Virtual Hardware In the Loop (vHIL) for Accelerating xEV Application Software Development

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Agenda

1. Objectives
2. AURIX™ TC4x Virtual Prototype
3. AURIX™ TC4x Virtual Motor Control Application Kit
4. Summary

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Objectives

- To start early pre-silicon software development with complete debug and trace toolset support
- To validate inverter use case (with a focus on motor control) on AURIX™ TC4x microcontroller even before silicon is available
- To prepare software development kit (SDK) which will be used to control real motor
- To test algorithm behavior in corner cases without using real hardware

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Objectives
AURIX™ TC4x microcontroller architecture

Performance ASIL-D
Enhanced TriCore™
With up to 6CPUs @ **500MHz**

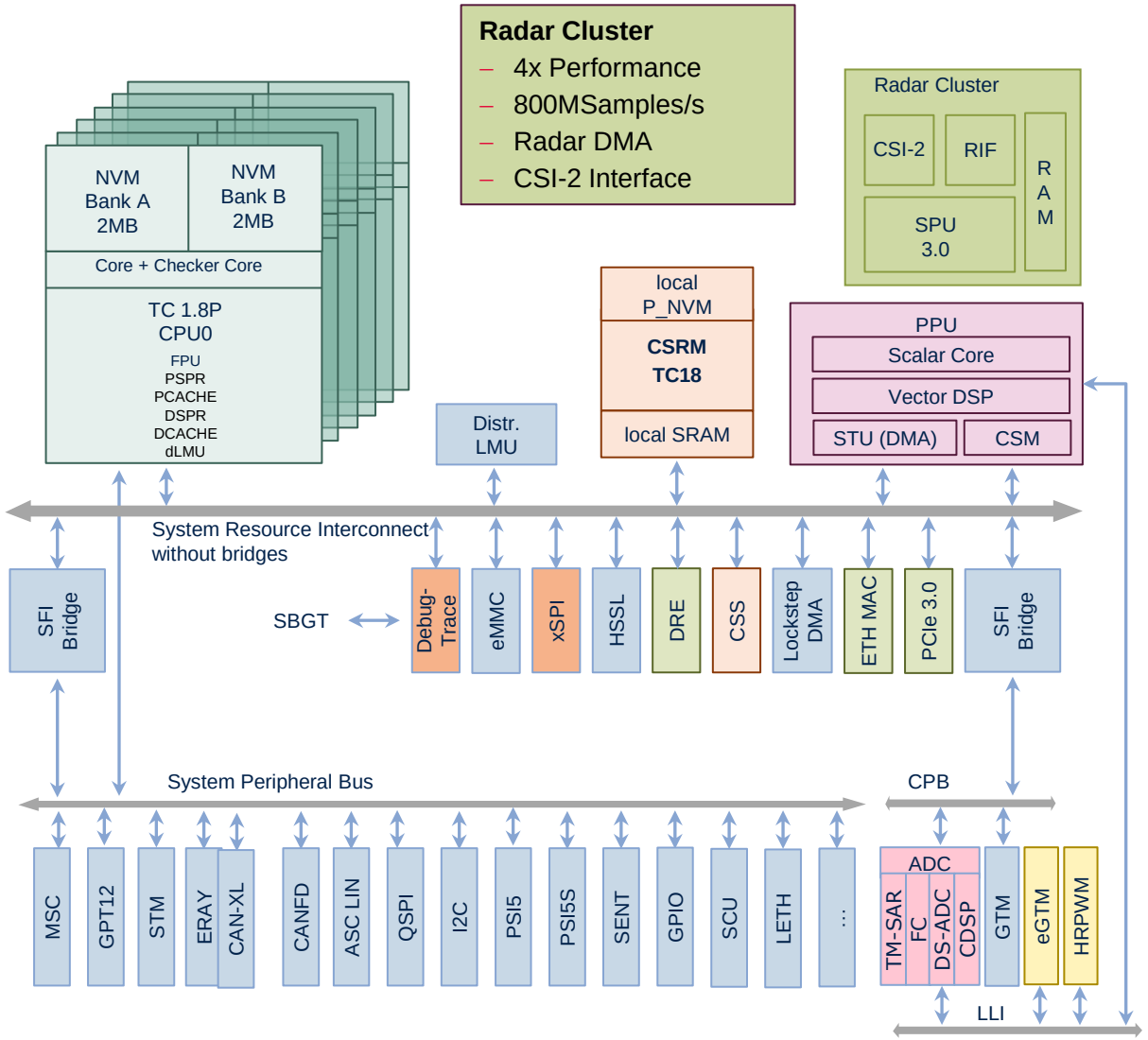
Bigger Tightly Coupled SRAM for increased performance

Full AB-Swap Support

Debug and Trace
Safe and the secure in field

xSPI
External Memory Interface

ADC
Dedicated DSPs
Enhanced ADCs



Radar Cluster
- 4x Performance
- 800MSamples/s
- Radar DMA
- CSI-2 Interface

CSRM
New high performance Security Modules with QM support

CSS
Dedicated communication security satellites

New Programmable HW Accelerator - PPU
SIMD Vector DSP + Scalar Core for Modelling and Precise Control – **ASIL D**

New high-speed comm Interfaces:
- PCIe 3.0
- 100Mb- 5 Gbps Ethernet

New 10 Mbit Ethernet and CAN-XL

New communication routing accelerator:
- DRE- Data Routing Engine

New eGTM timers and **High Resolution PWM** with **low latency interconnect (LLI)**

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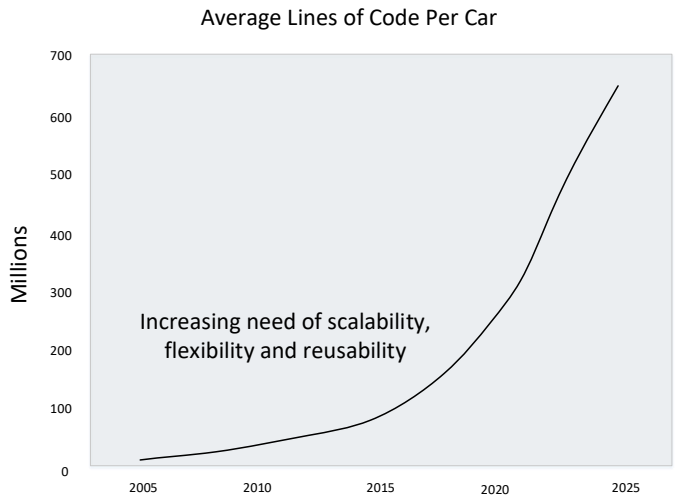
Increasing SW Complexity requires simulation based validation to reduce time and effort

