



Welcome to [E-XFL.COM](https://www.e-xfl.com)

What is "[Embedded - Microcontrollers](#)"?

"[Embedded - Microcontrollers](#)" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "[Embedded - Microcontrollers](#)"

Details

Product Status	Active
Core Processor	ARM® Cortex®-M4
Core Size	32-Bit Single-Core
Speed	50MHz
Connectivity	I ² C, IrDA, SPI, UART/USART
Peripherals	DMA, I ² S, LVD, POR, PWM, WDT
Number of I/O	33
Program Memory Size	128KB (128K x 8)
Program Memory Type	FLASH
EEPROM Size	2K x 8
RAM Size	16K x 8
Voltage - Supply (Vcc/Vdd)	1.71V ~ 3.6V
Data Converters	A/D 16x16b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 105°C (TA)
Mounting Type	Surface Mount
Package / Case	48-LQFP
Supplier Device Package	48-LQFP (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/mk10dx128vlf5

Terminology and guidelines

Field	Description	Values
FFF	Program flash memory size	<ul style="list-style-type: none">• 32 = 32 KB• 64 = 64 KB• 128 = 128 KB• 256 = 256 KB• 512 = 512 KB• 1M0 = 1 MB
R	Silicon revision	<ul style="list-style-type: none">• Z = Initial• (Blank) = Main• A = Revision after main
T	Temperature range (°C)	<ul style="list-style-type: none">• V = -40 to 105• C = -40 to 85
PP	Package identifier	<ul style="list-style-type: none">• FM = 32 QFN (5 mm x 5 mm)• FT = 48 QFN (7 mm x 7 mm)• LF = 48 LQFP (7 mm x 7 mm)• LH = 64 LQFP (10 mm x 10 mm)• MP = 64 MAPBGA (5 mm x 5 mm)• LK = 80 LQFP (12 mm x 12 mm)• MB = 81 MAPBGA (8 mm x 8 mm)• LL = 100 LQFP (14 mm x 14 mm)• ML = 104 MAPBGA (8 mm x 8 mm)• MC = 121 MAPBGA (8 mm x 8 mm)• LQ = 144 LQFP (20 mm x 20 mm)• MD = 144 MAPBGA (13 mm x 13 mm)• MJ = 256 MAPBGA (17 mm x 17 mm)
CC	Maximum CPU frequency (MHz)	<ul style="list-style-type: none">• 5 = 50 MHz• 7 = 72 MHz• 10 = 100 MHz• 12 = 120 MHz• 15 = 150 MHz
N	Packaging type	<ul style="list-style-type: none">• R = Tape and reel• (Blank) = Trays

2.4 Example

This is an example part number:

MK10DN32VLF5

3 Terminology and guidelines

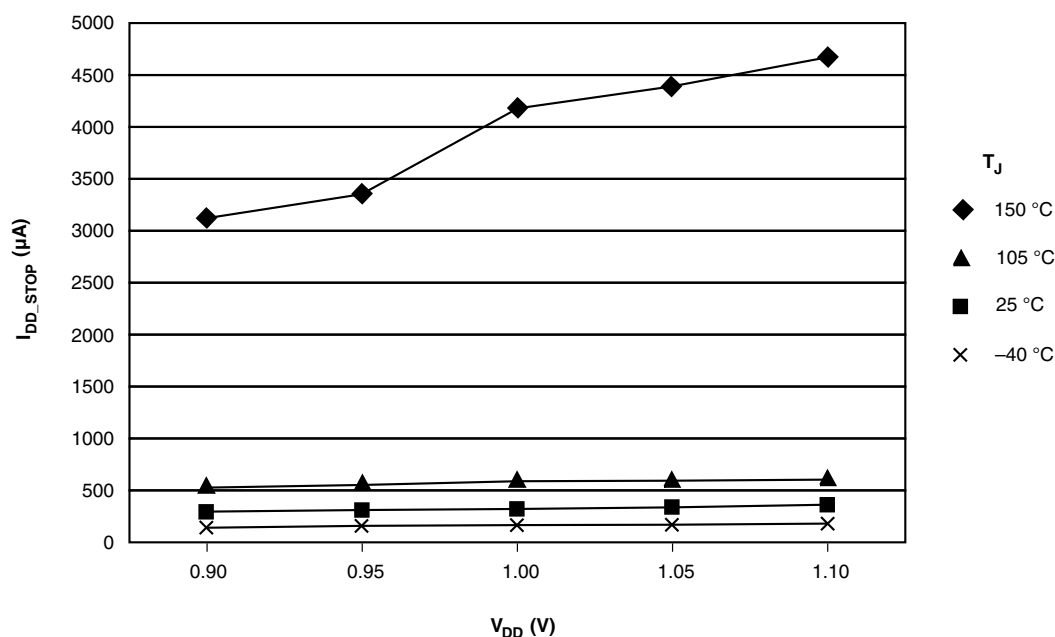
3.8.1 Example 1

This is an example of an operating behavior that includes a typical value:

Symbol	Description	Min.	Typ.	Max.	Unit
I_{WP}	Digital I/O weak pullup/pulldown current	10	70	130	μA

3.8.2 Example 2

This is an example of a chart that shows typical values for various voltage and temperature conditions:



3.9 Typical value conditions

Typical values assume you meet the following conditions (or other conditions as specified):

Symbol	Description	Value	Unit
T_A	Ambient temperature	25	°C
V_{DD}	3.3 V supply voltage	3.3	V

4 Ratings

4.1 Thermal handling ratings

Symbol	Description	Min.	Max.	Unit	Notes
T _{STG}	Storage temperature	–55	150	°C	1
T _{SDR}	Solder temperature, lead-free	—	260	°C	2

1. Determined according to JEDEC Standard JESD22-A103, *High Temperature Storage Life*.
2. Determined according to IPC/JEDEC Standard J-STD-020, *Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices*.

4.2 Moisture handling ratings

Symbol	Description	Min.	Max.	Unit	Notes
MSL	Moisture sensitivity level	—	3	—	1

1. Determined according to IPC/JEDEC Standard J-STD-020, *Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices*.

4.3 ESD handling ratings

Symbol	Description	Min.	Max.	Unit	Notes
V _{HBM}	Electrostatic discharge voltage, human body model	–2000	+2000	V	1
V _{CDM}	Electrostatic discharge voltage, charged-device model	–500	+500	V	2
I _{LAT}	Latch-up current at ambient temperature of 105°C	–100	+100	mA	

1. Determined according to JEDEC Standard JESD22-A114, *Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)*.
2. Determined according to JEDEC Standard JESD22-C101, *Field-Induced Charged-Device Model Test Method for Electrostatic-Discharge-Withstand Thresholds of Microelectronic Components*.

