



FTF | FREESCALE
TECHNOLOGY
FORUM 2015

Get Your Motor Spinning: Freescale Motor Control Enablement Reduces Development Time FTF-ACC-F1108

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J U N E . 2 0 1 5



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Session Introduction

This session introduces a Freescale solution for Automotive Motor Control as a complete **evaluation and development package**.

This session gives an overview of **easy-to-use hardware**, modular **software** and simple **tools** allowing the rapid prototyping and customer evaluation of the **motor control application** based on Freescale MCUs.



Session Objectives

By the end of this session you will:

- ✓ Be more familiar with Freescale **Automotive Motor Control enablement** offering
- ✓ Know where to look for presented **solutions**
- ✓ Know the advantages of the available **software libraries** as well as **tools**
- ✓ Know how and where to look for individual enablement pieces, support, documentation and examples



Agenda

- Electric Motor Control In Automotive
- Automotive Math and Motor Control Libraries
- Tools — FreeMASTER & MCAT
- Motor Control Development Kits
- Success Stories & Summary

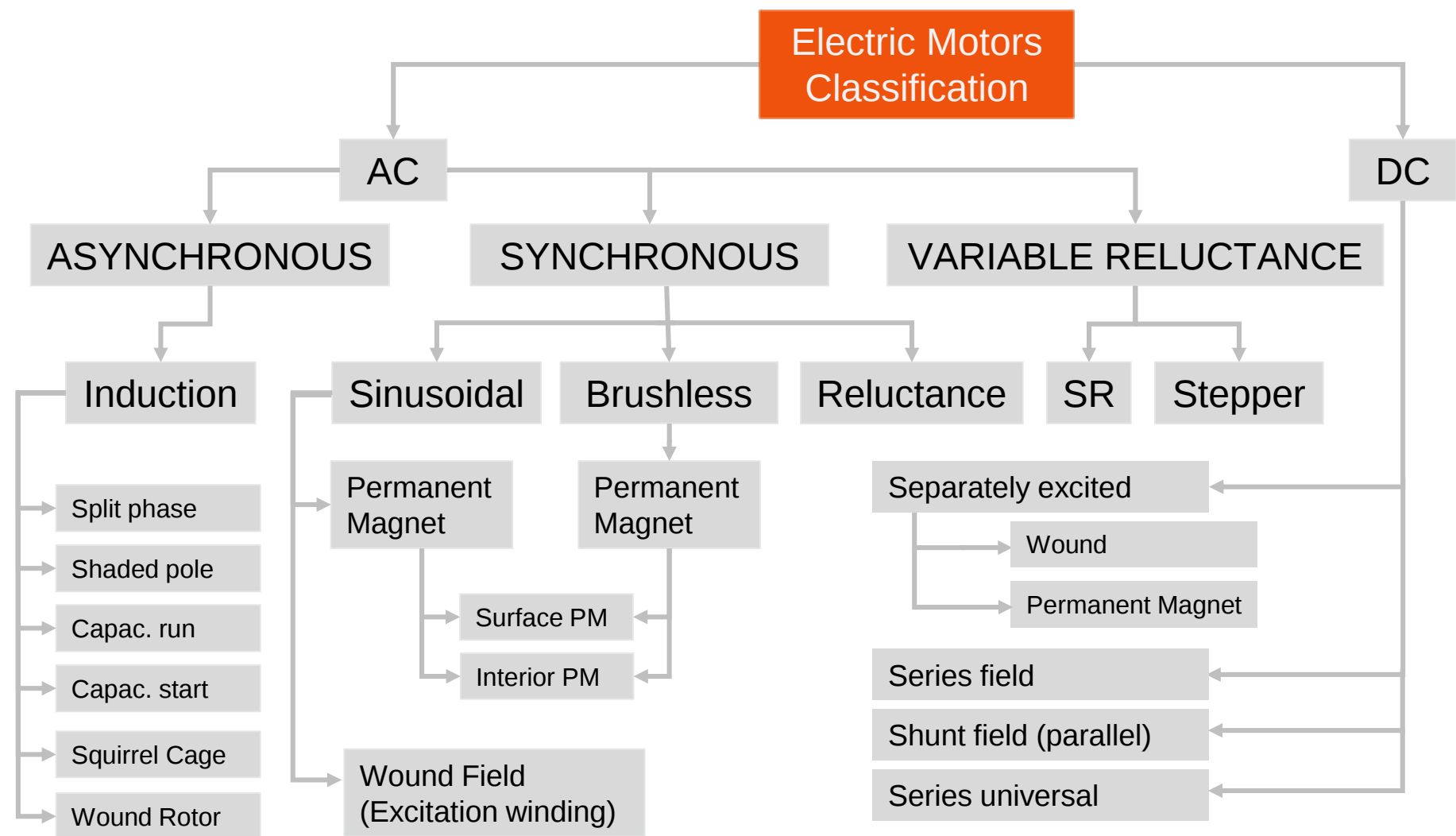




Electric Motors in Automotive



Electric Motors in Automotive



Why Motors in Automotive? Trends!

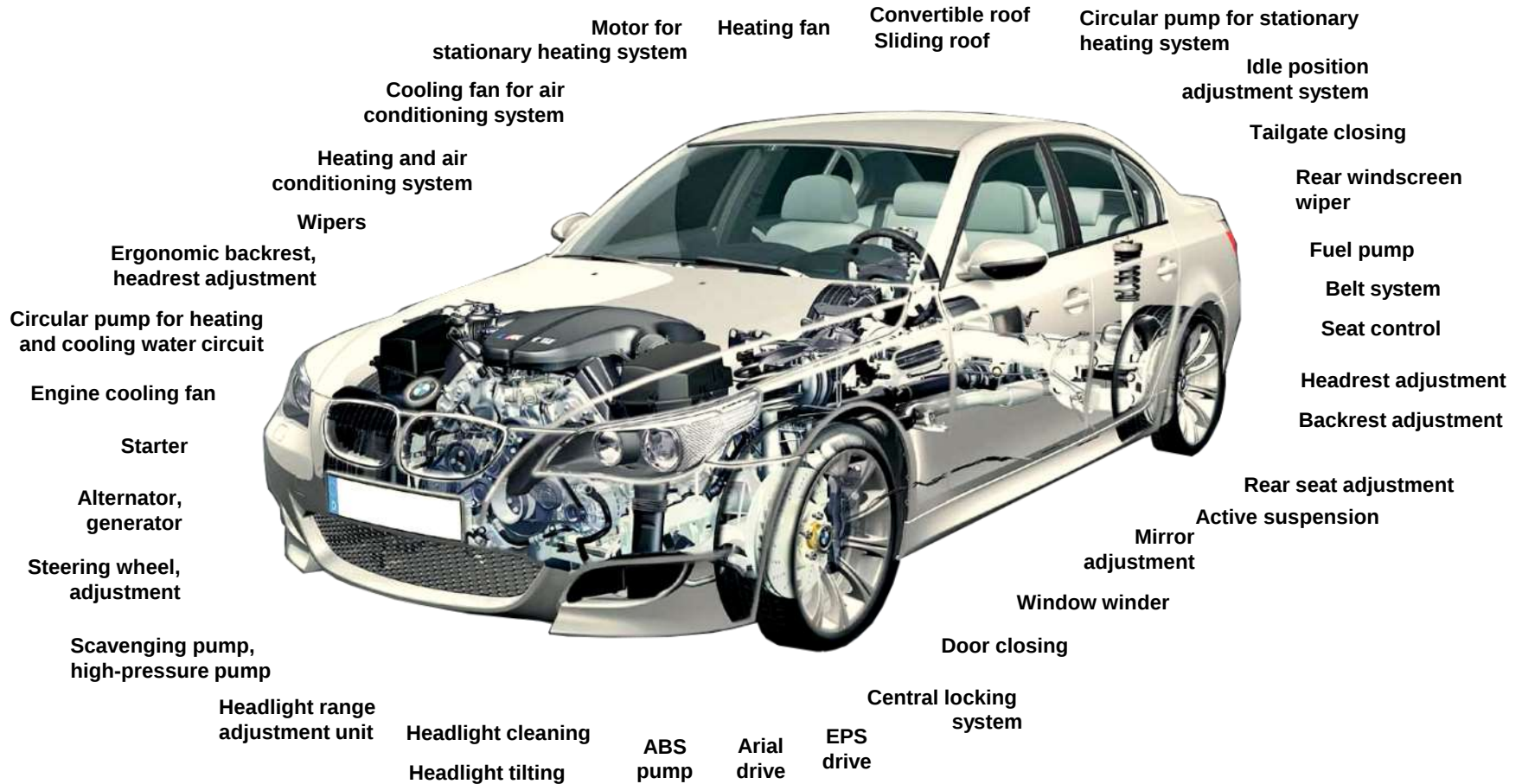
System Cost Reduction

- Electric motors replacing belts or hydraulic systems
- Wiring harness reduction by electronic decentralization
- Weight reduction (W/kg)
- Elimination of sensors
- Electronics integration (fans, pumps)

System Performance Improvement

- Improved reliability
- Brushless DC/AC motors replacing DC motors
- Advanced algorithms improving efficiency
- Recuperation & Green energy
- Functional safety & self diagnostics

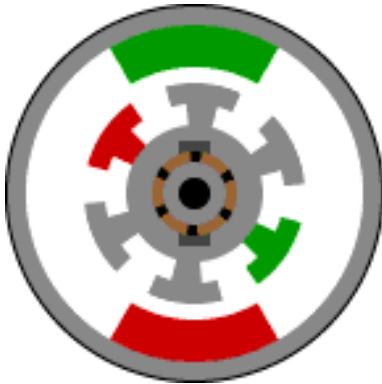
Where They Are in a Car?



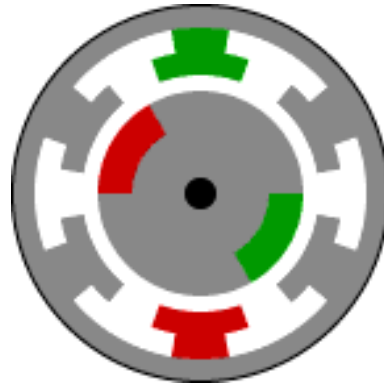
...., is Electric Motor Control Freescale Priority in Automotive?

- 29.5 motors per car in average by 2017 (1)
- 2.3 billion motors shipped in 2012, ~3 billion by 2017 (1)
- Across all automotive segments

DC motor



BLDC motor



AC IM motor



AC PM motor

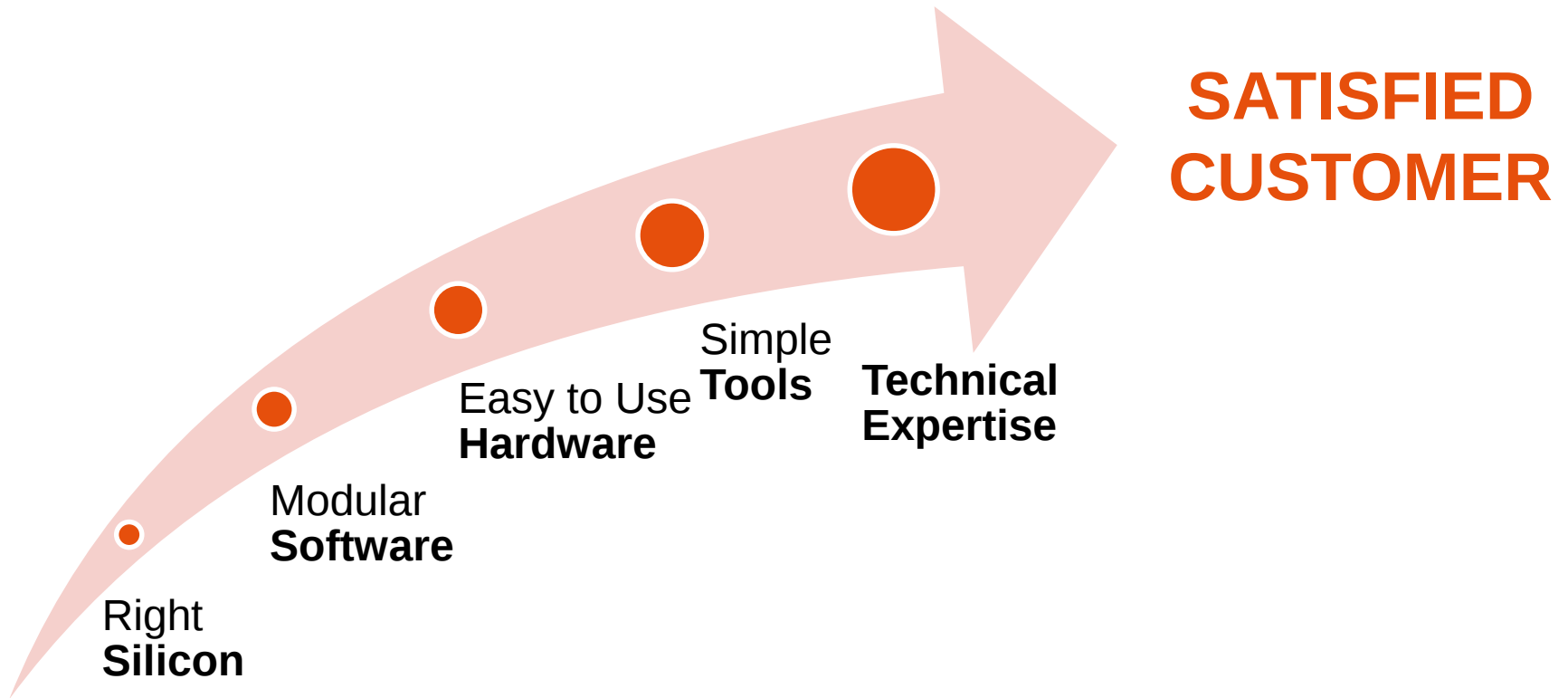


Different motors have different constructions and operating principles. Therefore, different control approaches are required.

