Kinetis MCUs based on ARM® Cortex™-M4 and ARM Cortex-M0+ Cores: Status, New Products and Roadmaps

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Global Kinetis Product Marketing

Microcontrollers Business Unit

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Microcontroller Markets

Market Dynamics

WSTS – Revenue 6MMA

Legend: 4 BIT$ — 8 BIT$ — 16 BIT$ — 32 BIT$
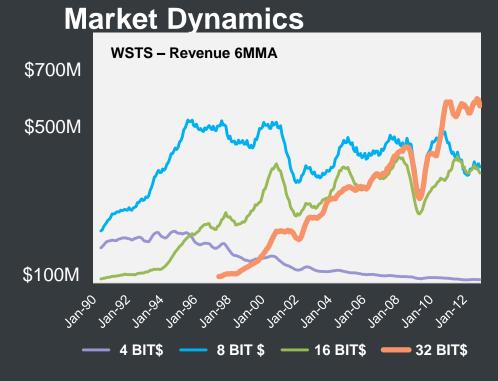
- 32-bit architectures over 40% of total MCU
- 8-bit down 23% in 2 yrs; $5.3B '10 to $4.1B '12
- 32-bit has become the key market growth driver with ARM architecture leading

Market Trends …

- Internet of Things (IoT)
    - Security & connectivity

- Software as building blocks to get to market faster

- Low power

- Human Machine Interface (HMI)

- Miniaturization: smaller form factor

INTERNET OF THINGS

Different Services,
Different Technologies
Different Meanings for Everyone

And the Word
"SMART"
Is Everywhere!

Our Vision

Be the leader in the broad-based and connected MCU market supporting the Internet of Things (IoT)

Smart Lighting

Smart Grid

Pedestrian Navigation

Remote Appliance Avoidance

Smart Cars

Smart Homes

M2M

BLDG Automation

MANY OTHER SERVICES

Auto Safety

Smart Tags

Smart Parking

Air Quality Control

Supply Chain Automation

Smart Health

Smart Energy

Technology Innovations

Miniaturization & advances in packaging technologies

Advances in flash

New class of powerful but low-cost & low-power MCUs

Cloud-based services

Applications

Software

Technology

Sensing
Accelerometer
Magnetometer
Gyroscope
Pressure
Altimeter
Temperature etc.

Embedded Processing
MCU
MPU
Hybrid MCU/MPU
Network Processor

Connectivity
NFC   GPS
6LoPAN   BT/BTLE
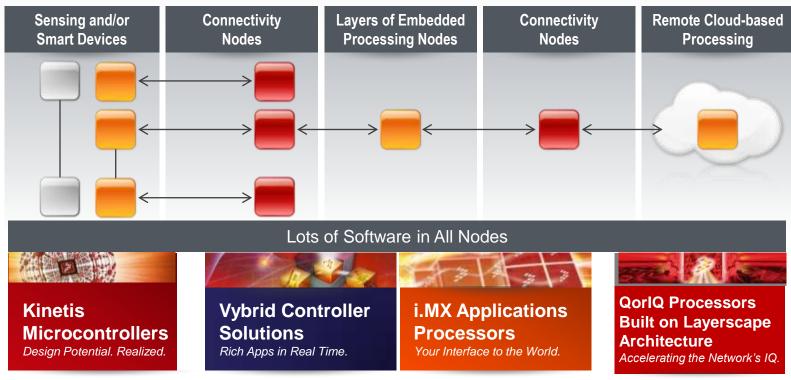Sub-Gig   Wi-Fi®
ZigBee®   RFID
              Cellular

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4

Internet of Things Building Blocks

Freescale has the industry's broadest range of solutions built on ARM® technology for industrial, consumer, automotive and networking applications.

Sensing and/or Smart Devices	Connectivity Nodes	Layers of Embedded Processing Nodes	Connectivity Nodes	Remote Cloud-based Processing

Lots of Software in All Nodes

Kinetis Microcontrollers
Design Potential. Realized.

Industry's most scalable ultra-low-power, mixed-signal MCU solutions based on the ARM® Cortex™-M and Cortex™-M0+ architectures.

Vybrid Controller Solutions
Rich Apps in Real Time.

Real-time, highly integrated solutions with best-in-class 2D graphics to enable your system to control, interface, connect, secure and scale.

i.MX Applications Processors
Your Interface to the World.

Industry's most versatile solutions for multimedia and display applications, with multicore scalability and market-leading power, performance & integration.

QorIQ Processors Built on Layerscape Architecture
Accelerating the Network's IQ.

Industry's first software-aware, core-agnostic networking system architecture for the smarter, more capable networks of tomorrow – end to end.

**Find your ideal solution at the price, performance and power level you desire,
and leverage the extensive software and tool bundles available to speed and ease your design process.**

Strategic R&D Investments

Kinetis
MCUs

- Industry's most scalable portfolio built on the ARM® architecture
- Industry-first ARM Cortex™-M4 MCU
- Industry-first ARM Cortex-M0+ MCU

ARM

Vybrid
Controller Solutions

- Unique asymmetrical-multiprocessing architecture
- Real-time, highly integrated solutions with best-in-class 2D graphics

ARM

i.MX
Applications Processors

- Number 1 eReader processor
- First quad-core for mobile devices
- Multimedia with power efficiency

ARM

Fully Refreshed And Expanded Portfolio:
Industry's Widest Portfolio of ARM Based MCU + MPU Products

Performance ↑

Integration →

i.MX Applications Processors
Your Interface to the World.

i.MX6 Availability NOW!

Availability NOW!

Vybrid Controller Solutions
Rich Apps in Real Time.

Availability NOW!

Kinetis K Series
Industry-first **ARM Cortex-M4** MCU families from 50MHz / 32KB with low power, FlexMemory, mixed-signal and broad connectivity, HMI and security features.

Availability NOW!

Kinetis E Series
Robust, 5V **ARM Cortex-M0+ & ARM Cortex-M4** MCU families for use in high electrical noise environments. Safety features for high-reliability applications.

Availability NOW!

Kinetis L Series
Ultra-low power/cost ARM Cortex-M0+ MCU families from 48MHz / 8KB with mixed-signal, connectivity and HMI features in low pin-count packages.

General Purpose

- -

Segment Focused

Kinetis W Series
Integrated wireless connectivity **ARM Cortex-M4 and M0+** MCU families with class-leading sub-1 GHz and 2.4 GHz RF transceivers.

Leading Performance - Low Power - Scalability - Industrial-grade Reliability & Temp

Freescale Bundled IDE, RTOS & Middleware - Rapid Prototyping Platform - Broad ARM Ecosystem Support

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Kinetis Enablement Overview

Kinetis MCU

ARM Cortex-M0+ Core
48MHz, 1.77 CoreMark/MHz, 2-Stage Pipeline, 1-Cycle GPIO, Micro Trace Buffer

ARM Cortex-M4 Core
50-150MHz, 3.40 CoreMark/MHz, HW-divide, MAC, DSP-commands, FPU option

Differentiators
Low-power, Performance, Flex-Memory, Mixed-Signal, Security, HMI Features

Special Functions
Analog Pre-Processing, 24b-Sigma Delta ADC, sub -1GHz & 2.4 GHz Transceiver

Enablement

Freescale Bundle

Hardware
Freedom board, Tower Platform

Software
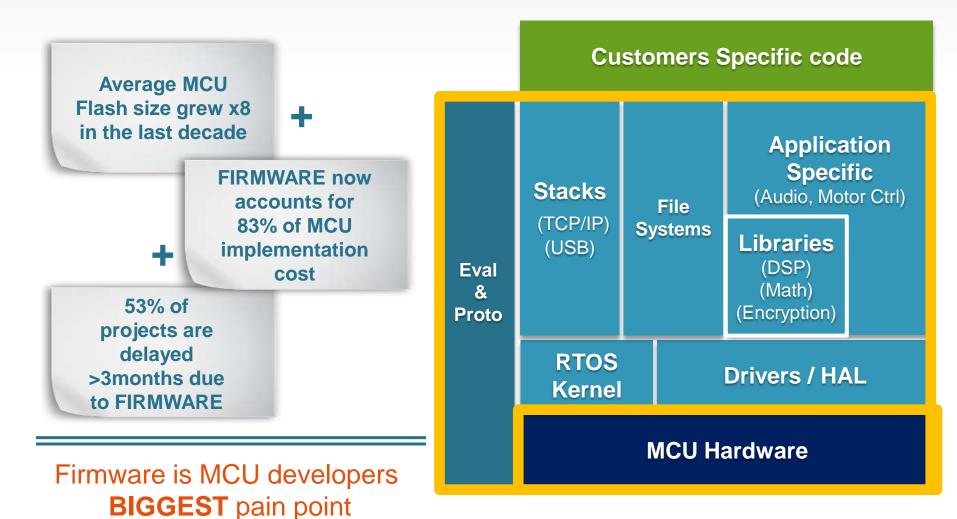CodeWarrior, Processor Expert, Driver Suite, eGUI, PEG, FreeMASTER

RTOS
MQX, MQX Lite

ARM Eco System

Growing Importance of Enablement

Average MCU Flash size grew x8 in the last decade

+

FIRMWARE now accounts for 83% of MCU implementation cost

+

53% of projects are delayed >3months due to FIRMWARE

Firmware is MCU developers **BIGGEST** pain point

Customers Specific code

Eval & Proto

Stacks (TCP/IP) (USB)

File Systems

Application Specific (Audio, Motor Ctrl)

Libraries (DSP) (Math) (Encryption)

RTOS Kernel

Drivers / HAL

MCU Hardware

Strategy to Reach and Expand a Broad Base of Customers
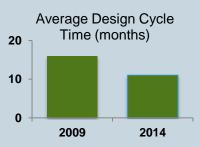
Designing with Freescale …	Solves Real Problems Now…	… And Here's How

Fast & Complete

Shorter Customer Development Cycles

Average Design Cycle Time (months)

	2009	2014
value	~16	~11

Scalable runtime software -- cross platform and feature-rich to **reuse and redeploy software investment**

RTOS & Middleware

Freescale MQX™ RTOS & Middleware — SWELL software

Modular hardware design **simplifies** mix-and-match solutions for **plug-and-play development**
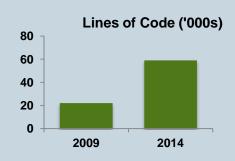
Tower System for Fast Prototyping

Easy & Affordable

Increased Project Complexity

Lines of Code ('000s)

	2009	2014
value	~21	~59

Solutions for industry standards **future-proof customers' investments**

Market-Driven Solutions

WiFi — Continua — ZigBee Alliance

Broad development tools support enabling developers to **leverage existing investments immediately**

In-House & 3rd-Party Development Environments

CodeWarrior — IAR SYSTEMS

Addressing customers' pain points early in the design cycle leads to increased customer loyalty and provides "sticky" solutions for the future

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Kinetis Development Software

IDE

- **CodeWarrior** – eclipse-based *Basic, Standard, Professional* and *Free* Suite with 128k code size limit
- **Processor Expert**/Driver Suite – configuration and code generation tool

RTOS

- **MQX** - Free real-time operating system with USB & Ethernet stacks and file system
- **MQX Lite** - Free and lightweight RTOS for small microcontrollers

Middleware

- **eGui** – Free and lightweight graphic frame-work for small microcontrollers
- **PEG** - high performance, high value tool for medium to high end MCUs with a licence fee associated

Libraries & Tools

- **FreeMaster** - Real-time monitor and control of an app
- **Math & Motor Control Lib** - Wide group of algorithms
- **Made For iPod** - supports development and rapid prototyping of electronic accessories for iPod, iPhone and iPad devices

Kinetis Development Hardware

Freedom Platform

- The new Freescale platform for Kinetis L and Kinetis K microcontroller

- Compatible with Arduino shields

- 4 different boards available today

Tower System

- The established and proven platform with highest flexibility and re-usability

- Over 50 add-on boards available.

