

Kinetis KL2x—Ultra-Low-Power MCUs with USB

Up to 512 KB of flash and 128 KB of SRAM

1. Kinetis L Family Introduction

The Kinetis L series MCUs combine the exceptional low-power performance, energy efficiency, and ease of use of the new ARM® Cortex®-M0+ processor with the performance, peripheral sets, enablement, and scalability of the Kinetis 32-bit MCU portfolio. The Kinetis ultra-low-power L series frees the power-critical designs from 8- and 16-bit MCU limitations by combining excellent dynamic and stop currents with superior processing performance, a broad selection of on-chip flash memory densities, and extensive analog, connectivity, and HMI peripheral options. Kinetis ultra-low-power L series MCUs are hardware- and software-compatible with the ARM-Cortex-M4-based Kinetis K series, providing a scalable migration path to higher performance, memory, and feature integration.

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2. Kinetis KL2x Subfamily Overview

The Kinetis KL2x ultra-low-power MCU family features a full-speed USB 2.0 On-the-Go (OTG) controller or a full-speed crystal-less USB 2.0 device controller in addition to the Kinetis KL1x series. The Kinetis KL2x MCU family is also compatible with the Kinetis K20 MCU family (based on the ARM Cortex-M4 core), and with all other Kinetis KL1x, KL3x, and KL4x series MCUs, providing a migration path for lower and higher performance and feature integration.

- KL24—a broad offering with mixed signal integration and full-speed USB OTG 2.0.
- KL25—an expansion from the KL24 family with the addition of 16-bit ADC and TSI.
- KL26—an expansion from the KL25 family with up to 256 KB flash and 32 KB SRAM, together with the addition of I²S and 16-bit SPI.
- KL27—up to 1:4 SRAM-to-flash ratio, device-only crystal-less USB 2.0, built-in ROM bootloader, enhanced mixed signal integration with high-accuracy VREF, ISO7816, two LPUARTs, FlexIO, and high-accuracy 48 MHz IRC.
- KL28—up to 512 KB flash, 128 KB SRAM, 72 MHz core frequency (up to 96 MHz for a high-speed run), advanced smart peripherals including LPUART, LPSPI, LPI2C, EVSIM, parallel FlexIO, crystal-less USB OTG, and others.

3. Kinetis KL2x Key Features

- Ultra-low-power 72 MHz MCUs supported with baseline functions, and with up to 512 KB flash and 128 KB RAM.
- Full-speed USB 2.0 OTG, or full-speed crystal-less USB 2.0 device controller supporting asynchronous wakeup on resume, signaling down to the STOP/VLPS modes.
- Asynchronous DMA enables energy-saving peripherals (for example, ADC, UART, and Timer/PWM) to trigger an asynchronous DMA request in the STOP/VLPS modes, to perform the DMA transfer and return to the current power mode without CPU intervention.
- LPUART supports asynchronous transmit and receive operations to the bus clock, supporting communication down to the STOP/VLPS modes. The configurable receiver baud-rate oversampling ratio from 4× to 32× enables higher baud rates with lower clock sources.
- SPI supports the slave mode address match wakeup function and the first message capture down to the STOP/VLPS modes.
- I²C supports multiple address match wakeup functions down to the STOP/VLPS modes.
- FlexIO can emulate multiple serial interfaces (for example, UART, SPI, I²C, IrDA), and is fully functional in the STOP/VLPS modes.
- LPTPM supports 16-bit timer input capture, output compare, and PWM functions, down to the STOP/VLPS modes.
- LPTMR supports 16-bit timer and pulse-counter functions in all power modes.
- RTC supports a 32-bit second counter with a second interrupt and a programmable alarm in all power modes, including the temperature and voltage compensation.