(MOST) MOTORS NEEDS MCU TO BE CONTROLLED!



Turning Silicon Into Solutions

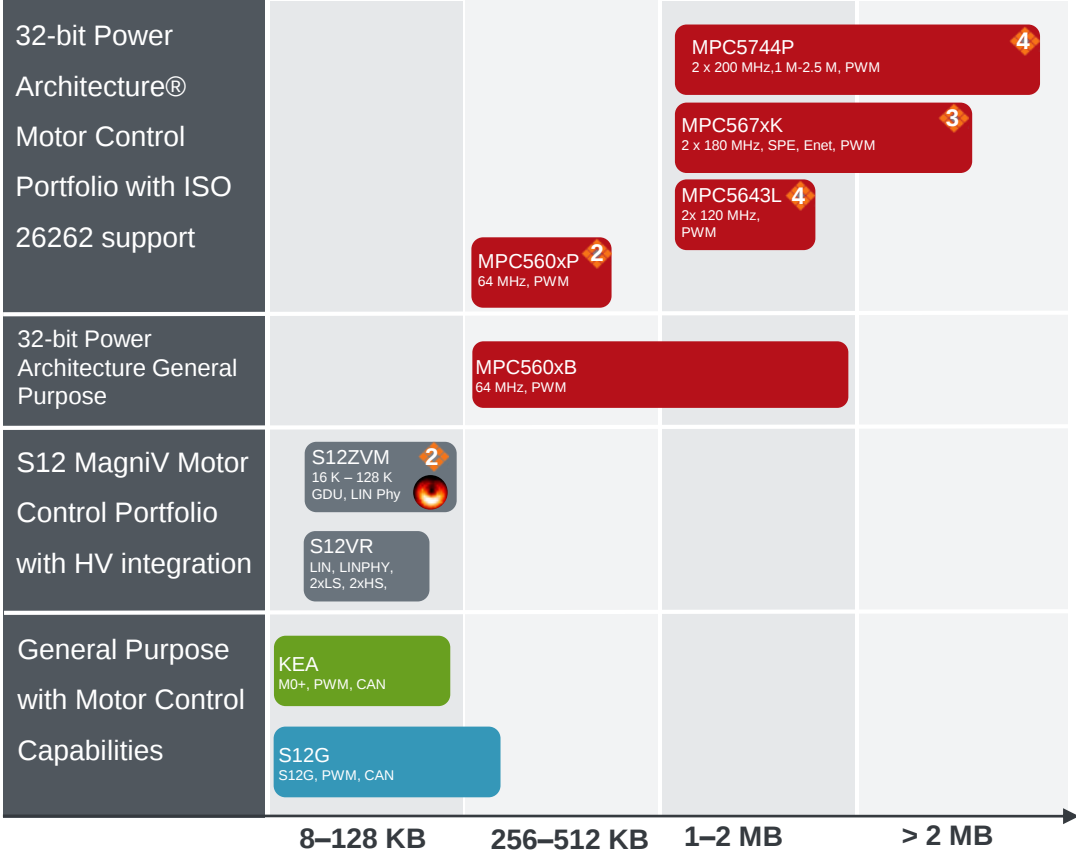




Automotive MCUs for Motor Control



Automotive MCUs for Motor Control



Application Examples

- EPS
- Door Module
- Seat Module
- Oil Pump
- Water Pump
- Fuel Pump
- Cooling Fan
- HVAC Blower
- Window Lift
- Sunroof
- Sliding Doors
- Wipers

- 32-bit Power Architecture
- 16-bit S12 MagniV mixed-signal MCUs
- 32-bit ARM® Cortex®-M0+
- 16-bit S12G

High temp 150 °C ambient temperature

Target Safety Level (ISO 26262)
 Level 2 = ASIL-B
 Level 3 = ASIL-C
 Level 4 = ASIL-D

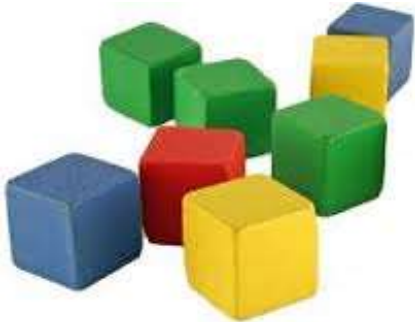


Solutions for Electric Motor Control

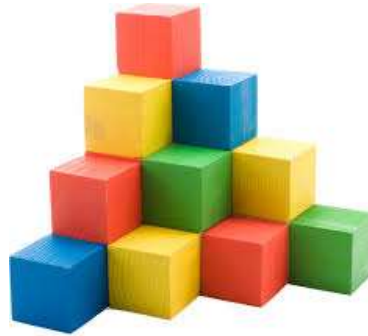


The Complete Solutions Offering for Motor Control

Automotive Math & Motor Control Library Set



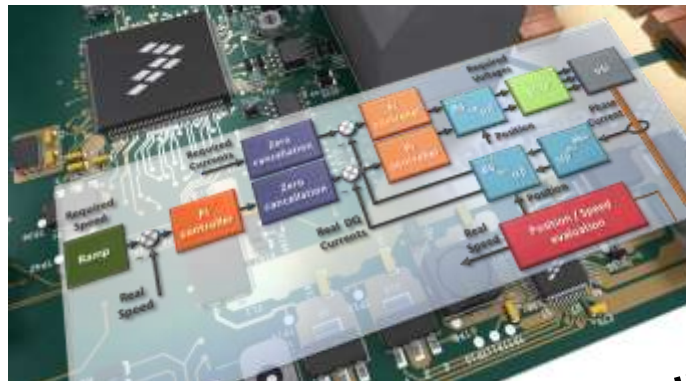
Automotive Motor Control Development Kit Series



FreeMASTER & Motor Control Application Tuning (MCAT) Tools



FSL Electric Motor Control Know-How



Final customer applications, based on MPC / S12 MagniV family / Cortex processors

[illegible]

Input Application Parameters

Motor Parameters

Ra 5
Ld 0.249
Lq 0.325
ke 0.0051275
Rt 0.067
J 0.000016
pp 3
tph nom 5.2
ft nom 3000

Application Scales

Back-EMF Calculator

Pole Pairs 3
Speed 0 m/s
Voltage 0 m/V

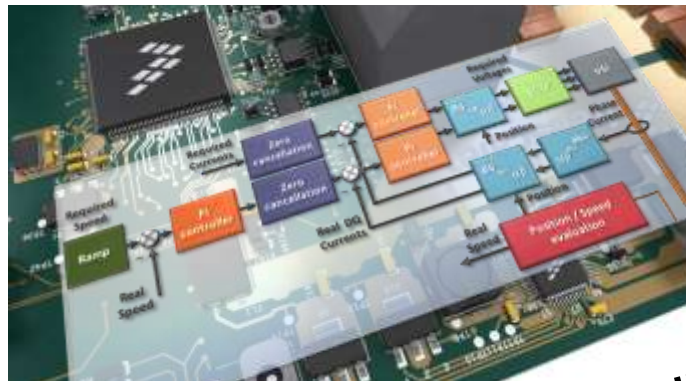
Calculation Data

☐ Round
Back-EMF constant 0.000000
Kt 0.000000

Hardware Scales

I max 11
U DCB max 36

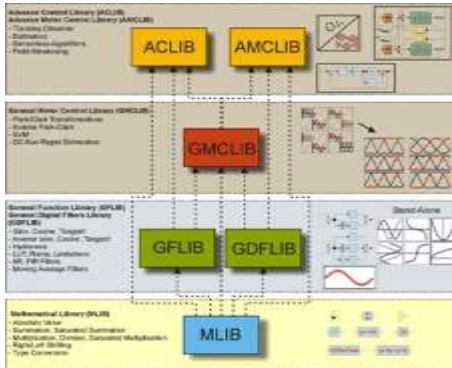
IMPORT -> EXOT **CANCEL**



Final customer applications, based on MPC / S12 MagniV family / Cortex processors

The Complete Solutions Offering for Motor Control

Automotive Math & Motor Control Library Set



freescale.com/AutoMCLib

Automotive Motor Control Development Kit Series



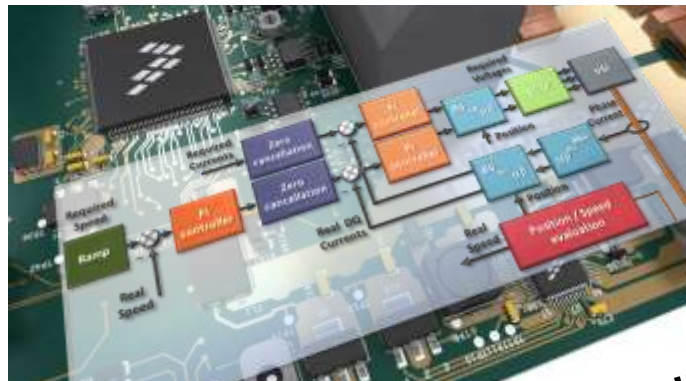
freescale.com/AutoMCDevKits

FreeMASTER & Motor Control Application Tuning (MCAT) Tools



freescale.com/FreeMASTER, MCAT

FSL Electric Motor Control Know-How



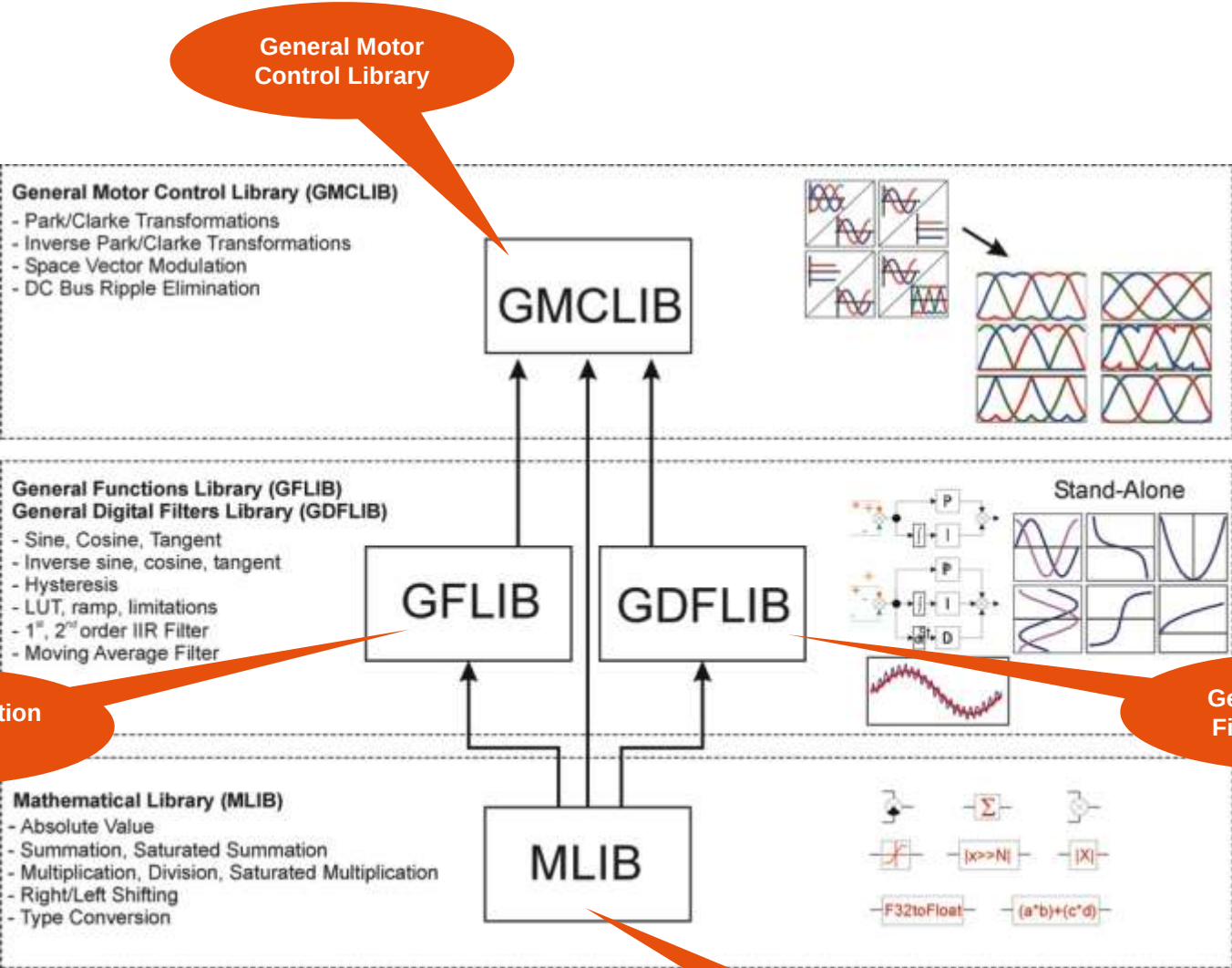
Final customer applications, based on MPC / S12 MagniV family / Cortex processors



