

Kinetis V Series Overview: Motor Control and Power Conversion Made Easy with ARM[®] Cortex[®]-M-Based Solutions

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Agenda

- Positioning & target applications
- MCU families
- Enablement
- Kinetis Motor Suite
- Enablement Details



Kinetis V Series MCUs based on ARM Cortex Cores

For Motor Control & Digital Power Conversion



- Freescale's **extensive motor and power control expertise** and the latest **ARM Cortex-M0+, M4 and M7 cores** bring secure, connected, high efficiency motor control and power conversion to the mass market
- Efficient, next generation BLDC, PMSM and ACIM designs are enabled by **optimized MCU performance** and **high speed/resolution analog and timing peripherals**. High resolution **eFlexPWMs** support digital power conversion
- Performance and feature scalable MCU families from **entry-level 75MHz MCUs**, to **advanced 240MHz MCUs**, maximize hardware & software reuse and end product flexibility
- Enablement including **Freescale Tower** and **Freedom development boards**, **Embedded Software Libraries** and **Kinetis motor suite** reduce motor control learning curve and speed time to market



Freescale is investing heavily in Motor & Power Control Solutions



- Providing the right product
 - The right level of performance with the right peripherals
 - Build on our rich DSC legacy – we have decades of experience in motor and power control.
 - Freescale is the only supplier to offer DSC and Cortex solutions for the same market segment
- The best in class enablement
 - Hardware and Software solutions
- Access to dedicated technical resources
 - Products & Application Focused Engineers
 - Local and Globally accessible -

Kinetis V Series MCUs: Target Applications

Motor Control

- Sensored BLDC / PMSM
 - High Dynamic Control
- Sensored ACIM
- Sensorless FOC
 - PMSM/BLDC
 - High Dynamic Control
 - Low Dynamic Control
- Sensorless ACIM
- Multi-Motor Control

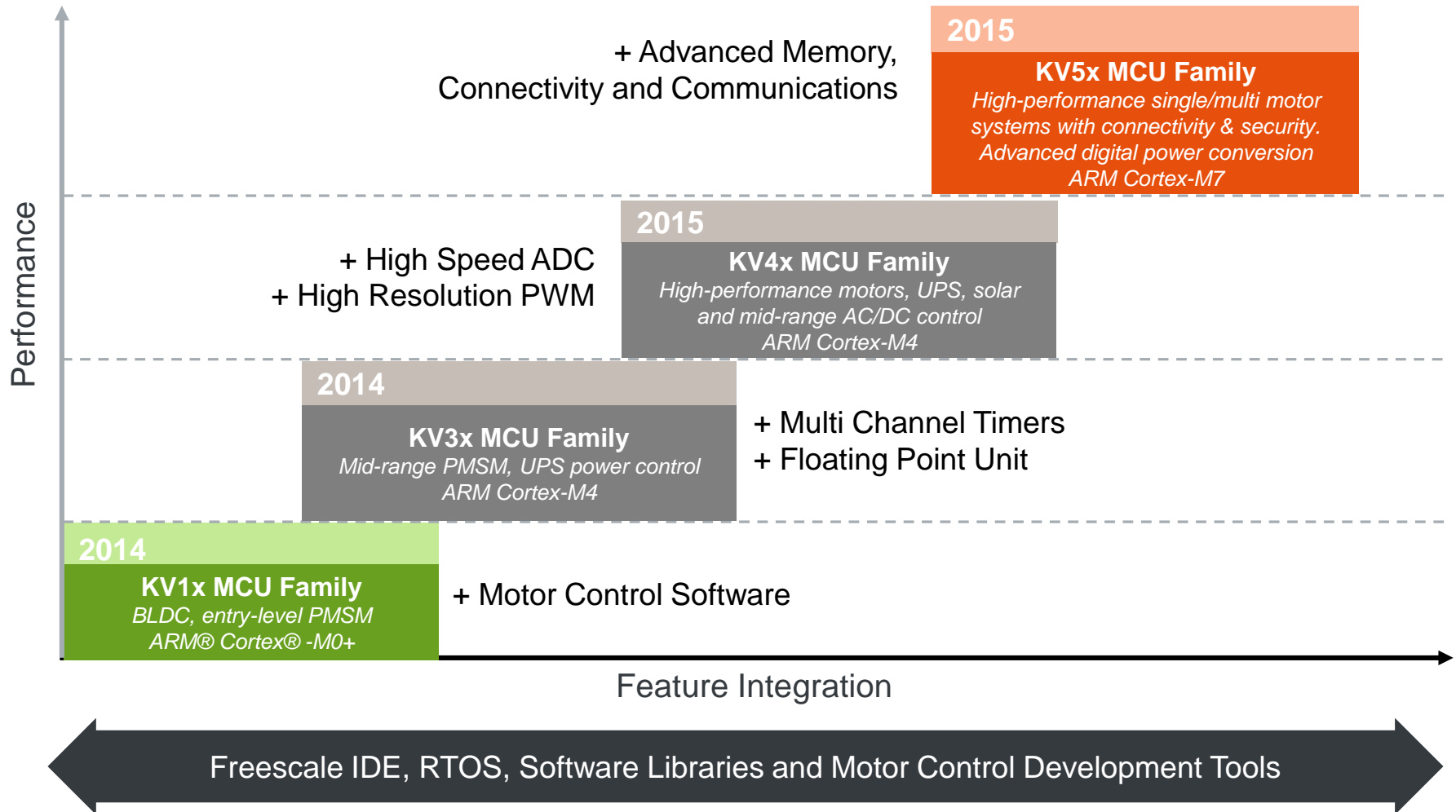


Digital Power Conversion

- Solar Inverters
 - Grid-Tied
 - Non Grid Tied
- Power factor correction
- Switch Mode Power Supplies
 - AC/DC
 - DC/DC
- UPS
 - On-Line
 - Offline
- Inductive cooking
 - Multi cook plate



New Levels of Performance, Reliability and Power Efficiency for Motor Control and Digital Power Conversion



Kinetis V Series KV1x: Block Diagram

Core/System

- 75MHz Cortex-M0+ with Hardware Divide & Square Root
- 4ch DMA

Memory

- **16/32/64/128KB Flash**
- **8/16KB SRAM**
- Option with FAC

Communications

- Multiple serial ports + **1 FlexCAN***

Analog

- 2 x 8ch 16-bit ADC
 - 1.2Msps in 12-bit mode (835ns)
- 1 x12-bit DAC
- 2 x ACMP with 6-bit DAC

Timers

- **Up to 2x6ch FlexTimer (PWM) ***
- Up to 4x2ch FlexTimer (PWM/Quad Dec.)
- Low-Power Timer

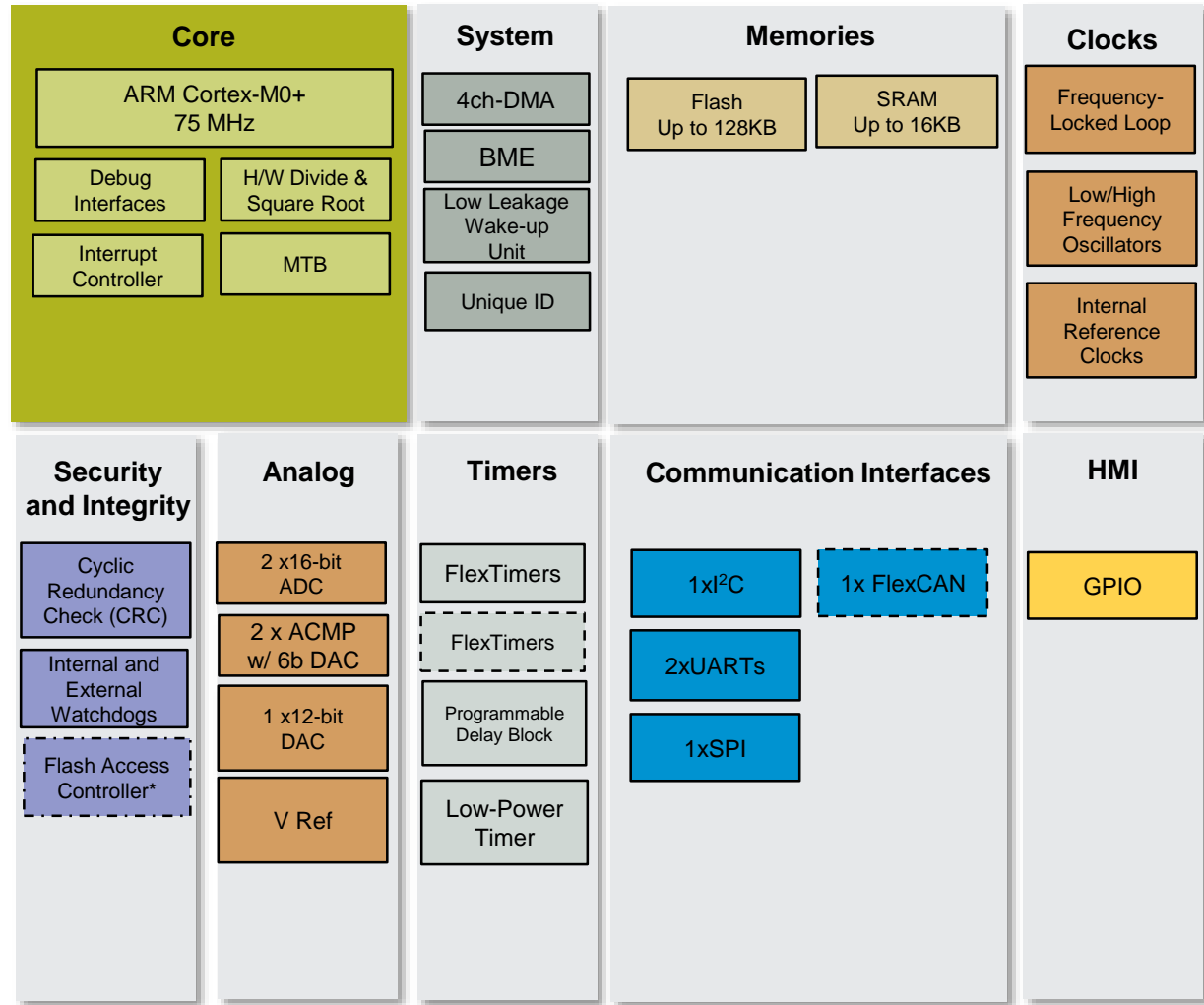
Other

- 32-bit CRC
- Up to 54 GPIO
- 1.71V-3.6V; -40 to 105C

Packages

- 32QFN, *32LQFP, 48LQFP, 64LQFP
- * Package Your Way

From **\$0.90 to \$1.56 @ 10k units**



*Optional

Availability: Production Now
TWR Board now, production - mid Sept



Kinetis V Series KV1x: Features and Benefits

Features	Benefits
Cortex M0+ @75MHz	Fastest Cortex M0+ in the market enables PMSM motor control with a M0+ solution
Hardware Square Root & Divide Hardblock	More than 25% performance improvement running math intensive applications such as Sensorless PMSM FOC algorithms
Dual ADC Blocks sampling @ 1.2MS/s in 12b mode	Capture current & voltage simultaneously for the most accurate result
4ch DMA	Further improvements in performance realized through increased CPU bandwidth-
6ch FlexTimer + 2x2ch FlexTimer	Motor control PWM generation with integrated PFC, or integrated speed sensor decoder (incremental decoder / hall sensor)
Optional Additional 6ch FlexTimer	Capability to operate a 2 nd motor from a single MCU
Integrated 6b DAC & CMP	Reduce BOM costs with integrated components for over current over voltage fault detection
Peripheral Interconnection	ADC and CMP interconnected with PWM and PDB for real time hardware control.
Light weight peripheral and memory configuration	Enough performance for the majority of Motor Control applications, with the right amount of memory to fit complex motor control algorithms, FlexCAN available for extended communications
Dual Watchdog	IEC60730 Compliant solution

