# Enabling Motor Control Across a Range of NXP MCUs with MCUXpresso and FreeMASTER Visualization Tools

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**MARCH 2020**

SECURE CONNECTIONS FOR A SMARTER WORLD

# Agenda

- Motor control & power conversion overview
- NXP MCUs and crossover MCUs platforms
- NXP tools and support
  - Programming and debugging tools
  - Embedded software libraries
  - Functional safety
- NXP web pages, useful links
- Summary

# NXP SOLUTION MOTOR CONTROL AND POWER CONVERSION

Appliance safety

Industrial safety

SR

SR

Industrial

Motor Control

Appliance

PMSM

ACIM

BLDC

PMSM

ACIM

BLDC

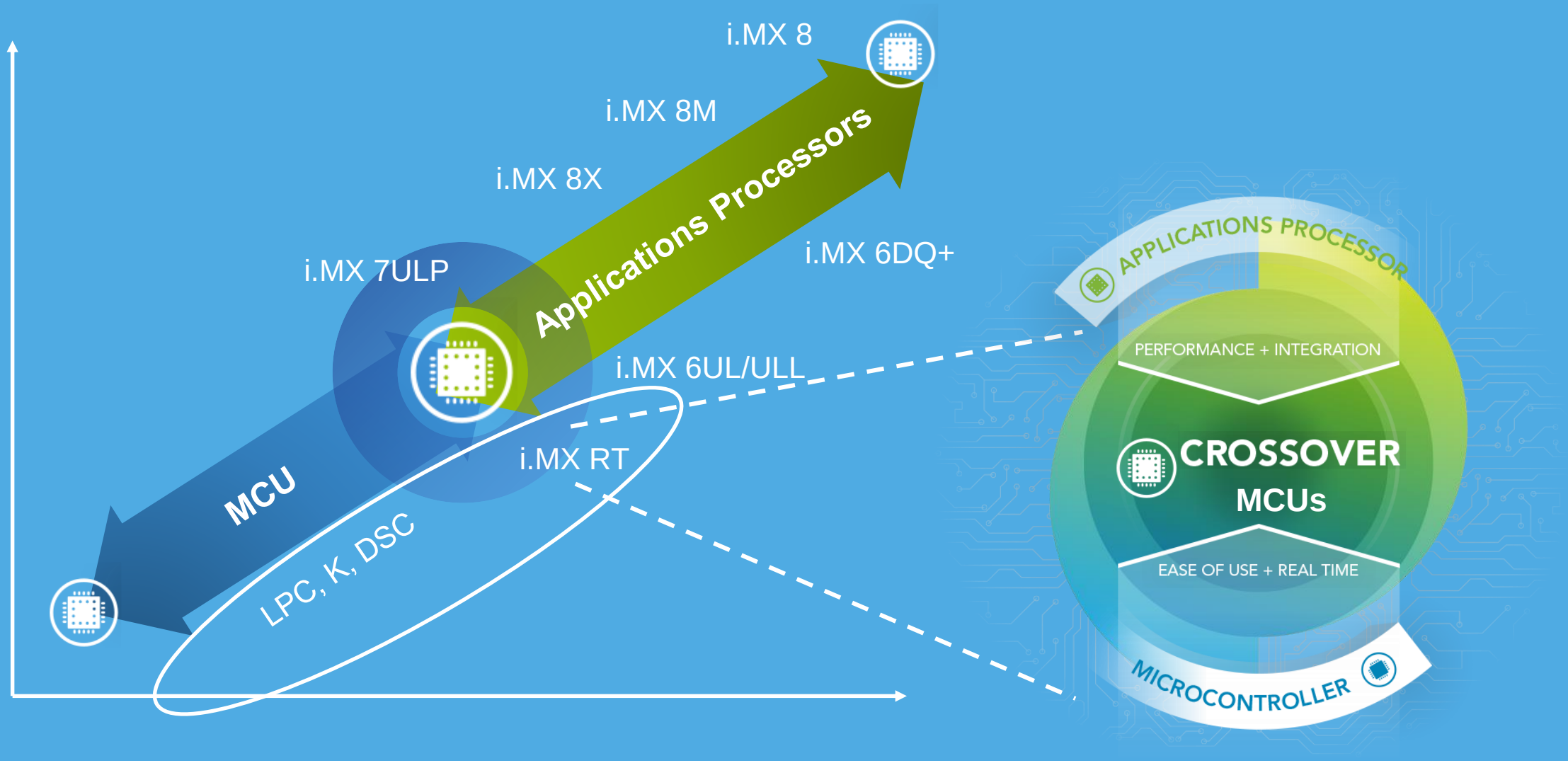
**NXP Solutions for Motor Control & Power Conversion**