Increased Software Complexity

Tomorrow's Vehicle
6X more lines of code



Simulation and Virtual Testing

Benefits

- ✓ Time to Market
- ✓ Cost saving
- ✓ Improved Quality and Safety

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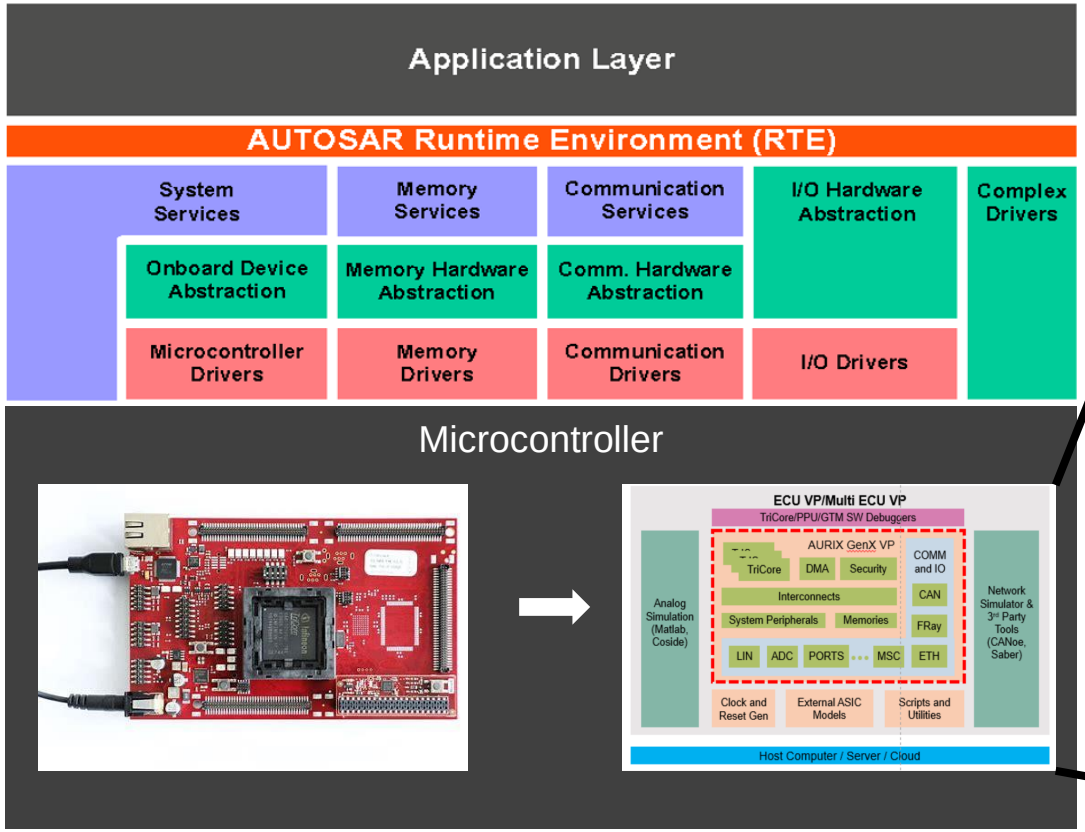
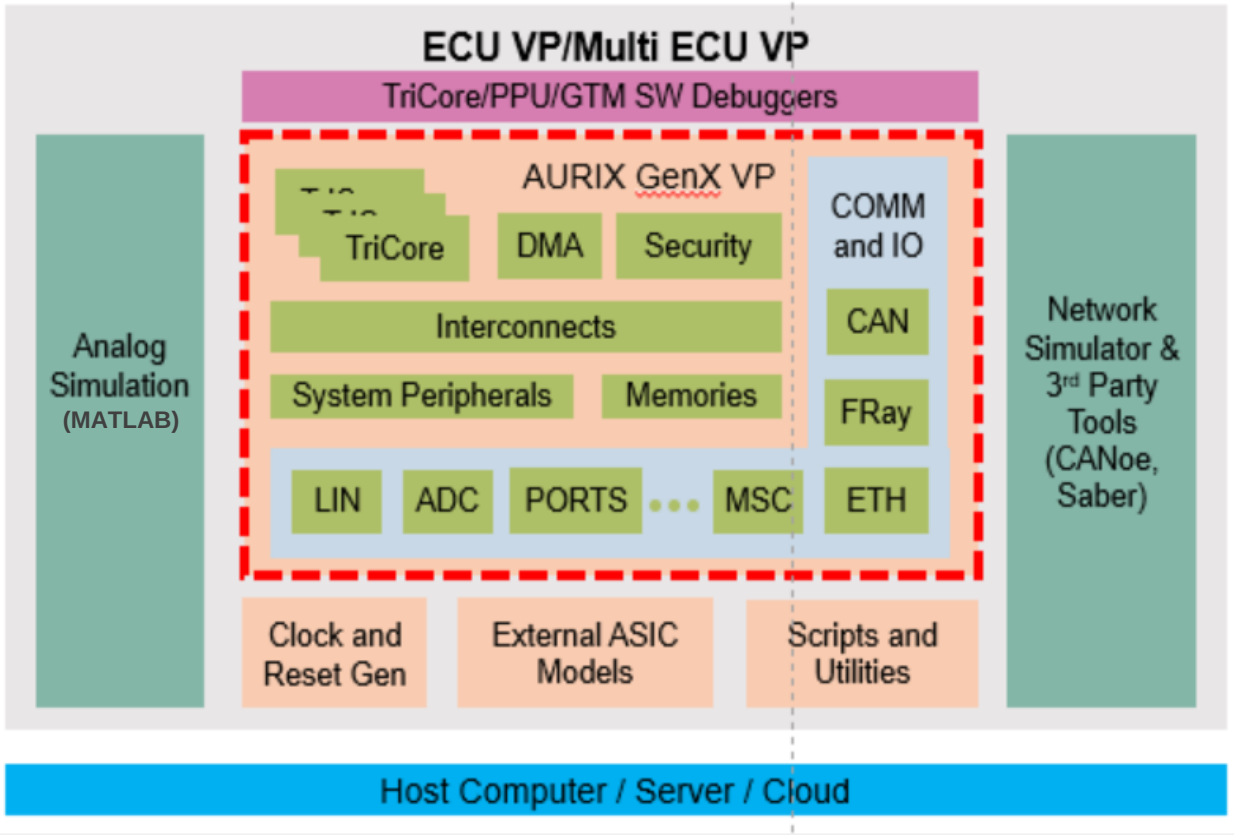
What is Virtual Prototype (VP) ?