- ADC supports single conversions in multiple result registers down to the STOP/VLPS modes along with hardware averaging and automatic compare modes.
- CMP supports threshold-crossing detection in all power modes (except for VLLS0) along with a triggered compare mode for lower average power compares.
- DAC and VREF support static reference in all power modes (except for VLLS0).
- TSI supports wake-on capacitive touch on a single channel in all power modes.
- LLWU supports eight wakeup pins, the RESET and NMI wakeup pins, and energy-saving peripherals in the LLS and VLLSx modes.
- Outstanding low-power operation with the core mark currents down to 100 μ A/MHz, the state retention stop mode down to 1.7 μ A with 7.5 μ S wake-up time, and the lowest power mode down to 87 nA.
- Highly reliable, fast-access flash memory with four levels of protection for code security/protection.
- Lower time to market with comprehensive enablement solutions, including SDK (drivers, libraries, stacks), IDE, bootloader, RTOS, online community, and more.

4. Kinetis KL2x Family Feature Summary

Table 1. Family feature summary

| Subfamily | KL24 | KL25 | KL26 | KL27 | KL28 |
|-----------------------------|--|--|--|---|---|
| CPU frequency | 48 MHz | 48 MHz | 48 MHz | 48 MHz | 72 MHz (up to 96 MHz) |
| Flash memory | 32–64 KB | 32–128 KB | 32–256 KB | 32–256 KB | 256–512 KB |
| SRAM | 4–8 KB | 4–16 KB | 4–32 KB | 8–32 KB | 128 KB |
| ROM bootloader | — | — | — | 16 KB | 32 KB |
| Analog | 12-bit ADC, CMP | 16-bit ADC, 12-bit DAC, CMP | 16-bit ADC, 12-bit DAC, CMP | 16-bit ADC, 12-bit DAC, CMP, VREF | 16-bit ADC, 12-bit DAC, CMP, VREF |
| Full-speed USB (2.0 OTG) | Yes | Yes | Yes | Crystal-less USB | Crystal-less USB |
| Connectivity | UART, LPUART, SPI, I ² C | UART, LPUART, SPI, I ² C | UART, LPUART, SPI, I ² C, I ² S | UART w/ ISO7816, LPUART, SPI, I ² C, I ² S, FlexIO | EMVSIM, LPUART, LPSPI, LPI ² C, I ² S, FlexIO, TSI |
| Package options | 32QFN, 48QFN, 64LQFP, 80LQFP | 32QFN, 48QFN, 64LQFP, 80LQFP | 32QFN, 48QFN, 64LQFP, 64MAPBGA, 100LQFP, 121MAPBGA, 36WLCSP | 32QFN, 48QFN, 36XFBGA, 64LQFP, 64MAPBGA | 100 LQFP |