4.4 Voltage and current operating ratings

Symbol	Description	Min.	Max.	Unit
V _{DD}	Digital supply voltage	–0.3	3.8	V

Table continues on the next page...

Table 2. V_{DD} supply LVD and POR operating requirements (continued)

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
V _{LVDH}	Falling low-voltage detect threshold — high range (LVDV=01)	2.48	2.56	2.64	V	
V _{LVW1H}	Low-voltage warning thresholds — high range <ul style="list-style-type: none"> Level 1 falling (LVWV=00) Level 2 falling (LVWV=01) Level 3 falling (LVWV=10) Level 4 falling (LVWV=11) 	2.62	2.70	2.78	V	1
V _{LVW2H}		2.72	2.80	2.88	V	
V _{LVW3H}		2.82	2.90	2.98	V	
V _{LVW4H}		2.92	3.00	3.08	V	
V _{HYSH}	Low-voltage inhibit reset/recover hysteresis — high range	—	±80	—	mV	
V _{LVDL}	Falling low-voltage detect threshold — low range (LVDV=00)	1.54	1.60	1.66	V	
V _{LVW1L}	Low-voltage warning thresholds — low range <ul style="list-style-type: none"> Level 1 falling (LVWV=00) Level 2 falling (LVWV=01) Level 3 falling (LVWV=10) Level 4 falling (LVWV=11) 	1.74	1.80	1.86	V	1
V _{LVW2L}		1.84	1.90	1.96	V	
V _{LVW3L}		1.94	2.00	2.06	V	
V _{LVW4L}		2.04	2.10	2.16	V	
V _{HYSL}	Low-voltage inhibit reset/recover hysteresis — low range	—	±60	—	mV	
V _{BG}	Bandgap voltage reference	0.97	1.00	1.03	V	
t _{LPO}	Internal low power oscillator period — factory trimmed	900	1000	1100	μs	

1. Rising thresholds are falling threshold + hysteresis voltage

Table 3. VBAT power operating requirements

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
V _{POR_VBAT}	Falling VBAT supply POR detect voltage	0.8	1.1	1.5	V	

Table 6. Power consumption operating behaviors (continued)

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
I_{DD_VLLS0}	Very low-leakage stop mode 0 current at 3.0 V with POR detect circuit disabled <ul style="list-style-type: none"> • @ -40 to 25°C • @ 70°C • @ 105°C 	— — —	0.176 2.2 13	0.859 13.1 23.9	μA μA μA	
I_{DD_VBAT}	Average current with RTC and 32kHz disabled at 3.0 V <ul style="list-style-type: none"> • @ -40 to 25°C • @ 70°C • @ 105°C 	— — —	0.19 0.49 2.2	0.22 0.64 3.2	μA μA μA	
I_{DD_VBAT}	Average current when CPU is not accessing RTC registers <ul style="list-style-type: none"> • @ 1.8V <ul style="list-style-type: none"> • @ -40 to 25°C • @ 70°C • @ 105°C • @ 3.0V <ul style="list-style-type: none"> • @ -40 to 25°C • @ 70°C • @ 105°C 	— — — — — — —	0.57 0.90 2.4 0.67 1.0 2.7	0.67 1.2 3.5 0.94 1.4 3.9	μA μA μA μA μA μA	9

1. The analog supply current is the sum of the active or disabled current for each of the analog modules on the device. See each module's specification for its supply current.
2. 50MHz core and system clock, 25MHz bus clock, and 25MHz flash clock. MCG configured for FEI mode. All peripheral clocks disabled.
3. 50MHz core and system clock, 25MHz bus clock, and 25MHz flash clock. MCG configured for FEI mode. All peripheral clocks enabled, and peripherals are in active operation.
4. Max values are measured with CPU executing DSP instructions
5. 25MHz core and system clock, 25MHz bus clock, and 12.5MHz flash clock. MCG configured for FEI mode.
6. 4 MHz core, system, and bus clock and 1MHz flash clock. MCG configured for BLPE mode. All peripheral clocks disabled. Code executing from flash.
7. 4 MHz core, system, and bus clock and 1MHz flash clock. MCG configured for BLPE mode. All peripheral clocks enabled but peripherals are not in active operation. Code executing from flash.
8. 4 MHz core, system, and bus clock and 1MHz flash clock. MCG configured for BLPE mode. All peripheral clocks disabled.
9. Includes 32kHz oscillator current and RTC operation.

5.2.5.1 Diagram: Typical I_{DD_RUN} operating behavior

The following data was measured under these conditions:

- MCG in FBE mode
- No GPIOs toggled
- Code execution from flash with cache enabled
- For the ALLOFF curve, all peripheral clocks are disabled except FTFL

emission level is the value of the maximum measured emission, rounded up to the next whole number, from among the measured orientations in each frequency range.

2. $V_{DD} = 3.3\text{ V}$, $T_A = 25\text{ }^{\circ}\text{C}$, $f_{OSC} = 12\text{ MHz}$ (crystal), $f_{SYS} = 48\text{ MHz}$, $f_{BUS} = 48\text{ MHz}$
3. Specified according to Annex D of IEC Standard 61967-2, *Measurement of Radiated Emissions—TEM Cell and Wideband TEM Cell Method*

5.2.7 Designing with radiated emissions in mind

To find application notes that provide guidance on designing your system to minimize interference from radiated emissions:

1. Go to <http://www.freescale.com>.
2. Perform a keyword search for “EMC design.”

5.2.8 Capacitance attributes

Table 8. Capacitance attributes

Symbol	Description	Min.	Max.	Unit
C_{IN_A}	Input capacitance: analog pins	—	7	pF
C_{IN_D}	Input capacitance: digital pins	—	7	pF

5.3 Switching specifications

5.3.1 Device clock specifications

Table 9. Device clock specifications

Symbol	Description	Min.	Max.	Unit	Notes
Normal run mode					
f_{SYS}	System and core clock	—	50	MHz	
f_{BUS}	Bus clock	—	50	MHz	
f_{FLASH}	Flash clock	—	25	MHz	
f_{LPTMR}	LPTMR clock	—	25	MHz	
VLPR mode ¹					
f_{SYS}	System and core clock	—	4	MHz	
f_{BUS}	Bus clock	—	4	MHz	
f_{FLASH}	Flash clock	—	1	MHz	
f_{ERCLK}	External reference clock	—	16	MHz	

Table continues on the next page...

Table 9. Device clock specifications (continued)

Symbol	Description	Min.	Max.	Unit	Notes
$f_{\text{LPTMR_pin}}$	LPTMR clock	—	25	MHz	
$f_{\text{LPTMR_ERCLK}}$	LPTMR external reference clock	—	16	MHz	
$f_{\text{I2S_MCLK}}$	I2S master clock	—	12.5	MHz	
$f_{\text{I2S_BCLK}}$	I2S bit clock	—	4	MHz	

1. The frequency limitations in VLPR mode here override any frequency specification listed in the timing specification for any other module.

