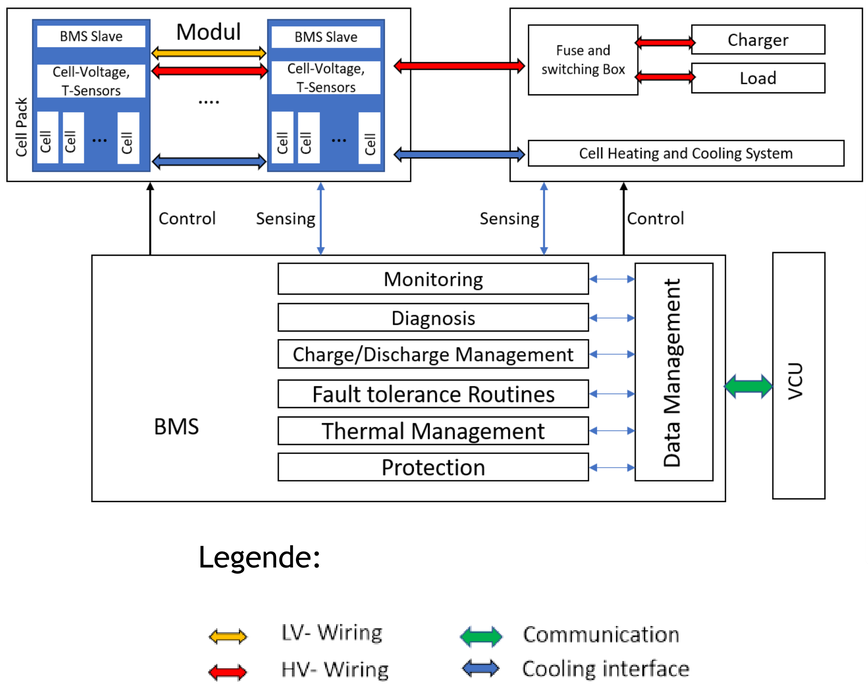
Overview of typical BMS functions and interfaces



Typical BMS functions and interface tests

Extensive testing needed on BMS Hardware (HW) and Software (SW)

- Testing of BMS on real batteries:
  - Time- and cost-intensive
  - Can lead to Safety critical and hazardous situations, such as:
    - short-circuit
    - over-temperature
    - cell over-charge and discharge
  - Difficult to create and reproduce test cases

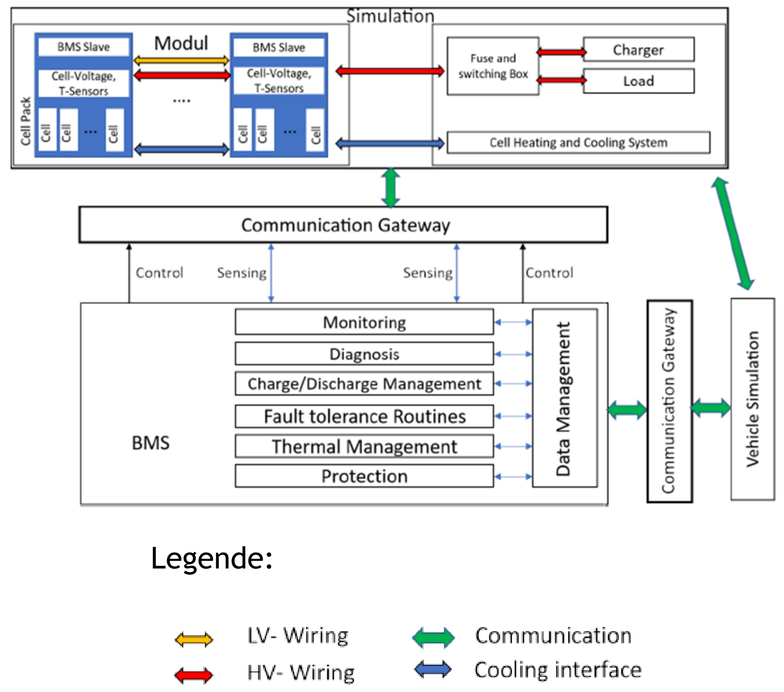
Scope

Introducing a novel test approach for a **battery system**, that is driven by a unified, standardized interface between hardware- and software components. This allows to seamlessly exchange real hardware components with software components, and vice versa. The **Distributed Co-Simulation Protocol (DCP)** is used to encapsulate and virtualize these components. A DCP master is used for effective configuration and re-configuration of these so called DCP slaves.