Kinetis V Series KV3x: Block Diagram

Core/System

- Cortex-M4 @ 100/120MHz with FPU
- 4 or 16ch DMA

Memory

- 64/128/256/512KB Flash,
- 16/24/48/96KB SRAM
- FlexBus (512KB version only)
- Bootloader

Communications

- Multiple serial ports

Analog

- 2 x16-bit ADC: 1.2Msps in 12-bit mode
- Up to 2 x12-bit DAC
- 2 x ACMP with 6-bit DAC

Timers

- Up to 2x8ch FTM (PWM)
- 2x2ch FTM (PWM/Quad Dec.)
- Programmable Delay Block
- Low Power Timer

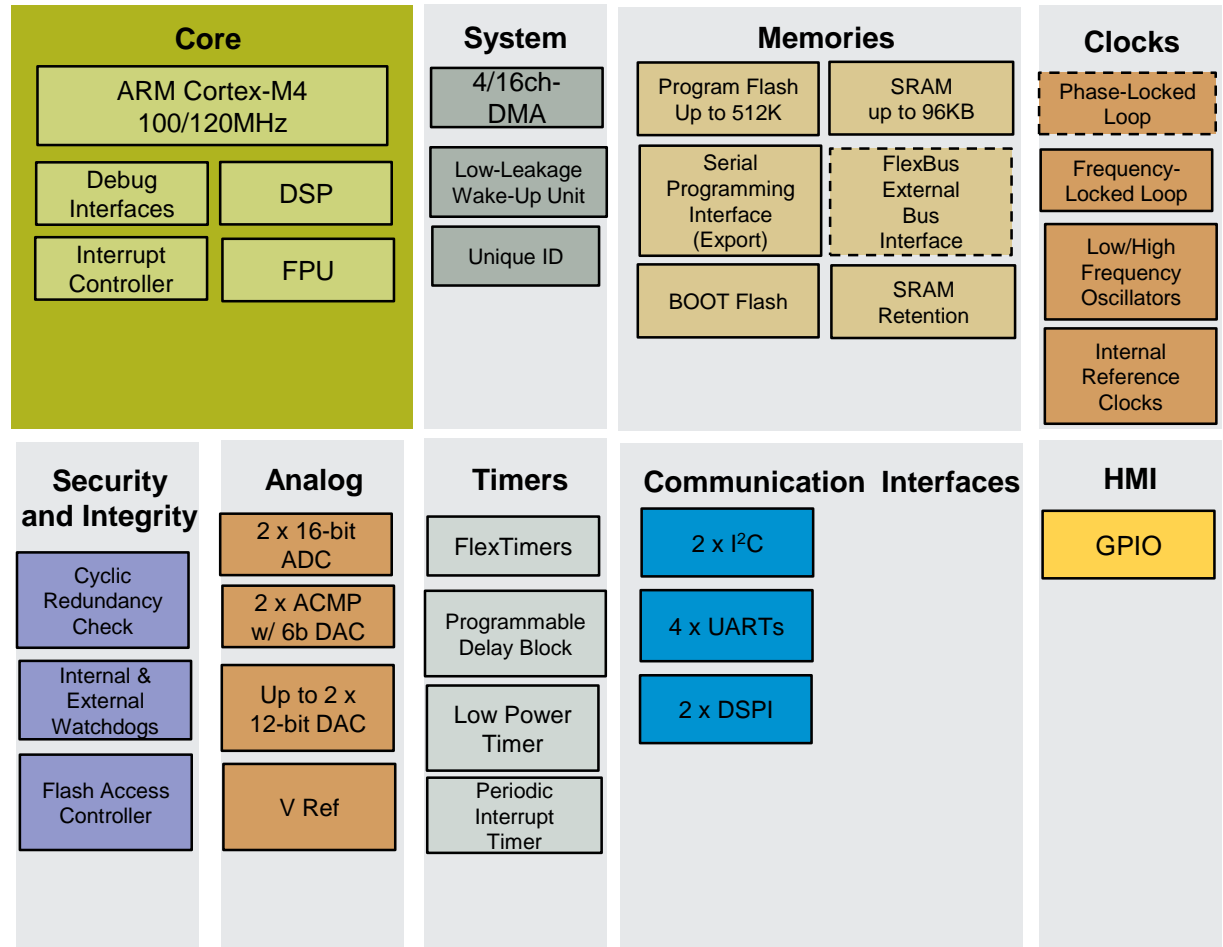
Other

- Up to 70 I/Os
- 6 high-drive I/Os (20mA) – SPI/I2C
- 1.71V-3.6V; -40 to 105C

Packages

- 32QFN, *48LQFP, 64/100LQFP
- *Alternative, non committed package

From \$1.19 to \$2.76 @ 10k units



Availability: Production Now

Kinetis V Series KV3x: Features and Benefits

Features	Benefits
Cortex M4 solution with up to 120MHz performance	Cortex M class core with DSP functionality enabling all motor control applications
Scalable memory solutions	Highly scalable family with dedicated cost effective solutions for Motor Control
Single Precision Floating Point Unit	Increased numeric resolution for Math Intensive calculations enabling easy conversion from Matlab models
Scalable Timer Solutions	Support for single and multiple motor control with PFC
Dual ADC blocks sampling at 1.2MS/s in 12b mode	Capture current & voltage simultaneously for the most accurate result
Integrated 6b DAC & CMP	Reduce BOM costs with integrated components for over current over voltage fault detection
Dual Watchdog	IEC60730 Compliant Solution
SRAM Retention	Low power RAM memory retention in LLS3 and VLLS3 modes
FlexBus (512KB version only)	Enables further memory expansion allowing all system needs to be included.

Kinetis V Series KV4x: Block Diagram

Core/System

- 168MHz Cortex-M4, FPU

Memory

- 64/128/256KB Flash @ 128-bits wide w/ 128Byte cache
- 16/24/32KB SRAM

- Bootloader

Communications

- Multiple serial ports
- Up to 2 x CAN

Analog

- 2 x 8ch 12-bit ADC
 - Sampling at up to 4.1MS/s
 - PGA x1, x2, x4
- 12-bit DAC
- 4 x ACMP with 6-bit DAC

Timers

- Up to 12ch eFlexPWM
 - Up to 312ps PWM and PFM Resolution
- 2x8ch + 1x2ch FlexTimer (PWM)
- Quadrature Encoder
- 2 x Programmable Delay Blocks

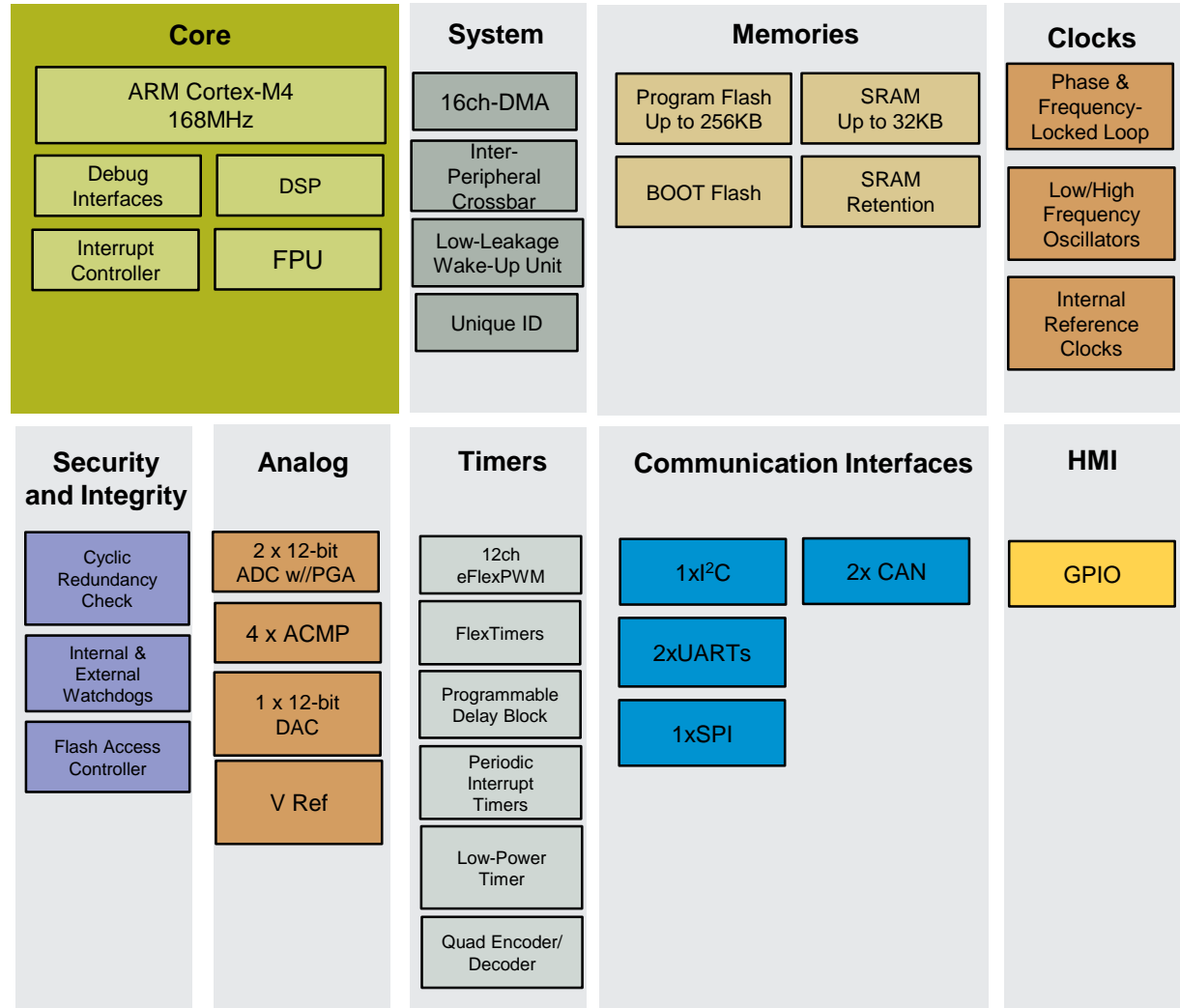
Other

- 32-bit CRC
- Inter-Peripheral Crossbar with AND/OR interface
- Up to 56 I/Os
- 1.71V-3.6V; -40 to 105oC

Packages

- *48LQFP, 64 LQFP & 100LQFP
- *Alternative, non committed package

From \$2.19 to \$3.41 @ 10k units



Availability: Production Oct 2015

Kinetis V Series KV4x: Features and Benefits

Features	Benefits
168Hz cortex M4 core	High performance core needed for the most demanding mathematically dependant applications
128-bit wide, 128-bit cache Flash Interface	Fast Flash access with reduced wait states
ADC sampling at 4.1MS/s	The fastest ADC conversion time is the Freescale Microcontroller portfolio
eFlexPWM Timer	The most advanced and flexible timer options available simplifying development and implementation
Nano edge timer capability	First Cortex solution to feature very high resolution PWM capability enabling true power conversion
Up to 30 Timer channels	Manage multiple control loops in parallel
Dual CAN	Increased systems options, perfect for UPS applications
Quadrature Encoder	Integrated speed sensor decoder (incremental decoder / hall sensor)
Floating point unit as standard across family	Increase numeric resolution for Math Intensive calculations and enabling
Dual ADC blocks with dual sample and hold	Capture current & voltage simultaneously for the most accurate result
Inter Peripheral Crossbar w/ AND & OR interface	Configure your peripheral communication as your topology demands, simplifying pin out and reducing cross peripheral & CPU communication.
Dual Watchdog	IEC60730 Compliant Solution

Kinetis KV5x MCU Family

Key Features:

Core/System

- Up to 220MHz Cortex-M7 with FPU and 32ch DMA
- 16KB Instruction Cache / 8KB Data Cache

