



SECURE CONNECTIONS
FOR A SMARTER WORLD

Rapid Prototyping Embedded Designs using NXP Model-Based Design Toolbox: A Battery Management System Application

Irina Costachescu



Marius-Lucian Andrei



MATLAB EXPO

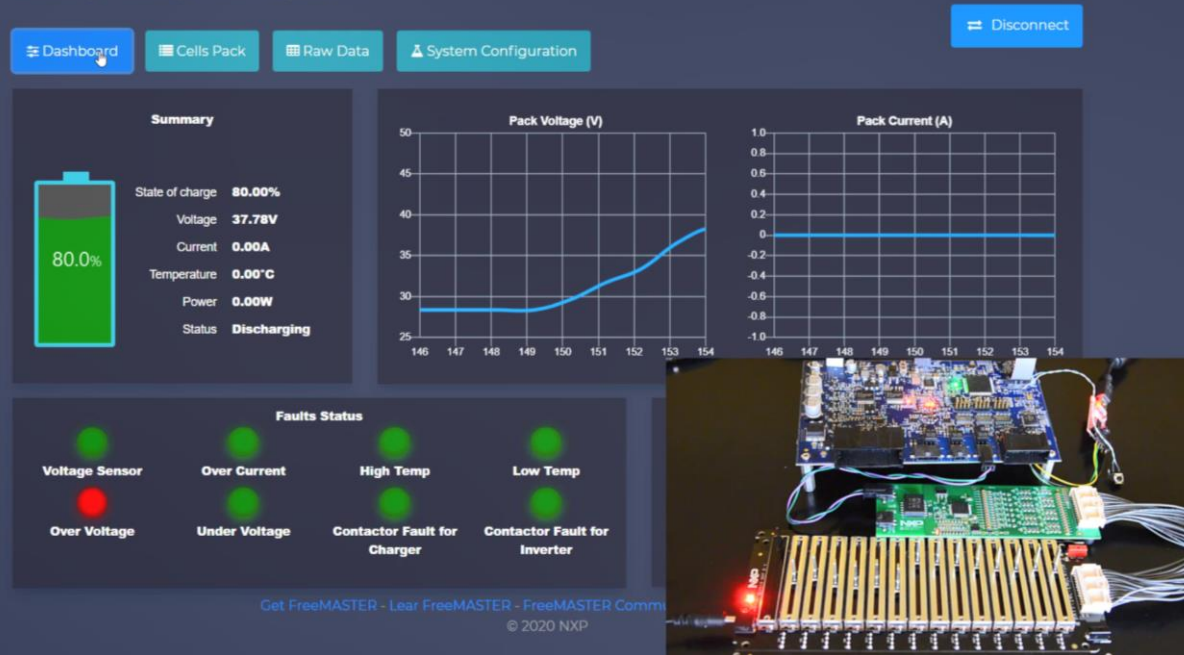
AGENDA

1. NXP Ecosystem

2. NXP's Model-Based Design Toolbox Introduction

3. Model-Based Design Toolbox for **Battery Management Systems**

Battery Management System



NXP SEMICONDUCTORS WORLDWIDE

Together with our valued customers, we're not just advancing technology, we're advancing society.



AUTOMOTIVE

Enabling carmakers to develop smarter solutions for complex autonomy, connectivity, and electrification challenges

Accelerating the shift to greater mobility



INDUSTRIAL

Reducing wasted time, money, and effort by helping business run more efficiently.

Enabling more efficient data processing



MOBILE

Giving wearable and mobile devices easier access to the services that make modern life more convenient without compromising security and safety.

Transforming how people and devices connect



SMART HOME

Solutions that listen, learn, and adapt into the places we call home for more comfort, affordability, safety, and convenience.

Powering the intelligence behind the technologies



SMART CITY

Simplifying how people access and interact with local services to achieve new standards of sustainability, efficiency, mobility, and economic growth.

Anticipating the demands of tomorrow



COMMUNICATION INFRASTRUCTURE

Powering insights and inspiring performance with hardware solutions for handling 5G connectivity across the emerging communications spectrum.

Delivering real-time responsiveness at the speed of 5G

60 years of combined experience and expertise
Operations in more than **30 countries** worldwide

Approximately **31,000 employees**

Headquarters in The Netherlands – **Eindhoven**



NXP ECOSYSTEM

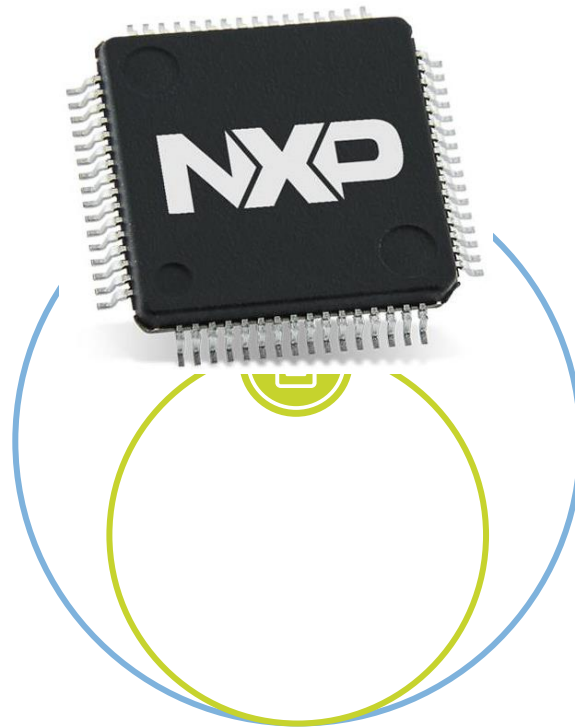


DRIVERS, MIDDLEWARE, LIBRARIES

- Simplify hardware access by using hardware optimized software



BUILD, DEBUG, CONFIGURATION TOOLS



BUILD, DEBUG, CONFIGURATION TOOLS

The screenshot displays the NXP S32V2 configuration tool interface, showing a clock diagram, a clock table, and a code preview.

Diagram: A clock tree diagram showing the derivation of various system clocks from the FXOSC source. The diagram includes components like ARMPLL, VIDEOPLL, PERIPPLL, and various dividers leading to clocks such as SYSCLK0, SYSCLK1, SYSCLK2, SYSCLK3, GPU_CLK, MIPI_LL_CLK, and others.

Clock Table:

Name	Value	Accuracy
FXOSC clock	40 MHz	
FIRC clock	48 MHz	
DDR_PLL PHI0 clock	500 MHz	
DDR_PLL PHI1 clock	1 GHz	
DDR_PLL DFS1 clock	499.02... MHz	
DDR_PLL DFS2 clock	499.02... MHz	
DDR_PLL DFS3 clock	349.72... MHz	

Code Preview:

```

clock_config.c clock_config.h
524         .clockName = DEC ^
525         .mc_me_RunPeriphConfig = MC_
526     },
527     {
528         .clockName = CRC
529         .mc_me_RunPeriphConfig = MC_
530     },
531     {

```

Problems: The Problems panel is currently empty, indicating no issues were detected during the configuration process.

NXP ECOSYSTEM



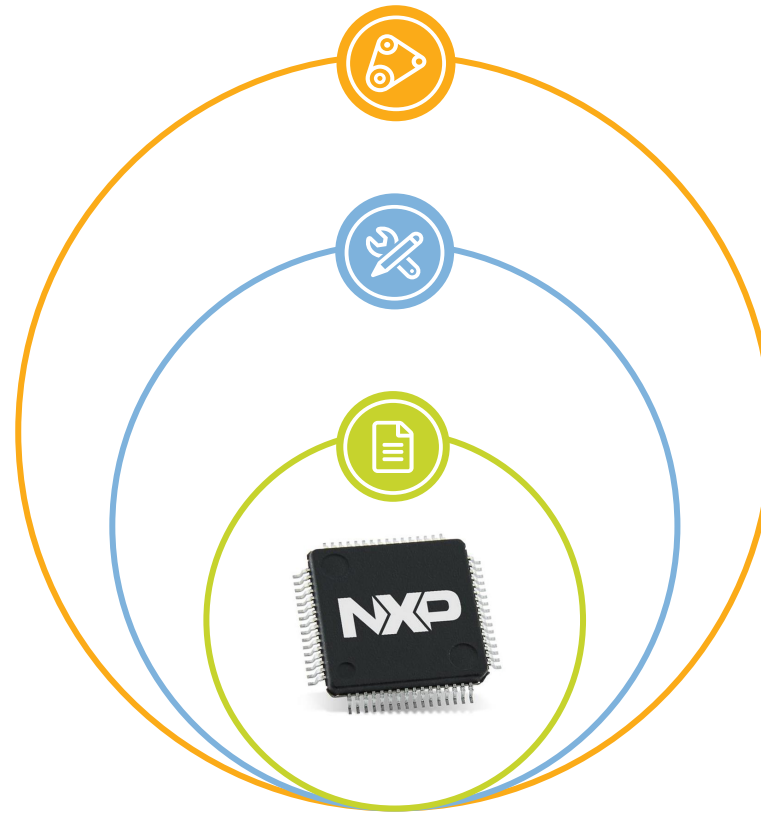
DRIVERS, MIDDLEWARE, LIBRARIES

- Simplify hardware access by using hardware optimized software



BUILD, DEBUG, CONFIGURATION TOOLS

- Application development inside an IDE
- Build Tools, Debug Tools and Configuration Tools integrated within the IDE
- Drivers, Middleware and Libraries configuration and initialization in a graphical environment



REAL TIME MONITOR, DEMO TOOLS



REAL TIME MONITOR, DEMO TOOLS

The screenshot displays the FreeMASTER interface for a PMSM motor control system. The main window shows a detailed block diagram of the control system, including a Slow Control Loop with PI controllers for speed and current, a Fast Control Loop with dq/αβ and SVM blocks, and observers for back-EMF and tracking. The system is connected to a VSI (Voltage Source Inverter) and a PMSM motor. Below the diagram are images of the NXP evaluation board and the motor.

