

## MSPM0C110x, MSPS003 Mixed-Signal Microcontrollers

### 1 Features

- **Core**
  - Arm® 32-bit Cortex®-M0+ CPU, frequency up to 24MHz
- **Operating characteristics**
  - Extended temperature: –40°C to 125°C
  - Wide supply voltage range: 1.62V to 3.6V
- **Memories**
  - Up to 16KB of flash
  - 1KB of SRAM
- **High-performance analog peripherals**
  - One analog-to-digital converter (ADC) with up to 10 total external channels, 1.7Msps at 10 bit or 1.5Msps at 12 bit with VDD as the voltage reference
  - Configurable 1.4V or 2.5V internal ADC voltage reference (VREF)
  - Integrated temperature sensor
  - Integrated supply monitor
- **Optimized low-power modes**
  - RUN: 87µA/MHz
  - STOP: 609µA at 4MHz, 311µA at 32kHz
  - STANDBY: 5µA with SRAM retention
  - SHUTDOWN: 200nA
- **Intelligent digital peripherals**
  - 1-channel DMA controller dedicated for ADC
  - Three timers supporting up to 14 PWM channels
    - One 16-bit advanced timers with deadband support up to 8 PWM channels
    - One 16-bit general purpose timer with 4 capture/compares
    - One 16-bit general purpose timer with 2 capture/compares
  - Windowed watchdog timer
  - BEEPER generating 1kHz, 2kHz, 4kHz, or 8kHz square wave to drive the external beeper
- **Enhanced communication interfaces**
  - One UART interface supporting LIN, IrDA, DALI, smart card, Manchester and low-power operation in STANDBY mode
  - One I<sup>2</sup>C interface supporting FM+ (1Mbps), SMBus, PMBus, and wakeup from STOP mode
  - One SPI supporting up to 12Mbps

- **Clock system**
  - Internal 24MHz oscillator with an accuracy from -2% to +1.2% (SYSOSC)
  - Internal 32kHz low-frequency oscillator (LFOSC)
- **Data integrity**
  - Cyclic redundancy checker (CRC-16)
- **Flexible I/O features**
  - Up to 18 GPIOs
  - Two 5V-tolerant open-drain I/Os
- **Development support**
  - 2-pin serial wire debug (SWD)
- **Package options**
  - 20-pin TSSOP (PW)
  - 20-pin VSSOP (DGS)
  - 20-pin WQFN (RUK)
  - 16-pin SOT (DYY)
  - 8-pin SOT (DDF)
  - 8-pin WSON (DSG)
- **Family members** (also see [Device Comparison](#))
  - MSPS003F4: 16KB of flash, 1KB of RAM
  - MSPS003F3: 8KB of flash, 1KB of RAM
  - MSPM0C1104: 16KB of flash, 1KB of RAM
  - MSPM0C1103: 8KB of flash, 1KB of RAM
- **Development kits and software** (also see [Tools and Software](#))
  - LP-MSPM0C1104 LaunchPad™ development kit
  - MSP Software Development Kit (SDK)

### 2 Applications

- [Battery charging and management](#)
- [Power supplies and power delivery](#)
- [Personal electronics](#)
- [Building security and fire safety](#)
- [Connected peripherals and printers](#)
- [Grid infrastructure](#)
- [Smart metering](#)
- [Communication modules](#)
- [Medical and healthcare](#)
- [Lighting](#)



### 3 Description

MSPM0C110x microcontrollers (MCUs) are part of the MSP highly-integrated ultra-low-power 32-bit MCU family based on the enhanced Arm® Cortex®-M0+ core platform operating at up to 24MHz frequency. These cost-optimized MCUs offer high-performance analog peripheral integration, support extended temperature ranges from -40°C to 125°C, and operate with supply voltages from 1.62V to 3.6V.

The MSPM0C110x devices provide up to 16KB embedded flash program memory with 1KB SRAM. These MCUs incorporate a high-speed on-chip oscillator with an accuracy from -2% to +1.2%, eliminating the need for an external crystal. Additional features include a 1-channel DMA, CRC-16 accelerator, and a variety of high-performance analog peripherals such as one 12-bit 1.5Msps ADC with VDD as the voltage reference, and an on-chip temperature sensor. These devices also offer intelligent digital peripherals such as one 16-bit advanced timer, two 16-bit general purpose timer, one windowed watchdog timer, and a variety of communication peripherals including one UART, one SPI, and one I<sup>2</sup>C. These communication peripherals offer protocol support for LIN, IrDA, DALI, Manchester, smart card, SMBus, and PMBus.

The TI MSPM0 family of low-power MCUs consists of devices with varying degrees of analog and digital integration let customers find the MCU that meets their project needs. The architecture combined with extensive low-power modes is optimized to achieve extended battery life in portable measurement applications.

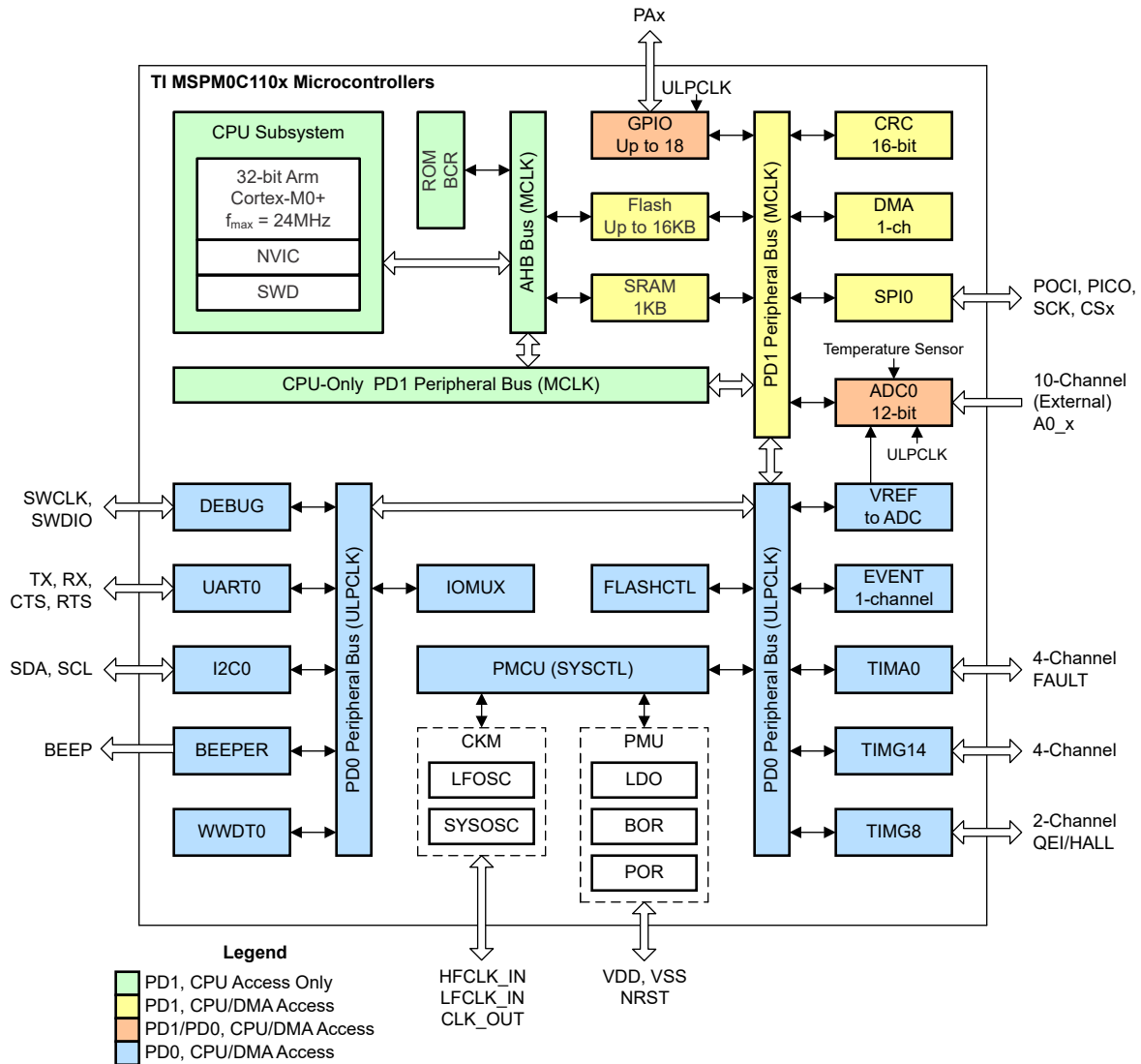
MSPM0C110x MCUs are supported by an extensive hardware and software ecosystem with reference designs and code examples to get the design started quickly. Development kits include a LaunchPad™ kit available for purchase and design files for a target-socket board. TI also provides a free MSP Software Development Kit (SDK), which is available as a component of [Code Composer Studio™ IDE](#) desktop and cloud version within the [TI Resource Explorer](#). MSPM0 MCUs are also supported by extensive online collateral, training with [MSP Academy](#), and online support through the [TI E2E™ support forums](#).

For complete module descriptions, see the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

#### CAUTION

System-level ESD protection must be applied in compliance with the device-level ESD specification to prevent electrical overstress or disturbing of data or code memory. See [MSP430™ System-Level ESD Considerations](#) for more information, as the principles in that application note also apply to MSPM0 MCUs.

