

# MWCT1x23 Data Sheet

## 168 MHz Wireless Power Microcontroller with FPU

The MWCT1x23 MCU family is a member of the Wireless Power parts family and provides a high-performance solution for wireless energy transfer. Built upon the Arm® Cortex®-M4 core operating at up to 168 MHz with DSP and floating point unit, features include; dual 12-bit analog-to-digital converters with 240ns conversion time, up to 30 PWM channels for support of multi-coil systems, eFlexPWM module with 312 ps resolution for high-speed power control applications, programmable delay block, memory protection unit, dual FlexCAN modules and 256 KB of flash memory.

MWCT1023IFVLL  
MWCT1123FVLL



100 LQFP  
14 x 14 x 1.4 Pitch 0.5 mm

### Core

- Arm® Cortex®-M4 core up to 168 MHz with single precision Floating Point Unit (FPU)

### Memories

- Up to 256 KB of program flash memory
- Up to 32 KB of RAM

### System peripherals

- 16-channel DMA controller
- Low-leakage wakeup unit
- SWD interface and Micro Trace buffer
- Advanced independent clocked watchdog

### Clocks

- 32 to 40 kHz or 3 to 32 MHz crystal oscillator
- Multipurpose clock generator (MCG) with frequency-locked loop and phase-locked loop referencing either internal or external reference clock

### Operating Characteristics

- Voltage range: 1.71 to 3.6 V
- Temperature range: -40 to 105 °C

### Human-machine interface

- General-purpose input/output

### Communication interfaces

- Two Universal Asynchronous Receiver/Transmitter (UART) / FlexSCI modules with programmable 8- or 9-bit data format
- One 16-bit SPI module
- One I2C module
- Two FlexCAN modules

### Analog Modules

- Two 12-bit cyclic ADCs
- Four analog comparator (CMP) containing a 6-bit DAC and programmable reference input
- One 12-bit DAC

### Timers

- One eFlexPWM with 4 sub-modules, providing 12 PWM outputs
- Two 8-channel FlexTimers (FTM0 and FTM3)
- One 2-channel FlexTimers (FTM1)
- Four Periodic interrupt timers (PIT)
- Two Programmable Delay Blocks (PDB)
- Quadrature Encoder/Decoder (ENC)
- Ratio of timer input clock frequency vs. core frequency is 1:2 when core frequency is 168 Mhz, and 1:1 when core frequency is less than or equal to 100 Mhz

### Security and integrity modules

- Hardware CRC module to support fast cyclic redundancy checks
- External Watchdog Monitor (EWM)

## Orderable part numbers summary<sup>1</sup>

| NXP part number | CPU frequency (MHz) | Pin count | Total flash memory (KB) | SRAM (KB) | ADC   |       | eFlexPWM |       | PWM Nano-Edge | Flex Timers |       |       | DAC | FlexCAN |      |
|-----------------|---------------------|-----------|-------------------------|-----------|-------|-------|----------|-------|---------------|-------------|-------|-------|-----|---------|------|
|                 |                     |           |                         |           | ADC A | ADC B | PWMA     | PWMX  |               | FTM 0       | FTM 3 | FTM 1 |     | CAN0    | CAN1 |
| MWCT1123FVLL    | 168                 | 100       | 256                     | 32        | 18ch  | 20ch  | 1x8ch    | 1x4ch | Yes           | 1x8ch       | 1x8ch | 1x2ch | 1   | 1       | 1    |
| MWCT1023IFVLL   | 168                 | 100       | 256                     | 32        | 18ch  | 20ch  | 1x8ch    | 1x4ch | Yes           | 1x8ch       | 1x8ch | 1x2ch | 1   | 1       | 1    |

1. To confirm current availability of orderable part numbers, go to <http://www.nxp.com> and perform a part number search.

### Device Revision Number

| Device Mask Set Number | SIM_SDID[REVID] | JTAG ID Register[PRN] |
|------------------------|-----------------|-----------------------|
| 1N72K                  | 0001            | 0001                  |

### Related Resources

| Type            | Description  | Resource  |
|-----------------|--|---|
| Package drawing | Package dimensions are provided in package drawings. | <ul style="list-style-type: none"> <li>LQFP 100-pin: <a href="#">98ASS23308W</a></li> </ul> |



**Figure 1. MWCT1x23 block diagram**

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# 1 Application Description

The MWCT1x23 is a wireless power transmitter controller that integrates all required functions for 65 W consumer wireless power transfer system using the induction principle and in premium version also for WPC PC0 “Qi” compliant wireless power transmitter design. It is an intelligent device which uses periodically analog PING to detect a device for charging while gaining super low standby power. Once the device is detected, the MWCT1x23 controls the power transfer by adjusting the current and voltage of the power stage according to required operating point of power receiver.

The key characteristics and features of the system are:

- Enables single or multi-coil power transmitter topology
- Variable Z-gap range (vertical movement) from 4 mm to 35 mm – depends on coils setup. This range is limited by the 65-W power transfer programable thresholds
- Modularity in design of power transmitter unit to extend the number of transmitter coils to form a larger active area, which requires:
  - Minor reconfiguration of software
  - Extension of the multiplexer hardware (coil switches and control signal multiplexer).
  - No major impact on the system topology
- Fast wireless power transfer start-up time below 2.5 s (applicable for up to seven transmitter coils).
- No power from powered device is needed for the power receiver unit to start-up.
- Support of one Power Class 1 (PC1) device with up to 65 W of PRU output. Premium version support also one Qi-certified Power Class 0 (PC0) device with support for 5-W and 15-W receivers.
- Peak power transfer efficiency (input of power transmitter unit to output of power receiver unit) of over 86 % at the best coil placement and 65 W of power receiver unit output.
- Power receiver unit output-integrated protections for over-power and over-current scenarios.
- SRun-time system resonant frequency tracking ranging from 100 kHz to 145 kHz to improve the power-transfer efficiency.
- The power receiver unit power output acts as a constant 19.5-V source, forming an alternative to standard 65-W (or lower) AC power adapters, and thus simplifying its integration into the target system. Output voltage is adjustable.
- Foreign Object Detection during and prior to the power transfer.

## Ratings

- Interface for Bluetooth Low Energy (BLE) out-band communication between the power receiver unit and power transmitter unit for secured data and firmware update transfer towards the power transmitter unit.
- The power receiver unit is enabled with authentication devices to ensure that only safe and authentic devices initiate the power transfer in premium version.
- Compliance with the EMC regulation for commercial electronic devices.

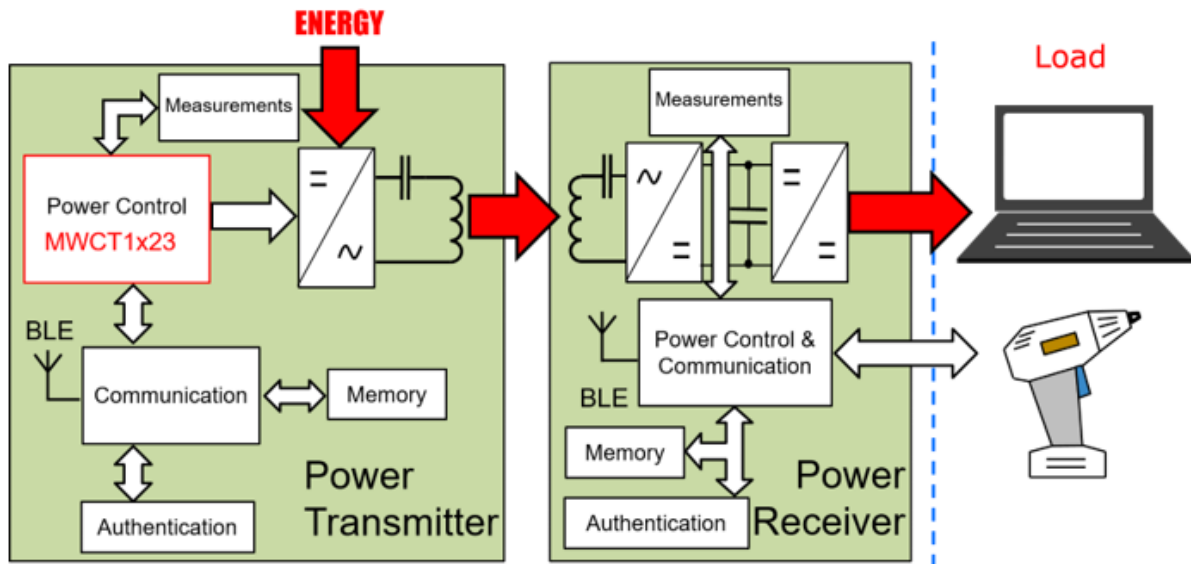


Figure 2. Wireless charging system functional diagram

## 2 Ratings

### 2.1 Thermal handling ratings

| Symbol           | Description                   | Min. | Max. | Unit | Notes |
|------------------|-------------------------------|------|------|------|-------|
| T <sub>STG</sub> | Storage temperature           | -55  | 150  | °C   | 1     |
| T <sub>SDR</sub> | 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*.

## 2.2 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*.

## 2.3 ESD handling ratings

| Symbol           | Description   | Min.  | Max.  | Unit | Notes |
|------------------|---|-------|-------|------|-------|
| V <sub>HBM</sub> | Electrostatic discharge voltage, human-body model     | -2000 | +2000 | V    | 1     |
| V <sub>CDM</sub> | Electrostatic discharge voltage, charged-device model | -500  | +500  | V    | 2     |
| I <sub>LAT</sub> | Latch-up current at ambient temperature of 105 °C     | -100  | +100  | mA   | 3     |

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*.
3. Determined according to JEDEC Standard JESD78, *IC Latch-up Test*.

## 2.4 Voltage and current operating ratings

| Symbol           | Description   | Min.                  | Max.                               | Unit |
|------------------|---|-----------------------|------------------------------------|------|
| V <sub>DD</sub>  | Digital supply voltage  | -0.3                  | 3.8                                | V    |
| I <sub>DD</sub>  | Digital supply current  | —                     | 120                                | mA   |
| V <sub>IO</sub>  | Digital pin input voltage (except open drain pins)                        | -0.3                  | V <sub>DD</sub> + 0.3 <sup>1</sup> | V    |
|                  | Open drain pins (PTC6 and PTC7)   | -0.3                  | 5.5                                | V    |
| I <sub>D</sub>   | Instantaneous maximum current single pin limit (applies to all port pins) | -25                   | 25                                 | mA   |
| V <sub>DDA</sub> | Analog supply voltage   | V <sub>DD</sub> - 0.3 | V <sub>DD</sub> + 0.3              | V    |

1. Maximum value of V<sub>IO</sub> (except open drain pins) must be 3.8 V.

## 2.5 Absolute Maximum Ratings

Absolute maximum ratings are stress ratings only, and functional operation at the maxima is not guaranteed. Stress beyond the limits specified in [Table 1](#) may affect device reliability or cause permanent damage to the device. For functional operating conditions, refer to the remaining tables in this section.

**Table 1. Absolute Maximum Ratings ( $V_{SS} = 0\text{ V}$ ,  $V_{SSA} = 0\text{ V}$ )**

| Symbol          | Description  | Notes <sup>1</sup> | Min  | Max   | Unit |
|-----------------|--|--------------------|------|-------|------|
| $V_{DD}$        | Supply Voltage Range                                     |                    | -0.3 | 4.0   | V    |
| $V_{DDA}$       | Analog Supply Voltage Range                              |                    | -0.3 | 4.0   | V    |
| $V_{REFHx}$     | ADC High Voltage Reference                               |                    | -0.3 | 4.0   | V    |
| $V_{REFLx}$     | ADC Low Voltage Reference                                |                    | -0.3 | 0.3   | V    |
| $\Delta V_{DD}$ | Voltage difference $V_{DD}$ to $V_{DDA}$                 |                    | -0.3 | 0.3   | V    |
| $\Delta V_{SS}$ | Voltage difference $V_{SS}$ to $V_{SSA}$                 |                    | -0.3 | 0.3   | V    |
| $V_{IN}$        | Digital Input Voltage Range                              | Pin Groups 1, 2    | -0.3 | 4.0   | V    |
| $V_{OSC}$       | Oscillator Input Voltage Range                           | Pin Group 4        | -0.4 | 4.0   | V    |
| $V_{INA}$       | Analog Input Voltage Range                               | Pin Group 3        | -0.3 | 4.0   | V    |
| $I_{IC}$        | Input clamp current, per pin ( $V_{IN} < 0$ )            |                    | —    | -20.0 | mA   |
| $I_{OC}$        | Output clamp current, per pin ( $V_O < 0$ ) <sup>2</sup> |                    | —    | -20.0 | mA   |
| $V_{OUT}$       | Output Voltage Range (Normal Push-Pull mode)             | Pin Group 1        | -0.3 | 4.0   | V    |
| $V_{OUTOD}$     | Output Voltage Range (Open Drain mode)                   | Pin Group 2        | -0.3 | 5.5   | V    |
| $V_{OUT\_DAC}$  | DAC Output Voltage Range                                 | Pin Group 5        | -0.3 | 4.0   | V    |
| $T_A$           | Ambient Temperature Industrial                           |                    | -40  | 105   | °C   |
| $T_{STG}$       | Storage Temperature Range (Extended Industrial)          |                    | -55  | 150   | °C   |

### 1. Default Mode

- Pin Group 1: GPIO, TDI, TDO, TMS, TCK
- Pin Group 2: RESET, PORTC6, and PORTC7
- Pin Group 3: ADC and Comparator Analog Inputs
- Pin Group 4: XTAL, EXTAL
- Pin Group 5: DAC analog output

### 2. Continuous clamp current per pin is -2.0 mA

## 3 General

Electromagnetic compatibility (EMC) performance depends on the environment in which the MCU resides. Board design and layout, circuit topology choices, location, characteristics of external components, and MCU software operation play a significant role in EMC performance.

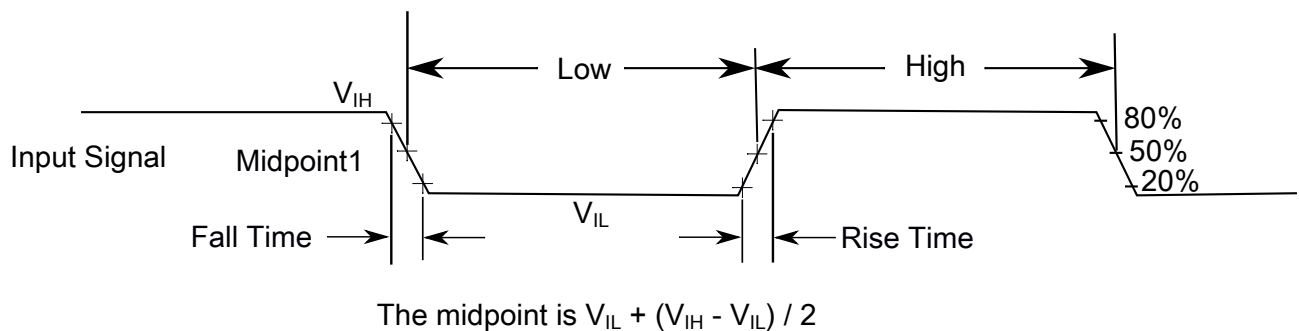


See the following applications notes available on [nxp.com](http://nxp.com) for guidelines on optimizing EMC performance.

- [AN2321: Designing for Board Level Electromagnetic Compatibility](#)
- [AN1050: Designing for Electromagnetic Compatibility \(EMC\) with HCMOS Microcontrollers](#)
- [AN1263: Designing for Electromagnetic Compatibility with Single-Chip Microcontrollers](#)
- [AN2764: Improving the Transient Immunity Performance of Microcontroller-Based Applications](#)
- [AN1259: System Design and Layout Techniques for Noise Reduction in MCU-Based Systems](#)

### 3.1 AC electrical characteristics

Unless otherwise specified, propagation delays are measured from the 50% to the 50% point, and rise and fall times are measured at the 20% and 80% points, as shown in the following figure.



**Figure 3. Input signal measurement reference**

All digital I/O switching characteristics, unless otherwise specified, assume:

1. output pins
  - have  $C_L=30\text{pF}$  loads,
  - are slew rate disabled, and
  - are normal drive strength

### 3.2 Nonswitching electrical specifications

### 3.2.1 Recommended Operating Conditions

This section includes information about recommended operating conditions.

#### NOTE

Recommended  $V_{DD}$  ramp rate is between 1 ms and 200 ms.