5. Kinetis KL2x Family Block Diagram

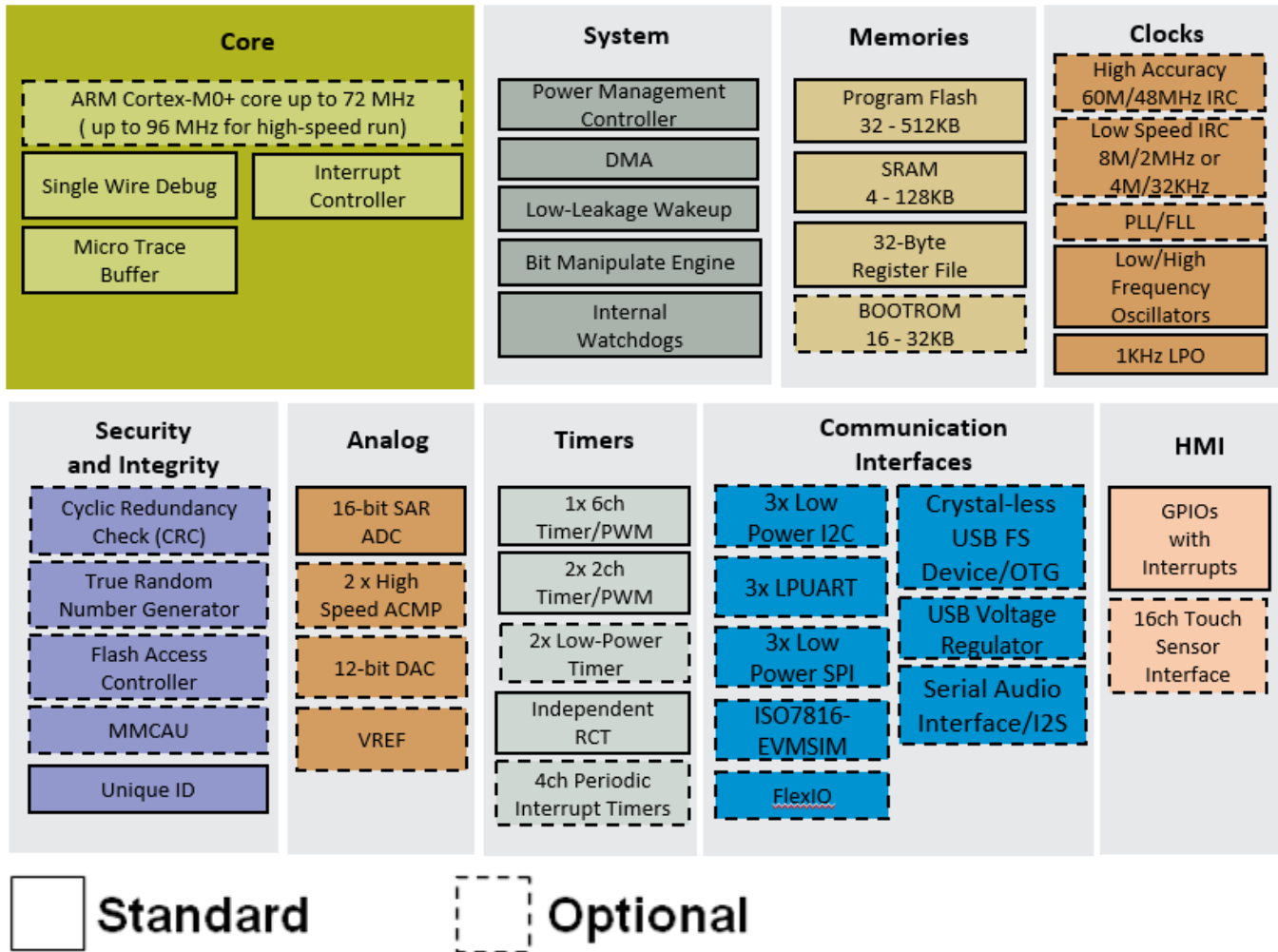


Figure 1. Kinetis KL2x family block diagram

6. KL2x Family Common Features

The following features are present on all KL2x MCUs:

- ARM Cortex-M0+ core running at up to 72 MHz (up to 96 MHz for high-speed run).
- 2-pin Serial Wire Debug (SWD), Micro Trace Buffer (MTB).
- 4–8-channel DMA controller.
- Integrated Bit Manipulation Engine (BME).
- 64 B cache and 32 B register file.
- 1 × 6-channel and 2 × 2-channel LPTPM.
- Low- and high-frequency OSC.
- RTC (32 KHz OSC).

- 1 × low-power timer, 1 × 2-channel PIT.
- Power Management Controller (PMC) with nine power modes.
- Non-Maskable Interrupt (NMI).
- Software and COP watchdog.
- Voltage range of 1.71–3.6 V.
- Temperature range (T_A) of -40–105 °C.

