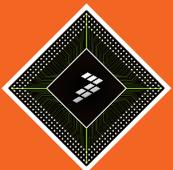# Low-Power MCU Solutions
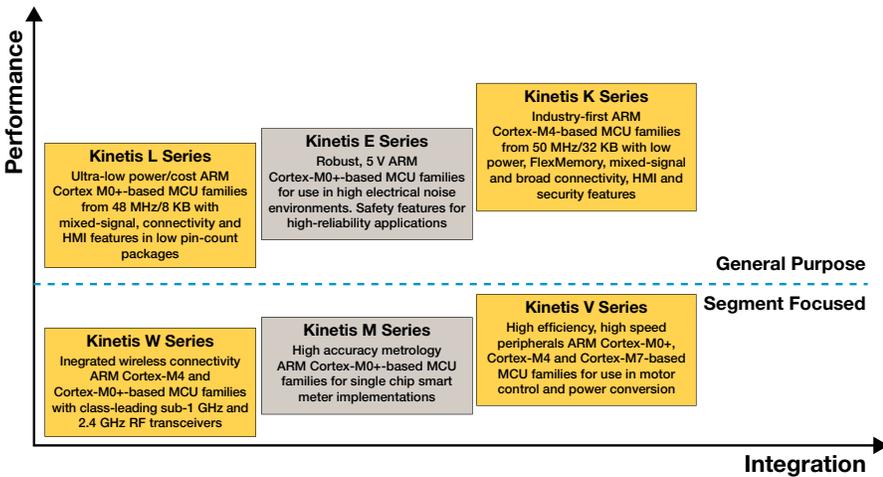
Providing a broad portfolio of innovation for low-power applications enabling the Internet of Things.

freescale.com/LowPower

Low-Power MCU Solutions

Freescale provides the broadest portfolio of energy efficient, 32-bit microcontroller (MCU) products for low-power applications enabling the Internet of Things. The Kinetis MCU portfolio includes devices based on the ARM® Cortex®-M0+, Cortex-M4 and Cortex-M7 core. The scalability offered by the Kinetis MCU portfolio enables a range of low-power MCUs from the high performance Kinetis K series to the ultra-low power Kinetis L series, providing industry-leading energy efficiency. The Kinetis MCU portfolio is supported by the most comprehensive set of development tools and software.

Low-Power MCU Solutions Diagram

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

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

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

General Purpose
Segment Focused

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

Kinetis M Series
High accuracy metrology ARM Cortex-M0+-based MCU families for single chip smart meter implementations

Kinetis V Series
High efficiency, high speed peripherals ARM Cortex-M0+, Cortex-M4 and Cortex-M7-based MCU families for use in motor control and power conversion

Performance — Integration

Kinetis K Series
Performance efficient, industry leading low-power numbers and significant BOM savings through smart on-chip integration

Kinetis L Series
Excellent dynamic and stop current values and wake up times from deep sleep modes

Kinetis E Series
Robust 5 V operation with the power efficient ARM Cortex-M0+ core and bit manipulation capability designed for high noise environments

Kinetis M Series
Power efficient processing coupled with analog front end and independent real-time clock (RTC) capabilities architected for low-power metering solutions

Kinetis V Series
Real-time control peripherals such as fast ADCs and high resolution PWMs coupled with hardware accelerators to supplement processing capabilities delivering excellent dynamic power

Kinetis W Series
Robust feature sets for reliable, secure and low-power embedded wireless solutions

2

Easy-to-Use Development Tools

Kinetis MCUs are supported by a market-leading enablement bundle from Freescale and ARM third-party ecosystem partners. Designed to simplify and accelerate development, this portfolio of software and tools can help further energy savings through power mode management software, clock and peripheral configuration tools, and more.

The Kinetis software development kit (SDK), for example, is an extensive suite of robust peripheral drivers, stacks and middleware designed to simplify and accelerate application development on any Kinetis MCU. The Kinetis SDK is complimentary and includes full source code under a permissive open source license for all hardware abstraction and peripheral driver software.