**Table 2. Recommended Operating Conditions ( $V_{REFLX}=0V$ ,  $V_{SSA}=0V$ ,  $V_{SS}=0V$ )**

| Symbol          | Description   | Notes <sup>1</sup> | Min                 | Typ | Max                  | Unit |
|-----------------|---|--------------------|---------------------|-----|----------------------|------|
| $V_{DD}$        | Supply Voltage Digital  | 2, 3               | 1.71                |     | 3.6                  | V    |
| $V_{DDA}$       | Supply voltage (analog)   | 2, 3               | 2.7                 | 3.0 | 3.6                  | V    |
| $V_{REFHx}$     | ADC (Cyclic) Reference Voltage High   |                    | 2.7                 |     | $V_{DDA}$            | V    |
| $\Delta V_{DD}$ | Voltage difference $V_{DD}$ to $V_{DDA}$  |                    | -0.1                | 0   | 0.1                  | V    |
| $\Delta V_{SS}$ | Voltage difference $V_{SS}$ to $V_{SSA}$  |                    | -0.1                | 0   | 0.1                  | V    |
| $F_{MCGOUT}$    | Device Clock Frequency  |                    | 0.04                |     | 168                  | MHz  |
| $T$             | <ul style="list-style-type: none"> <li>using internal RC oscillator</li> <li>using external clock source</li> </ul> |                    | 0                   |     | 168                  |      |
| $V_{IH}$        | Input Voltage High (digital inputs)   | Pin Groups 1, 2    | $0.7 \times V_{DD}$ |     | 3.6                  | V    |
| $V_{IL}$        | Input Voltage Low (digital inputs)  | Pin Groups 1, 2    |                     |     | $0.35 \times V_{DD}$ | V    |
| $V_{IHOSC}$     | Oscillator Input Voltage High   | Pin Group 4        | 2.0                 |     | $V_{DD} + 0.3$       | V    |
|                 | XTAL driven by an external clock source   |                    |                     |     |                      |      |
| $V_{ILOSC}$     | Oscillator Input Voltage Low  | Pin Group 4        | -0.3                |     | 0.8                  | V    |
| $C_{out}$       | DAC Output Current Drive Strength   | Pin Group 5        |                     |     | 1                    | mA   |
| $T_A$           | Ambient Operating Temperature   |                    | -40                 |     | 105                  | °C   |

#### 1. Default Mode

- Pin Group 1: GPIO, TDI, TDO, TMS, TCK
  - Pin Group 2: RESET
  - Pin Group 3: ADC and Comparator Analog Inputs
  - Pin Group 4: XTAL, EXTAL
  - Pin Group 5: DAC analog output
  - Pin Group 6: PTB0, PTB1, PTD4, PTD5, PTD6, PTD7, PTC3, and PTC4. have high output current capability
  - Pin Group 7: PTC6 and PTC7 are true open drain pins and have no P-chanl transistor. A external pull-up resistor is required when these pins are outputs.
- If the ADC is enabled, minimum  $V_{DD}$  is 2.7 V and minimum  $V_{DDA}$  is 2.7 V. ADCA and ADCB are not guaranteed to operate below 2.7 V. All other analog modules besides the ADC and Nano-edge will operate down to 1.71 V.
  - If the Nano-edge is enabled, minimum  $V_{DD}$  is 3.0 V and minimum  $V_{DDA}$  is 3.0 V. Nano-edge is not guaranteed to operate below 3.0 V. All other analog modules besides the ADC and Nano-edge will operate down to 1.71 V.

### 3.2.2 LVD and POR operating requirements

**Table 3.  $V_{DD}$  supply LVD and POR operating requirements**

| Symbol    | Description                         | Min. | Typ. | Max. | Unit | Notes |
|-----------|-------------------------------------|------|------|------|------|-------|
| $V_{POR}$ | Falling $V_{DD}$ POR detect voltage | 0.8  | 1.1  | 1.5  | V    |       |

Table continues on the next page...

**Table 3. V<sub>DD</sub> supply LVD and POR operating requirements (continued)**

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

1. Rising thresholds are falling threshold + hysteresis voltage

### 3.2.3 Voltage and current operating behaviors

**Table 4. Voltage and current operating behaviors**

| Symbol           | Description   | Min.                  | Typ. | Max. | Unit | Notes |
|------------------|---|-----------------------|------|------|------|-------|
| V <sub>OH</sub>  | Output high voltage — normal drive pad <ul style="list-style-type: none"> <li>2.7 V ≤ V<sub>DD</sub> ≤ 3.6 V, I<sub>OH</sub> = -10mA</li> <li>1.71 V ≤ V<sub>DD</sub> ≤ 2.7 V, I<sub>OH</sub> = -5mA</li> </ul> | V <sub>DD</sub> - 0.5 | —    | —    | V    | 1     |
|                  |   | V <sub>DD</sub> - 0.5 | —    | —    | V    |       |
|                  | Output high voltage — High drive pad <ul style="list-style-type: none"> <li>2.7 V ≤ V<sub>DD</sub> ≤ 3.6 V, I<sub>OH</sub> = -20mA</li> <li>1.71 V ≤ V<sub>DD</sub> ≤ 2.7 V, I<sub>OH</sub> = -10mA</li> </ul>  | V <sub>DD</sub> - 0.5 | —    | —    | V    |       |
|                  |   | V <sub>DD</sub> - 0.5 | —    | —    | V    |       |
| I <sub>OHT</sub> | Output high current total for all ports   | —                     | —    | 100  | mA   |       |
| V <sub>OL</sub>  | Output low voltage — open drain pad   | —                     | —    | 0.5  | V    | 2     |

Table continues on the next page...

**Table 4. Voltage and current operating behaviors (continued)**

| Symbol    | Description   | Min. | Typ.  | Max. | Unit             | Notes |
|-----------|---|------|-------|------|------------------|-------|
|           | <ul style="list-style-type: none"> <li>• <math>2.7\text{ V} \leq V_{DD} \leq 3.6\text{ V}</math>, <math>I_{OH} = 3\text{ mA}</math></li> <li>• <math>1.71\text{ V} \leq V_{DD} \leq 2.7\text{ V}</math>, <math>I_{OH} = 1\text{ mA}</math></li> </ul>   | —    | —     | 0.5  | V                |       |
| $V_{OL}$  | Output low voltage — normal drive pad   | —    | —     | 0.5  | V                |       |
|           | <ul style="list-style-type: none"> <li>• <math>2.7\text{ V} \leq V_{DD} \leq 3.6\text{ V}</math>, <math>I_{OL} = 10\text{ mA}</math></li> <li>• <math>1.71\text{ V} \leq V_{DD} \leq 2.7\text{ V}</math>, <math>I_{OL} = 5\text{ mA}</math></li> </ul>  | —    | —     | 0.5  | V                |       |
|           | Output low voltage — high drive pad   | —    | —     | 0.5  | V                | 1     |
|           | <ul style="list-style-type: none"> <li>• <math>2.7\text{ V} \leq V_{DD} \leq 3.6\text{ V}</math>, <math>I_{OL} = 20\text{ mA}</math></li> <li>• <math>1.71\text{ V} \leq V_{DD} \leq 2.7\text{ V}</math>, <math>I_{OL} = 10\text{ mA}</math></li> </ul> | —    | —     | 0.5  | V                |       |
| $I_{OLT}$ | Output low current total for all ports  | —    | —     | 100  | mA               |       |
| $I_{IN}$  | Input leakage current, analog and digital pins <ul style="list-style-type: none"> <li>• <math>V_{SS} \leq V_{IN} \leq V_{DD}</math></li> </ul>  | —    | 0.002 | 0.5  | $\mu\text{A}$    | 3     |
| $R_{PU}$  | Internal pullup resistors(except RTC_WAKEUP pins)   | 20   | —     | 50   | $\text{k}\Omega$ | 4     |
| $R_{PD}$  | Internal pulldown resistors   | 20   | —     | 50   | $\text{k}\Omega$ | 5     |

1. High drive pads are PTB0, PTB1, PTC3, PTC4, PTD4, PTD5, PTD6 and PTD7.
2. Open drain pads are PTC6 and PTC7.
3. Measured at  $V_{DD}=3.6\text{V}$
4. Measured at  $V_{DD}$  supply voltage =  $V_{DD}$  min and  $V_{input} = V_{SS}$
5. Measured at  $V_{DD}$  supply voltage =  $V_{DD}$  min and  $V_{input} = V_{DD}$

### 3.2.4 Power mode transition operating behaviors

All specifications except  $t_{POR}$  and  $VLLSx \rightarrow \text{RUN}$  recovery times in the following table assume this clock configuration:

- CPU and system clocks = 100 MHz
- Bus and flash clock = 25 MHz
- FEI clock mode

**Table 5. Power mode transition operating behaviors**

| Symbol    | Description  | Min. | Typ. | Max. | Unit          | Notes |
|-----------|--|------|------|------|---------------|-------|
| $t_{POR}$ | After a POR event, amount of time from the point $V_{DD}$ reaches 1.71 V to execution of the first instruction across the operating temperature range of the chip. | —    | —    | 300  | $\mu\text{s}$ |       |
|           | <ul style="list-style-type: none"> <li>• <math>VLLS0 \rightarrow \text{RUN}</math></li> </ul>  | —    | —    | 173  | $\mu\text{s}$ |       |

Table continues on the next page...

**Table 5. Power mode transition operating behaviors (continued)**

| Symbol | Description   | Min. | Typ. | Max. | Unit | Notes |
|--------|---------------|------|------|------|------|-------|
|        | • VLLS1 → RUN | —    | —    | 172  | μs   |       |
|        | • VLLS2 → RUN | —    | —    | 96   | μs   |       |
|        | • VLLS3 → RUN | —    | —    | 96   | μs   |       |
|        | • VLPS → RUN  | —    | —    | 5.4  | μs   |       |
|        | • STOP → RUN  | —    | —    | 5.4  | μs   |       |

### 3.2.5 Power consumption operating behaviors

#### NOTE

The maximum values represent characterized results equivalent to the mean plus three times the standard deviation (mean+3σ)

**Table 6. Power consumption operating behaviors (All IDD values are Target values)**

| Symbol              | Description   | Min. | Typ. | Max. | Unit | Notes                      |
|---------------------|---|------|------|------|------|----------------------------|
| I <sub>DD_RUN</sub> | Run mode current — all peripheral clocks disabled, code executing from flash, excludes IDDA | —    | 6.8  | 17.2 | mA   | Core frequency of 25 MHz.  |
|                     |   | —    | 6.9  | 17.4 | mA   |                            |
| I <sub>DD_RUN</sub> | Run mode current — all peripheral clocks disabled, code executing from flash, excludes IDDA | —    | 9.9  | 19.7 | mA   | Core frequency of 50 MHz.  |
|                     |   | —    | 10.0 | 19.8 | mA   |                            |
| I <sub>DD_RUN</sub> | Run mode current — all peripheral clocks disabled, code executing from flash, excludes IDDA | —    | 17.0 | 25.9 | mA   | Core frequency of 100 MHz. |
|                     |   | —    | 17.2 | 26.1 | mA   |                            |

Table continues on the next page...

**Table 6. Power consumption operating behaviors (All IDD's are Target values) (continued)**

| Symbol                | Description   | Min. | Typ. | Max.  | Unit | Notes   |
|-----------------------|---|------|------|-------|------|---|
| I <sub>DD_HSRUN</sub> | Run mode current — all peripheral clocks disabled, code executing from flash, excludes IDDA <ul style="list-style-type: none"> <li>• @ 1.8V</li> <li>• @ 3.0V</li> </ul>                  | —    | 26.3 | 45.3  | mA   | Core frequency of 168 MHz.                            |
|                       |   | —    | 26.5 | 45.5  | mA   |   |
| I <sub>DD_HSRUN</sub> | Run mode current — all peripheral clocks enabled, code executing from flash,excludes IDDA <ul style="list-style-type: none"> <li>• @ 3.0V</li> <li>• @ 25°C</li> <li>• @ 105°C</li> </ul> | —    | 34.0 | 45.5  | mA   | Core frequency of 168 MHz. Nanoedge module at 84 MHz. |
|                       |   | —    | 39.0 | 53.2  | mA   |   |
|                       |   | —    | —    | —     | —    |   |
| I <sub>DD_WAIT</sub>  | Wait mode high frequency current at 3.0 V — all peripheral clocks disabled  | —    | 8.9  | —     | mA   |   |
| I <sub>DD_VLPR</sub>  | Very-low-power run mode current at 3.0 V — all peripheral clocks disabled   | —    | 0.58 | —     | mA   | Core frequency of 4 Mhz.                              |
| I <sub>DD_VLPR</sub>  | Very-low-power run mode current at 3.0 V — all peripheral clocks enabled  | —    | 0.83 | —     | mA   | Core frequency of 4 Mhz.                              |
| I <sub>DD_VLPW</sub>  | Very-low-power wait mode current at 3.0 V — all peripheral clocks disabled  | —    | 0.34 | —     | mA   | Bus frequency of 2 MHz.                               |
| I <sub>DD_STOP</sub>  | Stop mode current at 3.0 V <ul style="list-style-type: none"> <li>• @ -40 to 25°C</li> <li>• @ 70°C</li> <li>• @ 105°C</li> </ul>   | —    | 0.43 | 2.03  | mA   |   |
|                       |   | —    | 1.16 | 4.27  | mA   |   |
|                       |   | —    | 3.05 | 10.13 | mA   |   |
|                       |   | —    | —    | —     | —    |   |
| I <sub>DD_VLPS</sub>  | Very-low-power stop mode current at 3.0 V <ul style="list-style-type: none"> <li>• @ -40 to 25°C</li> <li>• @ 70°C</li> <li>• @ 105°C</li> </ul>  | —    | 58   | 218   | μA   |   |
|                       |   | —    | 280  | 1340  | μA   |   |
|                       |   | —    | 924  | 2870  | μA   |   |
|                       |   | —    | —    | —     | —    |   |
| I <sub>DD_VLLS3</sub> | Very low-leakage stop mode 3 current at 3.0 V <ul style="list-style-type: none"> <li>• @ -40 to 25°C</li> <li>• @ 70°C</li> <li>• @ 105°C</li> </ul>                                      | —    | 2.8  | 5.3   | μA   |   |
|                       |   | —    | 9.6  | 35.1  | μA   |   |
|                       |   | —    | 37.4 | 134.8 | μA   |   |
|                       |   | —    | —    | —     | —    |   |
| I <sub>DD_VLLS2</sub> | Very low-leakage stop mode 2 current at 3.0 V <ul style="list-style-type: none"> <li>• @ -40 to 25°C</li> <li>• @ 70°C</li> <li>• @ 105°C</li> </ul>                                      | —    | 2.7  | 3.3   | μA   |   |
|                       |   | —    | 6.6  | 12.2  | μA   |   |
|                       |   | —    | 25.9 | 50.5  | μA   |   |
|                       |   | —    | —    | —     | —    |   |

Table continues on the next page...

**Table 6. Power consumption operating behaviors (All IDD's are Target values) (continued)**

| Symbol                 | Description  | Min. | Typ. | Max. | Unit | Notes |
|------------------------|--|------|------|------|------|-------|
| I <sub>DD_VLLS1</sub>  | Very low-leakage stop mode 1 current at 3.0 V<br><ul style="list-style-type: none"> <li>@ -40 to 25°C</li> <li>@ 70°C</li> <li>@ 105°C</li> </ul>                                  | —    | 740  | 1200 | nA   |       |
|                        |  | —    | 2.5  | 10.6 | μA   |       |
|                        |  | —    | 11.1 | 26.5 | μA   |       |
|                        |  |      |      |      |      |       |
| I <sub>DD_VLLS0B</sub> | Very low-leakage stop mode 0 current at 3.0 V with POR detect circuit enabled<br><ul style="list-style-type: none"> <li>@ -40 to 25°C</li> <li>@ 70°C</li> <li>@ 105°C</li> </ul>  | —    | 420  | 832  | nA   |       |
|                        |  | —    | 1.9  | 9.4  | μA   |       |
|                        |  | —    | 10.8 | 26.3 | μA   |       |
|                        |  |      |      |      |      |       |
| I <sub>DD_VLLS0A</sub> | Very low-leakage stop mode 0 current at 3.0 V with POR detect circuit disabled<br><ul style="list-style-type: none"> <li>@ -40 to 25°C</li> <li>@ 70°C</li> <li>@ 105°C</li> </ul> | —    | 200  | 599  | nA   |       |
|                        |  | —    | 1.8  | 10.5 | μA   |       |
|                        |  | —    | 10.8 | 26.3 | μA   |       |
|                        |  |      |      |      |      |       |

**Table 7. Low power mode peripheral adders — typical value**

| Symbol                     | Description   | Temperature (°C) |     |     |     |     |     | Unit |
|----------------------------|---|------------------|-----|-----|-----|-----|-----|------|
|                            |   | -40              | 25  | 50  | 70  | 85  | 105 |      |
| I <sub>IREFSTEN4MHZ</sub>  | 4 MHz internal reference clock (IRC) adder. Measured by entering STOP or VLPS mode with 4 MHz IRC enabled.  | 56               | 56  | 56  | 56  | 56  | 56  | μA   |
| I <sub>IREFSTEN32KHz</sub> | 32 kHz internal reference clock (IRC) adder. Measured by entering STOP mode with the 32 kHz IRC enabled.  | 52               | 52  | 52  | 52  | 52  | 52  | μA   |
| I <sub>IREFSTEN4MHZ</sub>  | External 4 MHz crystal clock adder. Measured by entering STOP or VLPS mode with the crystal enabled.  | 206              | 228 | 237 | 245 | 251 | 258 | μA   |
| I <sub>IREFSTEN32KHz</sub> | External 32 kHz crystal clock adder by means of the OSC0_CR[EREFSTEN and EREFSTEN] bits. Measured by entering all modes with the crystal enabled.<br><br>VLLS1<br>VLLS3<br>VLPS<br>STOP |                  |     |     |     |     |     | nA   |
|                            |   | 440              | 490 | 540 | 560 | 570 | 580 |      |
|                            |   | 440              | 490 | 540 | 560 | 570 | 580 |      |
|                            |   | 510              | 560 | 560 | 560 | 610 | 680 |      |
|                            |   | 510              | 560 | 560 | 560 | 610 | 680 |      |
| I <sub>CMP</sub>           | CMP peripheral adder measured by placing the device in VLLS1 mode with CMP  | 22               | 22  | 22  | 22  | 22  | 22  | μA   |

Table continues on the next page...