## 4 Functional Block Diagram



**Figure 4-1. MSPM0C110x Functional Block Diagram**

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## 5 Device Comparison

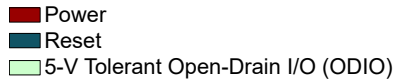
Table 5-1. Device Comparison

| DEVICE NAME <sup>(1) (3)</sup> | FLASH /<br>SRAM (KB) | ADC<br>CHANNELS | UART / I2C /<br>SPI | TIMG | TIMA | GPIOs | 5V<br>TOLERANT<br>IO | PACKAGE<br>[PACKAGE SIZE] <sup>(2)</sup> |
|--------------------------------|----------------------|-----------------|---------------------|------|------|-------|----------------------|--|
| MSPS003F4SPW20R                | 16 / 1               | 9               | 1 / 1 / 1           | 2    | 1    | 17    | 2                    | 20 TSSOP<br>[6.5mm × 5.0mm]              |
| MSPS003F3SPW20R                | 8 / 1                |                 |                     |      |      |       |                      |  |
| MSPM0C1104SDGS20R              | 16 / 1               | 10              | 1 / 1 / 1           | 2    | 1    | 18    | 2                    | 20 VSSOP<br>[5.1mm × 4.9mm]              |
| MSPM0C1103SDGS20R              | 8 / 1                |                 |                     |      |      |       |                      |  |
| MSPM0C1104SRUKR                | 16 / 1               | 10              | 1 / 1 / 1           | 2    | 1    | 18    | 2                    | 20 WQFN<br>[3mm × 3mm]                   |
| MSPM0C1103SRUKR                | 8 / 1                |                 |                     |      |      |       |                      |  |
| MSPM0C1104SDYYR                | 16 / 1               | 8               | 1 / 1 / 1           | 2    | 1    | 14    | 2                    | 16 SOT<br>[4.2mm × 3.26mm]               |
| MSPM0C1103SDYYR                | 8 / 1                |                 |                     |      |      |       |                      |  |
| MSPM0C1104SDSGR                | 16 / 1               | 3               | 1 / 1 / 1           | 2    | 1    | 6     | 2                    | 8 WSON<br>[2mm × 2mm]                    |
| MSPM0C1103SDSGR                | 8 / 1                |                 |                     |      |      |       |                      |  |
| MSPM0C1104SDDFR                | 16 / 1               | 3               | 1 / 1 / 1           | 2    | 1    | 6     | 2                    | 8 SOT<br>[2.9mm × 2.8mm]                 |
| MSPM0C1103SDDFR                | 8 / 1                |                 |                     |      |      |       |                      |  |

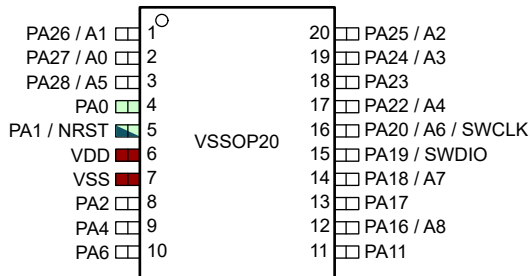
- (1) For the most current part, package, and ordering information for all available devices, see the *Package Option Addendum* in [Section 12](#), or see the [TI web site](#).
- (2) The package size (length × width) is a nominal value and includes pins, where applicable. For package dimensions with tolerances, see the *Mechanical Data* in [Section 12](#).
- (3) For more information about the device name, see [Section 10.1](#).

## 6 Pin Configuration and Functions

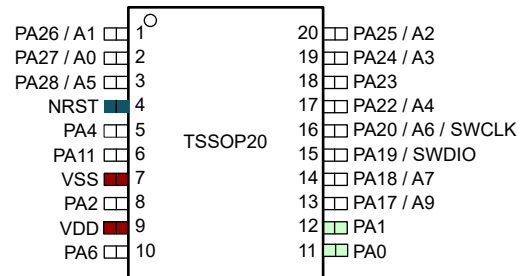
### 6.1 Pin Diagrams



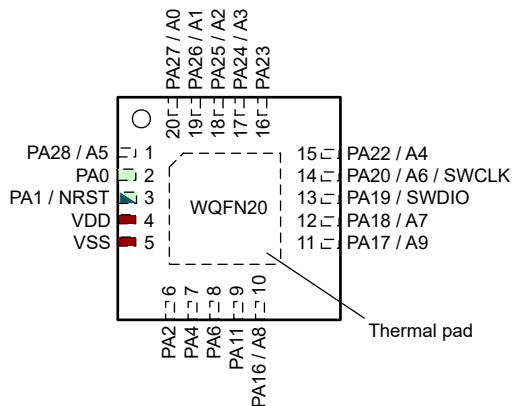
**Figure 6-1. Pin Diagram Color Coding**



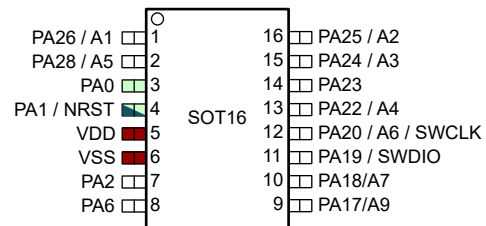
**Figure 6-2. 20-Pin DGS20 (VSSOP) (Top View)**



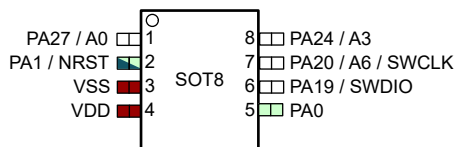
**Figure 6-3. 20-Pin PW20 (TSSOP) (Top View)**



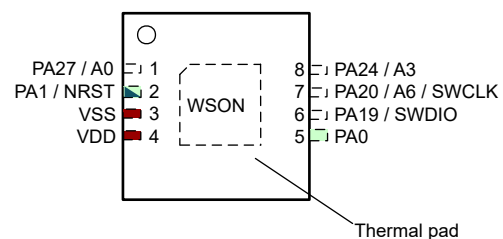
**Figure 6-4. 20-Pin RUK (WQFN) (Top View)**



**Figure 6-5. 16-Pin DYY (SOT) (Top View)**



**Figure 6-6. 8-Pin DDF (SOT) (Top View)**



**Figure 6-7. 8-Pin DSG (WSON) (Top View)**

## 6.2 Pin Attributes

The following table describes the functions available on every pin for each device package.

### Note

Each digital I/O on a device is mapped to a specific Pin Control Management Register (PINCMx) that lets users configure the desired *Pin Function* using the PINCM.PF control bits.

**Table 6-1. Pin Attributes**

| PINCMx | PIN FUNCTION |        |   | PIN NUMBER |          |         |        |       |        | I/O Structure          |
|--------|--------------|--------|---|------------|----------|---------|--------|-------|--------|------------------------|
|        | PIN NAME     | ANALOG | DIGITAL <sup>(1)</sup>  | 20 VSSOP   | 20 TSSOP | 20 WQFN | 16 SOT | 8 SOT | 8 WSON |                        |
| N/A    |              |        | VDD   | 6          | 9        | 4       | 5      | 4     | 4      | Power                  |
| N/A    |              |        | VSS   | 7          | 7        | 5       | 6      | 3     | 3      | Power                  |
| 1      | PA0          |        | BEEP [2] / I2C0_SDA [3] / TIMG8_C0 [4] / SPI0_CS1 [5] / FCC_IN [6] / TIMA_FAL1 [7]    | 4          | 11       | 2       | 3      | 5     | 5      | 5V Tolerant Open-Drain |
| 2      | PA1          |        | I2C0_SCL [2] / TIM8_C0 [3] / HFCLK_IN [4] / TIMA0_C1 [5]                              | 5          | 12       | 3       | 4      | 2     | 2      | 5V Tolerant Open-Drain |
| N/A    |              |        | NRST  |            | 4        |         |        |       |        | Reset                  |
| 3      | PA2          |        | TIMG8_C1[2] / SPI0_CS0[3] / TIMA0_C0[4] / TIMG8_IDX[5]                                | 8          | 8        | 6       | 7      | -     | -      | Standard               |
| 5      | PA4          |        | TIMA0_C0N[2] / SPI0_POCI[3] / LFCLK_IN[4] / HFCLK_IN[5] / TIMA0_C1N[6]                | 9          | 5        | 7       | -      | -     | -      | Standard               |
| 7      | PA6          |        | TIMG14_C1[2] / SPI0_SCK[3] / TIMA0_C1[4] / TIMG14_C2[5] / SPI0_CS0[6] / TIMA_FAL0[7]  | 10         | 10       | 8       | 8      | -     | -      | Standard               |
| 12     | PA11         |        | SPI0_SCK[2] / I2C0_SCL[3] / TIMA_FAL0[4]  | 11         | 6        | 9       | -      | -     | -      | Standard               |
| 17     | PA16         | A8     | TIMA0_C1N[2] / SPI0_POCI[3] / TIMG14_C0[4] / FCC_IN[5]                                | 12         | -        | 10      | -      | -     | -      | Standard               |
| 18     | PA17         | A9     | UART0_TX[2] / TIMA0_C0N[3] / SPI0_SCK[4] / TIMA0_C2[5] / SPI0_CS1[6] / TIMA0_C3[7]    | 13         | 13       | 11      | 9      | -     | -      | Standard               |
| 19     | PA18         | A7     | UART0_RX[2] / SPI0_PICO[3] / TIMA0_C1N[4] / CLK_OUT[5] / TIMA0_C3[6] / TIMA0_C3N[7]   | 14         | 14       | 12      | 10     | -     | -      | Standard               |
| 20     | PA19         |        | SWDIO[2] / SPI0_SCK[3] / SPI0_POCI[4] / TIMA0_C2[5] / TIMG14_C0[6] / UART0_CTS[7]     | 15         | 15       | 13      | 11     | 6     | 6      | Standard               |
| 21     | PA20         | A6     | SWCLK[2] / TIMA_FAL1[3] / SPI0_PICO[4] / TIMA0_C2N[5] / TIMA0_C0[6] / UART0_RTS[7]    | 16         | 16       | 14      | 12     | 7     | 7      | Standard               |
| 23     | PA22         | A4     | UART0_RX[2] / SPI0_POCI[3] / UART0_RTS[4] / CLK_OUT[5] / TIMA0_C1[6]                  | 17         | 17       | 15      | 13     | -     | -      | Standard               |
| 24     | PA23         |        | UART0_TX[2] / SPI0_CS3[3] / TIMG14_C0[4] / UART0_CTS[5] / TIMA0_C3[6] / TIMG14_C1[7]  | 18         | 18       | 16      | 14     | -     | -      | Standard               |
| 25     | PA24         | A3     | SPI0_CS2[2] / TIMG14_C1[3] / UART0_RTS[4] / TIMG14_C2[5] / TIMA0_C3N[6] / UART0_RX[7] | 19         | 19       | 17      | 15     | 8     | 8      | Standard               |
| 26     | PA25         | A2     | TIMG14_C3[2] / UART0_TX[3] / SPI0_PICO[4] / TIMG14_C1[5] / TIMA_FAL2[6]               | 20         | 20       | 18      | 16     | -     | -      | Standard               |
| 27     | PA26         | A1     | TIMG8_C0[2] / UART0_RX[3] / SPI0_POCI[4] / BEEP[5] / TIMG14_C0[6] / TIMA_FAL0[7]      | 1          | 1        | 19      | 1      | -     | -      | Standard               |
| 28     | PA27         | A0     | TIMG8_C1[2] / SPI0_CS3[3] / TIMA0_C0N[4] / UART0_TX[5] / SPI0_POCI[6] / TIMA_FAL2[7]  | 2          | 2        | 20      | -      | 1     | 1      | Standard               |
| 29     | PA28         | A5     | TIMA0_C0[2] / UART0_RX[3] / TIMG8_IDX[4]  | 3          | 3        | 1       | 2      | -     | -      | Standard               |

- (1) PINCM.PF and PINCM.PC in [IOMUX](#) must be set to 0 for analog functions like ADC inputs. Each digital I/O on a device is mapped to a specific Pin Control Management Register (PINCMx) that lets users configure the desired *Pin Function* using the PINCM.PF control bits.