7. Kinetic KL2x Family Differences

Table 2. Family differences

| Subfamily | | KL24 | KL25 | KL26 | KL27 | KL28 |
|-------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|---|---|
| CPU frequency | | 48 MHz | 48 MHz | 48 MHz | 48 MHz | 72 MHz (up to 96 MHz) |
| Memory | Flash/SRAM size | 32 KB/4–128 KB /16 KB | 32 KB/4–128 KB /16 KB | 32 KB/4–256 KB /32 KB | 32 KB/8–128 KB /32 KB, 256 KB/32 KB | 512 KB/128 KB |
| | ROM | — | — | — | 16 KB | 32 KB |
| Connectivity | USB | USB OTG 2.0 LS/FS | USB OTG 2.0 LS/FS | USB OTG 2.0 LS/FS | FS USB 2.0 Slave, Crystal-less USB | Crystal-less USB |
| | UART (LPUART /with ISO7816) | 2(1 / –) | 2(1 / –) | 2(1 / –) | 2(2 / 1) | 3(3 / –) |
| | SPI | 2 ¹ | 2 ¹ | 2 ² | 2 ² | 3 ⁶ |
| | I ² C | 2 | 2 | 2 | 2 ³ | 3 ⁶ |
| | I ² S | — | — | 1 | 1 | 1 |
| | FlexIO | — | — | — | YES | YES ⁷ |
| EMVSIM | — | — | — | — | 1 | |
| Analog modules | ADC | 12-bit | 16-bit | 16-bit | 16-bit | 16-bit |
| | ADC channels (SE/DE) | 7/0–16/0 | 7/0–16/2 | 7/0–20/4 | 7/0–17/2 | — |
| | DAC | — | 12-bit | 12-bit | Optional ⁴ | 12-bit |
| | VREF | — | — | — | YES | YES |
| Other modules | CRC | — | — | — | Optional ⁵ | YES |
| | Security | — | — | — | — | MMCAU, FAC, TRNG |
| | TSI | — | 9 ch–16 ch | 9 ch–16 ch | — | 16 ch |
| | Total GPIOs | 23–66 | 23–66 | 23–80 | 23–51 | 82 |
| | MCG | 4 MHz/32 KHz IRC PLL/FLL | 4 MHz/32 KHz IRC PLL/FLL | 4 MHz/32 KHz IRC PLL/FLL | High-accuracy 48 MHz IRC, 8/2 MHz IRC | High-accuracy 60/48 MHz IRC, 8/2 MHz IRC, |

Table 2. Family differences

| Subfamily | KL24 | KL25 | KL26 | KL27 | KL28 |
|-----------------|------------------------------------|------------------------------------|---|--|---------|
| | | | | | PLL |
| Package options | 32QFN, 48QFN, 64LQFP, 80LQFP | 32QFN, 48QFN, 64LQFP, 80LQFP | 32QFN, 48QFN, 64LQFP, 64MAPBGA, 100LQFP, 121MAPBGA 36WLCSP | 32QFN, 48QFN, 64LQFP, 64MAPBGA, 36XFBGA | 100LQFP |

¹8-bit SPI, one SPI with FiFo

²16-bit SPI, one SPI with FiFo

³Double buffering with support up to 1 Mbps

⁴DAC is only available in 128 KB and 256 KB Flash KL27

⁵CRC is only available in 32 KB and 64 KB Flash KL27

⁶LPSP1 and LPI2C

⁷Support parallel mode

8. Comprehensive Enablement Solutions

8.1. Kinetis Software Development Kit (SDK)

- Extensive suite of robust peripheral drivers, stacks, and middleware.
- Includes software examples demonstrating the usage of HAL, peripheral drivers, middleware, and RTOSes.
- Operating System Abstraction (OSA) for Freescale MQX RTOS, FreeRTOS, and Micrium μ C/OS[®] kernels and bare-metal (no RTOS) applications.

8.2. Processor Expert

- Free software generation tool for device drivers/start-up code.
- Seven steps from project creation to debug—dramatically reduces the development time.
- Available within Kinetis Design Studio or as a standalone plug-in for IAR[®]/Keil[®]/GNU IDEs.