***(MCUs, MPUs, tools, app. examples, ref. designs, functional safety)***

Power Conversion

SCALABILITY OF EMBEDDED PROCESSING

# THE NEW NORMAL



# NXP MCUs AND CROSSOVER MCUs

**MCUs** | **Crossover MCUs**

**Motor Control & Power Conversion**

## MC56F8xxxx

Core: 56800EX

Clock: up to 100 MHz

Flash: internal up to 160 kB

Peripheral modules:

- Motor control: smart set of modules
- Safety: IEC 60730 support
- Motor control and power conversion application use:
  - From low-end to mid-end
  - Support of power conversion
  - Up to 2 motors (PMSM, ACIM, BLDC, SR, SynR)
  - Power conversion supported – high frequency and high PWM resolution applications

## MKVxx & MKExx

Core: Arm® Cortex®-M0+, M4, M7

Clock: up to 240 MHz

Flash: internal up to 1 MB

Peripheral modules:

- Motor control: smart set of modules
- Safety: IEC 60730 support
- Motor control and power conversion application use:
  - From low-end to high-end
  - Up to 4 motors (PMSM, ACIM, BLDC, SR, SynR)
  - Power conversion supported – high PWM frequency and high PWM resolution applications

## LPC55xx

Core: Cortex-M33

Clock: up to 150 MHz

Flash: internal up to 640 kB

Peripheral modules:

- Motor control: peripheral modules support
- Safety: IEC 60730 support
- Security: advanced support
- Motor control and power conversion application use:
  - From low-end to mid-end
  - Single motor solution (PMSM, ACIM, BLDC, SR, SynR)
  - Power conversion supported – middle (low) PWM frequency and middle (low) PWM resolution applications

## i.MX RT10xx

Core: Cortex-M7

Clock: up to 600 MHz

Flash: external Flash

Peripheral modules:

- Motor control: smart set of modules
- Safety: IEC 60730 support
- Security: advanced support
- Motor control and power conversion application use:
  - From low-end to high-end
  - Up to 4 motors (PMSM, ACIM, BLDC, SR, SynR)
  - Power conversion supported – middle (low) PWM frequency and middle (low) PWM resolution applications