**Table 6-2. Digital IO Features by IO Type**

| IO Structure           | INVERSION CONTROL | DRIVE STRENGTH CONTROL | HYSTERESIS CONTROL | PULLUP RESISTOR | PULLDOWN RESISTOR |
|------------------------|-------------------|------------------------|--------------------|-----------------|-------------------|
| Standard-drive         | Y                 |                        |                    | Y               | Y                 |
| 5V tolerant open-drain | Y                 |                        | Y                  |                 | Y                 |

### 6.3 Signal Descriptions

| FUNCTION         | SIGNAL NAME | PIN NO. <sup>(1)</sup> |          |         |        |       |        | PIN TYPE <sup>(2)</sup> | DESCRIPTION  |
|------------------|-------------|------------------------|----------|---------|--------|-------|--------|-------------------------|--|
|                  |             | 20 VSSOP               | 20 TSSOP | 20 WQFN | 16 SOT | 8 SOT | 8 WSON |                         |  |
| ADC              | A0          | 2                      | 2        | 20      | -      | 1     | 1      | I                       | ADC0 analog input 0                                    |
|                  | A1          | 1                      | 1        | 19      | 1      | -     | -      | I                       | ADC0 analog input 1                                    |
|                  | A2          | 20                     | 20       | 18      | 16     | -     | -      | I                       | ADC0 analog input 2                                    |
|                  | A3          | 19                     | 19       | 17      | 15     | 8     | 8      | I                       | ADC0 analog input 3                                    |
|                  | A4          | 17                     | 17       | 15      | 13     | -     | -      | I                       | ADC0 analog input 4                                    |
|                  | A5          | 3                      | 3        | 1       | 2      | -     | -      | I                       | ADC0 analog input 5                                    |
|                  | A6          | 16                     | 16       | 14      | 12     | 7     | 7      | I                       | ADC0 analog input 6                                    |
|                  | A7          | 14                     | 14       | 12      | 10     | -     | -      | I                       | ADC0 analog input 7                                    |
|                  | A8          | 12                     | -        | 10      | -      | -     | -      | I                       | ADC0 analog input 8                                    |
|                  | A9          | 13                     | 13       | 11      | 9      | -     | -      | I                       | ADC0 analog input 9                                    |
| Clock            | CLK_OUT     | 14, 17                 | 14, 17   | 12, 15  | 10, 13 | -     | -      | O                       | Configurable clock output                              |
| Debug            | SWDIO       | 15                     | 15       | 14      | 11     | 6     | 6      | I/O                     | Serial wire debug data input/output                    |
|                  | SWCLK       | 16                     | 16       | 13      | 12     | 7     | 7      | I                       | Serial wire debug input clock                          |
| GPIO             | PA0         | 4                      | 11       | 2       | 3      | 5     | 5      | I/O                     | General-purpose digital I/O with open-drain capability |
|                  | PA1         | 5                      | 12       | 3       | 4      | 2     | 2      | I/O                     | General-purpose digital I/O with open-drain capability |
|                  | PA2         | 8                      | 8        | 6       | 7      | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA4         | 9                      | 5        | 7       | -      | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA6         | 10                     | 10       | 8       | 8      | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA11        | 11                     | 6        | 9       | -      | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA16        | 12                     | -        | 10      | -      | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA17        | 13                     | 13       | 11      | 9      | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA18        | 14                     | 14       | 12      | 10     | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA19        | 15                     | 15       | 13      | 11     | 6     | 6      | I/O                     | General-purpose digital I/O                            |
|                  | PA20        | 16                     | 16       | 14      | 12     | 7     | 7      | I/O                     | General-purpose digital I/O                            |
|                  | PA22        | 17                     | 17       | 15      | 13     | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA23        | 18                     | 18       | 16      | 14     | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA24        | 19                     | 19       | 17      | 15     | 8     | 8      | I/O                     | General-purpose digital I/O                            |
|                  | PA25        | 20                     | 20       | 18      | 16     | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA26        | 1                      | 1        | 19      | 1      | -     | -      | I/O                     | General-purpose digital I/O                            |
|                  | PA27        | 2                      | 2        | 20      | -      | 1     | 1      | I/O                     | General-purpose digital I/O                            |
|                  | PA28        | 3                      | 3        | 1       | 2      | -     | -      | I/O                     | General-purpose digital I/O                            |
| I <sup>2</sup> C | I2C0_SCL    | 5, 11                  | 6        | 3, 9    | 4      | 2     | 2      | I/O                     | I2C0 serial clock                                      |
|                  | I2C0_SDA    | 4                      | 11       | 2       | 3      | 5     | 5      | I/O                     | I2C0 serial data                                       |



| FUNCTION | SIGNAL NAME | PIN NO. <sup>(1)</sup> |                 |                       |            |       |        | PIN TYPE <sup>(2)</sup> | DESCRIPTION  |
|----------|-------------|------------------------|-----------------|-----------------------|------------|-------|--------|-------------------------|--|
|          |             | 20 VSSOP               | 20 TSSOP        | 20 WQFN               | 16 SOT     | 8 SOT | 8 WSON |                         |  |
| Power    | VSS         | 7                      | 7               | 5                     | 6          | 3     | 3      | P                       | Ground supply  |
|          | VDD         | 6                      | 9               | 4                     | 5          | 4     | 4      | P                       | Power supply   |
|          | QFN Pad     | -                      | -               | Pad                   | -          | -     | Pad    | P                       | QFN package exposed thermal pad. TI recommends connection to V <sub>SS</sub> .             |
| SPI      | SPI0_CS0    | 8                      | 8               | 6                     | 7          | -     | -      | I/O                     | SPI0 chip-select 0   |
|          | SPI0_CS1    | 4, 13                  | 11, 13          | 2, 11                 | 3, 9       | 5     | 5      | I/O                     | SPI0 chip-select 1   |
|          | SPI0_CS2    | 19                     | 19              | 17                    | 15         | 8     | 8      | I/O                     | SPI0 chip-select 2   |
|          | SPI0_CS3    | 2, 18                  | 2, 18           | 16, 20                | 14         | 1     | 1      | I/O                     | SPI0 chip-select 3   |
|          | SPI0_SCK    | 10, 11, 13, 15         | 6, 10, 13, 15   | 8, 9, 11, 13          | 8, 9, 11   | 6     | 6      | I/O                     | SPI0 clock signal input – SPI peripheral mode<br>Clock signal output – SPI controller mode |
|          | SPI0_POCI   | 1, 2, 9, 12, 15, 17    | 1, 2, 5, 15, 17 | 7, 10, 13, 15, 19, 20 | 1, 11, 13  | 1, 6  | 1, 6   | I/O                     | SPI0 controller in/peripheral out  |
|          | SPI0_PICO   | 14, 16, 20             | 14, 16, 20      | 12, 14, 18            | 10, 12, 16 | 7     | 7      | I/O                     | SPI0 controller out/peripheral in  |
| System   | NRST        | 5                      | 4               | 3                     | 4          | 2     | 2      | I                       | Reset input active low   |

