EXTENSION OF A POWERNET TESTBENCH WITH A VEHICLE SIMULATION INCLUDING ENVIRONMENT FOR A INTEGRATED DEVELOPMENT

Stefan Kurtz, BMW Group
Prof. Dr.-Ing. H.-G. Herzog, TUM
AGENDA.

- Introduction
  - Origin

- Approach
  - General approach
  - Finalized work
  - Latest achievements
  - Status Quo
  - Requirements

- Architecture
  - HiL architecture overview
  - Hardware architecture
  - Software architecture

- Realization
  - Implementation
  - Simple approach of a passenger model
  - Results

- Summary
  - Advantages
  - Outlook
Automotive power net designs grow more and more complex, they contain…

– Energy storages (e.g. AGM battery, Li-Ion battery)
– Power supplies (e.g. generator, DC/DC converter)
– Consumer (e.g. ohmic sinks, electric motors and systems consuming constant power)

In other words, there are…

– Different voltage levels
– 100+ ECUs in highly equipped vehicles
– 100+ actuators in highly equipped vehicles
– Massively connected functions that command several ECUs and actuators

→ Major question: How to coordinate energy and power aspects at it’s best?
GENERAL APPROACH.
The institute for Power Conversion Technology (EWT) at Technische Universität München (TUM) builds up a reference power net test bench in cooperation with BMW Group.

The test bench consists of…
- An original BMW F01 (series 7) chassis
- An original wiring harness
- Numerous electronic sinks as replacement for real components
- An original AGM battery
- An original generator carried by an electric motor
- A second voltage level (48V)

Additionally to a normal vehicle the test bench is equipped with…
- Numerous measuring points for voltage and current
- Simulated consumer behavior (decided to be independent of static ECU software versions)
A DETAILED VIEW TO THE TEST BENCH.

- measuring points
- electronic sinks
- wiring harness
- generator carried by an electric motor
- BMW F01 (series 7) chassis
- TUM EWT reference power net test bench
- AGM battery
LATEST ACHIEVEMENTS.

– Next generation Energy and Power Management [3, 4] analogue to an up-to-date BMW series 7 (G11)
  – With complete access to the operation strategy and every parameter

– (Optional) replacement of the AGM battery by a powerful battery simulation test bench [5] containing
  – Electronic source (analogue to the performance of a battery)
  – Electronic sink
  – Different battery simulation models
STATUS QUO.

The test bench can…

- Rerun every situation logged in a real vehicle, with preparation of the logged data
- Run every artificial scenario
- Be configured as a customer can choose extra equipment

We can…

- Analyze and optimize every operation strategy and parameter
- Integrate any thinkable consumer or function for testing purposes
REQUIREMENTS.

For further work we need…

- The possibility to analyze and optimize in a massive dimension to identify the global optimum
  - For the operation strategy of the energy management system
  - The classifiers of the prediction model for the power management

Which means to…

- Find the relevant situations
- Identify or even generate corresponding driving scenarios
- Parametrize the consumers and the battery simulation in the test bench
- Stimulate the whole test bench in a realistic way in real time
- Report the gain of the management system
HARDWARE ARCHITECTURE (RUNNING OPERATION).

- **Generator**
- **Impress current**
- **El. Load #1…n**
- **Battery**

- **A/D conversion**
  - **Measure**
  - **Co-Simulation**

- **NI PXI**
- **COTS PC PharLab**
- **COTS PC Host**
- **COTS PC Measuring**

- **Analogue output**
- **Analogue input**
- **Ethernet**
- **NI PXImc**
SOFTWARE ARCHITECTURE.

NI Verisimant (2)

- Predicti
- FMI Power Mgmt (Dymola)
- FMI Consumer model #n (Dymola)

IPG CarMaker (custom device)

Passenger model (Simulink)

A/D Hardware

- A/D converter

NI Labview

- Measure
- Measurement GUI (LabView)

A/D Hardware

- (sensor) data
- command
- measurement
IMPLEMENTATION.

- Integration of MATLAB/Simulink passenger model using CarMaker Template
- Creation of a custom CarMaker kernel for LVRT
- Integration of IPG custom device in NI VeriStand
- Connection of all necessary inputs and outputs using aliases

- Integration of Dymola customer / producer / management models using FMI [1]
- Integration of NI PXImc for communication to PC [2]
- Connection of all necessary inputs and outputs using aliases

➔ Deploy, wait, run, wait, have fun!
- Simple MATLAB/Simulink model representing passenger behavior
- Position specific behavior (driver, co-driver, passenger) → up to four (or even more?) instances thinkable
- Decisions linked to
  - Daytime and lightness
  - Driving time
  - Temperature (in- & outside)
  - Weather
- Nearly all inputs were natively generated by IPG CarMaker

Simulink passenger model snippet
IDEA AND DETAILS OF THE PASSENGER MODEL.  
LOW BEAM LIGHT DECISION.

Decision for low beam light (driver only)
- Driver wishes low beam light between sunset and sunrise or
- Otherwise when it’s dark like in a tunnel or a car park

Necessary inputs:
- Daytime
- Lightness

Possible optimization:
- Simple model of altitude of the sun
IDEA AND DETAILS OF THE PASSENGER MODEL. SEAT MASSAGE DECISION.

Decision for seat massage (possible for any passenger)
– Passenger wishes seat massage “randomly” or
– When he/she is sitting a long time

Necessary inputs:
- Driving time
- Pseudo random generator

Simulink passenger model snippet
RESULTS.

- Extension of IPG CarMaker by customer inputs without an additional interface
  - Every synchronization is made by IPG CarMaker
- Realistic real-time stimulation
  - of consumer models
  - of prediction models
- Simple replay of test scenarios with much more details like traffic
- Simple modification of test runs by changing the IPG CarMaker Simulation
ADVANTAGES.

- Any test drive can be run on the test bench
  - Real
  - Simulated
  - Synthetic (also not real or not realistic)
- Any parameter can be stressed
  - Individual
  - In combination (due to integration of IPG CarMaker simulation)

We now can…
- Run generated standard scenarios in great numbers and
- Rerun real test drives with the help of IPG CarMaker
OUTLOOK.

- Import of real test drives with options or modifications
  - With or without velocity profile
  - With or without traffic
- Build „fast-forward“ out of relevant situations to speed up simulation
THANKS FOR YOUR ATTENTION.

...further questions?
BACKUP.
REFERENCES.


REFERENCES.