On the right, an oscilloscope window titled "Oscilloscope - Speed" shows three traces: Speed Required (blue), SpeedRampOut (purple), and Speed Actual (green). The speed starts at 1500 rpm, drops to 500 rpm, and then returns to 1500 rpm. Below this, a current trace shows i_q (green) and i_q required (blue) in Amperes, with a significant transient during the speed change.

At the bottom, a Variable Watch table provides real-time data for various system parameters:

Name	Value	Unit	Period
Control Mode	VECTOR CONTROL [4]	ENUM	1000
Vector Control Type	Speed [1]	ENUM	1000
Speed Required	1500	rpm	500
Speed Actual	1501.97	rpm	1000
Uq	0	Volt	100
Scalar Frequency Required	0	Hz	100
Iq Required	0	Amps	1000
Iq	0.265763	Amps	1000
Ud_req	-0.650648	Volts	1000
Uq_req	4.05735	Volts	1000
DCB Voltage	23.9744	Volt	200

NXP ECOSYSTEM



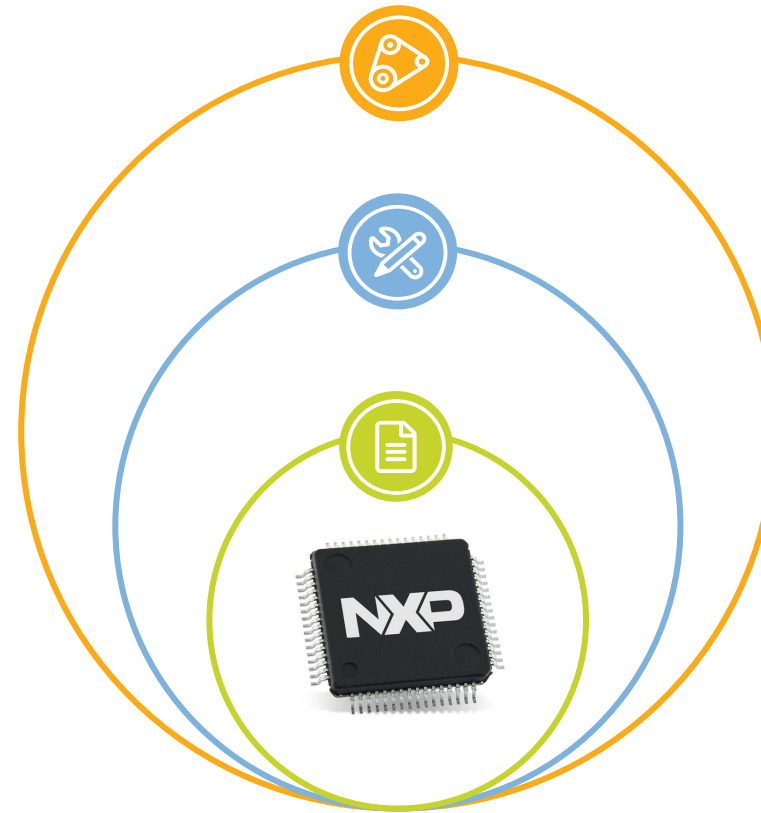
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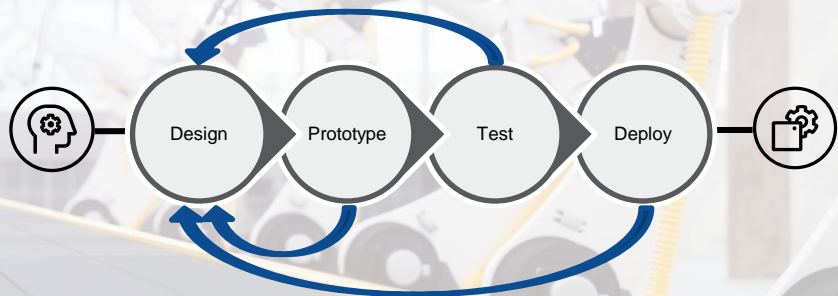
REAL TIME MONITOR, DEMO TOOLS

- Check the status of the running on target application in real time using **FreeMASTER**
- Write and read variables, registers, memory locations
- Monitor signals on the embedded target
- Fast demo design





FROM IDEA TO APPLICATION



DRIVERS, MIDDLEWARE, LIBRARIES

- Simplify hardware access by using hardware optimized software



BUILD, DEBUG, CONFIGURATION TOOLS

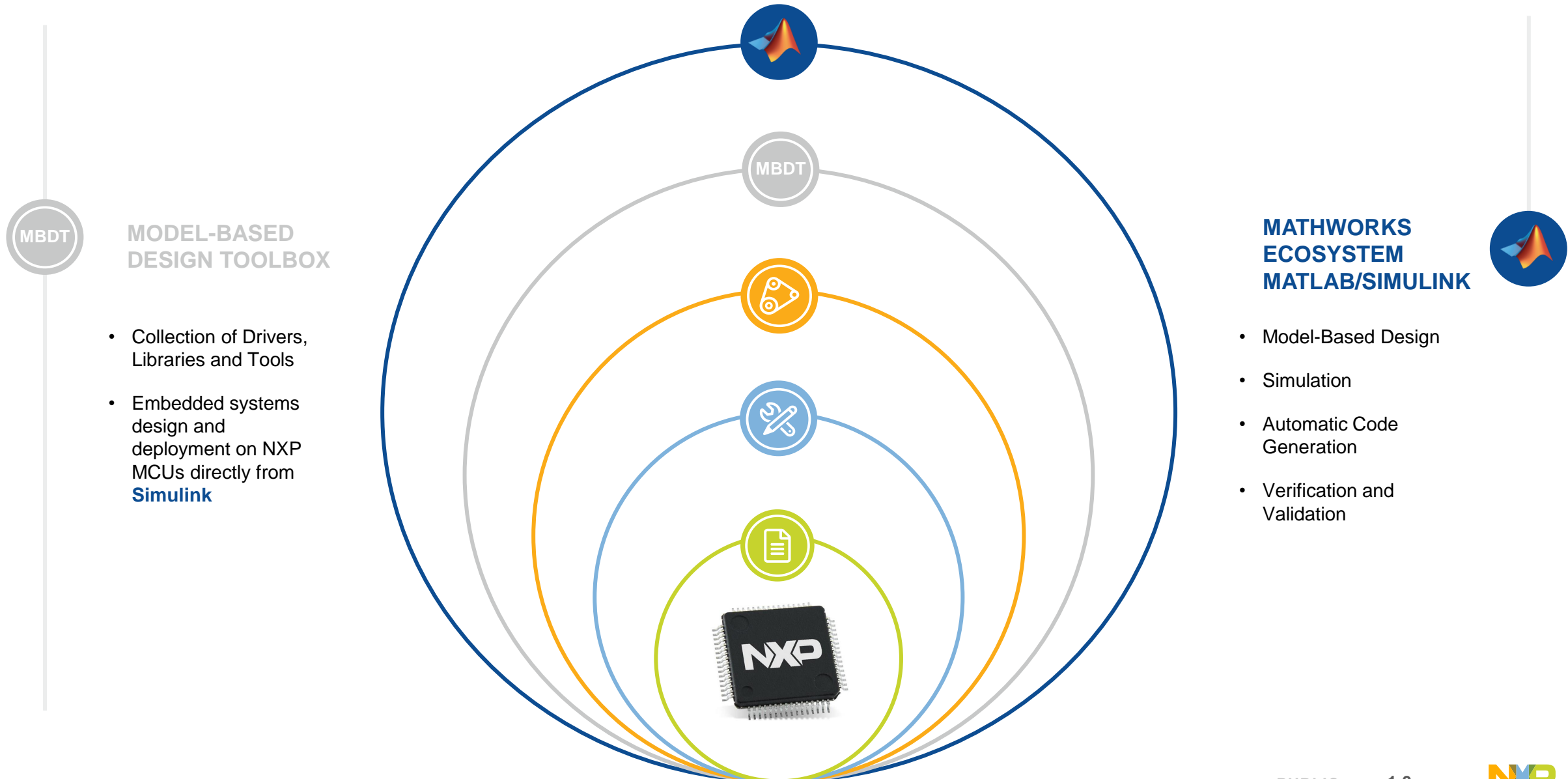
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REAL TIME MONITOR, DEMO TOOLS

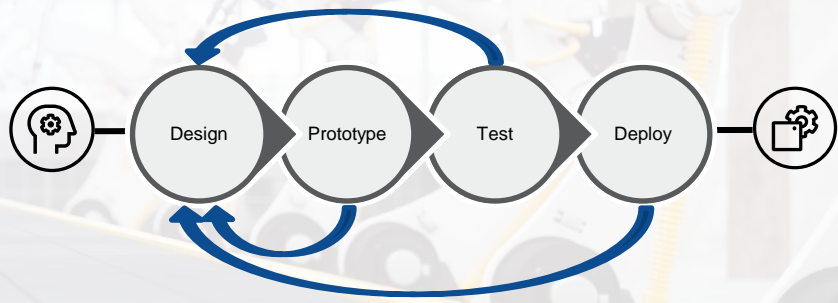
- Check the status of the running on target application in real time using **FreeMASTER**
- Write and read variables, registers, memory locations
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MODEL-BASED DESIGN