Memory

- 512KB/1MB Flash, 256bits wide, 128 Bytes cache
- 128/256KB SRAM
- Boot Flash

Communications

- Multiple serial ports
- 3 x FlexCAN

Analog

- 4 x 8ch 12-bit ADC
 - 5Msps Sample Time
- 1 x 16-bit SAR ADC
- 1 x12-bit DAC
- 4 x ACMP w/ 6b DAC

Timers

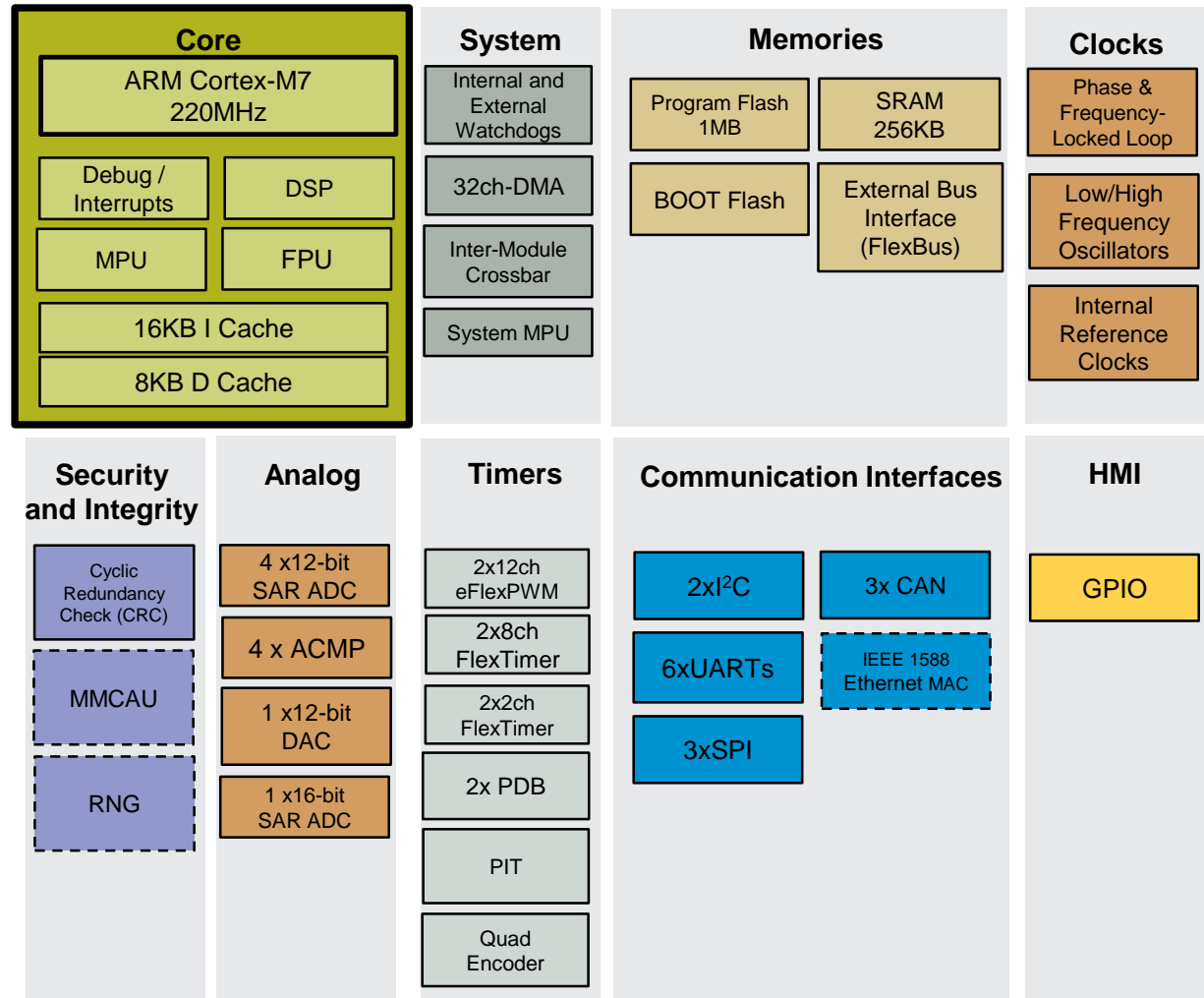
- 1 x 12ch eFlexPWM
 - 312ps PWM and PFM Resolution
- 1 x 12ch eFlexPWM
- 2x8ch FlexTimer (PWM)
- 2x2ch FlexTimer (PWM)
- Quadrature Encoder
- 2 x Programmable Delay Blocks
- Low-Power Timer

Others

- MMCAU & RNG
- 32-bit CRC
- Inter-module Crossbar Switch with AOI
- Memory Protection Unit
- 1.71V-3.6V; -40 to 105oC

Packages

- 100LQFP, 144LQFP, 144MAPBGA
- C Temp (85C) : 220MHz
- V Temp (105C) : 200MHz



Availability: PK samples Now, Launch, Oct'15
Production Q12016

Optional



Kinetis V Series KV5x: Features and Benefits

Features	Benefits
220MHz ARM Cortex M7 core + FPU, 16KB instruction & 8KB data caches	High performance + DSP capability suited to motor control algorithm management, Cache memories support low latency application functions
Internal Module Crossbar	Minimizes CPU interrupts by enabling flexible triggering events between timers, ADCs, DAC, analog comparators and external circuitry
1MB/512KB Flash memory, 256-bit wide Flash Interface	Large Flash density provides storage for motor control algorithm and application code. Wide Flash interface helps reduce wait states
128KB of Data TCM, 64KB of Instruction TCM	Maximizes high performance deterministic processing, ensuring optimum response for real-time motor speed and position detection
4 x 12-bit ADC, 5Msps sample rate	Support fully asynchronous dual 3-phase motor control with two dedicated ADCs and 8 channel PWMs per motor
Up to 44 Timer channels	Support multi 3-phase motor drive capabilities with dead time insertion, complementary pairing of PWMs, half cycle reload and fault detection
2 x 12ch eFlexPWM, 312 picosecond resolution	Supports up to 8 half-bridge power stages in power conversion applications
Quadrature Encoder	Integrated speed sensor decoder (incremental decoder / hall sensor)
IEEE 1588 Ethernet Controller	Connectivity via the IoT enabling remote system management, new services, reduced maintenance and increase reliability
CAU (Cryptographic Acceleration Unit) + RNG (Random Number Generator)	Secure data transmission over any communication interface
Memory Protection Unit, Cyclic Redundancy Check	Code partitioning for safety critical applications, Validation of transmitted code integrity
6 UART, 3SPI, 2IIC & 3CAN	Multiple communication interface options

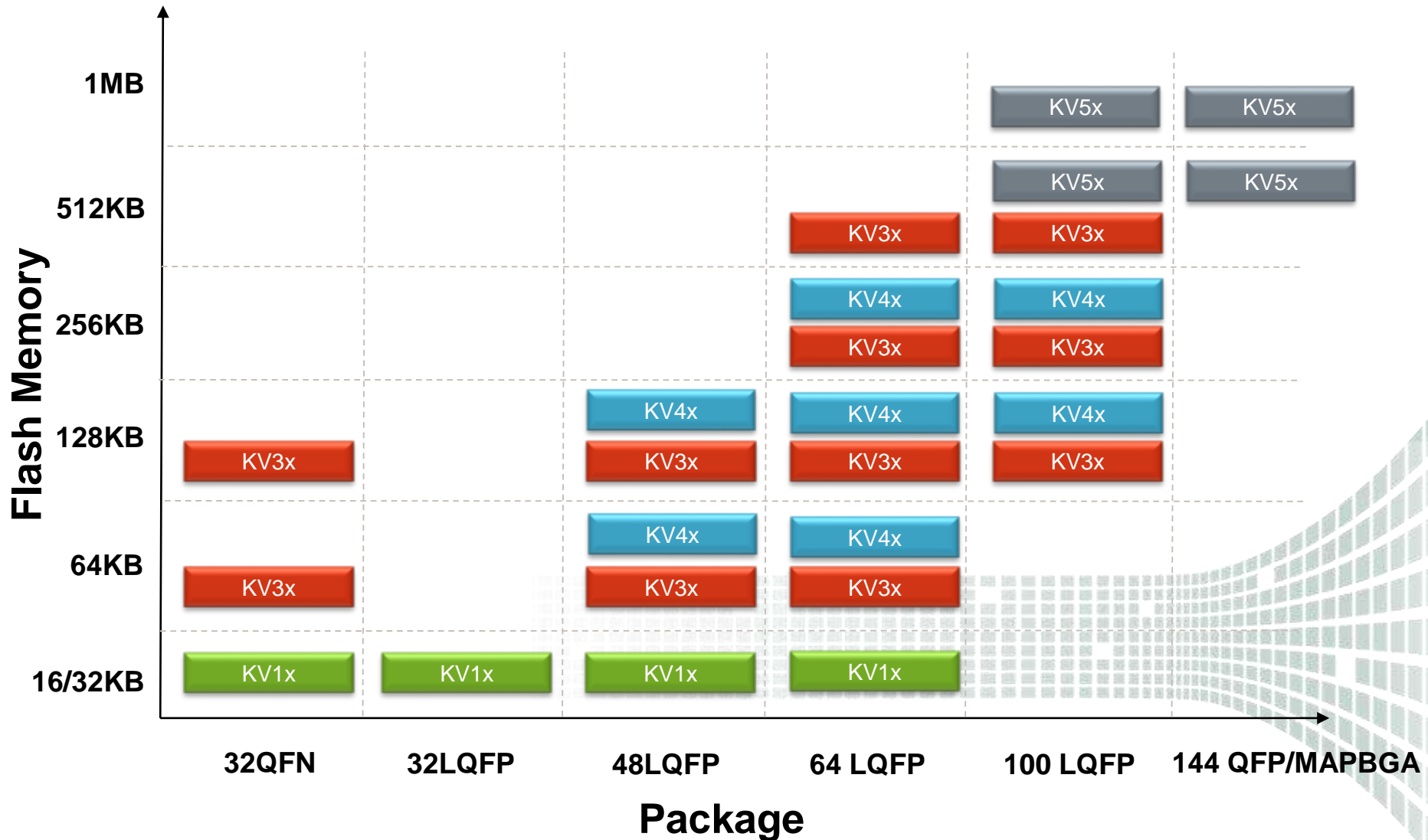
Kinetis V Series: Performance and Feature Scalability

Key Peripherals for Motor and Power Control Applications

MCU Family	Core	Memory	Motor Control Timers		ADC	DAC	ACMP	Comms.	Packages
			Flextimer	eFlexPWM					
KV5x	240MHz CM7 DSP + FPU	512kB-1MB Flash	2 x 8ch 1x 2ch FlexTimer	2 x 12ch eFlexPWM + Nano-Edge	4 x 12bit 5Msps, 1 x 16bit	1x 12-bit	4x ACMP with 6-bit DAC	Ethernet, 3 x CAN	144 pin 100 pin
KV4x	160MHz CM4 DSP + FPU	64-256kB Flash	2 x 8ch 1x 2ch FlexTimer	12ch eFlexPWM + Nano-Edge	2x 12bit 4.1Msps / 1.9Msps	2x 12-bit	4x ACMP with 6-bit DAC	2 x CAN	100 pin 64 pin 48 pin
KV3x	100/120MHz CM4 DSP + FPU	64-512kB Flash	2x 8ch 2x 2ch FlexTimer	-	2x 16-bit 1.2Msps	2x 12-bit	2x ACMP with 6-bit DAC	-	100 pin 64 pin 48 pin 32 pin
KV1x	75MHz CM0+ H/W DIV & SQRT	16-32kB Flash	1x 6ch 2x 2ch FlexTimer	-	2x 16-bit 1.2Msps	1x 12-bit	2x ACMP with 6-bit DAC	1 x CAN	64 pin 48 pin 32 pin

Scalable performance, timing and analog functionality based on application need

Kinetis V Series Package Scalability



Enablement Summary



H/w Development Platforms – MCU Modules

Freedom Platform (FRDM-KVxx)



