NXP | SECURE CONNECTIONS FOR A SMARTER WORLD

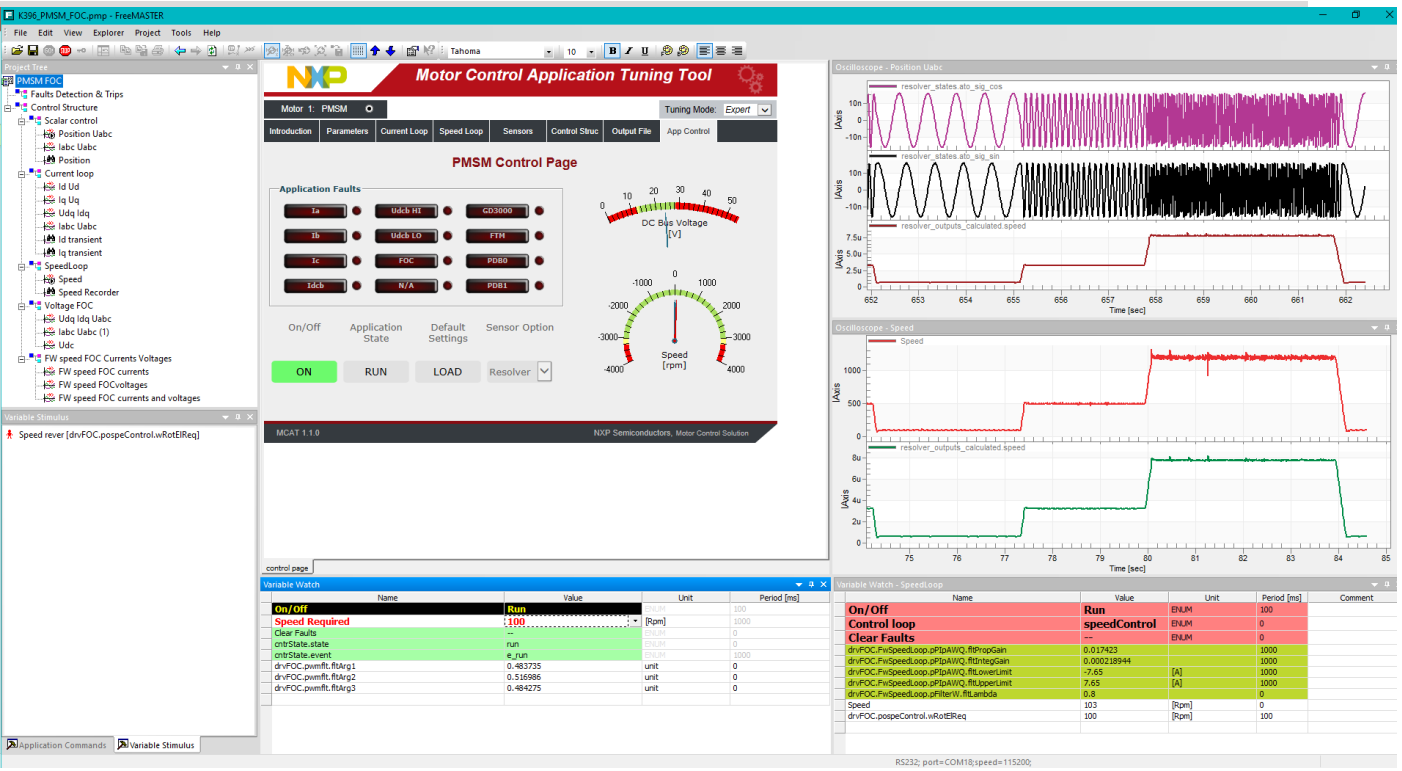
Optimized Motor Control Applications: from idea to deployment with NXP Model-Based Design Toolbox

Razvan Chivu

Stefan Cinipeanu

MATLAB EXPO

AGENDA



1. **NXP Software and Tools** Enablement
2. NXP's **Model-Based Design Toolbox** Introduction
3. NXP's Motor Control Solution with **S32K39x**
4. Model-Based Design Toolbox for **Motor Control Applications**

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From Virtual Vehicle to All-Electric Off-Road UTV in Less Than a Year

Going Green with an All-Electric Utility Task Vehicle

Vanderhall Motor Works' Brawley™ is an all-electric utility task vehicle (UTV). Also known as side-by-sides, UTVs are off-road vehicles popular with recreational users, farmers, and hunters. With 303 horsepower and a 140-mile driving range, the Brawley is designed to give users a powerful yet environmentally friendly ride over sand dunes and rocky terrain.

The Vanderhall team faced its own bumps and obstacles when it started its design process. Vanderhall's conventional gasoline-powered vehicles were based on a General Motors® powertrain. The engineers started by swapping the internal combustion engine with another vendor's electric powertrain hardware and software. Although EV powertrains are simpler with fewer components—just the battery, inverter, and electric motor—integrating the separate systems did not work out as the engineers anticipated.

"We needed the electric powertrain to communicate with all the other modules and controls from General Motors, such as the power steering and the anti-lock brakes," says Christopher Johnson, CTO of Vanderhall. "None of the components communicated well. We ended up with a vehicle that was hard to drive."

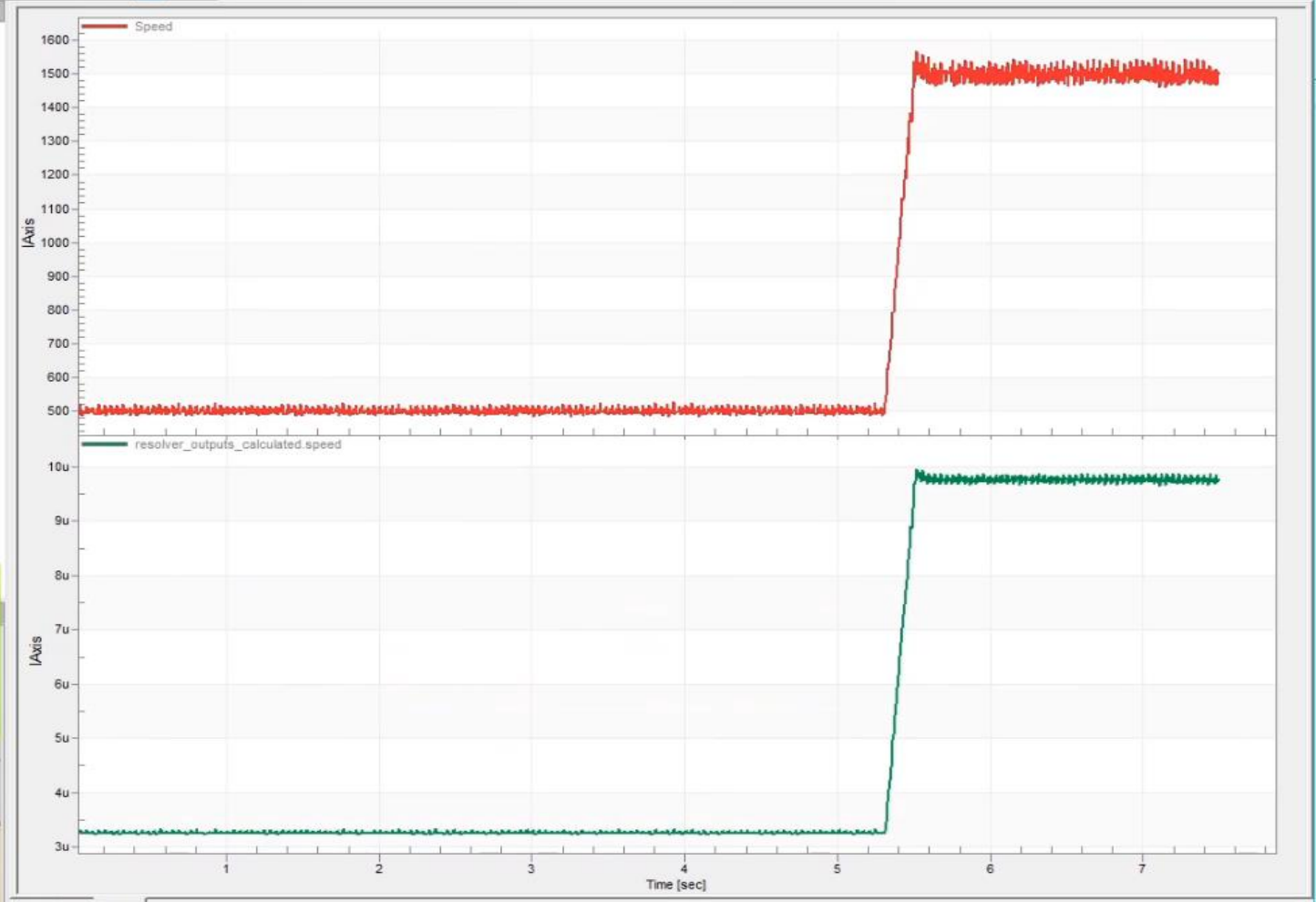
K396_PMSM_FOC.pmp - FreeMASTER

File Edit View Oscilloscope Project Tools Help

Tahoma 8

Project Tree

- PMSM FOC
  - Faults Detection & Trips
  - Control Structure
    - Scalar control
      - Position Uabc
      - Iabc Uabc
      - Position
    - Current loop
      - Id Ud
      - Iq Uq
      - Udq Idq
      - Iabc Uabc
      - Id transient
      - Iq transient
    - SpeedLoop
      - Speed
      - Speed Recorder
    - Voltage FOC
      - Udq Idq Uabc
      - Iabc Uabc (1)
      - Udc
    - FW speed FOC Currents Voltages
      - FW speed FOC currents
      - FW speed FOCvoltages
      - FW speed FOC currents and voltages