dcp Distributed Co-Simulation Protocol

Is an application level communication protocol. It is designed to integrate models or real-time systems into simulation environments. The DCP is standardized by **Modelica Association**

Proposed setup for testing a BMS using HiL

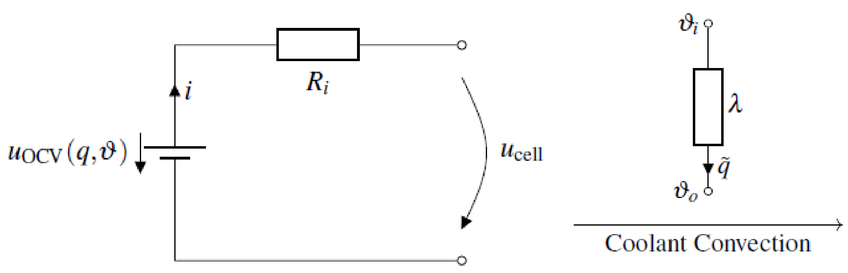


Tests conducted on a Hardware-in-the-loop (HiL) system

Useful especially at early stage in battery development processes.

- HiL system typically consists of:
  - A real-time simulator that emulates a battery
  - A control unit (e.g. Vehicle control unit, VCU)
  - Other vehicle system to interact with the BMS, e.g. the powertrain or the VTMS

Battery Model

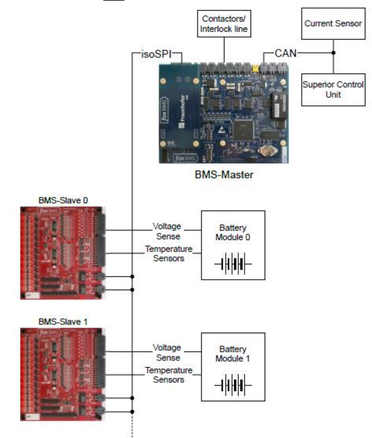


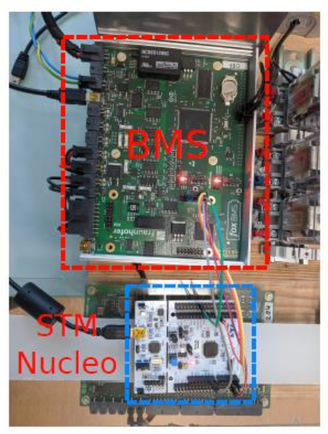
- Compute a single representative cell and scale the current and voltages via the number of cells in parallel or series, respectively.
- Individual model for single cells, to recognize “bad” and “good” cells in the battery pack.
- More complex Battery models possible.
- Additionally Lumped thermal model of a cell may be used, in analogy to the electric model.

Key Benefits

- **Safe testbed deployment for BMS function development and rapid reconfiguration possibilities using DCP**
- **HiL system to develop and test new functions in the context of BMS development by implementing the DCP standard.**
- **Vehicle and battery Simulation for efficient BMS functions development**
- **Systematic development process including CI/CD concepts**