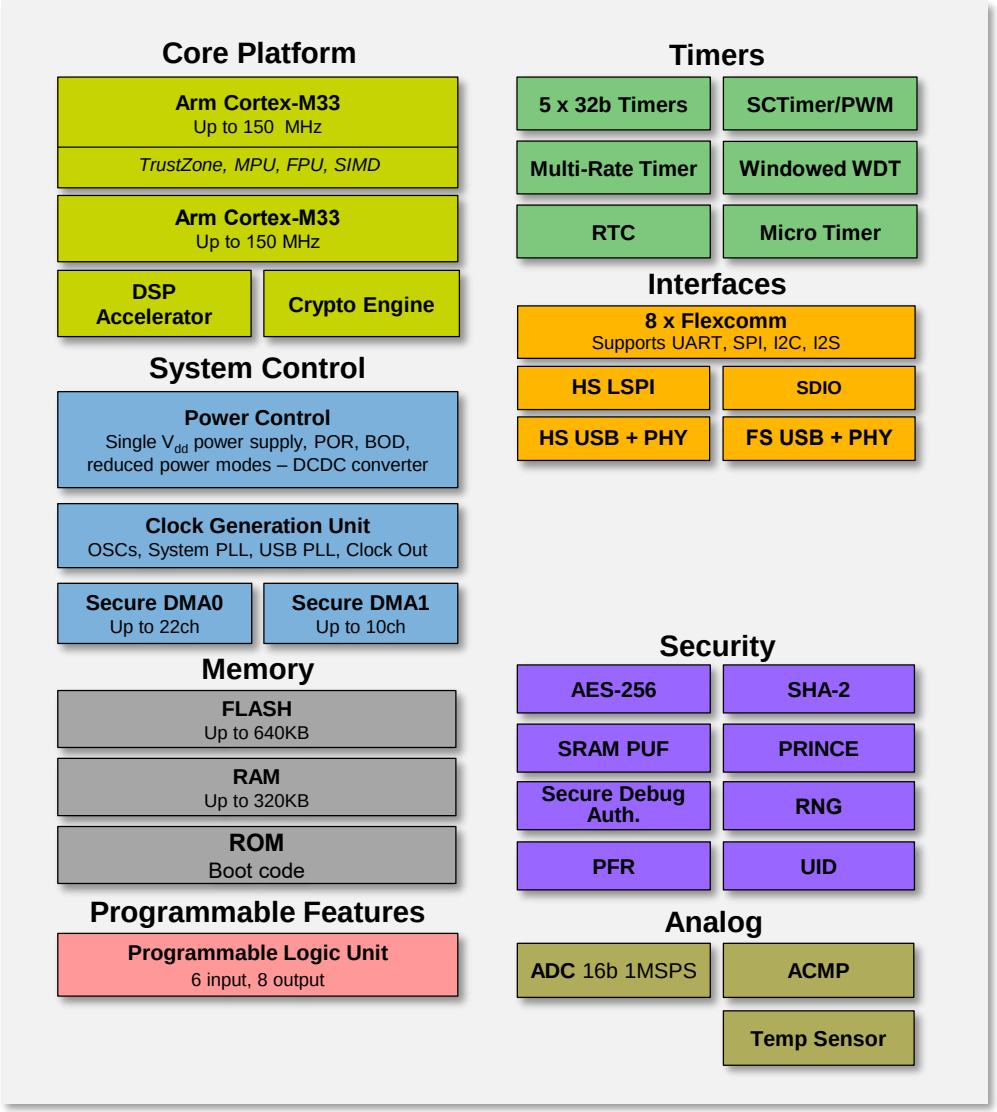
# i.MX RT (1010/1020/1050/1060/1064) SOLUTIONS FOR MOTOR CONTROL

- **Supported motor types & control algorithms**
  - **ACIM** – AC Induction Motor (asynchronous motor) – FOC, sensorless control, V/Hz
  - **BLDC** – Brushless DC motor – six-step commutation, sensorless control, sensored control with Hall sensors or encoder
  - **PMSM** – Permanent Magnet Synchronous Motor – FOC, DCT, sensorless control in whole speed range, sensored control with encoder sensor
  - **SR** – Switched Reluctance motor – sensorless control, sensored control
  - **SynR** – Synchronous Reluctance motor – sensorless control, sensored control
  - **Stepper motor** – standard algorithms, microstepping

- **HW - MCU peripheral modules supporting motor control**
  - **4 x FlexPWM** – flexible peripheral module for PWM generation, HW synchronization with ADC, periodic events generation (ISRs)
  - **4 x ACMP** – analog comparator for general use, motor control use – overcurrent, overvoltage, undervoltage protection, current limitation, etc.
  - **4 x QuadTimer** – very flexible timer supporting PWM generation, external signals processing, encoder interface for position and speed measurement, etc.
  - **4 x Quadrature ENC** - interface for encoder signals processing (phase A, phase B, index pulse), dedicated for servo-drives control
  - **2 x ADC** – analog signals measurement, HW synchronization with FlexPWM module and PWM generation

- **Number of motors controlled from single MCU**
  - **Up to 4 motors in parallel** even if FOC and sensorless control algorithm are used
  - When using QuadTimer as PWM generator additional motors could be control from single MCU
- **Applications**
  - Home appliances – washing machines, dishwashers, dryers, refrigerators, freezers, vacuum cleaners, mixers, blenders, etc.
  - Industrial application – servo-drives, circulating pumps, water pressure boosters, industrial inverters, etc.
  - Hand tools – drills, cutting tools, screw drivers, etc.
  - Medical applications – respirators, heart support/pumps, etc.