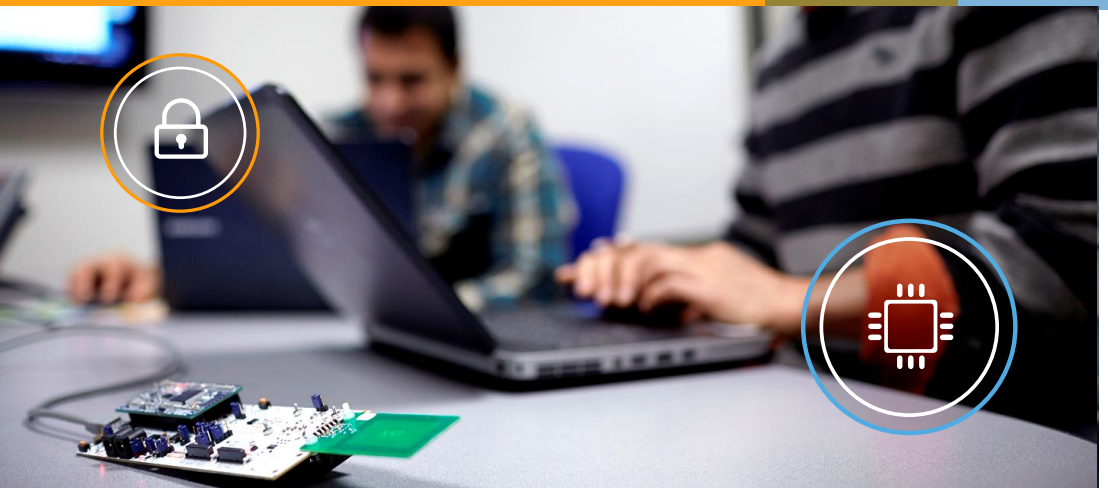
control page | Speed

Variable Watch

Name	Value	Unit	Period [ms]	Comment
On/Off	**Run**	ENUM	100	
Control loop	**speedControl**	ENUM	0	
Clear Faults	--	ENUM	0	
drvFOC.FwSpeedLoop.pPIpAWQ.fltPropGain	0.017423		1000	
drvFOC.FwSpeedLoop.pPIpAWQ.fltIntegGain	0.000218944		1000	
drvFOC.FwSpeedLoop.pPIpAWQ.fltLowerLimit	-7.65	[A]	1000	
drvFOC.FwSpeedLoop.pPIpAWQ.fltUpperLimit	7.65	[A]	1000	
drvFOC.FwSpeedLoop.pFilterW.fltLambda	0.8		0	
Speed	1502	[Rpm]	0	
drvFOC.pospeControl.wRotElReq	1500	[Rpm]	100	

RS232; port=COM18;speed=115200;

Scope Running



A POSITION OF STRENGTH TO BETTER SERVE OUR 26,000+ CUSTOMERS

We accelerate breakthroughs that advance the world through our semiconductor technology leadership

EMPLOYEES IN

30+ COUNTRIES

Headquartered in Eindhoven, Netherlands

~31,000

EMPLOYEES

9,500

Patent Families

$13.21B

Annual Revenue [1]

60+

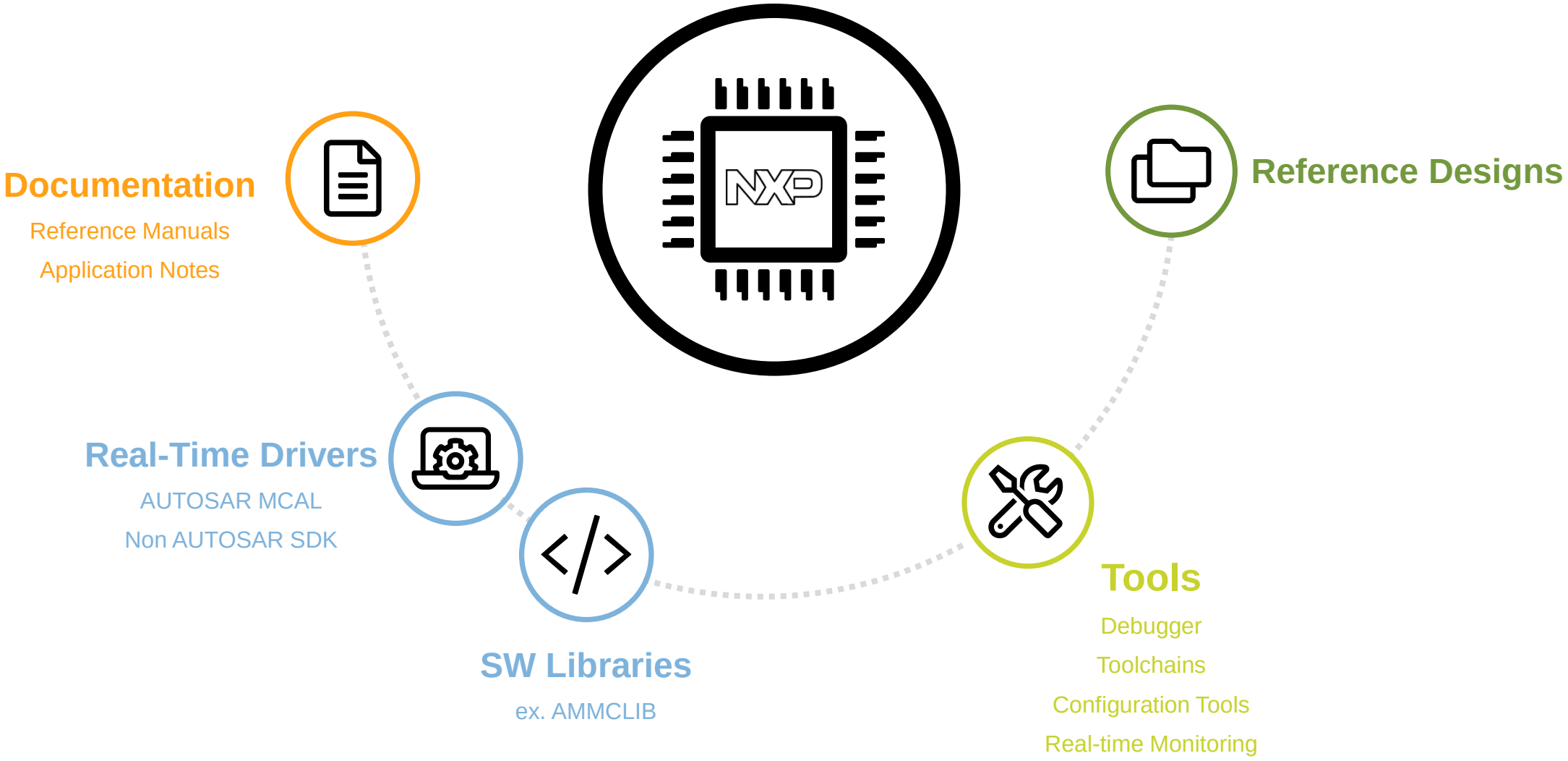
Year History

~11,000

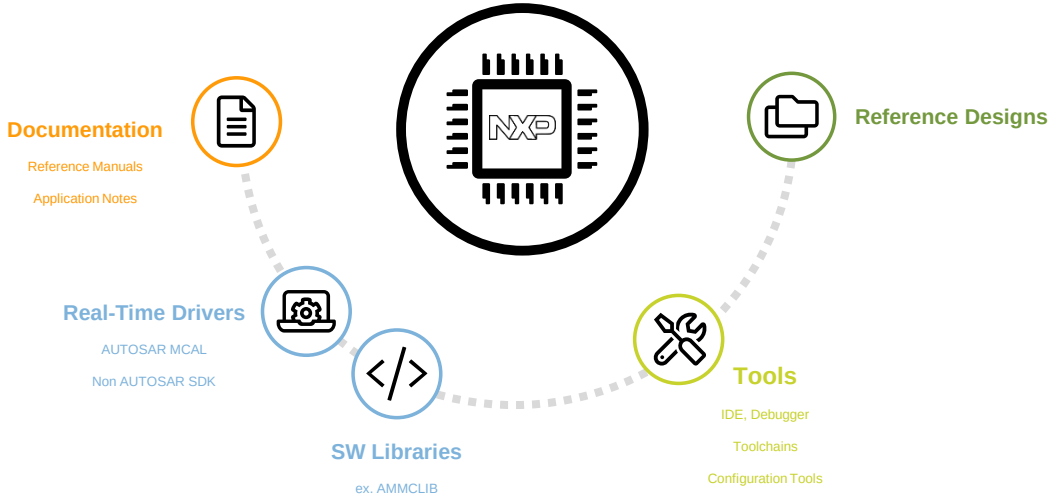
Engineers

[1] Posted revenue for 2022 – Please refer to the Financial Information page of the Investor Relations section of our website at www.nxp.com/investor for additional information

