Overview of Kinetis Microcontroller Portfolio based on ARM® Cortex®-M0+ and Cortex-M4 Cores

EUF-IND-T0976

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JAN. 2015
The Internet of Things is Driving **Explosive Growth** In Connected Devices

**Sense, Process, Communicate**

*Sources: Ericsson, February 2011; Cisco Internet Business Solutions Group (IBSG), April 2011*
Our Products Power The Internet of Things

Microcontrollers | Digital Networking | Auto MCU | Analog and Sensors | RF

- Advanced Safety
- Radar + Vision
- Infotainment
- Traffic Monitoring
- Home Health Monitors + Fitness
- Telehealth
- Connected Appliances
- Energy Meters
- Security
- Energy Management, Wind + Solar
- Smart Energy Grid
- Digital Power Conversion
- Base Stations
- Data Center
- Enterprise Gateways, Switchers, Routers
- Metro Cells Small Cells
- Security
- Networked Printers
- Connected Farms
- Industrial Networking
- Human – Machine Interface
- Machine – Machine
Internet of Things – Data Transport Scheme

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>User-driven actions via devices with screens or automatically driven actions based on data parameters</td>
</tr>
<tr>
<td>Sensors &amp; Actuators</td>
<td>Embedded Processing</td>
<td></td>
<td></td>
<td></td>
<td>Insights/Big Data</td>
</tr>
<tr>
<td>Connectivity: BAN/PAN/LAN/WAN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Data analytics for business intelligence</td>
</tr>
</tbody>
</table>

Legend:
- **S** Sensors & Actuators
- **P** Embedded Processing
- **C** Connectivity: BAN/PAN/LAN/WAN

Medtronic's glucose monitor uses Bluetooth to "talk" to Ford Sync
Freescale IoT Offerings

**Xtrinsic Sensing**
*Intelligent Contextual Sensing.*

The right combination of intelligent integration, logic and customizable software on the platform to deliver smarter, more differentiated applications.

For IoT it provides Context: Identity, Activity, Location, & Time

**Connectivity**
*BAN/ PAN/ LAN*

Fully integrated Short Range radios with best in class power performance, and Powerline Communications

**Edge products:**
- Very small
- Low cost
- Low power
- Low complexity
- Industrial grade & robust

**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.

Scalable Industry Standard Solutions, Software and Development Ecosystem
Microcontrollers/Processors Portfolio

**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.

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

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

**Kinetis V Series**
- High efficiency, high speed peripherals ARM Cortex-M0+ & Cortex-M4 MCU families for use in motor control & power conversion.

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

**Kinetis EA Series**
- Highly robust, enhanced ESD/EMC performance ARM Cortex-M0+ solution for cost-sensitive automotive applications.

**General Purpose**
- Leading Performance - Low Power - Scalability - Industrial-grade Reliability & Temp

**Integration**

**Performance**

**i.MX Applications Processors**
Your Interface to the World.

**Vybrid Controller Solutions**
Rich Apps in Real Time.
Leadership in Cortex-M  
*World’s Broadest, Most Scalable Portfolio*

<table>
<thead>
<tr>
<th>Cortex M</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>900+</td>
<td>Freescale - <strong>Kinetis</strong></td>
</tr>
<tr>
<td>650</td>
<td>ST Micro</td>
</tr>
<tr>
<td>250</td>
<td>NXP</td>
</tr>
<tr>
<td>250</td>
<td>SiLabs / Energy Micro</td>
</tr>
<tr>
<td>280</td>
<td>Atmel</td>
</tr>
<tr>
<td>50</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>None</td>
<td>Renesas</td>
</tr>
<tr>
<td>None</td>
<td>Microchip</td>
</tr>
</tbody>
</table>

1<sup>st</sup> to market Cortex-M4  
1<sup>st</sup> to market Cortex-M0+
Kinetis in Production
# Kinetis Platform Overview