# LPC55S6X MCU FAMILY BLOCK DIAGRAM




## Core Platform

- Up to 150MHz Cortex-M33
  - TrustZone, MPU, FPU, SIMD
- Up to 100MHz Cortex-M33
- Coprocessors
  - DSP Accelerator
  - Crypto Engine
- Multilayer Bus Matrix

## Memory

- Up to 640KB FLASH
- Up to 320KB RAM
- 128KB ROM

## Timers

- 5 x 32b Timers
- SCTimer/PWM
- Muiti-Rate Timer
- Windowed Watchdog Timer
- RTC
- Micro Timer

## Interfaces

- USB High-speed (H/D) w/ on-chip HS PHY
- USB Full-speed (H/D), Crystal-less
- SDIO, Support 2 cards
- 1 x High-Speed SPI up to 50MHz
- 8 x Flexcomms support up to 8x SPI, 8x I2C, 8x UART, 4x I²S channels (total 8 instances)

## Advanced Security

- **Protected Flash Region (PFR)**
- **AES-256 HW Encryption/Decryption Engine**
- **SHA-2**
- **SRAM PUF for Key Generation support**
- **PRINCE – Real-time Encrypt/Decrypt for flash data**
- **Secure debug authentication**
- **RNG**

## Analog

- 2x 16b ADC, 16ch, 1MSPS
- Analog Comparator
- Temperature Sensor

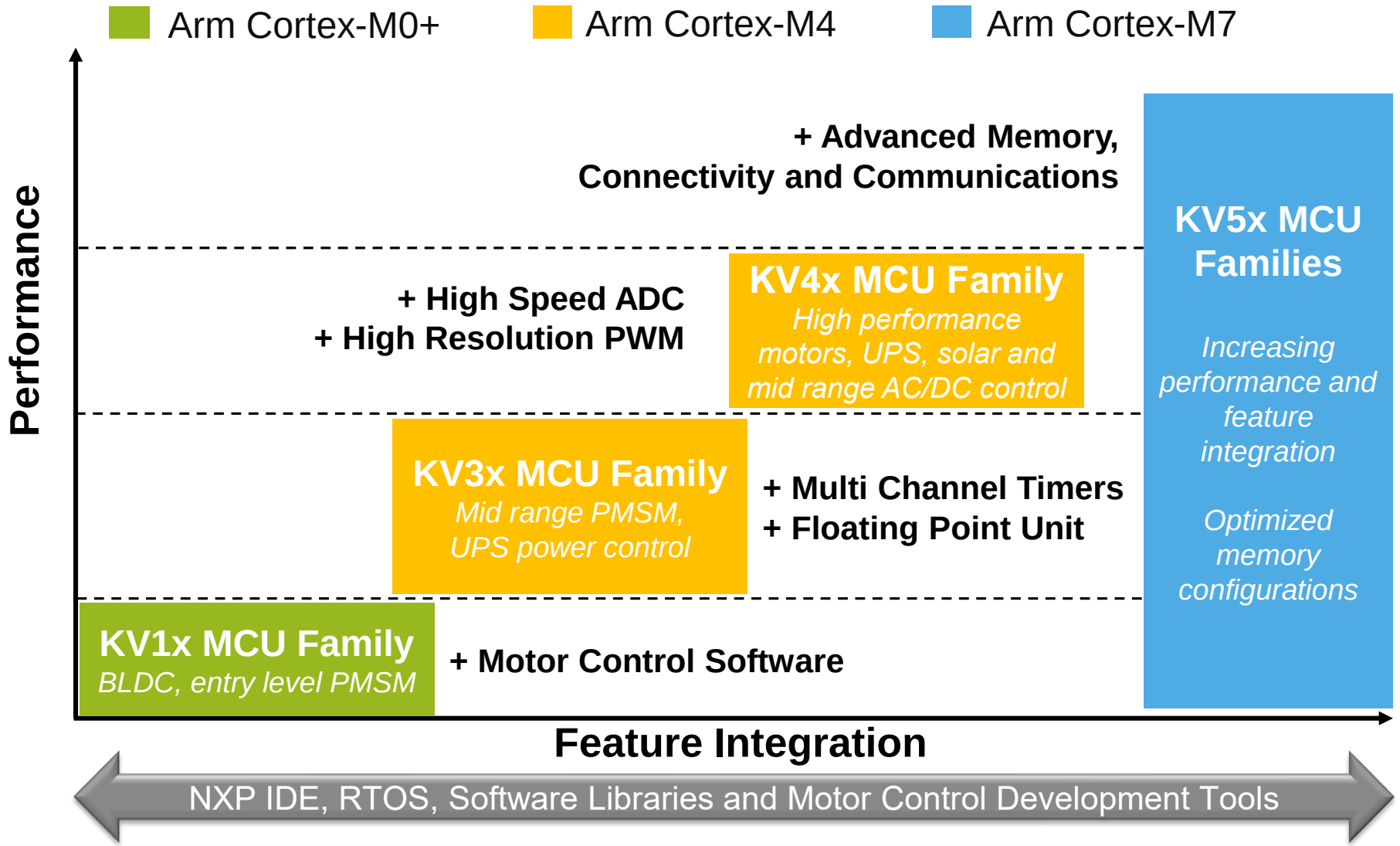
## Packages

- LQFP100, 14x14mm
- VFBGA98, 6x6mm
- LQFP64 or QFN64

## Other

- **Programmable Logic Unit**
- Buck DC-DC
- Operating voltage: 1.8 to 3.6V
- Temperature range: -40 to 105 °C