A simulation platform of HW that can execute target SW applications without any modifications



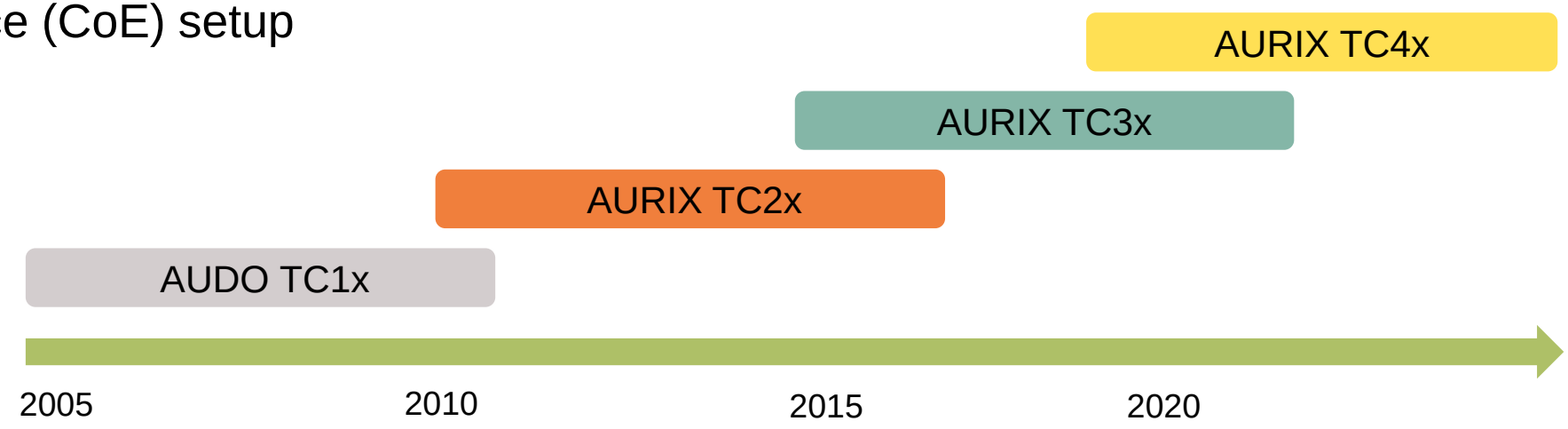


Successful collaboration between Infineon and Synopsys enabling Virtual Prototype across AURIX™ generations

- Long collaboration over 15 years
  - VP tools and integration
  - IP modelling
  - VP deployment and support
- Long term partnership for developing Fast Timed Model for TriCore™
  - Reuse of Register-Transfer Level (RTL) tests improves model quality and accuracy
- Successful deployment into many Tier1 and OEM projects
- Deepened partnership for AURIX™ TC4x VP via Centre of Excellence (CoE) setup

Synopsys Expands Center of Excellence with Infineon to Deliver Virtualizer Development Kit for AURIX TC4x Automotive Microcontroller

Collaboration for Third Generation Builds on Successful Deployment of VDKs for AURIX TC2x and TC3x Series to Enable Early Software Development at Tier1 and OEM Customers



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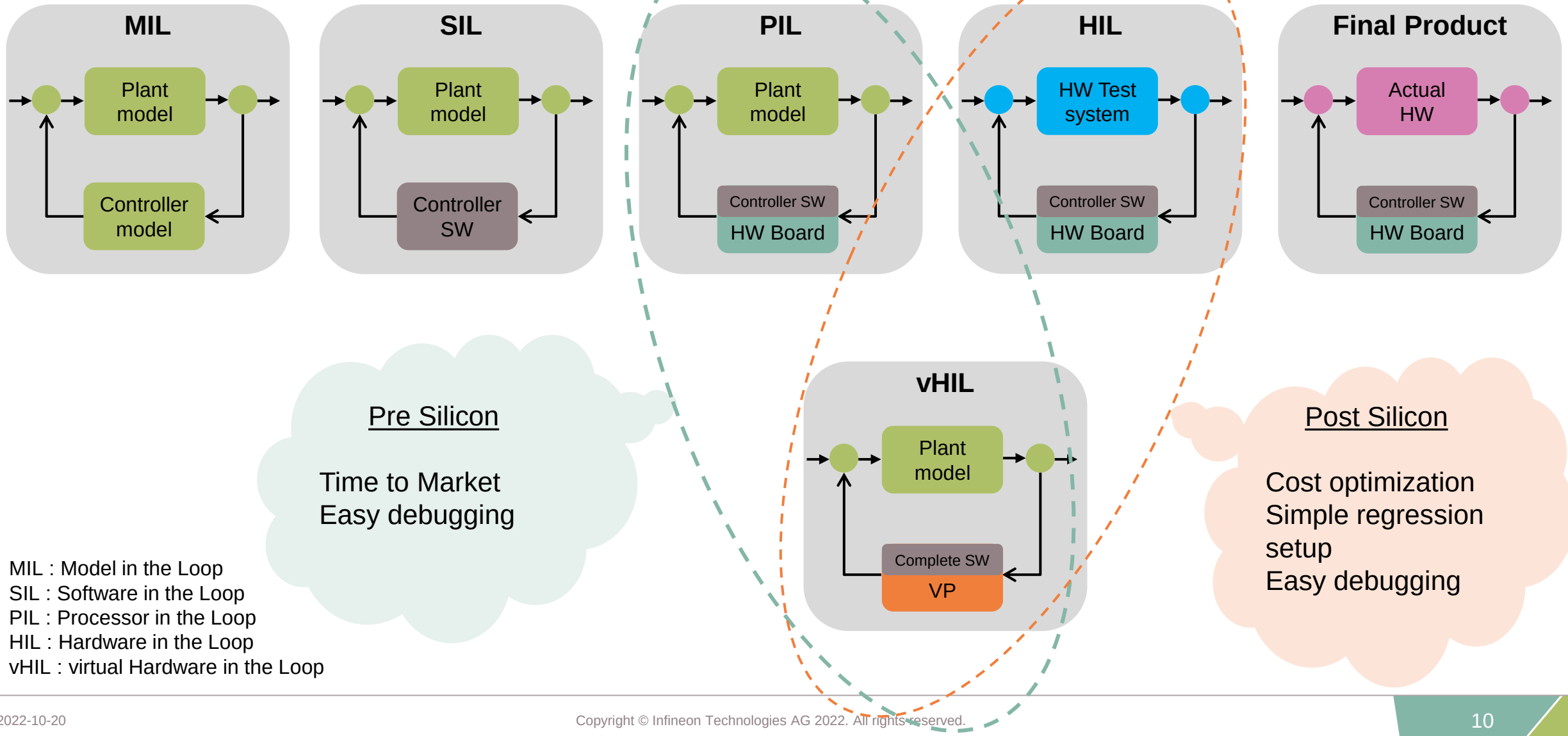
AURIX™ TC4x Virtual Prototype
Model-Based Design Flow