**Table 7. Low power mode peripheral adders — typical value (continued)**

| Symbol            | Description   | Temperature (°C) |     |     |     |     |     | Unit |
|-------------------|---|------------------|-----|-----|-----|-----|-----|------|
|                   |   | -40              | 25  | 50  | 70  | 85  | 105 |      |
|                   | enabled using the 6-bit DAC and a single external input for compare. Includes 6-bit DAC power consumption.  |                  |     |     |     |     |     |      |
| I <sub>UART</sub> | UART peripheral adder measured by placing the device in STOP or VLPS mode with selected clock source waiting for RX data at 115200 baud rate. Includes selected clock source power consumption. |                  |     |     |     |     |     | μA   |
|                   | MCGIRCLK (4 MHz internal reference clock)   | 66               | 66  | 66  | 66  | 66  | 66  |      |
|                   | OSCERCLK (4 MHz external crystal)   | 214              | 234 | 246 | 254 | 260 | 268 |      |
| I <sub>BG</sub>   | Bandgap adder when BGEN bit is set and device is placed in VLPx or VLLSx mode.  | 45               | 45  | 45  | 45  | 45  | 45  | μA   |

### 3.2.5.1 Diagram: Typical IDD\_RUN operating behavior

The following data was measured under these conditions:

- MCG in FBE for run mode, and BLPE for VLPR mode
- No GPIOs toggled
- Code execution from flash with cache enabled
- For the ALLOFF curve, all peripheral clocks are disabled except FTFA





**Figure 4. Run mode supply current vs. core frequency**



Figure 5. VLPR mode current vs. core frequency

### 3.2.6 EMC radiated emissions operating behaviors

**NOTE**

EMC measurements to IC-level IEC standards are available from NXP on request.

Table 8. EMC radiated emissions operating behaviors

| Symbol              | Description                        | Frequency band (MHz) | Typ. | Unit | Notes |
|---------------------|------------------------------------|----------------------|------|------|-------|
| V <sub>RE1</sub>    | Radiated emissions voltage, band 1 | 0.15–50              | 20   | dBμV | 1, 2  |
| V <sub>RE2</sub>    | Radiated emissions voltage, band 2 | 50–150               | 18   | dBμV |       |
| V <sub>RE3</sub>    | Radiated emissions voltage, band 3 | 150–500              | 14   | dBμV |       |
| V <sub>RE4</sub>    | Radiated emissions voltage, band 4 | 500–1000             | 8    | dBμV |       |
| V <sub>RE_IEC</sub> | IEC level                          | 0.15–1000            | L    | —    | 2, 3  |

1. Determined according to IEC Standard 61967-1, *Integrated Circuits - Measurement of Electromagnetic Emissions, 150 kHz to 1 GHz Part 1: General Conditions and Definitions* and IEC Standard 61967-2, *Integrated Circuits - Measurement of Electromagnetic Emissions, 150 kHz to 1 GHz Part 2: Measurement of Radiated Emissions—TEM Cell and Wideband TEM Cell Method*. Measurements were made while the microcontroller was running basic application code. The reported 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.  $V_{DD} = 3.3\text{ V}$ ,  $T_A = 25\text{ °C}$ ,  $f_{OSC} = 10\text{ MHz}$  (crystal),  $f_{SYS} = 75\text{ MHz}$ ,  $f_{BUS} = 25\text{ MHz}$
3. Specified according to Annex D of IEC Standard 61967-2, *Measurement of Radiated Emissions—TEM Cell and Wideband TEM Cell Method*

### 3.2.7 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 [www.nxp.com](http://www.nxp.com).
2. Perform a keyword search for “EMC design.”

### 3.2.8 Capacitance attributes

Table 9. 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   |

## 3.3 Switching specifications

### 3.3.1 Typical device clock specifications

Table 10. Typical device clock specifications

| Symbol              | Description           | Min. | Max. | Unit | Notes |
|---------------------|-----------------------|------|------|------|-------|
| High Speed RUN mode |                       |      |      |      |       |
| $f_{SYS}$           | System and core clock | —    | 168  | MHz  |       |
| $f_{BUS}$           | Bus and Flash clock   | —    | 24   | MHz  |       |
| $f_{FPCK}$          | Fast peripheral clock | —    | 84   | MHz  |       |
| $f_{NANO}$          | Nano-edge clock       | —    | 168  | MHz  |       |
| Normal run mode     |                       |      |      |      |       |
| $f_{SYS}$           | System and core clock | —    | 100  | MHz  |       |
| $f_{BUS}$           | Bus and Flash clock   | —    | 25   | MHz  |       |

Table continues on the next page...

**Table 10. Typical device clock specifications (continued)**

| Symbol             | Description           | Min. | Max. | Unit | Notes |
|--------------------|-----------------------|------|------|------|-------|
| f <sub>FPCK</sub>  | Fast peripheral clock | —    | 100  | MHz  |       |
| f <sub>NANO</sub>  | Nano-edge clock       | —    | 200  | MHz  |       |
| Low Speed RUN mode |                       |      |      |      |       |
| f <sub>SYS</sub>   | System and core clock | —    | 50   | MHz  |       |
| f <sub>BUS</sub>   | Bus and Flash clock   | —    | 25   | MHz  |       |
| f <sub>FPCK</sub>  | Fast peripheral clock | —    | 100  | MHz  |       |
| f <sub>NANO</sub>  | Nano-edge clock       | —    | 200  | MHz  |       |

**NOTE**

When NanoEdge circuit is enabled, the following clock set must be followed:

1. NanoEdge clock source must be from the PLL output
2. NanoEdge clock must be 2x the fast peripheral clock
3. NanoEdge clock must in the range of 164 Mhz ~232 Mhz

**3.3.2 General switching specifications**

These general purpose specifications apply to all signals configured for GPIO, UART, and I<sup>2</sup>C signals.

**Table 11. 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     |
|        | External RESET and NMI pin interrupt pulse width — Asynchronous path               | 100  | —    | ns               | 2     |
|        | GPIO pin interrupt pulse width — Asynchronous path                                 | 16   | —    | ns               | 2     |
|        | Port rise and fall time  |      |      |                  | 3     |
|        | Fast slew rate   |      |      |                  |       |
|        | 1.71 ≤ VDD ≤ 2.7 V   | —    | 8    | ns               |       |
|        | 2.7 ≤ VDD ≤ 3.6 V  | —    | 7    | ns               |       |
|        | Port rise and fall time  |      |      |                  |       |
|        | Slow slew rate   |      |      |                  |       |
|        | 1.71 ≤ VDD ≤ 2.7 V   | —    | 25   | ns               |       |
|        | 2.7 ≤ VDD ≤ 3.6 V  | —    | 15   | ns               |       |

1. The greater synchronous and asynchronous timing must be met.
2. This is the shortest pulse that is guaranteed to be recognized.

3. For high drive pins with high drive enabled, load is 75pF; other pins load (low drive) is 25pF.

## 3.4 Thermal specifications

### 3.4.1 Thermal operating requirements

Table 12. Thermal operating requirements

| Symbol | Description              | Min. | Max. | Unit |
|--------|--------------------------|------|------|------|
| $T_J$  | Die junction temperature | -40  | 125  | °C   |
| $T_A$  | Ambient temperature      | -40  | 105  | °C   |

### 3.4.2 Thermal attributes

Table 13. Thermal attributes

| Board type        | Symbol           | Description   | 100 LQFP | Unit | Notes |
|-------------------|------------------|---|----------|------|-------|
| Single-layer (1S) | $R_{\theta JA}$  | Thermal resistance, junction to ambient (natural convection)                                    | 62       | °C/W | 1     |
| Four-layer (2s2p) | $R_{\theta JA}$  | Thermal resistance, junction to ambient (natural convection)                                    | 49       | °C/W |       |
| Single-layer (1S) | $R_{\theta JMA}$ | Thermal resistance, junction to ambient (200 ft./min. air speed)                                | 52       | °C/W |       |
| Four-layer (2s2p) | $R_{\theta JMA}$ | Thermal resistance, junction to ambient (200 ft./min. air speed)                                | 43       | °C/W |       |
| —                 | $R_{\theta JB}$  | Thermal resistance, junction to board   | 35       | °C/W | 2     |
| —                 | $R_{\theta JC}$  | Thermal resistance, junction to case  | 17       | °C/W | 3     |
| —                 | $\Psi_{JT}$      | Thermal characterization parameter, junction to package top outside center (natural convection) | 3        | °C/W | 4     |

1. Determined according to JEDEC Standard JESD51-2, *Integrated Circuits Thermal Test Method Environmental Conditions—Natural Convection (Still Air)*, or EIA/JEDEC Standard JESD51-6, *Integrated Circuit Thermal Test Method Environmental Conditions—Forced Convection (Moving Air)*.
2. Determined according to JEDEC Standard JESD51-8, *Integrated Circuit Thermal Test Method Environmental Conditions—Junction-to-Board*.
3. 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.
4. Determined according to JEDEC Standard JESD51-2, *Integrated Circuits Thermal Test Method Environmental Conditions—Natural Convection (Still Air)*.

## 4 Peripheral operating requirements and behaviors

### 4.1 Core modules

#### 4.1.1 SWD Electricals

Table 14. SWD full voltage range electricals

| Symbol | Description  | Min. | Max. | Unit |
|--------|--|------|------|------|
|        | Operating voltage  | 1.71 | 3.6  | V    |
| J1     | SWD_CLK frequency of operation <ul style="list-style-type: none"> <li>Serial wire debug</li> </ul> | 0    | 25   | MHz  |
| J2     | SWD_CLK cycle period   | 1/J1 | —    | ns   |
| J3     | SWD_CLK clock pulse width <ul style="list-style-type: none"> <li>Serial wire debug</li> </ul>      | 20   | —    | ns   |
| J4     | SWD_CLK rise and fall times  | —    | 3    | ns   |
| J9     | SWD_DIO input data setup time to SWD_CLK rise  | 10   | —    | ns   |
| J10    | SWD_DIO input data hold time after SWD_CLK rise  | 0    | —    | ns   |
| J11    | SWD_CLK high to SWD_DIO data valid   | —    | 32   | ns   |
| J12    | SWD_CLK high to SWD_DIO high-Z   | 5    | —    | ns   |

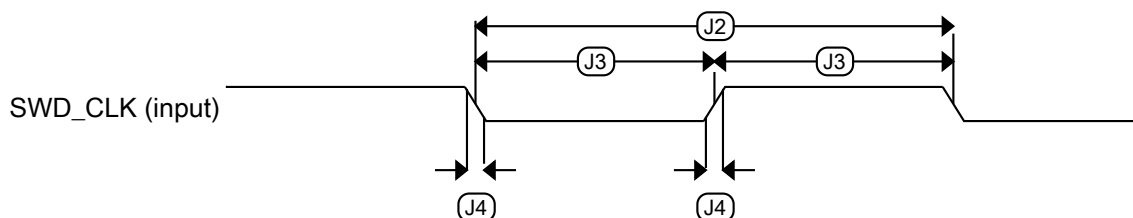


Figure 6. Serial wire clock input timing



Figure 7. Serial wire data timing

## 4.1.2 Debug trace timing specifications

Table 15. Debug trace operating behaviors

| Symbol    | Description              | Min.                | Max. | Unit |
|-----------|--------------------------|---------------------|------|------|
| $T_{cyc}$ | Clock period             | Frequency dependent |      | MHz  |
| $T_{wl}$  | Low pulse width          | 2                   | —    | ns   |
| $T_{wh}$  | High pulse width         | 2                   | —    | ns   |
| $T_r$     | Clock and data rise time | —                   | 3    | ns   |
| $T_f$     | Clock and data fall time | —                   | 3    | ns   |
| $T_s$     | Data setup               | 3                   | 1.5  | ns   |
| $T_h$     | Data hold                | 2                   | 1.0  | ns   |

Peripheral operating requirements and behaviors



Figure 8. TRACE\_CLKOUT specifications



Figure 9. Trace data specifications

### 4.1.3 JTAG electricals

Table 16. JTAG limited voltage range electricals

| Symbol | Description  | Min. | Max. | Unit |
|--------|--|------|------|------|
|        | Operating voltage  | 2.7  | 3.6  | V    |
| J1     | TCLK frequency of operation <ul style="list-style-type: none"> <li>• Boundary Scan</li> <li>• JTAG and CJTAG</li> <li>• Serial Wire Debug</li> </ul> | 0    | 10   | MHz  |
|        |  | 0    | 25   |      |
|        |  | 0    | 50   |      |
| J2     | TCLK cycle period  | 1/J1 | —    | ns   |
| J3     | TCLK clock pulse width <ul style="list-style-type: none"> <li>• Boundary Scan</li> <li>• JTAG and CJTAG</li> <li>• Serial Wire Debug</li> </ul>      | 50   | —    | ns   |
|        |  | 20   | —    | ns   |
|        |  | 10   | —    | ns   |
| J4     | TCLK rise and fall times   | —    | 3    | ns   |
| J5     | Boundary scan input data setup time to TCLK rise   | 20   | —    | ns   |
| J6     | Boundary scan input data hold time after TCLK rise   | 2.0  | —    | ns   |
| J7     | TCLK low to boundary scan output data valid  | —    | 28   | ns   |
| J8     | TCLK low to boundary scan output high-Z  | —    | 25   | ns   |
| J9     | TMS, TDI input data setup time to TCLK rise  | 8    | —    | ns   |
| J10    | TMS, TDI input data hold time after TCLK rise  | 1    | —    | ns   |

Table continues on the next page...



