Rapid Control Prototyping for Automotive Control Software

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• Basics on Prototyping

• Types of Prototyping

• ETAS solution to prototyping tool chain

• Use case -Throttle
Basic of Prototyping

![Diagram of prototyping process]

- Function Design
- Calibration
- Hardware-In-the-Loop Test
- Automatic Code Generation
- Rapid Controls Prototyping

**Process Flow**

- Start
- Complete

**Hardware**

- PC h/w
- Target h/w
Basics of Prototyping

Need for Prototyping

- Absence of real ECU for testing the functionality.

- Verifying the control functions against real world signals

- To extend product lifetime by adding necessary features and eliminating redundant features early in the design.

- Reduction in both the cost of new product development and time to market.

- External Bypass
Types of Prototyping Setups

- Prototyping Hardware
- Virtual Prototyping
- ECU with Bypass
Prototyping Hardware Setup
Virtual Prototyping

Plant + Controller

Host PC

Driver

Environment

Setpoint device

Controller

Actuator

Plant

Sensors

Vehicle
Real ECU with Bypass

Prototyping Hardware

Real ECU

Prototyping Hardware

Real ECU with Bypass
Various MBD tools

• Different domains use different modeling tools
  • Functional development
    • Simulink, ASCET, Statemate, SCADE, ...
  • Software development
    • ASCET, TargetLink, Embedded Coder, hand-written C-Code, ...
  • Environment Model Development
    • Simulink, GT-Power, AmeSim, Tesis, ...

• New functionality on top of existing
  • External Bypass is commonly used
INTECRIO – Universal Prototyping System
Basic Element – General System Setup

INTECRIO Integration and Configuration Platform for Prototyping Systems

VP on PC  RP on PC  RP on high end HW  RP on cost effective HW

Simulink Coder  ASCET  AMESim  GT-Power  Tesis

Embedded Coder  TargetLink  Handwritten C-Code

Proprietary Basic SW

RTA-OS

Crossbar / RTA-RTE

INCA + EIP

C  SCOOP  A2L

AUTOSAR

AUTOSAR

A2L  HEX

C

TargetLink

Handwritten C-Code

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INTECRIO – Universal Prototyping System
Model Integration & Configuration – Simulink

Simulink

Select Real-Time Workshop
INTECRIO Target

Module Representation

Generate Module Code

Import Module Description

Software Module Representation

Tool independent

Tool dependent

C Code
Data Description File (ASAM-2)
Interface Description File (SCOOP-IX)
- Uniqueness:
  - Control Algorithm Model not hardware dependent
  - Hardware Configuration and integration not inside the model

- Benefits:
  - Model can be used for Simulation, Rapid Prototyping and Code Generation
- Simulink model remains unchanged
  - Hardware Interface Configuration and integration in INTECRIO; not in Simulink model
  - Model can be used as is for Simulation, Rapid Prototyping, Code Generation

- Integration of multiple Simulink models into one Prototype
  - Integration of Simulink models from different versions
    - Support of all versions since 2007a to R2012a
ETAS solution to prototyping tool chain →
Rapid Prototyping Hardware – With ES910 and ES930
INTECRIOS – Universal Prototyping System
Rapid Prototyping Hardware – ES910 – Ultra Compact RP-System

- Standalone operation
- Hidden installation
- Automatic wakeup
- Automotive Temp. Range
- 1x FlexRay Channel A&B or 2x CAN
- 2x CAN
- 2x LIN
- 1x ETK
- Ethernet and CAN based I/O Modules
- PowerPC double precision floating point unit, 800MHz
- 512 MBytes RAM
- 128 kBytes NVRAM
- 64 MBytes Flash
- Automotive Temp. Range

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Daisy-Chain topology
One cable = power + data
100MBit/s Ethernet

Temp. Range
-40 °C to +70 °C

4 x Thermo
K-Type

6 x Digital Output
PWM, Pulse, State

6 x Digital Input
PWM, Counter, Timer
Event Raster Source

4 x Analog Output
0 V to 10 V, 14 Bit

8 x Analog Input
±1/10/60 V
10 kHz, 16 Bit

4 x Sensor Supply 5 V
to 15 V or Off

4 x Half-Switch-Bridges
with Current Measurement
ETAS solution to prototyping tool chain ➔
Rapid Prototyping Hardware – With RTPRO-PC

Function models or SWCs

Integration & configuration of HW & SW
INTECRIO

Experiment Environment
INCA + EIP
Or
INTECRIO-EE

Rapid Prototyping System
– RTPRO-PC with one ES581 and one ES930

Temperature Position Buttons

Ethernet

USB

CAN

Fan E-motors
RTPRO-PC software turns a x86 based PC into a real time rapid prototyping target.

There’s no need for a dedicated RP hardware.

The x86 platform gives a very powerful simulation node.

Windows can run on the same PC in parallel and at the same time.

Automotive I/O interfaces are provided via the PCs USB and Ethernet ports.
ETAS solution to prototyping tool chain → Virtual Prototyping

Closed or Open Loop

Integration & configuration of HW & SW INTECRIO

Experiment Environment INCA + EIP
Or INTECRIO-EE

Plant + Controller

Driver

Environment

Setpoint

Controller

Actuator

Plant

Sensors

Function models or SWCs
INTECRIIO for Virtual Prototyping enables …
- Specification of Virtual Prototypes of Embedded Control System
  - Integration of Control Algorithm and Environment Model
- Execution of Virtual Prototypes on a standard Windows PC
  - Validation of a functional architecture
  - Verification of an electronic architecture

INTECRIIO for Virtual Prototyping is …
- The ability to ‘front-load’ the development process
  - Do more validation in the office before going to the test bench or the test vehicle
  - Do more validation & verification with an ECU similar SW structure
Integration of Vehicle, Driver and Environment Models
- In addition to Function Software Models, models of the vehicle, the driver or the environment can be integrated
- This enables additional possibilities through model-in-the-loop (MiL) and software-in-the-loop (SiL)
  - Function validation within a simulation model
  - Pre-calibration on function or software
  - In-depth analysis of the function behavior
  - Time-lapse and slow motion

Function or Software Model

DVE Model

INTECRIO – Universal Prototyping System
Virtual Prototyping – Features
ETAS solution to prototyping tool chain → Rapid Prototyping Hardware – External Bypass
INTECRIO – Universal Prototyping System
Basic Element – Rapid Prototyping – External Bypass

Scheduling & Cooperation
- 100 ms
- 20 ms
- 5 ms
- 1 ms

Standard ECU functions:
- e.g.: ignition, injection, lambda, ...

Dedicated Real-Time Link
(x)ETK or CAN

Experimental Target(s)

Synchronized Data Exchange

New functions on experimental target

C-Code

Experiment Environment INCA

Standard ECU functions:
- e.g.: ignition, injection, lambda, ...

Experimental Target(s)

Synchronized Data Exchange

New functions on experimental target

C-Code
What Does EHOOKS Do?

Hook Types: External Bypass Hook

Allows an ECU variable to be hooked and bypassed by an external rapid prototyping system.
Use Case: Throttle Control

Controller

Plant

Stimuli
Thank you

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