- Entry-level developer
- Compatible with FRDM motor driver boards (BLDC/PMSM)
- Voltage: 12-48V
- Price: \$20
- Availability:
 - [FRDM-KV10Z](#): Nov'15
 - [FRDM-KV31F](#): Nov'15
- Supported devices
 - KV1x, KV3x

Tower Platform (TWR-KVxx)



- Professional developer
- Highly scalable with large range of plug-in cards including motor driver board (TWR-MC-LV3PH)
- Voltage: 12-50V
- Price: from \$100
- Availability:
 - [TWR-KV10Z32](#): now
 - [TWR-KV11Z75](#): Oct 20th
 - [TWR-KV32F120M](#): now
 - [TWR-KV46F150M](#): now
 - [TWR-KV58F220M](#): Oct 20th
- Supported devices
 - KV1x, KV3x, KV4x, KV5x

High Voltage Platform (HVP-MC3PH)



- 115/230 volt, 1KW 3-ph motor control development platform for BLDC, PMSM and ACIM motors of >1Hp.
- Main board with inverter & PFC circuitry supports plug-in controller cards for Kinetis KV1x/KV3x/KV4x MCUs and MC56Fxxxx DSCs
- Voltage: 85 to 240V
- Price: \$600 (main board + KV46 card)
- Controller cards: KV10/31/46 MCU & 56F827xx DSC (\$50 each)
- Availability:
 - [HVP-MC3PH](#): now (includes [HVP-KV46F150M](#) card)
 - [HVP-KV10Z32](#): now
 - [HVP-KV31F120M](#): now
 - [HVP-KV46F150M](#): now
- Supported devices
 - KV1x, KV3x, KV4x, KV5x

H/w Development Platforms – Motor Driver Modules

Freedom Platform (FRDM-MC-LVxxxx)



- FRDM-MC-LVBLDC: \$30
 - 12V, 5Amp, 60W
 - Trapezoidal control algorithm
- FRDM-MC-LVPMSM: \$50
 - 48V, 5Amp, 240W
 - Sinusoidal control algorithm
- Partner motors available
- Availability:
 - [FRDM-MC-LVBLDC](#): Nov '15
 - [FRDM-MC-LVPMSM](#): Nov' 15
- Supported devices
 - KV1x, KV3x

Tower Platform (TWR-MC-LV3PH)



- Low voltage motor driver module, included BLDC motor
- Voltage: 12-24/50V
- Output: 8Amp, 400W
- Over current & under voltage protection, encoder/hall sensor sensing circuitry
- Supported architectures: 3-phase BLDC & PMSM
- Price: \$249 (includes motor)
- Availability:
 - [TWR-MC-LV3PH](#): now
- Supported devices
 - KV1x, KV3x, KV4x, KV5x

High Voltage Platform (HVP-MC3PH)



- 115/230 volt, 1KW 3-ph motor control development platform for BLDC, PMSM and ACIM motors of >1Hp.
- Main board with inverter & PFC circuitry supports plug-in controller cards for Kinetis KV1x/KV3x/KV4x MCUs
- Voltage: 85 to 240V
- Price: \$600 (main board + KV46 card)
- Availability:
 - [HVP-MC3PH](#): now (includes [HVP-KV46F150M](#) card)
 - [HVP-KV10Z32](#): now
 - [HVP-KV31F120M](#): now
 - [HVP-KV46F150M](#): now
 - [HVP-56F82748](#): now
- Supported devices
 - KV1x, KV3x, KV4x, KV5x



S/w Development Platforms

Freedom Platform (FRDM-MC-LVxxxx)



- BLDC Reference Solution incorporating FSL Embedded Software Library: Q4 2015
- PMSM Reference Solution incorporating FSL Embedded Software Library: Q4 2015
- Kinetis Motor Suite PMSM Position and Sensorless Solutions: Q4 2015

Tower Platform (TWR-MC-LV3PH)



- BLDC Reference Solution incorporating FSL Embedded Software Library
- PMSM Reference Solution incorporating FSL Embedded Software Library
- Kinetis Motor Suite PMSM Position and Sensorless Solutions: Q3 2015

Alpha - now

High Voltage Platform (HVP-MC3PH)



- BLDC Reference Solution incorporating FSL Embedded Software Library
- PMSM Reference Solution incorporating FSL Embedded Software Library
- ACIM Reference Solution incorporating FSL Embedded Software Library: Oct 2015
- Kinetis Motor Suite PMSM Position and Sensorless Solutions: Q4 2015
- Kinetis Motor Suite ACIM Sensorless Solution: Q1 2016

Alpha - now

Alpha - now

H/w Development Platforms – Power Control Solutions

Tower Platform (TWR-LV-SMPS)



- Low voltage, low cost modular board for developing topology used in high voltage, high power applications such as server and telecom power supplies
- Input voltage 20-30V DC or AC-DC adapter with 24V @ 3A
- Output power up to 40 watt, output voltage 5V @ 8A
- Can be used to implement Phase shift full bridge topology
- Price: \$190 (includes simulated load)
- Availability:
 - [TWR-LV-SMPS: now](#)
- Supported devices
 - KV4x, KV5x

High Voltage Platform (HVP-MC3PH)



- 115/230 volt, 1KW 3-ph motor control development platform for BLDC, PMSM and ACIM motors of >1Hp.
- Main board with inverter & **2 phase Boost PFC circuitry supports plug-in controller cards for Kinetis KV1x/KV3x/KV4x MCUs**
- Voltage: 85 to 240V
- Price: \$600 (main board + KV46 card)
- Availability:
 - [HVP-MC3PH: now \(includes HVP-KV46F150M card\)](#)
 - [HVP-KV10Z32: now](#)
 - [HVP-KV31F120M: now](#)
 - [HVP-KV46F150M: now](#)
 - [HVP-KV58F220M: Nov'15](#)
- Supported devices
 - KV1x, KV3x, KV4x, KV5x



S/W Development Platforms – Power Control Solutions

Tower Platform (TWR-LV-SMPS)



- Support for main Digital Power Function for Power Control included in the FSL Embedded Software Libraries.
 - PI compensation $K_p + K_i/s$
 - PID Compensation $K_p + K_i/s + s * K_d$
 - PI+Lowpassfilter $(K_p + K_i/s) * ((s+a)/((s+b)))$
 - 2P 2Z Compensation $(s+a) * (s+b) / ((s+c) * (s+d))$
 - 3P 3Z Compensation $(s+a) * (s+b) * (s+x) / ((s+c) * (s+d) * (s+y))$
- Can be used with any power topology to implement voltage mode, average current mode or peak current mode control.

High Voltage Platform (HVP-MC3PH)



Alpha - now

- Interleaved Boost PFC; Available : Oct 2015
- Output power: 800W
- Input voltage: 90-265V AC
- Output voltage: 390V DC
- 2-phase interleaved boost topology
- Measured quantities: primary current, primary voltage, output voltage,
- Overcurrent fault protection
- Safe development via isolated debug interface, allows development without high voltage
- Supported with complete software reference solution based on KV4x

S/w Enablement Guide

Kinetis Motor Suite



- Integrated h/w & s/w tools that allow any developer to identify, tune and control any type of 3-ph synchronous or asynchronous motor of any power level
- Disturbance rejection control algorithm ensures high performance even in highly dynamic operating conditions
- Motor control algorithms pre-programmed into the MCU
- Intuitive GUI for easy motor configuration & tuning
- Cost: ~20% adder to standard MCU price
- Supported devices
 - KV3x Q315, then KV1x & KV4x

Embedded Software Libraries



- Libraries of software algorithms for Math, Motor Control, Power Conversion, Filters and Advanced functions. ~200 algorithms available
- Core self test library for IEC60730 with UL Certifications for CM0+
- Free option: binary code released through FSL.com
- Paid option: source code, optimized code, advanced functions (including patented)
- **Cost: free of charge**
- Supported devices
 - KV1x, KV3x, KV4x,
 - KV5x (Oct '15)

Kinetis SDK & Processor Expert Code Generator



- SDK – a complete software framework for developing applications across all Kinetis MCUs. h/w abstraction, peripheral drivers, stacks, RTOS's, utilities, and usage examples; delivered in C source
- Processor Expert – GUI Eclipse plug-in tool for creating and configuring software and peripheral drivers quickly & easily
- **Cost: free of charge**
- Supported devices
 - KV1x, KV3x & KV4x
 - KV5x (Oct '15)

MQX RTOS



- Commercial-grade MCU software platform at no cost with optional support packages
- RTOS Kernel, Real Time TCP/IP Communication Suite, File System, USB Host/Device Stack and Board Support Packages
- **Cost: free of charge**
- Supported devices
 - KV3x & KV4x
 - KV5x (Oct '15)



S/w Enablement Guide

MCAT

(Motor Control Application Tuner)



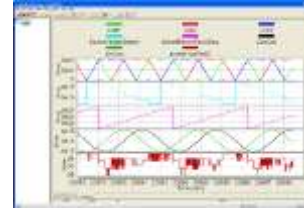
- Complimentary GUI based run-time debug monitor and data visualization tool
- Replaces debugger in situations when the core can not be simply stopped, ideal for motor control and power conversion application development
- <http://www.youtube.com/watch?v=vKVlXu8ecdg>
- **Cost: free of charge**
- Supported devices
 - KV1x, KV3x, KV4x,
 - KV5x (Sept '15)

FreeMASTER



- GUI based FreeMASTER plug-in tool that provides real-time monitoring, tuning and updating of motor control system parameters
- Provided as a plug-in for the FreeMASTER tool. Designed to work with FSL Ref. Design s/w
- <http://www.youtube.com/watch?v=ZsLQzSTnhg0>
- **Cost: free of charge**
- Supported devices
 - KV1x, KV3x, KV4x,
 - KV5x (Sept '15)

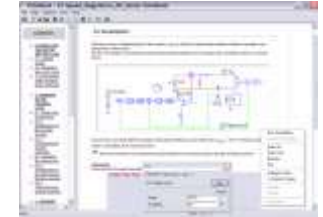
Motor Control Toolbox



- MATLAB™/Simulink™ modelling environment motor control plug-in tool for automatic code generation. Supports multiple compilers. FreeMASTER compatible.
- <http://www.youtube.com/watch?v=5pTuOEwq78g>
- Cost: \$8K license cost
- Supported devices
 - KV1x, KV3x, KV4x
 - KV5x (Q3/5 2015)

POWERSIM

Motor Control Design Suite



- Low cost Simulation software specifically designed for power electronics and motor drives
- Cost: \$700 (1st license)
- Supported devices
 - KV3x (Now)
 - Others to follow



Motor Control Reference Solutions

Building on FSL Embedded Software Libraries

Motor Topology	Product Supported	HW Platform	Target Applications	Availability
PMSM Sensorless FOC	KV1x, KV3x, KV4x,	TWR-MC-LV3PH HVP FRDM	General drives, Pumps	Now FRDM - Nov
BLDC Sensorless Trapezoidal	KV1x	TWR-MC-LV3PH	Fan, Pumps	Now
PMSM Zero-speed Sensorless FOC	56F8xxxx	TWR-MC-LV3PH HVP	e-scooter	Now
ACIM Sensorless FOC	KV5x, (KV4x, KV3x)	HVP	Pumps, Fan	Alpha Now October 2015
Dual BLDC Trapezoidal Control	KV11	TWR-MC-LV3PH	Appliances	Now
Dual PMSM Sensorless FOC	KV5x	TWR-MC-LV3PH	lot Motor Control	Oct'15