**Table 16. JTAG limited voltage range electricals (continued)**

| Symbol | Description   | Min. | Max. | Unit |
|--------|---|------|------|------|
| J11    | TCLK low to TDO data valid                                  | —    | 19   | ns   |
| J12    | TCLK low to TDO high-Z                                      | —    | 17   | ns   |
| J13    | $\overline{\text{TRST}}$ assert time                        | 100  | —    | ns   |
| J14    | $\overline{\text{TRST}}$ setup time (negation) to TCLK high | 8    | —    | ns   |

**Table 17. JTAG full voltage range electricals**

| Symbol | Description  | Min.             | Max.           | Unit           |
|--------|--|------------------|----------------|----------------|
|        | Operating voltage  | 1.71             | 3.6            | V              |
| J1     | TCLK frequency of operation <ul style="list-style-type: none"> <li>• Boundary Scan</li> <li>• JTAG and CJTAG</li> <li>• Serial Wire Debug</li> </ul> | 0<br>0<br>0      | 10<br>20<br>40 | MHz            |
| J2     | TCLK cycle period  | 1/J1             | —              | ns             |
| J3     | TCLK clock pulse width <ul style="list-style-type: none"> <li>• Boundary Scan</li> <li>• JTAG and CJTAG</li> <li>• Serial Wire Debug</li> </ul>      | 50<br>25<br>12.5 | —<br>—<br>—    | ns<br>ns<br>ns |
| J4     | TCLK rise and fall times   | —                | 3              | ns             |
| J5     | Boundary scan input data setup time to TCLK rise   | 20               | —              | ns             |
| J6     | Boundary scan input data hold time after TCLK rise   | 2.0              | —              | ns             |
| J7     | TCLK low to boundary scan output data valid  | —                | 30.6           | ns             |
| J8     | TCLK low to boundary scan output high-Z  | —                | 25             | ns             |
| J9     | TMS, TDI input data setup time to TCLK rise  | 8                | —              | ns             |
| J10    | TMS, TDI input data hold time after TCLK rise  | 1.0              | —              | ns             |
| J11    | TCLK low to TDO data valid   | —                | 19.0           | ns             |
| J12    | TCLK low to TDO high-Z   | —                | 17.0           | ns             |
| J13    | $\overline{\text{TRST}}$ assert time   | 100              | —              | ns             |
| J14    | $\overline{\text{TRST}}$ setup time (negation) to TCLK high  | 8                | —              | ns             |

**Figure 10. Test clock input timing**

Peripheral operating requirements and behaviors

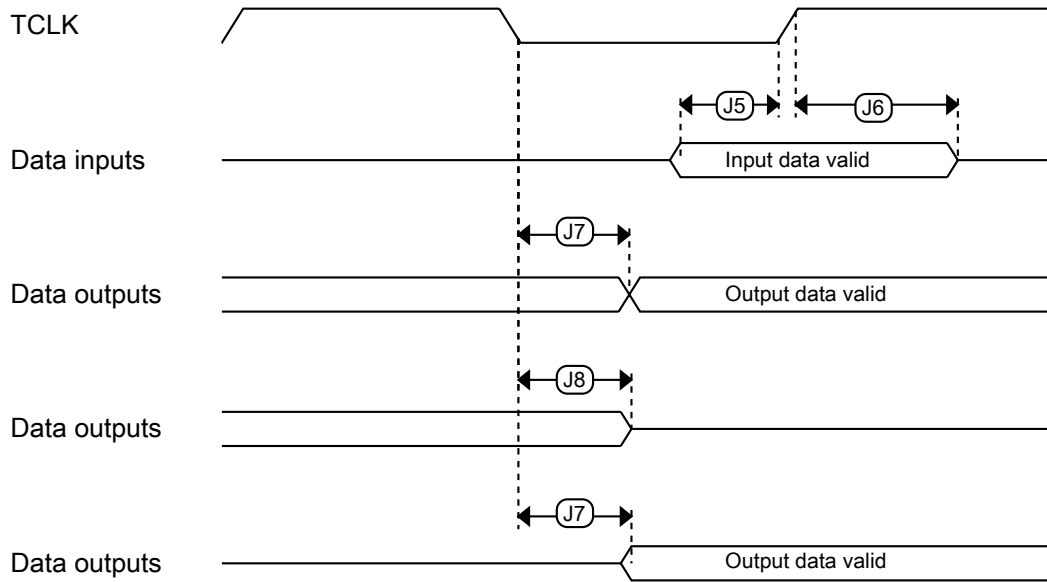


Figure 11. Boundary scan (JTAG) timing

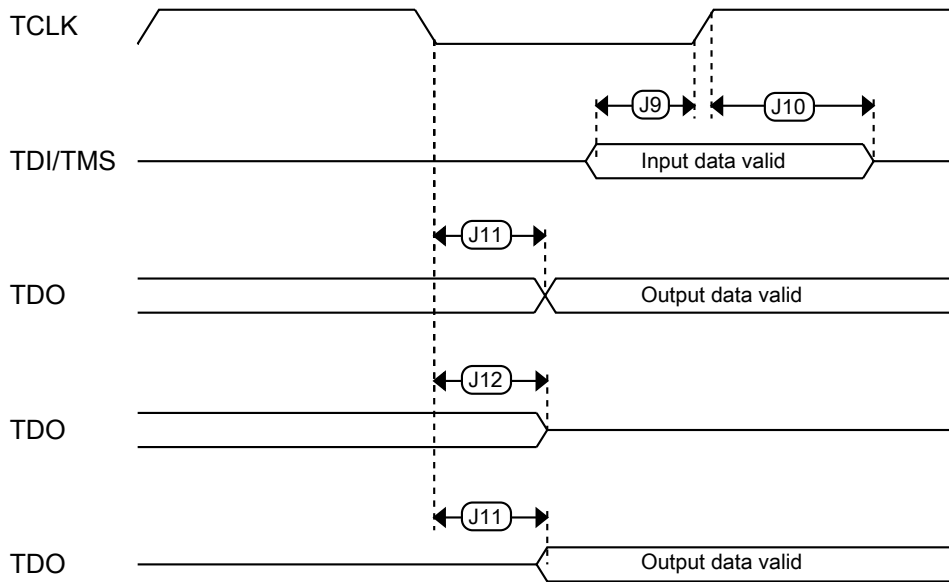


Figure 12. Test Access Port timing

Figure 13.  $\overline{\text{TRST}}$  timing

## 4.2 System modules

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

## 4.3 Clock modules

### 4.3.1 MCG specifications

Table 18. 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 | —                                 | $\pm 0.3$ | $\pm 0.6$ | $\%f_{\text{dco}}$ | 1     |
| $\Delta f_{\text{dco\_res\_t}}$ | Resolution of trimmed average DCO output frequency at fixed voltage and temperature — using SCTRIM only        | —                                 | $\pm 0.2$ | $\pm 0.5$ | $\%f_{\text{dco}}$ | 1     |
| $\Delta f_{\text{dco\_t}}$      | Total deviation of trimmed average DCO output frequency over voltage and temperature                           | —                                 | $\pm 0.5$ | $\pm 2$   | $\%f_{\text{dco}}$ | 1     |
| $\Delta f_{\text{dco\_t}}$      | Total deviation of trimmed average DCO output frequency over fixed voltage and temperature range of 0–70°C     | —                                 | —         | $\pm 1$   | $\%f_{\text{dco}}$ | 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                |       |

Table continues on the next page...

Table 18. MCG specifications (continued)

| Symbol              | Description  | Min.  | Typ.       | Max.    | Unit | Notes |      |
|---------------------|--|---|------------|---------|------|-------|------|
| $f_{loc\_high}$     | Loss of external clock minimum frequency —<br>RANGE = 01, 10, or 11  | $(16/5) \times f_{ints\_t}$                           | —          | —       | kHz  |       |      |
| FLL                 |  |   |            |         |      |       |      |
| $f_{fll\_ref}$      | FLL reference frequency range  | 31.25   | —          | 39.0625 | kHz  |       |      |
| $f_{dco}$           | DCO output frequency range   | Low range (DRS=00)<br>$640 \times f_{fll\_ref}$       | 20         | 20.97   | 25   | MHz   | 2, 3 |
|                     |  | Mid range (DRS=01)<br>$1280 \times f_{fll\_ref}$      | 40         | 41.94   | 50   | MHz   |      |
|                     |  | Mid-high range (DRS=10)<br>$1920 \times f_{fll\_ref}$ | 60         | 62.91   | 75   | MHz   |      |
|                     |  | High range (DRS=11)<br>$2560 \times f_{fll\_ref}$     | 80         | 83.89   | 100  | MHz   |      |
| $f_{dco\_t\_DMX32}$ | DCO output frequency   | Low range (DRS=00)<br>$732 \times f_{fll\_ref}$       | —          | 23.99   | —    | MHz   | 4, 5 |
|                     |  | Mid range (DRS=01)<br>$1464 \times f_{fll\_ref}$      | —          | 47.97   | —    | MHz   |      |
|                     |  | Mid-high range (DRS=10)<br>$2197 \times f_{fll\_ref}$ | —          | 71.99   | —    | MHz   |      |
|                     |  | High range (DRS=11)<br>$2929 \times f_{fll\_ref}$     | —          | 95.98   | —    | MHz   |      |
| $J_{cyc\_fll}$      | FLL period jitter<br>• $f_{DCO} = 48$ MHz<br>• $f_{DCO} = 98$ MHz  | —   | 180<br>150 | —       | ps   |       |      |
| $t_{fll\_acquire}$  | FLL target frequency acquisition time  | —   | —          | 1       | ms   | 6     |      |
| PLL                 |  |   |            |         |      |       |      |
| $f_{pll\_ref}$      | PLL reference frequency range  | 8   | —          | 16      | MHz  |       |      |
| $f_{vcoclk\_2x}$    | VCO output frequency   | 220   | —          | 480     | MHz  |       |      |
| $f_{vcoclk}$        | PLL output frequency   | 110   | —          | 240     | MHz  |       |      |
| $f_{vcoclk\_90}$    | PLL quadrature output frequency  | 110   | —          | 240     | MHz  |       |      |
| $I_{pll}$           | PLL operating current<br>• VCO @ 176 MHz ( $f_{osc\_hi\_1} = 32$ MHz,<br>$f_{pll\_ref} = 8$ MHz, VDIV multiplier = 22) | —   | 2.8        | —       | mA   | 7     |      |
| $I_{pll}$           | PLL operating current<br>• VCO @ 360 MHz ( $f_{osc\_hi\_1} = 32$ MHz,<br>$f_{pll\_ref} = 8$ MHz, VDIV multiplier = 45) | —   | 4.7        | —       | mA   | 7     |      |
| $J_{cyc\_pll}$      | PLL period jitter (RMS)<br>• $f_{vco} = 48$ MHz<br>• $f_{vco} = 120$ MHz   | —   | 120        | —       | ps   | 8     |      |
|                     |  | —   | 75         | —       | ps   |       |      |
| $J_{acc\_pll}$      | PLL accumulated jitter over 1 $\mu$ s (RMS)  |   |            |         |      | 8     |      |

Table continues on the next page...

**Table 18. MCG specifications (continued)**

| Symbol                 | Description   | Min.       | Typ. | Max.   | Unit | Notes |
|------------------------|---|------------|------|--|------|-------|
|                        | <ul style="list-style-type: none"> <li><math>f_{VCO} = 48 \text{ MHz}</math></li> <li><math>f_{VCO} = 120 \text{ MHz}</math></li> </ul> | —          | 1350 | —  | ps   |       |
|                        |   | —          | 600  | —  | ps   |       |
| $D_{\text{unt}}$       | Lock exit frequency tolerance   | $\pm 4.47$ | —    | $\pm 5.97$   | %    |       |
| $t_{\text{pll\_lock}}$ | Lock detector detection time  | —          | —    | $150 \times 10^{-6} + 1075(1/f_{\text{pll\_ref}})$ | s    | 9     |

1. This parameter is measured with the internal reference (slow clock) being used as a reference to the FLL (FEI clock mode).
2. These typical values listed are with the slow internal reference clock (FEI) using factory trim and DMX32=0.
3. The resulting system clock frequencies should not exceed their maximum specified values. The DCO frequency deviation ( $\Delta f_{\text{dco}_t}$ ) over voltage and temperature should be considered.
4. These typical values listed are with the slow internal reference clock (FEI) using factory trim and DMX32=1.
5. The resulting clock frequency must not exceed the maximum specified clock frequency of the device.
6. This specification applies to any time the FLL reference source or reference divider is changed, trim value is changed, DMX32 bit is changed, DRS bits are changed, or changing from FLL disabled (BLPE, BLPI) to FLL enabled (FEI, FEE, FBE, FBI). If a crystal/resonator is being used as the reference, this specification assumes it is already running.
7. Excludes any oscillator currents that are also consuming power while PLL is in operation.
8. This specification was obtained using a NXP developed PCB. PLL jitter is dependent on the noise characteristics of each PCB and results will vary.
9. This specification applies to any time the PLL VCO divider or reference divider is changed, or changing from PLL disabled (BLPE, BLPI) to PLL enabled (PBE, PEE). If a crystal/resonator is being used as the reference, this specification assumes it is already running.

## 4.3.2 Oscillator electrical specifications

### 4.3.2.1 Oscillator DC electrical specifications

**Table 19. Oscillator DC electrical specifications**

| Symbol             | Description  | Min. | Typ. | Max. | Unit          | Notes |
|--------------------|--|------|------|------|---------------|-------|
| $V_{\text{DD}}$    | Supply voltage   | 1.71 | —    | 3.6  | V             |       |
| $I_{\text{DDOSC}}$ | Supply current — low-power mode (HGO=0) <ul style="list-style-type: none"> <li>32 kHz</li> <li>4 MHz</li> <li>8 MHz</li> <li>16 MHz</li> <li>24 MHz</li> <li>32 MHz</li> </ul> | —    | 500  | —    | nA            | 1     |
|                    |  | —    | 200  | —    | $\mu\text{A}$ |       |
|                    |  | —    | 300  | —    | $\mu\text{A}$ |       |
|                    |  | —    | 950  | —    | $\mu\text{A}$ |       |
|                    |  | —    | 1.2  | —    | mA            |       |
|                    |  | —    | 1.5  | —    | mA            |       |
| $I_{\text{DDOSC}}$ | Supply current — high gain mode (HGO=1) <ul style="list-style-type: none"> <li>4 MHz</li> </ul>  | —    | 400  | —    | $\mu\text{A}$ | 1     |

Table continues on the next page...

**Table 19. Oscillator DC electrical specifications (continued)**

| Symbol                       | Description   | Min. | Typ.            | Max. | Unit | Notes |
|------------------------------|---|------|-----------------|------|------|-------|
|                              | <ul style="list-style-type: none"> <li>• 8 MHz</li> <li>• 16 MHz</li> <li>• 24 MHz</li> <li>• 32 MHz</li> </ul> | —    | 500             | —    | μA   |       |
|                              |   | —    | 2.5             | —    | mA   |       |
|                              |   | —    | 3               | —    | mA   |       |
|                              |   | —    | 4               | —    | mA   |       |
| C <sub>x</sub>               | EXTAL load capacitance  | —    | —               | —    |      | 2, 3  |
| C <sub>y</sub>               | XTAL load capacitance   | —    | —               | —    |      | 2, 3  |
| R <sub>F</sub>               | 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 <sub>S</sub>               | 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 <sub>pp</sub> <sup>5</sup> | 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 <sub>DD</sub> | —    | 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 <sub>DD</sub> | —    | V    |       |

1. V<sub>DD</sub>=3.3 V, Temperature =25 °C
2. See crystal or resonator manufacturer's recommendation
3. C<sub>x</sub>, C<sub>y</sub> can be provided by using the integrated capacitors when the low frequency oscillator (RANGE = 00) is used. For all other cases external capacitors must be used.
4. When low power mode is selected, R<sub>F</sub> 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.

### 4.3.2.2 Oscillator frequency specifications

**Table 20. 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  |       |
| $f_{ec\_extal}$ | Input clock frequency (external clock mode)                                       | —    | —    | 48   | 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)               | —    | 1000 | —    | ms   | 3, 4  |

1. Other frequency limits may apply when external clock is being used as a reference for the FLL or PLL.
2. When transitioning from FEI or FBI to FBE 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.

#### NOTE

The 32 kHz oscillator works in low power mode by default and cannot be moved into high power/gain mode.

## 4.4 Memories and memory interfaces

### 4.4.1 Flash electrical specifications

This section describes the electrical characteristics of the flash memory module.

#### 4.4.1.1 Flash timing specifications — program and erase

The following specifications represent the amount of time the internal charge pumps are active and do not include command overhead.

**Table 21. NVM program/erase timing specifications**

| Symbol         | Description                        | Min. | Typ. | Max. | Unit    | Notes |
|----------------|------------------------------------|------|------|------|---------|-------|
| $t_{hypgm4}$   | Longword Program high-voltage time | —    | 7.5  | 18   | $\mu$ s | —     |
| $t_{hversscr}$ | Sector Erase high-voltage time     | —    | 13   | 113  | ms      | 1     |
| $t_{hversall}$ | Erase All high-voltage time        | —    | 208  | 1808 | ms      | 1     |

1. Maximum time based on expectations at cycling end-of-life.

### 4.4.1.2 Flash timing specifications — commands

**Table 22. Flash command timing specifications**

| Symbol         | Description                                   | Min. | Typ. | Max. | Unit    | Notes |
|----------------|---|------|------|------|---------|-------|
| $t_{rd1sec4k}$ | Read 1s Section execution time (flash sector) | —    | —    | 60   | $\mu$ s | 1     |
| $t_{pgmchk}$   | Program Check execution time                  | —    | —    | 45   | $\mu$ s | 1     |
| $t_{rdsrc}$    | Read Resource execution time                  | —    | —    | 30   | $\mu$ s | 1     |
| $t_{pgm4}$     | Program Longword execution time               | —    | 65   | 145  | $\mu$ s | —     |
| $t_{ersscr}$   | Erase Flash Sector execution time             | —    | 14   | 114  | ms      | 2     |
| $t_{rd1all}$   | Read 1s All Blocks execution time             | —    | —    | 0.9  | ms      | 1     |
| $t_{rdonce}$   | Read Once execution time                      | —    | —    | 25   | $\mu$ s | 1     |
| $t_{pgmonce}$  | Program Once execution time                   | —    | 65   | —    | $\mu$ s | —     |
| $t_{ersall}$   | Erase All Blocks execution time               | —    | 280  | 2100 | ms      | 2     |
| $t_{vfykey}$   | Verify Backdoor Access Key execution time     | —    | —    | 30   | $\mu$ s | 1     |

1. Assumes 25 MHz flash clock frequency.
2. Maximum times for erase parameters based on expectations at cycling end-of-life.