FROM IDEA TO APPLICATION



MBDT

MODEL-BASED DESIGN TOOLBOX

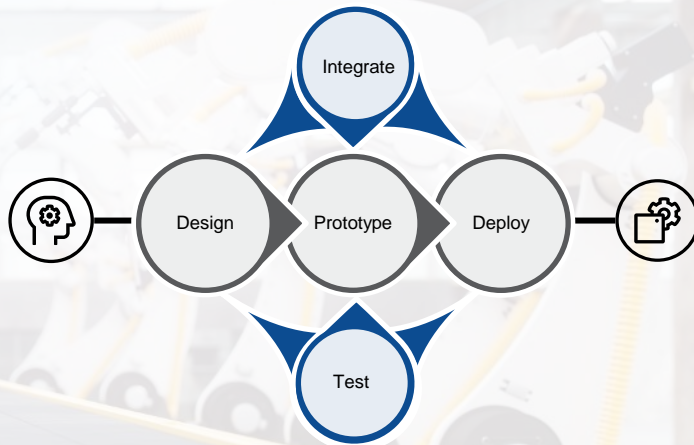
- Collection of Drivers, Libraries and Tools
- Embedded systems design and deployment on NXP MCUs directly from **Simulink**



MATHWORKS ECOSYSTEM MATLAB/SIMULINK

- Model-Based Design
- Simulation
- Automatic Code Generation
- Verification and Validation

FROM IDEA TO APPLICATION



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

MBDT

MODEL-BASED DESIGN TOOLBOX

- Collection of Drivers, Libraries and Tools
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MATHWORKS ECOSYSTEM MATLAB/SIMULINK

- Model-Based Design
- Simulation
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MODEL-BASED DESIGN TOOLBOX – SUPPORTED PLATFORMS