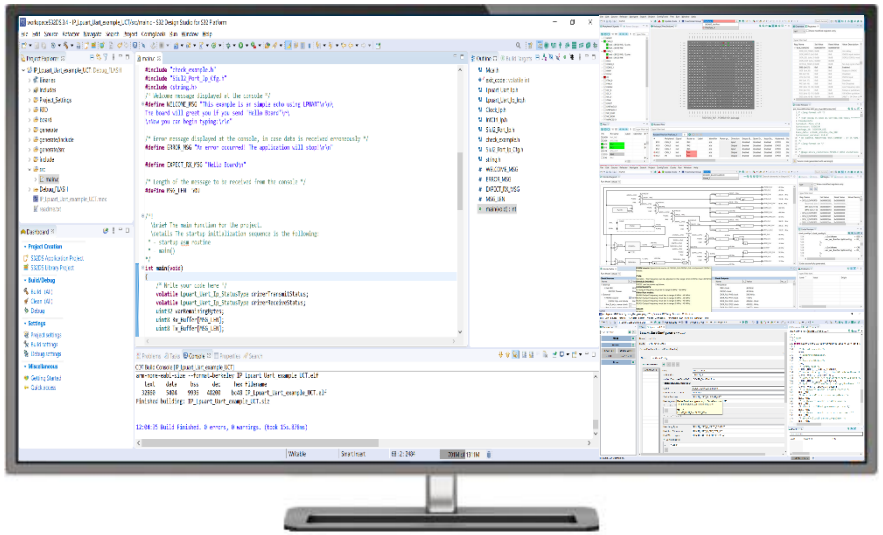
NXP SOFTWARE AND TOOLS ENABLEMENT – THE ECOSYSTEM



NXP SOFTWARE AND TOOLS ENABLEMENT



S32 Design Studio – IDE – Debugger - Toolchains

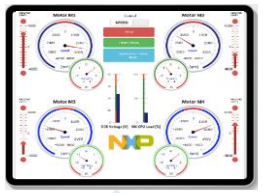


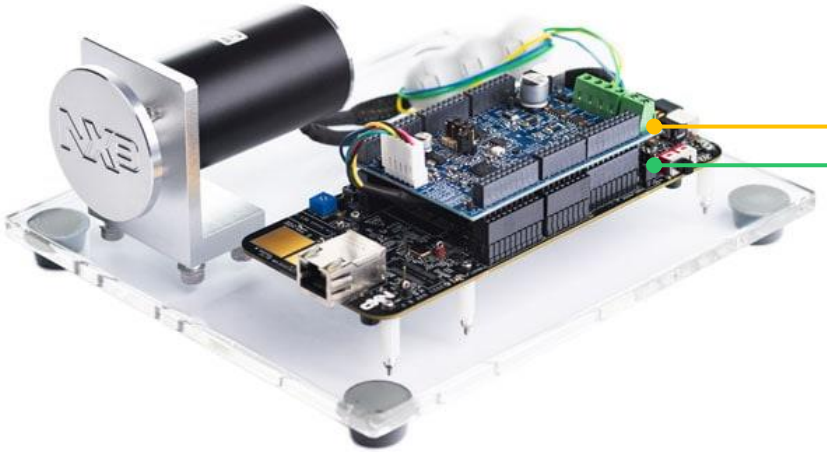
Pins Tool

Clocks Tool

Peripheral Tool

FreeMASTER Lite





JTAG

UART

FreeMASTER MCAT

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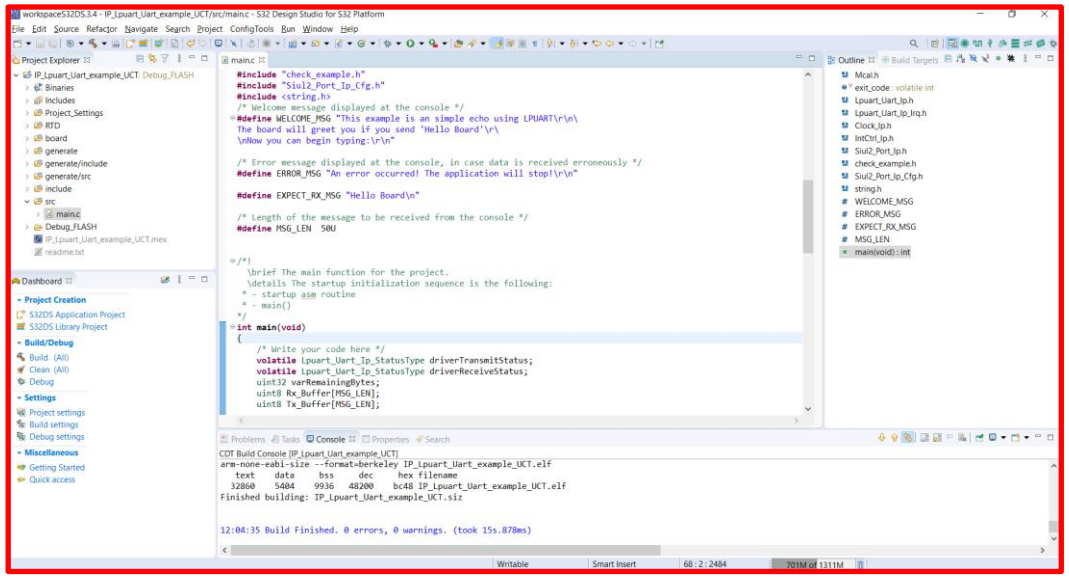
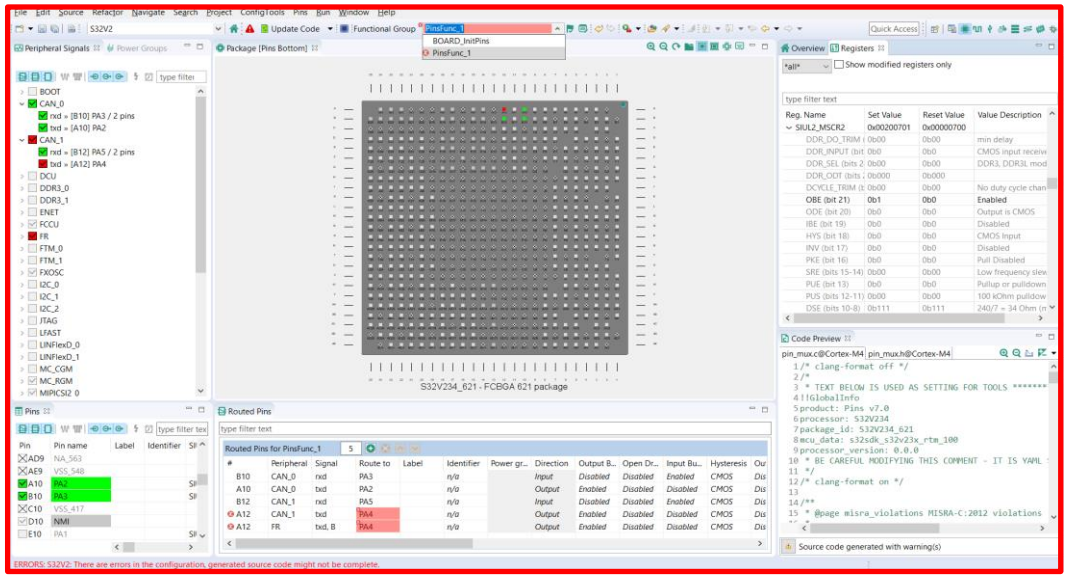
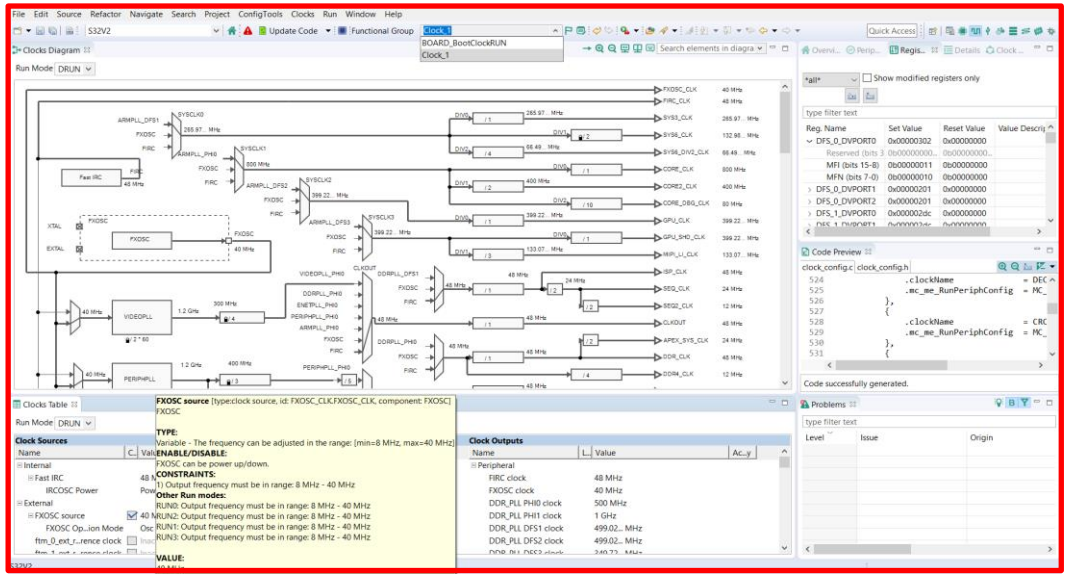
S32 DESIGN STUDIO IDE – CAPABILITIES AND TOOLS