Pre Silicon

Time to Market
Easy debugging

Post Silicon

Cost optimization
Simple regression setup
Easy debugging

MIL : Model in the Loop
SIL : Software in the Loop
PIL : Processor in the Loop
HIL : Hardware in the Loop
vHIL : virtual Hardware in the Loop

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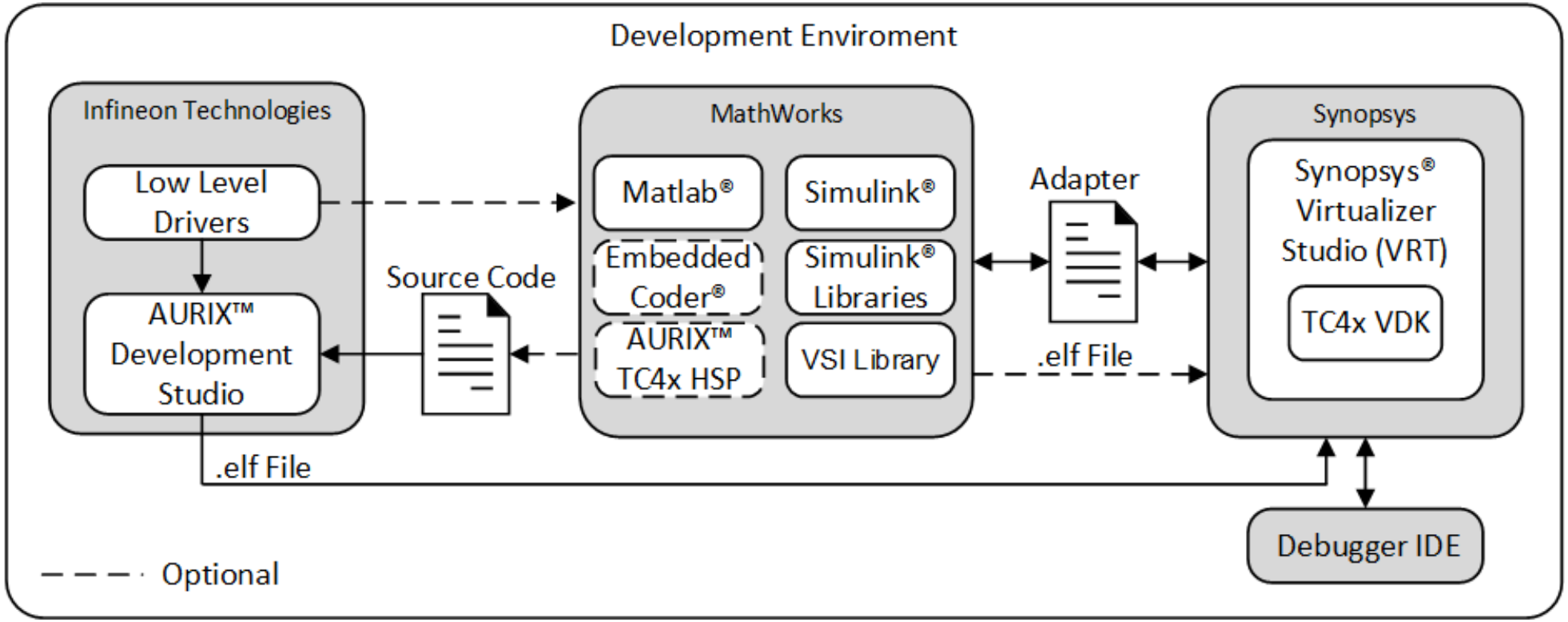
AURIX™ TC4x Virtual Motor Control Application Kit Development Environment for fast prototyping



AURIX™ TC4x HSP – Embedded coder support package for Infineon Technologies AURIX™ TC4x microcontroller

VSI Library - Virtualizer System Interface is a MATLAB®/Simulink® and Synopsys® VDK library, developed by Synopsis® for better co-simulation

Adapter – The adapter is an environment which gives an interface between different simulation environment. Developed using Python

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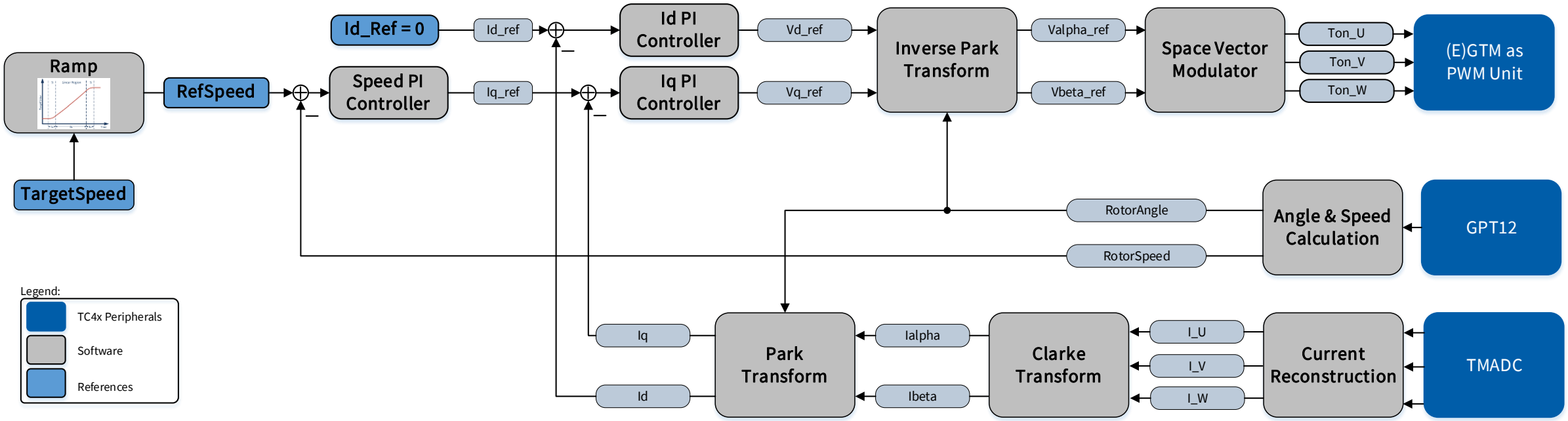
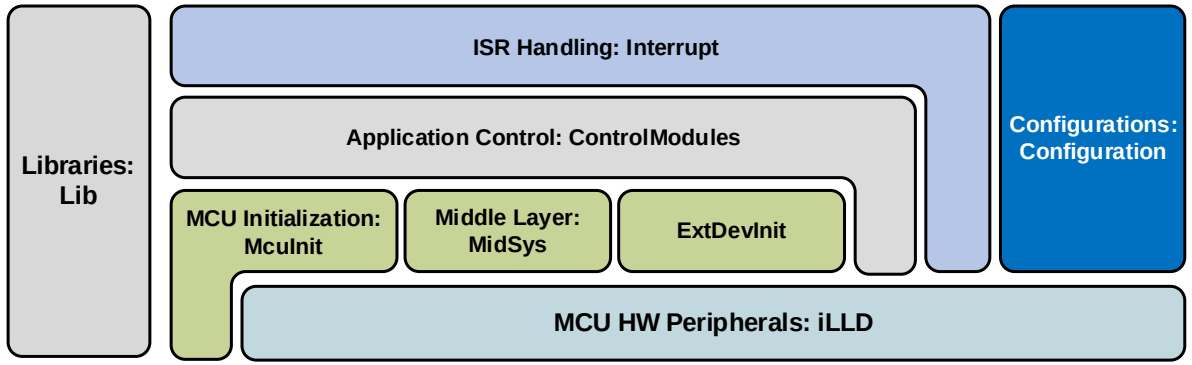
AURIX™ TC4x Virtual Motor Control Application Kit Software Development Kit