# KVXX SOLUTION FOR MOTOR CONTROL AND DIGITAL POWER CONVERSION



# NXP PROGRAMMING AND DEBUGGING TOOLS ACROSS NXP MCUS AND CROSSOVER PROCESSORS PLATFORMS

**MCUs**
**KVxx, KExx, LPC8xx, LPC55x, MC56F8xxxx (DSCs)**

**Crossover MCUs**
**i.MX RT10xx**

**NXP Programming and Debugging Tools & NXP Supporting SW**

## MCUXpresso

**MCUXpresso IDE**

(Editor, Compiler, Linker, Debugger)

**MCUXpresso Config Tools**

(Clock Tool, Pin Tool)

## Realtime Debugger

**FreeMASTER**

Realtime Debugger

Realtime Monitor

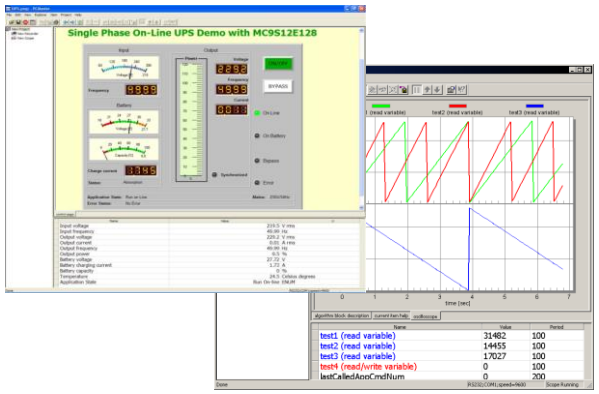
Graphical Control Panel

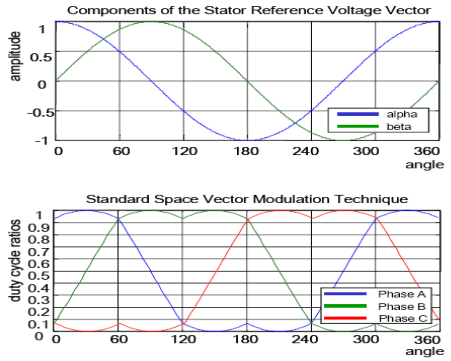
## RTCESL Library

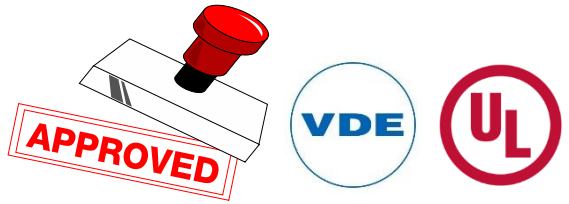
Real-Time Control Embedded Software Motor Control and Power Conversion Libraries