Automotive Math and Motor Control Library



Building Blocks for Your Motor Control Software



General Function Library

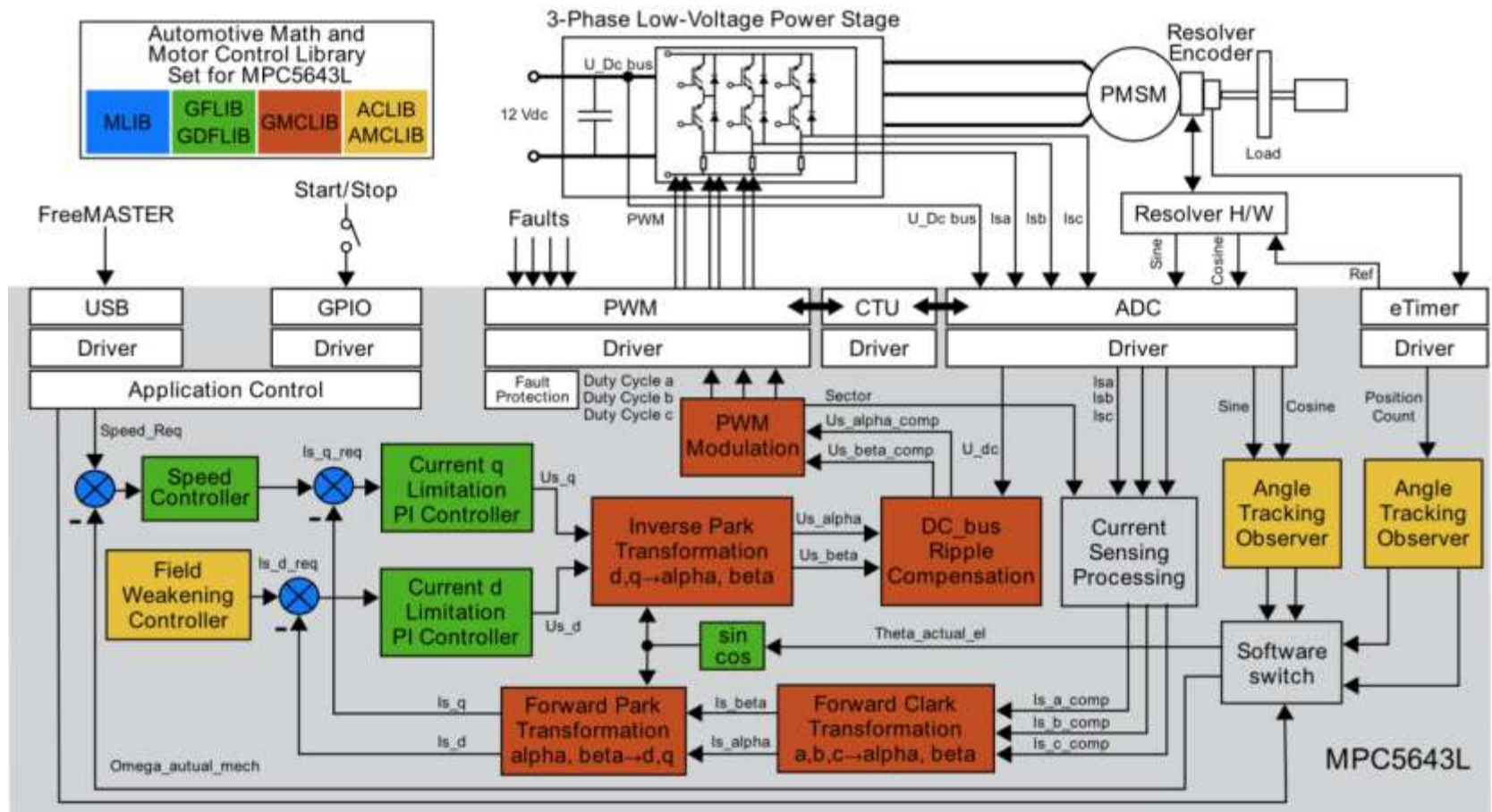
General Digital Filters Library

Mathematical Library



Automotive Math and Motor Control Library Set

PMSM Field Oriented Control Example





Automotive Math and Motor Control Library Set

Executive Summary

- **Set of basic trigonometric, general math, filter & motor control algorithms** as the building blocks for the motor control applications
- Provided in highly optimized implementation and in a layered architecture
- Support of **16 & 32-bit fixed-point** and **single precision floating point** arithmetic
- Available in both **production ready version** and **in evaluation version for free**
- Latest service release **1.1.0** (MPC560xP, MPC564xL, MPC567xK, MPC567xF, MPC574xP, MC9S12ZVM, MPC577xK and KEAx)

Target Platform	GreenHills Multi	CodeWarrior	WindRiver Diab	Cosmic
	Version 2013.5.4	Version 10.5	Version 5.9.4	Version 4.2.7
MPC560xP	Available	Available	Available	Not supported
MPC560xB	Available	Available	Available	Not supported
MPC564xL	Available	Available	Available	Not supported
MPC567xK	Available	Available	Available	Not supported
MPC567xF	Available	Available	Available	Not supported
S12ZVM	N/A	Available	N/A	Available
MPC574xP	Available	N/A	Available	Not supported
MPC577xK	Available	N/A	Available	Not supported
KEAx	Available	Available	Not supported	Not supported

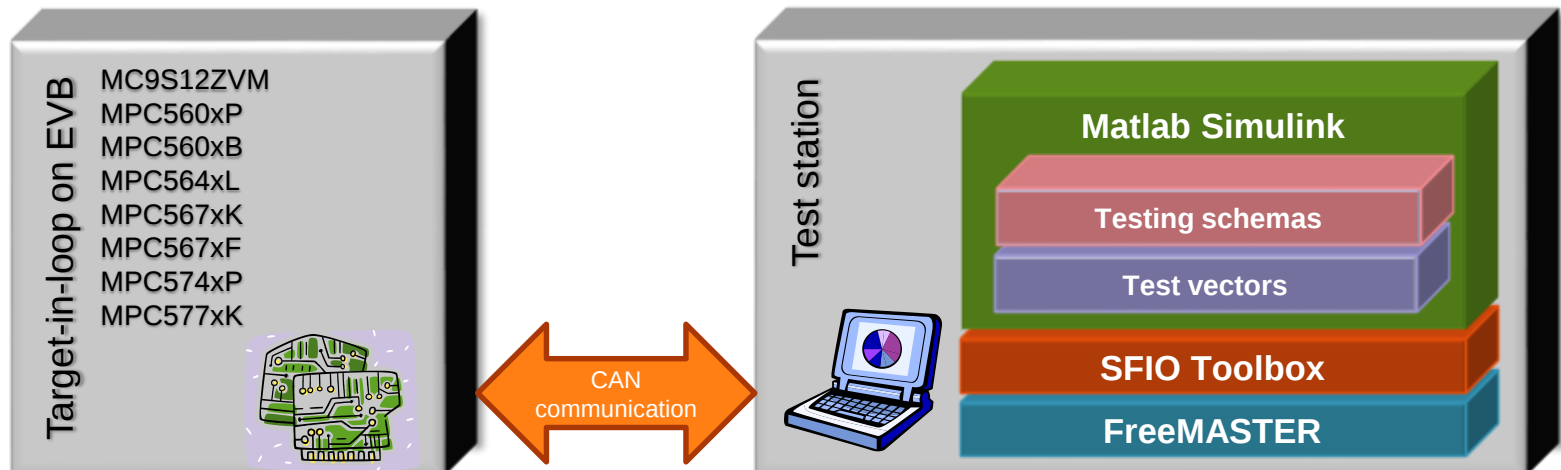




Automotive Math and Motor Control Library Set

Automated Testing Features

- Testing of all variants (frac32, frac16, float) on supported platforms using target-in-loop approach
- All supported compilers (Classic CW, Eclipse CW, GHS, Diab, Cosmic) covered
- **Fully automated testing** based on SFIO Toolbox and Matlab (single click testing of all implementations for one platform)
- Test vector for each function contains more than **30,000 test cases**
- Four independent test machines to run the tests in parallel
- Code coverage measured using standard LDRA tool
- Pure test time for one MCU: approx. **120 hours**





Automotive Math and Motor Control Library Set

Products Variants

- **Pre-compiled** object code version **free of charge**, available at www.freescale.com/AutoMCLib
 - Can be used for **AMMCLib evaluation only**
 - Contains all header files, user docs and pre-compiled object code of the library for all supported compilers
 - **Forbidden use in the production/series** version of the target application
- **Production source code** version, provided based on the **license fee**
 - **Can be used in final production** of the target application (license model dependent)
 - **Various license models** available:
 - DISM Pack (Delivery / Information / Support & Maintenance)
 - Object code Project License
 - Source code Project / Product Line / Family Multi-Project License
 - Auto software quality process compliant with automotive **SPICE Level 3, CMMI** and **ISO 9001/TS16949**
 - Contains all header files, user docs, pre-compiled object code of the library and all **source files**
 - For Power Architecture, contains **highly optimized SPE/SPE2/LSP implementations** bringing even higher performance
 - Provided with the **quality pack**:
 - Test reports
 - Code coverage summary report
 - MISRA report, MISRA deviation list
 - Traceability matrix
 - LDRA reports
 - Release strategy plan