Device Specific

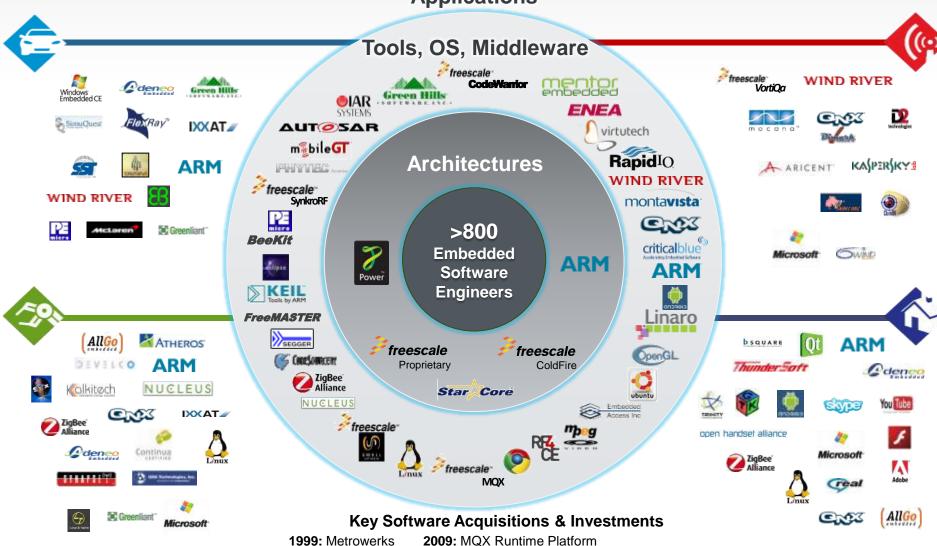- Evaluation boards addressing special functions and capabilities of Kinetis devices

Reference Designs

- Home Energy Gateway, 1ph Meter, 3ph Meter, pre-/post-paid Meter, Home Area Network, Home Display, …

- Available through Freescale RSM

Robust Software & Development Ecosystem

Applications

Tools, OS, Middleware

Architectures

>800 Embedded Software Engineers

freescale Proprietary

freescale ColdFire

Key Software Acquisitions & Investments

1999: Metrowerks
2002: AMC, Lineo
2008: Intoto

2009: MQX Runtime Platform
2010: Processor Expert, Chipwerks, Swell

Kinetis K/L Series: Packaging

Common Packages

32QFN
5 x 5 mm
0.5mm pitch
(K10/20)
(KL0/1/2)

48QFN
7 x 7 mm
0.5mm pitch
(K10/20)
(KL1/2)

32LQFP
7 x 7 mm
0.8mm pitch
(K10/20)
(KL0x)

48LQFP
7 x 7 mm
0.55mm pitch
(K10/20)
(KL0)

64LQFP
10 x 10 mm
0.5mm pitch
(K10/20/30/40/50)
(KL1/2/3/4)

80LQFP
12 x 12 mm
0.5mm pitch
(K10/20/30/40/50)
(KL1/2)

100LQFP
14 x 14 mm
0.5mm pitch
(K10/20/30/40/50/60)
(KL2/3/4)

64MAPBGA
5 x 5 mm
0.5mm pitch
(K10/20)
(KL1*/2*/3*/4*)

121MAPBGA
8 x 8 mm
0.65mm pitch
(K1/2/30/40/50/60)
(KL2/3/4)

Kinetis L Series only

New
20CSP
2x2x0.56 mm
0.4mm pitch
(KL02)

New
25CSP
2.3x2.3x0.56 mm
0.4mm pitch
(KL05*)

New
35CSP
2.55x3x0.56 mm
0.4mm pitch
(KL15*/25*)

New
16QFN
3x3x1 mm
0.5mm pitch
(KL02)

New
24QFN
4 x4x1 mm
0.5mm pitch
(KL0x)

Kinetis K Series only

New
56CSP
2.9x3.3x0.56 mm
0.4mm pitch
(K10*/20*)

New
90CSP
3.9x4.4x0.56 mm
0.4mm pitch
(K10*/20*)

New
121CSP
5.3x5.3x0.56 mm
0.4mm pitch
(K10/20/60)

New
143CSP
6.5x5.6x0.56 mm
0.4mm pitch
(K61)

144LQFP
20 x 20 mm
0.5mm pitch
(K10/20/30/40/50/60)

144MAPBGA
13 x 13 mm
1.0mm pitch
(K10/20/30/40/50/60)

256MAPBGA
17 x 17 mm
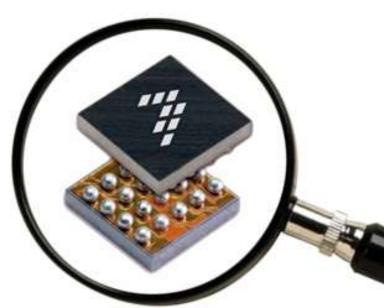1.0mm pitch
(K60/70)

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The World's Smallest ARM® Powered MCU

Microscopic Package. Massive Potential.

- 1.9 mm x 2.0 mm x 0.56 mm

- Advanced wafer-level chip scale package for the ultimate in PCB area reduction

- 25% smaller with 60% more GPIO than the next competing solution

- 32-bit ARM® Cortex™-M0+ core with high density feature integration: 32 KB flash, precision analog, ultra low power and more

- Start developing today with the Kinetis L series FRDM-KL05Z Freescale Freedom development platform

- Mass Production planned for June 2013

For more information, visit
freescale.com/Kinetis/KL02CSP

Freescale Product Longevity Program

- The embedded market needs **long-term product support**

- Freescale has a longstanding track record of **providing long-term production support** for our products

- Freescale is pleased to introduce a formal **product longevity program** for the market segments we serve

  - For the automotive and medical segments, Freescale will make a broad range of program devices available for a minimum of **15 years**

  - For all other market segments in which Freescale participates, Freescale will make a broad range of devices available for a minimum of **10 years**

  - Life cycles begin at the time of launch

- For terms and conditions and to see a list of participating **Freescale products** available under this program: www.freescale.com/productlongevity

Kinetis:

Leading Edge ARM Cortex-M Cores

Kinetis: Why ARM® Cortex™-M4?

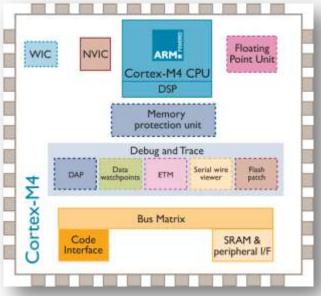- **Backwards compatible with ARM Cortex-M3**
  - Does everything the Cortex-M3 does and more but in less cycles (more energy efficient!)

- **New features**
  - Single cycle MAC (Up to 32 x 32 + 64 -> 64)
  - DSP extensions, Single Precision Floating Point Unit

- **Freescale IP and Innovation**
  - Cache, Cross-Bar and DMA for increased throughput
  - MPU for system resource protection
  - Low-leakage Wake-up Unit for low power operation

- **Architected for Digital Signal Processing**
  - Motor Control: advanced algorithms, faster control loops, more responsive to speed commands and changing loads, increased power efficiency
  - Automation: high calculation and algorithm bandwidth at a low cost
  - Power management: designed for low/battery powered systems (CLK @ 0.5x ARM Cortex M3)
  - Audio and Video: 5x performance improvement over software, extended battery operation
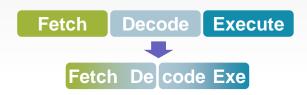
Dotted boxes denote optional blocks

ARM Cortex-M0+ Processor

Fetch	Decode	Execute

Fetch	De	code	Exe

**Shorter Pipeline
optimized for energy efficiency**

BKPT	BLX	ADC	ADD	ADR
BX	CPS	AND	ASR	B
DMB		BL		BIC
DSB	CMN	CMP		EOR
ISB	LDR	LDRB	LDM	
MRS	LDRH	LDRSB	LDRSH	
MSR	LSL	LSR	MOV	
NOP	REV	MUL	MVN	ORR
REV16	REVSH	POP	PUSH	ROR
SEV	SXTB	RSB	SBC	STM
SXTH	UXTB	STR	STRB	STRH
UXTH	WFE	SUB	SVC	TST
WFI	YIELD			

Cortex-M0/M0+/M1

Full ARMv6-M compatible

From Cortex-M3
Re-locatable Vector Table
Memory Protection Unit (MPU)

New
Fast I/O Port
Micro Trace Buffer (MTB)

More Options

CM0+ Core & Platform Features

- ARM Cortex-M0+ Core
  - 100% compatible with Cortex M0
  - Efficient instruction set for low power and small code size
  - 0.95 DMIPS per MHz performance when executing from internal RAM (single cycle accesses)
  - Single cycle 32 bit x 32 bit multiply
  - NVIC with 4 priority levels and hardware preemption
  - I/O port for single cycle GPIO loads and stores
- Peripheral Bridge Crossbar (AXBS-Lite)
  - Support for concurrent accesses from DMA/CORE to memory and peripherals
- Bit Manipulation Engine (BME)
  - Decorated load and store capability for peripherals improving processing efficiency and small code size
- Flash Memory Controller (FMC)
  - 4-way, 4-set 32-bit Flash cache for improving flash access times
- Debug Facilities
  - Supports the standard ARM 2-pin serial wire debug (SWD) debug port only
  - Micro-Trace Buffer (MTB) for on-chip trace capabilities

Kinetis Series powered by ARM® Cortex™

ARMv7-M architecture	**Cortex-M4**	High performance data processing & I/O control. Support hardware divide, MAC, bit field processing, DSP. Floating point unit optional (Cortex-M4F).	**Kinetis K Series**
	Cortex-M3	High performance data processing & I/O control. Support hardware divide, MAC (Multiply Accumulate), bit field processing.	
ARMv6-M architecture	**Cortex-M0+**	General data processing, high performance I/O control, mixed signal ASICs, replacement for 8/16-bit MCUs	**Kinetis L Series**
	Cortex-M0	General data processing, I/O control, mixed signal ASICs, replacement for 8/16-bit MCUs	
	Cortex-M1	For FPGA designs only. Optimized for FPGA and can work in most FPGA devices	

Kinetis K Series MCUs
Design Potential. Realized.

Ultra-Scalable – Market's most scalable portfolio of ARM Cortex MCUs consisting of multiple hardware and software compatible devices ranging from entry-level ARM Cortex-M0+ Kinetis L series to high-performance, feature-rich ARM Cortex-M4 Kinetis K series
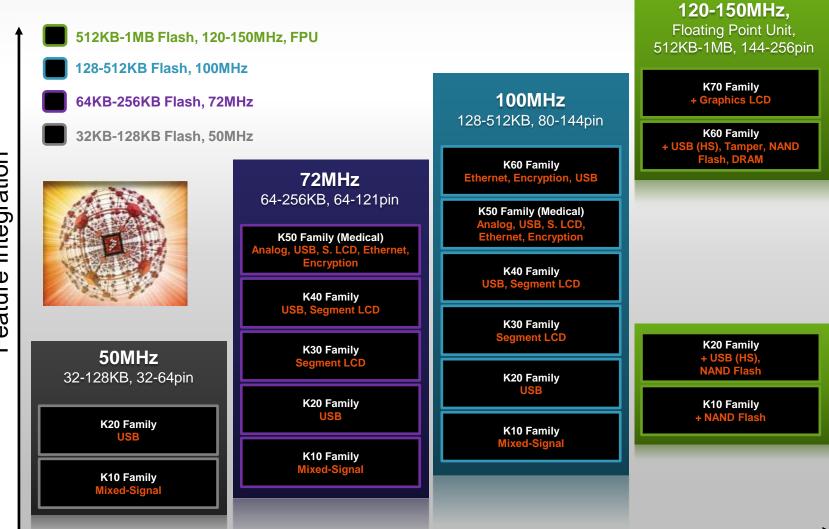
Innovative Flex Memory – Low-power 90nm Thin-Film Storage Flash with FlexMemory offers EEPROM capability with unprecedented programming speed and endurance

Mixed Signal – Exceptional integration with fast 16-bit ADCs, DACs, PGAs and more. Powerful, cost-effective signal conversion, conditioning and control

Comprehensive Enablement – Freescale MQX RTOS and Eclipse-based CodeWarrior IDE, as well as IAR, KEIL and other ARM ecosystem providers

Kinetis K-Series: Original Portfolio Complete!