Availability

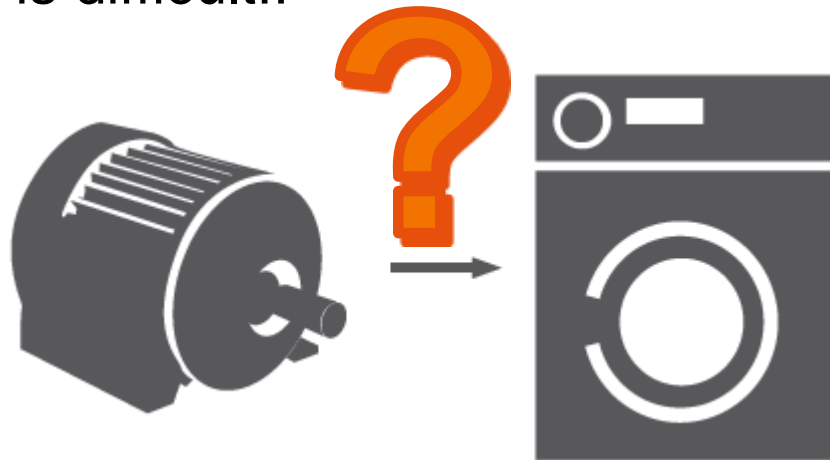
	Embedded Software Libraries	SDK	KDS	PEx	Kinetis Motor Suite	MQX
KV1x 16 & 32kb	Now	Now	Now	Now	NA	Not Available
KV1x 64 & 128kb	Now	Now	Now	Now	Q4'15	Now
KV3x	Now	Now	Now	Now	Nov'15	Now
KV4x	Now	Now	Now	Now	Q1'16	Now
KV5x	Oct'15	Oct'15	Oct'15	Oct'15	NA	Oct'15

Kinetis Motor Suite (KMS) Motor Control Software



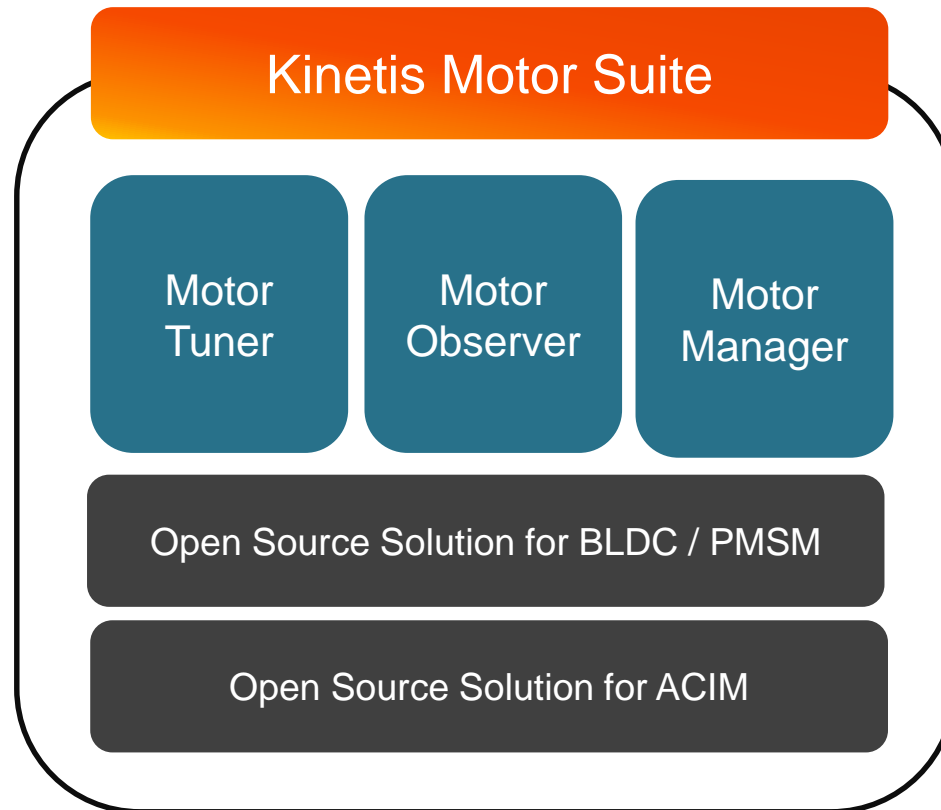
Motor Control needs a PhD!

- Too Hard to Tune! - I can never get the right level of performance
- Too Hard to Debug! - When I have a problem its difficult to resolve
- Takes Too Long! - PID tuning takes months to get right
- Needs Special Expertise! - Need a motor control expert
- Even after I have done all that, it Still Doesn't Work Right!
- Motor Control is difficult!!



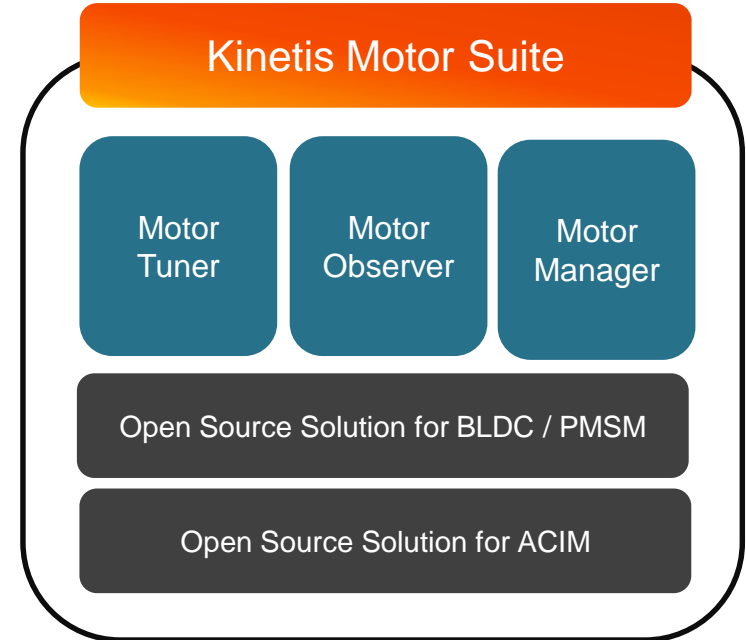
New Kinetis Motor Suite

- Kinetis Motor Suite is a software solution that provides all the low level and middleware software required to tune and control your motor.
- Lets our customers focus their resources on their end application, removing the complex and time consuming task of motor control solution development.



New Kinetis Motor Suite

- KMS focus's on 2 key areas:
 1. **Simplicity**
 - On-chip expertise eliminates the need for in-depth knowledge of motor control, allowing those with limited experience to develop an application.
 - All motor configuration and control carried out through the graphical user interface, or the dedicated API
 - Single digit tuning replaces labor-intensive, outdated PID tuning
 - State Machine Builder enables you to graphical define the operating states and the conditions that force the transitions between them.

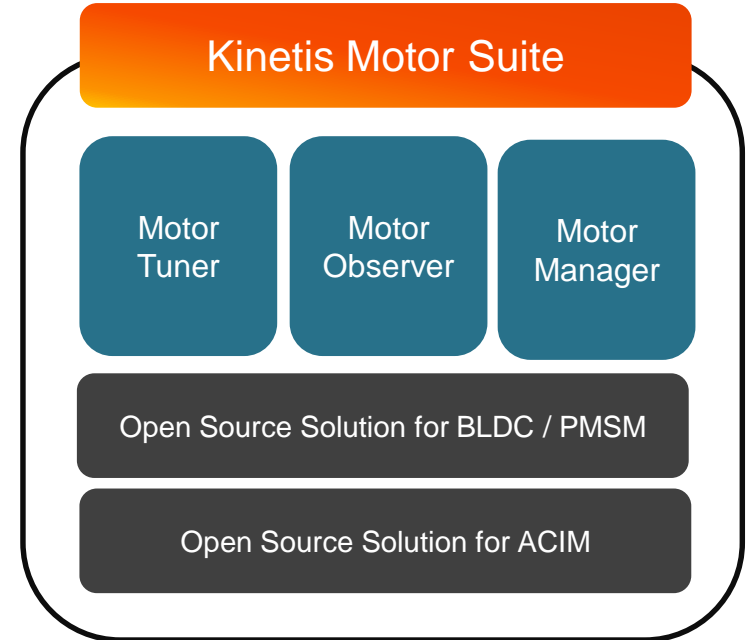


New Kinetis Motor Suite

- KMS focus's on 2 key areas:

2. *Performance*

- The system can dynamically compensate “on the fly” for changes in load and speed due to wear and tear on the motor or the surrounding mechanical system.
- Extends machine life, improves energy efficiency and performance.
- Compensates for motor variation in mass production, simplifying production process.



Design Principles

Radical Simplicity

Pre-programmed, on-chip expertise connected to streamlined user interface

Powerful Performance

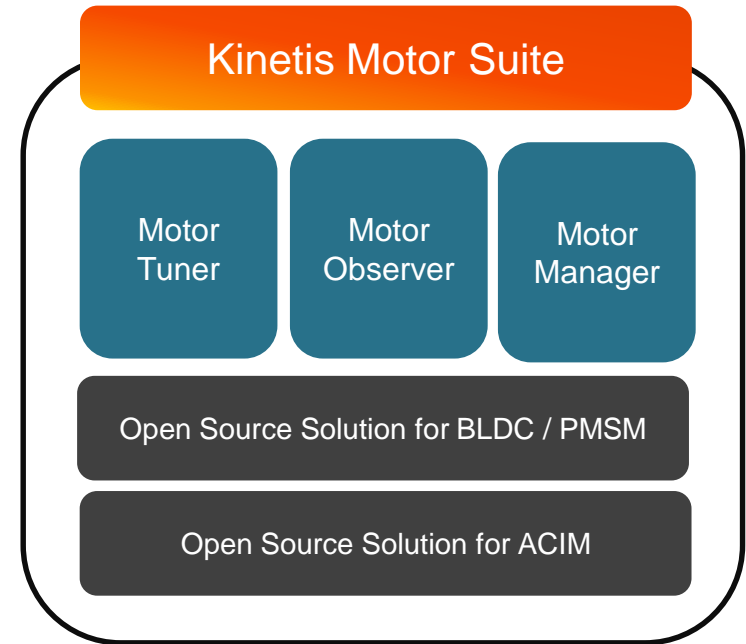
Dynamic compensating control that increases system performance & efficiency

Designed for the User

Enables any developer, regardless of experience, to efficiently run a motor out of the box

Kinetis Motor Suite - Components

- KMS consists of 4 main components:
- **Motor Tuner:**
 - Wizard for initial motor configuration – gets your motor spinning in 5 steps
- **Motor Manager:**
 - Application development environment where customers access and update real-time system components during their application development.
- **Motor Observer:**
 - Factory programmed flash with embedded motor control firmware for dynamic motor tuning and control.
- **Open Source Solution:**
 - The open source project with the motor control firmware configured via the GUI, and also accessible via an API.