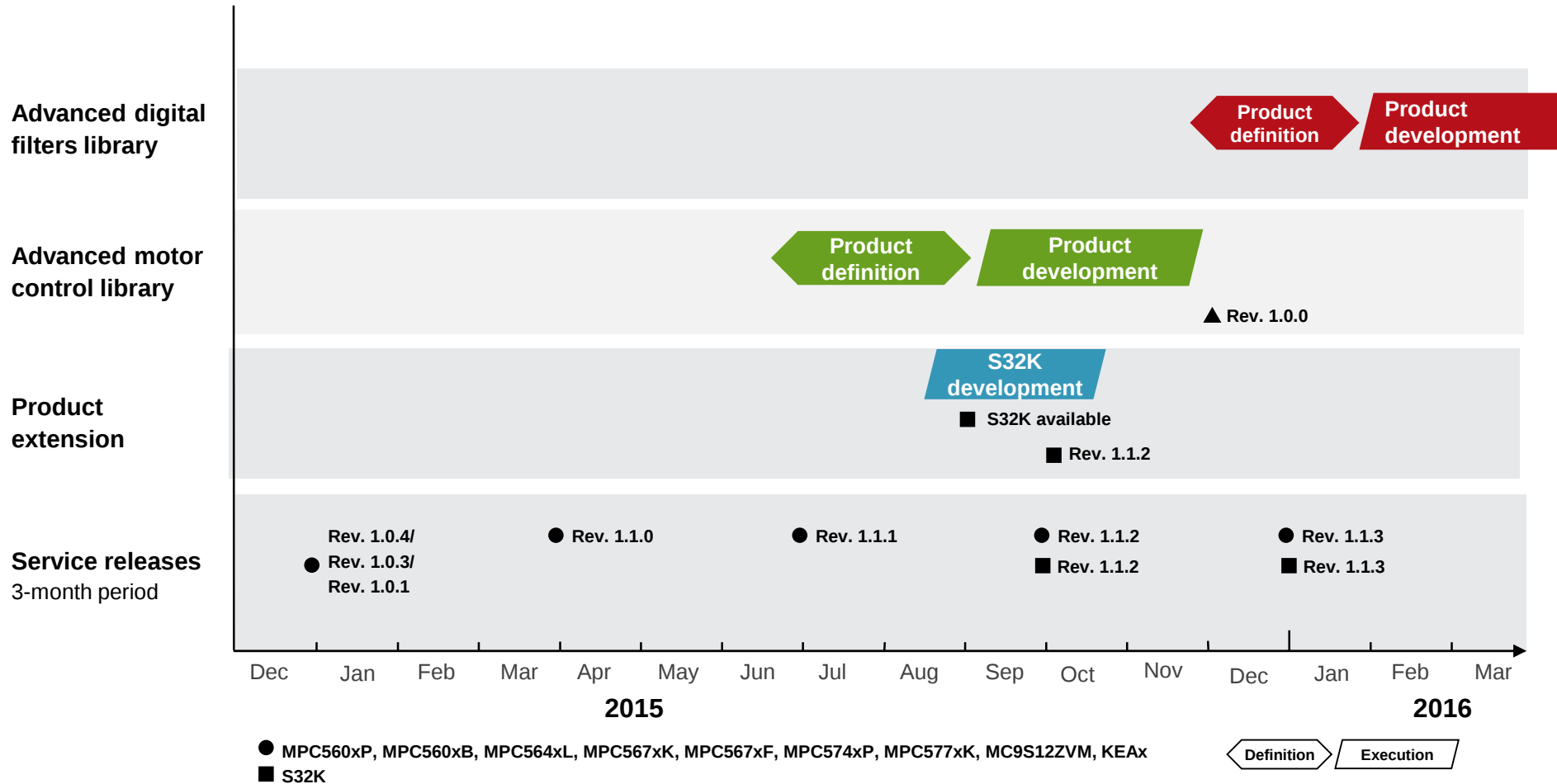




Automotive Math and Motor Control Library Set

Plans for 2015

Features

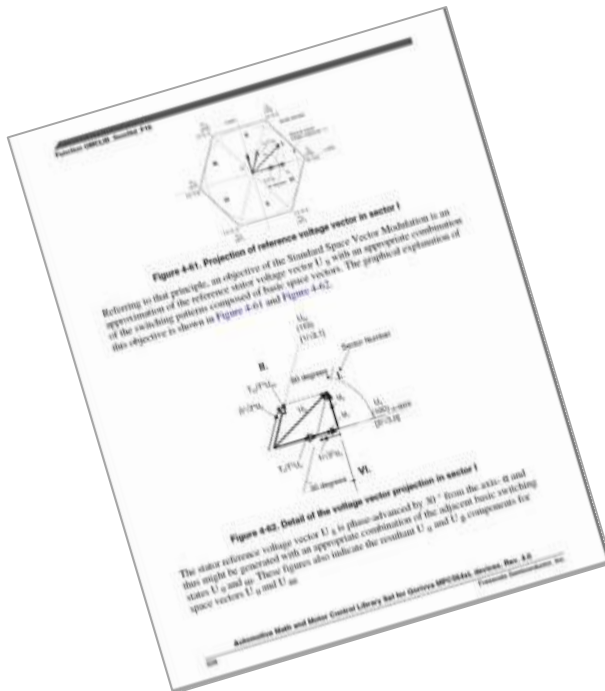


Product Web Page

www.freescale.com/AutoMCLib

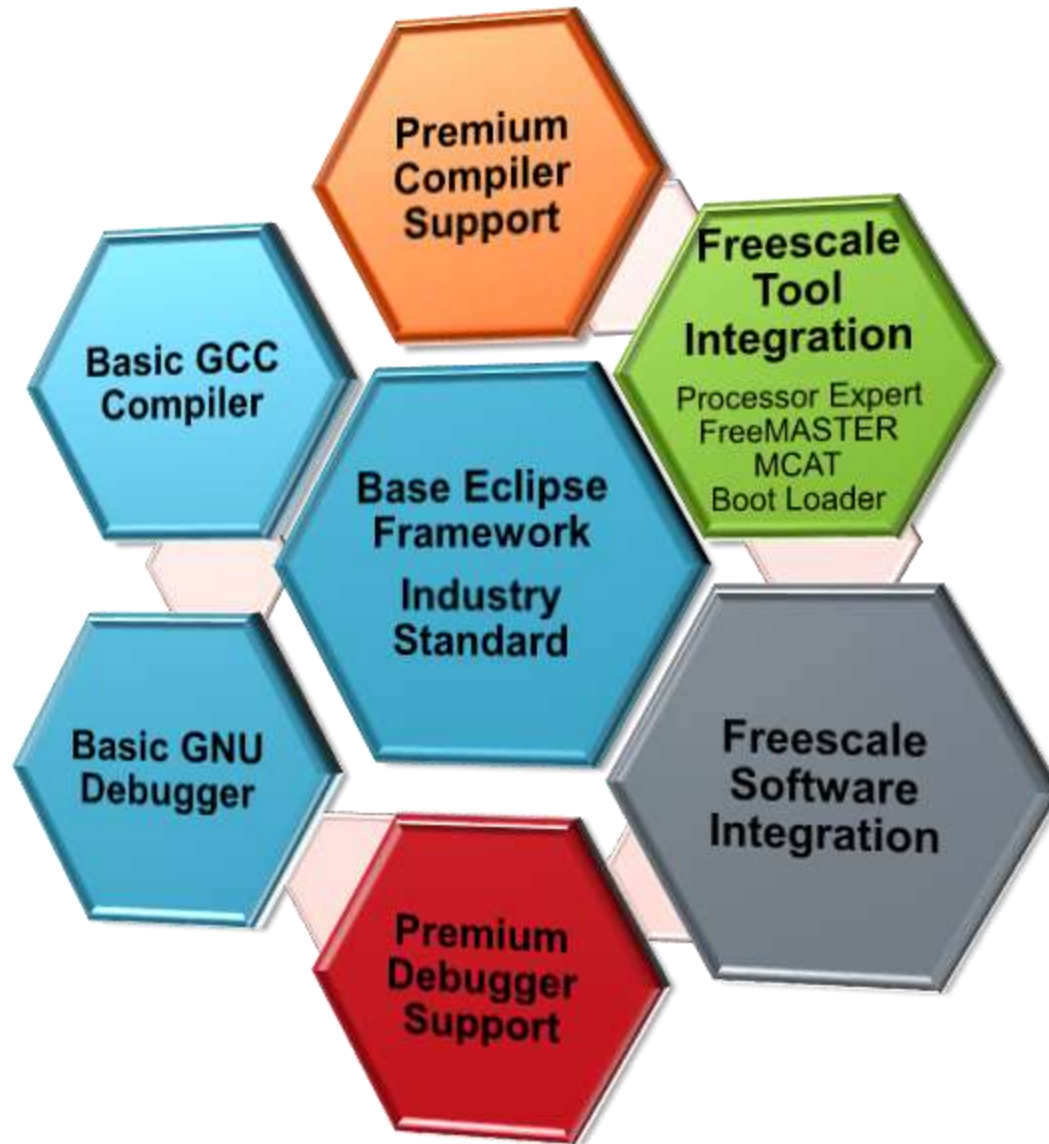
Features:

- Software details
- Download latest releases
- Extensive documentation with theoretical background, examples, description, etc. ...



User's Guide

S32 Design Studio – Freescale Software Integration





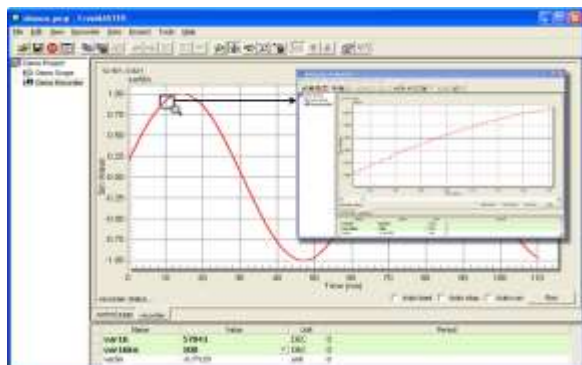
Tools



FreeMASTER — “Debugger for Real-Time Applications”

- **Real-Time Data Monitor Tool**

- Read / modify your variables run-time
- Oscilloscope / recorder capability



- **Demonstration Platform**

- Create a comprehensive support package for your product



- **Scriptable Graphical User Interface**

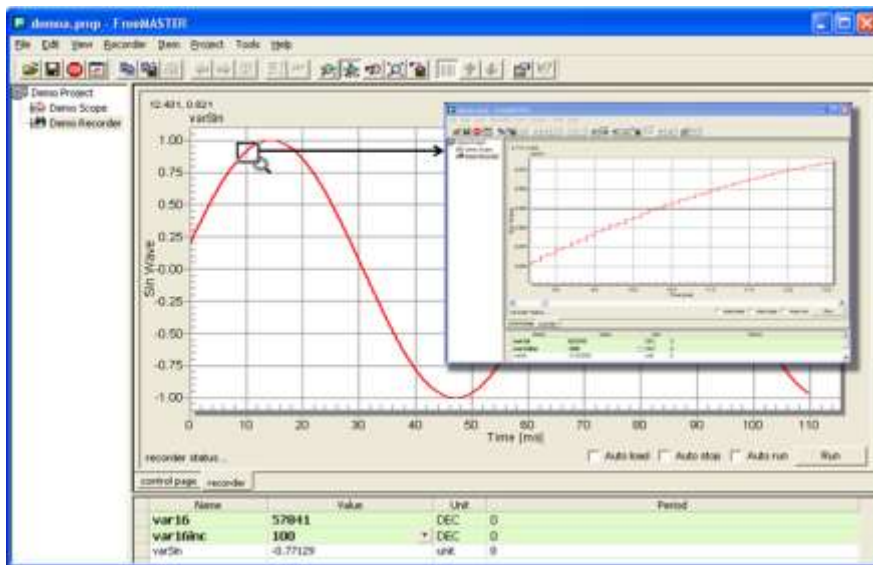
- Build your own GUI using sliders, gauges, buttons



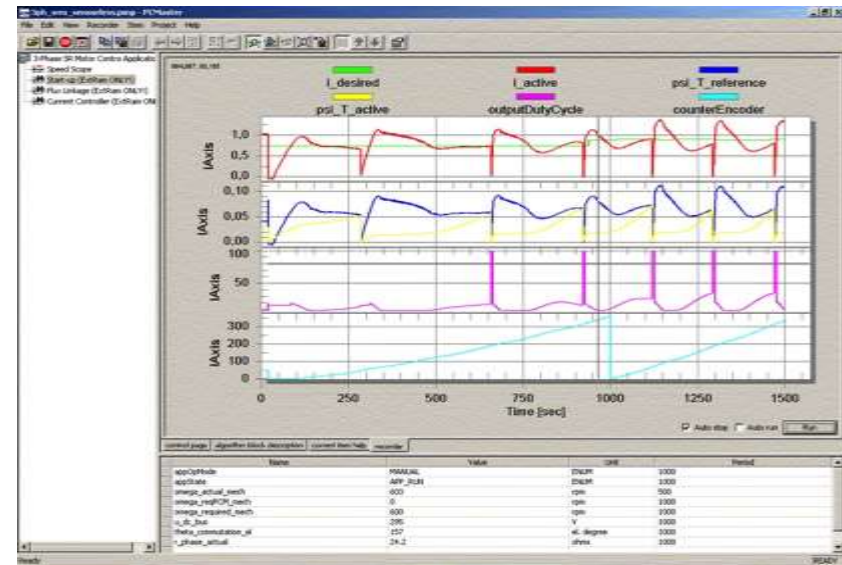
www.freescale.com/FreeMASTER

FreeMASTER — Oscilloscope / Recorder Features

- Real-time at ~millisecond resolution with the Oscilloscope
 - limited by serial comm. speed
- Real-time at ~10 μ s resolution with the Recorder
 - Recorder runs on the board with buffer



Zoom feature shows highly granular details

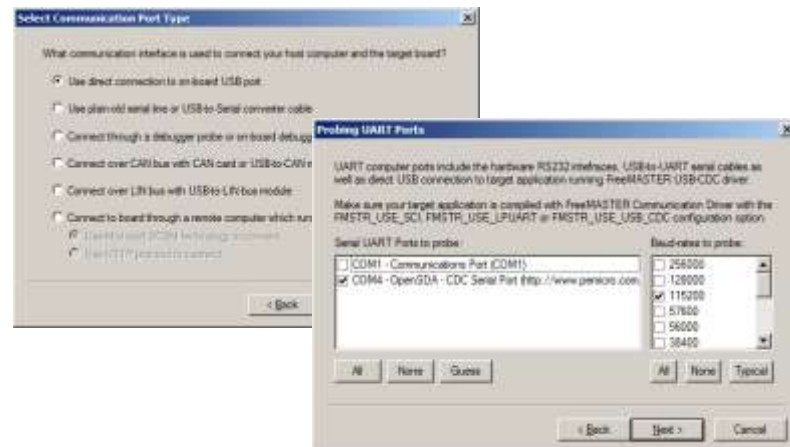


Displays up to 8 variables separately

FreeMASTER — New in Version 2.0

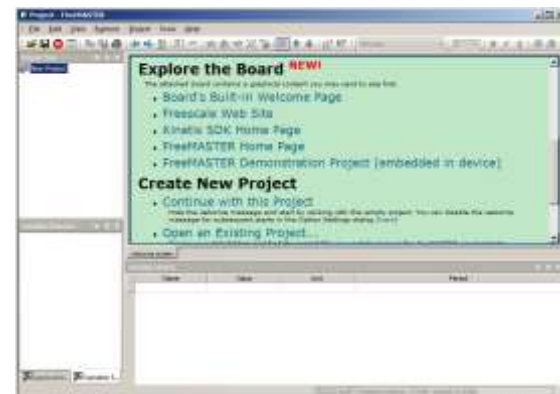
• Connection Wizard

- Simplifies the connection to target
- Scans available COM ports and speeds
- Helps to select communication plug-in
- True plug & play experience when combined with Active Content



• TSA with memory safety and **Active Content** stored in MCU Flash

- Enables variables to be defined without parsing ELF file
- Enables MCU to protect memory and enable access to “safe” variables only
- v2.0: TSA enables GUI files, pictures, scripts, project files and web links to be stored in MCU Flash
- User may “browse” available pages and project as soon as the board is connected