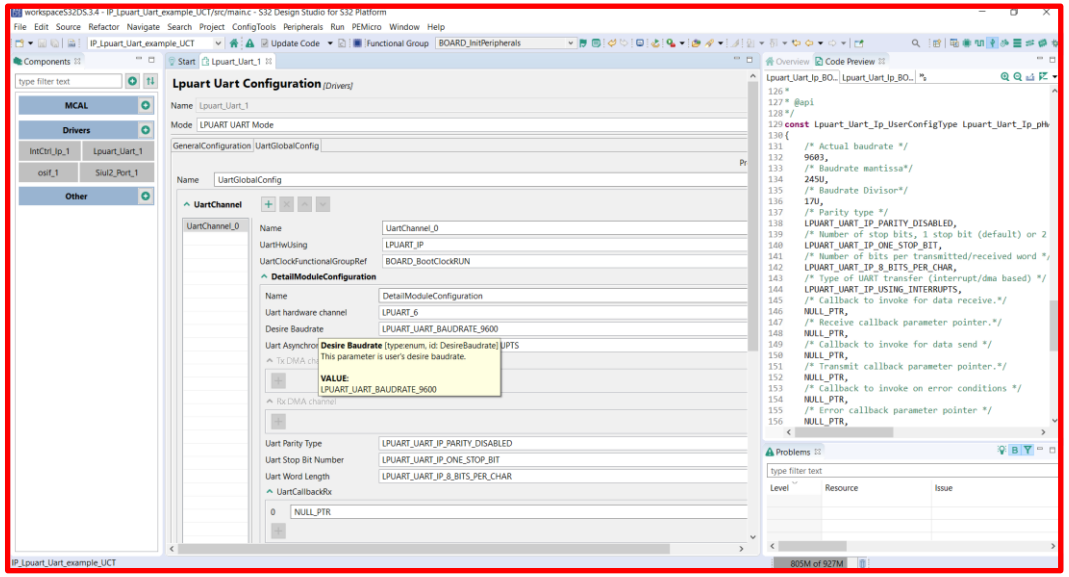
S32 Design Studio IDE



Pins Tool

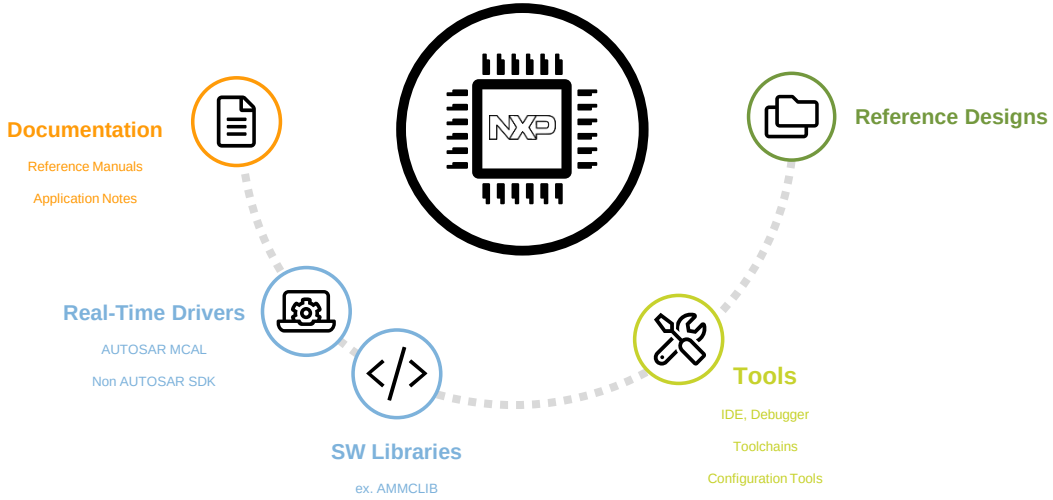


Clocks Tool

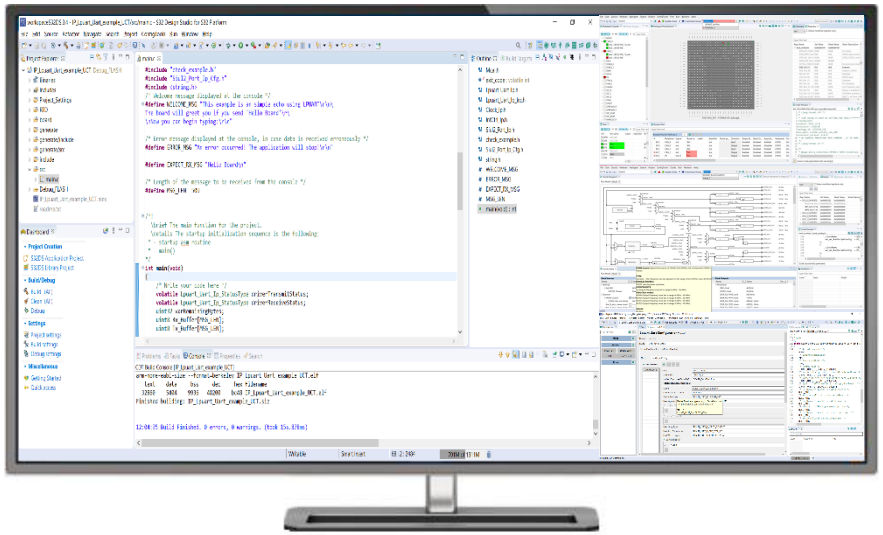


Peripherals Tool

NXP SOFTWARE AND TOOLS ENABLEMENT



S32 Design Studio – IDE – Debugger - Toolchains

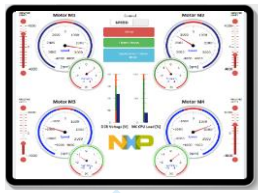


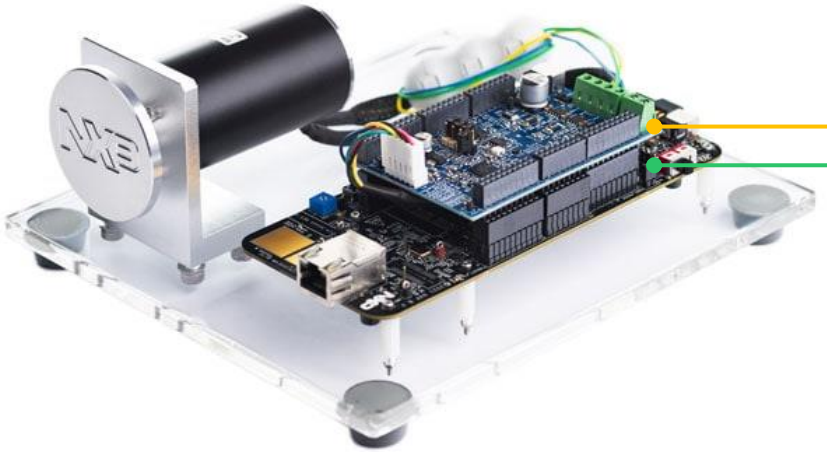
Pins Tool

Clocks Tool

Peripheral Tool

FreeMASTER Lite





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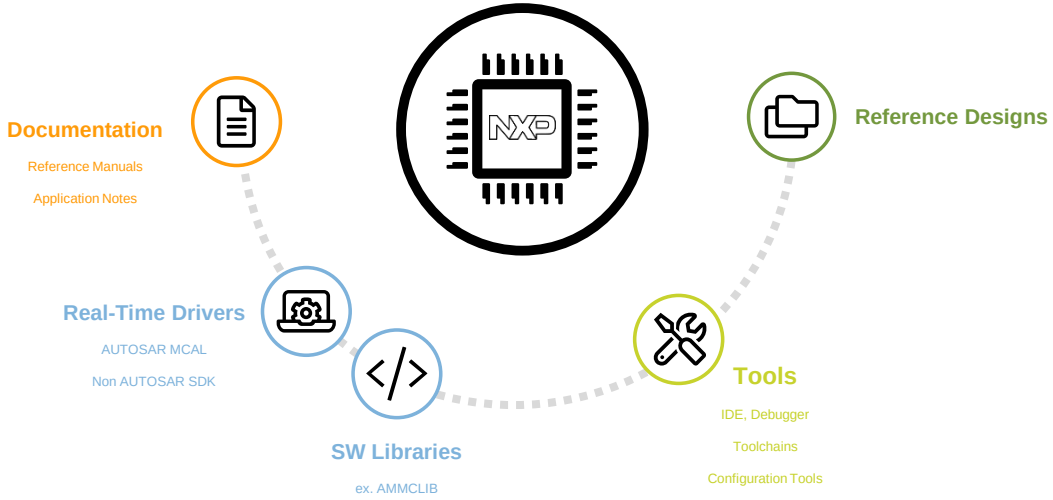
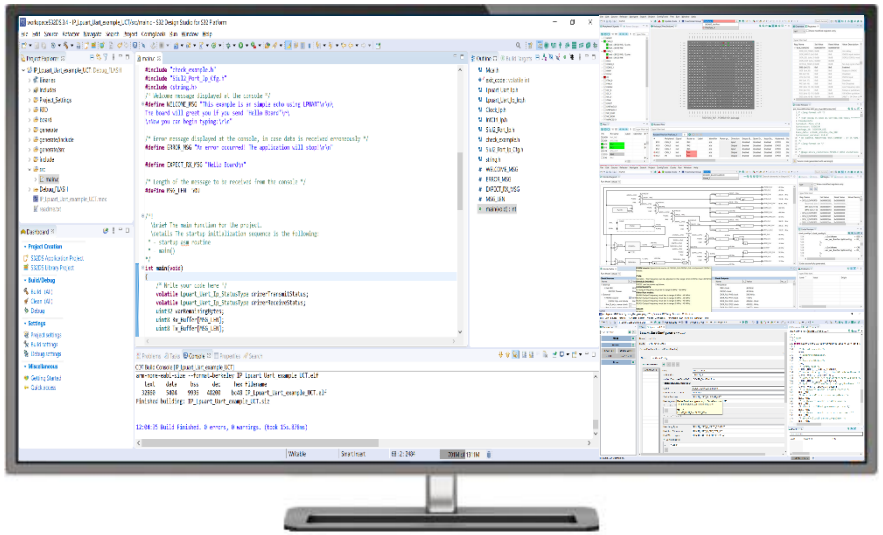
FREEMASTER - DATA VISUALIZATION

NXP SOFTWARE AND TOOLS ENABLEMENT



S32 Design Studio – IDE – Debugger - Toolchains

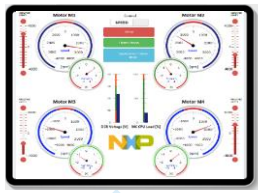


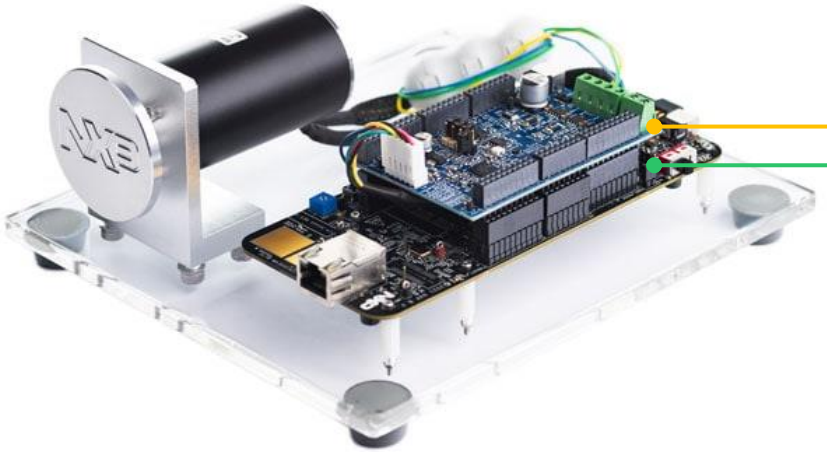
Pins Tool

Clocks Tool

Peripheral Tool

FreeMASTER Lite





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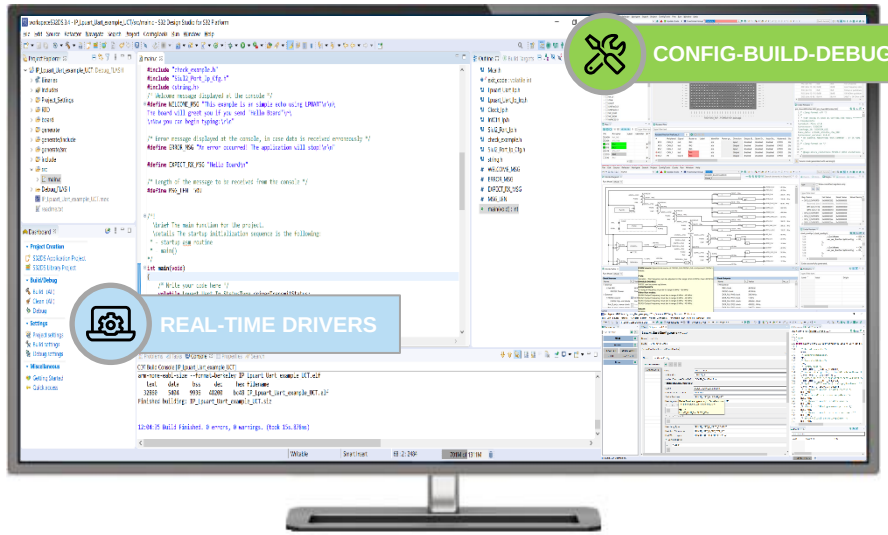
PUBLIC

NXP SOFTWARE AND TOOLS ENABLEMENT

S32 Design Studio – IDE – Debugger - Toolchains



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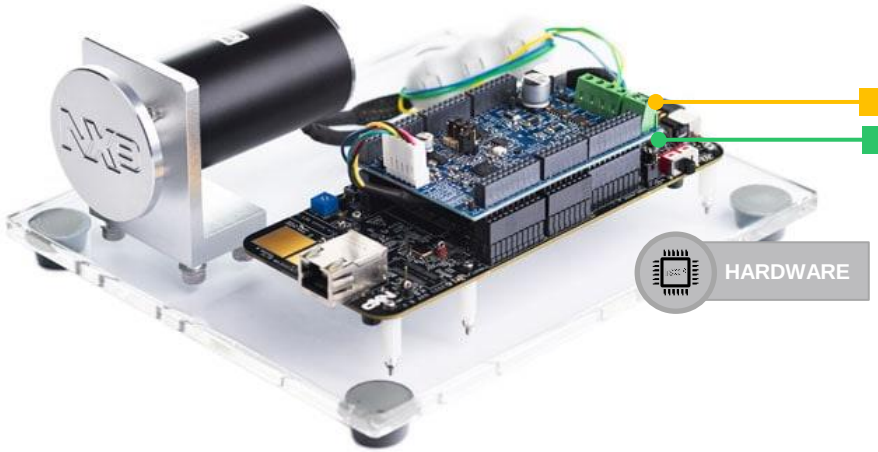
Clocks Tool

Peripheral Tool



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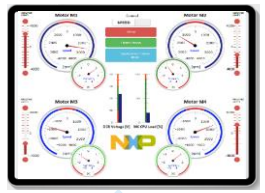

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NXP SOFTWARE AND TOOLS ENABLEMENT