5.3.2 General switching specifications

These general purpose specifications apply to all signals configured for GPIO, UART, CMT, and I²C signals.

Table 10. General switching specifications

Symbol	Description	Min.	Max.	Unit	Notes
	GPIO pin interrupt pulse width (digital glitch filter disabled) — Synchronous path	1.5	—	Bus clock cycles	1, 2
	GPIO pin interrupt pulse width (digital glitch filter disabled, analog filter enabled) — Asynchronous path	100	—	ns	3
	GPIO pin interrupt pulse width (digital glitch filter disabled, analog filter disabled) — Asynchronous path	50	—	ns	3
	External reset pulse width (digital glitch filter disabled)	100	—	ns	3
	Mode select ($\overline{\text{EZP_CS}}$) hold time after reset deassertion	2	—	Bus clock cycles	
	Port rise and fall time (high drive strength) <ul style="list-style-type: none"> Slew disabled <ul style="list-style-type: none"> $1.71 \leq V_{\text{DD}} \leq 2.7\text{V}$ $2.7 \leq V_{\text{DD}} \leq 3.6\text{V}$ Slew enabled <ul style="list-style-type: none"> $1.71 \leq V_{\text{DD}} \leq 2.7\text{V}$ $2.7 \leq V_{\text{DD}} \leq 3.6\text{V}$ 	— — — —	13 7 36 24	ns ns ns ns	4

Table continues on the next page...

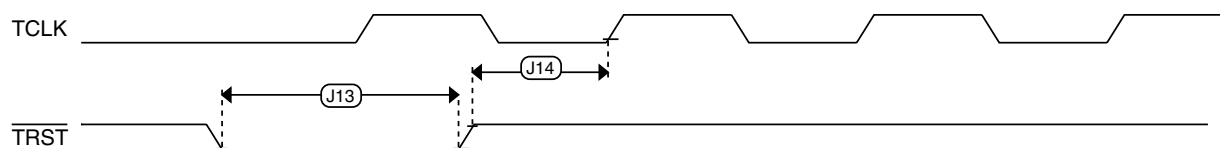
Peripheral operating requirements and behaviors

Board type	Symbol	Description	48 LQFP	48 QFN	Unit	Notes
Single-layer (1s)	$R_{\theta JA}$	Thermal resistance, junction to ambient (200 ft./min. air speed)	58	66	°C/W	1,3
Four-layer (2s2p)	$R_{\theta JA}$	Thermal resistance, junction to ambient (200 ft./min. air speed)	40	23	°C/W	,
—	$R_{\theta JB}$	Thermal resistance, junction to board	24	11	°C/W	5
—	$R_{\theta JC}$	Thermal resistance, junction to case	18	1.4	°C/W	6
—	Ψ_{JT}	Thermal characterization parameter, junction to package top outside center (natural convection)	3	4	°C/W	7

1. Junction temperature is a function of die size, on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance.
2. Determined according to JEDEC Standard JESD51-2, *Integrated Circuits Thermal Test Method Environmental Conditions—Natural Convection (Still Air)* with the single layer board horizontal. For the LQFP, the board meets the JESD51-3 specification. For the MAPBGA, the board meets the JESD51-9 specification.
3. Determined according to JEDEC Standard JESD51-6, *Integrated Circuits Thermal Test Method Environmental Conditions—Forced Convection (Moving Air)* with the board horizontal.
5. Determined according to JEDEC Standard JESD51-8, *Integrated Circuit Thermal Test Method Environmental Conditions—Junction-to-Board*. Board temperature is measured on the top surface of the board near the package.
6. Determined according to Method 1012.1 of MIL-STD 883, *Test Method Standard, Microcircuits*, with the cold plate temperature used for the case temperature. The value includes the thermal resistance of the interface material between the top of the package and the cold plate.
7. Determined according to JEDEC Standard JESD51-2, *Integrated Circuits Thermal Test Method Environmental Conditions—Natural Convection (Still Air)*.

6 Peripheral operating requirements and behaviors

6.1 Core modules

Figure 7. $\overline{\text{TRST}}$ timing

6.2 System modules

There are no specifications necessary for the device's system modules.

6.3 Clock modules

6.3.1 MCG specifications

Table 13. MCG specifications

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
$f_{\text{ints_ft}}$	Internal reference frequency (slow clock) — factory trimmed at nominal VDD and 25 °C	—	32.768	—	kHz	
$f_{\text{ints_t}}$	Internal reference frequency (slow clock) — user trimmed	31.25	—	39.0625	kHz	
$\Delta f_{\text{dco_res_t}}$	Resolution of trimmed average DCO output frequency at fixed voltage and temperature — using SCTRIM and SCFTRIM	—	± 0.3	± 0.6	$\%f_{\text{dco}}$	1
$\Delta f_{\text{dco_t}}$	Total deviation of trimmed average DCO output frequency over voltage and temperature	—	+0.5/-0.7	± 3	$\%f_{\text{dco}}$	1
$\Delta f_{\text{dco_t}}$	Total deviation of trimmed average DCO output frequency over fixed voltage and temperature range of 0–70°C	—	± 0.3	—	$\%f_{\text{dco}}$	1
$f_{\text{intf_ft}}$	Internal reference frequency (fast clock) — factory trimmed at nominal VDD and 25°C	—	4	—	MHz	
$f_{\text{intf_t}}$	Internal reference frequency (fast clock) — user trimmed at nominal VDD and 25 °C	3	—	5	MHz	
$f_{\text{loc_low}}$	Loss of external clock minimum frequency — RANGE = 00	$(3/5) \times f_{\text{ints_t}}$	—	—	kHz	
$f_{\text{loc_high}}$	Loss of external clock minimum frequency — RANGE = 01, 10, or 11	$(16/5) \times f_{\text{ints_t}}$	—	—	kHz	
FLL						

Table continues on the next page...