- Field Oriented Control (FOC) of Permanent Magnet Synchronous Motor (PMSM)
- Layered approach
- Infineon Low Level Drivers (iLLD)
- AURIX™ Development Studio



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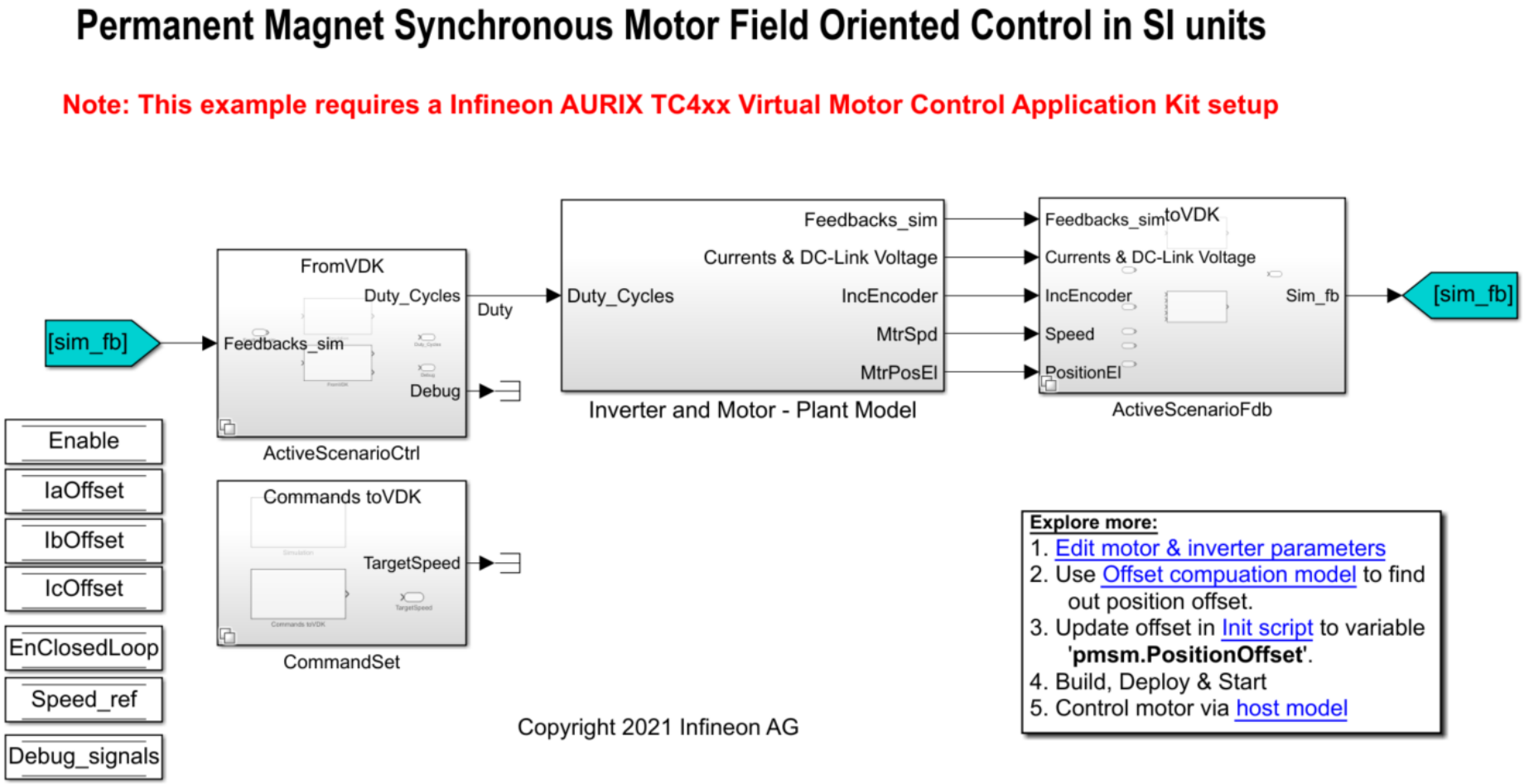
AURIX™ TC4x Virtual Motor Control Application Kit
Complete model in Simulink®



- Active scenario = 0: Control algorithm executed on AURIX™ TC4x VDK, developed using Infineon Technologies hand-written code
- Active scenario = 1: Control algorithm executed on Simulink®, developed using MathWorks Motor Control Blockset™ (part of ActiveScenarioCtrl subsystem, MIL)