| FUNCTION | SIGNAL NAME | PIN NO. <sup>(1)</sup> |                    |                     |               |       |        | PIN TYPE <sup>(2)</sup> | DESCRIPTION  |
|----------|-------------|------------------------|--------------------|---------------------|---------------|-------|--------|-------------------------|--|
|          |             | 20 VSSOP               | 20 TSSOP           | 20 WQFN             | 16 SOT        | 8 SOT | 8 WSON |                         |  |
| Timer    | TIMA_FAL0   | 1, 10, 11              | 1, 6, 10           | 8, 9, 19            | 1, 8          | -     | -      | I/O                     | Advanced control timer fault 0 handling input                          |
|          | TIMA_FAL1   | 4, 16                  | 11, 16             | 2, 14               | 3, 12         | 5, 7  | 5, 7   | I/O                     | Advanced control timer fault 1 handling input                          |
|          | TIMA_FAL2   | 2, 20                  | 2, 20              | 18, 20              | 16            | 1     | 1      | I/O                     | Advanced control timer fault 2 handling input                          |
|          | TIMA0_C0    | 2, 3, 8, 9, 13, 16     | 2, 3, 5, 8, 13, 16 | 1, 6, 7, 11, 14, 20 | 2, 7, 9, 12   | 1, 7  | 1, 7   | I/O                     | Advanced control timer 0 CCR0 capture input/compare output             |
|          | TIMA0_C0N   | 2, 9, 13               | 2, 5, 13           | 7, 11, 20           | 9             | 1     | 1      | I/O                     | Advanced control timer 0 CCR0 capture input/compare output (inverting) |
|          | TIMA0_C1    | 5, 9, 10, 12, 14, 17   | 5, 10, 12, 14, 17  | 3, 7, 8, 10, 12, 15 | 4, 8, 10, 13  | 2     | 2      | I/O                     | Advanced control timer 0 CCR1 capture input/compare output             |
|          | TIMA0_C1N   | 9, 12, 14              | 5, 14              | 7, 10, 12           | 10            | -     | -      | I/O                     | Advanced control timer 0 CCR1 capture input/compare output (inverting) |
|          | TIMA0_C2    | 13, 15, 16             | 13, 15, 16         | 11, 13, 14          | 9, 11, 12     | 6, 7  | 6, 7   | I/O                     | Advanced control timer 0 CCR2 capture input/compare output             |
|          | TIMA0_C2N   | 16                     | 16                 | 14                  | 12            | 7     | 7      | I/O                     | Advanced control timer 0 CCR2 capture input/compare output (inverting) |
|          | TIMA0_C3    | 13, 14, 18, 19         | 13, 14, 18, 19     | 11, 12, 16, 17      | 9, 10, 14, 15 | 8     | 8      | I/O                     | Advanced control timer 0 CCR3 capture input/compare output             |
|          | TIMA0_C3N   | 14, 19                 | 14, 19             | 12, 17              | 10, 15        | 8     | 8      | I/O                     | Advanced control timer 0 CCR3 capture input/compare output (inverting) |
|          | TIMG14_C0   | 1, 12, 15, 18          | 1, 15, 18          | 10, 13, 16, 19      | 1, 11, 14     | 6     | 6      | I/O                     | General purpose timer 0 CCR0 capture input/compare output              |
|          | TIMG14_C1   | 10, 18, 19, 20         | 10, 18, 19, 20     | 8, 16, 17, 18       | 8, 14, 15, 16 | 8     | 8      | I/O                     | General purpose timer 0 CCR1 capture input/compare output              |
|          | TIMG14_C2   | 10, 19                 | 10, 19             | 8, 17               | 8, 15         | 8     | 8      | I/O                     | General purpose timer 0 CCR2 capture input/compare output              |
|          | TIMG14_C3   | 20                     | 20                 | 18                  | 16            | -     | -      | I/O                     | General purpose timer 0 CCR3 capture input/compare output              |
|          | TIMG8_C0    | 1, 4                   | 1, 11              | 2, 19               | 1, 3          | 5     | 5      | I/O                     | General purpose timer 8 CCR0 capture input/compare output              |
|          | TIMG8_C1    | 2, 5, 8                | 2, 8, 12           | 3, 6, 20            | 4, 7          | 1, 2  | 1, 2   | I/O                     | General purpose timer 8 CCR1 capture input/compare output              |
|          | TIMG8_IDX   | 3, 8                   | 3, 8               | 1, 6                | 2, 7          | -     | -      | I                       | General purpose timer 8 quadrature encoder index pulse input           |

| FUNCTION | SIGNAL NAME | PIN NO. <sup>(1)</sup> |                  |                   |                  |       |        | PIN TYPE <sup>(2)</sup> | DESCRIPTION                                 |
|----------|-------------|------------------------|------------------|-------------------|------------------|-------|--------|-------------------------|---|
|          |             | 20 VSSOP               | 20 TSSOP         | 20 WQFN           | 16 SOT           | 8 SOT | 8 WSON |                         |   |
| UART     | UART0_TX    | 2, 13, 18, 20          | 2, 13, 18, 20    | 11, 16, 18, 20    | 9, 14, 16        | 1     | 1      | O                       | UART0 transmit data                         |
|          | UART0_RX    | 1, 3, 14, 17, 19       | 1, 3, 14, 17, 19 | 1, 12, 15, 17, 19 | 1, 2, 10, 13, 15 | 8     | 8      | I                       | UART0 receive data                          |
|          | UART0_CTS   | 15, 18                 | 15, 18           | 13, 16            | 11, 14           | 6     | 6      | I                       | UART0 "clear to send" flow control input    |
|          | UART0_RTS   | 16, 17, 19             | 16, 17, 19       | 14, 15, 17        | 12, 13, 15       | 7, 8  | 7, 8   | O                       | UART0 "request to send" flow control output |
| Beeper   | BEEP        | 1, 4                   | 1, 11            | 2, 19             | 1, 3             | 5     | 5      | O                       | Beep output                                 |
| FCC      | FCC_IN      | 4, 12                  | 11               | 2, 10             | 3                | 5     | 6      | I                       | Frequency clock counter input               |

(1) '-' = not available

(2) I = input, O = output, I/O = input or output, P = power

## 6.4 Connections for Unused Pins

Table 6-3 lists the correct termination of unused pins.

**Table 6-3. Connection of Unused Pins**

| PIN <sup>(1)</sup> | POTENTIAL | COMMENT   |
|--------------------|-----------|---|
| PAX                | Open      | Set corresponding pin functions to GPIO (PINCMx.PF = 0x1) and configure unused pins to output low or input with internal pullup or pulldown resistor. |
| NRST               | VCC       | NRST is an active-low reset signal. Pull high to VCC or the device cannot start. For more information, see <a href="#">Section 9.1</a> .              |

(1) Any unused pin with a function that is shared with general-purpose I/O must follow the "PAX" unused pin connection guidelines.

## 7 Specifications

### 7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

|                  |                         |   | MIN  | MAX                                | UNIT |
|------------------|-------------------------|---|------|------------------------------------|------|
| V <sub>DD</sub>  | Supply voltage          | At VDD pin  | −0.3 | 4.1                                | V    |
| V <sub>I</sub>   | Input voltage           | Applied to any 5-V tolerant open-drain pins                     | −0.3 | 5.5                                | V    |
| V <sub>I</sub>   | Input voltage           | Applied to any common tolerance pins                            | −0.3 | V <sub>DD</sub> + 0.3<br>(4.1 MAX) | V    |
| I <sub>VDD</sub> | Current of VDD pin      | Current into VDD pin (source), −40 °C ≤ T <sub>a</sub> ≤ 85 °C  |      | 80                                 | mA   |
| I <sub>VSS</sub> | Current of VSS pin      | Current out of VSS pin (sink), −40 °C ≤ T <sub>a</sub> ≤ 85 °C  |      | 80                                 | mA   |
| I <sub>VDD</sub> | Current of VDD pin      | Current into VDD pin (source), −40 °C ≤ T <sub>a</sub> ≤ 125 °C |      | 48                                 | mA   |
| I <sub>VSS</sub> | Current of VSS pin      | Current out of VSS pin (sink), −40 °C ≤ T <sub>a</sub> ≤ 125 °C |      | 48                                 | mA   |
| I <sub>IO</sub>  | Current for SDIO pin    | Current sunk or sourced by SDIO pin                             |      | 6                                  | mA   |
|                  | Current for ODIO pin    | Current sunk by ODIO pin  |      | 20                                 | mA   |
| I <sub>D</sub>   | Supported diode current | Diode current at any device pin except PA24                     |      | ±2 <sup>(2)</sup>                  | mA   |
| T <sub>stg</sub> |                         | Storage temperature   | −40  | 150                                | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Rating* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Condition*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) PA24 has an internal connection for the testing purpose, there is no injection current allowed on this pin.

### 7.2 ESD Ratings

|                    |                         |  | VALUE | UNIT |
|--------------------|-------------------------|--|-------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/ JEDEC JS-001, all pins <sup>(1)</sup>             | ±2000 | V    |
| V <sub>(ESD)</sub> | Electrostatic discharge | Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup> | ±500  | V    |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

|                   |   | MIN                 | NOM | MAX | UNIT |
|-------------------|---|---------------------|-----|-----|------|
| V <sub>DD</sub>   | Supply voltage <sup>(2)</sup>                           | 1.62 <sup>(3)</sup> |     | 3.6 | V    |
| C <sub>VDD</sub>  | Capacitor placed between VDD and VSS <sup>(1)</sup>     |                     | 10  |     | μF   |
| T <sub>A</sub>    | Ambient temperature                                     | −40                 |     | 125 | °C   |
| T <sub>J</sub>    | Max junction temperature                                |                     |     | 130 | °C   |
| f <sub>MCLK</sub> | MCLK, CPUCLK, ULPCLK frequency with 0 flash wait states |                     |     | 24  | MHz  |

- (1) Connect C<sub>VDD</sub> between VDD/VSS, as close to the device pins as possible. A low-ESR capacitor with at least the specified value and tolerance of ±20% or better is required for C<sub>VDD</sub>.
- (2) There is no dependency on MCLK frequency with respect to VDD recommended operating range.
- (3) Functionality is guaranteed down to VBOR0-(min).

## 7.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |  | PACKAGE          | VALUE | UNIT |
|-------------------------------|--|------------------|-------|------|
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | VSSOP-20 (DGS20) | 91.3  | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    |                  | 29.3  | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         |                  | 48.3  | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   |                  | 0.7   | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter |                  | 47.9  | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance |                  | N/A   | °C/W |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | TSSOP-20 (PW20)  | 98.2  | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    |                  | 39.3  | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         |                  | 50.0  | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   |                  | 5.6   | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter |                  | 49.5  | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance |                  | N/A   | °C/W |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | WQFN-20 (RUK)    | 52.9  | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    |                  | 55.5  | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         |                  | 26.4  | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   |                  | 2.1   | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter |                  | 26.4  | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance |                  | 12.0  | °C/W |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | SOT-16 (DYY)     | 117.1 | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    |                  | 54.5  | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         |                  | 54.6  | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   |                  | 3.0   | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter |                  | 54.5  | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance |                  | N/A   | °C/W |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | SOT-8 (DDF)      | 142.3 | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    |                  | 65.7  | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         |                  | 62.7  | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   |                  | 3.2   | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter |                  | 62.5  | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance |                  | N/A   | °C/W |
| R <sub>θJA</sub>              | Junction-to-ambient thermal resistance       | WSO8-8 (DSG)     | 70.7  | °C/W |
| R <sub>θJC(top)</sub>         | Junction-to-case (top) thermal resistance    |                  | 85.6  | °C/W |
| R <sub>θJB</sub>              | Junction-to-board thermal resistance         |                  | 37.5  | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   |                  | 2.7   | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter |                  | 37.5  | °C/W |
| R <sub>θJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance |                  | 12.8  | °C/W |

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 7.5 Supply Current Characteristics

## 7.5.1 RUN/SLEEP Modes

VDD=3.3V. All inputs tied to 0V or VDD. Outputs do not source or sink any current. All peripherals are disabled.