Feature Integration (vertical axis label)

- 512KB-1MB Flash, 120-150MHz, FPU
- 128-512KB Flash, 100MHz
- 64KB-256KB Flash, 72MHz
- 32KB-128KB Flash, 50MHz

50MHz
32-128KB, 32-64pin

K20 Family
USB

K10 Family
Mixed-Signal

72MHz
64-256KB, 64-121pin

K50 Family (Medical)
Analog, USB, S. LCD, Ethernet, Encryption

K40 Family
USB, Segment LCD

K30 Family
Segment LCD

K20 Family
USB

K10 Family
Mixed-Signal

100MHz
128-512KB, 80-144pin

K60 Family
Ethernet, Encryption, USB

K50 Family (Medical)
Analog, USB, S. LCD, Ethernet, Encryption

K40 Family
USB, Segment LCD

K30 Family
Segment LCD

K20 Family
USB

K10 Family
Mixed-Signal

120-150MHz,
Floating Point Unit,
512KB-1MB, 144-256pin

K70 Family
+ Graphics LCD

K60 Family
+ USB (HS), Tamper, NAND Flash, DRAM

K20 Family
+ USB (HS), NAND Flash

K10 Family
+ NAND Flash

Kinetis K Series: Feature Overview

Common Features

System
- Arm® Cortex™-M4 Core + DSP
- Multiple Low-Power Operation Modes, Clock Gating, 1.71V-3.6V, 5V Tolerant I/O [1]
- DMA, Memory Protection Unit [2], Cross Bar Switch
- Operating Temp: -40°C to + 105°C [3]

Memory
- 90nm TFS Flash Memory (High Reliability, Fast Access)
- FlexMemory (EEPROM) [4]
- SRAM
- Internal Memory Security/Protection

Analog Peripherals
- 16-bit ADC
- Programmable Gain Amplifiers [1]
- 12-bit DAC [5]
- High-Speed Comparators Low-Power Touch Sense Interface [7]

Serial Interfaces
- UART, SPI, I2C
- SAI (I2S)

Timers
- RTC
- Motor Control Timers
- Low-Power Timers
- Programmable Delay Block
- System Timers

Other Peripherals
- CRC
- eSDHC [4]
- External Bus Interface [4]

Optional Features

CPU	Internal Memory		Communication			HMI	Security		Memory/Expansion		Analog

K70 Family: Graphics LCD

| 120 to 150 MHz | Floating Point Unit | 512 KB to 1 MB Flash | 128 KB SRAM | USB OTG (FS and HS) [6] | CAN | Ethernet (IEEE® 1588) | Graphics LCD | Hardware Encryption | Tamper Detection | NAND Flash Controller | DRAM Controller | -- |

K60 Family: Ethernet, Security

| 100 to 150 MHz | Floating Point Unit | 256 KB to 1 MB Flash | 64 KB to 128 KB SRAM | USB OTG (FS and HS) | CAN | Ethernet (IEEE1588) | -- | Hardware Encryption | Tamper Detection | NAND Flash Controller | DRAM Controller | -- |

K50 Family: Analog Measurement Engine

| 72 to 100 MHz | -- | 128 KB to 512 KB Flash | 32 KB to 128 KB SRAM | USB OTG (FS) | -- | Ethernet (IEEE 1588) | Segment LCD | Hardware Encryption | -- | -- | -- | Measurement Engine |

K40 Family: USB, Segment LCD

| 72 to 100 MHz | -- | 64 KB to 512 KB Flash | 16 KB to 128 KB SRAM | USB OTG (FS) | CAN | -- | Segment LCD | -- | -- | -- | -- | -- |

K30 Family; Segment LCD

| 72 to 100 MHz | -- | 64 KB to 512 KB Flash | 16 KB to 128 KB SRAM | -- | CAN | -- | Segment LCD | -- | -- | -- | -- | -- |

K20 Family: USB

| 50 to 120 MHz | Floating Point Unit | 32 KB to 1 MB Flash | 8 KB to 128 KB SRAM | USB OTG (FS and HS) | CAN | -- | -- | Hardware Encryption | Tamper Detection | NAND Flash Controller | -- | -- |

K10 Family: General Purpose

| 50 to 120 MHz | Floating Point Unit | 32 KB to 1 MB Flash | 8 KB to 128 KB SRAM | -- | CAN | -- | -- | Hardware Encryption | Tamper Detection | NAND Flash Controller | -- | -- |

[1] Feature not available on 50 MHz MCUs
[2] Feature not available on 50 MHz and 72 MHz MCUs
[3] Feature not available on 50 MHz MCUs and CSP packages
(K50 and CSP package are -40°C to +85°C)

[4] Feature not available on all K10, K20, K30, K40, K50, K60 and K70 MHz MCUs
[5] Feature not available on K10 and K20 50 MHz MCUs
[6] HS USB on 120/150 MHz MCUs only
[7] Feature not available on K11/12/21/22 MCUs
(K50 and CSP package are -40°C to +85°C)

New K-Series devices

- <u>New K10 Sub-families – General Purpose</u>
  - K1**1** adds Cryptography acceleration and Tamper detection to K10
  - K1**2** adds additional GPIO in some packages, all support a new power mode for complete shutdown (VLLS0 ~300nA)

- <u>New K20 Sub Families – USB Connectivity</u>
  - K2**1** adds Cryptography acceleration and Tamper detection to K20
  - K2**2** adds additional GPIO in some packages, all support a new power mode for complete shutdown (VLLS0 ~300nA)

K11/K12/K21/K22D	
CPU Speed	Up to 50MHz
Memory	Up to 512KB flash, 64KB of SRAM
Packages	48LQFP to 121MBGA
Availability	Production Q1 2013

K21/K22F	
CPU Speed	Up to 100MHz or higher – With Floating Point
Memory	Up to 1MB flash, 128KB of SRAM
Packages	64LQFP to 144MBGA
Availability	Production Q2 2013

Kinetis: Security
K10/K20/K30/K40/K50/K60/K70

Flash Security Options:
- User backdoor access disable
- Factory access disable
- Mass erase disable
- Multiple transfers from Flash to config register

Prevent External accesses for reading or programming

Prevents block and security bit erase, and re-programming. Protects against system impersonation

Protects secure system against electrical noise attacks

Memory Protection Unit (MPU):
- 16 areas, supervisor/user (config registers are fully accessible)

Allows "sandboxing", running software with restricted access permissions

Cryptographic Acceleration Unit (CAU): (K10/20/50/60/70 only)
- Symmetrical crypto
- Hashing functions
- Random Number Generator (RNG)

Reduces CPU loading for cryptographic functions

Facilitates detection of data tampering

Facilitates generation of FIPS140 certifiable random numbers

Enablement:
- Crypto stacks

Secure storage:
- 128 bit unique chip identifier

Facilitates certificate and authentication to a specific MCU

Hardware Cyclic Redundancy Check (CRC)

Accelerates basic data integrity checking

Kinetis: Security
K10/K20/K60/K70, 50/120/150MHz

Flash Security Options:
• User backdoor access disable
• Factory access disable
• Mass erase disable
• Multiple transfers from Flash to config register

Memory Protection Unit (MPU):
• 16 areas, supervisor/user (config registers are fully accessible)

Tamper Detection (with battery backup):
• Integrated sensors –
  • Frequency
  • Voltage
  • Temperature
• 4x passive external tamper sources (inputs)
• 2x active external tamper sources (2x output and input)

Cryptographic Acceleration Unit (CAU):
• Symmetrical crypto
• Hashing functions
• Random Numbers

Enablement:
• High Assurance Boot (HAB) with tools
• Crypto stacks

Secure storage:
• 256 bit user area, erased by tamper
• 128 bit unique chip identifier

Secure Real Time Clock (RTC):
• Monotonic
• Overflow and reprogram protection

Hardware Cyclic Redundancy Check (CRC)

> Protects against a wide range physical attacks on MCU, even during low power modes

> Protected storage of user key or authentication code, may be used as master key to encrypt additional key depository

> Protects against a wide range physical attacks on hardware system outside the MCU

> Highly secure firmware verification, with secure firmware upgrade capability

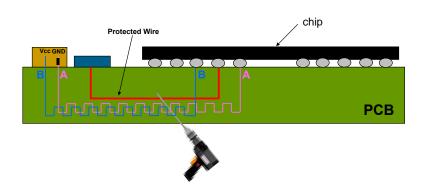> May be used to prevent firmware downgrading

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Kinetis Security Summary

- The entire (current) Kinetis family includes enhanced Flash security, with user selectable:

  - Security bit, disables external and debug access

  - Backdoor access enable

  - Factory access enable

  - Block erase & re-program disable

  - Hardware protection against "Noise injection" attacks

  - Memory Protection Unit
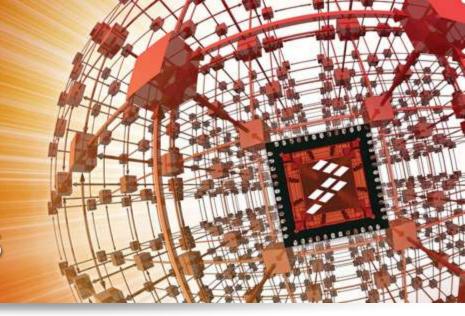
  - 128-bit unique part identifier

- K21, K60 and K70 120/150 MHz parts in 256 MAPBGA packages, and K11/K21 50 MHz parts add:

  - Battery backed up Tamper detection, monitoring-

    - Supply voltage

    - Clock frequency

    - Temperature

    - External sensors

    - External physical tampering (e.g. drilling into PCB)

  - 256-bit secure user storage (key), erased on tamper

  - Secure real time clock

Introducing the
New Entry-Level
Kinetis L Series

Design Made Simple.

Ultra-low Power

Architected for power efficiency, the Kinetis L series takes advantage of ARM's ultra-low-power Cortex-M0+ processor and features peripherals that help you optimize power consumption.

Leading Scalability and Integration

Expanding on well-known features of the Kinetis platform with leading scalability, best-in-class integration with rich analog features and low-power connectivity, the L series redefines entry-level.

Super Simple

It's 32-bit functionality with 8-bit ease-of-use. Built on the new ARM Cortex-M0+ core (the smallest, lowest-power ARM core), the L series simplifies development with an upward migration path to Kinetis K and X series, software reuse and flexible power optimization. And, with a comprehensive enablement bundle including CodeWarrior IDE, MQX RTOS and the ARM support ecosystem, development is simple.

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Why 32-bit, as 8-/16-bit can do the job already?