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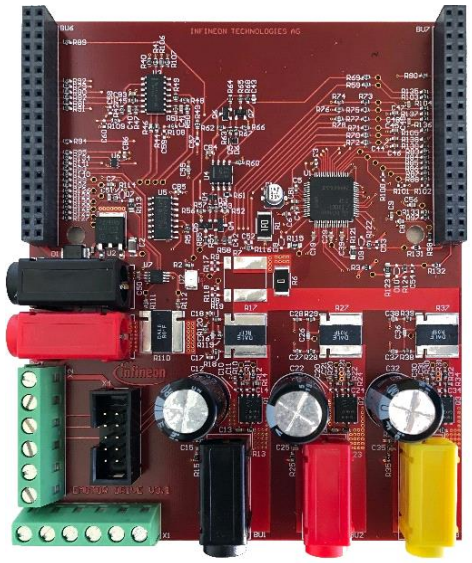
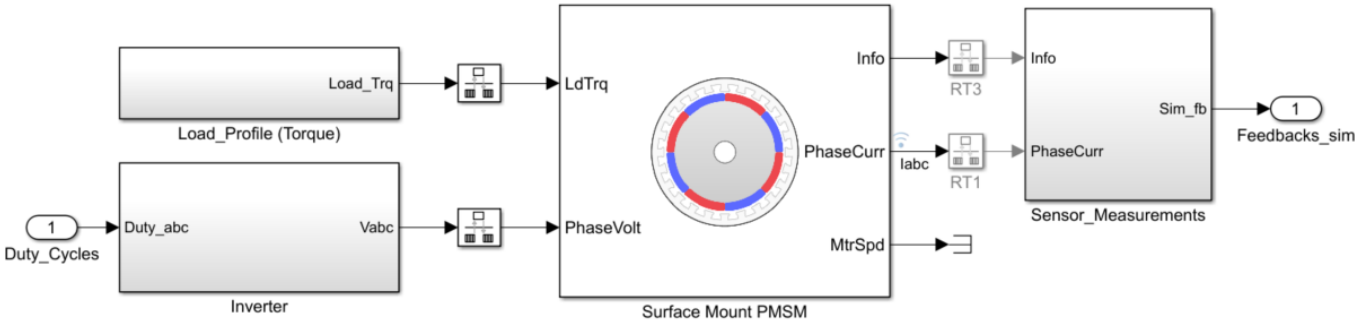
AURIX™ TC4x Virtual Motor Control Application Kit
Plant model in Simulink®

Real inverter and motor



KIT_A2G_TC387_MOTORCTR

Simple model of inverter, motor and load in Simulink®




```
%% System Parameters // Hardware parameters

pmsm = mcb_SetPMSMMotorParameters('DB42S02');
pmsm.PositionOffset = 0.0;

%% Parameters below are not mandatory for offset computation

inverter = mcb_SetInverterParameters('AurixTC3xx_Mctr_PowerBoard_v2');
```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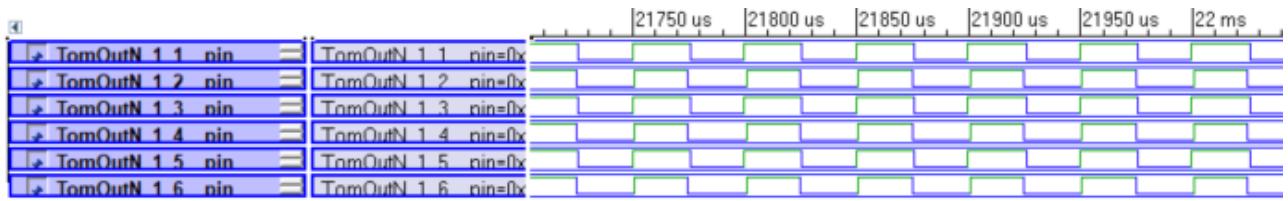
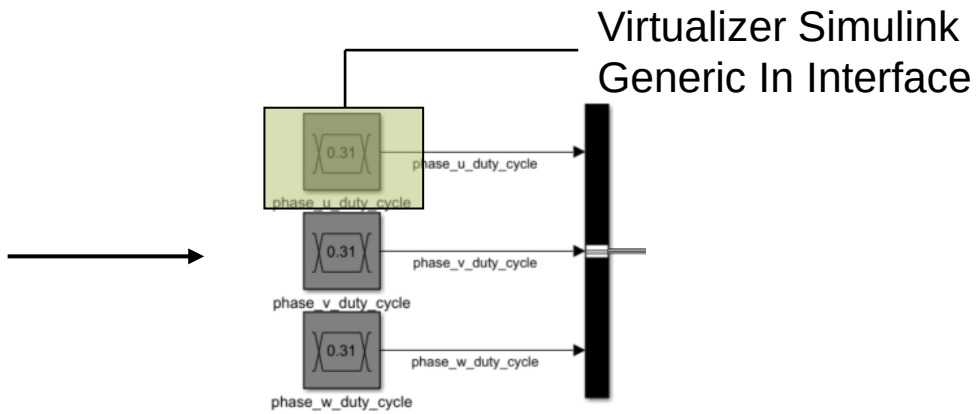
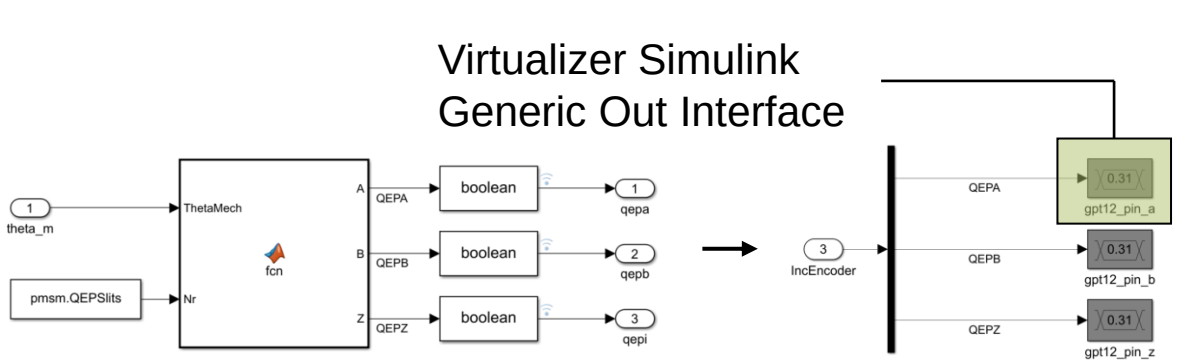
AURIX™ TC4x Virtual Motor Control Application Kit
Synopsys® Virtualizer Blocks in Simulink®

› General Timer Module (GTM) Timer Output Module (TOM) is used for PWM generation

