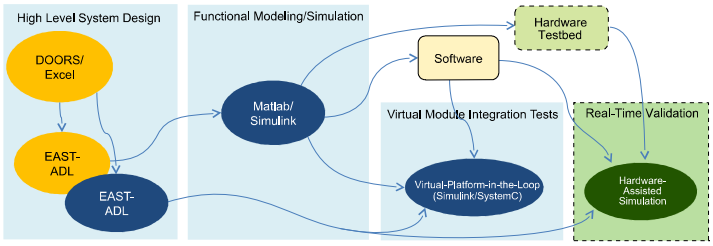
Model-Based Design and Virtual Integration of an Intelligent and Safe Electrical Powertrain

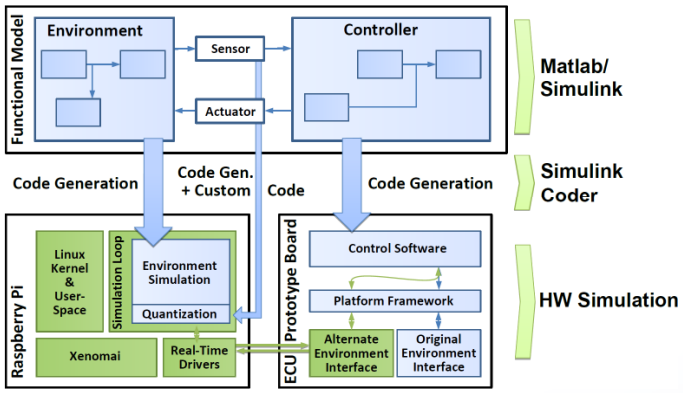
Affordable Hardware-in-the-Loop Real-Time Simulation

- Development of the electric powertrain follows the idea of the model based design.
- 9-phase E-motor will be available later during the research project but corresponding motor control must be tested in advance.
- Validation of the motor control is done by different means of testing: Functional simulation in Matlab/Simulink, execution on a virtual prototype as well as Processor- and Hardware-in-the-Loop simulations using available controller hardware.
- Long-term stability tests of the motor control software requires fast simulation of motor behavior. Commercial solutions are expensive.
- **Aim of OFFIS**: Development of an affordable Hardware-in-the-Loop real-time simulation platform for early validation of the motor control algorithm.



Model-based design flow

Concept of Virtual Integration and Real-Time Simulation

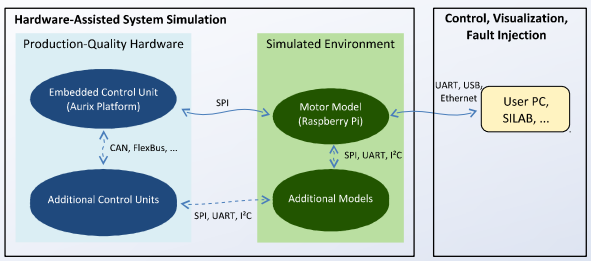


- Simulink Coder is used for code generation to bring the functional model
  - of the motor control algorithm to a prototype ECU using the target CPU
  - of the motor behavior to a low-cost ARM based Raspberry Pi computer
- Despite small changes regarding the interface, motor control remains untouched and is executed within the developed software framework on the Infineon AURIX multicore CPU.
- The RaspberryPi computer runs a Linux kernel with the Xenomai real-time patch. In addition, we developed a light-weight driver framework for direct hardware access.
- Digital sample values instead of analog signals are transmitted to avoid the need for any active components beyond the Raspberry Pi.
- The boards communicate through a low latency and high bandwidth (20MBit) SPI interface.

Realization and Results

Demonstrator setup: Motor simulation model executed on Raspberry Pi (bottom right) as environment for the motor control unit (left).

Conceptual setup of the hardware-aided system simulation



Visualization, control and fault injection through a host PC.
Link to driving simulation SILAB is planned.

Sensor Polling (transmission of ECU inputs)	26µs
ECU calculation	5µs
Actuator Updates (transmission of ECU outputs)	18µs
Motor Model Calculation	40µs
Total (<100µs for realtime)	89µs

System Simulation Timing

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