<table>
<thead>
<tr>
<th>L</th>
<th>E</th>
<th>K</th>
<th>W</th>
<th>M</th>
<th>V</th>
<th>EA</th>
</tr>
</thead>
<tbody>
<tr>
<td>48 MHz Cortex M0+</td>
<td>&lt;48 MHz Cortex M0+</td>
<td>&lt;180 MHz Cortex M4</td>
<td>&lt;50 MHz Cortex M4, Cortex M0+</td>
<td>&lt;48 MHz Cortex M0+</td>
<td>&gt;75 MHX Cortex M0+ &amp; M4</td>
<td>48 MHz Cortex M0+</td>
</tr>
<tr>
<td>8 KB – 512 kB Flash</td>
<td>8 KB – 128 kB Flash</td>
<td>32 KB – 2 MB Flash</td>
<td>32 KB – 512 kB Flash</td>
<td>32 KB – 128 kB Flash</td>
<td>&gt;16 KB Flash</td>
<td>8 KB – 128 kB Flash</td>
</tr>
<tr>
<td>&lt;128 KB RAM</td>
<td>&lt;16 KB RAM</td>
<td>&lt;256 KB RAM</td>
<td>&lt;64 KB RAM</td>
<td>&lt;32 KB RAM</td>
<td>&gt;4 KB RAM</td>
<td>1K-16 KB RAM</td>
</tr>
<tr>
<td>1.71 – 3.6 V</td>
<td>2.5 – 5.5 V</td>
<td>1.71 – 3.6 V</td>
<td>Now</td>
<td>Now</td>
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Leading Performance – Low Power – Scalability – Industrial Grade reliability & temp

Freescale Bundled IDE, RTOS & Middleware – Rapid Prototyping Platform – Broad ARM Ecosystem Support
Kinetis L Series MCUs: Moving from 8-/16-bit Architecture to 32-bit
Kinetis L Series MCUs: Enabling Differentiation in Entry-Level Products

Energy efficiency
Class-leading
CoreMark/mW

Scalability and integration
Kinetis L to K Series MCUs (ARM Cortex-M0+ to Cortex-M4)

Enablement
Freescale bundle + ARM ecosystem

Kinetis L Series MCUs
The evolution of the entry-level MCU

Ultra-low static
<1µA

Low cost
From <$0.50

Ease of use
Freedom Platform, Processor Expert and MCU Solution Advisor

Going Green
Health & Safety
Net Effect
<table>
<thead>
<tr>
<th>Benefits of Moving from 8/16-bit Architecture to a 32-bit Architecture Built on the ARM Cortex-M0+ Processor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8/16-bit</strong></td>
</tr>
<tr>
<td><strong>Performance</strong></td>
</tr>
<tr>
<td>• Older, slower architectures and technology</td>
</tr>
<tr>
<td>• Increased code size/complexity when performing complex math operations</td>
</tr>
<tr>
<td>• Fast single-cycle access to I/O</td>
</tr>
<tr>
<td><strong>Energy efficiency</strong></td>
</tr>
<tr>
<td>• Low energy efficiency</td>
</tr>
<tr>
<td><strong>Low cost</strong></td>
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<tr>
<td>• 6-35 kgates</td>
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<tr>
<td>• Variable code density</td>
</tr>
<tr>
<td><strong>Ease of development</strong></td>
</tr>
<tr>
<td>• Limited addressable memory</td>
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<tr>
<td>• Simplistic interrupt controllers</td>
</tr>
<tr>
<td>• Limited scalability (MHz, flash, features)</td>
</tr>
<tr>
<td>• Limited ecosystem support</td>
</tr>
<tr>
<td>• Micro Trace Buffer—lightweight, non-intrusive trace</td>
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</tbody>
</table>
Kinetis L Series MCUs
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 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.
Kinetis L: A Scalable Portfolio
Production-qualified Cortex-M0+

**KL0 Family**
8–32 KB, 8-bit compatible

**KL1 Family**
32–256 KB, General Purpose

**KL2 Family**
32–256 KB, USB OTG (FS)

**KL3 Family**
64–256 KB, SLCD

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

**Kinetis L Series**
Cortex-M0+ 48 MHz

10K# Suggested Resale Price shown
The **NEW**
Kinetis KL03

Design Made Simple.