| PARAMETER                    |   | MCLK  | -40°C |      | 25°C |      | 85°C |      | 125°C |      | UNIT   |
|------------------------------|---|-------|-------|------|------|------|------|------|-------|------|--------|
|                              |   |       | TYP   | MAX  | TYP  | MAX  | TYP  | MAX  | TYP   | MAX  |        |
| RUN Mode                     |   |       |       |      |      |      |      |      |       |      |        |
| IDD <sub>RUN</sub>           | MCLK=SYSOSC, While(1), execute from flash | 24MHz | 2.06  | 2.20 | 2.08 | 2.35 | 2.09 | 2.40 | 2.21  | 2.45 | mA     |
| IDD <sub>RUN</sub> , per MHz | MCLK=SYSOSC, While(1), execute from flash | 24MHz | 86    | 92   | 87   | 98   | 87   | 100  | 92    | 102  | μA/MHz |
| SLEEP Mode                   |   |       |       |      |      |      |      |      |       |      |        |
| IDD <sub>SLEEP</sub>         | MCLK=SYSOSC, CPU is halted                | 24MHz | 1115  | 1256 | 1132 | 1268 | 1149 | 1380 | 1214  | 1370 | μA     |

## 7.5.2 STOP/STANDBY Modes

VDD=3.3V unless otherwise noted. All inputs tied to 0V or VDD. Outputs do not source or sink any current. All peripherals not noted are disabled.

| PARAMETER    |  | ULPCLK | -40°C |     | 25°C |     | 85°C |      | 125°C |     | UNIT |
|--------------|--|--------|-------|-----|------|-----|------|------|-------|-----|------|
|              |  |        | TYP   | MAX | TYP  | MAX | TYP  | MAX  | TYP   | MAX |      |
| STOP Mode    |  |        |       |     |      |     |      |      |       |     |      |
| IDD_STOP0    | SYSOSC=24MHz, DISABLESTOP=0                    | 4MHz   | 598   | 640 | 609  | 646 | 622  | 710  | 662   | 733 | μA   |
| IDD_STOP2    | SYSOSC off, DISABLESTOP=1, ULPCLK=LFCLK        | 32kHz  | 305   | 343 | 311  | 346 | 324  | 359  | 364   | 430 |      |
| STANDBY Mode |  |        |       |     |      |     |      |      |       |     |      |
| IDD_STBY0    | STOPCLKSTBY=0, TIMG8, TIMG14 and TIMA0 enabled | 32kHz  | 3.8   | 8.3 | 5.1  | 14  | 17.8 | 35.4 | 57.4  | 93  | μA   |
| IDD_STBY1    | STOPCLKSTBY=1, TIMG8, TIMG14 and TIMA0 enabled |        | 3.4   | 8.5 | 5.1  | 14  | 17.5 | 35.1 | 57    | 93  |      |
|              | STOPCLKSTBY=1, GPIOA enabled                   |        | 3.4   | 8.5 | 5.0  | 14  | 17.5 | 35.2 | 57    | 93  |      |

## 7.5.3 SHUTDOWN Mode

All inputs tied to 0V or VDD. Outputs do not source or sink any current. Core regulator is powered down.

| PARAMETER           |                                 | VDD  | -40°C |     | 25°C |     | 85°C |     | 125°C |      | UNIT |
|---------------------|---------------------------------|------|-------|-----|------|-----|------|-----|-------|------|------|
|                     |                                 |      | TYP   | MAX | TYP  | MAX | TYP  | MAX | TYP   | MAX  |      |
| IDD <sub>SHDN</sub> | Supply current in SHUTDOWN mode | 3.3V | 140   | 320 | 200  | 350 | 428  | 932 | 1933  | 4680 | nA   |

## 7.6 Power Supply Sequencing

### 7.6.1 POR and BOR

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                |   | TEST CONDITIONS                       | MIN  | TYP   | MAX   | UNIT |
|--------------------------|---|---------------------------------------|------|-------|-------|------|
| dVDD/dt                  | VDD (supply voltage) slew rate                  | Rising                                |      |       | 0.1   | V/us |
|                          |   | Falling <sup>(2)</sup>                |      |       | 0.01  |      |
|                          |   | Falling, STANDBY                      |      |       | 0.1   | V/ms |
| V <sub>POR+</sub>        | Power-on reset voltage level                    | Rising <sup>(1)</sup>                 | 0.92 | 1.284 | 1.59  | V    |
| V <sub>POR-</sub>        |   | Falling <sup>(1)</sup>                | 0.87 | 1.236 | 1.54  | V    |
| V <sub>HYS, POR</sub>    | POR hysteresis                                  | <sup>(1)</sup>                        | 16   | 47    | 80    | mV   |
| V <sub>BOR0+, COLD</sub> | Brown-out reset voltage level 0 (default level) | Cold start, rising <sup>(1)</sup>     | 1.48 | 1.54  | 1.615 | V    |
| V <sub>BOR0+</sub>       |   | Rising <sup>(1)</sup> <sup>(2)</sup>  | 1.57 | 1.59  | 1.61  |      |
| V <sub>BOR0-</sub>       |   | Falling <sup>(1)</sup> <sup>(2)</sup> | 1.56 | 1.57  | 1.60  |      |

### 7.6.1 POR and BOR (continued)

over operating free-air temperature range (unless otherwise noted)

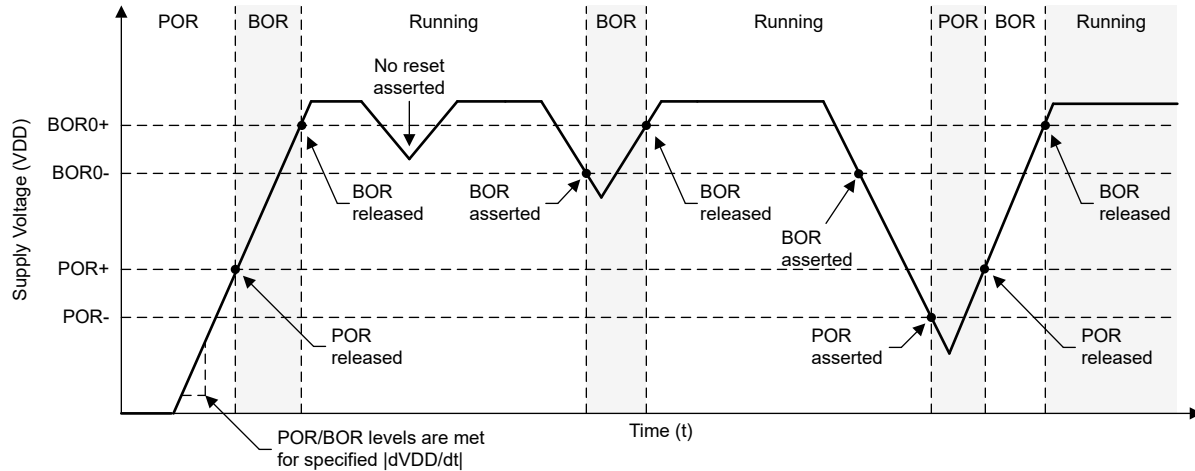
| PARAMETER               |   | TEST CONDITIONS             | MIN  | TYP  | MAX  | UNIT |
|-------------------------|---|-----------------------------|------|------|------|------|
| V <sub>BOR0, STBY</sub> | Brown-out reset voltage level 0 (default level) | STANDBY mode <sup>(1)</sup> | 1.52 | 1.57 | 1.60 | V    |
| V <sub>BOR1+</sub>      | Brown-out-reset voltage level 1                 | Rising <sup>(1) (2)</sup>   | 2.15 | 2.17 | 2.23 | V    |
| V <sub>BOR1-</sub>      |   | Falling <sup>(1) (2)</sup>  | 2.11 | 2.14 | 2.19 |      |
| V <sub>BOR1, STBY</sub> | Brown-out-reset voltage level 1                 | STANDBY mode <sup>(1)</sup> | 2.07 | 2.14 | 2.19 | V    |
| V <sub>BOR2+</sub>      | Brown-out-reset voltage level 2                 | Rising <sup>(1) (2)</sup>   | 2.74 | 2.77 | 2.83 | V    |
| V <sub>BOR2-</sub>      |   | Falling <sup>(1) (2)</sup>  | 2.71 | 2.73 | 2.80 |      |
| V <sub>BOR2, STBY</sub> | Brown-out-reset voltage level 2                 | STANDBY mode <sup>(1)</sup> | 2.67 | 2.73 | 2.80 | V    |
| V <sub>BOR3+</sub>      | Brown-out-reset voltage level 3                 | Rising <sup>(1) (2)</sup>   | 2.88 | 2.96 | 3.04 | V    |
| V <sub>BOR3-</sub>      |   | Falling <sup>(1) (2)</sup>  | 2.85 | 2.93 | 3.01 |      |
| V <sub>BOR3, STBY</sub> | Brown-out-reset voltage level 3                 | STANDBY mode <sup>(1)</sup> | 2.83 | 2.92 | 3.00 | V    |
| V <sub>HYS,BOR</sub>    | Brown-out reset hysteresis                      | Level 0 <sup>(1)</sup>      |      | 14   | 18   | mV   |
|                         |   | Levels 1-3 <sup>(1)</sup>   |      | 34   | 41   |      |
| T <sub>PD, BOR</sub>    | BOR propagation delay                           | RUN/SLEEP/STOP mode         |      |      | 10   | us   |
|                         |   | STANDBY mode                |      |      | 100  | us   |

(1) |dVDD/dt| ≤ 3V/s

(2) Device operating in RUN, SLEEP, or STOP mode.

### 7.6.2 Power Supply Ramp

Figure 7-1 gives the relationship of POR- POR+, BOR0-, and BOR0+ during power-up and power-down.



