Early Verification and Testing of a Mechatronic Active Roll Control

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Agenda

1. Background and Motivation
2. Virtual Testing with Silver
3. Use Case @Schaeffler
1 Background and Motivation

intelligent Active Roll Control (iARC)

- Electronic control unit
- Wire harness
- Coupling rod
- Stabilizer bearing
- Torsion bars
- Subframe
- Motor/gearbox unit

iARC system components, integrated in the front axle of an SUV (©Audi, Schaeffler)
1 Background and Motivation

System Functional Test: Status and Challenges

Test Environment
- Target signals: Test profiles
- External disturbances at coupling rods: 2x hydraulic pulser system
- Vehicle/Chassis communication: Restbus simulation
- Supply voltage: 36V / 48V / 52V
- Ambient temperature: -30°C / 23°C / 80°C

Challenges
- Higher cost (compared with virtual testing)
- Bug-fix of unexpected errors brings more time consuming on test bench
- Test scheduling depends on the availability of the bench

Motivation
- Virtual testing on PC
  - Reduce cost on test bench
  - Increase the test coverage
  - Early verification and testing
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Workflow of Virtual Testing

- Virtual simulation platform in Silver
- Test assignments are synchronized with database, i.e. PTC Integrity
- Virtual simulation platform is parameterized by software release, parameter container, actuator type and so on
- Post-processing: e.g. boundary values
- Test report shown in the end with “pass/fail” results
Virtualization

Real object

Modelling

Simulation platform

Hydraulic pulser system

iARC

virtualization

virtualization

virtualization

ECU functions

RTOS emulation

4GB virtual memory

A2L conversion

flash

XCP

Silver
Virtualization of Physical Models

Hydraulic pulser system

iARC (actuator component)
Virtualization of ECU-SW

Options
- MATLAB/Simulink modules in MiL (Model-in-the-Loop)
- C code in SiL (Software-in-the-Loop)
- Delivered Hex file (binary containing data and program code)

Status
- SW is developed together with another supplier
- Hex file is delivered from SW department and verified against specification
- Use the identical SW as the one on test bench

Virtualization
- Chip simulation
### Virtual ECU with Chip Simulation

**ECU** (here: Autosar)
- **OS**
  - Standard BSW API
    - Com, Dem, Dcm, PduR, NvM, etc.
  - Standard MCAL API
    - Can, Lin, Fr, Fls, dc, Pwm, etc.
- **ASW** – Application Software and RTE
  - Non-standard API
    - IO hardware abstraction
  - Complex device drivers

**Target chip – ECU Hardware**

**Virtualization**
- **ASW**
- **BSW**
- **Windows PC**

**Principle of chip simulation**
- Mapping the instruction set of the target processor to the instruction set of the host processor on PC

**Use case of chip simulation**
- Only application SW
- Basic SW is verified in HiL (Hardware-in-the-Loop)
Virtual ECU with Chip Simulation

Needed files
- **Hex file**: Program code and data of the functions to run
- **A2L file**: Describes the inputs, outputs (MEASUREMENT elements) and parameters (CHARACTERISTIC and shared AXIS_PTS elements)
- **MAP file**: Maps function names to ECU memory addresses
- **DCM file** (for calibration): Calibration data to be flashed

ECU (here: Autosar)

- **ASW – Application Software and RTE**
  - Standard BSW API
  - Non-standard API
  - Complex device drivers
- **OS**
- **Target chip – ECU Hardware**

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01 #============================================= 02 # Spec file for tcbuild.exe and Silver module tcdebug.dll 03 #============================================= 04 # Used files 05 hex_file(iARC_SW_H03.A.V01_R0.2.0.167.hex, TriCore_1.6.1) 06 map_file(iARC_SW_H03.A.V01_R0.2.0.167.map) 07 a2l_file(iARC_SW_H03.A.V01_R0.2.0.167_rear.a2l) 08 # Specification of startup code 09 chip_config(STEP_SIZE, 0.001) # base clock tick in milli seconds 10 chip_config(TEXT_START, 0xa0000000) # 4 bytes for Silver internal use 11 # List of functions to run, in order of execution 12 task_initial(ATC_TaskInit, 0) 13 task_periodic(ATC_step, 2, 0) 14 a2l_function_inputs(ATC_Gen) 15 a2l_function_outputs(ATC_Gen)
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Early Software Verification and System Testing

1. Early system testing
   - Functional testing in system context

2. Early software verification
   - When SW-Build is deployed
   - Move selected tests from HiL
   - Component testing

3. Pre-calibration

Function developers
Simulink models → Code generation → C code → Compilation for target processor → Hex file (SW Build)

Early system testing
Early SW verification
Flash
System release
System functional test
System integration test and calibration
Pre-calibration
Status Quo

1. 46% IDs of system functional test can be verified in virtual environment

2. Virtual testing has a good correlation with measurements

3. Enlarge test strategy in a cost-effective way

4. Has been established for more than one project, and is also planned for other chassis mechatronic systems

5. Continuing improvement of physical models to increase test scenarios
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