Table 14. Oscillator DC electrical specifications (continued)

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
I _{DDOSC}	Supply current — high gain mode (HGO=1)					1
	• 32 kHz	—	25	—	μA	
	• 4 MHz	—	400	—	μA	
	• 8 MHz (RANGE=01)	—	500	—	μA	
	• 16 MHz	—	2.5	—	mA	
	• 24 MHz	—	3	—	mA	
	• 32 MHz	—	4	—	mA	
C _x	EXTAL load capacitance	—	—	—		2, 3
C _y	XTAL load capacitance	—	—	—		2, 3
R _F	Feedback resistor — low-frequency, low-power mode (HGO=0)	—	—	—	MΩ	2, 4
	Feedback resistor — low-frequency, high-gain mode (HGO=1)	—	10	—	MΩ	
	Feedback resistor — high-frequency, low-power mode (HGO=0)	—	—	—	MΩ	
	Feedback resistor — high-frequency, high-gain mode (HGO=1)	—	1	—	MΩ	
R _S	Series resistor — low-frequency, low-power mode (HGO=0)	—	—	—	kΩ	
	Series resistor — low-frequency, high-gain mode (HGO=1)	—	200	—	kΩ	
	Series resistor — high-frequency, low-power mode (HGO=0)	—	—	—	kΩ	
	Series resistor — high-frequency, high-gain mode (HGO=1)	—	0	—	kΩ	
V _{pp} ⁵	Peak-to-peak amplitude of oscillation (oscillator mode) — low-frequency, low-power mode (HGO=0)	—	0.6	—	V	
	Peak-to-peak amplitude of oscillation (oscillator mode) — low-frequency, high-gain mode (HGO=1)	—	V _{DD}	—	V	
	Peak-to-peak amplitude of oscillation (oscillator mode) — high-frequency, low-power mode (HGO=0)	—	0.6	—	V	
	Peak-to-peak amplitude of oscillation (oscillator mode) — high-frequency, high-gain mode (HGO=1)	—	V _{DD}	—	V	

1. V_{DD}=3.3 V, Temperature =25 °C

2. See crystal or resonator manufacturer's recommendation

3. C_x,C_y can be provided by using either the integrated capacitors or by using external components.4. When low power mode is selected, R_F is integrated and must not be attached externally.

5. The EXTAL and XTAL pins should only be connected to required oscillator components and must not be connected to any other devices.

6.3.2.2 Oscillator frequency specifications

Table 15. Oscillator frequency specifications

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
f_{osc_lo}	Oscillator crystal or resonator frequency — low frequency mode (MCG_C2[RANGE]=00)	32	—	40	kHz	
$f_{osc_hi_1}$	Oscillator crystal or resonator frequency — high frequency mode (low range) (MCG_C2[RANGE]=01)	3	—	8	MHz	
$f_{osc_hi_2}$	Oscillator crystal or resonator frequency — high frequency mode (high range) (MCG_C2[RANGE]=1x)	8	—	32	MHz	
f_{ec_extal}	Input clock frequency (external clock mode)	—	—	50	MHz	1, 2
t_{dc_extal}	Input clock duty cycle (external clock mode)	40	50	60	%	
t_{cst}	Crystal startup time — 32 kHz low-frequency, low-power mode (HGO=0)	—	750	—	ms	3, 4
	Crystal startup time — 32 kHz low-frequency, high-gain mode (HGO=1)	—	250	—	ms	
	Crystal startup time — 8 MHz high-frequency (MCG_C2[RANGE]=01), low-power mode (HGO=0)	—	0.6	—	ms	
	Crystal startup time — 8 MHz high-frequency (MCG_C2[RANGE]=01), high-gain mode (HGO=1)	—	1	—	ms	

1. Other frequency limits may apply when external clock is being used as a reference for the FLL or PLL.
2. When transitioning from FBE to FEI mode, restrict the frequency of the input clock so that, when it is divided by FRDIV, it remains within the limits of the DCO input clock frequency.
3. Proper PC board layout procedures must be followed to achieve specifications.
4. Crystal startup time is defined as the time between the oscillator being enabled and the OSCINIT bit in the MCG_S register being set.

6.3.3 32 kHz Oscillator Electrical Characteristics

This section describes the module electrical characteristics.

6.3.3.1 32 kHz oscillator DC electrical specifications

Table 16. 32kHz oscillator DC electrical specifications

Symbol	Description	Min.	Typ.	Max.	Unit
V_{BAT}	Supply voltage	1.71	—	3.6	V
R_F	Internal feedback resistor	—	100	—	MΩ

Table continues on the next page...

Table 21. NVM reliability specifications (continued)

Symbol	Description	Min.	Typ. ¹	Max.	Unit	Notes
$t_{\text{nvmretd1k}}$	Data retention after up to 1 K cycles	20	100	—	years	
n_{nvmcyed}	Cycling endurance	10 K	50 K	—	cycles	2
FlexRAM as EEPROM						
$t_{\text{nvmretee100}}$	Data retention up to 100% of write endurance	5	50	—	years	
$t_{\text{nvmretee10}}$	Data retention up to 10% of write endurance	20	100	—	years	
	Write endurance					3
$n_{\text{nvmwree16}}$	• EEPROM backup to FlexRAM ratio = 16	35 K	175 K	—	writes	
$n_{\text{nvmwree128}}$	• EEPROM backup to FlexRAM ratio = 128	315 K	1.6 M	—	writes	
$n_{\text{nvmwree512}}$	• EEPROM backup to FlexRAM ratio = 512	1.27 M	6.4 M	—	writes	
$n_{\text{nvmwree4k}}$	• EEPROM backup to FlexRAM ratio = 4096	10 M	50 M	—	writes	
$n_{\text{nvmwree8k}}$	• EEPROM backup to FlexRAM ratio = 8192	20 M	100 M	—	writes	

1. Typical data retention values are based on measured response accelerated at high temperature and derated to a constant 25°C use profile. Engineering Bulletin EB618 does not apply to this technology. Typical endurance defined in Engineering Bulletin EB619.
2. Cycling endurance represents number of program/erase cycles at $-40^{\circ}\text{C} \leq T_j \leq 125^{\circ}\text{C}$.
3. Write endurance represents the number of writes to each FlexRAM location at $-40^{\circ}\text{C} \leq T_j \leq 125^{\circ}\text{C}$ influenced by the cycling endurance of the FlexNVM (same value as data flash) and the allocated EEPROM backup. Minimum and typical values assume all byte-writes to FlexRAM.

6.4.1.5 Write endurance to FlexRAM for EEPROM

When the FlexNVM partition code is not set to full data flash, the EEPROM data set size can be set to any of several non-zero values.

The bytes not assigned to data flash via the FlexNVM partition code are used by the flash memory module to obtain an effective endurance increase for the EEPROM data. The built-in EEPROM record management system raises the number of program/erase cycles that can be attained prior to device wear-out by cycling the EEPROM data through a larger EEPROM NVM storage space.