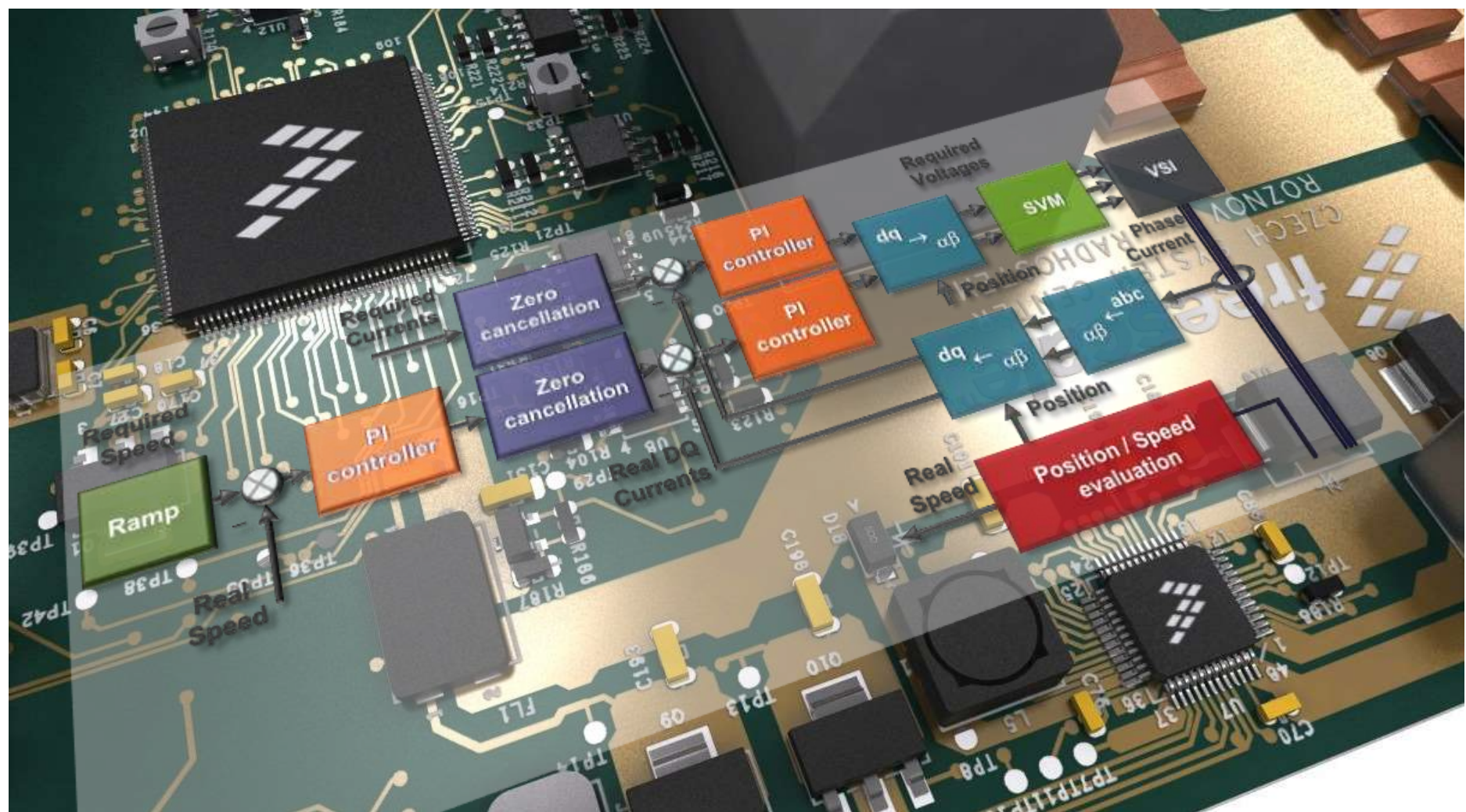


FreeMASTER — Platform and Protocol Support

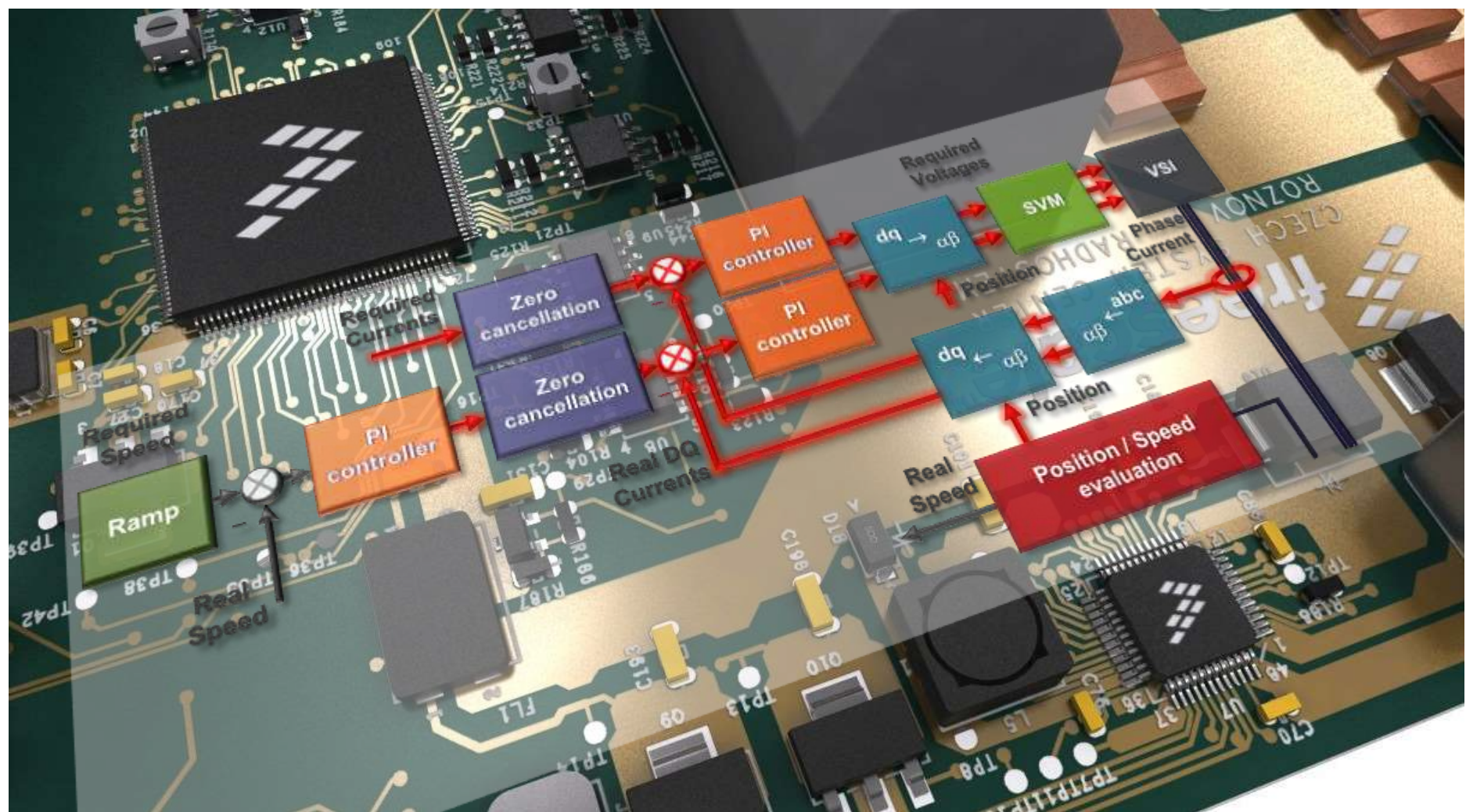
	No Driver	Target Driver Required						
Processor	BDM	Packet-Driven BDM	Serial	CAN	LIN	USB	MQX IO	JTAG
S08	✓	✓	✓	✓		✓		
Freescale DSC			✓	✓				✓
Kinetis	✓	✓	✓	✓		✓	✓	
S12/S12X/S12Z	✓	✓	✓	✓	✓			
MPC56xx/57xx			✓	✓				
ColdFire V1,V2	✓	✓	✓	✓		✓	✓	

- **BDM access is almost transparent to CPU execution (near-zero interference with real-time performance)**
 - Supports memory read/write, oscilloscope
 - Does not support features provided by driver (TSA, memory protection, recording)
- **Other methods (including Packet-driven BDM) supports all FreeMASTER features**
 - Does require driver to be linked with user code
 - Requires processing time (polling mode, interrupt mode or mixed mode of operation)