S32K1xx

S32K3xx

MPC57xx

S12ZVMx

S32G2

S32S2

AUTOMOTIVE

IMXRT1xxx

KVx

DSC

**INDUSTRIAL
& IoT**

S32V234

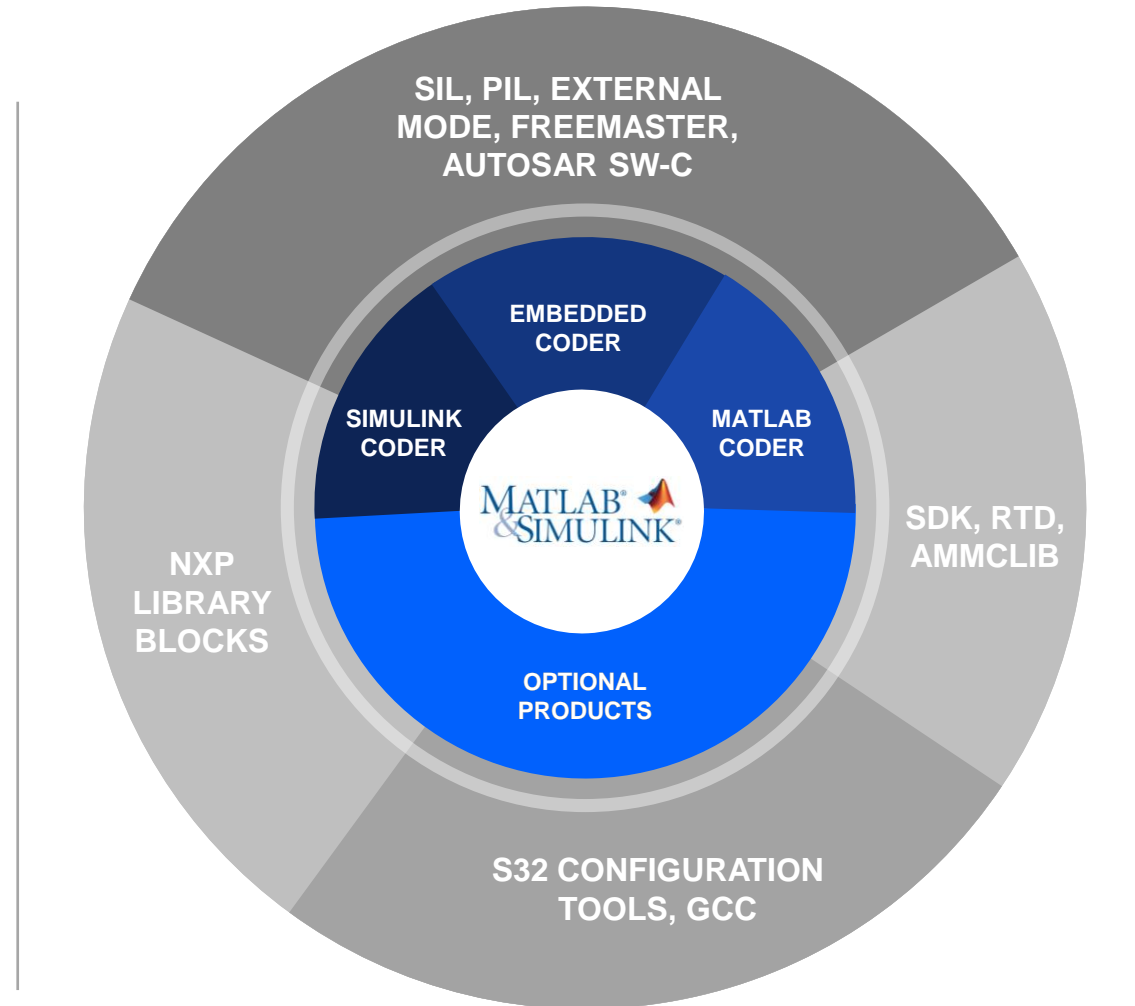
VISION

S32R41

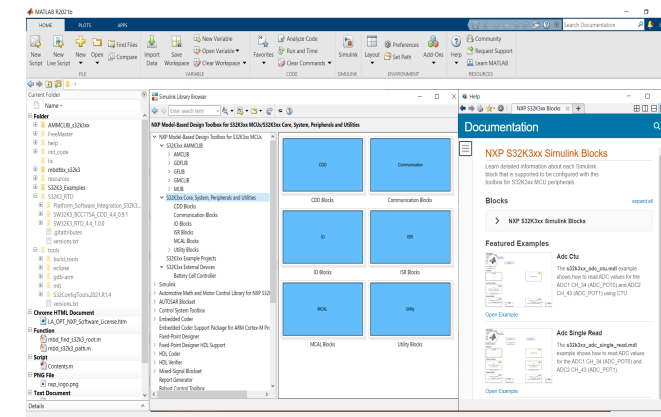
RADAR

MODEL-BASED DESIGN TOOLBOX – SOFTWARE DEVELOPMENT ENVIRONMENT AND MODULES

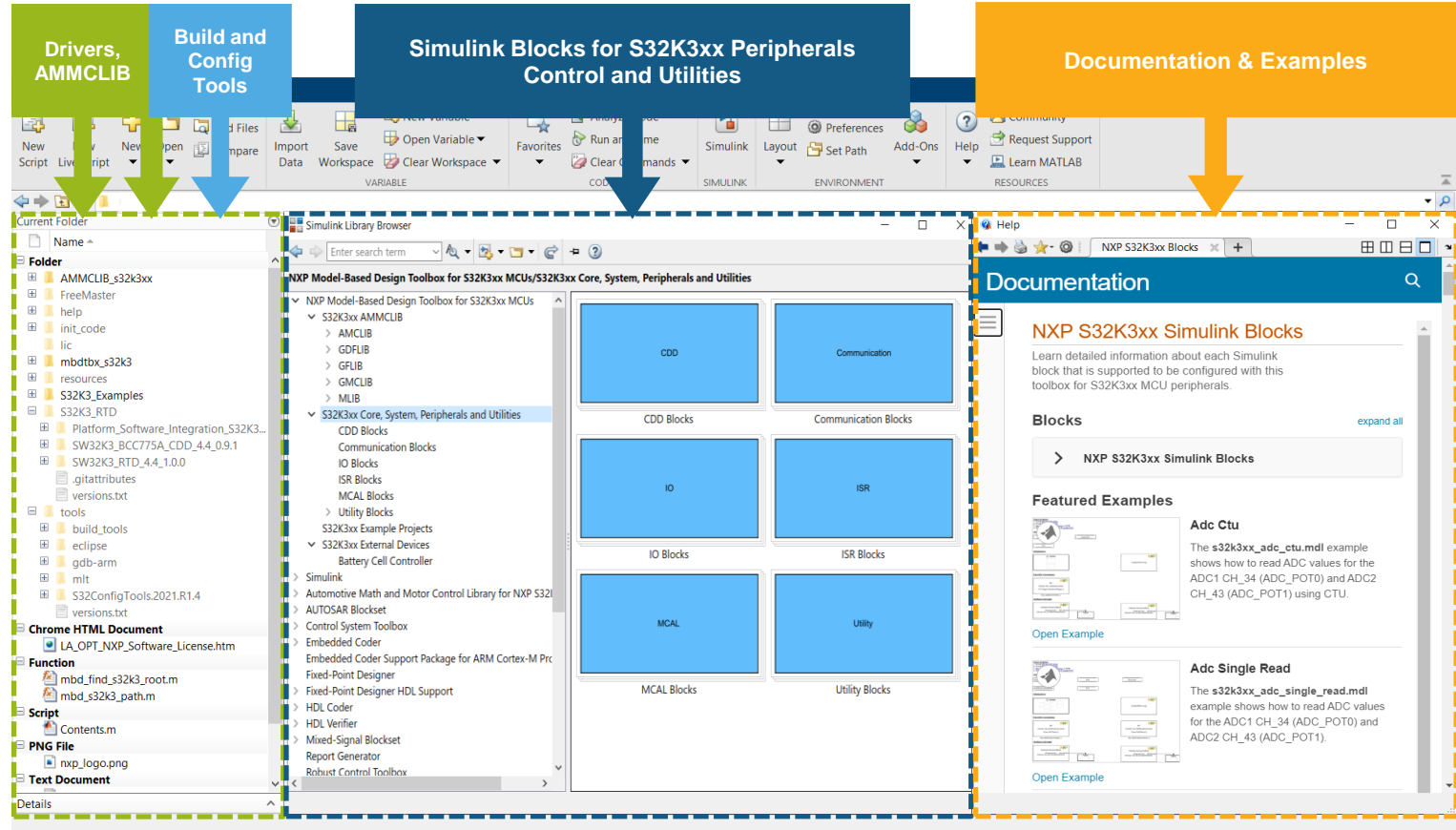
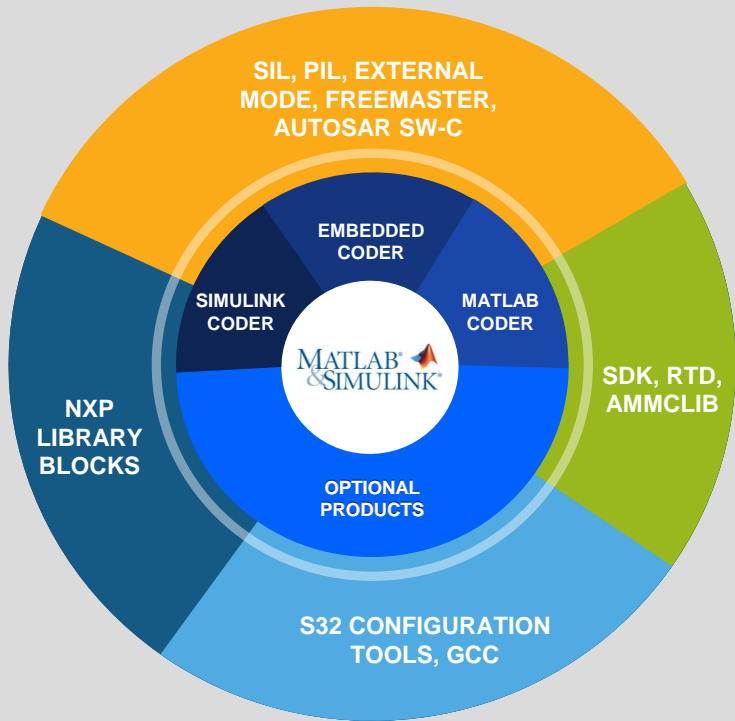
- Stateflow
- Simscape
- Motor Control Blockset
- AUTOSAR Blockset
- Deep Learning Toolbox
- Vehicle Network Toolbox



MODEL-BASED DESIGN TOOLBOX OVERVIEW



MODEL-BASED DESIGN TOOLBOX - OVERVIEW



- ✓ MCU Peripherals **Configuration & Control** using NXP's **Real-Time Drivers (RTD) / Software Development Kit (SDK)** APIs
- ✓ **External Tools** integration for peripherals, pins and clocks configuration; **Build Tools**
- ✓ **MBDT** blocks generate code on top of RTD/SDK
- ✓ **Example applications** covering all the toolbox features and functionalities

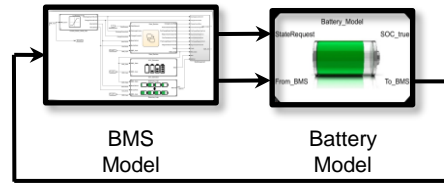
* AMMCLIB – Automotive Math and Motor Control Library

BATTERY MANAGEMENT SYSTEM – DEVELOPMENT FLOW WITH MATHWORKS AND NXP



MODEL-BASED DESIGN DEVELOPMENT FLOW

Idea Incubation

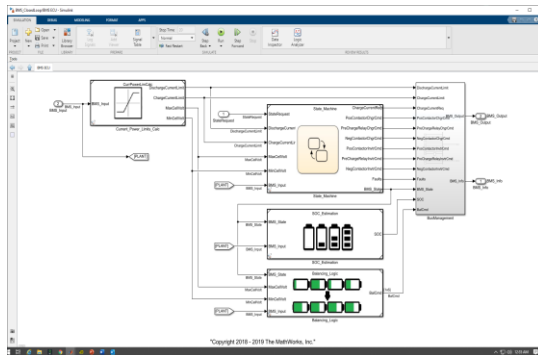


PC Environment

Step 1 – System Requirements

Model-in-the-Loop

- Software requirements
- Control system requirements
- Overall application control strategy

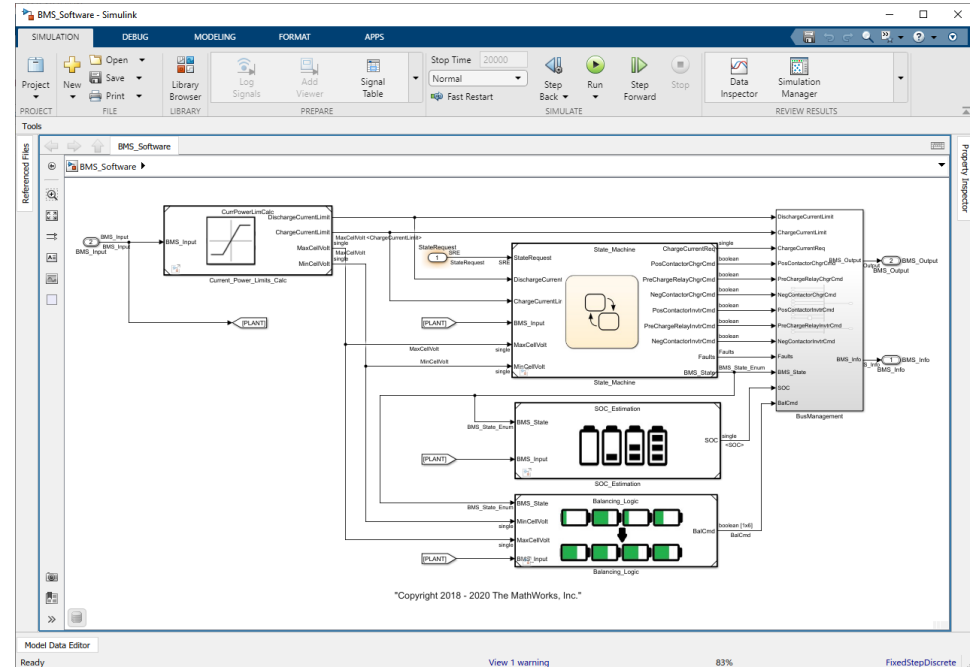
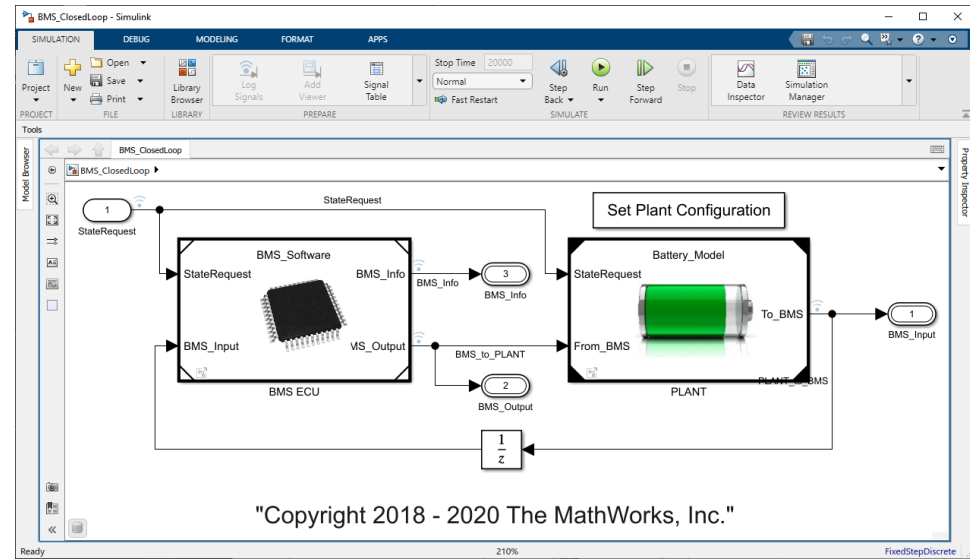


IDEA INCUBATION MODEL-IN-THE-LOOP

MIL

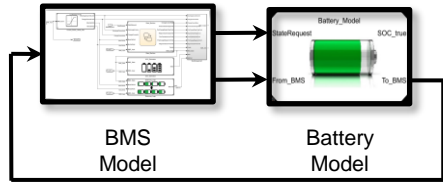
Model-in-the-Loop

- Software requirements
- Control system requirements
- Overall application control strategy
- Model testing