While different partitions of the FlexNVM are available, the intention is that a single choice for the FlexNVM partition code and EEPROM data set size is used throughout the entire lifetime of a given application. The EEPROM endurance equation and graph shown below assume that only one configuration is ever used.

$$\text{Writes_FlexRAM} = \frac{\text{EEPROM} - 2 \times \text{EEESIZE}}{\text{EEESIZE}} \times \text{Write_efficiency} \times n_{\text{nvmcyed}}$$

where

- Writes_FlexRAM — minimum number of writes to each FlexRAM location

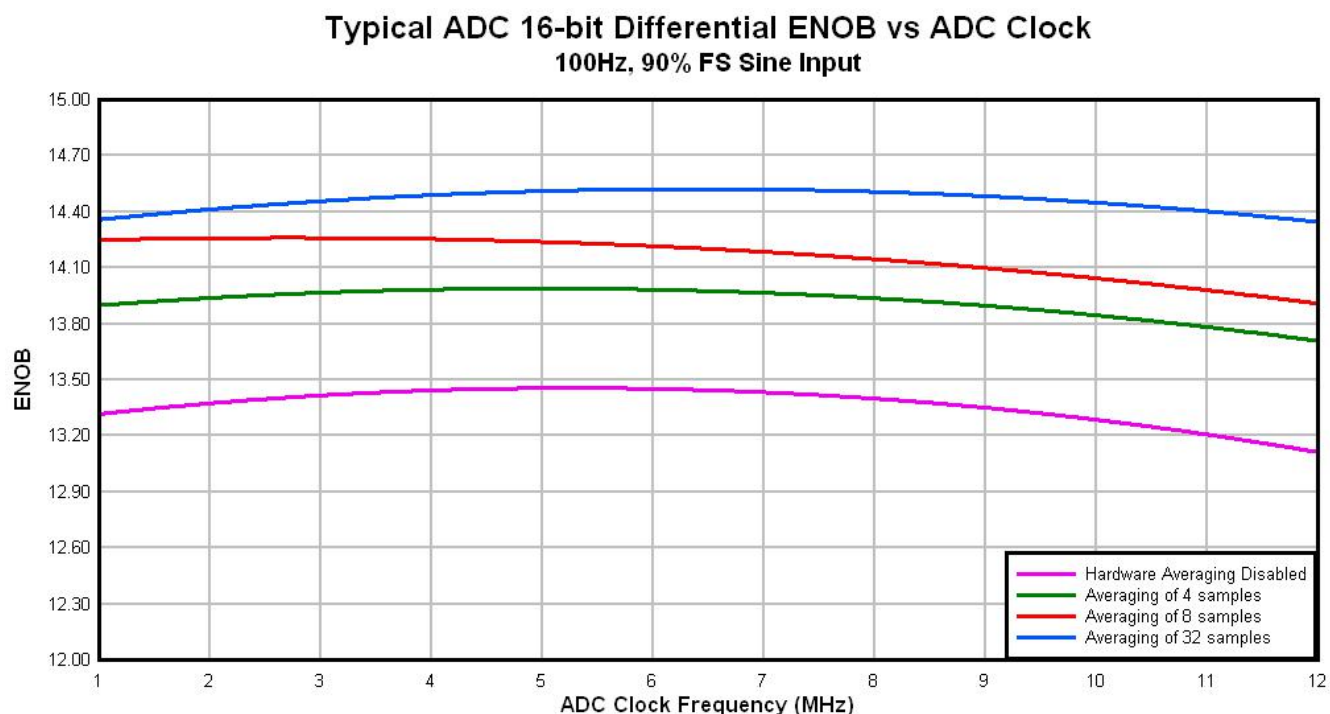


Figure 11. Typical ENOB vs. ADC_CLK for 16-bit differential mode

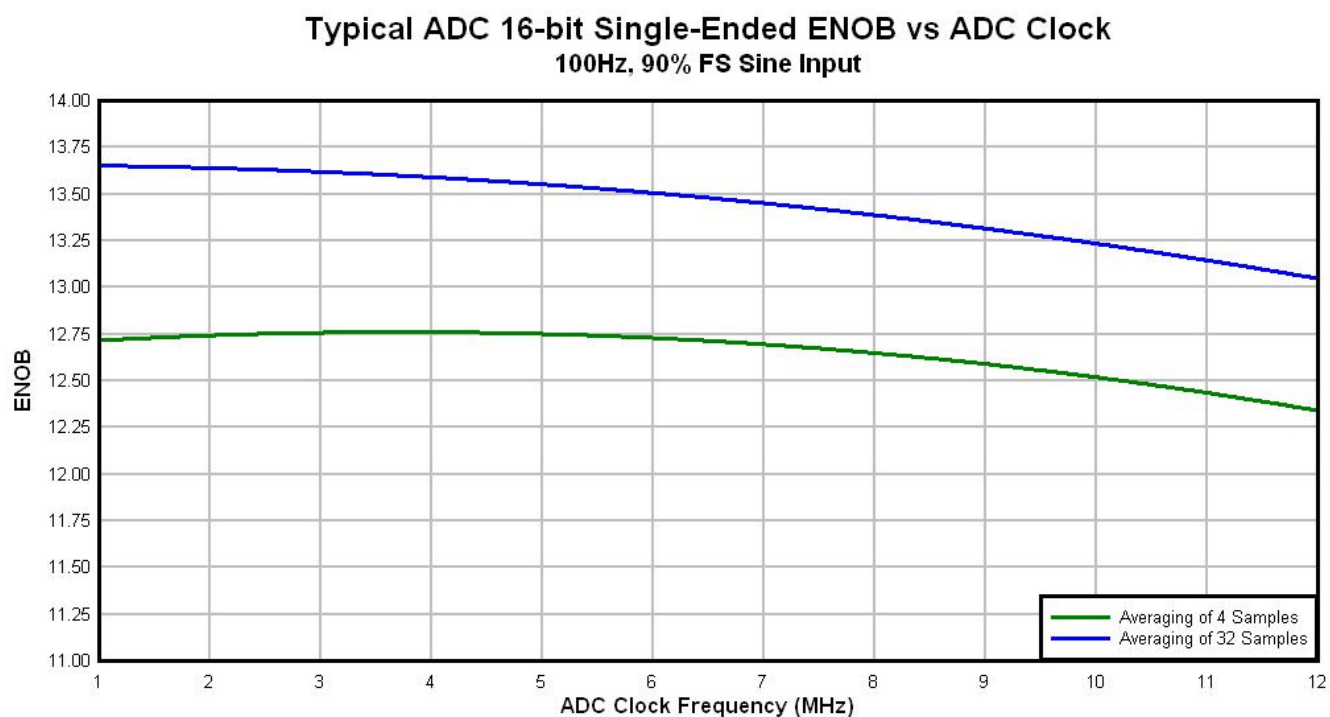


Figure 12. Typical ENOB vs. ADC_CLK for 16-bit single-ended mode

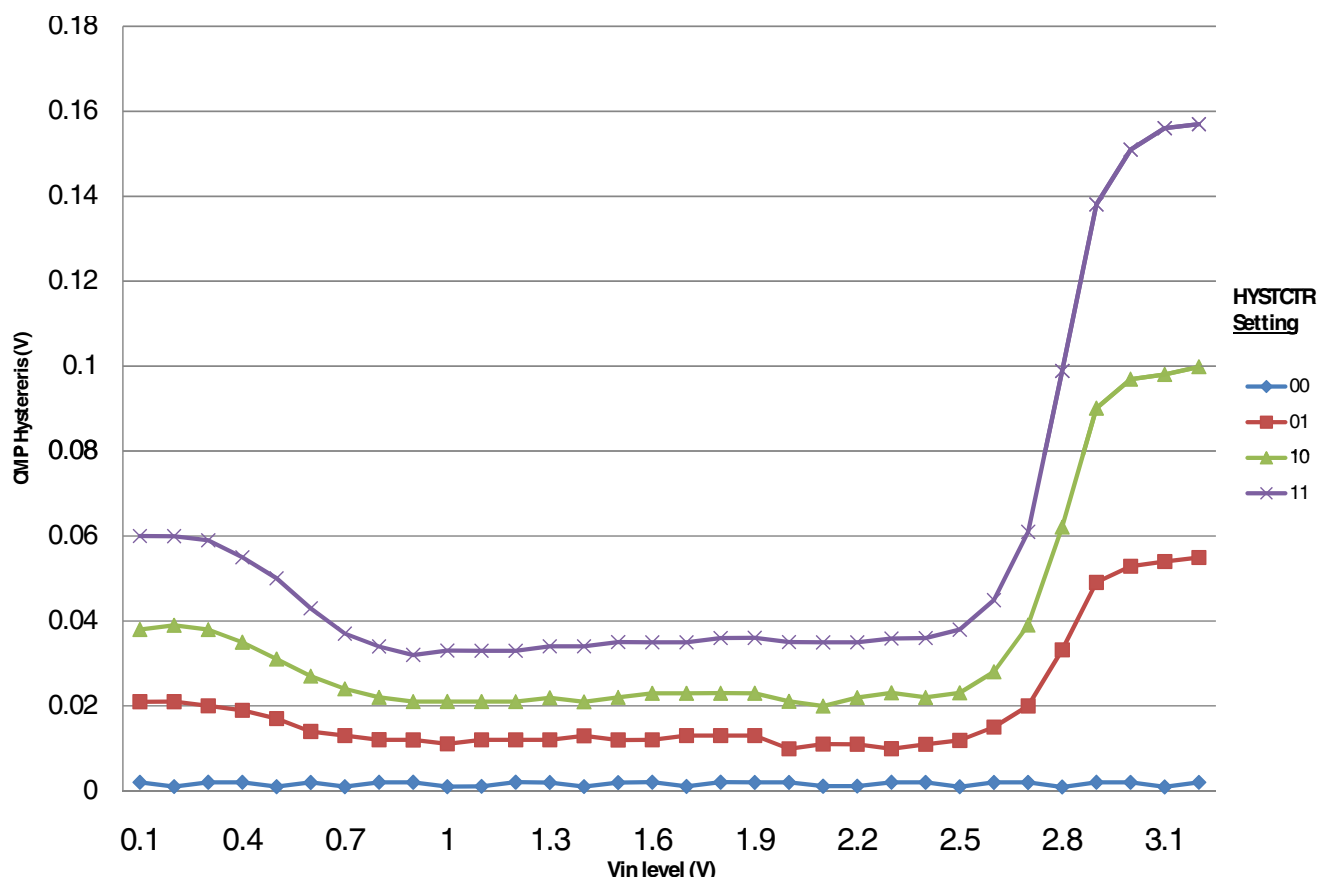


Figure 14. Typical hysteresis vs. Vin level (VDD=3.3V, PMODE=1)

6.6.3 Voltage reference electrical specifications

Table 26. VREF full-range operating requirements

Symbol	Description	Min.	Max.	Unit	Notes
V_{DDA}	Supply voltage	1.71	3.6	V	
T_A	Temperature	-40	105	°C	
C_L	Output load capacitance	100		nF	1, 2

1. C_L must be connected to VREF_OUT if the VREF_OUT functionality is being used for either an internal or external reference.
2. The load capacitance should not exceed +/-25% of the nominal specified C_L value over the operating temperature range of the device.

Table 27. VREF full-range operating behaviors

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