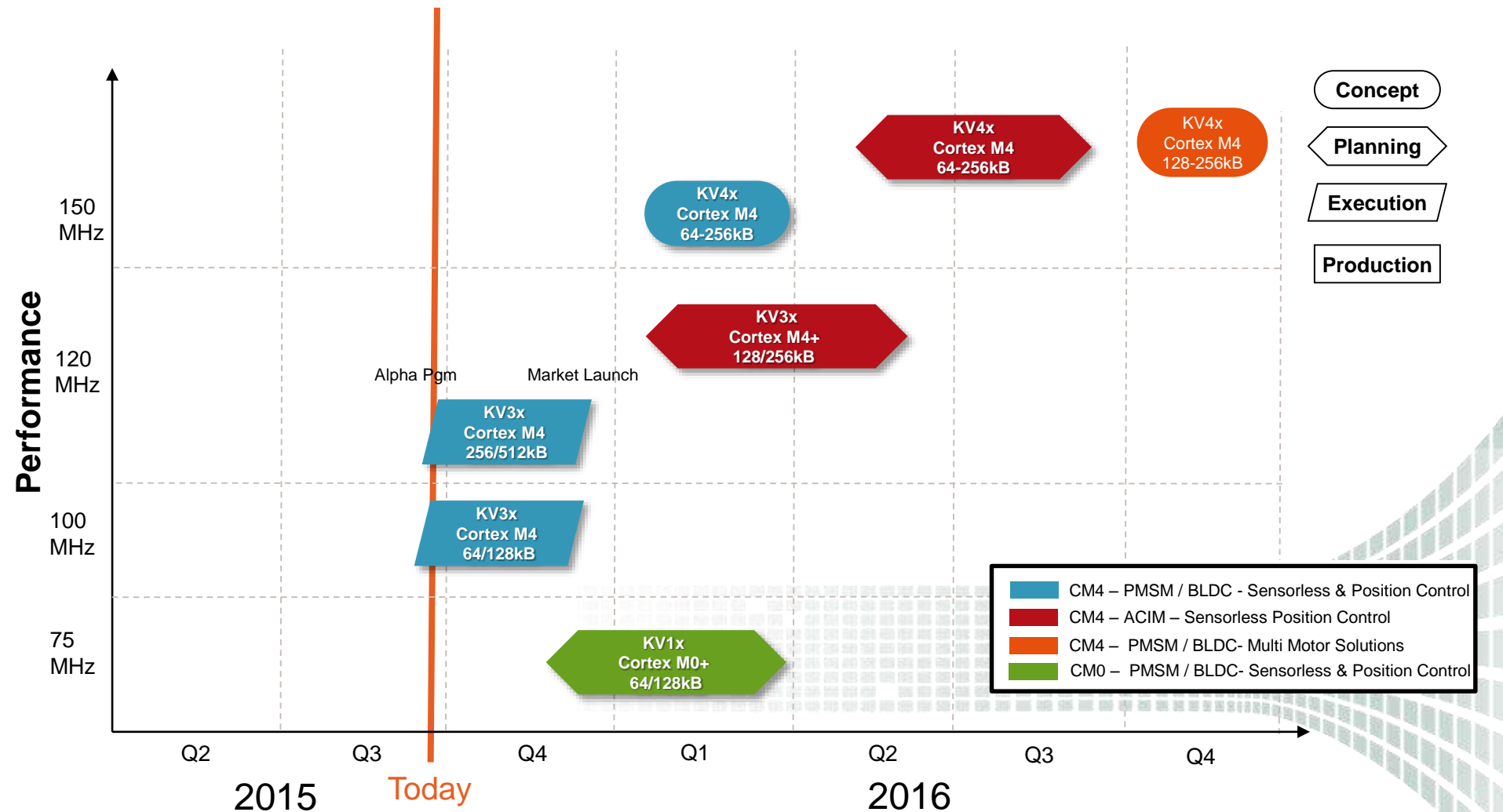
Kinetis V Series KV3x: Family Overview

Sub-Family	Part Number	Max. Freq.	Package	Flash	SRAM	Flex. Bus	DMA	PLL / FLL	FTMs	DAC	GPIO	I/O with Digital Filters	Suggested Resale Price (10K#)	Availability 'PK' engineering 'MK' production
KV31	MKV31F512VLL12	120MHz	100LQFP	512K	96KB	Yes	16-ch	PLL	2x8ch; 2x2ch	2	70	16	\$2.76	MK Now
	MKV31F512VLH12	120MHz	64LQFP	512K	96KB	Yes	16-ch	PLL	2x8ch; 2x2ch	2	46	16	\$2.63	MK Now
	MKV31F256VLL12	120MHz	100LQFP	256K	48KB	No	16-ch	PLL	1x8ch; 2x2ch	1	70	8	\$2.19	MK Now
	MKV31F256VLH12	120MHz	64LQFP	256K	48KB	No	16-ch	PLL	1x8ch; 2x2ch	1	46	8	\$2.06	MK Now
	MKV31F128VLL10	100MHz	100LQFP	128K	24KB	No	4-ch	FLL	1x8ch; 2x2ch	1	70	8	\$1.83	MK Now
	MKV31F128VLH10	100MHz	64LQFP	128K	24KB	No	4-ch	FLL	1x8ch; 2x2ch	1	46	8	\$1.71	MK Now
KV30	MKV30F128VLH10	100MHz	64LQFP	128K	16KB	No	4-ch	FLL	1x8ch; 2x2ch	1	46	8	\$1.66	MK Now
	MKV30F128VLF10	100MHz	*48LQFP	128K	16KB	No	4-ch	FLL	1x8ch; 2x2ch	1	35	8	\$1.53	MK Now
	MKV30F128VFM10	100MHz	32QFN	128K	16KB	No	4-ch	FLL	1x8ch; 2x2ch	1	26	8	\$1.40	MK Now
	MKV30F64VLH10	100MHz	64LQFP	64K	16KB	No	4-ch	FLL	1x8ch; 2x2ch	1	46	8	\$1.46	MK Now
	MKV30F64VLF10	100MHz	48LQFP	64K	16KB	No	4-ch	FLL	1x8ch; 2x2ch	1	35	8	\$1.33	MK Now
	MKV30F64VFM10	100MHz	32QFN	64K	16KB	No	4-ch	FLL	1x8ch; 2x2ch	1	26	8	\$1.19	MK Now
KMS Enabled*	MKV31F512VLL12P	120MHz	100LQFP	512K	96KB	Yes	16-ch	PLL	2x8ch; 2x2ch	2	70	16	\$3.31	Oct'15
	MKV31F256VLH12P	120MHz	64LQFP	256K	48KB	No	16-ch	PLL	1x8ch; 2x2ch	1	46	8	\$2.47	Oct'15
	MKV31F128VLH10P	100MHz	64LQFP	128K	24KB	No	4-ch	FLL	1x8ch; 2x2ch	1	46	8	\$1.99	Oct'15
	MKV30F64VLF10P	100MHz	48LQFP	64K	16KB	No	4-ch	FLL	1x8ch; 2x2ch	1	35	8	\$1.59	Oct'15

* Initial part offering. Other parts available on request.



Kinetis Motor Suite (KMS) Availability Roadmap



KMS H/w Platforms – MCU Modules

Freedom Platform (FRDM-KV31)



- Entry-level developer
- Compatible with FRDM motor driver boards (BLDC/PMSM)
- Pre-programmed with Kinetis Motor Suite Nov'15
- Voltage: 12-48V
- Price: \$20
- Availability:
 - FRDM-KV31F: Nov '15

Tower Platform (TWR-KV31)



- Professional developer
- Highly scalable with large range of plug-in cards including motor driver board (TWR-MC-LV3PH)
- Voltage: 12-50V
- Price: from \$100
- Availability:
 - TWR-KV31F120M: Pre-programmed with Kinetis Motor Suite Nov'15

High Voltage Platform (HVP-MC3PH)



- 115/230 volt, 1KW 3-ph motor control development platform for BLDC, PMSM and ACIM motors of >1Hp.
- Main board with inverter & PFC circuitry supports plug-in controller cards for Kinetis KV1x/KV3x/KV4x MCUs and MC56Fxxxx DSCs
- Voltage: 85 to 240V
- Price: \$600 (main board + KV46 card)
- Controller cards: KV10/31/46 MCU & 56F827xx DSC (\$50 each)
- Availability:
 - HVP-MC3PH: now
 - HVP-KV31F120M: Pre-programmed with Kinetis Motor Suite Nov'15



KMS H/w Platforms – Motor Driver Modules

Freedom Platform (FRDM-MC-LVPMSM)



- FRDM-MC-LVPMSM: \$50
 - 48V, 5Amp, 240W
 - Sinusoidal control algorithm
- Partner motors available
- Availability:
 - [FRDM-MC-LVPMSM: Nov'15](#)
- Supported devices
 - KV1x, KV3x

Tower Platform (TWR-MC-LV3PH)



- Low voltage motor driver module, included BLDC motor
- Voltage: 12-24/50V
- Output: 8Amp, 400W
- Over current & under voltage protection, encoder/hall sensor sensing circuitry
- Supported architectures: 3-phase BLDC & PMSM
- Price: \$249 (includes motor)
- Availability:
 - [TWR-MC-LV3PH: now](#)
- Supported devices
 - KV1x, KV3x, KV4x, KV5x

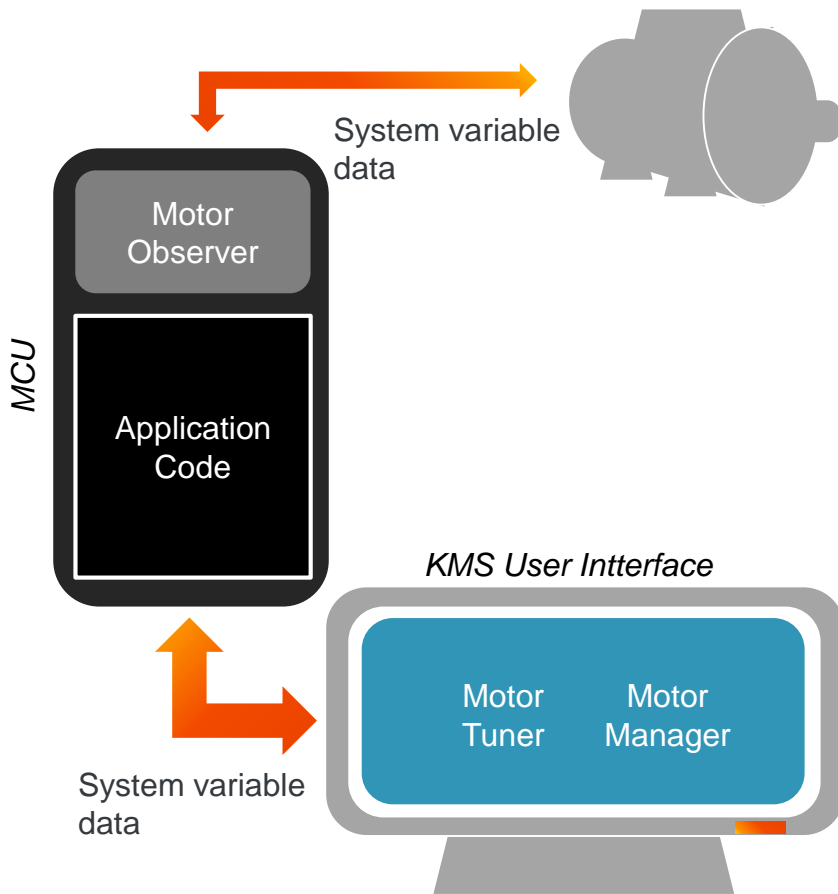
High Voltage Platform (HVP-MC3PH)



- 115/230 volt, 1KW 3-ph motor control development platform for BLDC, PMSM and ACIM motors of >1Hp.
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- Voltage: 85 to 240V
- Price: \$600 (main board + KV46 card)
- Availability:
 - HVP-MC3PH: now (includes HVP-KV46F150M card)
 - HVP-KV10Z32: now
 - [HVP-KV31F120M: Nov for KMS](#)
 - HVP-KV46F150M: now
 - HVP-56F82748: now
- Supported devices
 - KV1x, KV3x, KV4x, KV5x



New Kinetis Motor Suite



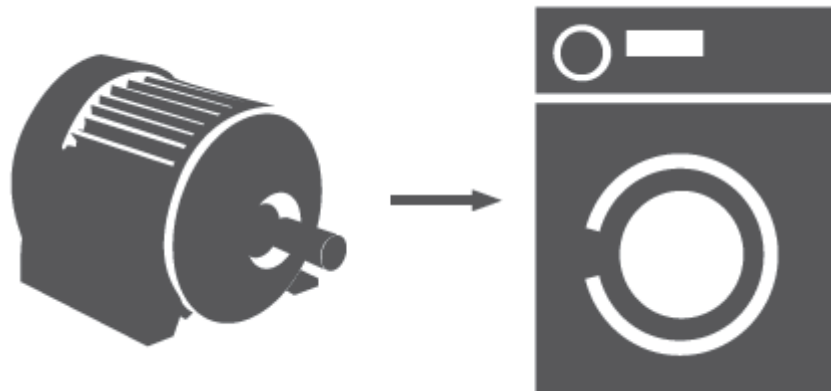
Customer Design Flow

1. Identify Motor Parameters
2. Identify Application Inertia
3. Tune Speed Regulator
4. Build Motion Profiles and Application State Machine
5. Test Profiles with real application loads and debug.