MathWorks ECOSYSTEM – MATLAB / Simulink

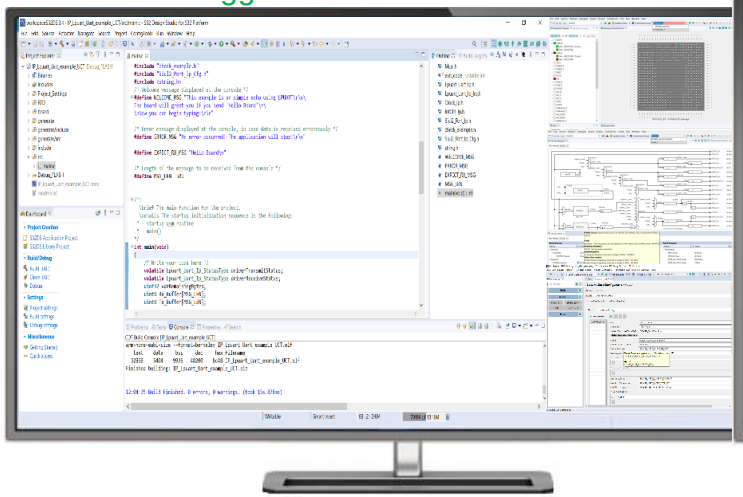
REAL-TIME MONITOR + DEMO TOOLS

CONFIG-BUILD-DEBUG TOOLS

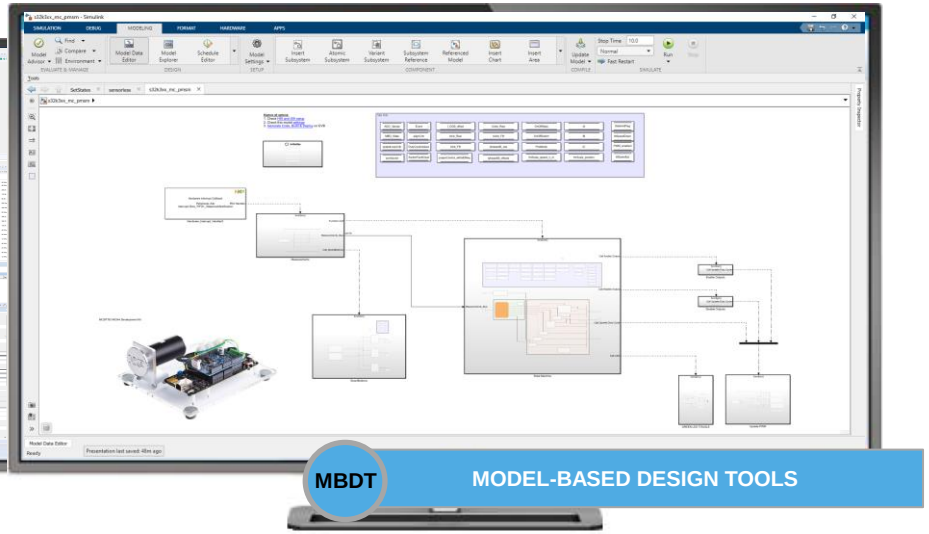
REAL-TIME DRIVERS

HARDWARE

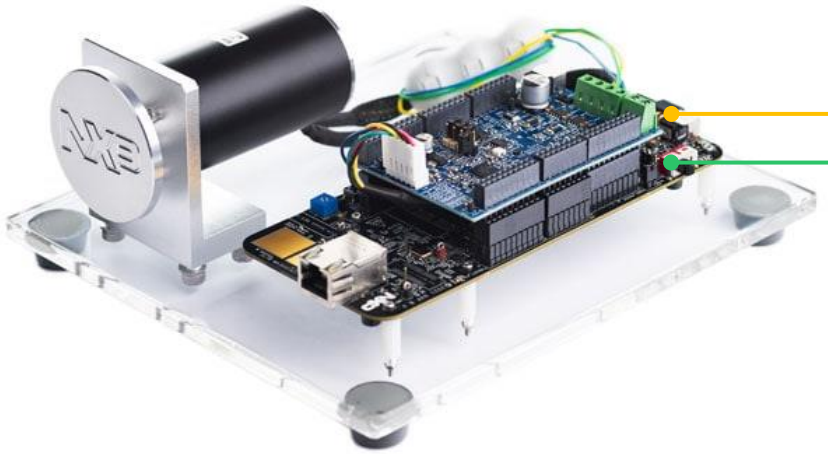
S32 Design Studio
IDE – Debugger - Toolchains



Model-Based Design Tools for Simulink



MBDT MODEL-BASED DESIGN TOOLS

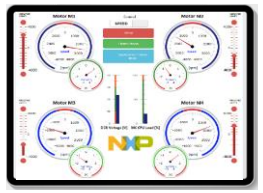


JTAG

UART

FreeMASTER MCAT

FreeMASTER Lite



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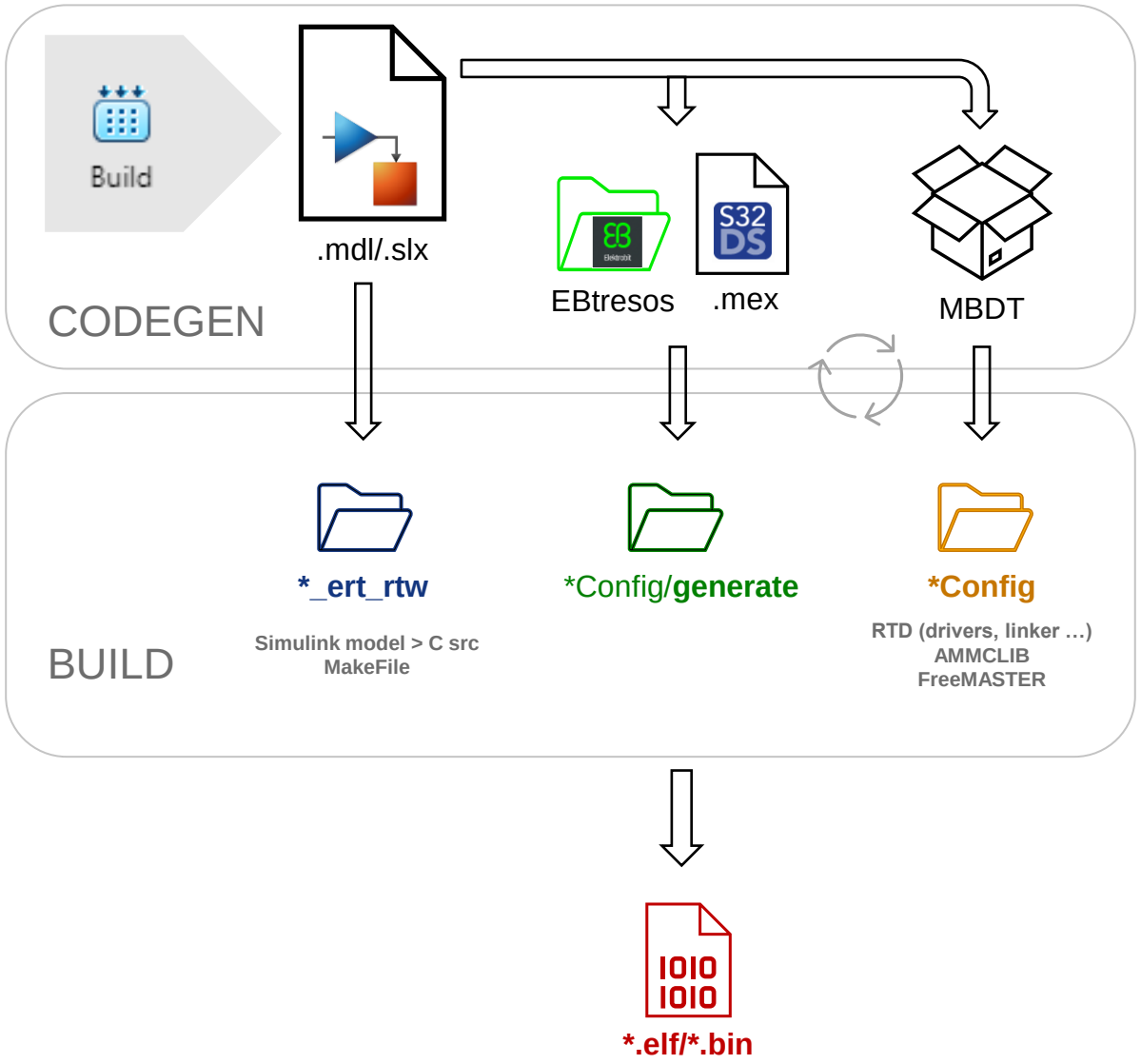
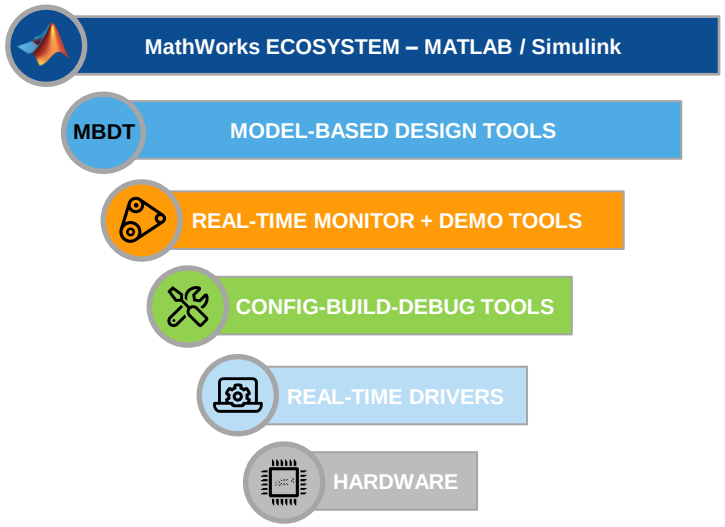
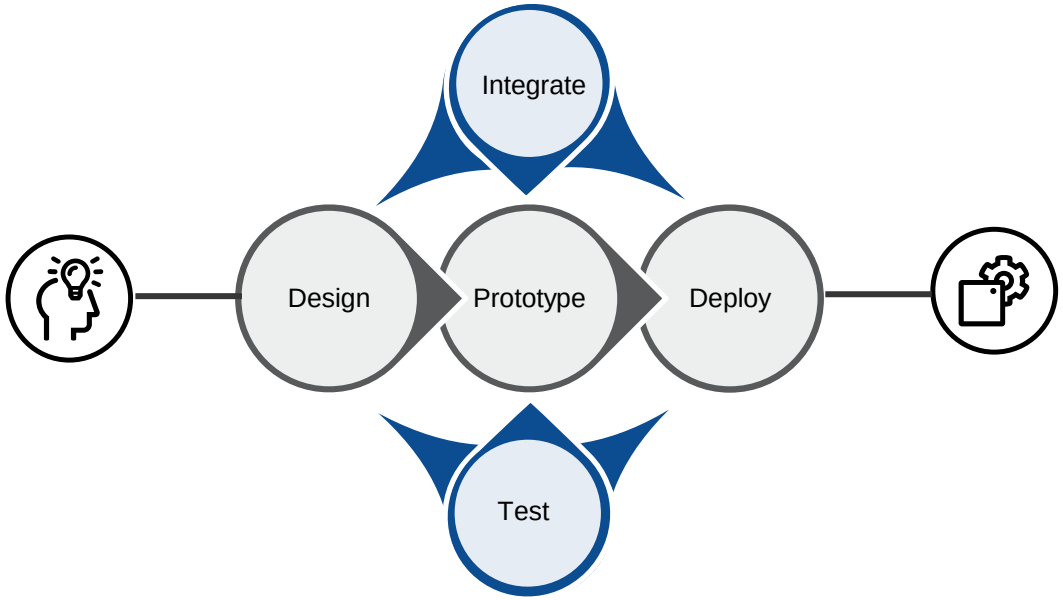
CODE GENERATION FLOW