The New World’s Smallest & Most Energy Efficient 32-bit MCU

Starting with 35% smaller package size than any other competing 32-bit MCU based on ARM architecture, and designed for power efficiency, the Kinetis KL03 family takes advantage of ARM’s ultra-low-power Cortex-M0+ architecture and features peripherals that help you optimize power consumption.

Size represents actual comparison.
Kinetis L has Real Low-Power Capabilities

- **Best in Cortex-M0 class for low-power**
  Up to 25% lower power than STM32F0x, SAMD20 or NXP LPC11x (Typ.)
  50% lower power than STM32L1 in RUN mode

- **Better low-power flexibility**
  12 Low-Power Modes (incl. Compute mode) when competitor MCUs have max 7 LP Modes

- **Energy saving peripherals**
  More peripherals available in lowest-power modes (LPTMR, CMP, TSI) than competition

- **High-performance processor**
  9% increased performance from Cortex-M0 (1.77Coremark/MHz)
Kinetis K Series MCUs: Performance Without Compromise
Kinetis K-Series MCUs

*Design Potential. Realized.*

**Ultra-Scalable** – Over 300 hardware and software compatible ARM Cortex-M4 MCUs with DSP + low-power, connectivity, communications, HMI and security features

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

**Innovative Flex Memory** – Low-power 90nm Thin-Film Storage Flash with FlexMemory offers EEPROM capability with unprecedented programming speed and endurance

**Comprehensive Enablement** – Freescale MQX RTOS and Eclipse-based CodeWarrior IDE, as well as IAR, KEIL and other ARM ecosystem providers
Cortex-M4: Efficient Blend

The Cortex-M4 is ~2X more efficient on most DSP tasks than leading 16 and 32 bit MCU devices with DSP extensions.
Kinetis K 1\textsuperscript{st} Generation

Key Pillars:
- **Ultra-Scalable** hardware and software compatible Cortex-M4 MCUs
- Exceptional **mixed signal** integration
- **Innovative Flex memory** offers EEPROM capability with unprecedented programming speed, low-power and endurance
- **Comprehensive enablement** – Freescale MQX RTOS and Eclipse-based CodeWarrior IDE, as well as IAR, KEIL and other ARM ecosystem providers

Key Application Examples:
- Applications requiring:
  - Rich Mixed-Signal integration
  - Broad offer of FlexMemory (EEPROM)
  - Rich HMIs (SLCD, GLCD, Touch Sensing)

1\textsuperscript{st} Generation K-Series Families

- **Building Control**: Rich HMI Security & access control
- **Factory Automation**
- **Medical**: Heart rate monitors, Blood glucose monitors
- **Metering**: Flow meters, SLCD meters
- **HMI Rich Point of Sale**
- **Portable Instrumentation**

<table>
<thead>
<tr>
<th>Family</th>
<th>Description</th>
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<tbody>
<tr>
<td>K70</td>
<td>Graphics</td>
</tr>
<tr>
<td>K60/K61</td>
<td>Ethernet (optional Tamper)</td>
</tr>
<tr>
<td>K5x</td>
<td>Measurement (Medical)</td>
</tr>
<tr>
<td>K40</td>
<td>SLCD + USB</td>
</tr>
<tr>
<td>K30</td>
<td>SLCD</td>
</tr>
<tr>
<td>K20</td>
<td>USB</td>
</tr>
<tr>
<td>K10</td>
<td>Baseline</td>
</tr>
</tbody>
</table>
Kinetis K Series: Original Portfolio Complete!

- **512 KB-1 MB Flash, 120-150 MHz, FPU**
  - 120-150 MHz, Floating Point Unit, 512 KB-1 MB, 144-256pin
- **128-512 KB Flash, 100 MHz**
  - K60 Family + USB (HS), Tamper, NAND Flash, DRAM
- **64 KB-256 KB Flash, 72 MHz**
  - K70 Family + Graphics LCD
- **32 KB-128 KB Flash, 50 MHz**