8.3. Integrated Development Environments (IDEs)

- Atollic TrueSTUDIO[®] IDE www.atollic.com/index.php/partnerfreescale
- Green Hills Software MULTI[®] IDE www.ghs.com/products/kinetis.html
- IAR Embedded Workbench[®] IDE www.iar.com/kinetis
- ARM Keil[®] Microcontroller Development Kit IDE www.keil.com/freescale

- Kinetis Design Studio IDE.
 - No-cost IDE for Kinetis MCUs.
 - Eclipse and GCC-based IDE for C/C++ editing, compiling, and debugging.
- Broad ARM ecosystem support through Freescale Connect partners.

8.4. Online enablement with ARM mbed™ development platform

- Rapid and easy Kinetis MCU prototyping and development.
- Online mbed SDK, developer community.
- Free software libraries.

8.5. MQX Lite RTOS

- Free, light-weight MQX kernel customized for small-resource MCUs.
- Packaged as a Processor Expert component.
- Upwards compatible with MQX RTOS.

8.6. Bootloader

- Common bootloader for all Kinetis MCUs.
- 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.

8.7. Development hardware

- Tower System modular development platform:
 - Modular and expandable.
 - Rapid prototyping and evaluation.
 - Cost-effective.
- Freedom development platform:
 - Designed in an industry-standard compact form factor.
 - Integrated open-standard serial and debug interface (OpenSDA).
 - Compatible with a rich set of third-party expansion boards.
 - Low cost (< \$20)

9. Part Identification

9.1. Description

The chip part numbers have fields that identify the specific part. Use the values of these fields to determine the specific part you received.

9.2. Format

The part numbers for this device have this format: Q KL## A FFF T PP CC (N)

9.3. Fields

This table lists the possible values for each field in the part number (not all combinations are valid):

Table 3. Part number field descriptions

| Field | Description | Values |
|-------|-----------------------------|--|
| Q | Qualification status | M = fully qualified, general market flow P = prequalification |
| KL## | Kinetis family | KL24 KL25 KL26 KL27 KL28 |
| A | Key attribute | Z = Cortex-M0+ |
| FFF | Program flash memory size | 32 = 32 KB 64 = 64 KB 128 = 128 KB 256 = 256 KB 512 = 512 KB |
| R | Silicon revision | (Blank) = main A = revision after main |
| T | Temperature range | V = -40–105 °C |
| PP | Package identifier | FM = 32QFN (5 mm × 5 mm) AL = 36WLCSP (2.4 mm × 2.5 mm) DA = 36XFBGA (3.5 mm × 3.5 mm) FT = 48QFN (7 mm × 7 mm) LH = 64LQFP (10 mm × 10 mm) MP = 64MAPBGA (5 mm × 5 mm) LK = 80LQFP (12 mm × 12 mm) LL = 100LQFP (14 mm × 14 mm) MC = 121MAPBGA (8 mm × 8 mm) DC = 121XFBGA (8 mm × 8 mm) |
| CC | Maximum CPU frequency (MHz) | 4 = 48 MHz 7 = 72 MHz |

Table 3. Part number field descriptions

| Field | Description | Values |
|-------|----------------|--------------------------------------|
| N | Packaging type | R = tape and reel (Blank) = trays |