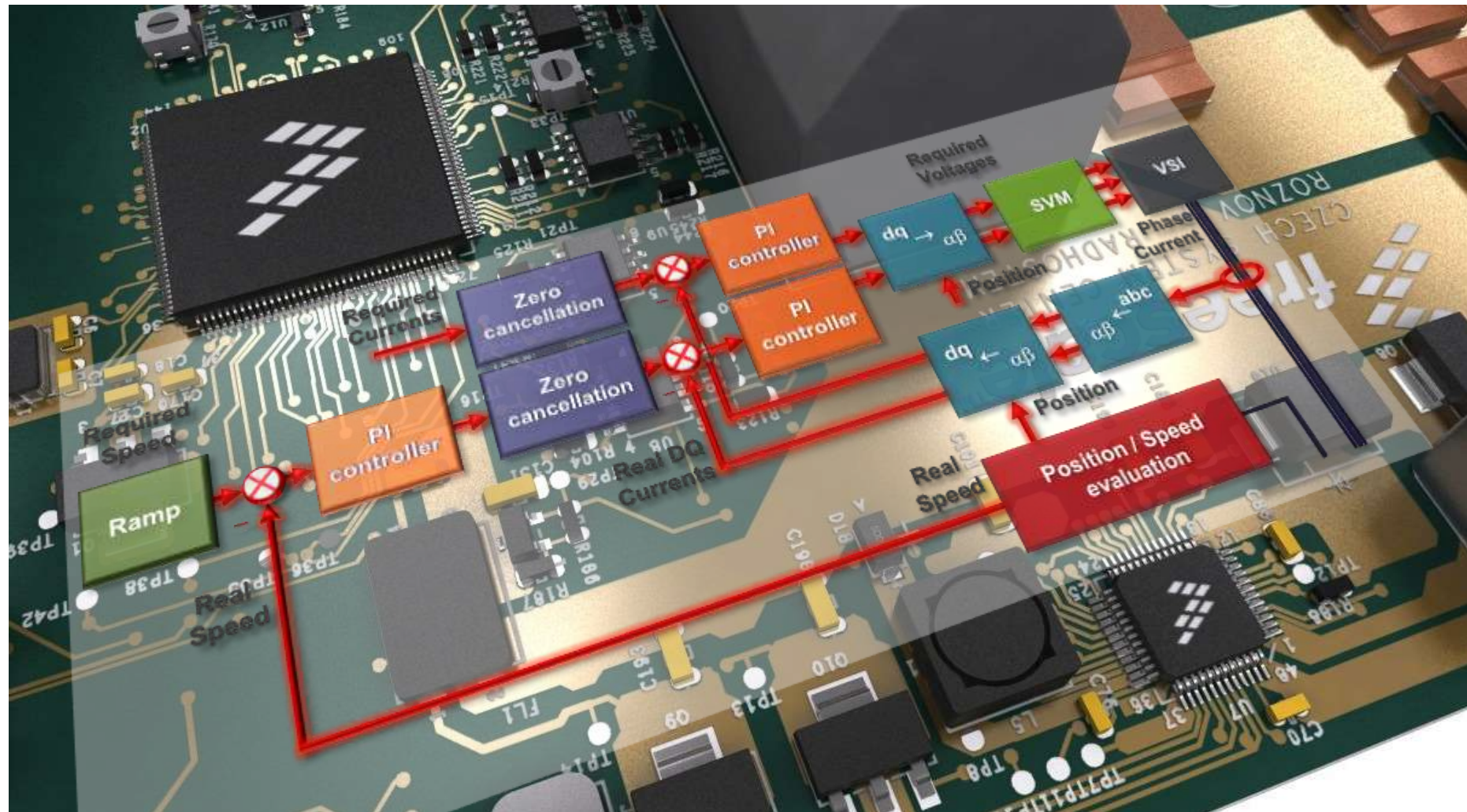
Motor Control Structure



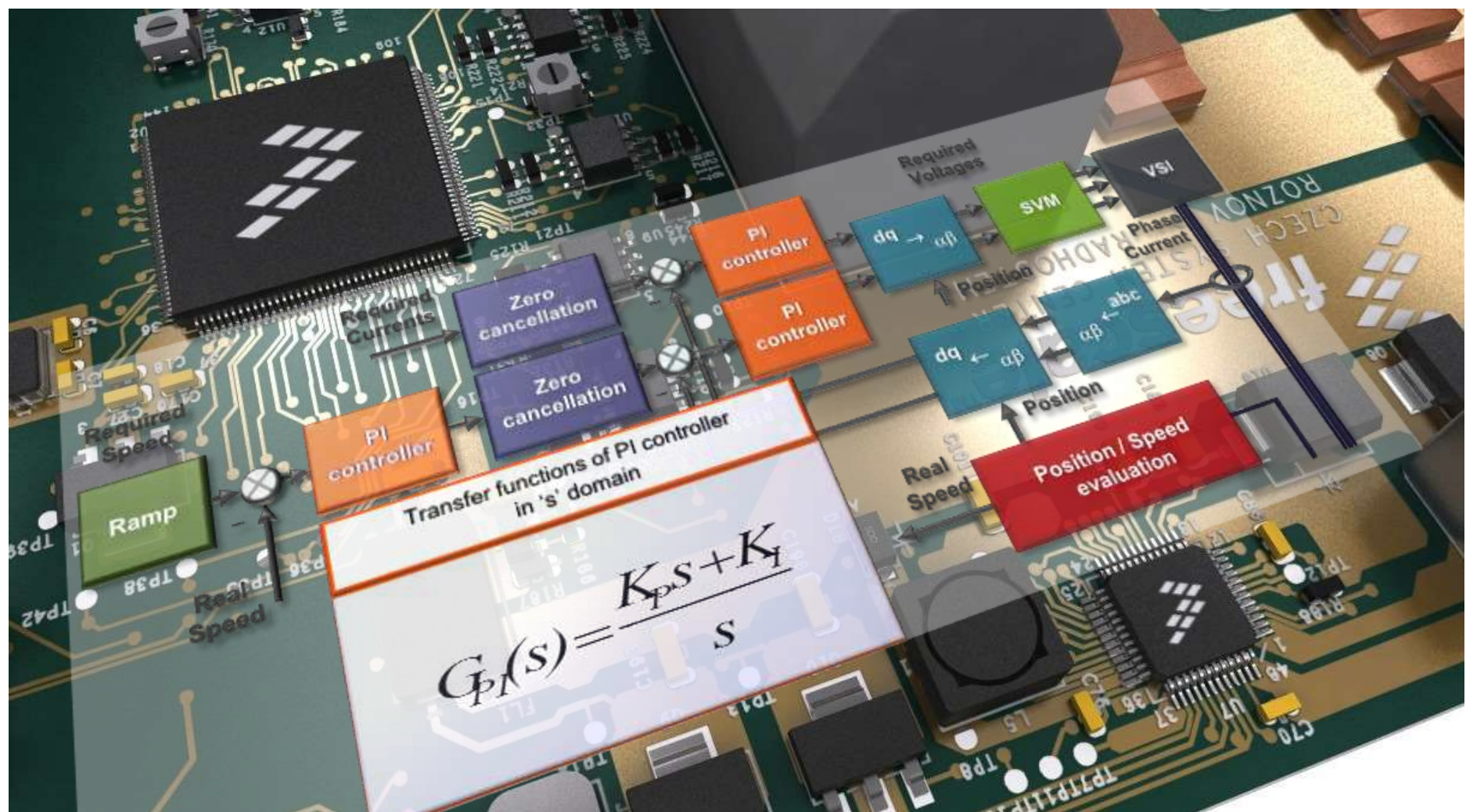
Current/Torque Control Loop



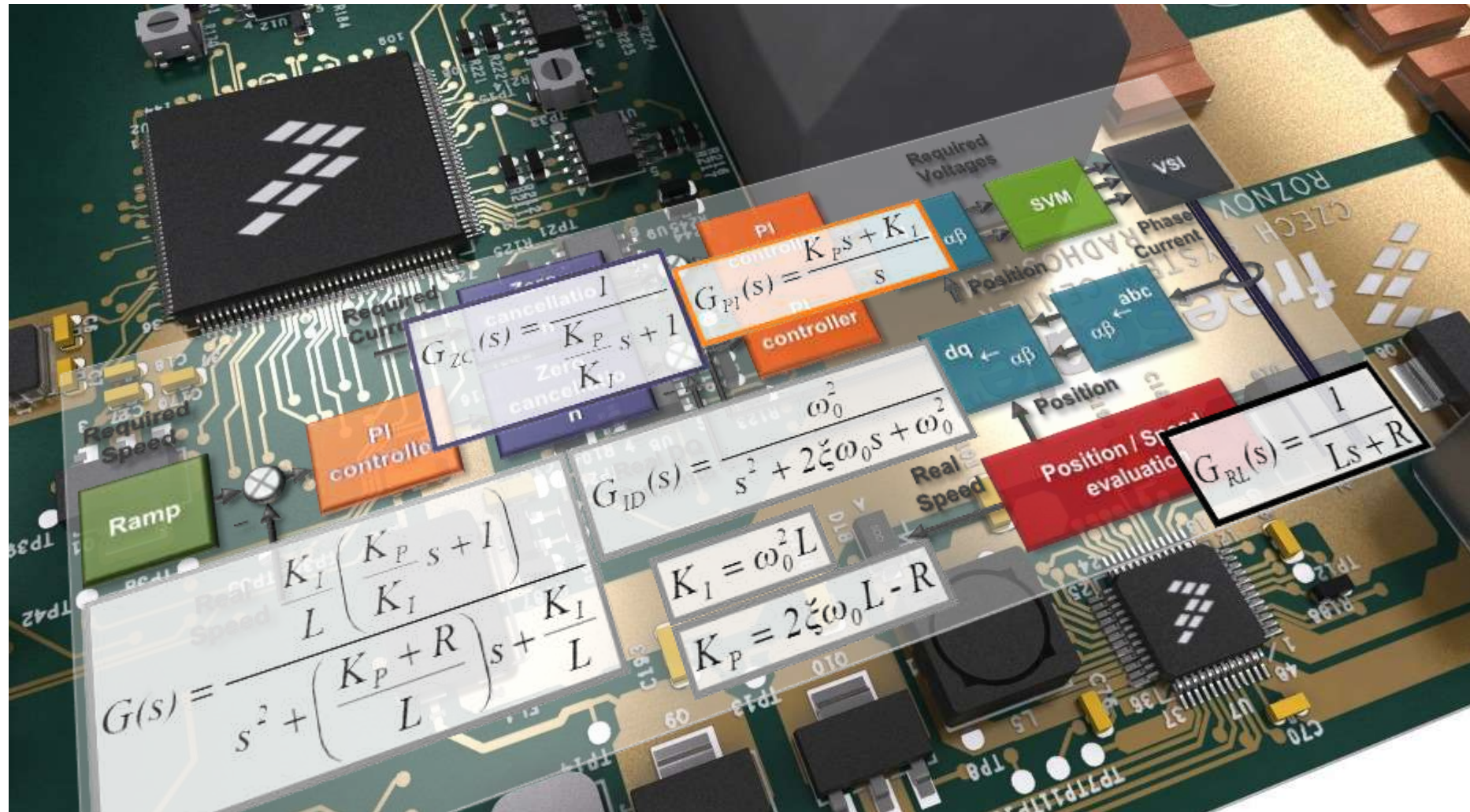
Speed Control Loop



Control Loop Controllers



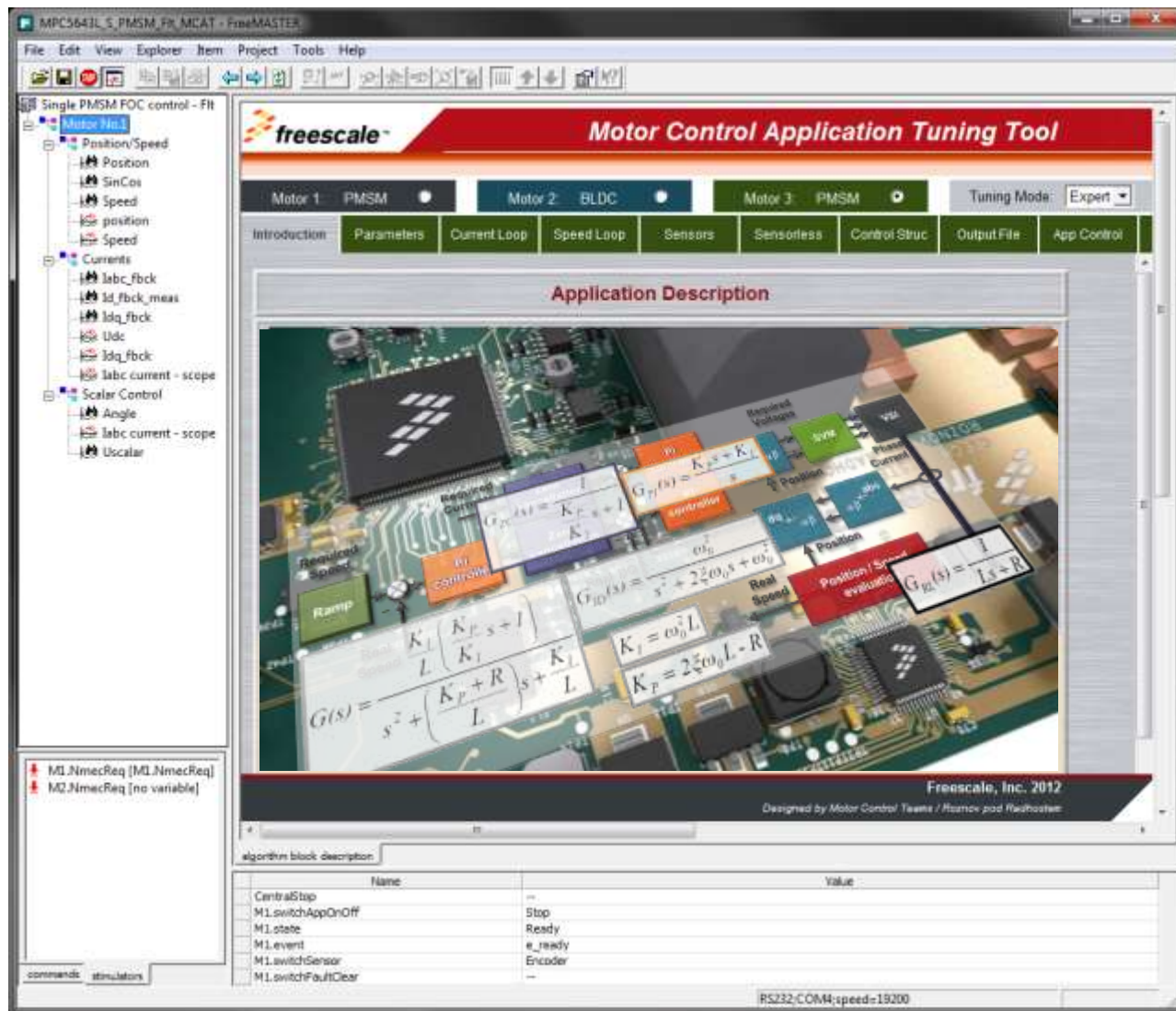
Math Behind Motor Control Controllers Tuning



Math Behind Motor Control Controllers Tuning



Motor Control Application Tuning (MCAT) Tool



FreeMASTER
real-time debugging tool

MCAT tool
FreeMASTER plug-in

MCAT features:

- **Basic/expert** tuning mode
- **Up to three motors** independent tuning
- **Real-time tuning** supported by FreeMASTER
- **Control scheme layering**



MCAT — Steps to Tune the Current Loop

1. Parameter Setting-Up

Input Application Parameters

Motor Parameters

- p: 3
- ka: 0.200
- lb: 0.00400
- ls: 0.00010
- le: 0.0577
- J: 0.00020
- qm: 5
- n: 10
- N: 3000

Application Scales

- UDCBtrip: 28.0
- UDCBunder: 14.4
- UDCBwv: 28.8
- Nmax: 2200.0
- Umax: 28.8
- Emax: 58.82
- It: 0.04711

Hardware Scales

- Imax: 8
- UDCBmax: 36

Alignment

- aligncurrent: 0.50
- alignduration: 0.00132

Update FRM

2. Control Loop Tuning

Current Control Loop

Loop Parameters

- Sample Time: 0.000020
- Fb: 230
- I: 1

D-Axis Controller

- Kp_gain: 0.032028
- Ki_gain: 0.771867
- Kp_scale: 1
- Ki_scale: 5

Q-Axis Controller

- Kp_gain: 0.580189
- Ki_gain: 0.500433
- Kp_scale: 0
- Ki_scale: 4

Current PI Controller Limits

- Output limit: 90

Update FRM

4. Generated .h file

```
// File Name: M1_PMSM_appconfig.h
// File Source: file:///C:/cc_view/vsp02c_view1/MC/MCATST_MC_Tuning_Wizard_Concept/SW/Wizard_update_10/M1_PMSM_appconfig.h
// Date: 18. October, 2012
// Automatically generated file for static configuration of the PMSM FOC application

#define PMSM_FOC_CONFIG_SETUP_0
#define PMSM_FOC_CONFIG_SETUP_1

// Application scales
#define M1_I_MAX (11.0)
#define M1_U_DCB_MAX (36.0)
#define M1_U_MAX (36.0)
#define M1_VE_MAX (942.0)
#define M1_E_MAX (90.0)
#define M1_U_DCB_TRIP FRAC16(0.972222222222)
#define M1_U_DCB_UNDERVOLTAGE FRAC16(0.222222222222)
#define M1_U_DCB_OVERVOLTAGE FRAC16(0.833333333333)
// Mechanical Alignment
#define M1_ALIGN_CURRENT FRAC16(0.090909090909)
#define M1_ALIGN_DURATION (48000)

// Current Loop Control
// Loop Bandwidth = 300 [Hz]
// Loop Attenuation = 0.25 [-]
// Loop sample time = 0.000020 [sec]
```

3. Output Control Constant Preview

Generate Configuration File

File Name: M1_PMSM_appconfig.h

File Source: 0:1

Date: October 23, 2012, 12:30:39

Description: Automatically generated file for static configuration of the PMSM FOC application

Application Scales

- #define M1_I_MAX (11.0)
- #define M1_U_DCB_MAX (36.0)
- #define M1_U_MAX (36.0)
- #define M1_VE_MAX (942.0)
- #define M1_E_MAX (90.0)
- #define M1_U_DCB_TRIP FRAC16(0.972222222222)
- #define M1_U_DCB_UNDERVOLTAGE FRAC16(0.222222222222)
- #define M1_U_DCB_OVERVOLTAGE FRAC16(0.833333333333)

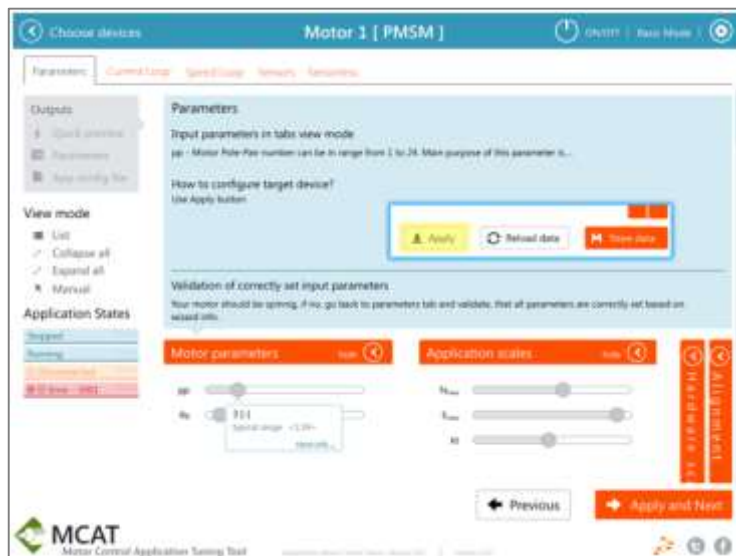
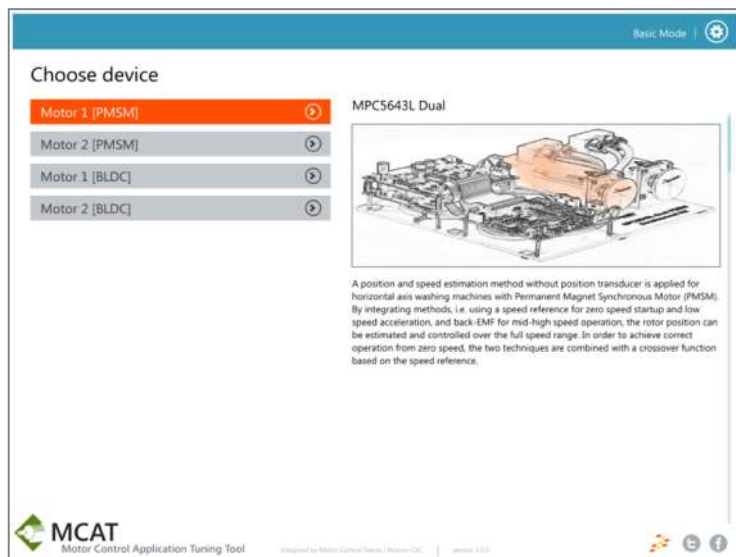
Mechanical Alignment

- #define M1_ALIGN_DURATION (48000)
- #define M1_ALIGN_CURRENT FRAC16(0.090909090909)