**Feature Integration**

- **50 MHz**
  - 32-128 KB, 32-64pin
    - K20 Family USB
    - K10 Family Mixed-Signal
  - **72 MHz**
    - 64-256 KB, 64-121pin
      - K50 Family (Medical) Analog, USB, S. LCD, Ethernet, Encryption
      - K40 Family USB, Segment LCD
    - **100 MHz**
      - 128-512 KB, 80-144pin
        - K60 Family Ethernet, Encryption, USB
        - K50 Family (Medical) Analog, USB, S. LCD, Ethernet, Encryption
      - **120-150 MHz**
        - Floating Point Unit, 512 KB-1 MB, 144-256pin
        - K60 Family + USB (HS), Tamper, NAND Flash, DRAM
- **Mixed-Signal**
  - K10 Family Mixed-Signal
  - K20 Family USB
  - K30 Family Segment LCD
  - K40 Family USB, Segment LCD
  - K50 Family Analog, NAND Flash
  - K60 Family USB
  - K70 Family Graphics LCD
  - K80 Family Floating Point Unit

freescale™
Kinetis K2 – the Next Generation

1. Improved ease of use and time to market with **new set of product enablement**

2. New products with **head turning low power** capabilities and **processing efficiency**

3. **New price points** to open new doors to faster market share gain
Next Generation Ease-of-Use Software Development
Launch with K2 and then supporting all Kinetis Families

✓ Kinetis Software Development Kit (SDK)

- A complete software framework for developing applications across all Kinetis MCUs
- HAL, peripheral drivers, libraries, middleware, utilities, and usage examples.

✓ Kinetis Design Studio

- No-cost integrated development environment (IDE) for Kinetis MCUs
- Eclipse and GCC-based IDE for C/C++ editing, compiling and debugging

✓ Kinetis Bootloader

- In-system flash programming over a serial connection: erase, program, verify
- ROM or flash based bootloader with open-source software and host-side programming utilities.
Kinetis K2 Tools Solutions (Addition to existing Kinetis Enablement)

✓ mbed Support – Expanding to Kinetis K-Series Families

- Rapid and easy Kinetis prototyping and development through the global mbed Developer Community providing free software libraries

✓ Expand Offer of K-Series Freedom Boards

- Ultra low-cost/low-power development platform
- Enables quick application prototyping and demonstration of Kinetis MCU families

Cloud enablement through freely available online design tools, communities, part selectors
K2 – The Next Generation of Kinetis Solutions

Key Pillars:
- Market’s Most **Comprehensive Software Development**
- New Heights in **Scalability** with **New Lows in Price**
- The Pinnacle in **Performance** and **Power Efficiency**

Key Application Examples:

**Building/Home Control**
- Security & access control

**Factory Automation**
- Metering
  - Smart metering
  - Grid Concentrators

**Consumer**
- Gaming systems / Wearables
- Printers / Portable media players

**Point of Sale**
- Remote Sensing
- Wireless Nodes
- Audio & Video Controllers

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2nd Generation Kinetis K Families

- K64, K66 – Ethernet MCUs
- K63, K65 – Ethernet w/ Tamper MCUs
- K24 – USBs MCU w/ extended RAM
- K22 – USB MCUs
- K21 – USB w/ Tamper MCUs
- K12 – Baseline MCUs
- K11 – Baseline w/Tamper MCUs
- K02 – L-Series Bridge Cortex-M4 MCUs
Kinetis K Series – Next Wave of Devices

Available & Scalable
Maximize R&D investment

Smart Optimization
Find perfect balance

Exceptional Enablement
Develop smart solutions faster

K22F 120 MHz
256 KB-1MB, 64-144pin
K22F: USB + FPU

K22F 100 MHz
128 KB, 32-64pin
K22F: USB + FPU

K24F:
USB + Ext. RAM

K64F / K24F 120 MHz
640 K-1 MB, 100-144-pin
K64F: Ethernet + USB + Ext. RAM
K24F: USB + Ext. RAM