V_{out}	Voltage reference output with factory trim at nominal V_{DDA} and temperature=25°C	1.1915	1.195	1.1977	V	

Table continues on the next page...

Table 27. VREF full-range operating behaviors (continued)

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
V_{out}	Voltage reference output — factory trim	1.1584	—	1.2376	V	
V_{out}	Voltage reference output — user trim	1.193	—	1.197	V	
V_{step}	Voltage reference trim step	—	0.5	—	mV	
V_{tdrift}	Temperature drift ($V_{max} - V_{min}$ across the full temperature range)	—	—	80	mV	
I_{bg}	Bandgap only current	—	—	80	μA	1
I_{lp}	Low-power buffer current	—	—	360	μA	1
I_{hp}	High-power buffer current	—	—	1	mA	1
ΔV_{LOAD}	Load regulation • current = ± 1.0 mA	—	200	—	μV	1, 2
T_{stup}	Buffer startup time	—	—	100	μs	
V_{vdrift}	Voltage drift ($V_{max} - V_{min}$ across the full voltage range)	—	2	—	mV	1

1. See the chip's Reference Manual for the appropriate settings of the VREF Status and Control register.
2. Load regulation voltage is the difference between the VREF_OUT voltage with no load vs. voltage with defined load

Table 28. VREF limited-range operating requirements

Symbol	Description	Min.	Max.	Unit	Notes
T_A	Temperature	0	50	$^{\circ}C$	

Table 29. VREF limited-range operating behaviors

Symbol	Description	Min.	Max.	Unit	Notes
V_{out}	Voltage reference output with factory trim	1.173	1.225	V	

6.7 Timers

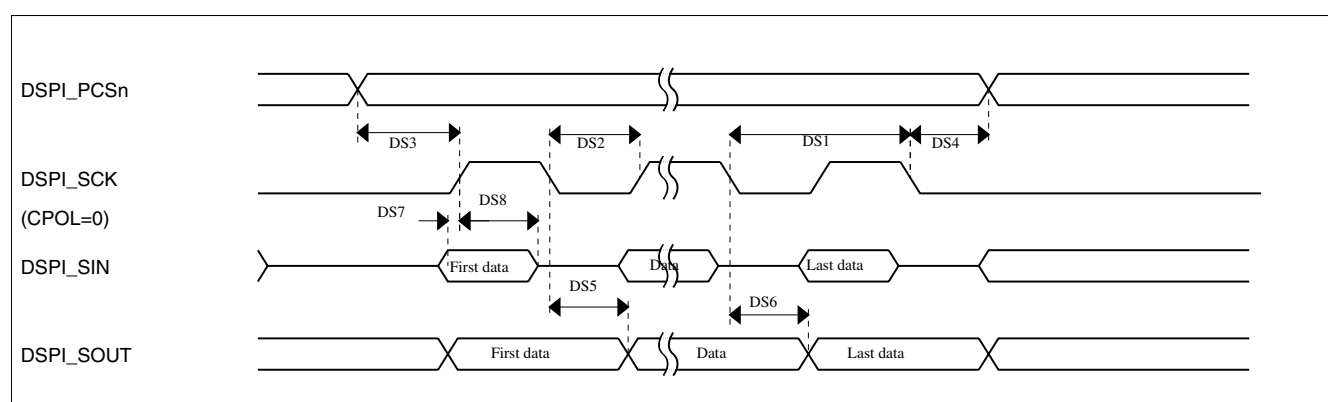
See [General switching specifications](#).