10. Orderable Part Numbers

Table 4. Ordering information

| Product | Memory | | Package | | IO and ADC channel | | |
|----------------|--------|-------|-----------|---------|--------------------|-----------------------------|----------------------|
| MC part number | Flash | SRAM | Pin count | Package | GPIOs | GPIOs (INT/HD) ¹ | ADC channels (SE/DP) |
| MKL24Z32VFM4 | 32 KB | 4 KB | 32 | QFN | 23 | 19/4 | 7/0 |
| MKL24Z32VFT4 | 32 KB | 4 KB | 48 | QFN | 36 | 24/4 | 14/0 |
| MKL24Z32VLH4 | 32 KB | 4 KB | 64 | LQFP | 50 | 31/4 | 16/0 |
| MKL24Z32VLK4 | 32 KB | 4 KB | 80 | LQFP | 66 | 39/4 | 16/0 |
| MKL24Z64VFM4 | 64 KB | 8 KB | 32 | QFN | 23 | 19/4 | 7/0 |
| MKL24Z64VFT4 | 64 KB | 8 KB | 48 | QFN | 36 | 24/4 | 14/0 |
| MKL24Z64VLH4 | 64 KB | 8 KB | 64 | LQFP | 50 | 31/4 | 16/0 |
| MKL24Z64VLK4 | 64 KB | 8 KB | 80 | LQFP | 66 | 39/4 | 16/0 |
| MKL25Z128VFM4 | 128 KB | 16 KB | 32 | QFN | 23 | 12/2 | 7/0 |
| MKL25Z128VFT4 | 128 KB | 16 KB | 48 | QFN | 36 | 16/4 | 14/1 |
| MKL25Z128VLH4 | 128 KB | 16 KB | 64 | LQFP | 50 | 19/4 | 16/2 |
| MKL25Z128VLK4 | 128 KB | 16 KB | 80 | LQFP | 66 | 23/4 | 16/2 |
| MKL25Z32VFM4 | 32 KB | 4 KB | 32 | QFN | 23 | 12/2 | 7/0 |
| MKL25Z32VFT4 | 32 KB | 4 KB | 48 | QFN | 36 | 16/4 | 14/1 |
| MKL25Z32VLH4 | 32 KB | 4 KB | 64 | LQFP | 50 | 19/4 | 16/2 |
| MKL25Z32VLK4 | 32 KB | 4 KB | 80 | LQFP | 66 | 23/4 | 16/2 |
| MKL25Z64VFM4 | 64 KB | 8 KB | 32 | QFN | 23 | 12/2 | 7/0 |
| MKL25Z64VFT4 | 64 KB | 8 KB | 48 | QFN | 36 | 16/4 | 14/1 |
| MKL25Z64VLH4 | 64 KB | 8 KB | 64 | LQFP | 50 | 19/4 | 16/2 |
| MKL25Z64VLK4 | 64 KB | 8 KB | 80 | LQFP | 66 | 23/4 | 16/2 |
| MKL26Z128CAL4 | 128 KB | 16 KB | 36 | WLCSP | 23 | 12/2 | 7/0 |
| MKL26Z128VFM4 | 128 KB | 16 KB | 32 | QFN | 23 | 19/4 | 7/0 |
| MKL26Z128VFT4 | 128 KB | 16 KB | 48 | QFN | 36 | 24/4 | 14/1 |
| MKL26Z128VLH4 | 128 KB | 16 KB | 64 | LQFP | 50 | 31/4 | 16/2 |
| MKL26Z128VLL4 | 128 KB | 16 KB | 100 | LQFP | 80 | 42/4 | 20/4 |