## Functional Safety Lib.

IEC/UL 60730 & IEC/UL 60335 Safety Library

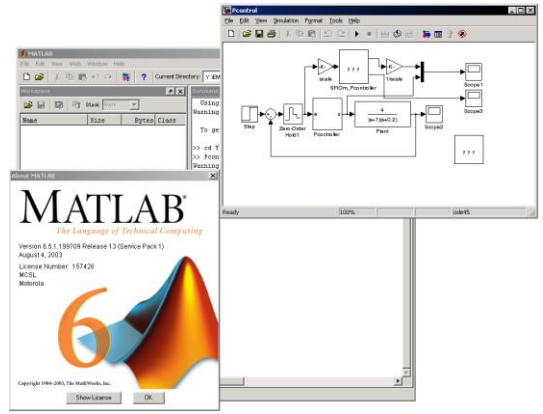



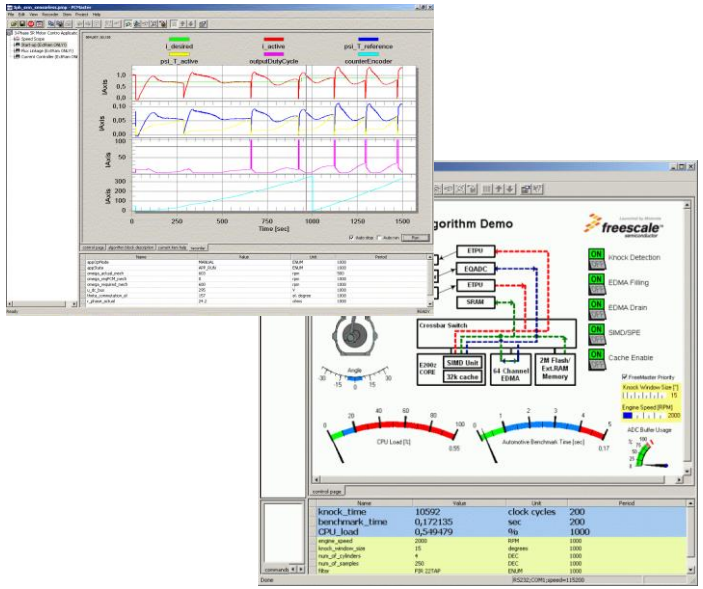
# FreeMASTER REAL-TIME DEBUGGING AND VISUALIZATION TOOL

## What is FreeMASTER?

- Real-Time Debugger
- Real-Time Monitor
- Graphical Control Panel
- Demonstration Platform & Selling Tool

FOR YOUR EMBEDDED APPLICATION



# RTCESL – REAL-TIME CONTROL EMBEDDED SOFTWARE MOTOR CONTROL AND POWER CONVERSION LIBRARIES

## Libraries of s/w algorithms
- math
- general
- motor control
- filters
- advanced control
- power conversion

## Deep algorithm testing
- millions of patterns
- MATLAB reference models
- 64-bit double precision

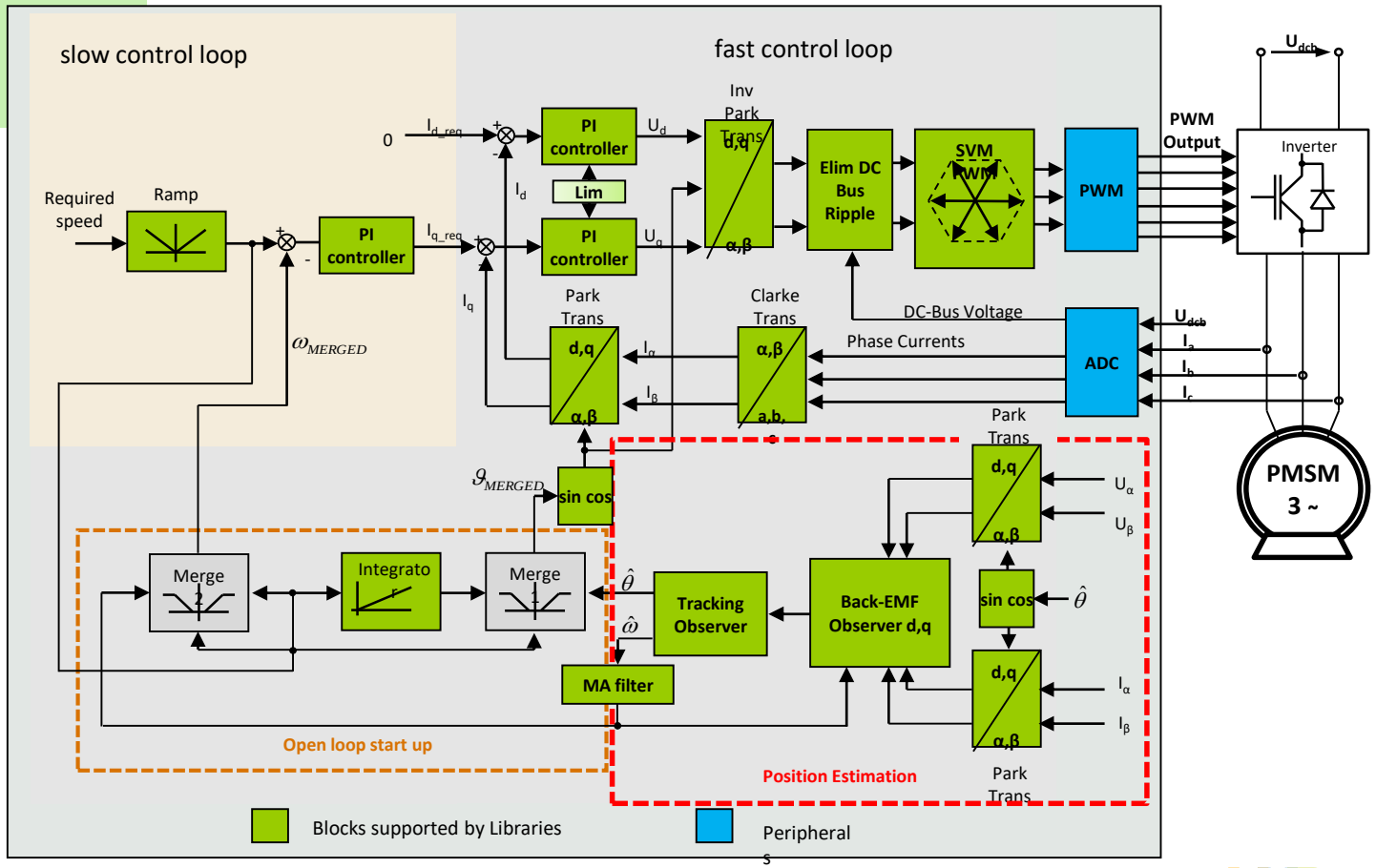
## Easy-to-use
- Unified API & types
- Detailed algorithms description
- Easy installation & inclusion