MODEL-BASED DESIGN DEVELOPMENT FLOW

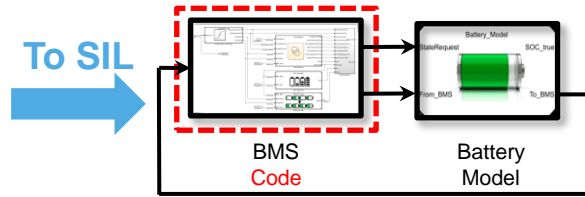
Idea Incubation



Step 1 – System Requirements Model-in-the-Loop

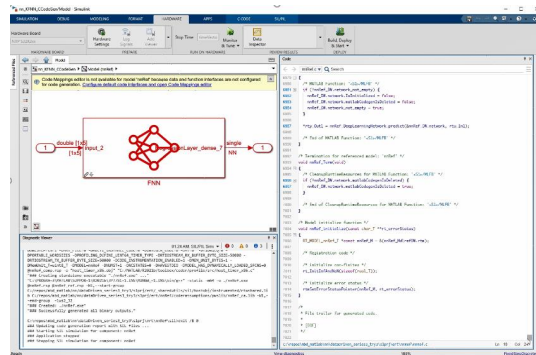
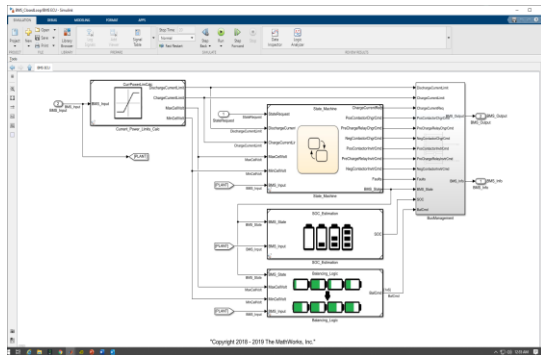
- Software requirements
- Control system requirements
- Overall application control strategy

Automatic Code Generation



Step 2 – Modeling/Simulation Software-in-the-Loop

- Control algorithm design
- Code generation preparation
- Control system design
- Start testing implementation approach

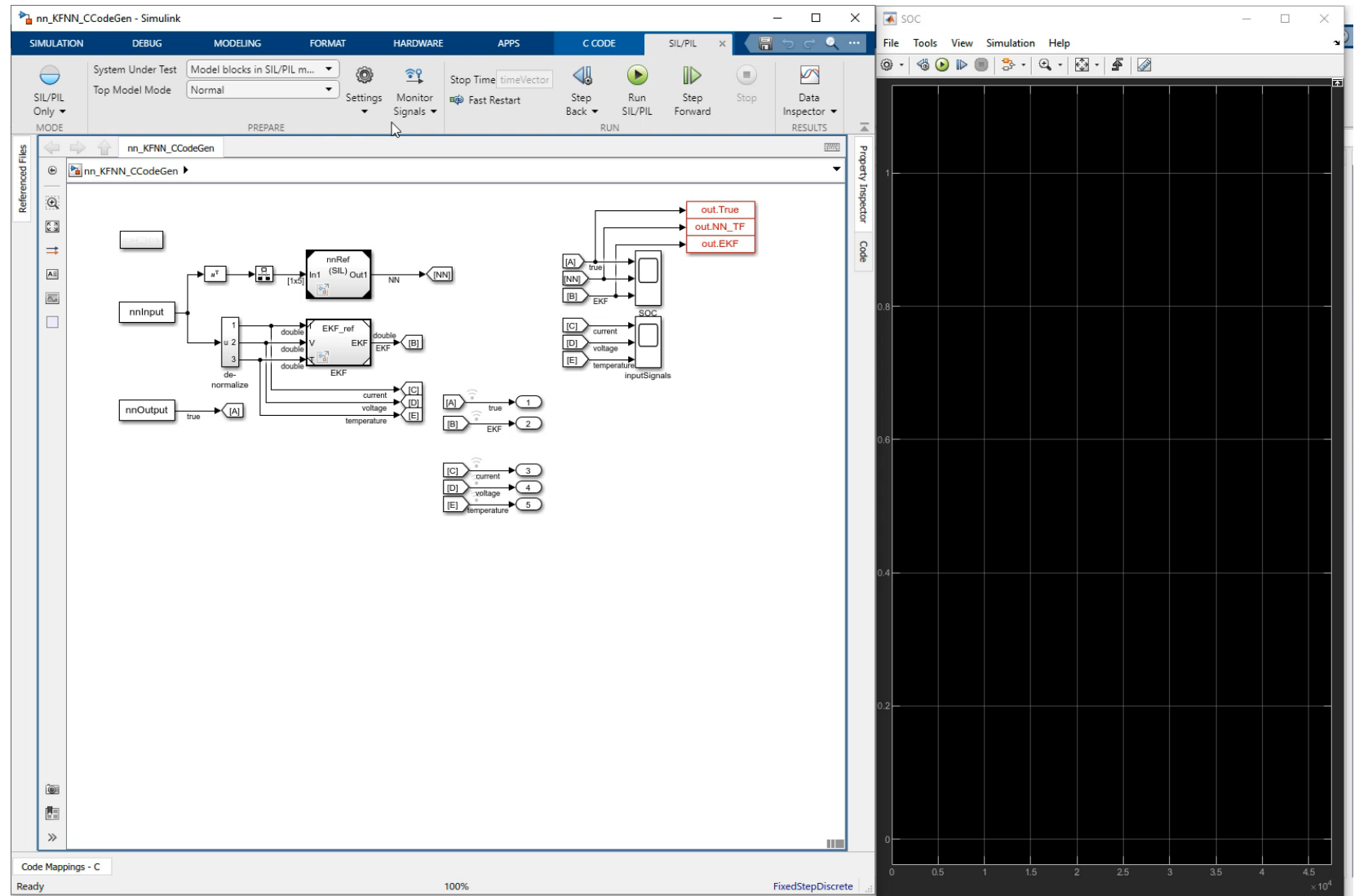


AUTOMATIC CODE GENERATION SOFTWARE-IN-THE-LOOP

SIL

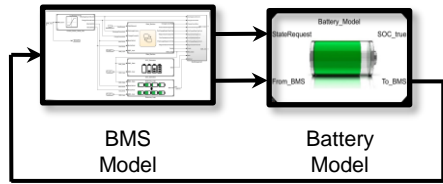
Software-in-the-Loop

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MODEL-BASED DESIGN DEVELOPMENT FLOW

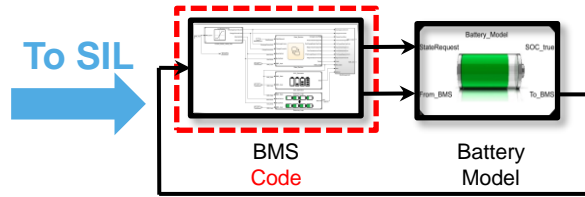
Idea Incubation



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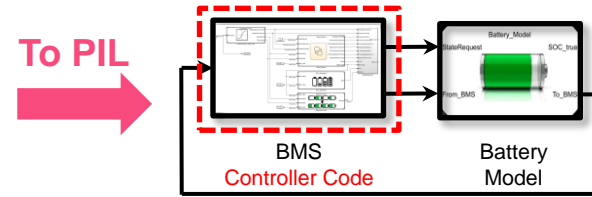
Automatic Code Generation



Step 2 – Modeling/Simulation Software-in-the-Loop

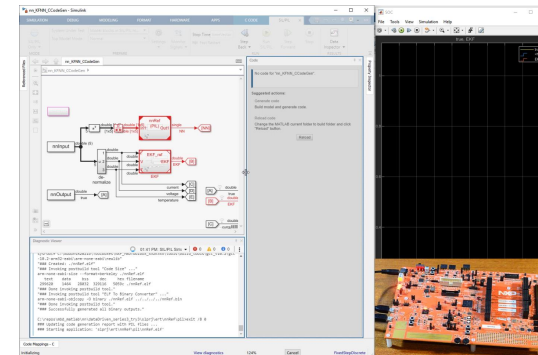
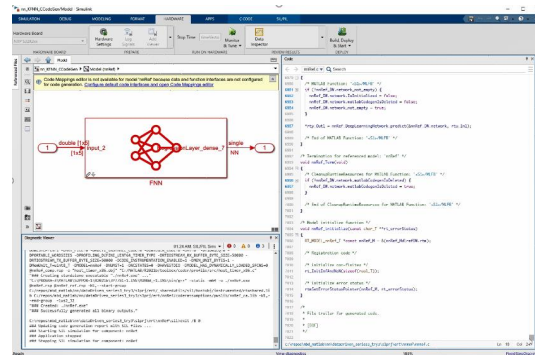
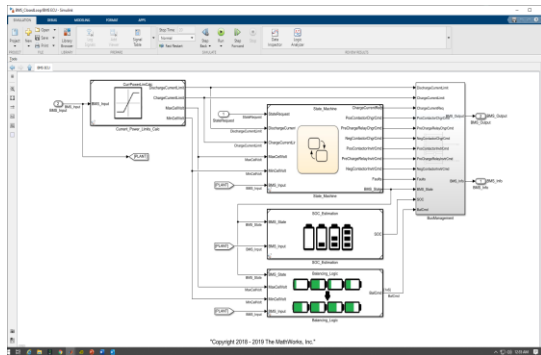
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Code Validation