Current Loop Control

- #define M1_LOOP_BANDWIDTH 300
- #define M1_LOOP_ATTENUATION 0.25
- #define M1_LOOP_SAMPLE_TIME 0.000020

MCAT 2.0 Look and Feel — End User Interface



Product Web Page

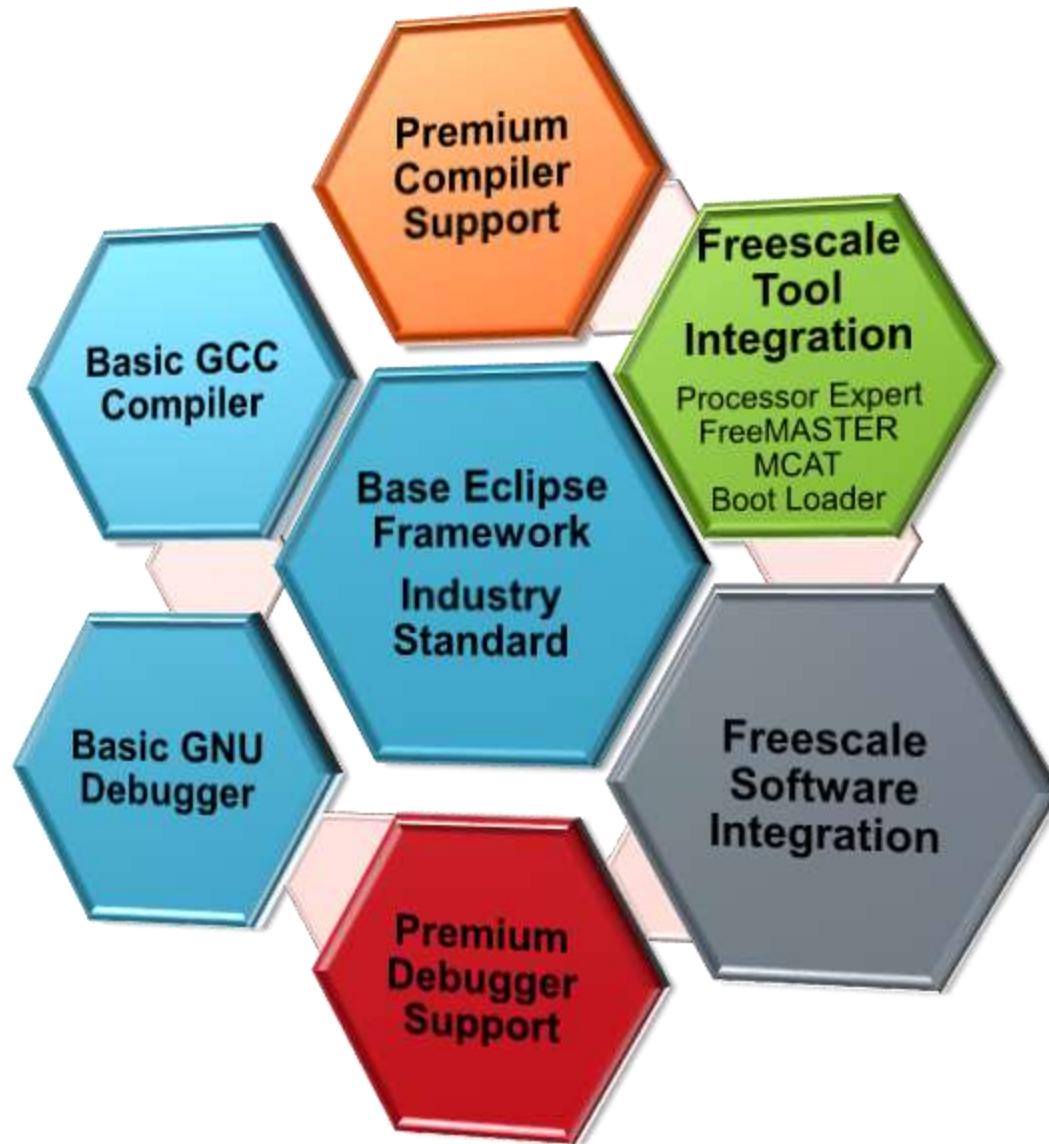
www.freescale.com/MCAT

Features:

- Promotional video
- Description
- Documentation



S32 Design Studio – Freescale Tool Integration





Motor Control Reference Development Kits





Automotive Motor Control Development Kit Series — Motivation

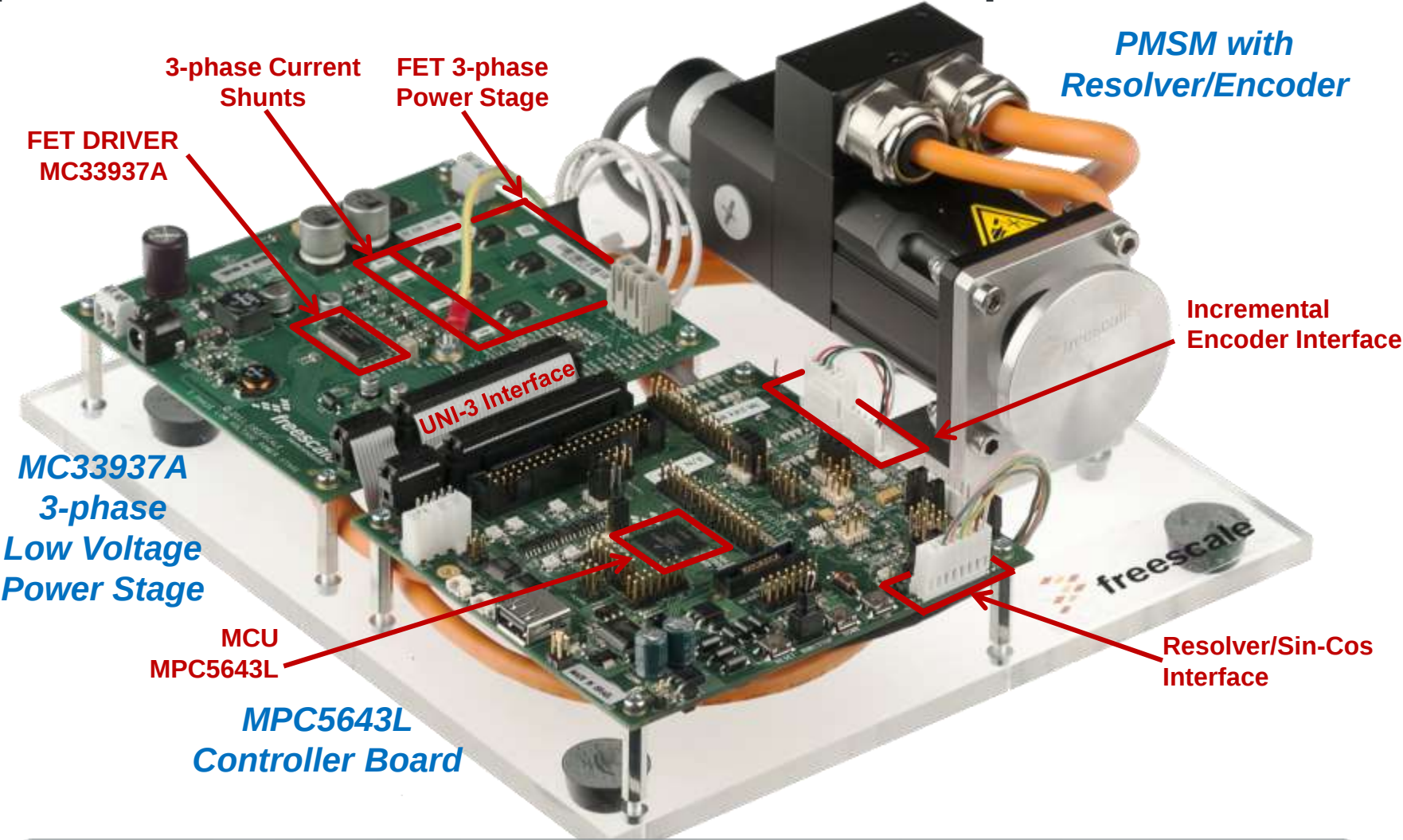
Out-of-the-box experience for automotive customers using Freescale MCUs towards electrical motor control domain.

- A complete evaluation and development package allowing the rapid prototyping and ctm evaluation of the motor control application
- Supporting variety of Freescale **32-bit/16-bit MCUs targeted for electric motor control**, 3-phase low-voltage power stage is based on MC33937A FET pre-driver
- It addresses **Permanent Magnet Synchronous (PMSM) and Brushless DC (BLDC)** types of the motors widely used in automotive

www.freescale.com/AutoMCDevKits



Spin a Motor Within Minutes w/ MC Development Kit



www.freescale.com/AutoMCDevKits

Other Motor? Different MCU? Dual Motor Application?

PMSM w/ MPC5604P

Dual PMSM w/ MPC5643L

PMSM w/ MPC5643L

BLDC w/ MPC5604P

BLDC w/ S12ZVM

BLDC w/ MPC5643L

BLDC w/ KEA128

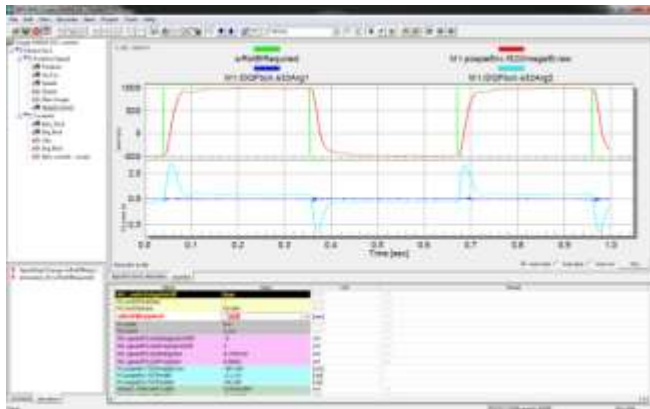
BLDC w/ MPC5606B

BLDC w/ S12G

Dual BLDC w/ MPC5643L

A True Reference Platform

- **Hardware** — complete **schematics** of the Development Kit hardware
- **Software** — complete **source code** of the Development Kit software application
 - **Six step commutation control** for BLDC motors
 - **Vector control** — FOC for PMSM motors
- **Software Libs** — **Automotive Math and Motor Control libraries (AMMCLib)** in object code
- **Tools** — **FreeMASTER & MCAT** interface to easy application visualization / control
- **Extensive documentation**



FreeMASTER Scope



FreeMASTER HTML based Control Page

A single click to download from freescale.com/AutoMCDevKits

Product Web Page

freescaler

Sign in | Locations | English

Parametric Search | Search keyword/part number

Products | Applications | Software & Tools | Training & Events | Support & Communities | Sample & Buy | About

Mark's Freescale | [1] | Login | Announcements | History | My Recommendations | My Favorites

Freescaler | Embedded Software and Tools | Automotive Embedded Software and Tools | Automotive Motor Control Development Solutions

Automotive Motor Control Development Solutions

Freescaler automotive motor control development solutions are complete development kits allowing the rapid prototyping and evaluation of motor control applications without the need to wait for final hardware design.

The kits consists of two boards:

1. A Freescaler 32-bit Qoriva controller board or 16-bit S12 controller board (device specific and orderable separately in some cases - see individual product pages for details)
2. A 3-phase low-voltage power stage board (device independent)

The automotive motor control development kits support two major types of electric motors:

- Brushless DC (BLDC) Motors
- Permanent Magnet Synchronous Motors (PMSM)

An integral part of the automotive motor control development solution is the application software which provides a complete, easy-to-use solution for motor control application including use of the automotive math and motor control library set.

Motor Control Kits

- MTRCKTDBN5643L: Dual 3-phase Sensorless BLDC Development Kit with Qoriva MPC5643L MCU
- MTRCKTSPS5643L: Dual 3-phase PMSM Development Kit with Qoriva MPC5643L MCU**
- MTRCKTSBN5604P: 3-phase Sensorless BLDC Development Kit with Qoriva MPC5604P MCU
- MTRCKTSBN5606B: 3-phase Sensorless BLDC Development Kit with Qoriva MPC5606B MCU
- MTRCKTSBN5643L: Single 3-phase Sensorless BLDC Development Kit with Qoriva MPC5643L MCU
- MTRCKTSBNG12B: 3-Phase Sensorless BLDC Development Kit with MC9S12G12B MCU **NEW**
- MTRCKTSBNZVM12B: 3-phase Sensorless BLDC Development Kit with S12 MagniV MC9S12ZVM12B MCU **NEW**
- MTRCKTSPS5604P: 3-phase PMSM Development Kit with Qoriva MPC5604P MCU

Design Resources

- Getting Started
 - Freescaler Motor Control Homepage
- Software and Tools
 - Automotive Math and Motor Control Library Set
 - Motor Control homepage
 - Motor Control Toolbars
 - FreeMASTER Run-Time Debugging Tool
 - CodeWarrior for Microcontrollers

Featured Videos

- Designing with Freescaler Automotive Motor Control Development Kits** (Video - 01:44 min) Fully-loaded motor control development kits are designed to give engineers a complete out-of-the-box experience for permanent magnet synchronous motor (PMSM) or brushed DC (BLDC) motor control solutions. These kits are targeted for automotive motor control applications.
- Freescaler Concept Car** (Video - 3:22) The Freescaler concept car demonstrates solutions for automotive systems in powertrain, infotainment, cluster, safety and body applications.
- Automotive Powertrain System** (Video - 3:31) Get an overview of the internal combustion engine (ICE) efficiency and electric vehicle (HEV/EV) motor control.

Training and Events

On-Demand Training
Motor Control

Featured Product

S12 MagniV S12ZVM MCUs
Targeting motor control

Connect with Us

Automobility Blog
by Freescaler's automotive



Application Notes



Example Source Codes

www.freescale.com/AutoMCDevKits

Product Web Page (cont.)