### 4.4.1.3 Flash high voltage current behaviors

**Table 23. Flash high voltage current behaviors**

| Symbol        | Description   | Min. | Typ. | Max. | Unit |
|---------------|---|------|------|------|------|
| $I_{DD\_PGM}$ | Average current adder during high voltage flash programming operation | —    | 2.5  | 6.0  | mA   |
| $I_{DD\_ERS}$ | Average current adder during high voltage flash erase operation       | —    | 1.5  | 4.0  | mA   |

### 4.4.1.4 Reliability specifications

**Table 24. NVM reliability specifications**

| Symbol          | Description                            | Min. | Typ. <sup>1</sup> | Max. | Unit   | Notes |
|-----------------|--|------|-------------------|------|--------|-------|
| Program Flash   |  |      |                   |      |        |       |
| $t_{nmretp10k}$ | Data retention after up to 10 K cycles | 5    | 50                | —    | years  | —     |
| $t_{nmretp1k}$  | Data retention after up to 1 K cycles  | 20   | 100               | —    | years  | —     |
| $n_{nmcyep}$    | Cycling endurance                      | 10 K | 50 K              | —    | cycles | 2     |

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  $-40\text{ °C} \leq T_j \leq 125\text{ °C}$ .



## 4.5 Security and integrity modules

There are no specifications necessary for the device's security and integrity modules.

## 4.6 Analog

### 4.6.1 12-bit cyclic Analog-to-Digital Converter (ADC) parameters

#### NOTE

The maximum values represent characterized results equivalent to the mean plus three times the standard deviation (mean+3 $\sigma$ ).

**Table 25. 12-bit ADC electrical specifications**

| Characteristic   | Symbol                | Min               | Typ                                      | Max               | Unit             |
|--|-----------------------|-------------------|--|-------------------|------------------|
| <b>Recommended Operating Conditions</b>  |                       |                   |  |                   |                  |
| Supply Voltage <sup>1</sup>  | V <sub>DDA</sub>      | 2.7               | 3.3                                      | 3.6               | V                |
| V <sub>refh</sub> Supply Voltage <sup>2</sup>  | V <sub>refhx</sub>    | 2.7               |  | V <sub>DDA</sub>  | V                |
| ADC Conversion Clock <sup>3</sup>  | f <sub>ADCCLK</sub>   | 0.6               |  | 25                | MHz              |
| Conversion Range   | R <sub>AD</sub>       | V <sub>REFL</sub> |  | V <sub>REFH</sub> | V                |
| Input Voltage Range  | V <sub>ADIN</sub>     |                   |  |                   | V                |
| External Reference   |                       | V <sub>REFL</sub> |  | V <sub>REFH</sub> |                  |
| Internal Reference   |                       | V <sub>SSA</sub>  |  | V <sub>DDA</sub>  |                  |
| <b>Timing and Power</b>  |                       |                   |  |                   |                  |
| Conversion Time  | t <sub>ADC</sub>      |                   | 6  |                   | ADC Clock Cycles |
| ADC Power-Up Time (from adc_pdn)   | t <sub>ADPU</sub>     |                   | 13                                       |                   | ADC Clock Cycles |
| ADC RUN Current (per ADC block)  | I <sub>ADRUN</sub>    |                   |  |                   | mA               |
| <ul style="list-style-type: none"> <li>• at 600 kHz ADC Clock, LP mode</li> <li>• ≤ 8.33 MHz ADC Clock, 00 mode</li> <li>• ≤ 12.5 MHz ADC Clock, 01 mode</li> <li>• ≤ 16.67 MHz ADC Clock, 10 mode</li> <li>• ≤ 20 MHz ADC Clock, 11 mode</li> <li>• ≤ 25 MHz ADC Clock</li> </ul> |                       |                   | 1<br>5.7<br>10.5<br>17.7<br>22.6<br>27.5 |                   |                  |
| ADC Powerdown Current (adc_pdn enabled)  | I <sub>ADPWRDWN</sub> |                   | 0.02                                     |                   | μA               |
| V <sub>REFH</sub> Current  | I <sub>VREFH</sub>    |                   | 0.001                                    |                   | μA               |
| <b>Accuracy (DC or Absolute)</b>   |                       |                   |  |                   |                  |
| Integral non-Linearity <sup>4</sup>  | INL                   |                   | +/- 3                                    | +/- 5             | LSB <sup>5</sup> |
| Differential non-Linearity <sup>4</sup>  | DNL                   |                   | +/- 0.6                                  | +/- 0.9           | LSB <sup>5</sup> |

Table continues on the next page...

**Table 25. 12-bit ADC electrical specifications (continued)**

| Characteristic  | Symbol              | Min | Typ    | Max                          | Unit             |
|---|---------------------|-----|--------|------------------------------|------------------|
| <b>Monotonicity</b>   |                     |     |        |                              |                  |
| Offset <sup>6</sup><br>• 1x gain mode<br>• 2x gain mode<br>• 4x gain mode | V <sub>OFFSET</sub> |     |        | +/- 25<br>+/- 20<br>+50, -10 | LSB <sup>4</sup> |
| Gain Error  | E <sub>GAIN</sub>   |     | 0.0002 | —                            | %                |
| <b>AC Specifications<sup>7</sup></b>                                      |                     |     |        |                              |                  |
| Signal to Noise Ratio   | SNR                 |     | 59     |                              | dB               |
| Total Harmonic Distortion   | THD                 |     | 64     |                              | dB               |
| Spurious Free Dynamic Range   | SFDR                |     | 65     |                              | dB               |
| Signal to Noise plus Distortion   | SINAD               |     | 59     |                              | dB               |
| Effective Number of Bits  | ENOB                |     | 9.1    |                              | bits             |
| <b>ADC Inputs</b>   |                     |     |        |                              |                  |
| Input Leakage Current   | I <sub>IN</sub>     |     | 0      | +/-2                         | μA               |
| Input Injection Current <sup>8</sup>                                      | I <sub>INJ</sub>    |     |        | +/-3                         | mA               |
| Input Capacitance<br>Sampling Capacitor                                   | C <sub>ADI</sub>    |     | 4.8    |                              | pF               |

1. If the ADC's reference is from V<sub>DDA</sub>: When V<sub>DDA</sub> is below 2.7 V, then the ADC functions, but the ADC specifications are not guaranteed.
2. When the input is at the V<sub>refl</sub> level, then the resulting output will be all zeros (hex 000), plus any error contribution due to offset and gain error. When the input is at the V<sub>refh</sub> level, then the output will be all ones (hex FFF), minus any error contribution due to offset and gain error.
3. ADC clock duty cycle min/max is 45/55% .
4. D<sub>NL</sub> and I<sub>NL</sub> conversion accuracy is not guaranteed from V<sub>REFL</sub> to V<sub>REFL</sub> + 0025 and V<sub>REFH</sub> to V<sub>REFH</sub> -0025.
5. LSB = Least Significant Bit = 0.806 mV at 3.3 V VDDA, x1 Gain Setting
6. Offset over the conversion range of 0025 to 4070, with internal/external reference.
7. Measured when converting a 1 kHz input Full Scale sine wave.
8. The current that can be *injected into or sourced from* an unselected ADC input, without affecting the performance of the ADC.

#### 4.6.1.1 Equivalent circuit for ADC inputs

The following figure shows the ADC input circuit during sample and hold. S1 and S2 are always opened/closed at non-overlapping phases, and both S1 and S2 operate at the ADC clock frequency. The following equation gives equivalent input impedance when the input is selected.

$$\frac{1}{(\text{ADC ClockRate}) \times 1.4 \times 10^{-12}} + 100\text{ohm} + 125\text{ohm}$$



1. Parasitic capacitance due to package, pin-to-pin and pin-to-package base coupling = 1.8pF
2. Parasitic capacitance due to the chip bond pad, ESD protection devices and signal routing = 2.04pF
3. Sampling capacitor at the sample and hold circuit. Capacitor C1 (4.8pF) is normally disconnected from the input, and is only connected to the input at sampling time.
4. S1 and S2 switch phases are non-overlapping and operate at the ADC clock frequency

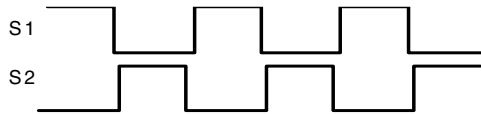


Figure 14. Equivalent circuit for A/D loading

## 4.6.2 CMP and 6-bit DAC electrical specifications

Table 26. Comparator and 6-bit DAC electrical specifications

| Symbol     | Description   | Min.     | Typ. | Max.     | Unit    |
|------------|---|----------|------|----------|---------|
| $V_{DD}$   | Supply voltage                                      | 1.71     | —    | 3.6      | V       |
| $I_{DDHS}$ | Supply current, high-speed mode (EN = 1, PMODE = 1) | —        | —    | 200      | $\mu$ A |
| $I_{DDLs}$ | Supply current, low-speed mode (EN = 1, PMODE = 0)  | —        | —    | 20       | $\mu$ A |
| $V_{AIN}$  | Analog input voltage                                | $V_{SS}$ | —    | $V_{DD}$ | V       |
| $V_{AI0}$  | Analog input offset voltage                         | —        | —    | 20       | mV      |

Table continues on the next page...

**Table 26. Comparator and 6-bit DAC electrical specifications (continued)**

| Symbol             | Description  | Min.                  | Typ. | Max. | Unit             |
|--------------------|--|-----------------------|------|------|------------------|
| V <sub>H</sub>     | Analog comparator hysteresis <sup>1</sup>              |                       |      |      |                  |
|                    | • CR0[HYSTCTR] = 00                                    | —                     | 5    | —    | mV               |
|                    | • CR0[HYSTCTR] = 01                                    | —                     | 10   | —    | mV               |
|                    | • CR0[HYSTCTR] = 10                                    | —                     | 20   | —    | mV               |
|                    | • CR0[HYSTCTR] = 11                                    | —                     | 30   | —    | mV               |
| V <sub>CMPOh</sub> | Output high  | V <sub>DD</sub> - 0.5 | —    | —    | V                |
| V <sub>CMPOl</sub> | Output low   | —                     | —    | 0.5  | V                |
| t <sub>DHS</sub>   | Propagation delay, high-speed mode (EN = 1, PMODE = 1) | 20                    | 50   | 200  | ns               |
| t <sub>DLS</sub>   | Propagation delay, low-speed mode (EN = 1, PMODE = 0)  | 80                    | 250  | 600  | ns               |
|                    | Analog comparator initialization delay <sup>2</sup>    | —                     | —    | 40   | μs               |
| I <sub>DAC6b</sub> | 6-bit DAC current adder (enabled)                      | —                     | 7    | —    | μA               |
| INL                | 6-bit DAC integral non-linearity                       | -0.5                  | —    | 0.5  | LSB <sup>3</sup> |
| DNL                | 6-bit DAC differential non-linearity                   | -0.3                  | —    | 0.3  | LSB              |

1. Typical hysteresis is measured with input voltage range limited to 0.7 to V<sub>DD</sub> - 0.7 V.
2. Comparator initialization delay is defined as the time between software writes to change control inputs (writes to DACEN, VRSEL, PSEL, MSEL, VOSEL) and the comparator output settling to a stable level.
3. 1 LSB = V<sub>reference</sub>/64



**Figure 15. Typical hysteresis vs. Vin level (V<sub>DD</sub> = 3.3 V, PMODE = 0)**



Figure 16. Typical hysteresis vs.  $V_{in}$  level ( $V_{DD} = 3.3\text{ V}$ ,  $PMODE = 1$ )

### 4.6.3 12-bit DAC electrical characteristics

#### 4.6.3.1 12-bit DAC operating requirements

Table 27. 12-bit DAC operating requirements

| Symbol     | Description             | Min. | Max. | Unit | Notes |
|------------|-------------------------|------|------|------|-------|
| $V_{DDA}$  | Supply voltage          | 1.71 | 3.6  | V    |       |
| $V_{DACR}$ | Reference voltage       | 1.13 | 3.6  | V    | 1     |
| $C_L$      | Output load capacitance | —    | 100  | pF   | 2     |
| $I_L$      | Output load current     | —    | 1    | mA   |       |

1. The DAC reference can be selected to be  $V_{DDA}$  or  $V_{REF\_OUT}$ .
2. A small load capacitance (47 pF) can improve the bandwidth performance of the DAC.

#### 4.6.3.2 12-bit DAC operating behaviors

Table 28. 12-bit DAC operating behaviors

| Symbol           | Description  | Min. | Typ. | Max. | Unit          | Notes |
|------------------|--|------|------|------|---------------|-------|
| $I_{DDA\_DACLP}$ | Supply current — low-power mode                            | —    | —    | 330  | $\mu\text{A}$ |       |
| $I_{DDA\_DACH}$  | Supply current — high-speed mode                           | —    | —    | 1200 | $\mu\text{A}$ |       |
| $t_{DACLP}$      | Full-scale settling time (0x080 to 0xF7F) — low-power mode | —    | 100  | 200  | $\mu\text{s}$ | 1     |

Table continues on the next page...

**Table 28. 12-bit DAC operating behaviors (continued)**

| Symbol               | Description   | Min.                    | Typ.        | Max.              | Unit             | Notes |
|----------------------|---|-------------------------|-------------|-------------------|------------------|-------|
| $t_{\text{DACHP}}$   | Full-scale settling time (0x080 to 0xF7F) — high-power mode   | —                       | 15          | 30                | $\mu\text{s}$    | 1     |
| $t_{\text{CCDACLP}}$ | Code-to-code settling time (0xBF8 to 0xC08) <ul style="list-style-type: none"> <li>High-speed mode</li> <li>Low speed mode</li> </ul>           | —                       | 1           | 5                 | $\mu\text{s}$    | 1     |
| $V_{\text{dacoutl}}$ | DAC output voltage range low — high-speed mode, no load, DAC set to 0x000   | —                       | —           | 100               | mV               |       |
| $V_{\text{dacouth}}$ | DAC output voltage range high — high-speed mode, no load, DAC set to 0xFFF  | $V_{\text{DACR}} - 100$ | —           | $V_{\text{DACR}}$ | mV               |       |
| INL                  | Integral non-linearity error — high speed mode  | —                       | —           | $\pm 8$           | LSB              | 2     |
| DNL                  | Differential non-linearity error — $V_{\text{DACR}} > 2\text{ V}$   | —                       | —           | $\pm 1$           | LSB              | 3     |
| DNL                  | Differential non-linearity error — $V_{\text{DACR}} = V_{\text{REF\_OUT}}$  | —                       | —           | $\pm 1$           | LSB              | 4     |
| $V_{\text{OFFSET}}$  | Offset error  | —                       | $\pm 0.4$   | $\pm 0.8$         | %FSR             | 5     |
| $E_{\text{G}}$       | Gain error  | —                       | $\pm 0.1$   | $\pm 0.6$         | %FSR             | 5     |
| PSRR                 | Power supply rejection ratio, $V_{\text{DDA}} \geq 2.4\text{ V}$  | 60                      | —           | 90                | dB               |       |
| $T_{\text{CO}}$      | Temperature coefficient offset voltage  | —                       | 3.7         | —                 | $\mu\text{V/C}$  | 6     |
| $T_{\text{GE}}$      | Temperature coefficient gain error  | —                       | 0.000421    | —                 | %FSR/C           |       |
| $R_{\text{op}}$      | Output resistance (load = 3 k $\Omega$ )  | —                       | —           | 250               | $\Omega$         |       |
| SR                   | Slew rate -80h → F7Fh → 80h <ul style="list-style-type: none"> <li>High power (SP<sub>HP</sub>)</li> <li>Low power (SP<sub>LP</sub>)</li> </ul> | 1.2<br>0.05             | 1.7<br>0.12 | —<br>—            | V/ $\mu\text{s}$ |       |
| BW                   | 3dB bandwidth <ul style="list-style-type: none"> <li>High power (SP<sub>HP</sub>)</li> <li>Low power (SP<sub>LP</sub>)</li> </ul>               | 550<br>40               | —<br>—      | —<br>—            | kHz              |       |

- Settling within  $\pm 1$  LSB
- The INL is measured for 0 + 100 mV to  $V_{\text{DACR}} - 100$  mV
- The DNL is measured for 0 + 100 mV to  $V_{\text{DACR}} - 100$  mV
- The DNL is measured for 0 + 100 mV to  $V_{\text{DACR}} - 100$  mV with  $V_{\text{DDA}} > 2.4\text{ V}$
- Calculated by a best fit curve from  $V_{\text{SS}} + 100$  mV to  $V_{\text{DACR}} - 100$  mV
- $V_{\text{DDA}} = 3.0\text{ V}$ , reference select set for  $V_{\text{DDA}}$  (DACx\_CO:DACRFS = 1), high power mode (DACx\_CO:LPEN = 0), DAC set to 0x800, temperature range is across the full range of the device



Figure 17. Typical INL error vs. digital code



Figure 18. Offset at half scale vs. temperature

## 4.7 Timers

See [General switching specifications](#).