**Figure 7-1. Power Cycle POR/BOR Conditions**

### 7.7 Flash Memory Characteristics

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                |  | TEST CONDITIONS      | MIN  | TYP | MAX | UNIT |
|--------------------------|--|----------------------|------|-----|-----|------|
| <b>Supply</b>            |  |                      |      |     |     |      |
| VDD <sub>PGM/ERASE</sub> | Program and erase supply voltage                 |                      | 1.62 |     | 3.6 | V    |
| IDDERASE                 | Supply current from VDD during erase operation   | Supply current delta |      | 2   |     | mA   |
| IDDPGM                   | Supply current from VDD during program operation | Supply current delta |      | 2.5 |     | mA   |

## 7.7 Flash Memory Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                       |   | TEST CONDITIONS                | MIN  | TYP | MAX | UNIT               |
|---------------------------------|---|--------------------------------|------|-----|-----|--------------------|
| <b>Endurance</b>                |   |                                |      |     |     |                    |
| NWEC <sub>(LOWER)</sub>         | Erase/program cycle endurance                                     |                                | 100  |     |     | k cycles           |
| NE <sub>(MAX)</sub>             | Total erase operations before failure <sup>(1)</sup>              |                                | 802  |     |     | k erase operations |
| NW <sub>(MAX)</sub>             | Write operations per word line before sector erase <sup>(1)</sup> |                                |      |     | 83  | write operations   |
| <b>Retention</b>                |   |                                |      |     |     |                    |
| t <sub>RET_85</sub>             | Flash memory data retention                                       | -40°C ≤ T <sub>j</sub> ≤ 85°C  | 60   |     |     | years              |
| t <sub>RET_105</sub>            | Flash memory data retention                                       | -40°C ≤ T <sub>j</sub> ≤ 105°C | 11.4 |     |     | years              |
| t <sub>RET_130</sub>            | Flash memory data retention                                       | -40°C ≤ T <sub>j</sub> ≤ 130°C | 2.4  |     |     | years              |
| <b>Program and Erase Timing</b> |   |                                |      |     |     |                    |
| t <sub>PROG (WORD, 64)</sub>    | Program time for flash word <sup>(2)</sup>                        |                                |      | 40  |     | μs                 |
| t <sub>PROG (SEC, 64)</sub>     | Program time for 1kB sector                                       |                                |      | 5.1 |     | ms                 |
| t <sub>ERASE (SEC)</sub>        | Sector erase time   | <10k erase/program cycles      |      | 20  | 200 | ms                 |
| t <sub>ERASE (BANK)</sub>       | Bank erase time   | <10k erase/program cycles      |      | 22  | 220 | ms                 |

- (1) Maximum number of write operations allowed per word line before the word line must be erased. If additional writes to the same word line are required, a sector erase is required once the maximum number of write operations per word line is reached.
- (2) Sector program time is defined as the time from when the first word program command is triggered until the final word program command completes and the interrupt flag is set in the flash controller. This time includes the time needed for software to load each flash word (after the first flash word) into the flash controller during programming of the sector.

## 7.8 Timing Characteristics

VDD=3.3V, T<sub>a</sub>=25 °C (unless otherwise noted)

| PARAMETER                              |   | TEST CONDITIONS  | MIN | TYP | MAX | UNIT   |
|--|---|------------------|-----|-----|-----|--------|
| Wakeup Timing                          |   |                  |     |     |     |        |
| t <sub>WAKE, SLEEP</sub>               | Wakeup time from SLEEP to RUN   |                  |     | 2   |     | cycles |
| t <sub>WAKE, STOP</sub>                | Wakeup time from STOP0 to RUN (SYSOSC enabled)                        |                  |     | 14  |     | us     |
|  | Wakeup time from STOP2 to RUN (SYSOSC disabled)                       |                  |     | 15  |     | us     |
| t <sub>WAKE, STBY</sub>                | Wakeup time from STANDBY to RUN                                       |                  |     | 20  |     | us     |
| t <sub>WAKE, SHDN</sub>                | Wakeup time from SHUTDOWN to RUN                                      |                  |     | 112 |     | us     |
| Asynchronous Fast Clock Request Timing |   |                  |     |     |     |        |
| t <sub>DELAY</sub>                     | Delay time from edge of asynchronous request to first 24MHz MCLK edge | Mode is SLEEP2   |     | 1.2 |     | us     |
|  |   | Mode is STOP2    |     | 1.2 |     | us     |
|  |   | Mode is STANDBY1 |     | 5.0 |     | us     |
| Startup Timing                         |   |                  |     |     |     |        |
| t <sub>START, RESET</sub>              | Device cold start-up time from reset/ power-up <sup>(1)</sup>         |                  |     | 210 |     | us     |
| NRST Timing                            |   |                  |     |     |     |        |
| t <sub>RST, BOOTRST</sub>              | Pulse length on NRST pin to generate BOOTRST                          | ULPCLK≥4MHz      |     | 2   |     | us     |
|  |   | ULPCLK=32kHz     |     | 100 |     | us     |



## 7.8 Timing Characteristics (continued)

VDD=3.3V, T<sub>a</sub>=25 °C (unless otherwise noted)

| PARAMETER             |  | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-----------------------|--|-----------------|-----|-----|-----|------|
| t <sub>RST, POR</sub> | Pulse length on NRST pin to generate POR |                 |     | 1   |     | s    |

- (1) The start-up time is measured from the time that VDD crosses VBOR0+ (cold start-up) to the time that the first instruction of the user program is executed.

## 7.9 Clock Specifications

### 7.9.1 System Oscillator (SYSOSC)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                   |  | TEST CONDITIONS  | MIN  | TYP | MAX | UNIT |
|-----------------------------|--|--|------|-----|-----|------|
| f <sub>SYSOSC</sub>         | Factory trimmed SYSOSC frequency   | SYSOSCCFG.FREQ=00 (BASE)   |      | 24  |     | MHz  |
| f <sub>SYSOSC</sub>         | SYSOSC frequency accuracy when frequency correction loop (FCL) is enabled when the internal ROSC resistor is used <sup>(1)</sup> | SETUSEFCL=1, T <sub>a</sub> = 25 °C                              | -1.2 |     | 1.2 | %    |
|                             |  | SETUSEFCL=1, 0 °C ≤ T <sub>a</sub> ≤ 85 °C                       | -1.6 |     | 1.4 |      |
|                             |  | SETUSEFCL=1 -40 °C ≤ T <sub>a</sub> ≤ 125 °C                     | -2   |     | 1.4 |      |
| f <sub>SYSOSC</sub>         | SYSOSC accuracy when frequency correction loop (FCL) is disabled, 24MHz  | SETUSEFCL=0, SYSOSCCFG.FREQ=00, -40 °C ≤ T <sub>a</sub> ≤ 125 °C | -2.5 |     | 2.5 | %    |
| t <sub>settle, SYSOSC</sub> | Settling time to target accuracy <sup>(2)</sup>  | SETUSEFCL=1  |      |     | 30  | us   |

- (1) The SYSOSC frequency correction loop (FCL) enables high SYSOSC accuracy via an internal reference resistor when using the FCL. See the SYSOSC section of the technical reference manual for details on computing SYSOSC accuracy.
- (2) When SYSOSC is enabled from a disabled state, the SYSOSC output will be released to the device within the time specified by t<sub>start, SYSOSC</sub>. Once the output is released, the SYSOSC worst-case accuracy is specified by f<sub>settle, SYSOSC</sub>. After the time specified by t<sub>settle, SYSOSC</sub>, the SYSOSC will have settled to the target f<sub>SYSOSC</sub> accuracy.

### 7.9.2 Low Frequency Oscillator (LFOSC)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                 |                           | TEST CONDITIONS                  | MIN | TYP   | MAX | UNIT |
|---------------------------|---------------------------|----------------------------------|-----|-------|-----|------|
| f <sub>LFOSC</sub>        | LFOSC frequency           |                                  |     | 32768 |     | Hz   |
| f <sub>LFOSC</sub>        | LFOSC accuracy            | -40 °C ≤ T <sub>a</sub> ≤ 125 °C | -5  |       | 5   | %    |
| f <sub>LFOSC</sub>        | LFOSC accuracy            | -40 °C ≤ T <sub>a</sub> ≤ 85 °C  | -3  |       | 3   | %    |
| I <sub>LFOSC</sub>        | LFOSC current consumption |                                  |     | 300   |     | nA   |
| t <sub>start, LFOSC</sub> | LFOSC start-up time       |                                  |     | 1.7   |     | ms   |

## 7.10 Digital IO

### 7.10.1 Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER       |                          | TEST CONDITIONS             |             | MIN     | TYP | MAX     | UNIT |
|-----------------|--------------------------|-----------------------------|-------------|---------|-----|---------|------|
| V <sub>IH</sub> | High level input voltage | ODIO <sup>(1)</sup>         | VDD ≥ 1.62V | 0.7*VDD |     | 5.5     | V    |
|                 |                          | ODIO <sup>(1)</sup>         | VDD ≥ 2.7V  | 2       |     | 5.5     | V    |
|                 |                          | All I/O except ODIO & Reset | VDD ≥ 1.62V | 0.7*VDD |     | VDD+0.3 | V    |
| V <sub>IL</sub> | Low level input voltage  | ODIO                        | VDD ≥ 1.62V | -0.3    |     | 0.3*VDD | V    |
|                 |                          | ODIO                        | VDD ≥ 2.7V  | -0.3    |     | 0.8     | V    |
|                 |                          | All I/O except ODIO & Reset | VDD ≥ 1.62V | -0.3    |     | 0.3*VDD | V    |

### 7.10.1 Electrical Characteristics (continued)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER        |                           | TEST CONDITIONS         |   | MIN      | TYP | MAX | UNIT |
|------------------|---------------------------|-------------------------|---|----------|-----|-----|------|
| V <sub>HYS</sub> | Hysteresis                | ODIO                    |   | 0.05*VDD |     |     | V    |
|                  |                           | All I/O except ODIO     |   | 0.1*VDD  |     |     | V    |
| I <sub>lkg</sub> | High-Z leakage current    | SDIO <sup>(2) (3)</sup> | VDD = 3V  |          |     | 50  | nA   |
| R <sub>PU</sub>  | Pull up resistance        | All I/O except ODIO     | VIN = VSS   |          | 40  |     | kΩ   |
| R <sub>PD</sub>  | Pull down resistance      |                         | VIN = VDD   |          | 40  |     | kΩ   |
| C <sub>I</sub>   | Input capacitance         |                         | VDD = 3.3V  |          | 5   |     | pF   |
| V <sub>OH</sub>  | High level output voltage | SDIO                    | VDD ≥ 2.7V,  I <sub>OL</sub>   <sub>max</sub> = 6mA   | VDD-0.5  |     |     | V    |
| V <sub>OH</sub>  | High level output voltage | SDIO                    | VDD ≥ 1.71V,  I <sub>OL</sub>   <sub>max</sub> = 2mA  | VDD-0.4  |     |     | V    |
| V <sub>OL</sub>  | Low level output voltage  | SDIO                    | VDD ≥ 2.7V,  I <sub>OL</sub>   <sub>max</sub> = 6mA<br>VDD ≥ 1.71V,  I <sub>OL</sub>   <sub>max</sub> = 2mA |          |     | 0.4 | V    |
| V <sub>OL</sub>  | Low level output voltage  | ODIO                    | VDD ≥ 2.7V, I <sub>OL</sub> <sub>max</sub> = 8mA<br>VDD ≥ 1.71V, I <sub>OL</sub> <sub>max</sub> = 4mA       |          |     | 0.5 | V    |

(1) I/O Types: ODIO = 5V Tolerant Open-Drain, SDIO = Standard-Drive, HSIO = High-Speed

(2) The leakage current is measured with VSS or VDD applied to the corresponding pin(s), unless otherwise noted.