Target Applications

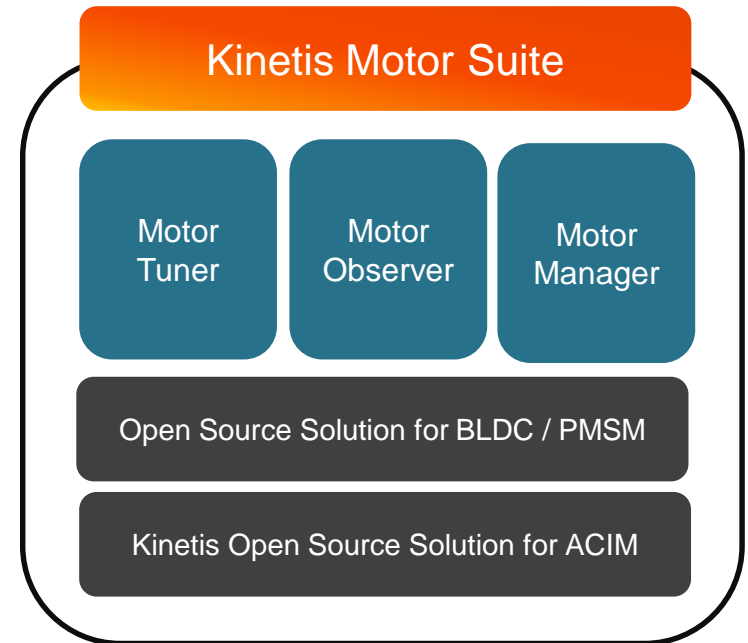
- Fans
- Pumps
- Compressors
- HVAC
- Appliances
- Blenders
- Dishwasher
- Air Filters
- Power Tools
- Robotics
- Pick-and-place
- Conveyor Belts
- Factory Automation
- Winders
- CNC Machines
- 3-D Printers
- Wind Power

...or anywhere there is a 3ph motor



Kinetis Motor Suite

- Will simplify your design, and reduce your time to market
- Increase you system efficiency and performance and reduce your wear
- Solutions for all levels of experience
 - Motor solutions for those that know a little of their application or want to customize the solution
- **Available in NOW in Alpha version on Kinetis KV3x with PMSM support.**
- Production version of KV3x with Sensorless and Position control in November '15
- Additional families rolling out over the next 12 months.



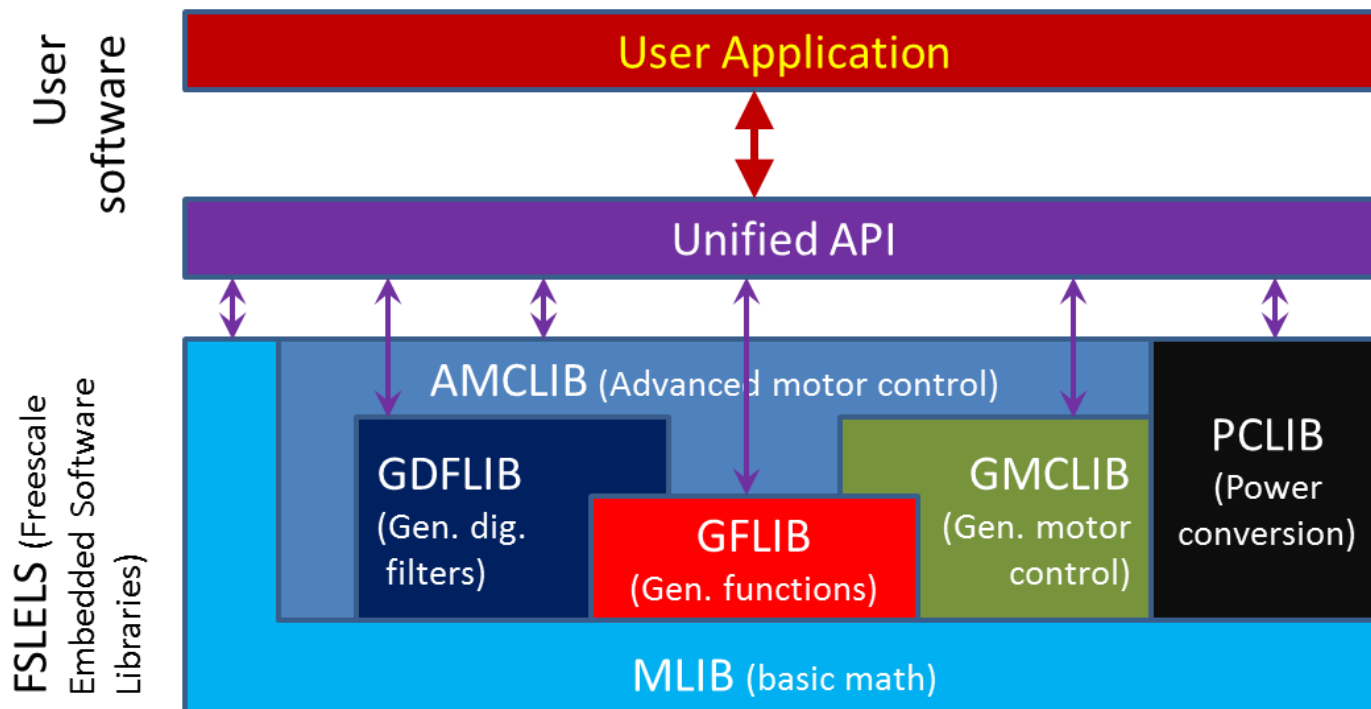
Embedded Software Libraries

<http://www.freescale.com/fslesl>



Freescale Embedded Software Libraries

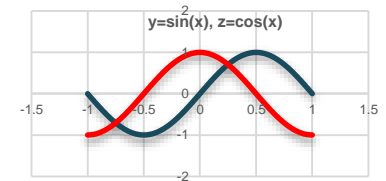
- Libraries of s/w algorithms for Math, Motor Control, Power Conversion, Filters and Advanced functions
 - Supports Kinetis MCUs, DSCs and key compilers (CW, KDS, IAR, Keil)
 - Algorithms tested extensively through MATLAB Simulink reference models
 - Version 4.0 includes optimized M0+ libraries for Motor Control, and the new Power Conversion Library
 - Version 4.1 will add H/W Sqr & Div capability for KV10 & KV11 – Available June 22nd
-
- **Free of charge** : Binary code released through FSL website
 - **Paid**: Source code, optimized code, advanced functions (including patented)



Library Structure

- **Math Library (MLIB)**

- Simple math functions (addition, subtraction, multiplication, division, shifts...) with and without saturation. Efficient, fast mathematics built on the MCU's instructions.

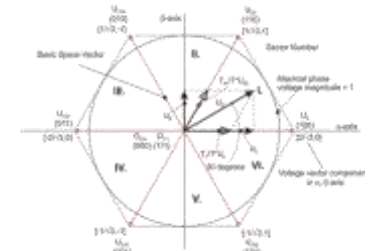


- **General Function Library (GFLIB)**

- Basic building blocks of a real-time control application. Functions for basic mathematical calculations, trigonometric functions, simple look-up table and control functions such as PI and PID controllers.

- **General Motor Control Library (GMCLIB)**

- Fundamental functional blocks of a motor control application including vector modulation, Park and Clarke transformations and specific functions to build digitally controlled motor drives.

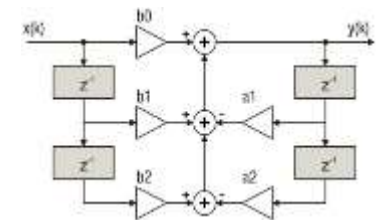


- **General Digital Filter Library (GDFLIB)**

- Includes filter functions for signal conditioning.

- **Advanced Motor Control Library (AMCLIB)**

- Functions that enable the construction of a variable speed, AC motor drive system that implements FOC techniques without position or speed sensors to provide the lowest cost solution.



- **Power Control Library (PCLIB)**

- Control loop algorithms required in Power Control applications.

PCLib (Digital Power Control Library): Overview

- **Library Provides:**

- Optimized and tested algorithms
- Full algorithms documentation
- S/W library in “.lib” form that can be included into any project

- **Algorithms:**

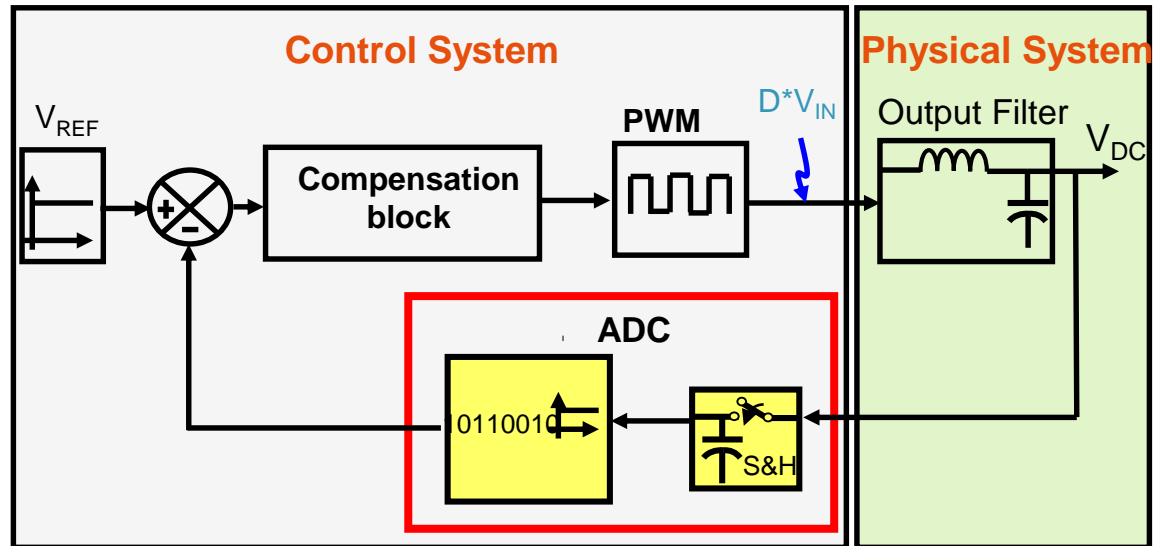
- ASM and C coded
- Optimized
- C callable interface
- fully tested using MATLAB

- **Compensation block:**

- PI compensation $K_p + K_i/s$
- PID Compensation $K_p + K_i/s + s \cdot K_d$
- PI+Lowpassfilter $(K_p + K_i/s) \cdot ((s+a)/(s+b))$
- 2P 2Z Compensation $(s+a) \cdot (s+b) / ((s+c) \cdot (s+d))$
- 3P 3Z Compensation $(s+a) \cdot (s+b) \cdot (s+x) / ((s+c) \cdot (s+d) \cdot (s+y))$

- The power conversion control loop library can be used with any power topology to implement voltage mode, average current mode or peak current mode control.