NXP SOFTWARE AND TOOLS ENABLEMENT - MBDT SOFTWARE AND TOOLS





- ✓ **FAST** – Time To Market
- ✓ Hardware **independent** simulations
- ✓ Easy To **Use-Reuse**

SUPPORTED PLATFORMS

S32ZE

S32K1xx

S32K3xx

MPC57xx

S12ZVMx

S32G2

S32S2

AUTOMOTIVE

IMXRT1xxx

KVx

DSC

INDUSTRIAL & IoT

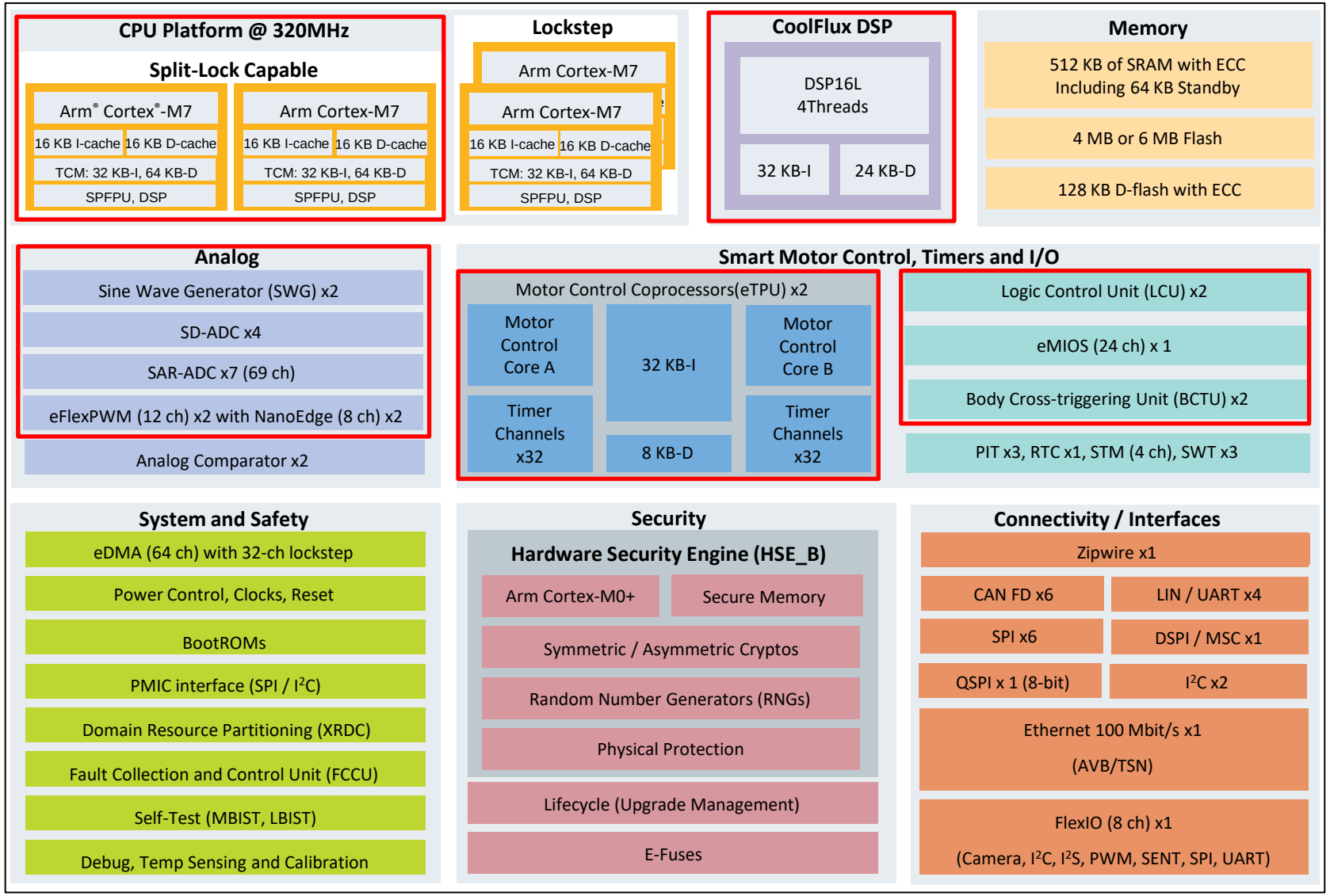
S32V234

VISION

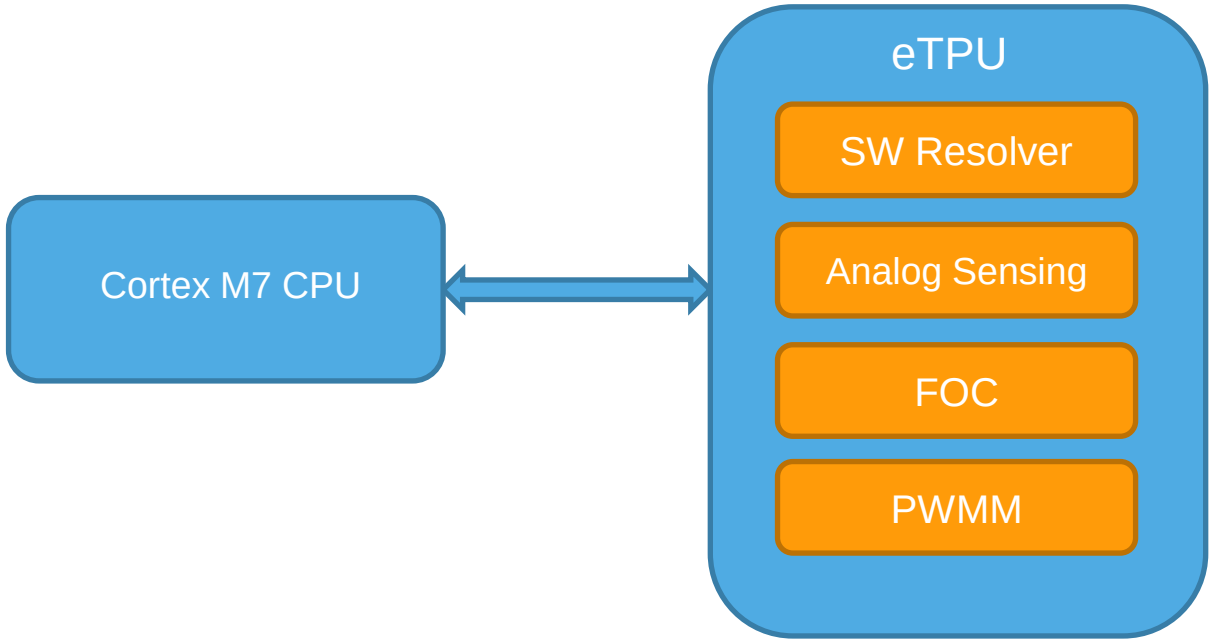
S32R41

RADAR

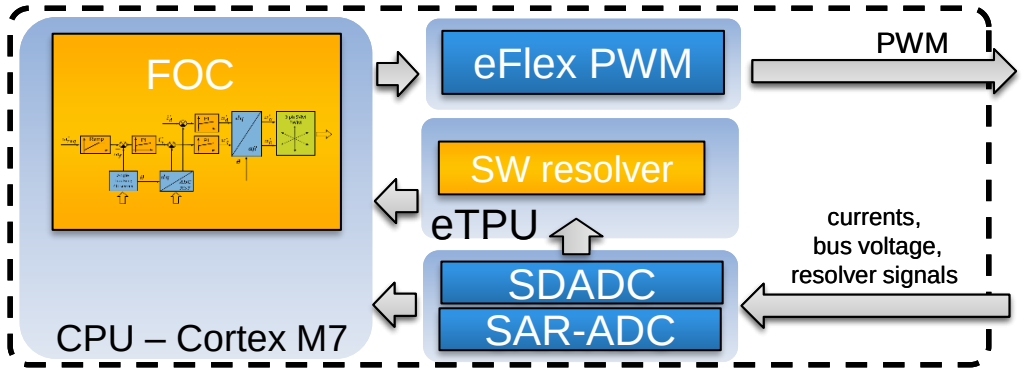
S32K39X MCU FOR MOTOR CONTROL APPLICATIONS