Step 3 – Rapid Prototype Processor-in-the-Loop

- Controller code generation
- Determine execution time on MCU
- Verify algorithm on MCU
- Check memory/stack usage on MCU

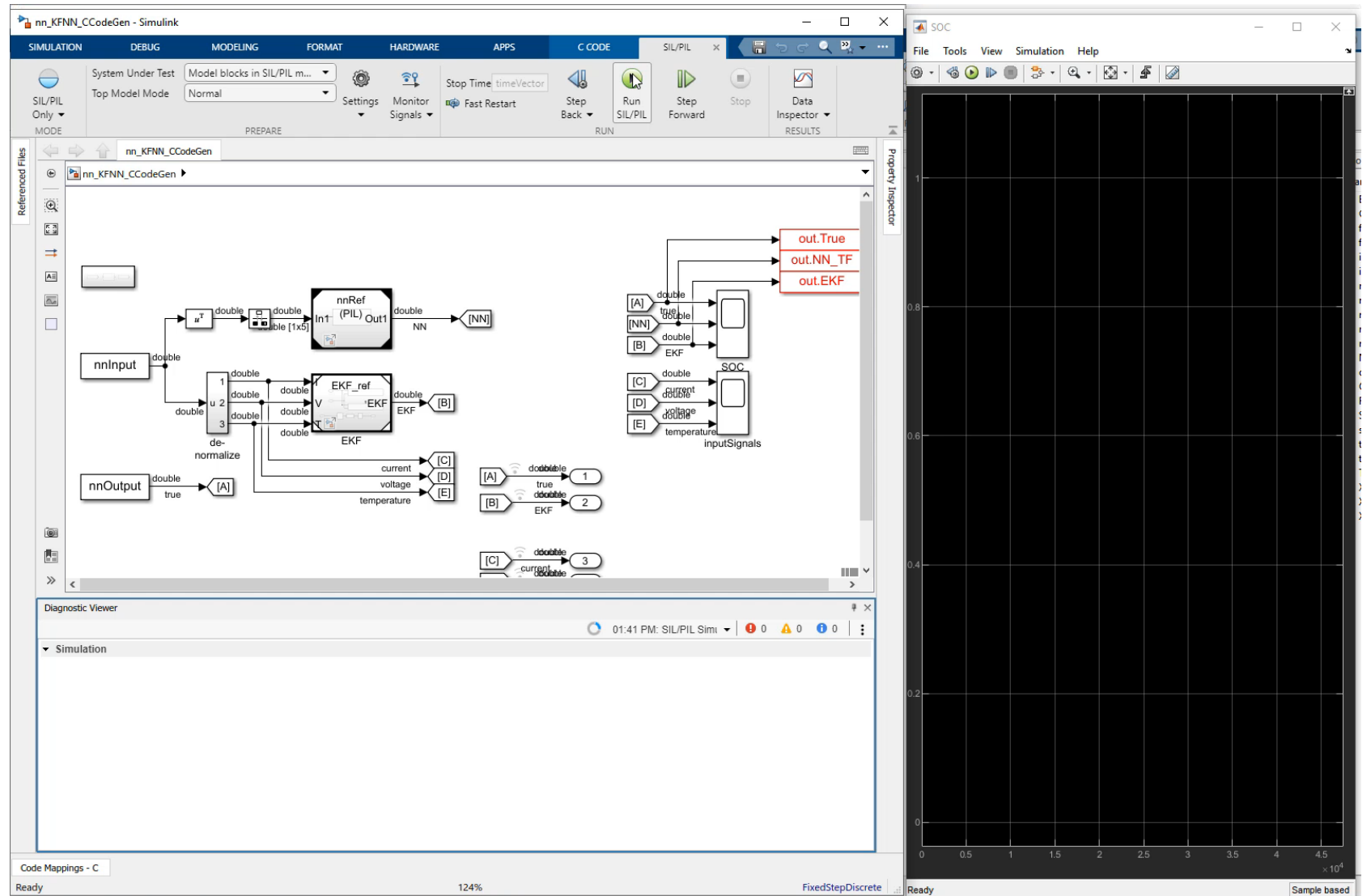


AUTOMATIC CODE GENERATION PROCESSOR-IN-THE-LOOP

PIL

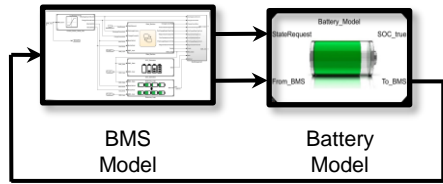
Processor-in-the-Loop

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MODEL-BASED DESIGN DEVELOPMENT FLOW

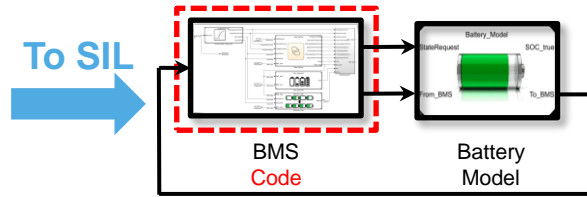
Idea Incubation



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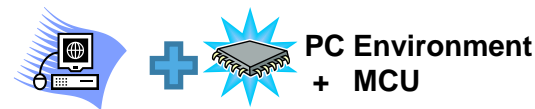
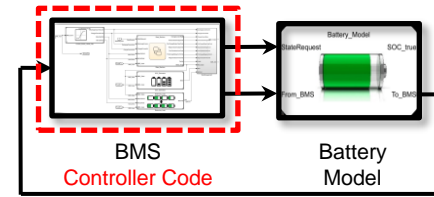
Automatic Code Generation



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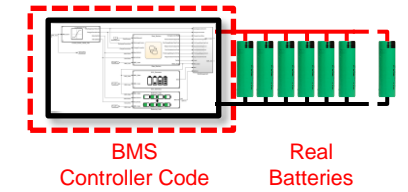
Code Validation



Step 3 – Rapid Prototype Processor-in-the-Loop

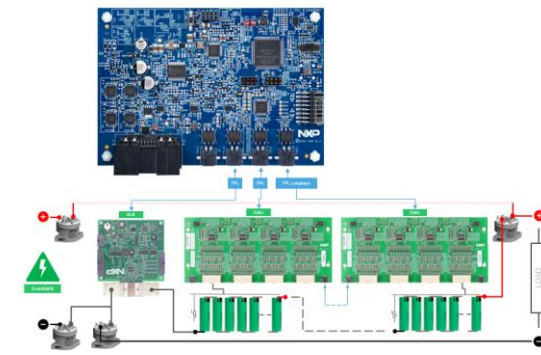
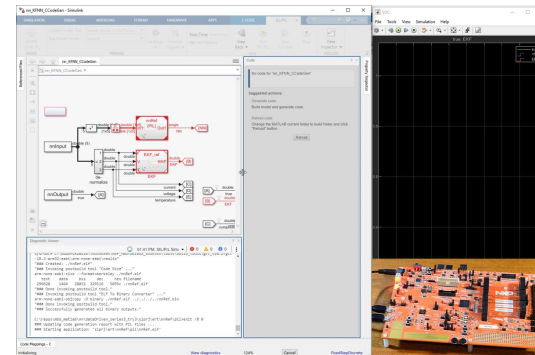
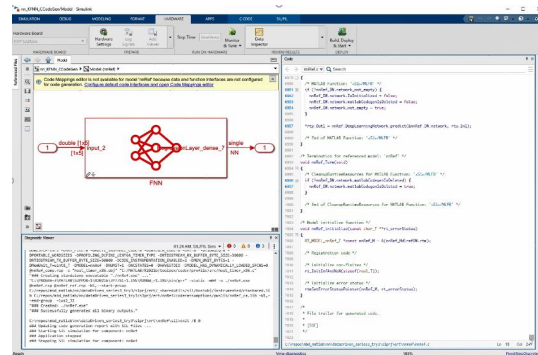
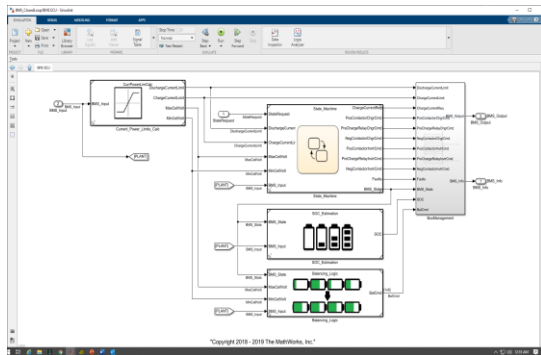
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Prototype