- Power Factor Correction / AC-DC Converter / DC-DC Converter / DC-AC Inverter
- Solar Inverter / Solar Charger
- Grid Connected Inverter / On-line, Off-line UPS

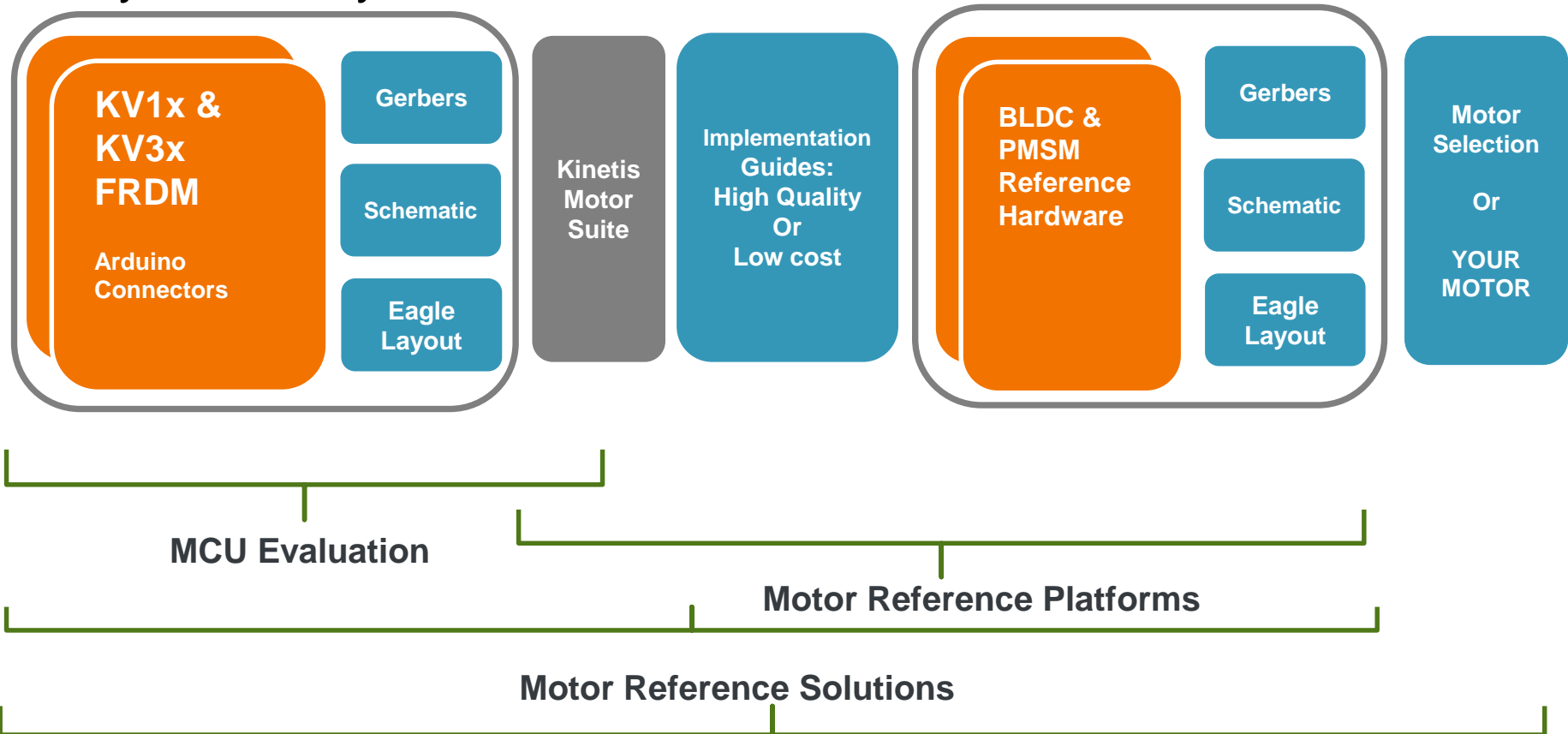


Kinetis V Series Freedom Development Platform



FRDM Solution – Motor Developer Kits – <\$100 ASP

- Provides a complete low cost solution that includes software and hardware that a customer can use as specified in production, or they can easily customize to their own needs.



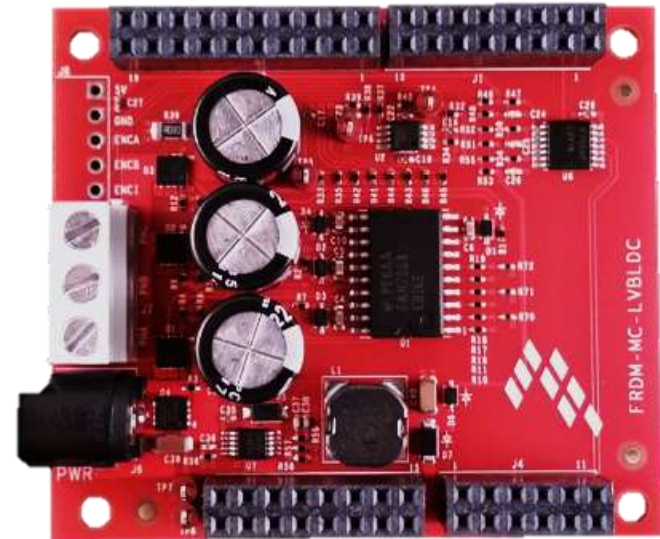
Kinetis V Series Freedom Development Platform

FRDM-KV10Z



- **Kinetis KV10 MCU Freedom Board**
 - 75MHz Cortex-M0+ MCU, 32KB Flash, FlexTimers, 16-bit ADC, 48LQFP
 - FXOS8700CQ accelerometer
 - OpenSDA Debug Interface (K20 MCU)
 - USB powered in stand-alone mode
 - IO Headers – Arduino™ R3 compatible

FRDM-MC-LVBLDC

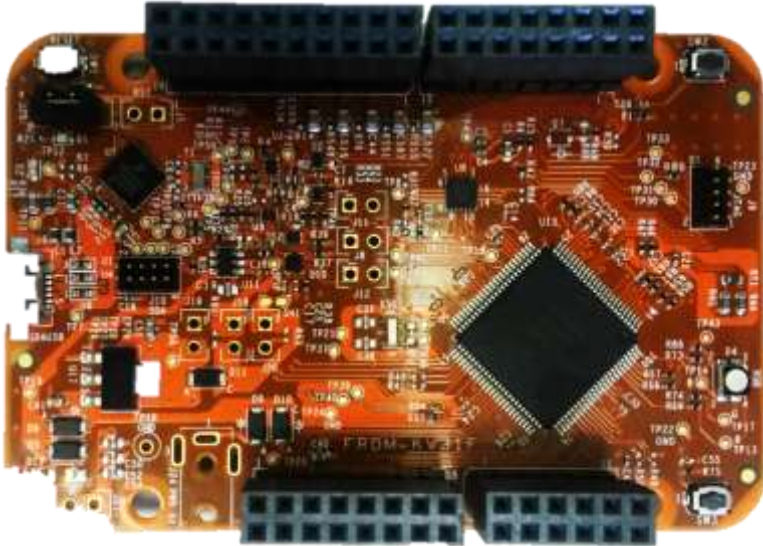


- **Low Voltage 3-ph BLDC Driver Board (up to 12V)**
 - Trapezoidal control algorithm
 - Fairchild half-bridge gate drivers & power MOSFETs
 - FAN7888MX 3ch half bridge gate driver
 - FDMC8030 40V dual N-channel power MOSFETs
 - FAN4852IMU8X low-power amplifier



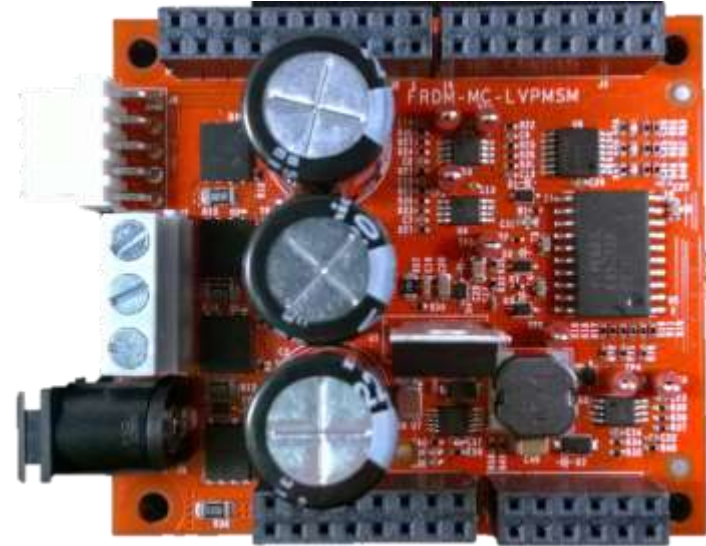
Kinetis V Series Freedom Development Platform

FRDM-KV31F



- **Kinetis KV31 MCU Freedom Board**
 - 120MHz Cortex-M4, 512KB Flash, FlexTimers, 16-bit ADC, FlexBus, 100LQFP
 - FXOS8700CQ accelerometer
 - OpenSDA Debug Interface (K20 MCU)
 - USB powered in stand-alone mode
 - IO Headers – Arduino™ R3 compatible

FRDM-MC-LVPMSM



- **Low Voltage 3-ph PMSM Driver Board (up to 48V)**
 - FOC control algorithm
 - Fairchild half-bridge gate drivers & power MOSFETs
 - FAN7888MX 3ch half bridge gate driver
 - FDMC8090 100V dual N-channel power MOSFETs
 - FAN4852IMU8X low-power amplifier

Kinetic V Series: KV5x Quadcopter Demo

Tear Down



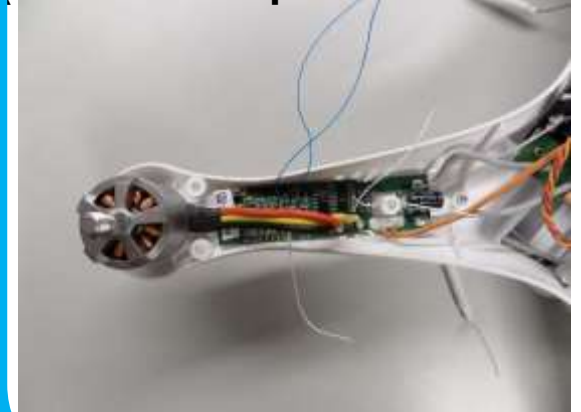
Disassembly:

<https://www.youtube.com/watch?v=YqmdU4bFe3w>

Flight Control Unit



ESC
Embedded Speed Controller



Parts being replaced with FSL ICs

ESC BOM (4 ESCs per drone) (partial list - only relevant items)	Part Number
Motor	DJI 2212 920kv
MCU (1 MCU per ESC, 4 in total)	C8051F330 MPU 8K
Transistors (Q2, Q3, Q4), 3 of	NXP PUMH10
Transistors (Q5, Q6, Q7), 3 of	NXP PUMZ1
Power MOSFETS (Q8, Q10, Q12)	AO4430 (IRF7455)
Power MOSFETS (Q9, Q11, Q13)	AO4407A (IRF7425)



- 4 ESC modules per drone
- Each ESC module contains 1 x SiLabs 8-bit 8051 MCU, and 3 x NXP PUMH10 and 3 x NXP PUMZ1 MOSFETS which drive the gates discretely
- Basic PWM based control scheme used between flight control unit and motor controller
 - PWM command from Flight Control unit determines applied voltage on the motor



Kinetis V Series: KV5x Quadcopter Demo

New FSL ESC Module (KV5x MCU & GD3000 Motor Driver IC)



- **1x KV5x MCU** driving all 4 motors using 6-step BLDC open loop control algorithm
Replaces 4x 8-bit MCUs!!
- KV4x (Cortex-M4) design also available
- **4x MC34GD3000 motor pre-drivers** - existing MC34937A in 56QFN, 8x8mm **Replaces 24 transistors!!**
- KV5x ESC design could be expanded to include
 - FOC algorithm...for quieter motor operation e.g. filming applications
 - 'NAZA' Flight Stability Controller using FSL GYRO

Summary

- Scalable, low-power MCUs for next-generation motor control and digital power conversion applications
 - **Addressing market requirements**

Cortex-M series MCUs with performance, analog and timing IP for every motor control use case. Advanced DSC peripherals for the most demanding motor control and power conversion systems.
 - **Product family scalability**

From the industry's fastest Cortex-M0+ MCU, to 240 MHz Cortex-M7 MCUs with FPU. Multiple memory, peripheral and package options for evolving end product feature and price requirements.
 - **Enabling every customer**

Class-leading tools including free software libraries and the new Kinetis motor suite designed for simpler, faster and more cost-effective system development.

www.freescale.com/kinetis/vseries



www.Freescale.com