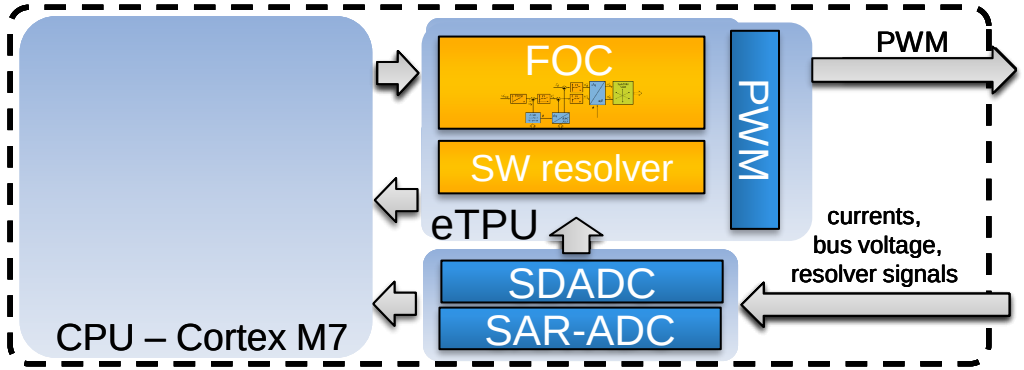


ENHANCED TIME PROCESSOR UNIT

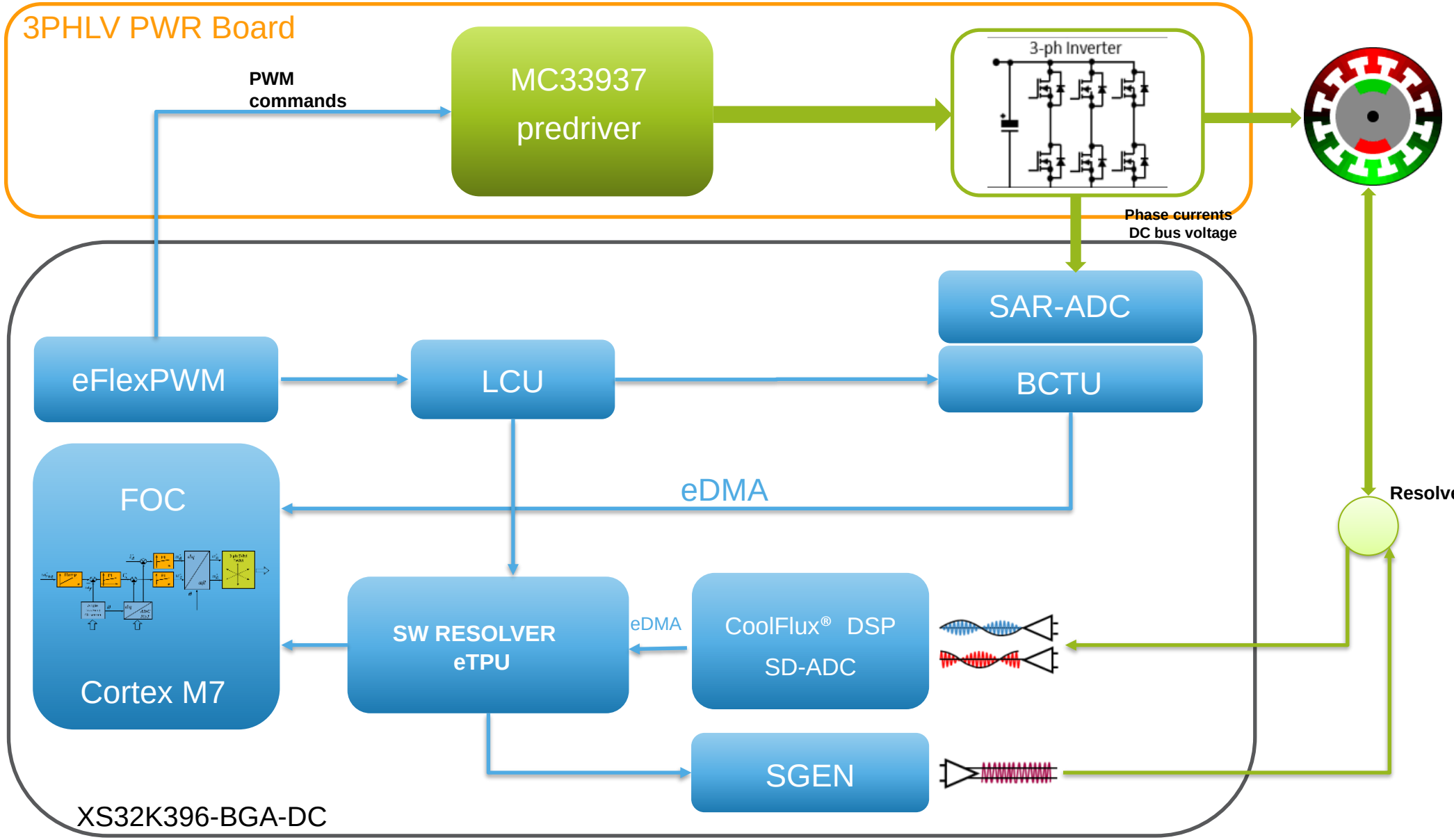


S32K39X MOTOR CONTROL CONFIGURATION USE-CASES

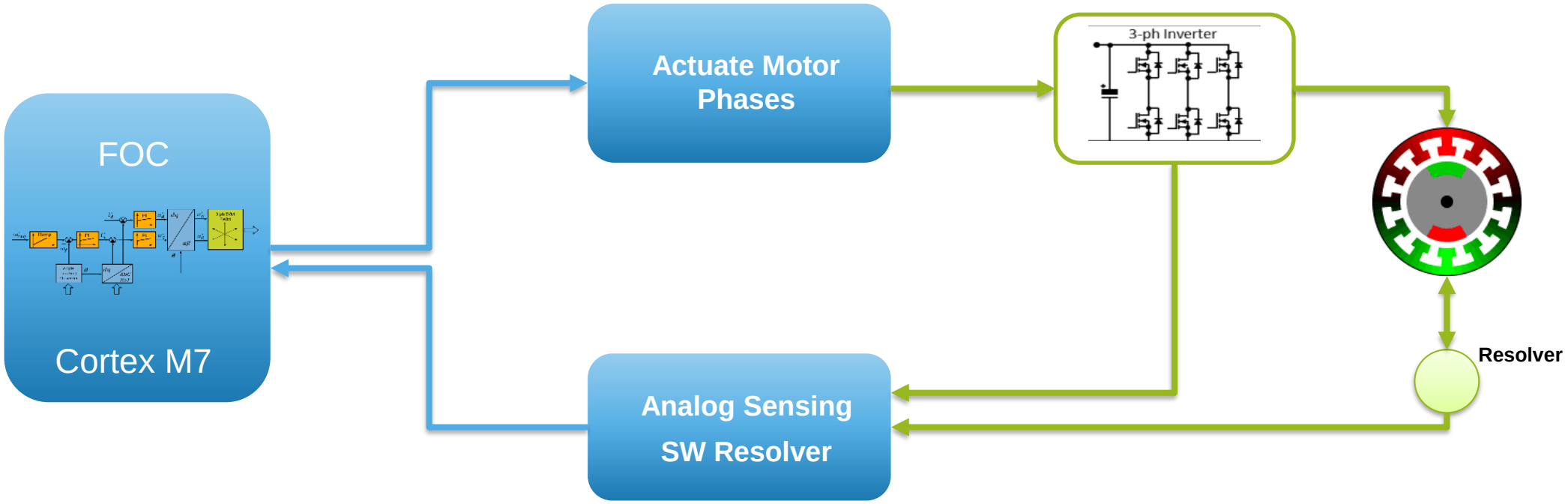




S32K39X MOTOR CONTROL ETPU RESOLVER – HARDWARE CONFIGURATION

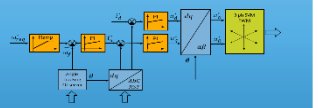


S32K39X MOTOR CONTROL ETPU RESOLVER – HARDWARE CONFIGURATION

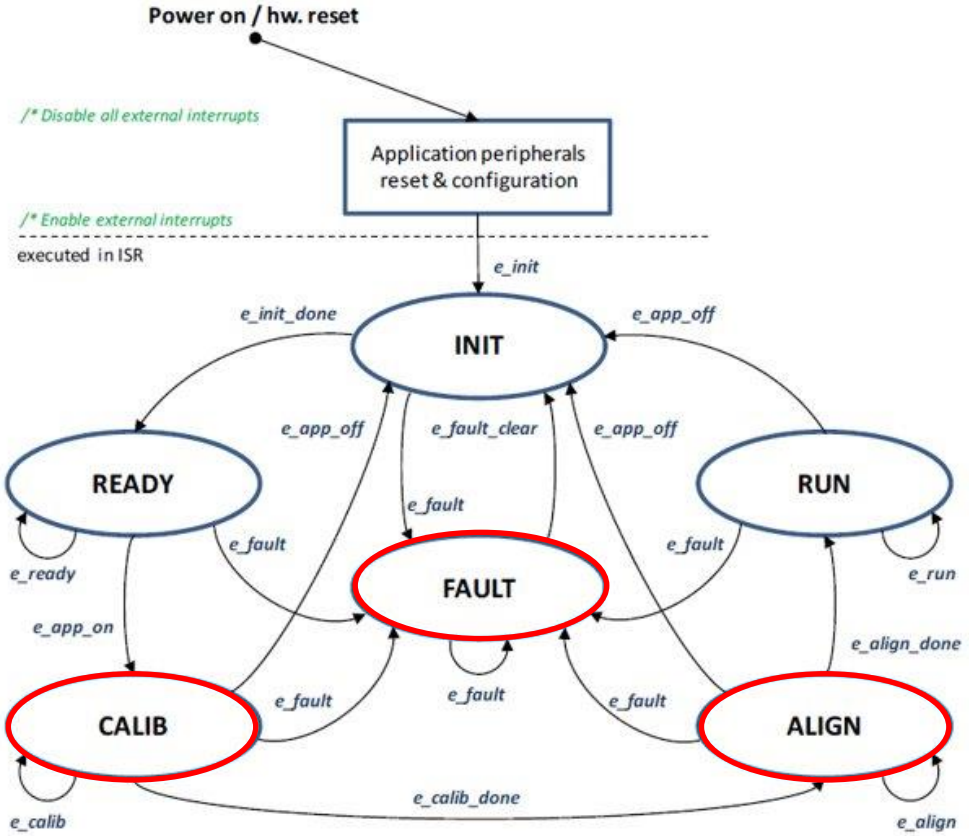


S32K39X MOTOR CONTROL ETPU RESOLVER – SOFTWARE ARCHITECTURE

FOC

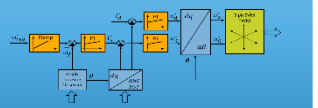


Cortex M7

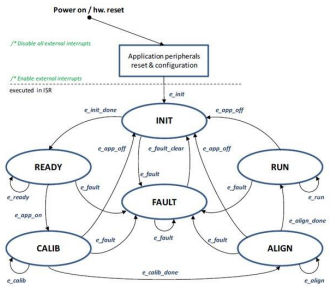


S32K39X MOTOR CONTROL ETPU RESOLVER – SOFTWARE ARCHITECTURE

FOC



Cortex M7



Analog Sensing ISR

Get Measurements

Fault Detection

event = e_fault

State Machine Execution

Clear Interrupt

NXP MOTOR CONTROL TOOLS WORKFLOW

FreeMASTER

S32 Design Studio IDE

Application static configuration

MCAT

Export generated code to S32DS

Application Source Code

C Drivers Peripherals

C Drivers Configuration Structures

Precompiled Library

Real-Time Drivers

Configuration Tools

AMMCLIB

C Drivers Peripherals

Auto Read Configuration

C Drivers Configuration Structures

Precompiled Library

COMPILER

Real-Time Communication

Flash

Model-Based Design Toolbox

MATLAB & Simulink

Application Simulink Model

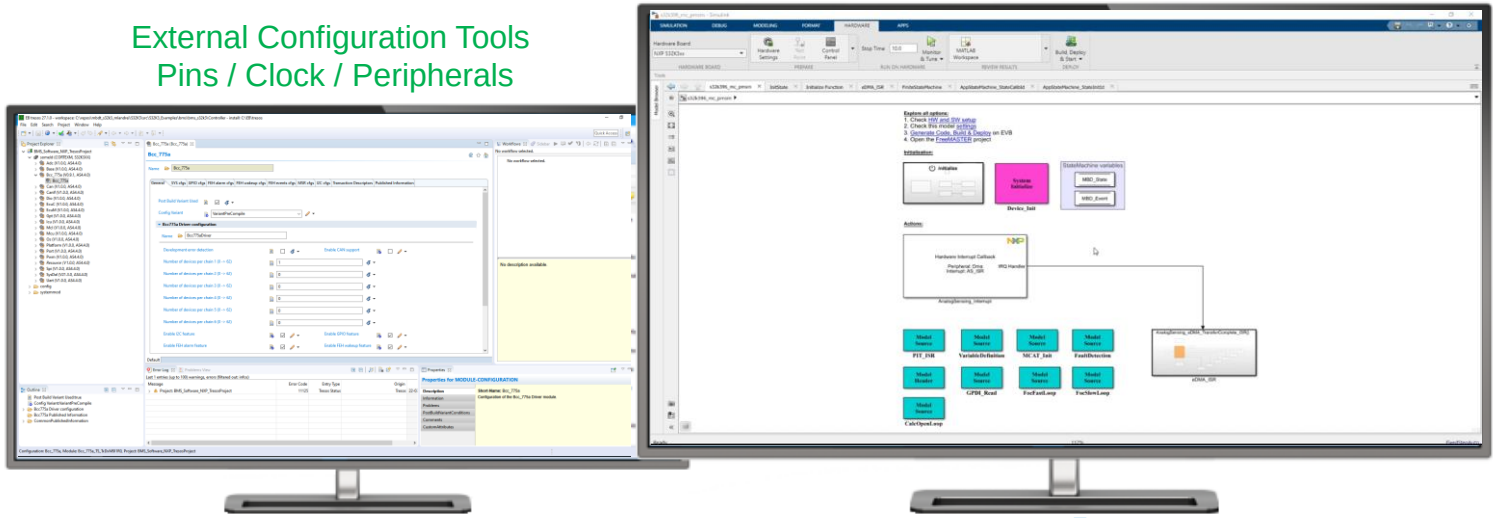
MBDT

Generated Application Source Code

MOTOR CONTROL RAPID PROTOTYPING – MBDT ENVIRONMENT

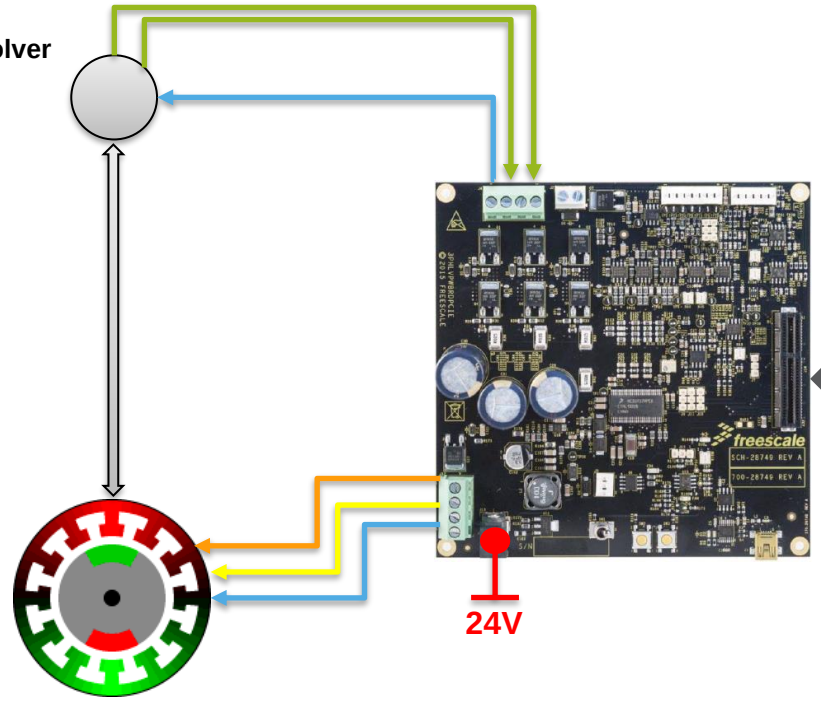
Model-Based Design Tools for Simulink

External Configuration Tools
Pins / Clock / Peripherals



Sin/Cos Resolver

Resolver



PCIe

XS32K396-BGA-DC

S32K39

JTAG

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s32k396_mc_pmsm - Simulink

SIMULATION | DEBUG | MODELING | FORMAT | HARDWARE | APPS

New | Open | Save | Print | Library Browser | Log Signals | Log Events | Add Viewer | Stop Time 10.0 | Normal | Fast Restart | Step Back | Run | Step Forward | Stop | Data Inspector | Sequence Viewer | Logic Analyzer | Bird's-Eye Scope | Simulation Manager

FILE | LIBRARY | PREPARE | SIMULATE | REVIEW RESULTS