Design of BMS Slave

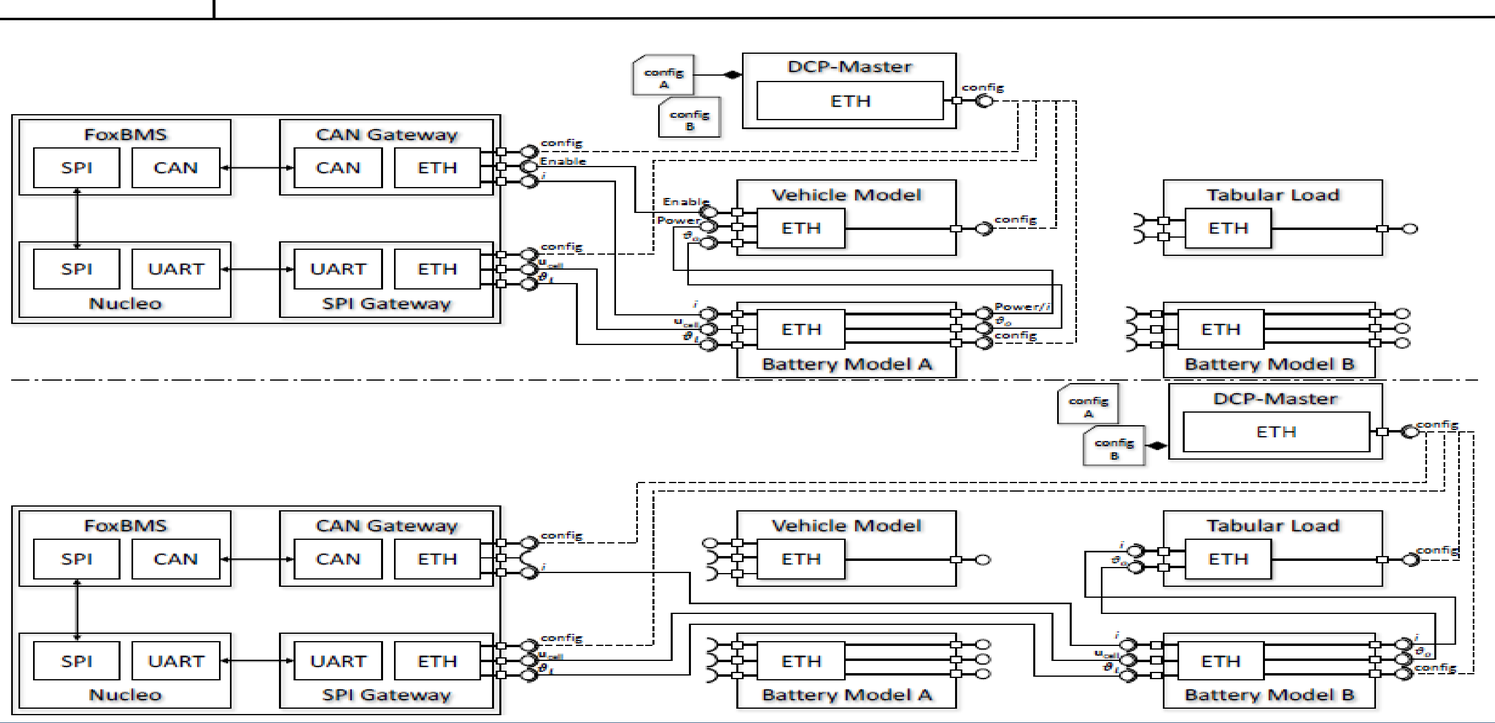




- Use an Isolated SPI (isoSPI) bus to connect to one or multiple cell monitoring boards. (source: Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. 2021)
- For low level emulation of the communication protocol development board STM Nucleo-F446 was utilized
- Possible extension to different communication protocols e.g. iso UART, CAN-bus etc.

Demonstrator

- The foxBMS Master HW is coupled into the DCP
- Vehicle simulation with separated battery model
- Distributed simulations are connected via UDP over Ethernet to the same network switch
- Quasi-stationary electric vehicle model implemented in MATLAB Simulink using the QSS-Toolbox and encapsulated into a DCP slave using AVL’s Model.CONNECT (AVL List GmbH 2021)



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