Engineers can speed up their hardware and software design cycles by using industry-standard development tools—like the Kinetis SDK—many of which offer evaluation versions. The result—faster time to market, a reduction in product development costs, and lower power designs. Check it all out at **freescale.com/Kinetis/SW**.

Kinetis Power Estimation Tool

The Power Estimation Tool for Kinetis MCUs lets you estimate and optimize your system's power consumption quickly with a simple graphical interface. This tool helps you design for efficient use of energy - a requirement for Internet of Things applications.

Simply install the tool (local version) or use the online tool to add details of your system - including the power mode, clock mode, peripheral settings and duration for each system state.

It also provides immediate system power estimation results including average current, battery life, and consumption charts. Features include:

- Estimates your application's power profile by analyzing the configuration details you provide for each state of your system

- Provides immediate energy consumption and battery life estimations

- Generates consumption and battery discharge graphs

- Provides ability to save and load profiles and generate reports

- Local and online versions to be available

- English and limited Chinese language support

- Backed by real power measurement data

- Quickly evaluate which Kinetis MCU fits your use-case and power budget

- Accelerates learning curve for advanced power management features

- Ideal tool for developing wearable and other battery-operated applications

Learn more at **freescale.com/kinetis/powertool**.

Low-Power Technology

Freescale understands the significance of energy efficiency in today's world, and is driving the Internet of Things by offering these five key features which enable Kinetis MCUs to achieve the lowest power possible:

Low-power boot

Non-volatile control bits (LPBOOT) to set default chip clocking upon power up to optimize for lowest power during the boot process. System level considerations like varying low voltage detect levels and optimizing decoupling cap for size and cost to match user's low power capabilities can also be addressed.

Intelligent clocking

Various clock sources and multipliers to set the clocks for peripherals, or CPU, across all power modes, allowing scalable performance as needed to meet application needs. Clock gating reduces overall run and wait mode current by turning clocks off to unused peripherals.

Ultra-efficient processing

The world's most efficient processor cores (Cortex-M), supplemented by Freescale proprietary features like 90 TFS technology, flash memory controller (FMC), bit manipulation engine (BME), low-power I/O and crossbar for real-time control and computation.

Flexible low-power modes

Numerous power modes to power gate memories and peripherals to allow dynamic and static power optimization for a wide range of use cases. Freescale expands the three traditional power modes to support numerous application use cases and thus, reducing the area underneath the energy curve.
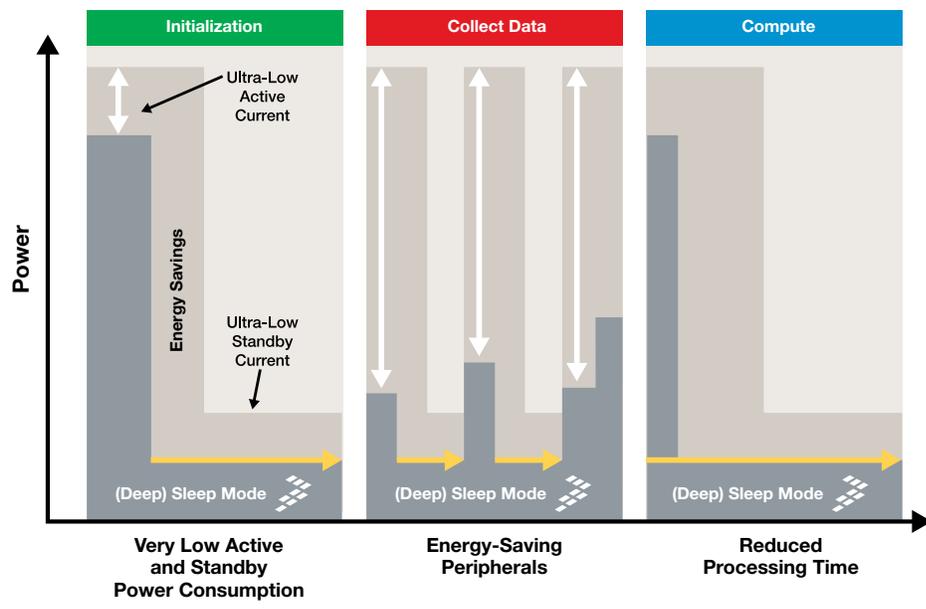
Kinetis MCU Technology: Low-power Modes