Table 4. Ordering information

| Product | Memory | | Package | | IO and ADC channel | | |
|---------------|----------------|--------|---------|---------------------|--------------------|-------|-----------------------------|
| | MC part number | Flash | SRAM | Pin count | Package | GPIOs | GPIOs (INT/HD) ¹ |
| MKL26Z128VMC4 | 128 KB | 16 KB | 121 | MAPBGA | 80 | 42/4 | 20/4 |
| MKL26Z128VMP4 | 128 KB | 16 KB | 64 | MAPBGA | 50 | 31/4 | 16/2 |
| MKL26Z256VLH4 | 256 KB | 32 KB | 64 | LQFP | 50 | 31/4 | 16/2 |
| MKL26Z256VLL4 | 256 KB | 32 KB | 100 | LQFP | 80 | 42/4 | 20/4 |
| MKL26Z256VMC4 | 256 KB | 32 KB | 121 | MAPBGA | 80 | 42/4 | 20/4 |
| MKL26Z256VMP4 | 256 KB | 32 KB | 64 | MAPBGA | 50 | 31/4 | 16/2 |
| MKL26Z32VFM4 | 32 KB | 4 KB | 32 | QFN | 23 | 19/4 | 7/0 |
| MKL26Z32VFT4 | 32 KB | 4 KB | 48 | QFN | 36 | 24/4 | 14/1 |
| MKL26Z32VLH4 | 32 KB | 4 KB | 64 | LQFP | 50 | 31/4 | 16/1 |
| MKL26Z64VFM4 | 64 KB | 8 KB | 32 | QFN | 23 | 19/4 | 7/0 |
| MKL26Z64VFT4 | 64 KB | 8 KB | 48 | QFN | 36 | 24/4 | 14/1 |
| MKL26Z64VLH4 | 64 KB | 8 KB | 64 | LQFP | 50 | 31/4 | 16/1 |
| MKL27Z128VFM4 | 128 KB | 32 KB | 32 | QFN | 23 | 19/6 | 7/0 |
| MKL27Z128VFT4 | 128 KB | 32 KB | 48 | QFN | 36 | 24/4 | 14/1 |
| MKL27Z128VLH4 | 128 KB | 32 KB | 64 | LQFP | 50 | 31/6 | 16/2 |
| MKL27Z128VMP4 | 128 KB | 32 KB | 64 | MAPBGA | 50 | 31/6 | 16/2 |
| MKL27Z256VFM4 | 256 KB | 32 KB | 32 | QFN | 23 | 19/6 | 7/0 |
| MKL27Z256VFT4 | 256 KB | 32 KB | 48 | QFN | 36 | 24/4 | 14/1 |
| MKL27Z256VLH4 | 256 KB | 32 KB | 64 | LQFP | 50 | 31/6 | 16/2 |
| MKL27Z256VMP4 | 256 KB | 32 KB | 64 | MAPBGA | 50 | 31/6 | 16/2 |
| MKL27Z32VDA4 | 32 KB | 8 KB | 36 | XFBGA | 30 | 30/6 | 14/3 |
| MKL27Z32VFM4 | 32 KB | 8 KB | 32 | QFN ² | 24 | 24/6 | 8/0 |
| MKL27Z32VFT4 | 32 KB | 8 KB | 48 | QFN ² | 37 | 37/6 | 15/1 |
| MKL27Z32VLH4 | 32 KB | 8 KB | 64 | LQFP | 51 | 51/6 | 17/2 |
| MKL27Z32VMP4 | 32 KB | 8 KB | 64 | MAPBGA ² | 51 | 51/6 | 17/2 |
| MKL27Z64VDA4 | 64 KB | 16 KB | 36 | XFBGA | 30 | 30/6 | 14/3 |
| MKL27Z64VFM4 | 64 KB | 16 KB | 32 | QFN ² | 24 | 24/6 | 8/0 |
| MKL27Z64VFT4 | 64 KB | 16 KB | 48 | QFN ² | 37 | 37/6 | 15/1 |
| MKL27Z64VLH4 | 64 KB | 16 KB | 64 | LQFP | 51 | 51/6 | 17/2 |
| MKL27Z64VMP4 | 64 KB | 16 KB | 64 | MAPBGA ² | 51 | 51/6 | 17/2 |
| MKL28Z512VLL7 | 512 KB | 128 KB | 100 | 100LQFP | 97 | TBD | TBD |

¹ INT: interrupt pin numbers; HD: high drive pin numbers² This package is included in a Package Your Way program for Kinetis MCUs. Please visit www.nxp.com/KPYW for more detail.

11. Revision History

This table summarizes the changes made to this document since the initial release:

Table 5. Revision history

| Revision | Date | Substantive changes |
|-----------------|-------------|----------------------------|
| 0 | 03/2015 | Initial release |
| 1 | 04/2016 | Updated KL28 |



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