Feature rich

Easy-to-use

Connectivity

Extended battery life

Sleek design

User expectations

Implications for Entry-Level MCUs

	8/16-bit MCU		32-bit MCU
Connectivity		→	HI-SPEED CERTIFIED USB • Bluetooth
User Interface		→	
Power Consumption	Ultra low sleep/ power-down currents	→	Maximum energy-efficiency (CoreMark/mW)
Computation	$+$ $\times$ $-$ $\div$	→	$\sqrt{}$ $\int_x^n$ $\sin$ $\log_n$
Software/Cost of Ownership	Unique platforms, MCU dependent/$$$	→	Scalable, reusable platforms with modern software techniques/$
Scalability	Limited choice, single-source	→	Broad MCU portfolios, multi-source

Kinetis L Series:
Enabling Differentiation in Entry-Level Products

32-bit

8-bit

Energy-efficiency
Class-leading
Coremark/mW

Scalability & Integration
Kinetis L to K Series
(Cortex M0+ to M4)

Enablement
Freescale bundle +
ARM ecosystem

Ultra Low Static
<1uA

Low Cost
From <$0.50

Ease-of-Use
Freedom Platform,
Processor Expert &
MCU Solution
Advisor

Kinetis L Series
The evolution of the entry-level MCU

Going **Green**

Health & **Safety**

Net **Effect**

Typical Markets and Applications for Kinetis L

Building Control

Smoke Detector

Thermostat

Banking

Cash Registers

OTP

Instrumentation, Medical & Metering

Mass-Market

ETC

Electronic Label

Fiber Module

RFID

Mass-Market

Joy Sticks

Remote Controller

Aero Model

Scale

Shaver

Mouse

GPS Watch
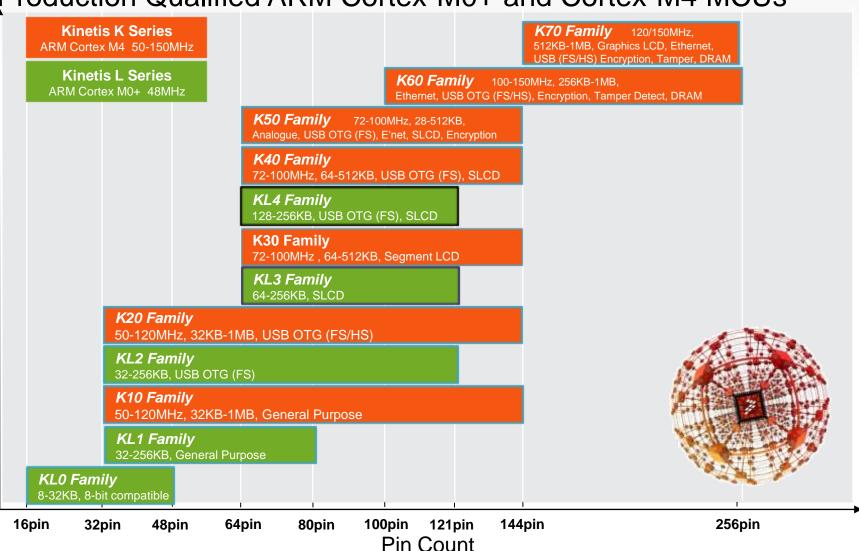
Kinetis L Series vs. Kinetis K Series

Category	Kinetis L Series	Kinetis K Series
Core, Performance	ARM Cortex-M0+ (48MHz)	ARM Cortex-M4 (50-150MHz)
Flash	8-256KB	32KB-1MB
Features	Mixed-Signal, USB, Seg. LCD	FlexMemory, Mixed-Signal, USB, Seg. LCD, CAN, Ethernet, Gra. LCD, DRAM, Crypto, Tamper Detect, DRAM
Pin-count	16-121pin	32-256pin
Low Power	~50uA/MHz (VLPR)	~200uA/MHz (VLPR)
Price	From $0.49 (MKL02, 8KB, 16QFN)	From $0.99 (MK10, 32KB, 32QFN)
Target Applications	8 &16-bit replacement	Low/mid/high –end 32-bit

Kinetis Portfolio Scalability
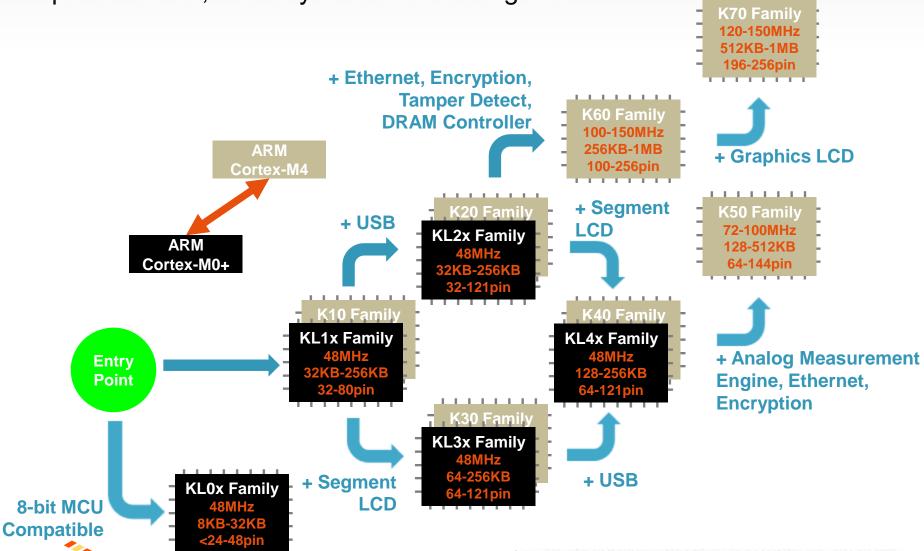## Production Qualified ARM Cortex-M0+ and Cortex-M4 MCUs

Kinetis K Series
ARM Cortex M4 50-150MHz

Kinetis L Series
ARM Cortex M0+ 48MHz

K70 Family 120/150MHz, 512KB-1MB, Graphics LCD, Ethernet, USB (FS/HS) Encryption, Tamper, DRAM

K60 Family 100-150MHz, 256KB-1MB, Ethernet, USB OTG (FS/HS), Encryption, Tamper Detect, DRAM

K50 Family 72-100MHz, 28-512KB, Analogue, USB OTG (FS) E'net, SLCD, Encryption

K40 Family 72-100MHz, 64-512KB, USB OTG (FS), SLCD

KL4 Family 128-256KB, USB OTG (FS), SLCD

K30 Family 72-100MHz , 64-512KB, Segment LCD

KL3 Family 64-256KB, SLCD

K20 Family 50-120MHz, 32KB-1MB, USB OTG (FS/HS)

KL2 Family 32-256KB, USB OTG (FS)

K10 Family 50-120MHz, 32KB-1MB, General Purpose

KL1 Family 32-256KB, General Purpose

KL0 Family 8-32KB, 8-bit compatible

Feature Integration (vertical axis)

Pin Count (horizontal axis): 16pin | 32pin | 48pin | 64pin | 80pin | 100pin | 121pin | 144pin | 256pin

10K# Suggested Resale Prices shown

netis L/K Series: MCU Family Compatibility

Hardware & software compatible MCU families with scalable performance, memory and feature integration

K70 Family
120-150MHz
512KB-1MB
196-256pin

+ Ethernet, Encryption, Tamper Detect, DRAM Controller

K60 Family
100-150MHz
256KB-1MB
100-256pin

+ Graphics LCD

ARM Cortex-M4

ARM Cortex-M0+

+ USB

K20 Family
KL2x Family
48MHz
32KB-256KB
32-121pin

+ Segment LCD

K50 Family
72-100MHz
128-512KB
64-144pin

Entry Point

K10 Family
KL1x Family
48MHz
32KB-256KB
32-80pin

K40 Family
KL4x Family
48MHz
128-256KB
64-121pin

+ Analog Measurement Engine, Ethernet, Encryption

K30 Family
KL3x Family
48MHz
64-256KB
64-121pin

8-bit MCU Compatible

KL0x Family
48MHz
8KB-32KB
<24-48pin

+ Segment LCD

+ USB

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Breakthrough Power Efficiency

	Kinetis Power Modes	Recovery Time	KL25 Measured Idd @ 3V and 25C
Leading Dynamic Power	RUN	-	83uA/MHz*
Innovative low power process technology (C90TFS)	VLPR	-	39uA/MHz**
Low Power focused Platform Design	WAIT	1.6us	3.88mA @ 48MHz
Next Generation Cortex M0+ core	VLPW	1.6us	112uA @ 4MHz
Asynchronous DMA Wake-up (ADMA)	STOP	1.3us	309uA
Energy-saving peripherals are operational with ADMA feature that can wake-up DMA to perform transfer and return to current mode when complete	VLPS	4.2us	2.4uA
Low Leakage Wake-up Unit	LLS	4.3us	1.7uA
Enables complete shut-down of core logic, including AWIC, further reducing leakage currents in all low power modes	VLLS3	39us	1.3uA
Supports 8 external input pins and 8 internal modules as wakeup sources; extends the low power wake-up capability of some internal peripherals to all power modes.	VLLS1	91us	713nA
Wake-up inputs are activated in LLS or VLLS modes	VLLS0	91us	205nA / 411nA

* Compute Operation enabled: 4.0mA @ 48MHz core / 24MHz bus)
** Compute Operation enabled: 156uA @ 4MHz core / 1MHz bus)
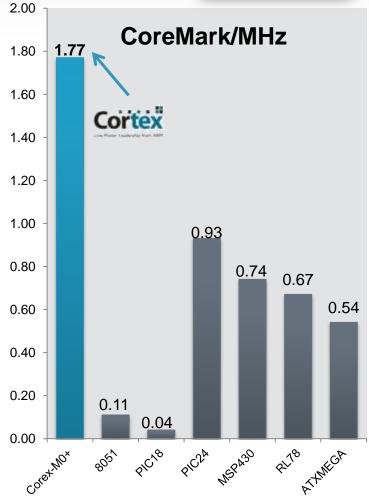
ARM Cortex-M0+ Processor:
No compromise in performance

Shorten run time in low-power applications.

- **More than 2x CoreMark/mA performance** than the closest 8-/16-bit competitor

- **2-stage pipeline** – reduced number of cycles per instruction (CPI) enables faster branch instruction and ISR entry, reduced power consumption and increased performance

- **Fast I/O port** – single-cycle access to I/O and critical peripherals (**2x faster than normal I/O**)

    - improves reaction time to external events allowing bit-banging and software protocol emulation using additional **Bit Manipulation Engine (BME)** resulting in smaller code size for XOR/AND/OR operations.

    - Implemented as **RGPIO** on **Kinetis L**

- **Single cycle 32x32bit multiply**

- **Interrupt latency reduced by 1 cycle**

CoreMark/MHz

Processor	CoreMark/MHz
Corex-M0+	1.77
8051	0.11
PIC18	0.04
PIC24	0.93
MSP430	0.74
RL78	0.67
ATXMEGA	0.54

Official data: www.coremark.org

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ARM Cortex-M0+ Core:
Code Efficiency

- **ARMv6-M Thumb Instruction Set**
  - 32-bit performance at 16-bit density, 56 instructions only
- **32-bit Simplification**
  - 32-bit data structure
  - 32-bit Address Space (no paging)
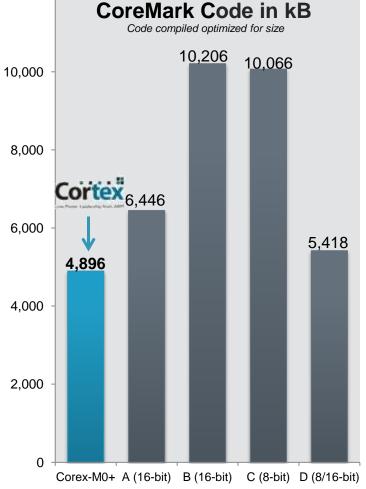
Comparing 16-bit multiply operations across processor architectures	8-bit example		16-bit example	ARM Cortex-M
	MOV A, XL ; 2 bytes	MUL AB; 1 byte	MOV R4,80130h	MULS r0,r1,r0
	MOV B, YL ; 3 bytes	ADD A, R1; 1 byte	MOV R5,80138h	
	MUL AB; 1 byte	MOV R1, A; 1 byte	MOV SumLo, R6	**1cycle**
	MOV R0, A; 1 byte	MOV A, B ; 2 bytes	MOV SumHi,R7	**2Byte Code Size**
	MOV R1, B; 3 bytes	ADDC A, R2 ; 1 bytes	(Operands are moved to and from a memory	
	MOV A, XL ; 2 bytes	MOV R2, A; 1 byte	mapped hardware multiply unit)	
	MOV B, YH ; 3 bytes	MOV A, XH ; 2 bytes		
	MUL AB; 1 byte	MOV B, YH ; 3 bytes	**8cycles,**	
	ADD A, R1; 1 byte	MUL AB; 1 byte	**8Byte Code Size**	
	MOV R1, A; 1 byte	ADD A, R2; 1 byte		
	MOV A, B ; 2 bytes	MOV R2, A; 1 byte		
	ADDC A, #0 ; 2 bytes	MOV A, B ; 2 bytes		
	MOV R2, A; 1 byte	ADDC A, #0 ; 2 bytes	*8051 needs at least 1cycle per instruction byte fetch as they only have an 8-bit interface	
	MOV A, XH ; 2 bytes	MOV R3, A; 1 byte		
	MOV B, YL ; 3 bytes			

48cycles*, 48Byte Code Size

N.B. The Cortex-M multiply in fact performs a 32-bit multiply, here we assume r0 and r1 contain 16-bit data.