Typical Power Modes in an Ebedded System	ARM Cortex-M4 Power Modes	Kinetis MCU Extended Power Modes	Typical* Recovery Time	Typical* Idd Range
Run	Run	Run	–	From 270 uA/MHz
		VLP Run	–	From 710 uA
Wait	Sleep	Wait	–	From 6.5 mA
		VLP Wait	–	From 450 uA
Stop	Deep Sleep	Stop	4 us	From 302 uA
		VLP Stop	4 us	From 5.1 uA
		LL Stop	4 us	2.1 uA–10 uA
		VLL Stop3	35 us	1420 nA–8 uA
		VLL Stop2	35 us	1420 nA–4 uA
		VLL Stop1	100 us	690 nA–2 uA
		VLL Stop0	100 us	190–300 nA

Freescale Adds Low Leakage Wake-up Unit

Very Low Power = VLP
LL = Low Leakage
Very Low Leakage = VLL

*Room temperature, 3 V

Low-Power Application Use Case

Power

| Initialization | Collect Data | Compute |

Ultra-Low Active Current

Energy Savings

Ultra-Low Standby Current

(Deep) Sleep Mode

Very Low Active and Standby Power Consumption | **Energy-Saving Peripherals** | **Reduced Processing Time**

Low-Power Technology (continued)
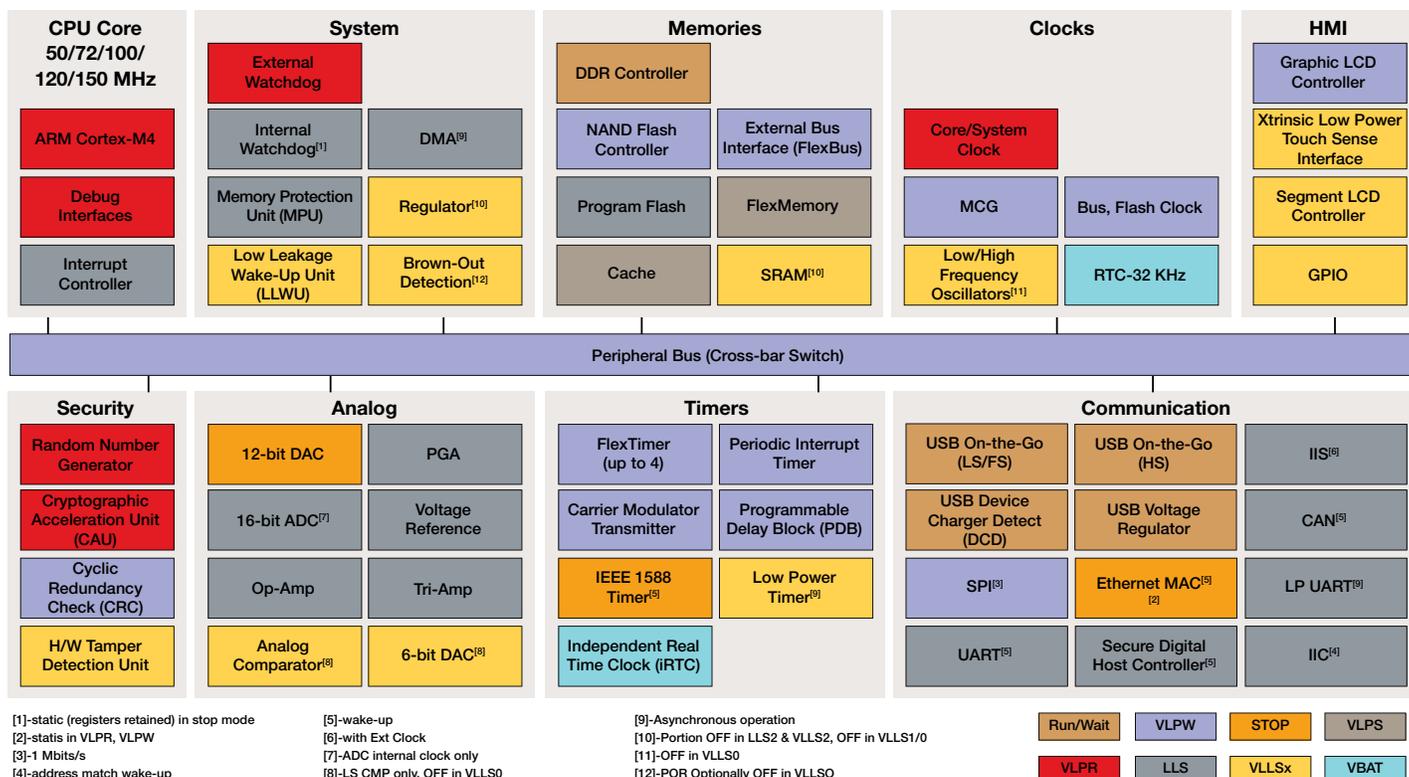
Autonomous, low-power peripherals