(3) The leakage of the digital port pins is measured individually. The port pin is selected for input and the pullup/pulldown resistor is disabled.

### 7.10.2 Switching Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER                       |                       | TEST CONDITIONS              |                                     | MIN        | TYP | MAX                  | UNIT |
|---------------------------------|-----------------------|------------------------------|-------------------------------------|------------|-----|----------------------|------|
| f <sub>max</sub>                | Port output frequency | SDIO <sup>(1)</sup>          | VDD ≥ 1.71V, C <sub>L</sub> = 20pF  |            |     | 24                   | MHz  |
| f <sub>max</sub>                | Port output frequency | ODIO                         | VDD ≥ 1.71V, FM*, CL = 20pF - 100pF |            |     | 1                    | MHz  |
| t <sub>r</sub> , t <sub>f</sub> | Output rise/fall time | All output ports except ODIO | VDD ≥ 1.71V                         |            |     | 0.3*f <sub>max</sub> | s    |
| t <sub>f</sub>                  | Output fall time      | ODIO                         | VDD ≥ 1.71V, FM*, CL = 20pF-100pF   | 20*VDD/5.5 |     | 120                  | ns   |

(1) I/O Types: ODIO = 5V Tolerant Open-Drain, SDIO = Standard-Drive, HSIO = High-Speed, HDIO = High-Drive

## 7.11 ADC

### 7.11.1 Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted), all TYP values are measured at 25°C and all accuracy parameters are measured using 12-bit resolution mode (unless otherwise noted)

| PARAMETER            |  | TEST CONDITIONS   |  | MIN | TYP  | MAX   | UNIT |
|----------------------|--|---|--|-----|------|-------|------|
| V <sub>IN(ADC)</sub> | Analog input voltage range <sup>(1)</sup>  | Applies to all ADC analog input pins  |  | 0   |      | VDD   | V    |
| V <sub>R+</sub>      | Positive ADC reference voltage             | V <sub>R+</sub> sourced from VDD  |  |     | VDD  |       | V    |
|                      |  | V <sub>R+</sub> sourced from internal reference (VREF)                                      |  |     | VREF |       | V    |
| V <sub>R-</sub>      | Negative ADC reference voltage             |   |  |     | 0    |       | V    |
| F <sub>S</sub>       | ADC sampling frequency                     | RES = 0x0 (12-bit mode), VDD Reference  |  |     |      | 1.5   | Msps |
|                      |  | RES = 0x1 (10-bit mode), VDD Reference  |  |     |      | 1.7   |      |
|                      |  | RES = 0x2 (8-bit mode), VDD Reference   |  |     |      | 2     |      |
| F <sub>S</sub>       | ADC sampling frequency                     | RES = 0x0 (12-bit mode), Internal Reference   |  |     |      | 0.866 | Msps |
|                      |  | RES = 0x1 (10-bit mode), Internal Reference   |  |     |      | 1     |      |
|                      |  | RES = 0x2 (8-bit mode), Internal Reference  |  |     |      | 1.2   |      |
| I <sub>(ADC)</sub>   | Operating supply current into VDD terminal | F <sub>S</sub> = 1.5MSPS, V <sub>R+</sub> = VDD   |  |     | 200  | 220   | μA   |
|                      |  | F <sub>S</sub> = 0.856MSPS, V <sub>R+</sub> = VREF = 2.5V (VREF power consumption included) |  |     | 220  | 250   |      |
| C <sub>S/H</sub>     | ADC sample-and-hold capacitance            |   |  |     | 0.22 |       | pF   |

### 7.11.1 Electrical Characteristics (continued)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted), all TYP values are measured at 25°C and all accuracy parameters are measured using 12-bit resolution mode (unless otherwise noted)

| PARAMETER              |  | TEST CONDITIONS   | MIN  | TYP  | MAX  | UNIT |
|------------------------|--|---|------|------|------|------|
| R <sub>in</sub>        | ADC switch resistance                              |   |      | 25   |      | kΩ   |
| ENOB                   | Effective number of bits                           | VDD reference <sup>(2)</sup>  | 9.3  | 10.4 |      | bit  |
|                        |  | VDD reference with over sampling  |      | 12.2 |      |      |
|                        |  | Internal reference, V <sub>R+</sub> = VREF = 2.5V   | 9.4  | 9.8  |      |      |
| SNR                    | Signal-to-noise ratio                              | VDD reference <sup>(2)</sup>  |      | 64   |      | dB   |
|                        |  | VDD reference with over sampling  |      | 75   |      |      |
|                        |  | Internal reference, V <sub>R+</sub> = VREF = 2.5V   |      | 61   |      |      |
| PSRR <sub>DC</sub>     | Power supply rejection ratio, DC                   | VDD = VDD <sub>(min)</sub> to VDD <sub>(max)</sub><br>Internal reference, V <sub>R+</sub> = VREF = 2.5V |      | 61   |      | dB   |
| T <sub>wakeup</sub>    | ADC Wakeup Time                                    | Assumes internal reference is active  |      |      | 5    | μs   |
| V <sub>SupplyMon</sub> | Supply Monitor voltage divider (VDD/3) accuracy    | ADC input channel: Supply Monitor <sup>(3)</sup>  | -0.6 |      | +2.5 | %    |
| I <sub>SupplyMon</sub> | Supply Monitor voltage divider current consumption | ADC input channel: Supply Monitor   |      | 10   |      | μA   |

- (1) The analog input voltage range must be within the selected ADC reference voltage range V<sub>R+</sub> to V<sub>R-</sub> for valid conversion results.
- (2) VDD reference specifications are measured with V<sub>R+</sub> = VDD = 3.3V and V<sub>R-</sub> = VSS = 0V
- (3) Analog power supply monitor. Analog input on channel 15 is disconnected and is internally connected to the voltage divider which is VDD/3.

### 7.11.2 Switching Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER                     |   | TEST CONDITIONS   | MIN   | TYP | MAX | UNIT          |
|-------------------------------|---|---|-------|-----|-----|---------------|
| f <sub>ADCCLK</sub>           | ADC clock frequency                     |   | 12    |     | 24  | MHz           |
| t <sub>ADC trigger</sub>      | Software trigger minimum width          |   | 3     |     |     | ADCCLK cycles |
| t <sub>Sample_step</sub>      | Sampling time for step input            | 12-bit mode, R <sub>S</sub> = 50Ω, C <sub>pext</sub> = 10pF | 0.166 |     |     | μs            |
| t <sub>Sample_SupplyMon</sub> | Sample time with Supply Monitor (VDD/3) |   | 3     |     |     | μs            |

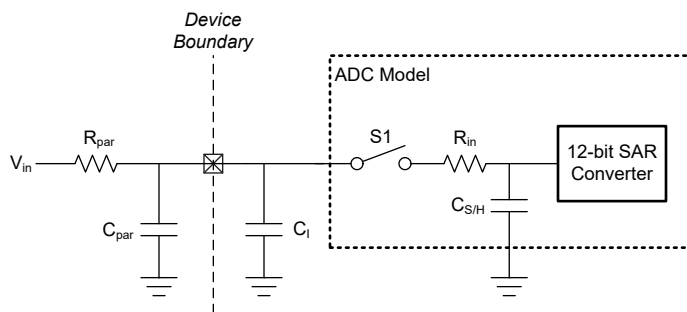
### 7.11.3 Linearity Parameters

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted), all TYP values are measured at 25°C and all linearity parameters are measured using 12-bit resolution mode (unless otherwise noted) <sup>(1)</sup>

| PARAMETER      |                                    | TEST CONDITIONS                      | MIN  | TYP | MAX  | UNIT |
|----------------|------------------------------------|--------------------------------------|------|-----|------|------|
| E <sub>I</sub> | Integral linearity error (INL)     | VDD reference, 10-bit <sup>(2)</sup> | -1.0 |     | +1.0 | LSB  |
|                |                                    | VDD reference, 12-bit <sup>(2)</sup> | -4.0 |     | +4.0 | LSB  |
| E <sub>D</sub> | Differential linearity error (DNL) | VDD reference, 10-bit <sup>(2)</sup> | -1.0 |     | +1.0 | LSB  |
|                |                                    | VDD reference, 12-bit <sup>(2)</sup> | -1.0 |     | +4.0 | LSB  |
| E <sub>O</sub> | Offset error                       | VDD reference, 10-bit <sup>(2)</sup> | -3   |     | 3    | mV   |
|                |                                    | VDD reference, 12-bit <sup>(2)</sup> | -3   |     | 3    | mV   |
| E <sub>G</sub> | Gain error                         | VDD reference, 10-bit <sup>(2)</sup> | -5   |     | 5    | LSB  |
|                |                                    | VDD reference, 12-bit <sup>(2)</sup> | -25  |     | 25   | LSB  |

- (1) Total Unadjusted Error (TUE) can be calculated from E<sub>I</sub>, E<sub>O</sub>, and E<sub>G</sub> using the following formula: TUE = √(E<sub>I</sub><sup>2</sup> + |E<sub>O</sub>|<sup>2</sup> + E<sub>G</sub><sup>2</sup>)  
Note: You must convert all of the errors into the same unit, usually LSB, for the above equation to be accurate
- (2) VDD reference specifications are measured with V<sub>R+</sub> = VDD and V<sub>R-</sub> = VSS = 0V.