## 4.8 Enhanced NanoEdge PWM characteristics

Table 29. NanoEdge PWM timing parameters - 100 Mhz operating frequency

| Characteristic   | Symbol | Min. | Typ. | Max. | Unit |
|--|--------|------|------|------|------|
| PWM clock frequency  |        |      | 100  |      | MHz  |
| NanoEdge Placement (NEP) Step Size <sup>1, 2</sup>         | pwmp   |      | 312  |      | ps   |
| Delay for fault input activating to PWM output deactivated |        | 1    |      |      | ns   |

Table continues on the next page...



**Table 29. NanoEdge PWM timing parameters - 100 Mhz operating frequency (continued)**

| Characteristic             | Symbol   | Min. | Typ. | Max. | Unit    |
|----------------------------|----------|------|------|------|---------|
| Power-up Time <sup>3</sup> | $t_{pu}$ |      | 25   |      | $\mu s$ |

1. Reference 100 MHz in NanoEdge Placement mode.
2. Temperature and voltage variations do not affect NanoEdge Placement step size.
3. Powerdown to NanoEdge mode transition.

**Table 30. NanoEdge PWM timing parameters - 84 Mhz operating frequency**

| Characteristic   | Symbol   | Min. | Typ. | Max. | Unit    |
|--|----------|------|------|------|---------|
| PWM clock frequency  |          |      | 84   |      | MHz     |
| NanoEdge Placement (NEP) Step Size <sup>1, 2</sup>         | pwmp     |      | 372  |      | ps      |
| Delay for fault input activating to PWM output deactivated |          | 1    |      |      | ns      |
| Power-up Time <sup>3</sup>                                 | $t_{pu}$ |      | 30   |      | $\mu s$ |

1. Reference 84 MHz in NanoEdge Placement mode.
2. Temperature and voltage variations do not affect NanoEdge Placement step size.
3. Powerdown to NanoEdge mode transition.

## 4.9 Communication interfaces

### 4.9.1 SPI (DSPI) switching specifications (limited voltage range)

The DMA Serial Peripheral Interface (DSPI) provides a synchronous serial bus with master and slave operations. Many of the transfer attributes are programmable. The tables below provide DSPI timing characteristics for classic SPI timing modes. Refer to the DSPI chapter of the Reference Manual for information on the modified transfer formats used for communicating with slower peripheral devices.

#### NOTE

##### Fast pads:

- SIN: PTE19
- SOUT: PTE18
- SCK: PTE17
- PCS: PTE16

##### Open drain pads:

Peripheral operating requirements and behaviors

- SIN: PTC7
- SOUT: PTC6

**Table 31. Master mode DSPI timing for normal pads (limited voltage range)**

| Num | Description                                    | Min.                     | Max.              | Unit | Notes |
|-----|--|--------------------------|-------------------|------|-------|
|     | Operating voltage                              | 2.7                      | 3.6               | V    |       |
|     | Frequency of operation                         | —                        | 25                | MHz  |       |
| DS1 | DSPI_SCK output cycle time                     | $2 \times t_{BUS}$       | —                 | ns   |       |
| DS2 | DSPI_SCK output high/low time                  | $(t_{SCK}/2) - 2$        | $(t_{SCK}/2) + 2$ | ns   |       |
| DS3 | DSPI_PCS <sub>n</sub> to DSPI_SCK output valid | $(t_{BUS} \times 2) - 2$ | —                 | ns   | 1     |
| DS4 | DSPI_SCK to DSPI_PCS <sub>n</sub> output hold  | $(t_{BUS} \times 2) - 2$ | —                 | ns   | 2     |
| DS5 | DSPI_SCK to DSPI_SOUT valid                    | —                        | 8.5               | ns   |       |
| DS6 | DSPI_SCK to DSPI_SOUT invalid                  | -2                       | —                 | ns   |       |
| DS7 | DSPI_SIN to DSPI_SCK input setup               | 17                       | —                 | ns   |       |
| DS8 | DSPI_SCK to DSPI_SIN input hold                | 0                        | —                 | ns   |       |

1. The delay is programmable in SPIx\_CTARn[PSSCK] and SPIx\_CTARn[CSSCK].
2. The delay is programmable in SPIx\_CTARn[PASC] and SPIx\_CTARn[ASC].

**Table 32. Master mode DSPI timing for fast pads (limited voltage range)**

| Num | Description                                    | Min.                     | Max.              | Unit | Notes |
|-----|--|--------------------------|-------------------|------|-------|
|     | Operating voltage                              | 2.7                      | 3.6               | V    |       |
|     | Frequency of operation                         | —                        | 37.5              | MHz  |       |
| DS1 | DSPI_SCK output cycle time                     | $2 \times t_{BUS}$       | —                 | ns   |       |
| DS2 | DSPI_SCK output high/low time                  | $(t_{SCK}/2) - 2$        | $(t_{SCK}/2) + 2$ | ns   |       |
| DS3 | DSPI_PCS <sub>n</sub> to DSPI_SCK output valid | $(t_{BUS} \times 2) - 2$ | —                 | ns   | 1     |
| DS4 | DSPI_SCK to DSPI_PCS <sub>n</sub> output hold  | $(t_{BUS} \times 2) - 2$ | —                 | ns   | 2     |
| DS5 | DSPI_SCK to DSPI_SOUT valid                    | —                        | 8.5               | ns   |       |
| DS6 | DSPI_SCK to DSPI_SOUT invalid                  | -2                       | —                 | ns   |       |
| DS7 | DSPI_SIN to DSPI_SCK input setup               | 13                       | —                 | ns   |       |
| DS8 | DSPI_SCK to DSPI_SIN input hold                | 0                        | —                 | ns   |       |

1. The delay is programmable in SPIx\_CTARn[PSSCK] and SPIx\_CTARn[CSSCK].
2. The delay is programmable in SPIx\_CTARn[PASC] and SPIx\_CTARn[ASC].

**Table 33. Master mode DSPI timing for open drain pads (limited voltage range)**

| Num | Description       | Min. | Max. | Unit | Notes |
|-----|-------------------|------|------|------|-------|
|     | Operating voltage | 2.7  | 3.6  | V    |       |

Table continues on the next page...

**Table 33. Master mode DSPI timing for open drain pads (limited voltage range) (continued)**

| Num | Description                        | Min.                            | Max.                     | Unit | Notes |
|-----|------------------------------------|---------------------------------|--------------------------|------|-------|
|     | Frequency of operation             | —                               | 25                       | MHz  |       |
| DS1 | DSPI_SCK output cycle time         | $2 \times t_{\text{BUS}}$       | —                        | ns   |       |
| DS2 | DSPI_SCK output high/low time      | $(t_{\text{SCK}}/2) - 2$        | $(t_{\text{SCK}}/2) + 2$ | ns   |       |
| DS3 | DSPI_PCSn to DSPI_SCK output valid | $(t_{\text{BUS}} \times 2) - 2$ | —                        | ns   | 1     |
| DS4 | DSPI_SCK to DSPI_PCSn output hold  | $(t_{\text{BUS}} \times 2) - 2$ | —                        | ns   | 2     |
| DS5 | DSPI_SCK to DSPI_SOUT valid        | —                               | 15.5                     | ns   |       |
| DS6 | DSPI_SCK to DSPI_SOUT invalid      | -3                              | —                        | ns   |       |
| DS7 | DSPI_SIN to DSPI_SCK input setup   | 17                              | —                        | ns   |       |
| DS8 | DSPI_SCK to DSPI_SIN input hold    | 0                               | —                        | ns   |       |

1. The delay is programmable in SPIx\_CTARn[PSSCK] and SPIx\_CTARn[CSSCK].
2. The delay is programmable in SPIx\_CTARn[PASC] and SPIx\_CTARn[ASC].

**Figure 19. DSPI classic SPI timing — master mode****Table 34. Slave mode DSPI timing for normal pads (limited voltage range)**

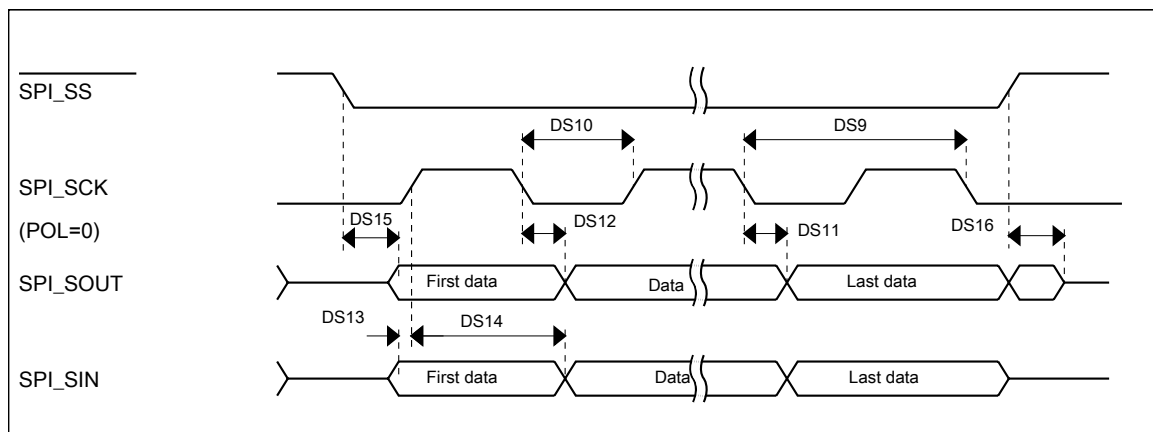
| Num  | Description   | Min.                      | Max.                     | Unit |
|------|---|---------------------------|--------------------------|------|
|      | Operating voltage   | 2.7                       | 3.6                      | V    |
|      | Frequency of operation  |                           | 12.5                     | MHz  |
| DS9  | DSPI_SCK input cycle time                                     | $4 \times t_{\text{BUS}}$ | —                        | ns   |
| DS10 | DSPI_SCK input high/low time                                  | $(t_{\text{SCK}}/2) - 2$  | $(t_{\text{SCK}}/2) + 2$ | ns   |
| DS11 | DSPI_SCK to DSPI_SOUT valid                                   | —                         | 21                       | ns   |
| DS12 | DSPI_SCK to DSPI_SOUT invalid                                 | 0                         | —                        | ns   |
| DS13 | DSPI_SIN to DSPI_SCK input setup                              | 2                         | —                        | ns   |
| DS14 | DSPI_SCK to DSPI_SIN input hold                               | 7                         | —                        | ns   |
| DS15 | $\overline{\text{DSPI\_SS}}$ active to DSPI_SOUT driven       | —                         | 15                       | ns   |
| DS16 | $\overline{\text{DSPI\_SS}}$ inactive to DSPI_SOUT not driven | —                         | 15                       | ns   |

**Table 35. Slave mode DSPI timing for fast pads (limited voltage range)**

| Num  | Description  | Min.               | Max.              | Unit |
|------|--|--------------------|-------------------|------|
|      | Operating voltage                                      | 2.7                | 3.6               | V    |
|      | Frequency of operation                                 |                    | 25                | MHz  |
| DS9  | DSPI_SCK input cycle time                              | $4 \times t_{BUS}$ | —                 | ns   |
| DS10 | DSPI_SCK input high/low time                           | $(t_{SCK}/2) - 2$  | $(t_{SCK}/2) + 2$ | ns   |
| DS11 | DSPI_SCK to DSPI_SOUT valid                            | —                  | 17                | ns   |
| DS12 | DSPI_SCK to DSPI_SOUT invalid                          | 0                  | —                 | ns   |
| DS13 | DSPI_SIN to DSPI_SCK input setup                       | 2                  | —                 | ns   |
| DS14 | DSPI_SCK to DSPI_SIN input hold                        | 7                  | —                 | ns   |
| DS15 | $\overline{DSPI\_SS}$ active to DSPI_SOUT driven       | —                  | 11                | ns   |
| DS16 | $\overline{DSPI\_SS}$ inactive to DSPI_SOUT not driven | —                  | 11                | ns   |

**Table 36. Slave mode DSPI timing for open drain pads (limited voltage range)**

| Num  | Description  | Min.               | Max.              | Unit |
|------|--|--------------------|-------------------|------|
|      | Operating voltage                                      | 2.7                | 3.6               | V    |
|      | Frequency of operation                                 |                    | 12.5              | MHz  |
| DS9  | DSPI_SCK input cycle time                              | $4 \times t_{BUS}$ | —                 | ns   |
| DS10 | DSPI_SCK input high/low time                           | $(t_{SCK}/2) - 2$  | $(t_{SCK}/2) + 2$ | ns   |
| DS11 | DSPI_SCK to DSPI_SOUT valid                            | —                  | 28                | ns   |
| DS12 | DSPI_SCK to DSPI_SOUT invalid                          | 0                  | —                 | ns   |
| DS13 | DSPI_SIN to DSPI_SCK input setup                       | 2                  | —                 | ns   |
| DS14 | DSPI_SCK to DSPI_SIN input hold                        | 7                  | —                 | ns   |
| DS15 | $\overline{DSPI\_SS}$ active to DSPI_SOUT driven       | —                  | 22                | ns   |
| DS16 | $\overline{DSPI\_SS}$ inactive to DSPI_SOUT not driven | —                  | 22                | ns   |



**Figure 20. DSPI classic SPI timing — slave mode**

## 4.9.2 SPI (DSPI) switching specifications (full voltage range)

The DMA Serial Peripheral Interface (DSPI) provides a synchronous serial bus with master and slave operations. Many of the transfer attributes are programmable. The tables below provides DSPI timing characteristics for classic SPI timing modes. Refer to the DSPI chapter of the Reference Manual for information on the modified transfer formats used for communicating with slower peripheral devices.

### NOTE

#### Fast pads:

- SIN: PTE19
- SOUT: PTE18
- SCK: PTE17
- PCS: PTE16

#### Open drain pads:

- SIN: PTC7
- SOUT: PTC6

**Table 37. Master mode DSPI timing for normal pads (full voltage range)**

| Num | Description                            | Min.                            | Max.                     | Unit | Notes |
|-----|--|---------------------------------|--------------------------|------|-------|
|     | Operating voltage                      | 1.71                            | 3.6                      | V    | 1     |
|     | Frequency of operation                 | —                               | 18.75                    | MHz  |       |
| DS1 | DSPI_SCK output cycle time             | $4 \times t_{\text{BUS}}$       | —                        | ns   |       |
| DS2 | DSPI_SCK output high/low time          | $(t_{\text{SCK}/2}) - 4$        | $(t_{\text{SCK}/2}) + 4$ | ns   |       |
| DS3 | DSPI_PCS $n$ valid to DSPI_SCK delay   | $(t_{\text{BUS}} \times 2) - 4$ | —                        | ns   | 2     |
| DS4 | DSPI_SCK to DSPI_PCS $n$ invalid delay | $(t_{\text{BUS}} \times 2) - 4$ | —                        | ns   | 3     |
| DS5 | DSPI_SCK to DSPI_SOUT valid            | —                               | 10                       | ns   |       |
| DS6 | DSPI_SCK to DSPI_SOUT invalid          | -7.8                            | —                        | ns   |       |
| DS7 | DSPI_SIN to DSPI_SCK input setup       | 24                              | —                        | 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 SPI $x$ \_CTAR $n$ [PSSCK] and SPI $x$ \_CTAR $n$ [CSSCK].
3. The delay is programmable in SPI $x$ \_CTAR $n$ [PASC] and SPI $x$ \_CTAR $n$ [ASC].

**Table 38. Master mode DSPI timing fast pads (full voltage range)**

| Num | Description                                     | Min.                     | Max.              | Unit | Notes |
|-----|---|--------------------------|-------------------|------|-------|
|     | Operating voltage                               | 1.71                     | 3.6               | V    | 1     |
|     | Frequency of operation                          | —                        | 25                | MHz  |       |
| DS1 | DSPI_SCK output cycle time                      | $4 \times t_{BUS}$       | —                 | ns   |       |
| DS2 | DSPI_SCK output high/low time                   | $(t_{SCK/2}) - 4$        | $(t_{SCK/2}) + 4$ | ns   |       |
| DS3 | DSPI_PCS <sub>n</sub> valid to DSPI_SCK delay   | $(t_{BUS} \times 2) - 4$ | —                 | ns   | 2     |
| DS4 | DSPI_SCK to DSPI_PCS <sub>n</sub> invalid delay | $(t_{BUS} \times 2) - 4$ | —                 | ns   | 3     |
| DS5 | DSPI_SCK to DSPI_SOUT valid                     | —                        | 10                | ns   |       |
| DS6 | DSPI_SCK to DSPI_SOUT invalid                   | -7.8                     | —                 | ns   |       |
| DS7 | DSPI_SIN to DSPI_SCK input setup                | 17                       | —                 | 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].