Peripheral operation and functionality with decision making capabilities in power down modes, saving precious energy by extending time spent in sleep.

- With the asynchronous DMA functionality, many peripherals like ADC, low-power UART and low-power timers can trigger DMA request even in STOP/VLPS modes to perform DMA transfer and return to the current mode without waking up the CPU.

- The low leakage wake-up unit (LLWU), which works in LLS and VLLS modes, gives the user a reduced set of wake-up sources for further power savings. It supports up to 8 wake-up pins, RESET and NMI wakeup pins, and some energy-saving peripherals in LLS and VLLSx modes.

- The real-time clock (RTC) supports 32-bit seconds counter with seconds interrupt and programmable alarm in all power modes.

- Some devices with optional crystal-less USB feature have an internal reference clock, which prevents the need for external crystal for implementing USB device and hence, reduces the BOM cost.

- The segment LCD supports alternate displays and blink capability in all power modes, which does not require CPU intervention. Touch sense interface (TSI) supports wake-on touch from a single channel in all power modes.

- Various modules and peripherals with their low-power mode functionality is shown in the figure below:

Low-Power Modules and Peripherals for Kinetis K Series MCUs

CPU Core 50/72/100/120/150 MHz	System	Memories	Clocks	HMI
	External Watchdog	DDR Controller		Graphic LCD Controller
ARM Cortex-M4	Internal Watchdog[1] / DMA[9]	NAND Flash Controller / External Bus Interface (FlexBus)	Core/System Clock	Xtrinsic Low Power Touch Sense Interface
Debug Interfaces	Memory Protection Unit (MPU) / Regulator[10]	Program Flash / FlexMemory	MCG / Bus, Flash Clock	Segment LCD Controller
Interrupt Controller	Low Leakage Wake-Up Unit (LLWU) / Brown-Out Detection[12]	Cache / SRAM[10]	Low/High Frequency Oscillators[11] / RTC-32 KHz	GPIO

Peripheral Bus (Cross-bar Switch)

Security	Analog	Timers	Communication		
Random Number Generator	12-bit DAC / PGA	FlexTimer (up to 4) / Periodic Interrupt Timer	USB On-the-Go (LS/FS)	USB On-the-Go (HS)	IIS[6]
Cryptographic Acceleration Unit (CAU)	16-bit ADC[7] / Voltage Reference	Carrier Modulator Transmitter / Programmable Delay Block (PDB)	USB Device Charger Detect (DCD)	USB Voltage Regulator	CAN[5]
Cyclic Redundancy Check (CRC)	Op-Amp / Tri-Amp	IEEE 1588 Timer[5] / Low Power Timer[9]	SPI[3]	Ethernet MAC[5][2]	LP UART[9]
H/W Tamper Detection Unit	Analog Comparator[8] / 6-bit DAC[8]	Independent Real Time Clock (iRTC)	UART[5]	Secure Digital Host Controller[5]	IIC[4]