MTRCKTDP5643L: Dual 3-phase PMSM Development Kit with Qorivva MPC5643L MCU ☆

Overview Documentation Downloads Buy / Specifications

Application Notes

The MTRCKTDP5643L motor control development kit is ideal for applications requiring two PMSM motors, like active suspension or electric powertrain. The kit is designed to enable rapid prototyping and evaluation of the motor control application without having to wait for the final hardware design. The kit includes a 32-bit Qorivva MPC5643L based controller board and the 3-phase low-voltage power stage board.

An integral part of the automotive motor control development kit is the application software which provides a complete reference implementation of the PMSM motor control application and also takes advantage of the Automotive Math and Motor Control Library Set.

Features

- 32-bit Qorivva MPC5643L controller board
- 3-phase low-voltage power stage based on SMARTMOS MC33397A pre-driver
- Supports low-voltage PMSM motors with resolver and encoder sensors
- DC-bus overvoltage, overcurrent and undervoltage fault detection
- FreeMASTER visualization/configuration support
- ANSI-C based motor control reference software with easy portability
- Extensive documentation for software and hardware

Related Software and Tools

AUTOMATH_MCL: Automotive Math and Motor Control Library Set
MC_TOOLBOX: Motor Control Development Toolbox
FREEMASTER: FreeMASTER Run-Time Debugging Tool

Dual 3-Phase PMSM Development Kit: Qorivva MPC5643L



Supported Devices

- MC33905: System Basis Chip Gen2 with High-speed CAN and LIN Interface
- MC33937: Three Phase Field Effect Transistor Pre-driver
- MPC564xL: Qorivva 32-bit MCU for Chassis and Safety Applications

Featured Documentation

MTRCKTDP5643LFS: MTRCKTDP5643L Fact Sheet
MTRCKTDP5643LQSG: MTRCKTDP5643L Quick Start Guide

Jump Start Your Design

Get Started With MTRCKTDP5643L Dual 3-phase PMSM Development Kit
This collection of resources will help you to get started ...

Kit Contains

- 3-phase low-voltage power stage based on SMARTMOS MC33397A pre-driver
- Freescale 32-bit Qorivva MPC5643L Dual Motor Controller Board
- AC/DC 24V Universal Power Supply Kit
- Two 3-phase PMSM low-voltage motors
- USB 2.0 A-A type cable, ribbon cables for power controller board connection
- Fact sheet and quick start guide

Get Started With MTRCKTDP5643L Dual 3-phase PMSM Development Kit

This collection of resources will help you to get started with the MTRCKTDP5643L Dual 3-phase PMSM Development Kit with Qorivva MPC5643L MCU.

1. An overview about the product can be found in the fact sheet document.
2. Follow the quick start guide below to run the pre-programmed application and spin the PMSM motors using the FreeMASTER run-time debugging tool.

MTRCKTDP5643L Fact Sheet MC DevKits documentation

Provides an overview and look and feel about the content of the Dual 3-phase PMSM Development Kit with Qorivva MPC5643L MCU.

Type: Fact Sheets Format: pdf Size: 971K

MTRCKTDP5643L Quick Start Guide

Provides an overview of the hardware, step-by-step instructions for running the out-of-box demo application and jumper settings quick reference table.

Type: Quick Reference Guides Format: pdf Size: 2129K

AN4518, Dual 3-Phase PMSM Development Kit with MPC5643L - Application Notes

Provides the 3-phase PMSM Development Kit with Qorivva MPC5643L MCU system concept and software implementation details. Covers both single and dual motor control implementations.

Type: Application Notes Format: pdf Size: 5918K

MTRCKTDP5643L Application Software MC DevKits Software

Complete motor control application software package.

Type: Application Specific Format: exe Size: 3000K Vendor: FREESCALE

MPC5643L Dual Motor Controller Board User Guide MC DevKits Hardware

Complete reference for the hardware design and features of the MPC5643L dual motor controller board.

Type: Users Guides Format: pdf Size: 3442K

3-Phase Low Voltage Power Stage User Guide

Complete reference for the hardware design and features of the 3-phase low-voltage power stage.

Type: Users Guides Format: pdf Size: 2205K

www.freescale.com/AutoMCDevKits

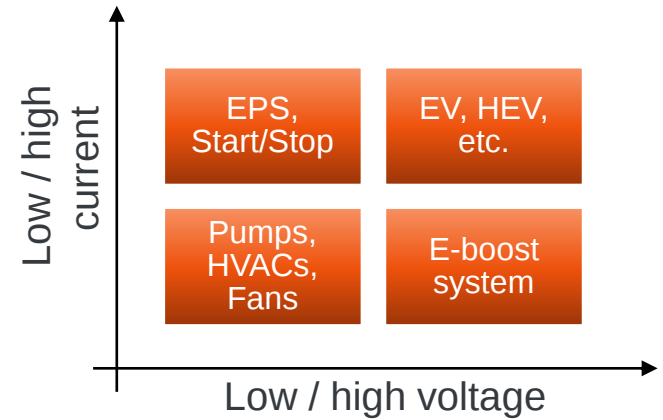
Product Pricing (USD) & Availability — Complete DevKits

Device	Marketing PN	Development Kit Type	Available	Direct Price
MPC5604P	MTRCKTSPS5604P	3-phs PMSM w/ Encoder/Resolver	Y	\$1,563
MPC5604P	MTRCKTSBN5604P	3-phs BLDC Sensorless	Y	\$912
MPC5606B	MTRCKTSBN5606B	3-phs BLDC Sensorless	Y	\$889
MPC5643L	MTRCKTSPS5643L	3-phs PMSM w/ Encoder/Resolver	Y	\$1,687
MPC5643L	MTRCKTDPS5643L	Dual 3-phs PMSM w/ Encoder/Resolver	Y	\$2,980
MPC5643L	MTRCKTSBN5643L	3-phs BLDC Sensorless	Y	\$1,117
MPC5643L	MTRCKTDBN5643L	Dual 3-phs BLDC Sensorless	Y	\$1,678
S12G128	MTRCKTSBNG128	3-phs BLDC Sensorless	Y	\$649
S12ZVM128	MTRCKTSBNZVM128	3-phs BLDC Sensorless	Y	\$789
KEA128	KEA128BLDCRD	3-phs BLDC Sensorless	Y	\$149
S12ZVM128	MTRCKTSPNZVM128	3-phs PMSM Sensorless	May '15	\$789
MPC5744P	MTRCKTSPS5744P	3-phs PMSM w/ Encoder/Resolver	Q3 '15	TBD

**For orders, get in touch w/ your Freescale representative,
Marketing PNs can be found @ www.freescale.com/AutoMCDevKits**

New Concept of the MC DevKit Series

- **Controller board cost reduction**
 - Reduced BOM & size of the PCB
 - Daughter card form of the PCB (no wired connection w/ PS)
- **Simplified CB design for new MCUs**
 - Design time reduction
- **Solution scaling for the different power needs**
- **One motor = One Power Stage**
 - All MC related circuits located on Power Stage
 - Improved measurement circuit (central ADC reference)
- **Compatibility with MCU tools**
 - Usage of the high voltage Power Stage



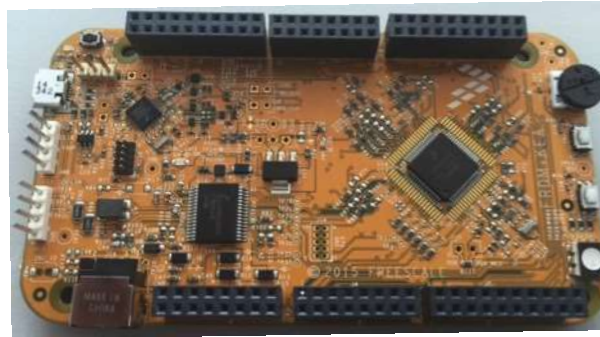
PMSM Development Kit w/ MPC5744P



Freescalé Freedom+ Based Motor Control Enablement



NXP Freescale Freedom+ Platform — Developed to Support Faster Growth



**FRDM+KEA launching
Aug'15**

Ease of Use

- Starting at only \$29/ea. (USD)
- Plug and play with any Arduino UNO shield
- Improved Quick Start Guide (QSG)
- Preloaded code examples
- Develop on Freescale Freedom+ (no PC necessary)
- Customize — All PCB files provided

Feature Rich

- All I/O routed to headers
- Potentiometer
- 12 V supply (5 V & 3.3 V operation)
- OpenSDA USB — Drag/drop programs
- CAN and LIN headers
- RGB LED
- Scalable up to 176 LQFP

Expanded Capability

- IoT capable (add Wi-Fi® to any Freescale Freedom+ platform)
- Easily add Motor Control
- Simplify design
- Tap into Arduino communities

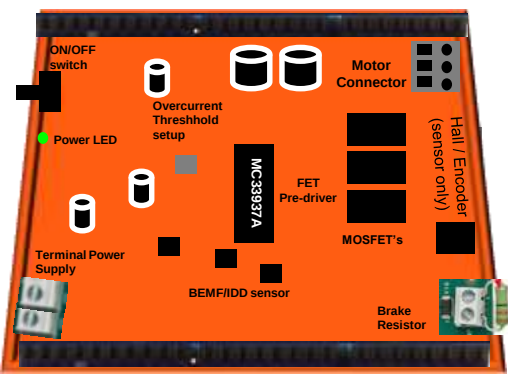


Motor Control Shield for Freescale Freedom+

Target Applications

Mass-market and entry level Automotive motor control

FRDM+KEA MCU board
+
Motor Control Shield



Motor Control shield for BLDC & PMSM
Supports 3-phase sensorless motor

Only \$49/ea. (USD)

- 5A nominal, (8–18 V)
- Plug & play with any Freescale Freedom+ platform
- Compatible with Arduino UNO
- Motor Control Software
- FreeMASTER & MCAT support



** Stacked visualization example*



Motor Control Enablement Success Story and Summary



China EPS Success Story

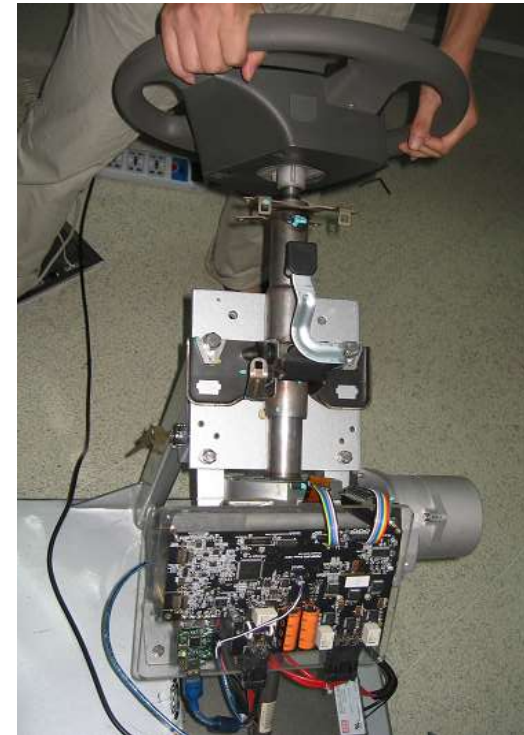


Background in 2012

- Trend from Hydraulic Steering to EPS in China, new cars equipped w/ EPS
- Only a few local EPS Tier1s can design DC Motor EPS, no knowledge on how to implement PMSM based EPS

Effort from 2012...

- Build local MC expertise w/in FAE community
- Work out the MPC5604P PMSM Motor EPS RefDes
- Provide the best EPS technical support among all the competitors, including an on site customer support
- Widely promote the Freescale Motor Control enablement
- Promote Motor Control Library and Field Weakening software to customers
- Work closely with the top 3 EPS Tier1s and help them build the PMSM based EPS system



China EPS Success Story (cont.)

Market potential and Revenue

EPS POS	2013	2014	2015	2016	2017	CAGR (13-17)
FSL (\$M)	0.4	2.2	3.9	5.3	7.0	105%
TAM(\$M)	13	16	21	25	28	21%
FSL MS	4.0%	13.8%	18.6%	21.2%	25.0%	



- Freescale PMSM EPS reference design won the best solution award for Best National Electronic Product Solutions 2012
- Help build local EPS Tier1s technical capability
- EPS Market share increased from 4.0%/Y2013 to 13.8%/Y2014
- Design in >90% new EPS platforms from more than 10 EPS Tier1s
- Design wins and SOP at several DC Motor EPS Tier1s.
- Design wins at top 3 PMSM EPS Tier1s, SOP in Y2016
- Got revenue from Motor Control Library software and Field Weakening software

“Where Integration Matters” Success Stories



Water and Oil Pumps Platform



Engine Cooling Fan Platform



Get to Production Faster

Premium level of technical support

Consultancy & Technical Development in Area of Motor Control According to Ctm Specs / Needs

Standard level of technical support

Motor Control Focused Technical Support

Trainings

(e.g. motor type X on device A)

Technical Trainings for Motor Control and MCUs

Advanced motor control & sensor topics

Single-shunt
3-phs currents
reconstruction

PMSM
sensorless control

Resolver interface
& diagnostic

Self tuning

Field Weakening

Zero RPM /
rotor alignment

Torque
ripple elimination

Noise reduction

Services

Reference motor control platform
for rapid hardware & software prototyping

Automotive Motor Control Development Kit series

Tools — FreeMASTER, MCAT, ...

Tools for Embedded Debugging & Motor Control Tuning

Advanced software libraries level
(w/ adv. math and motor control algorithms)

Advanced Math and Motor Control Library Set

Software libraries level
(w/ math & motor control algorithms)

Automotive Math and Motor Control Library Set

Products



www.Freescale.com