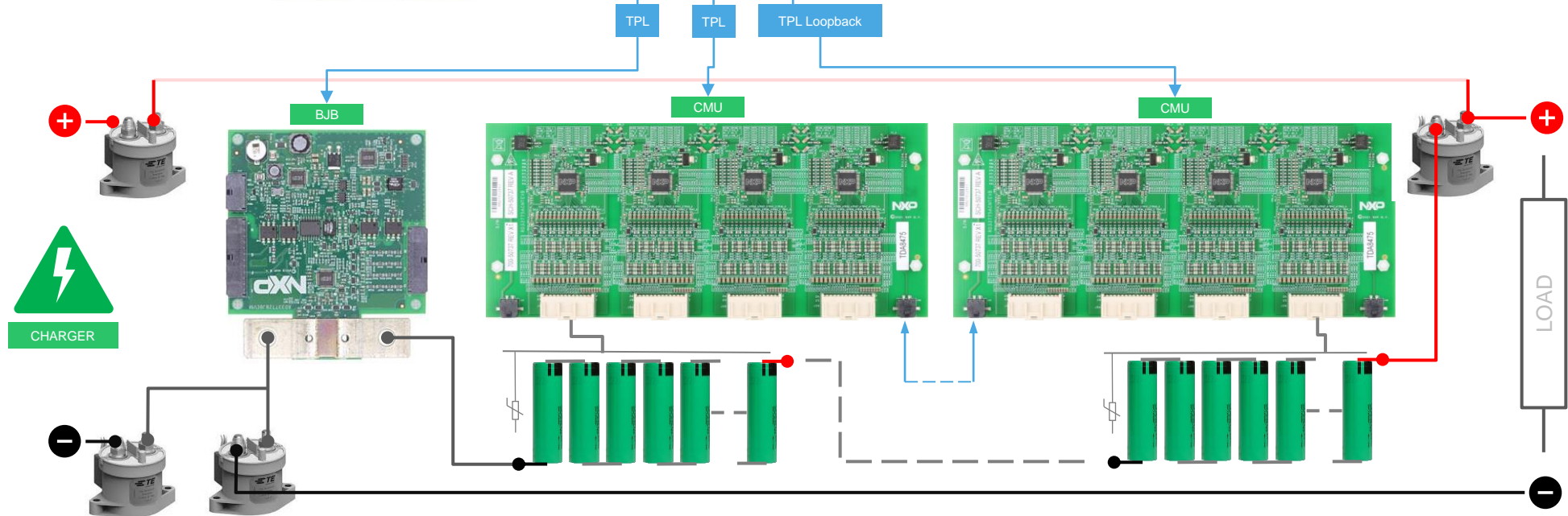
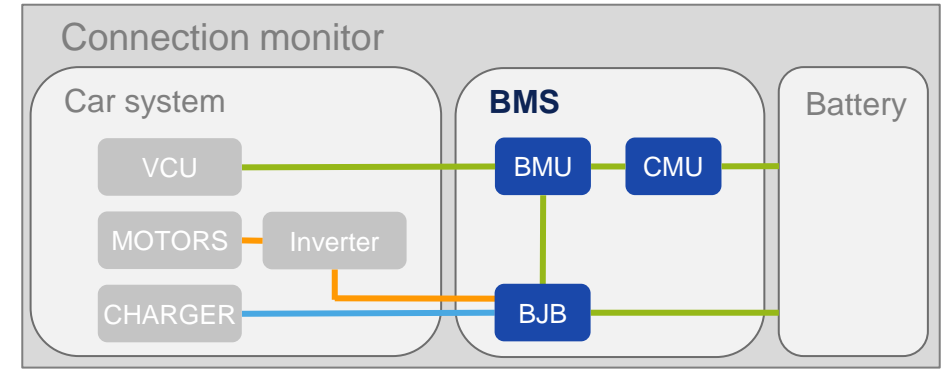
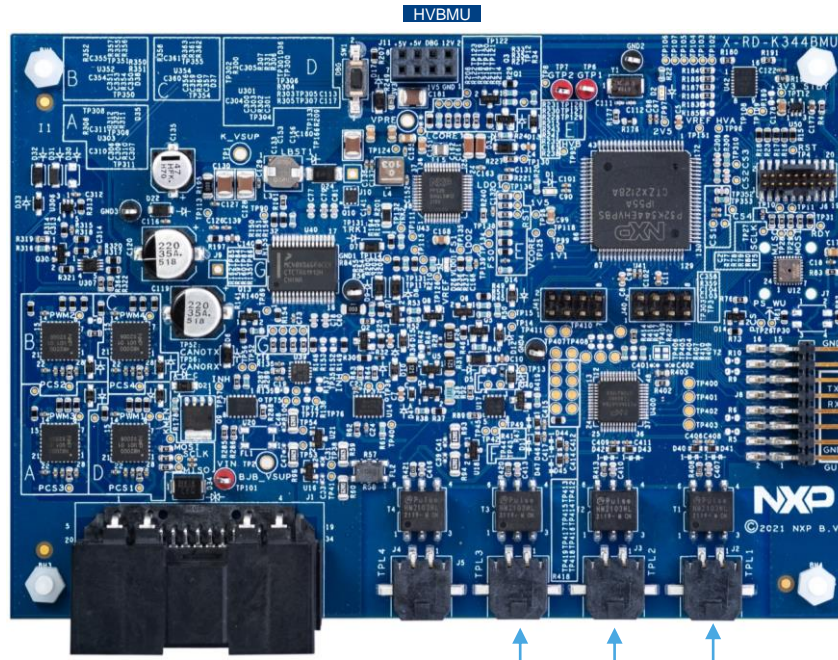
Step 4 – Target MCU Implementation MCU Final Application

- Validation/verification phase
- Controller code generation
- Test system in target environment using tools for data logging and parameter tuning



HIGH VOLTAGE BMS DESIGN

Prototype

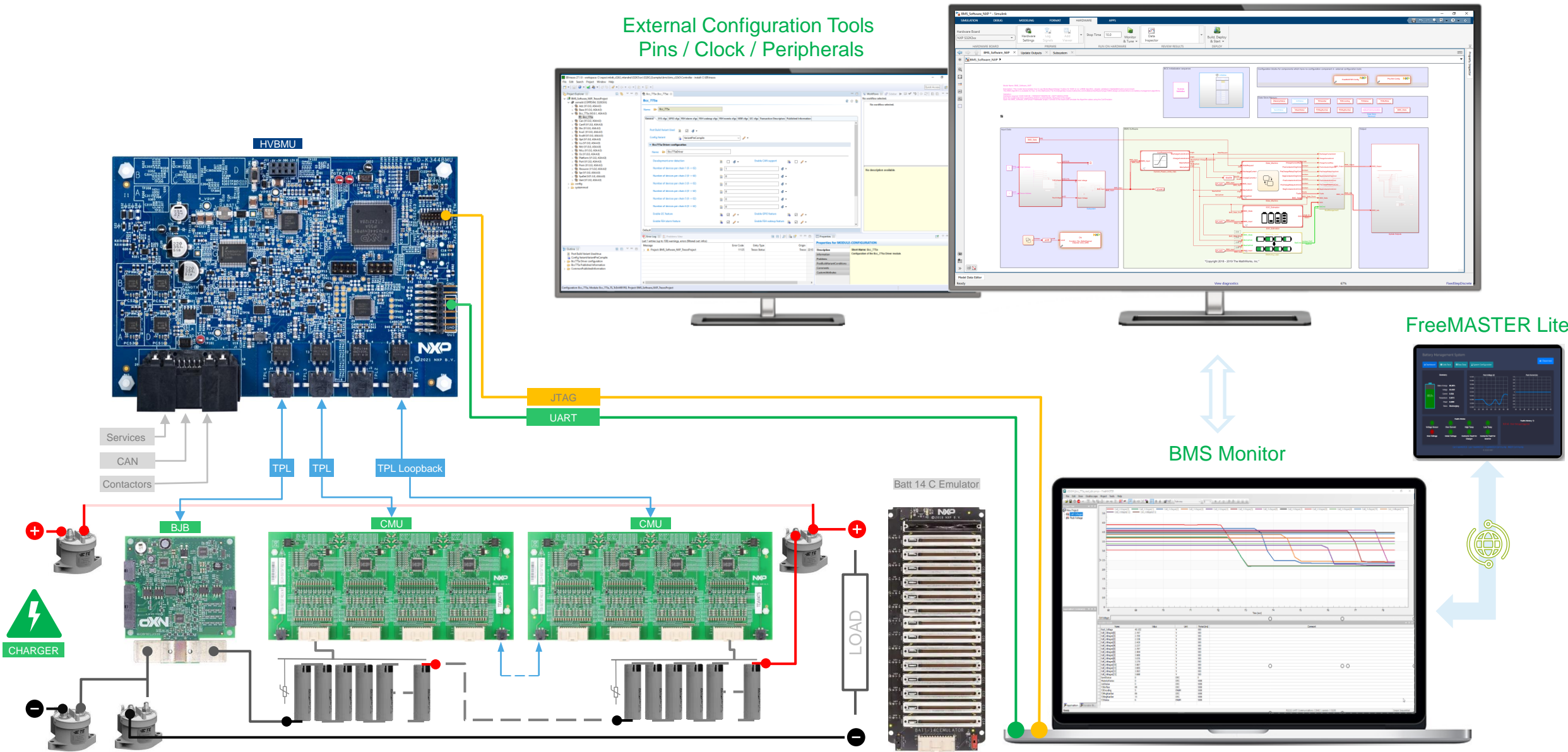


i Images presented are for illustration purposes only and may not be an exact representation of the product – their purpose is just exemplification of a concept.