## Compilers
- **i.MX RT & Kinetis:**
  - IAR
  - Keil
  - MCUXpresso
- **DSC:**
  - CodeWarrior

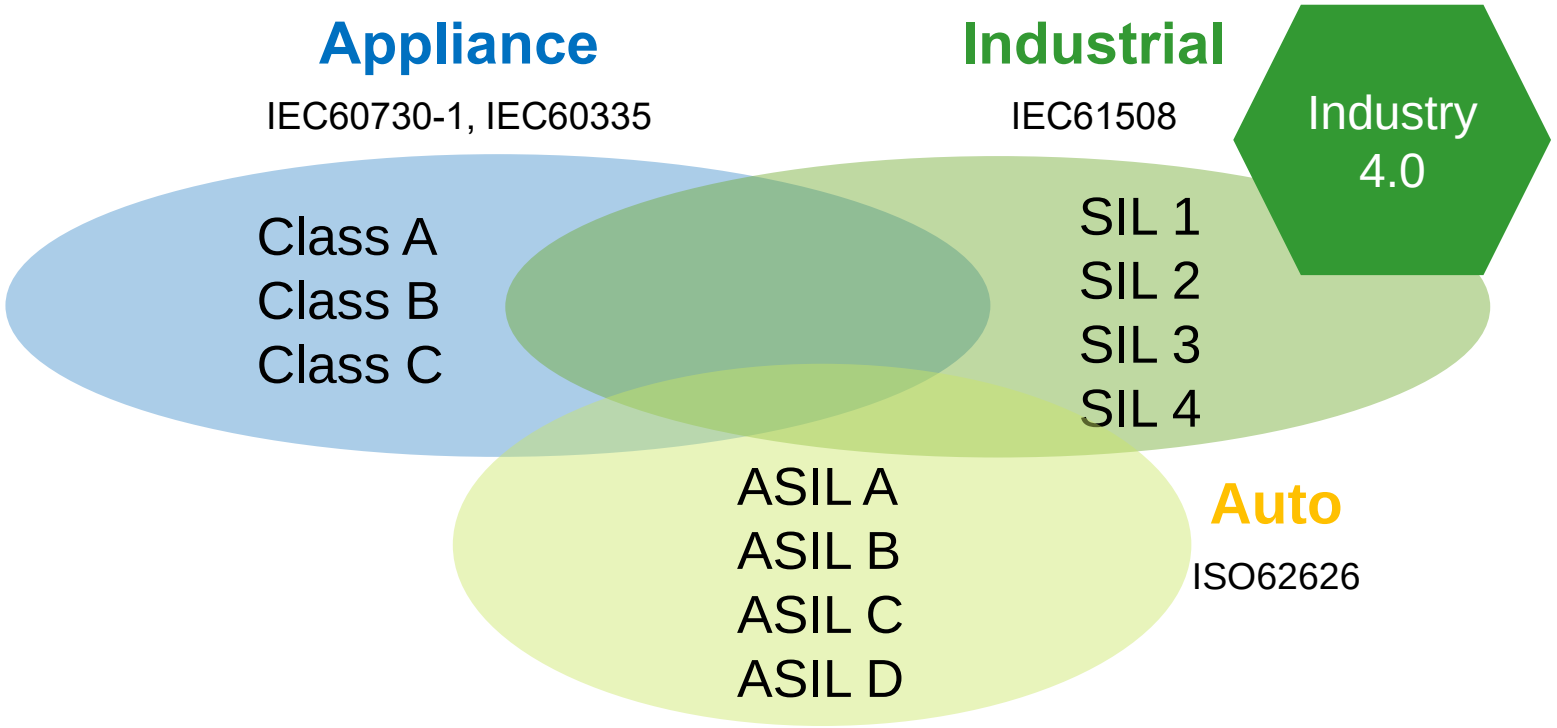
## Arithmetic
- fixed point: 16, 32 and 64-bit
- floating point: 32-bit single precision