6.8 Communication interfaces

Table 32. Master mode DSPI timing (full voltage range) (continued)

Num	Description	Min.	Max.	Unit	Notes
DS3	DSPI_PCSn valid to DSPI_SCK delay	$(t_{BUS} \times 2) - 4$	—	ns	2
DS4	DSPI_SCK to DSPI_PCSn invalid delay	$(t_{BUS} \times 2) - 4$	—	ns	3
DS5	DSPI_SCK to DSPI_SOUT valid	—	8.5	ns	
DS6	DSPI_SCK to DSPI_SOUT invalid	-1.2	—	ns	
DS7	DSPI_SIN to DSPI_SCK input setup	19.1	—	ns	
DS8	DSPI_SCK to DSPI_SIN input hold	0	—	ns	

1. The DSPI module can operate across the entire operating voltage for the processor, but to run across the full voltage range the maximum frequency of operation is reduced.
2. The delay is programmable in SPIx_CTARn[PSSCK] and SPIx_CTARn[CSSCK].
3. The delay is programmable in SPIx_CTARn[PASC] and SPIx_CTARn[ASC].

**Figure 17. DSPI classic SPI timing — master mode****Table 33. Slave mode DSPI timing (full voltage range)**

Num	Description	Min.	Max.	Unit
	Operating voltage	1.71	3.6	V
	Frequency of operation	—	6.25	MHz
DS9	DSPI_SCK input cycle time	$8 \times t_{BUS}$	—	ns
DS10	DSPI_SCK input high/low time	$(t_{SCK}/2) - 4$	$(t_{SCK}/2) + 4$	ns
DS11	DSPI_SCK to DSPI_SOUT valid	—	24	ns
DS12	DSPI_SCK to DSPI_SOUT invalid	0	—	ns
DS13	DSPI_SIN to DSPI_SCK input setup	3.2	—	ns
DS14	DSPI_SCK to DSPI_SIN input hold	7	—	ns
DS15	DSPI_SS active to DSPI_SOUT driven	—	19	ns
DS16	DSPI_SS inactive to DSPI_SOUT not driven	—	19	ns

Table 38. TSI electrical specifications (continued)

Symbol	Description	Min.	Typ.	Max.	Unit	Notes
f _{REFmax}	Reference oscillator frequency	—	8	15	MHz	2, 3
f _{ELEmax}	Electrode oscillator frequency	—	1	1.8	MHz	2, 4
C _{REF}	Internal reference capacitor	—	1	—	pF	
V _{DELTA}	Oscillator delta voltage	—	500	—	mV	2, 5
I _{REF}	Reference oscillator current source base current • 2 µA setting (REFCHRG = 0) • 32 µA setting (REFCHRG = 15)	— —	2 36	3 50	µA	2, 6
I _{ELE}	Electrode oscillator current source base current • 2 µA setting (EXTCHRG = 0) • 32 µA setting (EXTCHRG = 15)	— —	2 36	3 50	µA	2, 7
Pres5	Electrode capacitance measurement precision	—	8.3333	38400	fF/count	8
Pres20	Electrode capacitance measurement precision	—	8.3333	38400	fF/count	9
Pres100	Electrode capacitance measurement precision	—	8.3333	38400	fF/count	10
MaxSens	Maximum sensitivity	0.008	1.46	—	fF/count	11
Res	Resolution	—	—	16	bits	
T _{Con20}	Response time @ 20 pF	8	15	25	µs	12
I _{TSI_RUN}	Current added in run mode	—	55	—	µA	
I _{TSI_LP}	Low power mode current adder	—	1.3	2.5	µA	13

- The TSI module is functional with capacitance values outside this range. However, optimal performance is not guaranteed.
- Fixed external capacitance of 20 pF.
- REFCHRG = 2, EXTCHRG=0.
- REFCHRG = 0, EXTCHRG = 10.
- V_{DD} = 3.0 V.
- The programmable current source value is generated by multiplying the SCANC[REFCHRG] value and the base current.
- The programmable current source value is generated by multiplying the SCANC[EXTCHRG] value and the base current.
- Measured with a 5 pF electrode, reference oscillator frequency of 10 MHz, PS = 128, NSCN = 8; I_{ext} = 16.
- Measured with a 20 pF electrode, reference oscillator frequency of 10 MHz, PS = 128, NSCN = 2; I_{ext} = 16.
- Measured with a 20 pF electrode, reference oscillator frequency of 10 MHz, PS = 16, NSCN = 3; I_{ext} = 16.
- Sensitivity defines the minimum capacitance change when a single count from the TSI module changes. Sensitivity depends on the configuration used. The documented values are provided as examples calculated for a specific configuration of operating conditions using the following equation: $(C_{ref} * I_{ext}) / (I_{ref} * PS * NSCN)$

The typical value is calculated with the following configuration:

$$I_{ext} = 6 \mu A \text{ (EXTCHRG = 2), PS = 128, NSCN = 2, } I_{ref} = 16 \mu A \text{ (REFCHRG = 7), } C_{ref} = 1.0 \text{ pF}$$

The minimum value is calculated with the following configuration:

$$I_{ext} = 2 \mu A \text{ (EXTCHRG = 0), PS = 128, NSCN = 32, } I_{ref} = 32 \mu A \text{ (REFCHRG = 15), } C_{ref} = 0.5 \text{ pF}$$

The highest possible sensitivity is the minimum value because it represents the smallest possible capacitance that can be measured by a single count.

- Time to do one complete measurement of the electrode. Sensitivity resolution of 0.0133 pF, PS = 0, NSCN = 0, 1 electrode, EXTCHRG = 7.
- REFCHRG=0, EXTCHRG=4, PS=7, NSCN=0F, LPSCNITV=F, LPO is selected (1 kHz), and fixed external capacitance of 20 pF. Data is captured with an average of 7 periods window.

7 Dimensions

7.1 Obtaining package dimensions

Package dimensions are provided in package drawings.