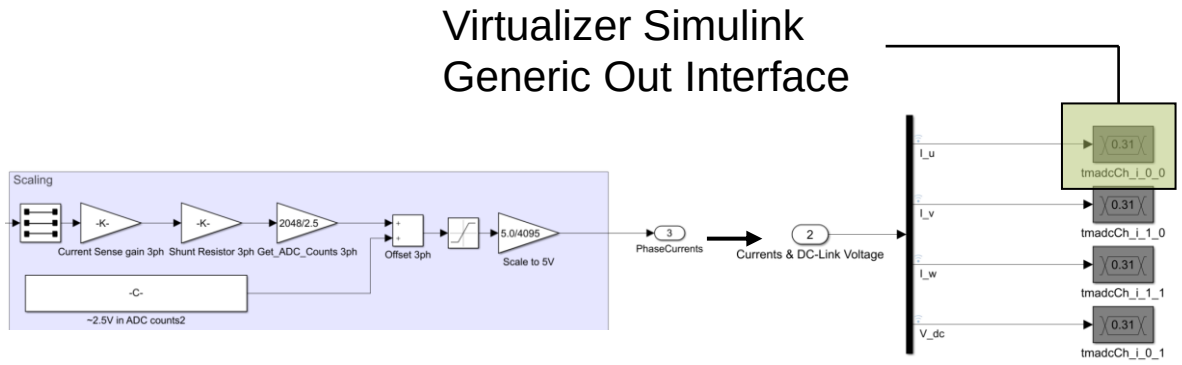




› General Purpose Timer (GPT12) module is used for incremental encoder support



› Time-multiplexed analog-to-digital converter (TMADC) is used for phase current sensing



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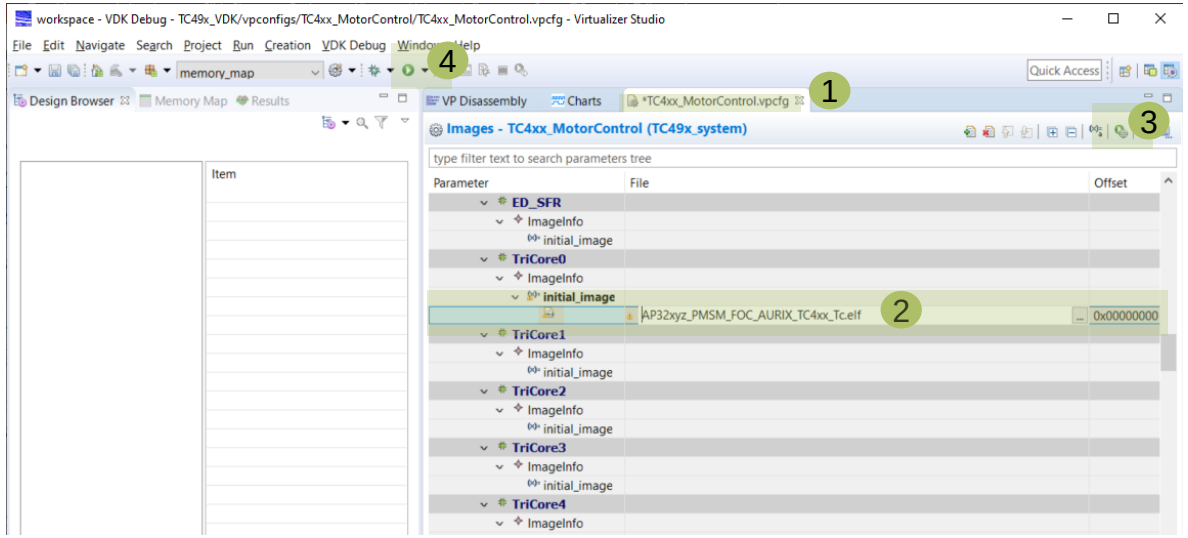
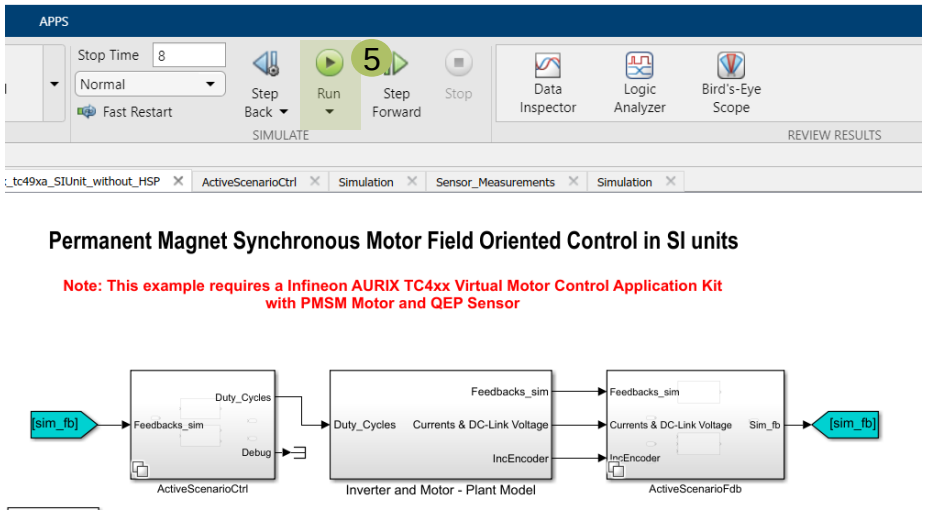
AURIX™ TC4x Virtual Motor Control Application Kit
Run the system simulation

› To run the system simulation one shall perform following steps:

1. Open TC4x_MotorControl configuration in VDK
2. Under TC49x_system/TC49x/Core_System/TriCore0 add .elf path to TriCore0 image
3. Run VDK_TC499_Simulink_ADC configuration up to initial_crunch
4. After reaching initial_crunch routine, simulation will be suspended. Click on Resume suspended simulation button in VDK
5. After VDK simulation reached Running state (indicated in bottom right corner), switch to Simulink window and run Simulink simulation





Note: Virtualizer System Interface Library assures that TC49xA VDK time step is synchronized with Simulink® time step.