16-bit Multiplication Example

CoreMark Code in kB
Code compiled optimized for size

Bar chart values:
- Corex-M0+: 4,896
- A (16-bit): 6,446
- B (16-bit): 10,206
- C (8-bit): 10,066
- D (8/16-bit): 5,418
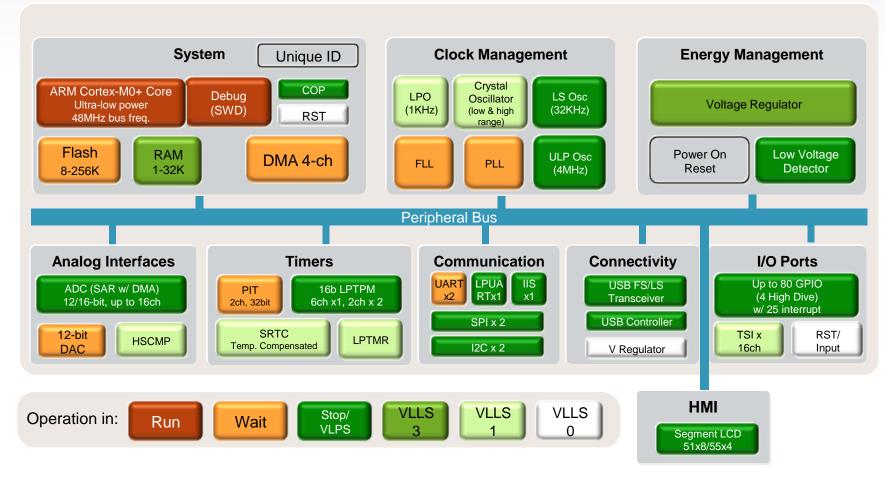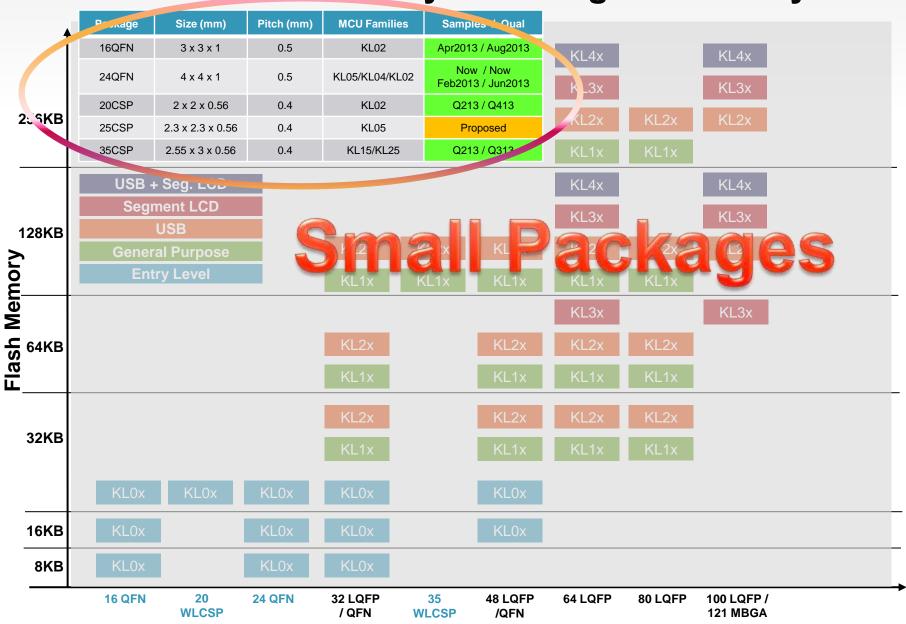
Kinetis L Series: Master Block Diagram

System

Unique ID

ARM Cortex-M0+ Core
Ultra-low power
48MHz bus freq.

Debug (SWD)

COP

RST

Flash
8-256K

RAM
1-32K

DMA 4-ch

Clock Management

LPO (1KHz)

Crystal Oscillator (low & high range)

LS Osc (32KHz)

FLL

PLL

ULP Osc (4MHz)

Energy Management

Voltage Regulator

Power On Reset

Low Voltage Detector

Peripheral Bus

Analog Interfaces

ADC (SAR w/ DMA)
12/16-bit, up to 16ch

12-bit DAC

HSCMP

Timers

PIT
2ch, 32bit

16b LPTPM
6ch x1, 2ch x 2

SRTC
Temp. Compensated

LPTMR

Communication

UART x2

LPUA RTx1

IIS x1

SPI x 2

I2C x 2

Connectivity

USB FS/LS Transceiver

USB Controller

V Regulator

I/O Ports

Up to 80 GPIO
(4 High Dive)
w/ 25 interrupt

TSI x 16ch

RST/ Input

Operation in:

Run

Wait

Stop/ VLPS

VLLS 3

VLLS 1

VLLS 0

HMI

Segment LCD
51x8/55x4

Packages: 16QFN, 20WLCSP, 24QFN, 32LQFP, 32QFN, 35WLCSP, 48LQFP, 48QFN, 64LQFP, 80LQFP, 100LQFP, 121MBGA

Kinetis L Series: Memory & Package Scalability

Package	Size (mm)	Pitch (mm)	MCU Families	Samples / Qual
16QFN	3 x 3 x 1	0.5	KL02	Apr2013 / Aug2013
24QFN	4 x 4 x 1	0.5	KL05/KL04/KL02	Now / Now Feb2013 / Jun2013
20CSP	2 x 2 x 0.56	0.4	KL02	Q213 / Q413
25CSP	2.3 x 2.3 x 0.56	0.4	KL05	Proposed
35CSP	2.55 x 3 x 0.56	0.4	KL15/KL25	Q213 / Q313

Flash Memory

256KB

USB + Seg. LCD		
Segment LCD		
USB		
General Purpose		
Entry Level		

Small Packages

128KB

64KB

32KB

16KB

8KB

KL4x, KL3x, KL2x, KL1x, KL0x

Package

16 QFN | 20 WLCSP | 24 QFN | 32 LQFP / QFN | 35 WLCSP | 48 LQFP /QFN | 64 LQFP | 80 LQFP | 100 LQFP / 121 MBGA

Small Footprint Package

Kinetis L Series: MCU Families

Common Features

System
ARM Cortex-M0+ Core, 48MHz

Multiple low-power modes & peripherals, low-power Boot, Clock Gating

1.71-3.6V, -40 to 105°C [1]

Memory
90nm TFS Flash, SRAM

Internal Memory Security/Protection

Analog Peripherals
12/16-Bit ADC, 12-bit DAC

High-Speed Comparator

Serial Interfaces
UART (Including 1 LPUART)

SPI, IIC

Timers
Real Time Clock [2]

16bit Low Power TPMs (GP Timer/PWM)

Low Power Timers

32bit Periodic Interrupt Timer

Optional Features

Family	Flash	SRAM	Pin Count	USB OTG	Seg LCD	DMA	ADC	DAC	I2S	TSI
				Key Features						
KL46	128-256KB	16-32KB	64-121	✓	✓	✓	16-bit	12-bit	✓	✓
KL36	64-256KB	8-32KB	64-121		✓	✓	16-bit	12-bit	✓	✓
KL34	64KB	8KB	64-100		✓	✓	12-bit			
KL26	128-256KB	16-32KB	64-121	✓		✓	16-bit	12-bit	✓	✓
KL25	32-128KB	4-16KB	32-80	✓		✓	16-bit	12-bit		✓
KL24	32-64KB	4-8KB	32-80	✓		✓	12-bit			
KL16	256KB	16-32KB	64-80			✓	16-bit	12-bit	✓	✓
KL15	32-128KB	4-16KB	32-80			✓	16-bit	12-bit		✓
KL14	32-64KB	4-8KB	32-80				12-bit			
KL05	8-32KB	1-4KB	24-48			✓	12-bit	12-bit		✓
KL04	8-32KB	1-4KB	24-48			✓	12-bit			
KL02	8-32KB	1-4KB	16-32				12-bit			

[1] Feature not available on CSP packages
[2] For KL02, use software to support

Kinetis E

Strong Robustness
High Efficiency
Low Cost
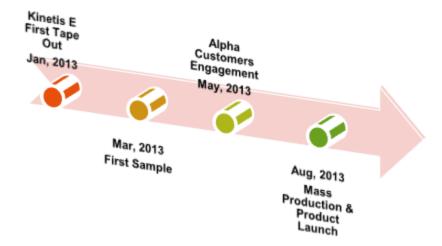
Strong Robustness – EMC/ESD design technology ensure strong noise immunity performance

High Efficiency – Cortex-M0+ core up to 48MHz and 40x more than 8/16-bit MCUs

Low Cost – Optimized for cost-sensitive applications offering low pin count option

Kinetis E First Tape Out
Jan, 2013

Mar, 2013 First Sample

Alpha Customers Engagement
May, 2013

Aug, 2013 Mass Production & Product Launch

Achieve Reliability with Kinetis E Series

1. Most Robust ARM portfolio

- **Proven passing EFT(IEC61000-4-4) / PESD(IEC61000-4-2) tests**
- IEC60730 Class B Safety S/W routines certified by VDE
- 5V operation provides better noise immunity
- Lower EMI noise than 8/16bit competition

2. 3x Higher Efficiency than 8/16 bit solutions

- **3x Coremark/ MHz with 15% better code density**
- One cycle GPIO – (5 x better than nearest competitor)

3. Make design easier

- **Widely available ARM & FSL Tools/ SW ecosystem**
- Open up your hiring options – ARM talent widely available
- Pin compatible and Peripheral reused within Kinetis-E and S08P families
- Freely available ESD/ EMC verification support
- Platform SDK availability

Kinetis E-Series: Market Focus and Value Proposition

Market	Value

Industry & Consumer 5V

- Appliance
- DC fans
- BLDC Motors
- PLC
- Offline UPS
- Analog Power Management
- DC/DC
- ww.freescale.com/kinetisEseries

- **Flexibility:** Full-featured, Scalable with high level family, Pin compatible with S08P
- **Reliability:** High performance in EMC/ESD to enhance the robustness
- **Saving:** Easy to do code level reuse
- **Support:** Total solution, Join free training to win free board, Ref design by IDH/Disty

High Performance	Open source, reusable HW/SW platform

Save your design cost ! Make your design better !

