Low-Power MCU Solutions

Providing a broad portfolio of innovation for low-power applications enabling the Internet of Things.

freescale.com/LowPower
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 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
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.

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**Kinetis MCU Technology: Low-power Modes**

<table>
<thead>
<tr>
<th>Typical Power Modes in an Embedded System</th>
<th>ARM Cortex-M4 Power Modes</th>
<th>Kinetis MCU Extended Power Modes</th>
<th>Typical* Recovery Time</th>
<th>Typical* Idd Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
<td>Run</td>
<td>Run</td>
<td>–</td>
<td>From 270 nA/MHz</td>
</tr>
<tr>
<td>Wait</td>
<td>Sleep</td>
<td>Wall</td>
<td>–</td>
<td>From 8.5 nA</td>
</tr>
<tr>
<td>Stop</td>
<td>Deep Sleep</td>
<td>Stop</td>
<td>4 µs</td>
<td>From 302 nA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VLP Stop</td>
<td>4 µs</td>
<td>From 5.1 nA</td>
</tr>
</tbody>
</table>

*Room temperature, 3 V

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**Low-Power Application Use Case**

![Diagram showing low-power application use case](image-url)
 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 wake-up 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
- ARM Cortex-M4
- Debug Interfaces
- Interrupt Controller
- System
  - External Watchdog
  - Internal Watchdog
  - Memory Protection Unit (MPU)
- DMA
- NAND Flash Controller
- External Bus Interface (FlexBus)
- Program Flash
- FlexMemory
- Cache
- SRAM
- Low Leakage Wake-Up Unit (LLWU)
- Brown-Out Detection
- Low/High Frequency Oscillators
- RTC-32 KHz
- Core/System Clock
- MCG
- Bus, Flash Clock
- Segment LCD Controller
- HMI
  - Graphic LCD Controller
  - Xtrinsic Low Power Touch Sense Interface
  - GPIO
- Security
  - Random Number Generator
  - Cryptographic Acceleration Unit (CAU)
  - Cyclic Redundancy Check (CRC)
  - H/W Tamper Detection Unit
- Analog
  - 12-bit DAC
  - 16-bit ADC
  - Op-Amp
  - Analog Comparator
  - Tri-Amp
- PGA
- Voltage Reference
- Timers
  - FlexTimer (up to 4)
  - IEEE 1588 Timer
  -独立实时时钟 (RTC)
  - Programmable Delay Block (PDB)
  - Low Power Timer
  - IEEE 1588 Timer
- Communication
  - USB On-the-Go (LS/FS)
  - USB On-the-Go (HD)
  - Ethernet MAC
  - SPI
  - UART
  - Secure Digital Host Controller

[1] - static (registers retained) in stop mode
[2] - static in VLPR, VLPS
[3] - 1 Mbit/s
[4] - address match wake-up
[5] - wake-up
[6] - with external clock
[7] - ADC internal clock only
[8] - LS CMP only, OFF in VLLS0
[9] - Asynchronous operation
[10] - POR optionally OFF in VLLSO
[11] - POR in VLPS0, OFF in VLPS1/0
[12] - POR in VLPS0

[220x625]• The real-time clock (RTC) supports 32-bit seconds counter with seconds interrupt and programmable alarm in all power modes.

[229x612]• 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 wake-up pins, and some energy-saving peripherals in LLS and VLLSx modes.

[229x599]• The real-time clock (RTC) supports 32-bit seconds counter with seconds interrupt and programmable alarm in all power modes.

[229x573]• 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.

[229x560]• 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.

[229x547]• Various modules and peripherals with their low-power mode functionality is shown in the figure below:
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

<table>
<thead>
<tr>
<th>Phases</th>
<th>Kinetis MCU Low-Power Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compute (VLPR @ 4 MHz)</td>
<td>Compute Phase and Update Time (10 msec. duration) every second</td>
</tr>
<tr>
<td>Collect (VLPR @ 4 MHz)</td>
<td>Kinetic 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).</td>
</tr>
<tr>
<td>Sleep/Time Keeping (LLS)</td>
<td>Collection Phase taking ADC samples (50 samples per second)</td>
</tr>
<tr>
<td></td>
<td>ADC data collection can be done with minimal impact to average current consumption using the capabilities of Kinetis MCU peripherals.</td>
</tr>
<tr>
<td>Sleep/Time-Keeping Phase using RTC</td>
<td>Low leakage stop (LLS) mode provides full RAM and state retention to enable fast wake-up times for continuous sensing applications.</td>
</tr>
</tbody>
</table>

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

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

-2 Years Battery Life