[1]-static (registers retained) in stop mode
[2]-statis in VLPR, VLPW
[3]-1 Mbits/s
[4]-address match wake-up

[5]-wake-up
[6]-with Ext Clock
[7]-ADC internal clock only
[8]-LS CMP only, OFF in VLLS0

[9]-Asynchronous operation
[10]-Portion OFF in LLS2 & VLLS2, OFF in VLLS1/0
[11]-OFF in VLLS0
[12]-POR Optionally OFF in VLLS0

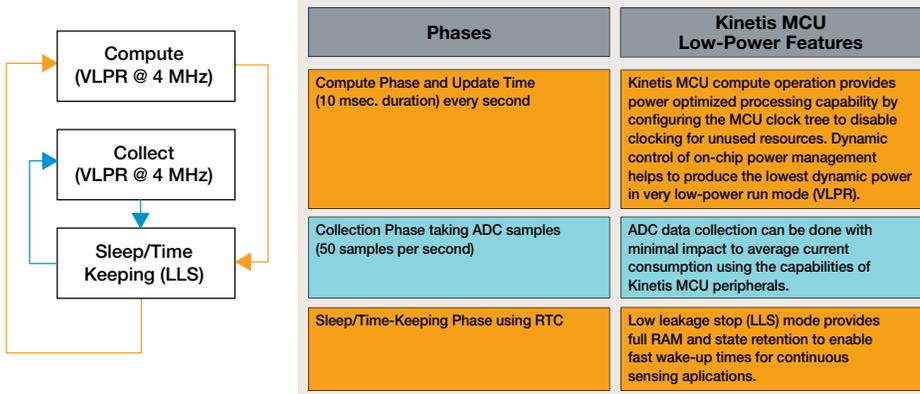| Run/Wait	VLPW	STOP	VLPS
VLPR	LLS	VLLSx	VBAT

Low-Power Use Case Application

The Kinetis MCU portfolio offers exceptional low-power performance with smart feature integration, peripheral sets, and scalability. Key applications for the Kinetis MCU portfolio include: Consumer devices, smart grid and smart metering, building control and medical/ healthcare.

Several Kinetis MCU families are featured best-in-class examples of Freescale Energy-Efficient Solutions. The Energy-Efficient Solutions mark highlights Freescale products that excel in effective implementation of energy-efficient technologies or deliver market-leading performance in the application spaces they are designed to address.

Our solutions enable secure embedded processing for the next generation of the Internet of Things (IoT). One such use case example is shown below:

Example Low-Power Use Case Using Kinetis MCUs

Fitness Watch Using Kinetis MCU Low-Power Capabilities:
Activity Tracking and Sleep/Time-Keeping Mode

Phases	Kinetis MCU Low-Power Features
Compute Phase and Update Time (10 msec. duration) every second	Kinetis MCU compute operation provides power optimized processing capability by configuring the MCU clock tree to disable clocking for unused resources. Dynamic control of on-chip power management helps to produce the lowest dynamic power in very low-power run mode (VLPR).
Collection Phase taking ADC samples (50 samples per second)	ADC data collection can be done with minimal impact to average current consumption using the capabilities of Kinetis MCU peripherals.
Sleep/Time-Keeping Phase using RTC	Low leakage stop (LLS) mode provides full RAM and state retention to enable fast wake-up times for continuous sensing aplications.

Compute (VLPR @ 4 MHz)

Collect (VLPR @ 4 MHz)

Sleep/Time Keeping (LLS)

Reach up to two years of battery life with Kinetis MCU low-power capabilities.

~2 Years Battery Life

☐ Wake up every 1 second to compute results ☐ Wake up every 20 msec. to collect data