**Table 39. Master mode DSPI timing open drain pads (full voltage range)**

| Num | Description                                     | Min.                     | Max.              | Unit | Notes |
|-----|---|--------------------------|-------------------|------|-------|
|     | Operating voltage                               | 1.71                     | 3.6               | V    | 1     |
|     | Frequency of operation                          | —                        | 18.75             | MHz  |       |
| DS1 | DSPI_SCK output cycle time                      | $4 \times t_{BUS}$       | —                 | ns   |       |
| DS2 | DSPI_SCK output high/low time                   | $(t_{SCK/2}) - 4$        | $(t_{SCK/2}) + 4$ | ns   |       |
| DS3 | DSPI_PCS <sub>n</sub> valid to DSPI_SCK delay   | $(t_{BUS} \times 2) - 4$ | —                 | ns   | 2     |
| DS4 | DSPI_SCK to DSPI_PCS <sub>n</sub> invalid delay | $(t_{BUS} \times 2) - 4$ | —                 | ns   | 3     |
| DS5 | DSPI_SCK to DSPI_SOUT valid                     | —                        | 26                | ns   |       |
| DS6 | DSPI_SCK to DSPI_SOUT invalid                   | -7.8                     | —                 | ns   |       |
| DS7 | DSPI_SIN to DSPI_SCK input setup                | 24                       | —                 | 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 21. DSPI classic SPI timing — master mode

Table 40. Slave mode DSPI timing for normal pads (full voltage range)

| Num  | Description  | Min.               | Max.              | Unit |
|------|--|--------------------|-------------------|------|
|      | Operating voltage                                      | 1.71               | 3.6               | V    |
|      | Frequency of operation                                 | —                  | 12.5              | 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                            | —                  | 27.5              | ns   |
| DS12 | DSPI_SCK to DSPI_SOUT invalid                          | 0                  | —                 | ns   |
| DS13 | DSPI_SIN to DSPI_SCK input setup                       | 2.5                | —                 | ns   |
| DS14 | DSPI_SCK to DSPI_SIN input hold                        | 7                  | —                 | ns   |
| DS15 | $\overline{DSPI\_SS}$ active to DSPI_SOUT driven       | —                  | 22                | ns   |
| DS16 | $\overline{DSPI\_SS}$ inactive to DSPI_SOUT not driven | —                  | 22                | ns   |

Table 41. Slave mode DSPI timing for fast pads (full voltage range)

| Num  | Description  | Min.               | Max.              | Unit |
|------|--|--------------------|-------------------|------|
|      | Operating voltage                                      | 1.71               | 3.6               | V    |
|      | Frequency of operation                                 | —                  | 18.75             | 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                            | —                  | 20.5              | ns   |
| DS12 | DSPI_SCK to DSPI_SOUT invalid                          | 0                  | —                 | ns   |
| DS13 | DSPI_SIN to DSPI_SCK input setup                       | 2.5                | —                 | ns   |
| DS14 | DSPI_SCK to DSPI_SIN input hold                        | 7                  | —                 | ns   |
| DS15 | $\overline{DSPI\_SS}$ active to DSPI_SOUT driven       | —                  | 15                | ns   |
| DS16 | $\overline{DSPI\_SS}$ inactive to DSPI_SOUT not driven | —                  | 15                | ns   |

## Dimensions

**Table 42. Slave mode DSPI timing for open drain pads (full voltage range)**

| Num  | Description  | Min.               | Max.              | Unit |
|------|--|--------------------|-------------------|------|
|      | Operating voltage                                      | 1.71               | 3.6               | V    |
|      | Frequency of operation                                 | —                  | 9.375             | 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                            | —                  | 43.5              | ns   |
| DS12 | DSPI_SCK to DSPI_SOUT invalid                          | 0                  | —                 | ns   |
| DS13 | DSPI_SIN to DSPI_SCK input setup                       | 2.5                | —                 | ns   |
| DS14 | DSPI_SCK to DSPI_SIN input hold                        | 7                  | —                 | ns   |
| DS15 | $\overline{DSPI\_SS}$ active to DSPI_SOUT driven       | —                  | 38                | ns   |
| DS16 | $\overline{DSPI\_SS}$ inactive to DSPI_SOUT not driven | —                  | 38                | ns   |



**Figure 22. DSPI classic SPI timing — slave mode**

### 4.9.3 I<sup>2</sup>C

See [General switching specifications](#).

### 4.9.4 UART

See [General switching specifications](#).

## 5 Dimensions



## 5.1 Obtaining package dimensions

Package dimensions are provided in package drawings.

To find a package drawing, go to [www.nxp.com](http://www.nxp.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 |
|--|-------------------------------|
| 100-pin LQFP                             | 98ASS23308W                   |

## 6 Pinout

### 6.1 MWCT1x23 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.

| 100 LQFP | Pin Name           | Default   | ALT0      | ALT1               | ALT2      | ALT3        | ALT4        | ALT5       | ALT6        | ALT7 |
|----------|--------------------|-----------|-----------|--------------------|-----------|-------------|-------------|------------|-------------|------|
| 1        | PTE0/<br>CLKOUT32K | ADCB_CH6f | ADCB_CH6f | PTE0/<br>CLKOUT32K |           | UART1_TX    | XBAR0_OUT10 | XBAR0_IN11 |             |      |
| 2        | PTE1/<br>LLWU_P0   | ADCB_CH7f | ADCB_CH7f | PTE1/<br>LLWU_P0   |           | UART1_RX    | XBAR0_OUT11 | XBAR0_IN7  |             |      |
| 3        | PTE2/<br>LLWU_P1   | ADCB_CH6g | ADCB_CH6g | PTE2/<br>LLWU_P1   |           | UART1_CTS_b |             |            |             |      |
| 4        | PTE3               | ADCB_CH7g | ADCB_CH7g | PTE3               |           | UART1_RTS_b |             |            |             |      |
| 5        | PTE4/<br>LLWU_P2   | DISABLED  |           | PTE4/<br>LLWU_P2   |           |             |             |            |             |      |
| 6        | PTE5               | DISABLED  |           | PTE5               |           |             |             |            | FTM3_CH0    |      |
| 7        | PTE6/<br>LLWU_P16  | DISABLED  |           | PTE6/<br>LLWU_P16  |           |             |             |            | FTM3_CH1    |      |
| 8        | VDD                | VDD       | VDD       |                    |           |             |             |            |             |      |
| 9        | VSS                | VSS       | VSS       |                    |           |             |             |            |             |      |
| 10       | PTE16              | ADCA_CH0  | ADCA_CH0  | PTE16              | SPI0_PCS0 | UART1_TX    | FTM_CLKIN0  |            | FTM0_FLT3   |      |
| 11       | PTE17/<br>LLWU_P19 | ADCA_CH1  | ADCA_CH1  | PTE17/<br>LLWU_P19 | SPI0_SCK  | UART1_RX    | FTM_CLKIN1  |            | LPTMR0_ALT3 |      |
| 12       | PTE18/<br>LLWU_P20 | ADCB_CH0  | ADCB_CH0  | PTE18/<br>LLWU_P20 | SPI0_SOUT | UART1_CTS_b | I2C0_SDA    |            |             |      |

## Pinout

| 100 LQFP | Pin Name                            | Default                             | ALT0                                | ALT1               | ALT2                            | ALT3        | ALT4       | ALT5       | ALT6            | ALT7                   |
|----------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------|---------------------------------|-------------|------------|------------|-----------------|------------------------|
| 13       | PTE19                               | ADCB_CH1                            | ADCB_CH1                            | PTE19              | SPI0_SIN                        | UART1_RTS_b | I2C0_SCL   |            | CMP3_OUT        |                        |
| 14       | ADCA_CH6a                           | ADCA_CH6a                           | ADCA_CH6a                           |                    |                                 |             |            |            |                 |                        |
| 15       | ADCA_CH7a                           | ADCA_CH7a                           | ADCA_CH7a                           |                    |                                 |             |            |            |                 |                        |
| 16       | PTE20                               | ADCA_CH6b                           | ADCA_CH6b                           | PTE20              |                                 | FTM1_CH0    | UART0_TX   |            |                 |                        |
| 17       | PTE21                               | ADCA_CH7b                           | ADCA_CH7b                           | PTE21              |                                 | FTM1_CH1    | UART0_RX   |            |                 |                        |
| 18       | ADCA_CH2                            | ADCA_CH2                            | ADCA_CH2                            |                    |                                 |             |            |            |                 |                        |
| 19       | ADCA_CH3                            | ADCA_CH3                            | ADCA_CH3                            |                    |                                 |             |            |            |                 |                        |
| 20       | ADCA_CH6c                           | ADCA_CH6c                           | ADCA_CH6c                           |                    |                                 |             |            |            |                 |                        |
| 21       | ADCA_CH7c                           | ADCA_CH7c                           | ADCA_CH7c                           |                    |                                 |             |            |            |                 |                        |
| 22       | VDDA                                | VDDA                                | VDDA                                |                    |                                 |             |            |            |                 |                        |
| 23       | VREFH                               | VREFH                               | VREFH                               |                    |                                 |             |            |            |                 |                        |
| 24       | VREFL                               | VREFL                               | VREFL                               |                    |                                 |             |            |            |                 |                        |
| 25       | VSSA                                | VSSA                                | VSSA                                |                    |                                 |             |            |            |                 |                        |
| 26       | PTE29                               | ADCA_CH4/<br>CMP1_IN5/<br>CMP0_IN5  | ADCA_CH4/<br>CMP1_IN5/<br>CMP0_IN5  | PTE29              |                                 | FTM0_CH2    |            | FTM_CLKIN0 |                 |                        |
| 27       | PTE30                               | DAC0_OUT/<br>CMP1_IN3/<br>ADCA_CH5  | DAC0_OUT/<br>CMP1_IN3/<br>ADCA_CH5  | PTE30              |                                 | FTM0_CH3    |            | FTM_CLKIN1 |                 |                        |
| 28       | ADCA_CH6d/<br>CMP0_IN4/<br>CMP2_IN3 | ADCA_CH6d/<br>CMP0_IN4/<br>CMP2_IN3 | ADCA_CH6d/<br>CMP0_IN4/<br>CMP2_IN3 |                    |                                 |             |            |            |                 |                        |
| 29       | VSS                                 | VSS                                 | VSS                                 |                    |                                 |             |            |            |                 |                        |
| 30       | VDD                                 | VDD                                 | VDD                                 |                    |                                 |             |            |            |                 |                        |
| 31       | PTE24                               | ADCB_CH4                            | ADCB_CH4                            | PTE24              | CAN1_TX                         | FTM0_CH0    | XBAR0_IN2  | I2C0_SCL   | EWM_OUT_b       | XBAR0_OUT4             |
| 32       | PTE25/<br>LLWU_P21                  | ADCB_CH5                            | ADCB_CH5                            | PTE25/<br>LLWU_P21 | CAN1_RX                         | FTM0_CH1    | XBAR0_IN3  | I2C0_SDA   | EWM_IN          | XBAR0_OUT5             |
| 33       | PTE26                               | DISABLED                            |                                     | PTE26              |                                 |             |            |            |                 |                        |
| 34       | PTA0                                | JTAG_TCLK/<br>SWD_CLK               |                                     | PTA0               | UART0_CTS_<br>b/<br>UART0_COL_b | FTM0_CH5    | XBAR0_IN4  | EWM_IN     |                 | JTAG_TCLK/<br>SWD_CLK  |
| 35       | PTA1                                | JTAG_TDI                            |                                     | PTA1               | UART0_RX                        | FTM0_CH6    | CMP0_OUT   |            | FTM1_CH1        | JTAG_TDI               |
| 36       | PTA2                                | JTAG_TDO/<br>TRACE_SWO              |                                     | PTA2               | UART0_TX                        | FTM0_CH7    | CMP1_OUT   |            | FTM1_CH0        | JTAG_TDO/<br>TRACE_SWO |
| 37       | PTA3                                | JTAG_TMS/<br>SWD_DIO                |                                     | PTA3               | UART0_RTS_b                     | FTM0_CH0    | XBAR0_IN9  | EWM_OUT_b  | FLEXPWMA_<br>A0 | JTAG_TMS/<br>SWD_DIO   |
| 38       | PTA4/<br>LLWU_P3                    | NMI_b                               |                                     | PTA4/<br>LLWU_P3   |                                 | FTM0_CH1    | XBAR0_IN10 | FTM0_FLT3  | FLEXPWMA_<br>B0 | NMI_b                  |
| 39       | PTA5                                | DISABLED                            |                                     | PTA5               |                                 | FTM0_CH2    |            | CMP2_OUT   |                 | JTAG_TRST_b            |
| 40       | VDD                                 | VDD                                 | VDD                                 |                    |                                 |             |            |            |                 |                        |
| 41       | VSS                                 | VSS                                 | VSS                                 |                    |                                 |             |            |            |                 |                        |
| 42       | PTA12                               | CMP2_IN0                            | CMP2_IN0                            | PTA12              | CAN0_TX                         | FTM1_CH0    |            |            |                 | FTM1_QD_<br>PHA        |

| 100 LQFP | Pin Name          | Default                | ALT0                   | ALT1              | ALT2      | ALT3                            | ALT4       | ALT5            | ALT6            | ALT7            |
|----------|-------------------|------------------------|------------------------|-------------------|-----------|---------------------------------|------------|-----------------|-----------------|-----------------|
| 43       | PTA13/<br>LLWU_P4 | CMP2_IN1               | CMP2_IN1               | PTA13/<br>LLWU_P4 | CAN0_RX   | FTM1_CH1                        |            |                 |                 | FTM1_QD_<br>PHB |
| 44       | PTA14             | CMP3_IN0               | CMP3_IN0               | PTA14             | SPI0_PCS0 | UART0_TX                        |            |                 |                 |                 |
| 45       | PTA15             | CMP3_IN1               | CMP3_IN1               | PTA15             | SPI0_SCK  | UART0_RX                        |            |                 |                 |                 |
| 46       | PTA16             | CMP3_IN2               | CMP3_IN2               | PTA16             | SPI0_SOUT | UART0_CTS_<br>b/<br>UART0_COL_b |            |                 |                 |                 |
| 47       | PTA17             | ADCA_CH7e              | ADCA_CH7e              | PTA17             | SPI0_SIN  | UART0_RTS_b                     |            |                 |                 |                 |
| 48       | VDD               | VDD                    | VDD                    |                   |           |                                 |            |                 |                 |                 |
| 49       | VSS               | VSS                    | VSS                    |                   |           |                                 |            |                 |                 |                 |
| 50       | PTA18             | EXTAL0                 | EXTAL0                 | PTA18             | XBAR0_IN7 | FTM0_FLT2                       | FTM_CLKIN0 | XBAR0_OUT8      | FTM3_CH2        |                 |
| 51       | PTA19             | XTAL0                  | XTAL0                  | PTA19             | XBAR0_IN8 | FTM1_FLT0                       | FTM_CLKIN1 | XBAR0_OUT9      | LPTMR0_ALT1     |                 |
| 52       | RESET_b           | RESET_b                | RESET_b                |                   |           |                                 |            |                 |                 |                 |
| 53       | PTB0/<br>LLWU_P5  | ADCB_CH2               | ADCB_CH2               | PTB0/<br>LLWU_P5  | I2C0_SCL  | FTM1_CH0                        |            |                 | FTM1_QD_<br>PHA | UART0_RX        |
| 54       | PTB1              | ADCB_CH3               | ADCB_CH3               | PTB1              | I2C0_SDA  | FTM1_CH1                        | FTM0_FLT2  | EWM_IN          | FTM1_QD_<br>PHB | UART0_TX        |
| 55       | PTB2              | ADCA_CH6e/<br>CMP2_IN2 | ADCA_CH6e/<br>CMP2_IN2 | PTB2              | I2C0_SCL  | UART0_RTS_b                     | FTM0_FLT1  |                 | FTM0_FLT3       |                 |
| 56       | PTB3              | ADCB_CH7e/<br>CMP3_IN5 | ADCB_CH7e/<br>CMP3_IN5 | PTB3              | I2C0_SDA  | UART0_CTS_<br>b/<br>UART0_COL_b |            |                 | FTM0_FLT0       |                 |
| 57       | PTB9              | DISABLED               |                        | PTB9              |           |                                 |            |                 |                 |                 |
| 58       | PTB10             | ADCB_CH6a              | ADCB_CH6a              | PTB10             |           |                                 |            |                 | FTM0_FLT1       |                 |
| 59       | PTB11             | ADCB_CH7a              | ADCB_CH7a              | PTB11             |           |                                 |            |                 | FTM0_FLT2       |                 |
| 60       | VSS               | VSS                    | VSS                    |                   |           |                                 |            |                 |                 |                 |
| 61       | VDD               | VDD                    | VDD                    |                   |           |                                 |            |                 |                 |                 |
| 62       | PTB16             | DISABLED               |                        | PTB16             |           | UART0_RX                        | FTM_CLKIN2 | CAN0_TX         | EWM_IN          | XBAR0_IN5       |
| 63       | PTB17             | DISABLED               |                        | PTB17             |           | UART0_TX                        | FTM_CLKIN1 | CAN0_RX         | EWM_OUT_b       |                 |
| 64       | PTB18             | DISABLED               |                        | PTB18             | CAN0_TX   |                                 | FTM3_CH2   |                 |                 |                 |
| 65       | PTB19             | DISABLED               |                        | PTB19             | CAN0_RX   |                                 | FTM3_CH3   |                 |                 |                 |
| 66       | PTB20             | DISABLED               |                        | PTB20             |           |                                 |            | FLEXPWMA_<br>X0 | CMP0_OUT        |                 |
| 67       | PTB21             | DISABLED               |                        | PTB21             |           |                                 |            | FLEXPWMA_<br>X1 | CMP1_OUT        |                 |
| 68       | PTB22             | DISABLED               |                        | PTB22             |           |                                 |            | FLEXPWMA_<br>X2 | CMP2_OUT        |                 |
| 69       | PTB23             | DISABLED               |                        | PTB23             |           | SPI0_PCS5                       |            | FLEXPWMA_<br>X3 | CMP3_OUT        |                 |
| 70       | PTC0              | ADCB_CH6b              | ADCB_CH6b              | PTC0              | SPI0_PCS4 | PDB0_EXTRG                      |            |                 | FTM0_FLT1       | SPI0_PCS0       |
| 71       | PTC1/<br>LLWU_P6  | ADCB_CH7b              | ADCB_CH7b              | PTC1/<br>LLWU_P6  | SPI0_PCS3 | UART1_RTS_b                     | FTM0_CH0   | FLEXPWMA_<br>A3 | XBAR0_IN11      |                 |
| 72       | PTC2              | ADCB_CH6c/<br>CMP1_IN0 | ADCB_CH6c/<br>CMP1_IN0 | PTC2              | SPI0_PCS2 | UART1_CTS_b                     | FTM0_CH1   | FLEXPWMA_<br>B3 | XBAR0_IN6       |                 |