## Cores
- **i.MX RTxx**
- **Kinetis:**
  - ARM Cortex M0+ (incl. hw div & sqrt)
  - ARM Cortex M4
  - ARM Cortex M7
- **DSC:**
  - DSP56800E(X)

- **Library algorithms are validated against Matlab/Simulink models**



# FUNCTIONAL SAFETY – INDUSTRIAL & APPLIANCE




| MCU | IEC60730B |
|---|---|
| Kxx | ✔ |
| KV1x/3x/5x | ✔ |
| KE15/16/18 | ✔ |
| i.MX RT 1020/50/60 | ✔ |
| LPC8xx | ✔ |
| LPC55Sxx | ✔ |
| 56F83xxx | ✔ |
| S08 PB16 | ✔ |
| 56F81xxx | 09/20 |
| i.MX RT 1010 | 06/20 |
| i.MX8M Mini / Nano | 06/20 |
| LPC54xx | 12/20 |
| i.MX RT1170 | ? |

- Appliance safety IEC/UL 60730 and IEC/UL 60335
- Compatible with applications targeting the industrial safety standard IEC 61508

https://www.nxp.com/iec60730

## ADDITIONAL RESOURCES

- Kinetis® V Series: Real-time Motor Control & Power Conversion MCUs based on Arm® Cortex®-M0+/M4/M7: KV MCU series webpage
- Kinetis® E Series: 5V, Robust Microcontrollers (MCUs) based on Arm® Cortex®-M0+/M4 Core: KE MCU series webpage
- LPC800 Series: Low-Cost Microcontrollers (MCUs) based on Arm® Cortex®-M0+ Cores: LPC800 MCU series webpage
- LPC5500 Series: World's Arm® Cortex® -M33 based Microcontroller Series for Mass Market, Leveraging 40nm Embedded Flash Technology: LPC5500 MCU series webpage
- i.MX RT Crossover MCUs: i.MX RT series of crossover MCUs webpage
- MC56F83xxx: Performance Level Digital Signal Controllers, USB FS OTG, CAN-FD: MC56F83xxx DSCs
- FREEMASTER: FreeMASTER Run-Time Debugging Tool: FreeMASTER tool webpage
- IEC60730: IEC 60730 Safety Standard for Household Appliances: IEC 60730 safety libraries
- RTCESL: Real Time Control Embedded Software Motor Control and Power Conversion Libraries: NXP SW libraires

## WE ARE HERE TODAY TO HELP ANSWER

### Questions

1. Does NXP have MCUs portfolio for motor control and power conversion application use?
2. What programming tools can NXP provide?
3. Does NXP have something unique to support real-time debugging and visualization?
4. Does NXP provide SW libraries simplifying development process?
5. Does NXP support functional safety? (IEC 60730, IEC 60335, IEC 61508)

### Answers

1. i.MX RT10xx, KVxx,  KExx, LPC8xx, LPC55x, MC56F8xxxx (DSCs)
2. MCUXpresso, SDK, Configuration tools
3. FreeMASTER tool
4. RTCESL – Real-Time Control Embedded Software Motor Control and Power Conversion Libraries
5. Certified IEC 60730 safety library compliant with class B

SECURE CONNECTIONS
FOR A SMARTER WORLD