Kinetis E EMC Performance
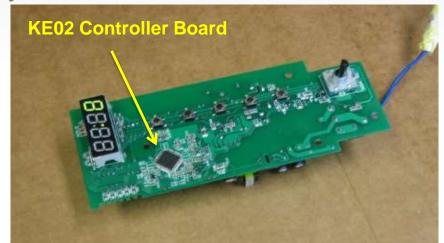
Robustness in EFT,PESD and AC Power Relay Tests

Test Conditions
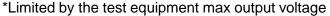
- Microwave Oven Controller board with KE02 as main control MCU
- Board and System level tests based on
  - *IEC 61000-4-4(EFT)*
  - *IEC 61000-4-2(PESD)*
  - *China Appliance local AC Power Relay test*

Test Results

- Board level
  - *IEC 61000-4-4(EFT):+/- 4.4kV**
  - *IEC 61000-4-2(PESD): Indirect Contact*
  - *Discharge +/- 20kV*
  - *China Appliance local test on AC Power Relay:*
  - *6-turns without Reset*

- System level
  - *IEC 61000-4-4(EFT):+/- 4.4kV**
  - *IEC 61000-4-2(PESD): Contact*
  - *Discharge(at the case) +/- 20kV*
  - *IEC 61000-4-2(PESD): Air Discharge(at the control panel) +/- 15kV*

*Limited by the test equipment max output voltage

KE02 Controller Board

Microwave Oven with the KE02 Controller Board

Benefits of Moving from 8/16-bit to 32-bit ARM Cortex-M0+

8/16-bit

Performance

• Older, slower architectures & technology

• Increased code size/complexity when performing complex math operations

Energy-Efficiency

• Low energy-efficiency

Low Cost

• 6-35kgates

• Variable code density

Ease-of-Development

• Limited addressable memory

• Simplistic interrupt controllers

• Limited scalability (MHz, flash, features)

• Limited ecosystem support

32-bit ARM Cortex-M0+

Performance

• 2x to 40x more than 8/16-bit, 9% more than Cortex-M0

• Fast 32-bit math processing

• Fast single-cycle access to I/O

Energy-Efficiency

• >2x CoreMark/mA than closest 8/16-bit MCU, +30% / CM0

Low Cost

• 12-35kgates

• Excellent code density

Ease-of-Development
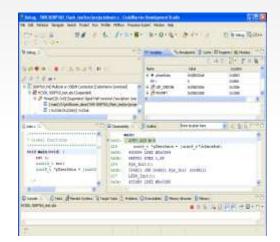
• Linear 4GB address space – no need for paging

• Full-featured interrupt controller – simpler s/w architecture

• Huge scalability – h/w and s/w reuse across end products

• Huge ARM ecosystem – off-the-shelf software/tools/training

• Micro Trace Buffer – lightweight, non-intrusive trace

Kinetis E-Series: Enablement

- Software Tools
  - CW10.4 with KE02 service pack
  - IAR 6.60.1
  - Keil uVision4 (v4.72)
  - Atollic TrueSTUDIO® for ARM (http://www.atollic.com)
  - Crossworks for ARM from Rowley Associates Limited
  - ProcessorExpert
  - IEC60730 compliant library (Class B Safety S/W routines certified by VDE)
  - Motor control library
  - Software Driver (SSD) for Flash and EEPROM
  - KE driver library
- Hardware Tools
  - FRDM-KE02
  - Freedom to motor tower board (FRDM2TWRMC-KE)
  - Debug interfaces: Jlink, U-link, UMultilink, OpenSDA
  - P&E Cyclone MAX
- Reference Design
  - Sensorless BLDC motor control based on motor tower board

Kinetis V-Series
Motor & Power Control

- **Full Kinetis portfolio compatibility** targeting low cost, stand alone motor control, to high performance digital power conversion

- **Optimized for processing efficiency** with performance ranging from 75MHz to beyond 200MHz

- ARM architecture with best in class, **high speed capture and control peripherals** for motor control and power management applications

- Enablement and tools built around reducing customer development time and cost, whilst increasing ease of use.

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Kinetis V Series Target Applications

Motor Control

- Sensored BLDC / PMSM
  - High Dynamic Control
- Sensored ACIM
- Sensorless VOC
  - PMSM/BLDC
  - High Dynamic Control
  - Low Dynamic Control
- Sensorless ACIM

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
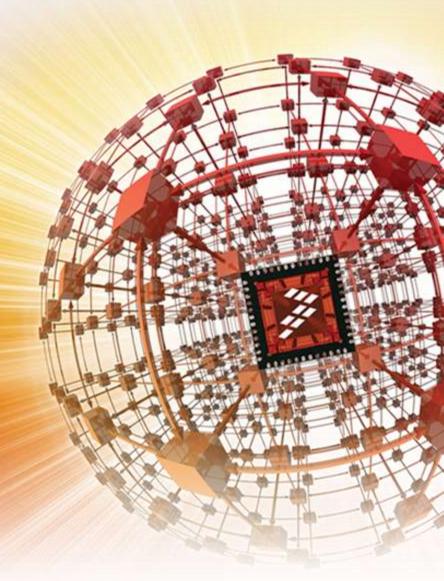
Kinetis W-Series
Integrated Wireless Connectivity

- **Integrates class-leading sub-1 GHz and 2.4 GHz RF transceivers** with Cortex™ core

- Robust feature sets for reliable, **secure and low-power** embedded wireless solutions

- **Optimized for wireless**, providing the right mix of performance, integration, connectivity and security

- Sub 1-GHz or 2.4 GHz wireless, simple **point-to-point or full mesh networking**
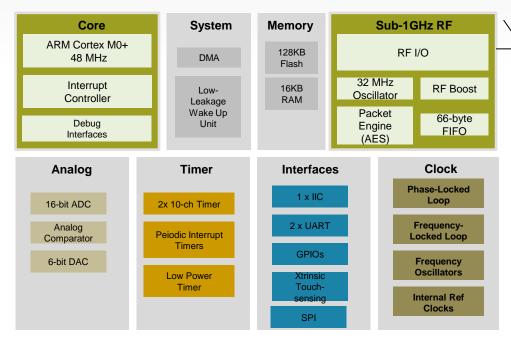
KW01 Wireless Kinetis Overview

- **Microcontroller Features**
  - 32-bit ARM Cortex M0+ 48MHz Core
  - Ultra Low Power
    - 30% power reduction from Cortex-M0
    - 56% increased energy efficiency from Cortex-M0

- **128KB Flash and 16KB SRAM**

- **Radio Transceiver Features**
  - Supports 290-340MHz, 424-510MHz, and 862-1020MHz frequency bands
  - FSK, GFSK, MSK, GMSK and OOK modulations up to 600kbps
  - Up to -120dBm sensitivity @ 1.2kbps
  - -18 to +17dBm output in step of 1dBm

- **Very low power suitable for battery operated devices**
  - Ultra Low power stand-by modes
    - 1.7µA / 4.3µs wake-up time
  - 16 mA Rx current
  - 20 mA Tx current at 0 dBm

- **Rich set of peripherals**
  - 16-bit ADC, TSI, I2C, SPI, UART, Timers

Core
- ARM Cortex M0+ 48 MHz
- Interrupt Controller
- Debug Interfaces

System
- DMA
- Low-Leakage Wake Up Unit

Memory
- 128KB Flash
- 16KB RAM

Sub-1GHz RF
- RF I/O
- 32 MHz Oscillator
- RF Boost
- Packet Engine (AES)
- 66-byte FIFO

Analog
- 16-bit ADC
- Analog Comparator
- 6-bit DAC

Timer
- 2x 10-ch Timer
- Peiodic Interrupt Timers
- Low Power Timer

Interfaces
- 1 x IIC
- 2 x UART
- GPIOs
- Xtrinsic Touch-sensing
- SPI

Clock
- Phase-Locked Loop
- Frequency-Locked Loop
- Frequency Oscillators
- Internal Ref Clocks

Device	Flash / Flex	RAM	Package
MKW01Z128CHN	128 KB	16 KB	8x8 56-pin LGA

Features	Description
Software and Protocol Stacks	Radio Utility 802.15.4g/e, SMAC

Kinetis MKW20 Wireless MCU

CPU

- 50 MHz Cortex M4 CPU core
- Up to 512KB Flash, 64KB SRAM, 32KB Flex Mem, 4KB EEPROM
- Typical current consume: 250 uA/Mhz run, 1.7uA RTC standby

Radio Transceiver, 2.4GHz

- IEEE-802.15.4 compliant
- -100 Rx sensitivity and +10dBm Tx output power
- Peak typical current consume: 15mA Tx and 16.5mA Rx
- Dual Personal Area Network (PAN) support in hardware
  - Run two RF networks simultaneously
- Antenna diversity with automatic antenna selection

Security
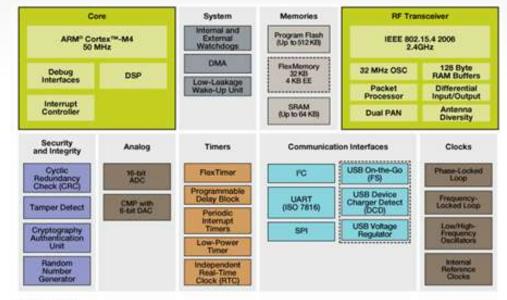
- Active and passive tamper detection with RTC timestamp
- Crypto engine: DES, 3DES, AES 128-256, SHA-1, SHA-256, MD5, RNG

Software

- 812.15.4 2006 MAC
- ZigBeePro, ZigBee IP
- Smart Energy 1.x & 2.0, HA 1.x, BA 1.x

System

- UART, SPI, I2C, optional USB 2.0 FS/LS H/D/OTG
- 16-bit ADC
- Operating range: 1.7V to 3.6V, -40C to +105C

[ ] Optional

Device	Flash	RAM	Feature	Package
MKW21D256VHA5	256 KB	32 KB	No USB	8x8 56-pin LGA
MKW22D512VHA5	512 KB	64 KB	USB	8x8 56-pin LGA
MKW24D512VHA5	512 KB	64 KB	USB and Smart Energy 2.0	8x8 56-pin LGA

Kinetis M-Series
Smart Metering with High Accuracy Analog

- **Dedicated smart metering peripherals** tailored with regional specifications

- Supports low-cost, highly integrated solutions for one- or two-phase meters with a **high accuracy sigma delta ADC metering front end**

- Address specific **regional needs** including neutral disconnect or split phase for North America and Japan.

- **Full metrology software**, including time or filter based, is provided as well as fast Fourier transform.