To find a package drawing, go to <http://www.freescale.com> and perform a keyword search for the drawing's document number:

If you want the drawing for this package	Then use this document number
48-pin LQFP	98ASH00962A
48-pin QFN	98ARH99048A

8 Pinout

8.1 K10 Signal Multiplexing and Pin Assignments

The following table shows the signals available on each pin and the locations of these pins on the devices supported by this document. The Port Control Module is responsible for selecting which ALT functionality is available on each pin.

48 LQFP -QFN	Pin Name	Default	ALT0	ALT1	ALT2	ALT3	ALT4	ALT5	ALT6	ALT7	EzPort
1	VDD	VDD	VDD								
2	VSS	VSS	VSS								
3	PTE16	ADC0_SE4a	ADC0_SE4a	PTE16	SPI0_PCS0	UART2_TX	FTM_CLKIN0		FTM0_FLT3		
4	PTE17	ADC0_SE5a	ADC0_SE5a	PTE17	SPI0_SCK	UART2_RX	FTM_CLKIN1		LPTMR0_ALT3		
5	PTE18	ADC0_SE6a	ADC0_SE6a	PTE18	SPI0_SOUT	UART2_CTS_b	I2C0_SDA				
6	PTE19	ADC0_SE7a	ADC0_SE7a	PTE19	SPI0_SIN	UART2_RTS_b	I2C0_SCL				
7	ADC0_DP0	ADC0_DP0	ADC0_DP0								
8	ADC0_DM0	ADC0_DM0	ADC0_DM0								
9	VDDA	VDDA	VDDA								
10	VREFH	VREFH	VREFH								
11	VREFL	VREFL	VREFL								
12	VSSA	VSSA	VSSA								
13	VREF_OUT/ CMP1_IN5/ CMP0_IN5	VREF_OUT/ CMP1_IN5/ CMP0_IN5	VREF_OUT/ CMP1_IN5/ CMP0_IN5								

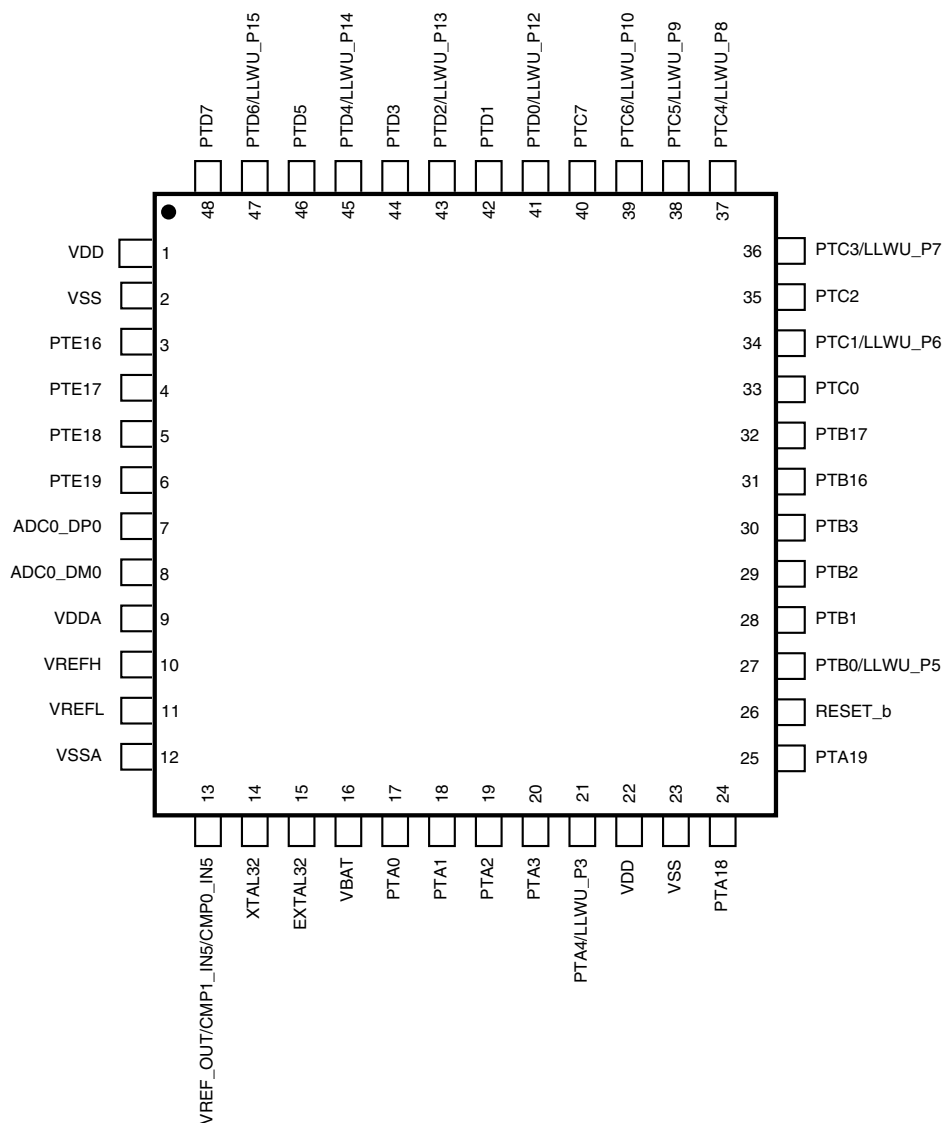


Figure 23. K10 48 LQFP/QFN Pinout Diagram

9 Revision History

The following table provides a revision history for this document.

Table 39. Revision History

Rev. No.	Date	Substantial Changes
2	2/2012	Initial public release

Table continues on the next page...

Table 39. Revision History (continued)

Rev. No.	Date	Substantial Changes
3	4/2012	<ul style="list-style-type: none"> • Replaced TBDs throughout. • Updated "Power mode transition operating behaviors" table. • Updated "Power consumption operating behaviors" table. • For "Diagram: Typical IDD_RUN operating behavior" section, added "VLPR mode supply current vs. core frequency" figure. • Updated "EMC radiated emissions operating behaviors" section. • Updated "Thermal operating requirements" section. • Updated "MCG specifications" table. • Updated "VREF full-range operating behaviors" table. • Updated "I2S/SAI Switching Specifications" section. • Updated "TSI electrical specifications" table.
4	5/2012	<ul style="list-style-type: none"> • For the "32kHz oscillator frequency specifications", added specifications for an externally driven clock. • Renamed section "Flash current and power specifications" to section "Flash high voltage current behaviors" and improved the specifications. • For the "VREF full-range operating behaviors" table, removed the Ac (aging coefficient) specification. • Corrected the following DSPI switching specifications: tightened DS5, DS6, and DS7; relaxed DS11 and DS13. • Removed references to USB as non-applicable. • For the "TSI electrical specifications", changed and clarified the example calculations for the MaxSens specification.