## Pinout

| 100 LQFP | Pin Name           | Default                | ALT0                   | ALT1               | ALT2      | ALT3                        | ALT4       | ALT5        | ALT6        | ALT7      |
|----------|--------------------|------------------------|------------------------|--------------------|-----------|-----------------------------|------------|-------------|-------------|-----------|
| 73       | PTC3/<br>LLWU_P7   | CMP1_IN1               | CMP1_IN1               | PTC3/<br>LLWU_P7   | SPI0_PCS1 | UART1_RX                    | FTM0_CH2   | CLKOUT      | FTM3_FLT0   |           |
| 74       | VSS                | VSS                    | VSS                    |                    |           |                             |            |             |             |           |
| 75       | VDD                | VDD                    | VDD                    |                    |           |                             |            |             |             |           |
| 76       | PTC4/<br>LLWU_P8   | DISABLED               |                        | PTC4/<br>LLWU_P8   | SPI0_PCS0 | UART1_TX                    | FTM0_CH3   |             | CMP1_OUT    |           |
| 77       | PTC5/<br>LLWU_P9   | DISABLED               |                        | PTC5/<br>LLWU_P9   | SPI0_SCK  | LPTMR0_ALT2                 | XBAR0_IN2  |             | CMP0_OUT    | FTM0_CH2  |
| 78       | PTC6/<br>LLWU_P10  | CMP2_IN4/<br>CMP0_IN0  | CMP2_IN4/<br>CMP0_IN0  | PTC6/<br>LLWU_P10  | SPI0_SOUT | PDB0_EXTRG                  | XBAR0_IN3  | UART0_RX    | XBAR0_OUT6  | I2C0_SCL  |
| 79       | PTC7               | CMP3_IN4/<br>CMP0_IN1  | CMP3_IN4/<br>CMP0_IN1  | PTC7               | SPI0_SIN  |                             | XBAR0_IN4  | UART0_TX    | XBAR0_OUT7  | I2C0_SDA  |
| 80       | PTC8               | ADCB_CH7c/<br>CMP0_IN2 | ADCB_CH7c/<br>CMP0_IN2 | PTC8               |           | FTM3_CH4                    |            |             |             |           |
| 81       | PTC9               | ADCB_CH6d/<br>CMP0_IN3 | ADCB_CH6d/<br>CMP0_IN3 | PTC9               |           | FTM3_CH5                    |            |             |             |           |
| 82       | PTC10              | ADCB_CH7d              | ADCB_CH7d              | PTC10              |           | FTM3_CH6                    |            |             |             |           |
| 83       | PTC11/<br>LLWU_P11 | ADCB_CH6e              | ADCB_CH6e              | PTC11/<br>LLWU_P11 |           | FTM3_CH7                    |            |             |             |           |
| 84       | PTC12              | DISABLED               |                        | PTC12              |           |                             | FTM_CLKIN0 |             | FTM3_FLT0   |           |
| 85       | PTC13              | DISABLED               |                        | PTC13              |           |                             | FTM_CLKIN1 |             |             |           |
| 86       | PTC14              | DISABLED               |                        | PTC14              |           | I2C0_SCL                    |            |             |             |           |
| 87       | PTC15              | DISABLED               |                        | PTC15              |           | I2C0_SDA                    |            |             |             |           |
| 88       | VSS                | VSS                    | VSS                    |                    |           |                             |            |             |             |           |
| 89       | VDD                | VDD                    | VDD                    |                    |           |                             |            |             |             |           |
| 90       | PTC16              | DISABLED               |                        | PTC16              | CAN1_RX   |                             |            |             |             |           |
| 91       | PTC17              | DISABLED               |                        | PTC17              | CAN1_TX   |                             |            |             |             |           |
| 92       | PTC18              | DISABLED               |                        | PTC18              |           |                             |            |             |             |           |
| 93       | PTD0/<br>LLWU_P12  | DISABLED               |                        | PTD0/<br>LLWU_P12  | SPI0_PCS0 |                             | FTM3_CH0   | FTM0_CH0    | FLEXPWMA_A0 |           |
| 94       | PTD1               | ADCA_CH7f              | ADCA_CH7f              | PTD1               | SPI0_SCK  |                             | FTM3_CH1   | FTM0_CH1    | FLEXPWMA_B0 |           |
| 95       | PTD2/<br>LLWU_P13  | DISABLED               |                        | PTD2/<br>LLWU_P13  | SPI0_SOUT |                             | FTM3_CH2   | FTM0_CH2    | FLEXPWMA_A1 | I2C0_SCL  |
| 96       | PTD3               | DISABLED               |                        | PTD3               | SPI0_SIN  |                             | FTM3_CH3   | FTM0_CH3    | FLEXPWMA_B1 | I2C0_SDA  |
| 97       | PTD4/<br>LLWU_P14  | DISABLED               |                        | PTD4/<br>LLWU_P14  | SPI0_PCS1 | UART0_RTS_b                 | FTM0_CH4   | FLEXPWMA_A2 | EWM_IN      | SPI0_PCS0 |
| 98       | PTD5               | ADCA_CH6g              | ADCA_CH6g              | PTD5               | SPI0_PCS2 | UART0_CTS_b/<br>UART0_COL_b | FTM0_CH5   | FLEXPWMA_B2 | EWM_OUT_b   | SPI0_SCK  |
| 99       | PTD6/<br>LLWU_P15  | ADCA_CH7g              | ADCA_CH7g              | PTD6/<br>LLWU_P15  | SPI0_PCS3 | UART0_RX                    | FTM0_CH6   | FTM1_CH0    | FTM0_FLT0   | SPI0_SOUT |
| 100      | PTD7               | DISABLED               |                        | PTD7               |           | UART0_TX                    | FTM0_CH7   | FTM1_CH1    | FTM0_FLT1   | SPI0_SIN  |

## 6.2 Pinout diagrams

The following diagrams show pinouts for the packages. For each pin, the diagrams show the default function. However, many signals may be multiplexed onto a single pin.

## Ordering parts



Figure 23. 100-pin LQFP

## 7 Ordering parts

## 7.1 Determining valid orderable parts

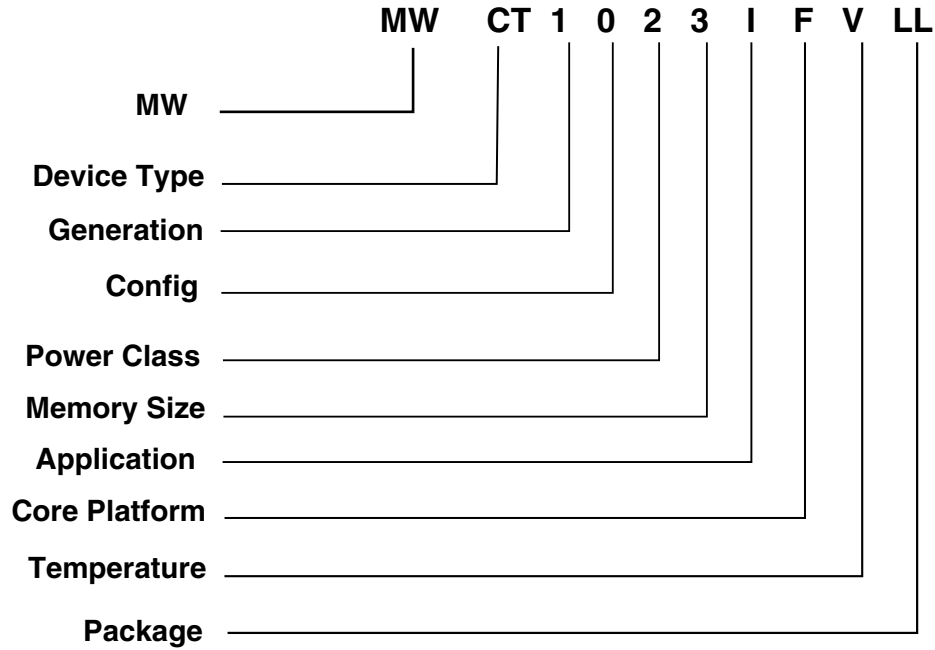
Valid orderable part numbers are provided on the web. To determine the orderable part numbers for this device, go to [www.nxp.com](http://www.nxp.com) and perform a part number search for the MWCT1x23 device numbers.

# 8 Part identification

## 8.1 Description

Part numbers for the chip have fields that identify the specific part. You can use the values of these fields to determine the specific part you have received.

## 8.2 Fields



### MW

#### Device Type

CT: Transmitter  
PR: Receiver

#### Generation

1: 1st product Gen  
2: 2nd product Gen

#### Config

0 = Standard  
1 = Premium  
2 = Multidevice charging  
R = Radio

#### Power Class

0 = 5 W  
1 = 15- 30 W  
2 = 30-100 W  
3 = 100+ W

### Memory size (Flash)

|     |       |     |     |
|-----|-------|-----|-----|
|     | 4     | 5   | 6   |
| M4F | 512 K | 1 M | 2 M |

#### Application

Blank =Customer  
A = Auto/Industr  
S = A + AUTOSAR  
I = not Qi

#### Core platform

Blank = DSC  
Z: CM0+  
F: CM4

#### Temperature

C: -40C to 85C  
V: -40C to 105C

### Package

AL: 36 WLCSP  
FM: 32 QFN  
LH: 64 LQFP  
LL: 100LQFP  
LQ: 144 LQFP  
MH: 100BGA  
HT: 48 QFN

Figure 24. Ordering information



## 8.3 Example

This is an example part number:

MWCT1123FVLL

# 9 Terminology and guidelines

## 9.1 Definition: Operating requirement

An *operating requirement* is a specified value or range of values for a technical characteristic that you must guarantee during operation to avoid incorrect operation and possibly decreasing the useful life of the chip.

### 9.1.1 Example

This is an example of an operating requirement:

| Symbol          | Description               | Min. | Max. | Unit |
|-----------------|---------------------------|------|------|------|
| V <sub>DD</sub> | 1.0 V core supply voltage | 0.9  | 1.1  | V    |

## 9.2 Definition: Operating behavior

Unless otherwise specified, an *operating behavior* is a specified value or range of values for a technical characteristic that are guaranteed during operation if you meet the operating requirements and any other specified conditions.

### 9.2.1 Example

This is an example of an operating behavior:

## Terminology and guidelines

| Symbol   | Description                              | Min. | Max. | Unit          |
|----------|--|------|------|---------------|
| $I_{WP}$ | Digital I/O weak pullup/pulldown current | 10   | 130  | $\mu\text{A}$ |

### 9.3 Definition: Attribute

An *attribute* is a specified value or range of values for a technical characteristic that are guaranteed, regardless of whether you meet the operating requirements.

#### 9.3.1 Example

This is an example of an attribute:

| Symbol | Description                     | Min. | Max. | Unit |
|--------|---------------------------------|------|------|------|
| CIN_D  | Input capacitance: digital pins | —    | 7    | pF   |

### 9.4 Definition: Rating

A *rating* is a minimum or maximum value of a technical characteristic that, if exceeded, may cause permanent chip failure:

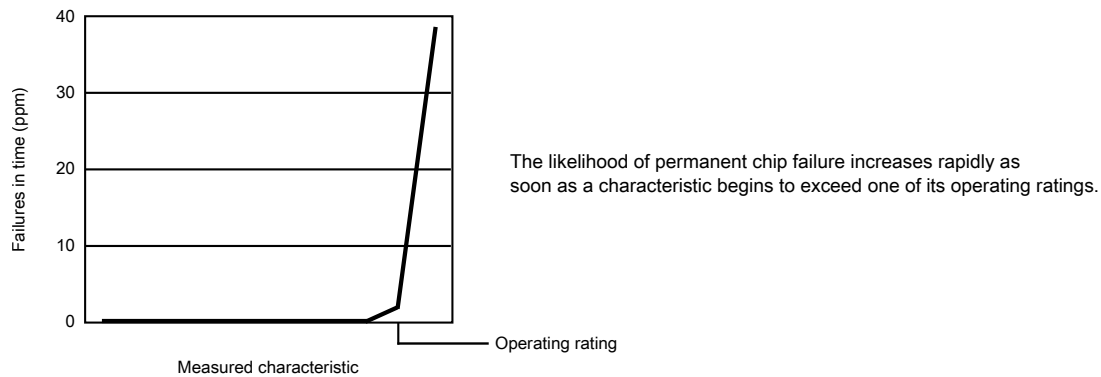
- *Operating ratings* apply during operation of the chip.
- *Handling ratings* apply when the chip is not powered.

#### 9.4.1 Example

This is an example of an operating rating:

| Symbol   | Description               | Min. | Max. | Unit |
|----------|---------------------------|------|------|------|
| $V_{DD}$ | 1.0 V core supply voltage | -0.3 | 1.2  | V    |

## 9.5 Result of exceeding a rating



## 9.6 Relationship between ratings and operating requirements



## 9.7 Guidelines for ratings and operating requirements

Follow these guidelines for ratings and operating requirements:

- Never exceed any of the chip's ratings.
- During normal operation, don't exceed any of the chip's operating requirements.
- If you must exceed an operating requirement at times other than during normal operation (for example, during power sequencing), limit the duration as much as possible.

## 9.8 Definition: Typical value

A *typical value* is a specified value for a technical characteristic that:

- Lies within the range of values specified by the operating behavior
- Given the typical manufacturing process, is representative of that characteristic during operation when you meet the typical-value conditions or other specified conditions

Typical values are provided as design guidelines and are neither tested nor guaranteed.

### 9.8.1 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  | $\mu A$ |

### 9.8.2 Example 2

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



## 9.9 Typical Value Conditions

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

| Symbol          | Description          | Value | Unit |
|-----------------|----------------------|-------|------|
| T <sub>A</sub>  | Ambient temperature  | 25    | °C   |
| V <sub>DD</sub> | 3.3 V supply voltage | 3.3   | V    |

## 10 Revision history

The following table provides a revision history for this document.

**Table 43. Revision history**

| Rev. No. | Date    | Substantial Changes |
|----------|---------|---------------------|
| 0        | 04/2019 | Initial release.    |