BMS RAPID PROTOTYPING - MBDT ENVIRONMENT

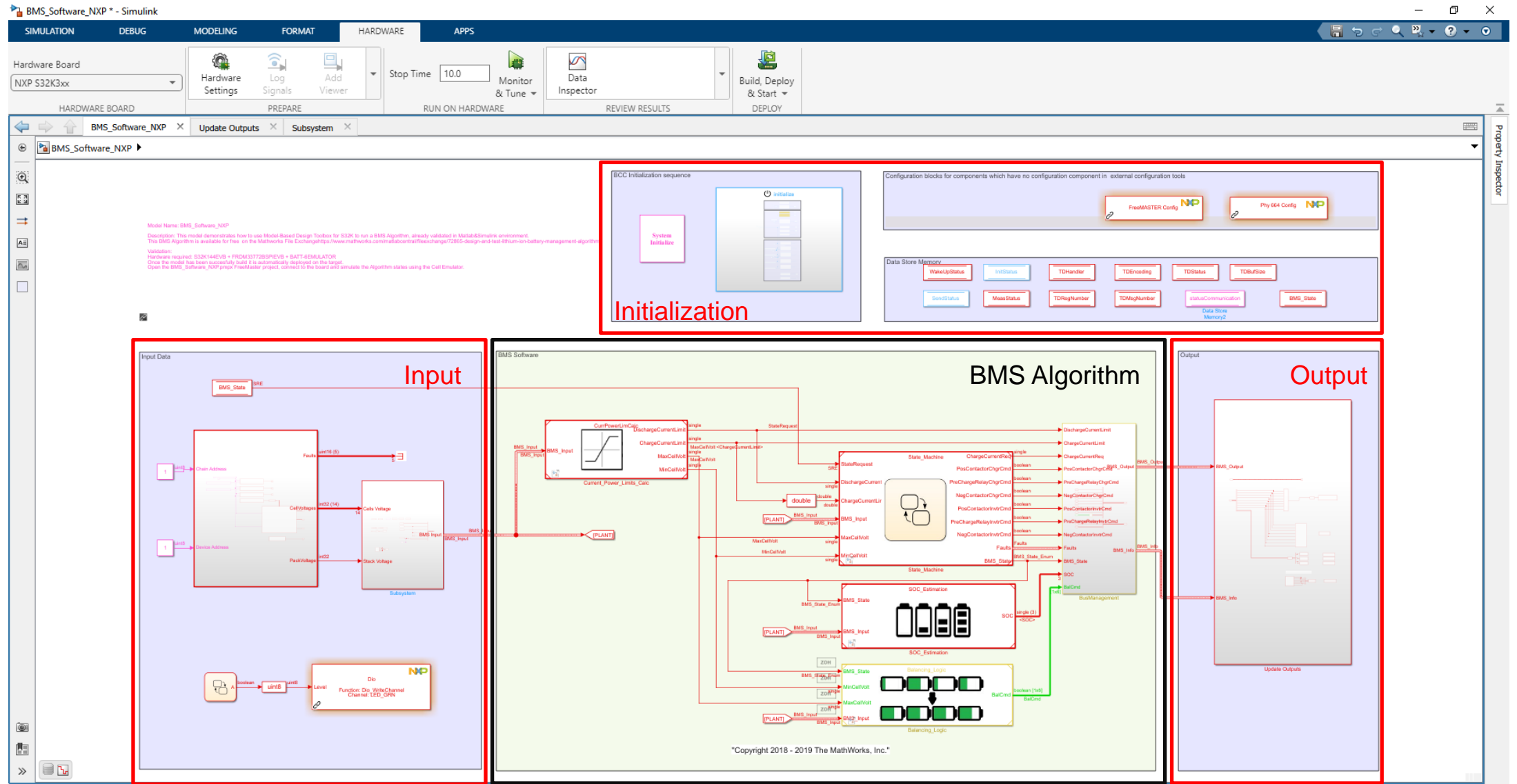
Model-Based Design Tools for Simulink

External Configuration Tools
Pins / Clock / Peripherals



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BMS MODEL ON MBDT



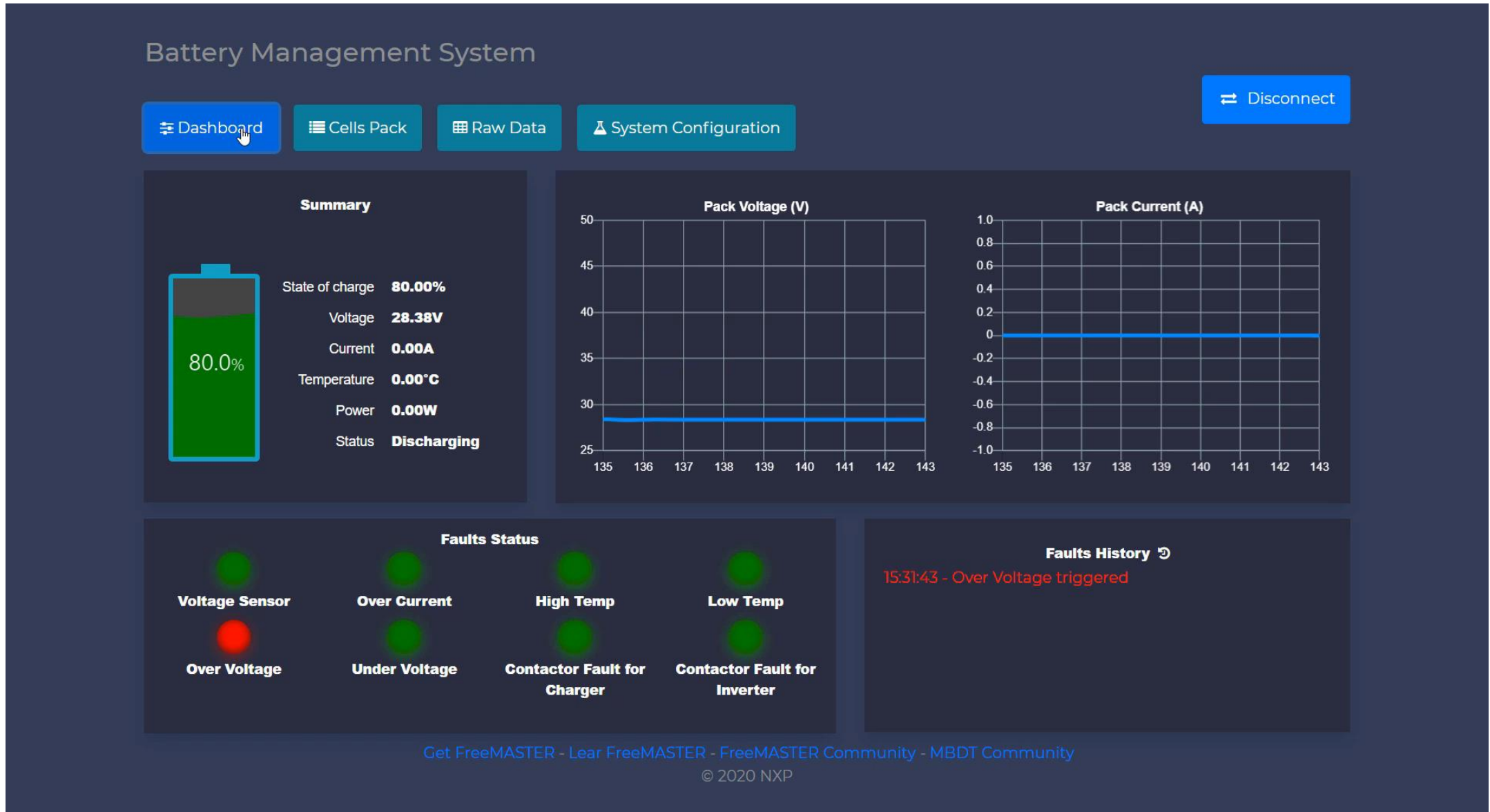
Model Data Editor
Ready

View diagnostics

67%

FixedStepDiscrete

FREEMASTER DEMO INTERFACE



ADDITIONAL RESOURCES & SUPPORT

Model-Based Design Toolbox (MBDT)

This board Search all content

Options

Announcement

MBDT for HCP Release Announcement:
NXP Model-Based Design Toolbox for High-Performance Computing Platform (HCP) - version 1.1.0 RFP

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

Model-Based Design Tools for Matlab and Simulink Support

S32K1xx <ul style="list-style-type: none">How toTutorialsVideosFAQ	MPC57xx <ul style="list-style-type: none">How toTutorialsVideosFAQ	S12ZVM <ul style="list-style-type: none">How toTutorialsVideos
S32K3xx <ul style="list-style-type: none">How toTutorialsVideosFAQ	HCP <ul style="list-style-type: none">How toTutorialsVideos	MathWorks <ul style="list-style-type: none">Motor ControlEmbedded Coder®Stateflow®Simulink™VideosSupport PackagesPolyspace
i.MX RT <ul style="list-style-type: none">How toTutorialsVideosFAQ	Kinetis V <ul style="list-style-type: none">How toTutorialsVideos	DSC <ul style="list-style-type: none">How toTutorialsVideos

The Model Based Design Toolbox provides an integrated development environment and toolchain for configuring and generating all of the necessary software automatically. Learn more.

Discussions

- MPC5748G PIL timeout error
by [championhang](#) yesterday • Latest post 9 hours ago by [championhang](#)
- MLIB and SPI compilation error
by [equiper_alita](#) 3 hours ago • Latest post yesterday by [equiper_alita](#)
- Code generated by mbdtool not excute on the MPC574...
by [m1387176142](#) on 04-05-2020 04:52 PM • Latest post Tuesday by [eusebio_bivoli](#)

ASK A QUESTION

Contents

- NXP Model-Based Design Tools Knowledge Base 94
- Hotfixes
 - S32K1xx
 - MPC57xx
 - S12ZVM
 - i.MX RT
 - Kinetis V

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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