Tools

Model Browser

s32k396_mc_pmsm | InitState | Initialize Function | eDMA_ISR | FiniteStateMachine | AppStateMachine_StateCalibId | AppStateMachine_StateInitId

s32k396_mc_pmsm

Explore all options:

1. Check HW and SW setup
2. Check this model settings
3. Generate Code, Build & Deploy on EVB
4. Open the FreeMASTER project

Initialization:

initialize

System Initialize

Device_Init

StateMachine variables

MBD_State

MBD_Event

Actions:

Hardware Interrupt Callback

Peripheral: Dma
Interrupt: AS_ISR

IRQ Handler

AnalogSensing_Interrupt

AnalogSensing_eDMA_TransferComplete_ISR()

eDMA_ISR

Model Source — PIT_ISR

Model Source — VariableDefinition

Model Source — MCAT_Init

Model Source — FaultDetection

Model Header

Model Source — GPDI_Read

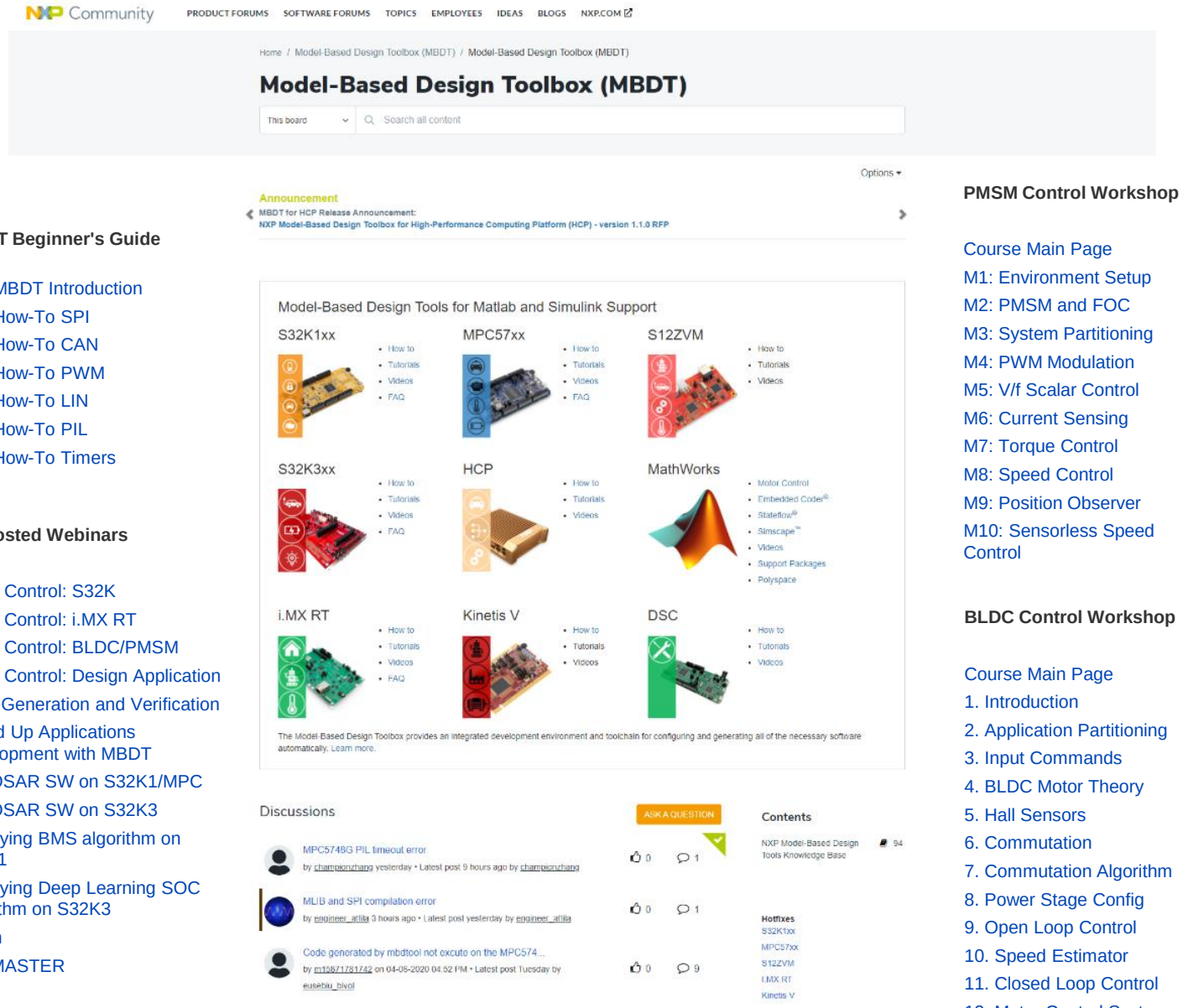
Model Source — FocFastLoop

Model Source — FocSlowLoop

Model Source — CalcOpenLoop

Ready | 129% | FixedStepAuto

ADDITIONAL RESOURCES & SUPPORT



MBDT Beginner's Guide

W1: MBDT Introduction
W2: How-To SPI
W3: How-To CAN
W4: How-To PWM
W5: How-To LIN
W6: How-To PIL
W7: How-To Timers

Co-hosted Webinars

Motor Control: S32K
Motor Control: i.MX RT
Motor Control: BLDC/PMSM
Motor Control: Design Application
Code Generation and Verification
Speed Up Applications Development with MBDT
AUTOSAR SW on S32K1/MPC
AUTOSAR SW on S32K3
Deploying BMS algorithm on S32K1
Deploying Deep Learning SOC algorithm on S32K3
Vision
FreeMASTER

PMSM Control Workshop

Course Main Page
M1: Environment Setup
M2: PMSM and FOC
M3: System Partitioning
M4: PWM Modulation
M5: V/f Scalar Control
M6: Current Sensing
M7: Torque Control
M8: Speed Control
M9: Position Observer
M10: Sensorless Speed Control

BLDC Control Workshop

Course Main Page
1. Introduction
2. Application Partitioning
3. Input Commands
4. BLDC Motor Theory
5. Hall Sensors
6. Commutation
7. Commutation Algorithm
8. Power Stage Config
9. Open Loop Control
10. Speed Estimator
11. Closed Loop Control
12. Motor Control System

MATLAB EXPO

Thank you

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