Core
- CM0+ core Up to 50MHz
- Separate FLL post-scalers for IPBus and Core clocks.
- Up to 128 KB Program Flash
- Up to 16 KB SRAM
- Dedicated PLL for ΣΔ modulator clock
- 4ch DMA
- Single 32kHz Crystal operation
  - MHz Crystal Optional

Security & Encryption
- MPU & AIPS
- IRTC w/t tamper detection
- 3 Tamper pins (operating from battery)
- Programmable 16/32-bit CRC
- Random Number Generator (NIST: SP800-90)
- AES Encryption (via software library)

Analog
- 4x24 bit ΣΔ (2xPGA) highly accurate supporting EN 50470-1, EN 50470-3, IEC 62053-21, IEC 62053-22 and IEC 62053-23, optimized for shunt sensor (≥50uOhm).
  - 0.1% error in active and reactive energy over a dynamic range of 2000 to 1
- Internal 1.2V reference voltage 10-15ppm/C
- 12-ch 16-bit SAR for auxiliary measurement
- 2x analog comparator
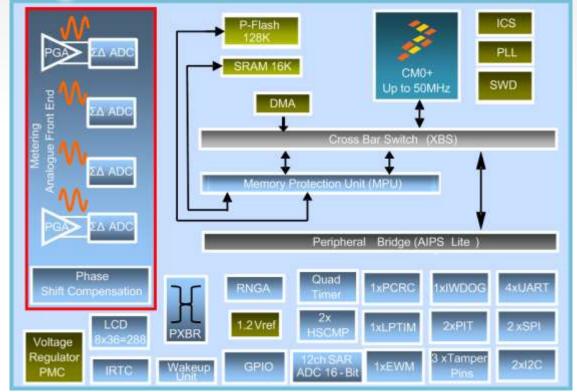
Serial Communications
- 2x SPI
- 4x UART
  - 1 combined with Quad Timer, HSCMP for IR
  - 2 support ISO7816
  - All support flow control
- 2× I2C
- All UARTs and SPIs are 3V compatible while 1 UARTs and 1 SPI are both 3V and 5V compatible (open drain / push pull configuration)

Peripheral XBAR
- Remapping peripheral IOs
- UART selection for IR

Timer/PWM/Clock
- Quad Timer (total 4 universal timers)
- 2x PIT
- 1x Watchdog Timer (windowed, independently clocked)
- 1x EWM (External Watchdog Monitor)
- 1x LPTimer

LCD Display
- Up to 288 segment LCD, up to 8 backplanes

Wakeup Unit
- Group selected GPIOs (16), LPTIM, RTC (+tamper pins) , HSCMP, SCI , Brownout and POR sources to wake up from Power Gated STOP mode

GPIO
- Up to 64 with open drain / push pull, pull up/down
- Up to 8 GPIO with filter
- Support for interruption on any edge

Power
- Power Management
- PMC (Power Manager Control Unit)
- 2.7V to 3.6V Operating voltage with AFE
- 1.71V to 3.6V Operating voltage without AFE
- 1.71V-3.6V IRTC VBAT supply
- 32kHz or 2MHz internal clock source
- 32.768kHz crystal oscillator

Package
- 100 LQFP, 64 LQFP and 44 LGA options
- -40°C ~ +85°C Temp

Kinetis Development Software

www.freescale.com/kinetis

Kinetis Development Software

IDE

- **CodeWarrior** – eclipse-based *Basic, Standard, Professional* and *Free* Suite with 128k code size limit
- **Processor Expert**/Driver Suite – configuration and code generation tool

RTOS

- **MQX** - Free real-time operating system with USB & Ethernet stacks and file system
- **MQX Lite** - Free and lightweight RTOS for small microcontrollers

Middleware

- **eGui** – Free and lightweight graphic frame-work for small microcontrollers
- **PEG** - high performance, high value tool for medium to high end MCUs with a licence fee associated

Libraries & Tools

- **FreeMaster** - Real-time monitor and control of an app
- **Math & Motor Control Lib** - Wide group of algorithms
- **Made For iPod** - supports development and rapid prototyping of electronic accessories for iPod, iPhone and iPad devices

Why MQX™?

- MQX is a run-time library of functions that programs use to become real-time multi-tasking applications.

- The main features are its scalable size, component-oriented architecture, and ease of use.

- MQX supports multi-processor applications and can be used with flexible embedded I/O products for networking, data communications, and file management

Past Customer Problem

MQX, the Solution

MQX™: What's free and what's add-on?

Free Components

- RTOS (Full priority-based, pre-emptive scheduler)
- Real-time TCP/IP Communication Suite (RTCS) - TCP/IP, FTP, Telnet, DHCP, SNMP etc..
- USB Host – PHDC (medical) ,HID, MASS, HUB, CDC,
- USB Device - HID, MASS, CDC, PHDC
- MS-DOS File System (MFS)
- BSP I/O Driver: CAN, UART etc…
- Basic HTTP Web server
- Benchmarking Tool
- Base Support: Freescale TIC, FAE, AE
- Compatible Freescale embedded GUI Library
- Free Freescale EGUI
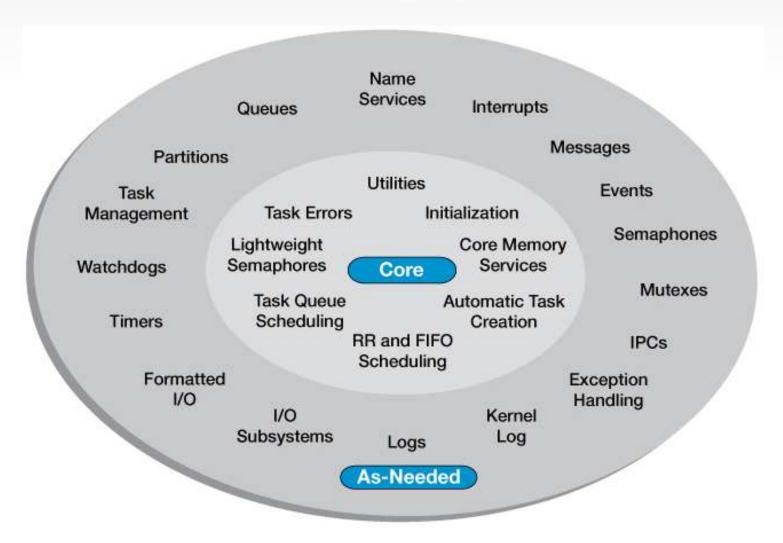
Add-on Components

- IAR & CW: MQX Task Aware Debugging integrated within tools
- Freescale - Level 2 Support
- Bluetooth
- Embedded Access: Webserver Basic/Standard/Pro, SNTP, XML, SMTP, POP3, SNMP (V3), SFFS Flash File System, On-Site Training, PEG Graphic Builder
- RTA & IXXAT: Industrial Protocols - 1588, CANopen etc.
- Freescale Low Cost NanoSSL™ and NanoSSH™
- Swell & Segger: Graphic Libraries

freescale ™

MQX™ Real-Time Operating System (RTOS)

MQX Lite RTOS - Overview

- **Very light MQX kernel for resource-limited MCUs**
  - Targeted at the Kinetis L family initially
  - Packaged as a Processor Expert component

- **I/O capability provided by Processor Expert**
  - USB via FSL bare-metal stack, also a Processor Expert component
  - No POSIX-like drivers or file access

- **Programming model allows upward code migration**
  - A true subset of the full MQX RTOS
  - Code built with MQX Lite will move to full MQX RTOS easily
  - Same task templates, same API – some very minor differences

- **Available as a component within the following Freescale s/ware offerings:**
  - Processor Expert software, MCU driver suite – Supports IAR, Keil, and GCC compilers / build chains
  - CodeWarrior Development Studio V10.3

MQX Lite RTOS - Benefits

✓ **Easy to configure**
  - ✓ Packaged as a Processor Expert component; with configurable options: set name of task function, priority, stack size (all the same parameters as an MQX task)

✓ **Easy to add existing application**
  - ✓ Just drop in the MQX Lite RTOS component, and get started in minutes

✓ **Very light-weight**
  - ✓ Minimal app (Hello task, idle task, interrupt stack) – less than 4 KB RAM; optimized for resource-limited MCUs like Kinetis L Series family

✓ **I/O capability provided by Processor Expert software**
  - ✓ Take advantage of the broad spectrum of MCU logical device drivers; with access to libraries/stacks like USB Processor Expert component

✓ **Real-time, priority-based pre-emptive task switching**
  - ✓ Threads execute in order of priority, allowing high-priority threads to meet their deadlines consistently, no matter how many other threads are competing for CPU time

✓ **Programming model allows upward code migration**
  - ✓ MQX Lite RTOS is a true subset of the full MQX RTOS: code built with MQX Lite RTOS will easily move to the full MQX RTOS

MQX Lite with CodeWarrior Processor Expert

Processor Expert: Creating an MQX Lite Project (CodeWarrior)

Processor Expert: An MQX Lite Example (CodeWarrior)
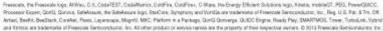
MQX Lite with Microcontroller Driver Suite Processor Expert

Processor Expert: Creating an MQX Lite Project (Driver Suite)
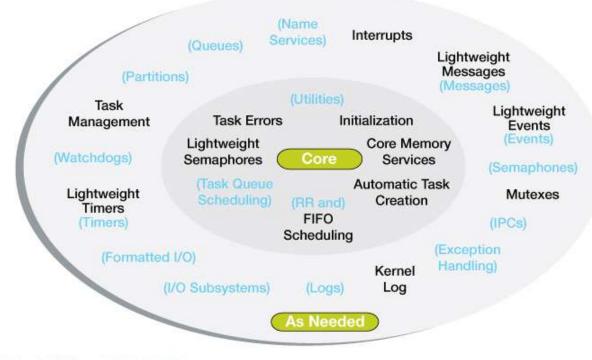
Processor Expert: An MQX Lite Example (Driver Suite)

MQX vs. MQX Lite

Attribute	MQX RTOS	MQX Lite RTOS
Delivery Mechanism	Traditional installer with full source for Kernel, services and BSPs	Processor Expert (PEx) Kernel and services component, configurable software generated by PEx
I/O Drivers	MQX POSIX compatible drivers with option for using PEx drivers	PEx drivers only
Configurability	User selects needed services from full or lightweight versions	Reduced services available; lightweight options only
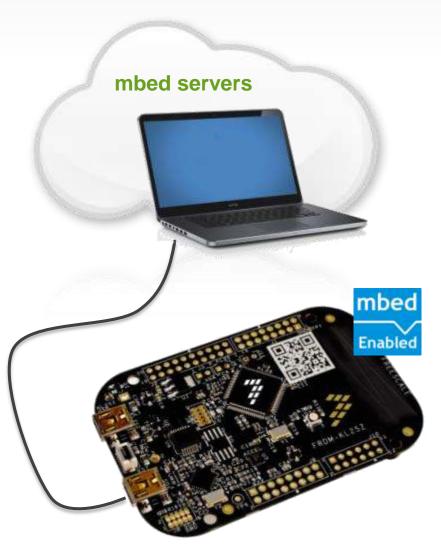
MQX Lite RTOS   (MQX RTOS)

mbed.org – What is it?

mbed servers

Tool for Rapid Prototyping with Microcontrollers

Web-based Development:

✦**Online IDE**

✦**Software Libraries**

✦**Robust Community**

OpenSDA on FRDM-KL25Z running mbed interface:

✦**Serial Communications**

✦**Flash Programming**

✦**Run-control debug**

www.mbed.org
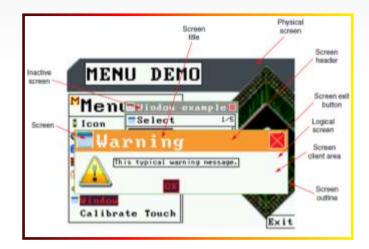
eGUI: Free Graphics LCD Driver

- Lightweight software component allowing graphics LCD panels to be driven from small microcontrollers
- Structure of driver brings complete software solution for applications needing a LCD screen
- Very light RAM and FLASH footprint
- The Freescale eGUI can be used stand alone or integrated into the MQX operating system.
- **Features**
  - Multiple platforms supported: S08, HCS12, ColdFire.
  - Extremely low flash and RAM footprint so that it can easily be used in a small MCU system.
  - Smart support for screen oriented structure of user code.
  - Supports LCD displays up to 1/4 VGA for MCU and larger for MPUs supported.
  - Touch screen support.
  - Tower LCD board supported.
  - Easily ported to new display/controller combinations

www.freescale.com/egui

Portable Embedded GUI (PEG)

PEG Pro™

Support for touchscreen displays, multi-layer alpha-blended graphics, high color depths and open GL support

- Screen transitions
- Multiple alpha-blended windows
- True anti-aliasing
- Gradient manager
- Open GL support
- Written in C++

Starting 225KB
Typical 225-250KB

PEG+™

Most portable graphics software package for high-performance embedded displays

- Multiple window updates
- Alpha-blended images
- Run-time image decoders & language resources
- Custom widget integration
- Dynamic themes
- Written in C++

Starting at 128KB
Typical 160-175KB

C/PEG™

One of the smallest footprint solutions available for embedded GUIs

- Designed for:
  - Small LCDs (QVGA)
  - Low colour-depth
- Very small footprint
- Single window update
- Multi-language capable
- Written in ANSI C