K66F 180 MHz
1.25 M-2 MB, 144-169-pin
K66F: Ethernet+2xUSB(HS PHY)+Ext.RAM

K66F 120 MHz
1.25 M-2 MB, 144-169-pin

K64F:
Ethernet + USB + Ext. RAM
K24F: USB + Ext. RAM

K22F 120 MHz
256 KB-1MB, 64-144pin
K22F: USB + FPU
Kinetis K Series Portfolio

1st Generation Key Differentiators

- Feature Rich MCUs
  - Analog Mixed Signal
    - Up to 4x 16-bit ADCs
    - 16-bit ADCs w/ PGAs
    - AmpOp
    - TriAmp
  - FlexMemory
    - EEPROM
    - Read-While-Write
  - HMI:
    - Touch Sensing
    - Segment LCD
    - Graphic LCD

- K70 Family + Graphics LCD
- K60/K61 Family Ethernet, USB
- K5x Family (Measurement)
  - Analog, USB, SLCD, Ethernet, Encryption
- K40 Family
  - Segment LCD + USB
- K30 Family
  - Segment LCD

2nd Generation Key Differentiators

- Graphics
  - K66F Family:
    - Ethernet + 2xUSB (HS PHY) + High RAM
- Measurement
  - K64F Family
    - Ethernet + USB + High RAM
- Segment LCD
  - K24F Family
    - USB + High RAM
- USB
  - K20 Family
    - USB
  - K10 Family
    - Mixed-Signal
- Baseline
  - K02 Family
    - L-Series Bridge
  - K11/12 Family
    - Baseline w/ opt. Tamper
  - K21/K22 Family
    - USB w/ opt. Tamper

Power / Processing Efficiency
- Excel in Power Efficiency
- Cortex-M4 w/ FPU >100MHz from 64KB to 2MB of Flash
- Power conscious peripherals

Streamline Feature Set
- Smart Integration: right features at the right price.
- Save BOM cost with Crystal-less USB device functionality

Introduction of New Tools
- Kinetis Software Development Library (SDK)
- Kinetis Development Studio
- Embed support
- Expansion of ultra-low cost development board offer (Freedom Boards)

Comprehensive Enablement - Hardware and Software Scalability
Kinetis K-Series Portfolio

ARM Cortex-M4 solutions for a wide range of embedded applications

1st Gen Kinetis K-Series Families

- K70 – Graphics
- K60/K61 – Ethernet w/optional Tamper
- K5x – Measurement (Medical)
- K40 – SLC + USB
- K30 – SLC
- K2x – USB
- K1x – Baseline

2nd Gen Kinetis K-Series Families

- K64, K66 – Ethernet MCUs
- K63, K65 – Ethernet w/Tamper MCUs
- K24 – USBs MCU w/extended RAM
- K22 – USB MCUs
- K21 – USB w/Tamper MCUs
- K12 – Baseline MCUs
- K11 – Baseline w/Tamper MCUs
- K02 – L-Series Bridge Cortex-M4
K2 Improvements over K 1\textsuperscript{st} Generation

Kinetis K 2\textsuperscript{nd} Generation leverages Freescale’s proven L-Series low power technology and drive a quantum performance/power efficiency leap over Kinetis K 1\textsuperscript{st} Generation of Microcontrollers

- **Highest Performance Efficiency**
  - Dynamic power consumption reduced of 30% compared to Kinetis 1\textsuperscript{st} gen
  - Half the dynamic power consumption in Very Low Power Run than previous gen

- **Best-in-Class State Retention Low Power Modes**
  - Up to 50x lower currents than previous Kinetis devices at 120MHz

- **10x lower Shelf Mode than previous generation**
  - K2 Deepest low-power mode down to 150nA
K2 Leading Performance / Power Efficiency

Kinetis K 2\textsuperscript{nd} Generation leverages Freescale’s proven L-Series low power technology and set a new height of performance / power efficiency for Cortex-M3/M4 MCUs

- **Highest Performance Efficiency**
  - Half the dynamic power consumption than STM32F103/F105 and STM32F3
  - 15\% lower dynamic power consumption than STM32F401 and Atmel SAMG

- **Best-in-Class State Retention Low Power Modes**
  - From 5 to 50\times lower currents than STM32F devices
  - 3\times lower than Atmel SAM5G

- **10\times lower Shelf Mode than STM32F**
  - K2 Deepest low-power mode down to 180nA