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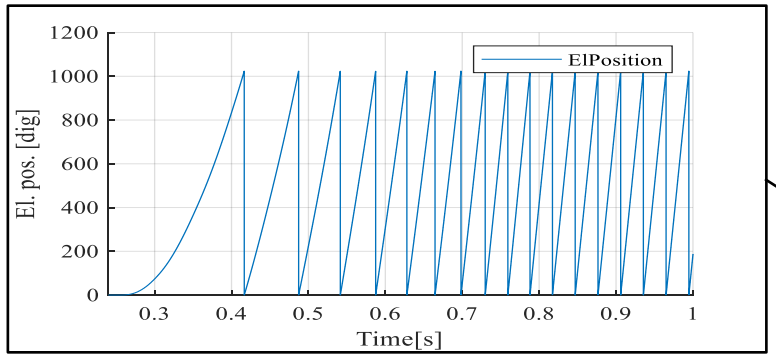
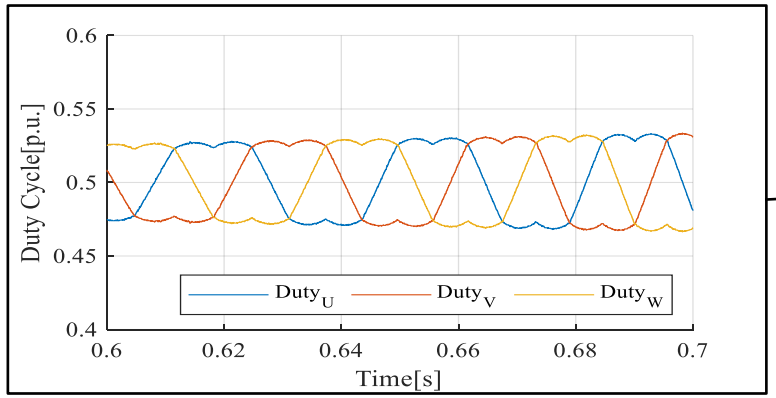
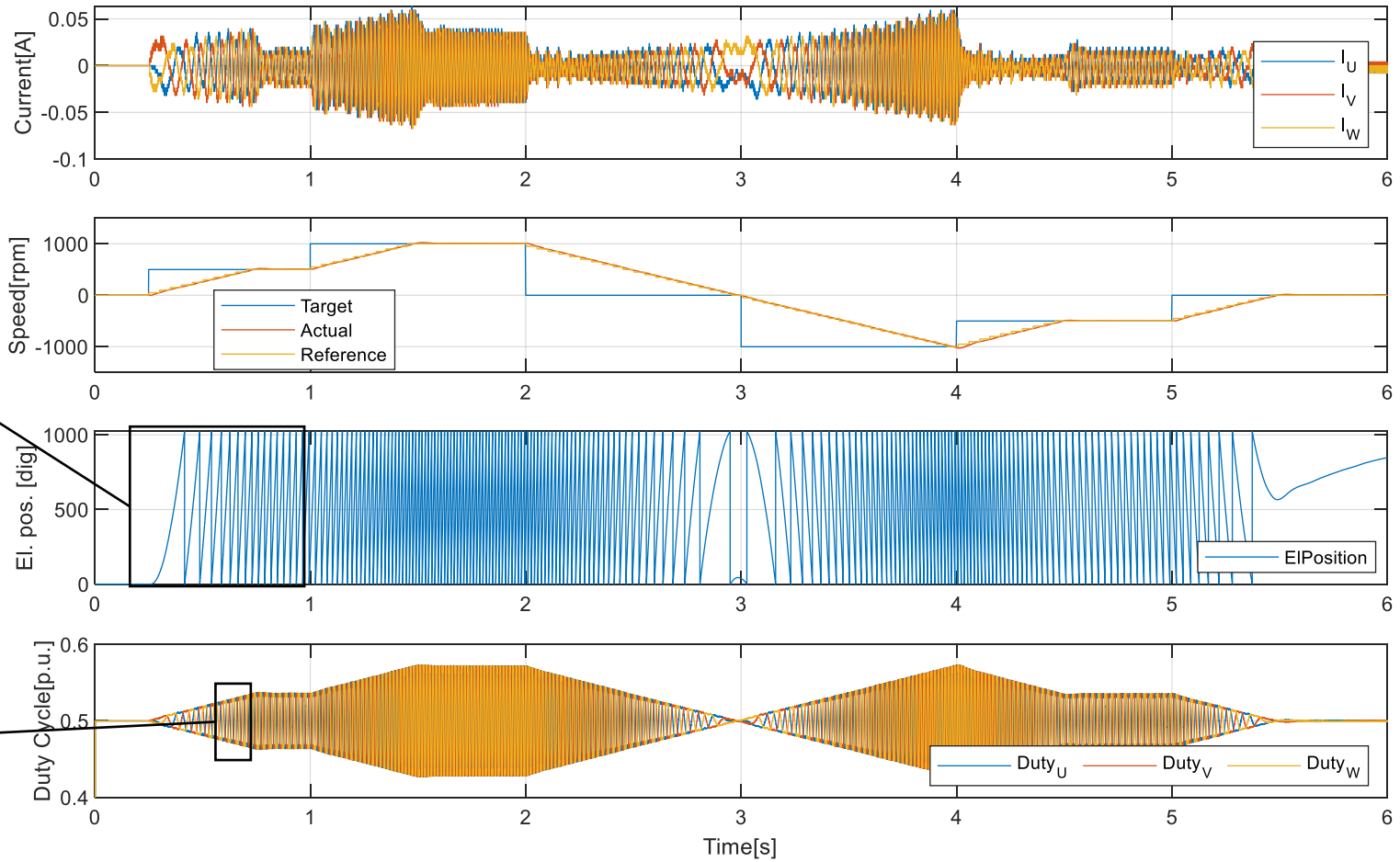
AURIX™ TC4x Virtual Motor Control Application Kit
Results – Closed loop

- FOC of PMSM
- GTM TOM is used for PWM generation
- Phase currents are measured by using TMADC
- GPT12 is used for incremental encoder support
- Maximum speed slew rate: 1000 [rpm/s]







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Summary

- Use of AURIX™ Virtual Prototype helps to shorten Time to Market, to save Cost and to improve SW Quality and Safety
- Closed loop co-simulation environment consisting of AURIX™ TC4x Virtual Prototype and Simulink based plant model helped to prepare and validate the motor control SW applications in pre silicon phase
- AURIX™ TC4x Virtual Motor Control Application Kit (combination of AURIX™ TC4x Virtual Prototype, Simulink based plant model and SW) enabled us to demonstrate xEV usecases to our customers and SDK partners
- The MATLAB®/Simulink® embedded coder support package for Infineon Technologies AURIX™ TC4x microcontroller is recently released and helps our customers to speed up prototyping phase

AURIX™ Development Studio

AURIX™ TC4x

Embedded Coder support for AURIX™ TC4x

AURIX™ TC4x VDK

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