Starting at 64KB
Typical 90-110KB

FreeMASTER
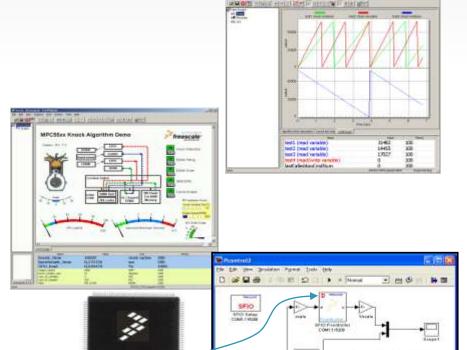
- Real-time monitor and control of an app
  - Track your variables
  - Modify them while the system runs

- Data visualization
  - Design your own dashboard

- Data streaming – e.g…
  - Send it to MATLAB$^®$ via FreeMASTER

- Demonstration platform
  - A product packaging tool

  www.frescale.com/FreeMASTER

freescale™
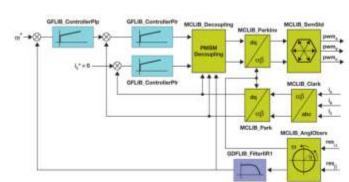
Embedded Software and Motor Control Libraries

- Wide group of algorithms
  - basic mathematics, logic, controllers, modulations, transformations up to advanced observers
- Tool for beginners as well as for professionals
  - motor control, power conversion, UPS etc.
- Libraries are optimized, tested and easy to use
- Implemented with C-callable function interface
- Implemented Algorithms
  - Sine , Cosine , Tangent , Arcus Sine, Arcus Cosine, Arcus Tangent, Arcus Tangent, Shifted Arcus Tangent, Square Root, Ramp, Limiter, Hysteresis, Signum, Look-up Table, PI Controller ,
  - Clarke Transformation, Inverse Clarke Transformation, Park Transformation, Inverse Park Transformation, Space Vector Modulation, Vector Limiter, PMSM Decoupling, DC Bus Ripple Elimination
  - IIR filter, Moving avg. filter

Embedded Software and Motor Control Libraries
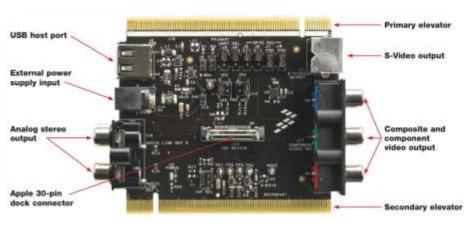
Freescale's Made For iPod (MFi) Solutions

Freescale's MFi solutions are based on the TWR-DOCK peripheral module
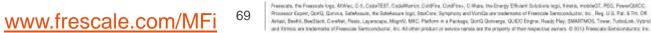
- TWR-DOCK supports development and rapid prototyping of electronic accessories for iPod, iPhone and iPad devices
    - Available to MFi licensees on the MFi portal for $139
    - Direct 30-pin dock connection
    - USB A receptacle for USB to 30-pin dock or Lightning™ cable connection
    - Analog audio and video signals with standard RCA and S-Video connectors
    - Digital audio streaming in both directions over USB
    - Control and communication with various devices
- Includes free interface software
- TWR-DOCK concentrates all MFi controlled items on one Tower module, without including any processors or other Freescale products
- TWR-DOCK may be used with a wide range of Tower System MCU/MPU, peripheral, sensor and communication modules
- Kinetis-based demos are available
- *A new TWR-DOCKx is in development for direct Lightning dock connection*

USB host port
External power supply input
Analog stereo output
Apple 30-pin dock connector

Primary elevator
S-Video output
Composite and component video output
Secondary elevator

The ARM® Eco System

Use the broad support for ARM® microcontroller by many companies.

- Re-use your existing RTOS know how for Freescale Kinetis.

Kinetis Development Hardware

www.freescale.com/kinetis

Kinetis Development Hardware

Freedom Platform

- The new Freescale platform for Kinetis L and Kinetis K microcontroller

- Compatible with Arduino shields

- 4 different boards available today

Tower System

- The established and proven platform with highest flexibility and re-usability

- Over 50 add-on boards available.

Device Specific

- Evaluation boards addressing special functions and capabilities of Kinetis devices

Reference Designs

- Home Energy Gateway, 1ph Meter, 3ph Meter, pre-/post-paid Meter, Home Area Network, Home Display, …

- Available through Freescale RSM

Freedom Platform

- small, low-power, cost-effective evaluation and development system

- quick application prototyping and demonstration

- Low–cost ($10–15 MSRP)

- Designed in an industry-standard compact form factor

- Easy access to the MCU I/O pins

- Integrated open-standard serial and debug interface (OpenSDA)

- Compatible with a rich-set of third-party expansion boards

FRDM-KL02Z	FRDM-KL26Z*
FRDM-KL05Z	FRDM-KL46Z*
FRDM-KL25Z	FRDM-K20D50M
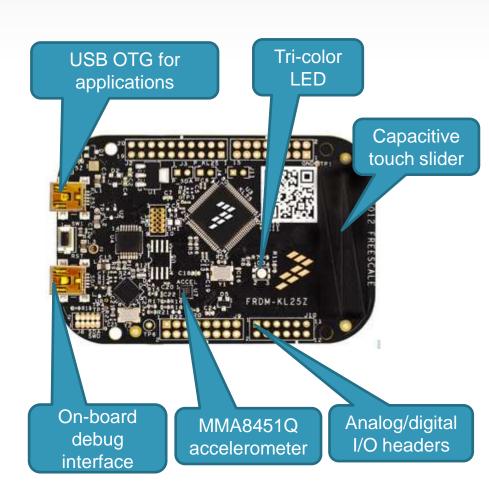
Kinetis L Freedom Board FRDM-KL25Z
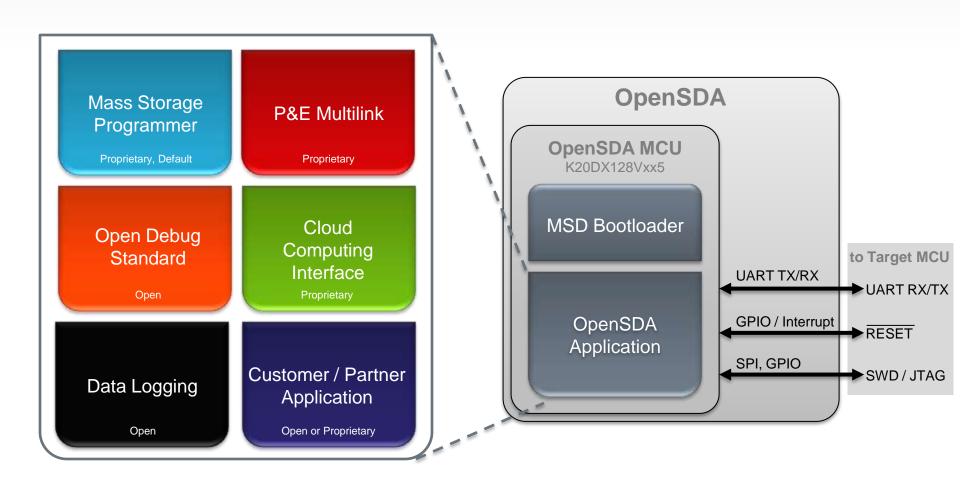
- Kinetis L Series Freedom Development Platform
- MKL25Z128VLK4 MCU, 80 LQFP
- MMA8451Q accelerometer with I2C interface
- Capacitive touch "slider"
- Tri-color LED
- Easy access to MCU I/O
- Sophisticated OpenSDA debug interface
- Powered from USB
- Mass storage device flash programming interface (default) – no tool installation required to evaluate demo apps
- Versatile I/O headers

USB OTG for applications

Tri-color LED

Capacitive touch slider

On-board debug interface

MMA8451Q accelerometer

Analog/digital I/O headers

OpenSDA Applications Overview

Mass Storage Programmer	P&E Multilink
Proprietary, Default	Proprietary
Open Debug Standard	Cloud Computing Interface
Open	Proprietary
Data Logging	Customer / Partner Application
Open	Open or Proprietary

OpenSDA

OpenSDA MCU
K20DX128Vxx5

MSD Bootloader

OpenSDA Application

UART TX/RX → UART RX/TX
GPIO / Interrupt → $\overline{\text{RESET}}$
SPI, GPIO → SWD / JTAG

to Target MCU

Latest OpenSDA applications and drivers: visit pemicro.com/opensda
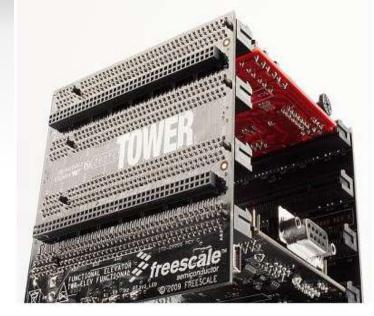
Freescale Tower System

- Modular development platform
- Also for rapid prototyping
- Interchangeable and reusable modules
- Open source design files
- Easy to customize
- Reduced low level design effort
- Sold in kits or as individual modules
- Processor modules with debug interface and stand-alone operation.
- Cost effective

www.freescale.com/tower

Available Tower System Modules

8bit

TWR-S08LL64
TWR-S08LH64
TWR-S08JE128
TWR-S08MM128
TWR-S08GW64
TWR-S08UNIV
TWR-S08PT60

ColdFire

TWR-MCF51AG
TWR-MCF51CN
TWR-MCF51JE
TWR-MCF51JF
TWR-MCF51MM
TWR-MCF51QM
TWR-MCF5225X
TWR-MCF5441X

Kinetis

TWR-KL25Z48M
TWR-K20D50M
TWR-K20D72M
TWR-K21D50M
TWR-K40X256
TWR-K40D100M
TWR-K53N512
TWR-K60N512
TWR-K60D100M
TWR-K60F120M
TWR-K70F120M

16bit

TWR-S12G64
TWR-S12G128
TWR-S12G240
TWR-S12GN32

Power Arch

TWR-MPC5125
TWR-MPC8309
TWR-P1025
TWR-PXD10
TWR-PXD20
TWR-PXN20
TWR-PXR40
TWR-PXS2010
TWR-PXS3020

DSC

TWR-56F8257
TWR-56F8400

Serial

TWR-SER
TWR-SER2

Prototyping

TWR-PROTO

Wi-Fi

TWR-WIFI-RS2101
TWR-WIFI-G1011MI
TWR-WIFI-GS1500M
TWR-WIFI-AR4100

Memory

TWR-MEM
TWR-MEM-PISMO

Sensors & Plug-Ins

TWR-SENSOR-PAK
TWR-SENSOR-PAK-AUTO
TWR-TWRPI-BD
TWRPI-MMA6900
TWRPI-MPL115A

Analog

TWR-ADCDAC-LTC

Audio

TWR-AUDIO-SGTL

Mesh Networking

TWR-RF-SNAP

Displays

TWR-LCD
TWR-LCD-RGB

Medical

MED-EKG

Motor-Control

TWR-MC-LV3P

Apple MFi

TWR-DOCK
TWR-DOCK2

Industrial

TWR-MECH
TWR-IND-IO

Radio

TWR-12311
TWR-METRO-KIT

www.freescale.com/tower

Reference Designs

The ARM® Eco System

Use the broad support for ARM® microcontroller by many companies.

- Re-use your existing debugger and programmer for Freescale Kinetis.

New MCU Solution Advisor: Interactive Product Selector Guide

- **Helps identify best MCU** choice by applying dynamic filters based on:
  - Operating characteristics
  - Packaging options
  - Memory configuration
  - Peripheral hardware library

- **Web-based application** featuring an interactive MCU product selector for Kinetis K, L series MCUs as well as 8-bit and Freescale DSC.

Now available:
  Motor Control Wizard
  Check pin-muxing
  Interactive Tower System page

www.freescale.com/solutionadvisor