### 7.11.4 Typical Connection Diagram



**Figure 7-2. ADC Input Network**

1. Refer to [ADC Electrical Characteristics](#) for the values of  $R_{in}$  and  $C_{S/H}$
2. Refer to [Digital IO Electrical Characteristics](#) for the value of  $C_I$
3.  $C_{par}$  and  $R_{par}$  represent the parasitic capacitance and resistance of the external ADC input circuitry

Use the following equations to solve for the minimum sampling time (T) required for an ADC conversion:

1.  $\tau = (R_{par} + R_{in}) \times C_{S/H} + R_{par} \times (C_{par} + C_I)$
2.  $K = \ln(2^n / \text{Settling error}) - \ln((C_{par} + C_I) / C_{S/H})$
3.  $T (\text{minimum sampling time}) = K \times \tau$

## 7.12 Temperature Sensor

over operating free-air temperature range (unless otherwise noted)

| PARAMETER            |   | TEST CONDITIONS   | MIN  | TYP  | MAX  | UNIT  |
|----------------------|---|---|------|------|------|-------|
| TS <sub>TRIM</sub>   | Factory trim temperature <sup>(1)</sup>         |   | 27   | 30   | 33   | °C    |
| TS <sub>c</sub>      | Temperature coefficient                         |   | -1.9 | -1.8 | -1.7 | mV/°C |
| t <sub>SET, TS</sub> | Temperature sensor settling time <sup>(2)</sup> | ADC and VREF configuration: RES=0 (12-bit mode), VRSEL=2h (VREF=1.4V), ADC CHANNEL=11 |      | 2.5  | 10   | us    |

(1) Higher absolute accuracy may be achieved through user calibration.

(2) This is the minimum required ADC sampling time when measuring the temperature sensor.

## 7.13 VREF

### 7.13.1 Voltage Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER          |  | TEST CONDITIONS | MIN   | TYP | MAX   | UNIT |
|--------------------|--|-----------------|-------|-----|-------|------|
| VDD <sub>min</sub> | Minimum supply voltage needed for VREF operation | BUFCNFIG = 1    | 1.62  |     |       | V    |
|                    |  | BUFCNFIG = 0    | 2.7   |     |       |      |
| VREF               | Voltage reference output voltage                 | BUFCNFIG = 1    | 1.378 | 1.4 | 1.421 | V    |
|                    |  | BUFCNFIG = 0    | 2.462 | 2.5 | 2.541 |      |

### 7.13.2 Electrical Characteristics

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER          |   | TEST CONDITIONS            |                             | MIN | TYP | MAX | UNIT   |
|--------------------|---|----------------------------|-----------------------------|-----|-----|-----|--------|
| I <sub>VREF</sub>  | VREF operating supply current (this spec is an estimation and will be more reliable once the IP is further in the design phase) | BUFCNFIG = {0, 1}, No load | BUFCNFIG = {0, 1}, No load. |     | 80  | 100 | μA     |
| TC <sub>VREF</sub> | Temperature coefficient of VREF <sup>(1)</sup>  | BUFCNFIG = {0, 1}          | BUFCNFIG = {0, 1}           |     |     | 75  | ppm/°C |

### 7.13.2 Electrical Characteristics (continued)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER            |                      | TEST CONDITIONS                                 |   | MIN | TYP | MAX | UNIT |
|----------------------|----------------------|---|---|-----|-----|-----|------|
| TC <sub>drift</sub>  | Long term VREF drift | Time = 1000 hours, BUFCONFIG = {0, 1}, T = 25°C | Time = 1000 hours, BUFCONFIG = {0, 1}, T = 25°C |     |     | 300 | ppm  |
| T <sub>startup</sub> | VREF startup time    | BUFCONFIG = {0, 1}, VDD = 2.7 V                 | BUFCONFIG = {0, 1}, VDD = 2.7 V                 |     |     | 10  | us   |

- (1) The temperature coefficient of the VREF output is the sum of TC<sub>V<sub>R</sub>BUF</sub> and the temperature coefficient of the internal bandgap reference.

## 7.14 I2C

### 7.14.1 I2C Characteristics

over operating free-air temperature range (unless otherwise noted)

| PARAMETERS          |  | TEST CONDITIONS      | Standard mode |      | Fast mode |     | Fast mode plus |      | UNIT |
|---------------------|--|----------------------|---------------|------|-----------|-----|----------------|------|------|
|                     |  |                      | MIN           | MAX  | MIN       | MAX | MIN            | MAX  |      |
| f <sub>I2C</sub>    | I2C input clock frequency                        | I2C in Power Domain0 |               | 24   |           | 24  |                | 24   | MHz  |
| f <sub>SCL</sub>    | SCL clock frequency                              |                      |               | 100  |           | 400 |                | 1000 | kHz  |
| t <sub>HD,STA</sub> | Hold time (repeated) START                       |                      | 4             |      | 0.6       |     | 0.26           |      | us   |
| t <sub>LOW</sub>    | LOW period of the SCL clock                      |                      | 4.7           |      | 1.3       |     | 0.5            |      | us   |
| t <sub>HIGH</sub>   | High period of the SCL clock                     |                      | 4             |      | 0.6       |     | 0.26           |      | us   |
| t <sub>SU,STA</sub> | Setup time for a repeated START                  |                      | 4.7           |      | 0.6       |     | 0.26           |      | us   |
| t <sub>HD,DAT</sub> | Data hold time                                   |                      | 0             |      | 0         |     | 0              |      | ns   |
| t <sub>SU,DAT</sub> | Data setup time                                  |                      | 250           |      | 100       |     | 50             |      | ns   |
| t <sub>SU,STO</sub> | Setup time for STOP                              |                      | 4             |      | 0.6       |     | 0.26           |      | us   |
| t <sub>BUF</sub>    | bus free time between a STOP and START condition |                      | 4.7           |      | 1.3       |     | 0.5            |      | us   |
| t <sub>VD,DAT</sub> | data valid time                                  |                      |               | 3.45 |           | 0.9 |                | 0.45 | us   |
| t <sub>VD,ACK</sub> | data valid acknowledge time                      |                      |               | 3.45 |           | 0.9 |                | 0.45 | us   |

### 7.14.2 I2C Filter

over operating free-air temperature range (unless otherwise noted)

| PARAMETERS      |   | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-----------------|---|-----------------|-----|-----|-----|------|
| f <sub>SP</sub> | Pulse duration of spikes suppressed by input filter | AGFSELx = 0     |     | 11  | 35  | ns   |
| f <sub>SP</sub> | Pulse duration of spikes suppressed by input filter | AGFSELx = 1     |     | 14  | 35  | ns   |
| f <sub>SP</sub> | Pulse duration of spikes suppressed by input filter | AGFSELx = 2     |     | 22  | 60  | ns   |
| f <sub>SP</sub> | Pulse duration of spikes suppressed by input filter | AGFSELx = 3     |     | 35  | 90  | ns   |

### 7.14.3 I<sup>2</sup>C Timing Diagram

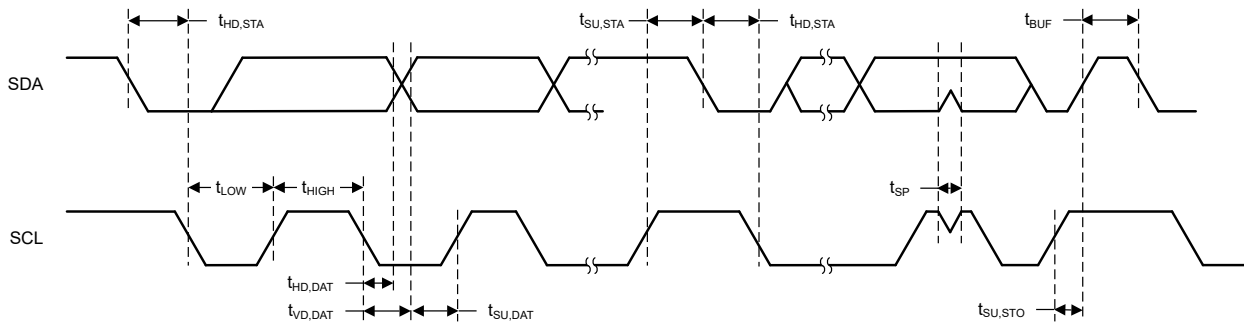


Figure 7-3. I2C Timing Diagram

## 7.15 SPI

### 7.15.1 SPI

over operating free-air temperature range (unless otherwise noted)

| PARAMETERS            |   | TEST CONDITIONS   | MIN                       | TYP                  | MAX                       | UNIT |
|-----------------------|---|---|---------------------------|----------------------|---------------------------|------|
| <b>SPI</b>            |   |   |                           |                      |                           |      |
| f <sub>SPI</sub>      | SPI clock frequency                                 | Clock max speed = 24MHz<br>1.62 < VDD < 3.6V<br>Controller mode |                           |                      | 12                        | MHz  |
| f <sub>SPI</sub>      | SPI clock frequency                                 | Clock max speed = 24MHz<br>1.62 < VDD < 3.6V<br>Peripheral mode |                           |                      | 12                        | MHz  |
| DC <sub>SCK</sub>     | SCK Duty Cycle                                      |   | 40                        | 50                   | 60                        | %    |
| <b>Controller</b>     |   |   |                           |                      |                           |      |
| t <sub>SCLK_H/L</sub> | SCLK High or Low time                               |   | (t <sub>SPI</sub> /2) - 1 | t <sub>SPI</sub> / 2 | (t <sub>SPI</sub> /2) + 1 | ns   |
| t <sub>CS.LEAD</sub>  | CS lead-time, CS active to clock                    |   | 1                         |                      |                           | ns   |
| t <sub>CS.LAG</sub>   | CS lag time, Last clock to CS inactive              |   | 11                        |                      |                           | ns   |
| t <sub>CS.ACC</sub>   | CS access time, CS active to PICO data out          |   |                           |                      | 93                        | ns   |
| t <sub>CS.DIS</sub>   | CS disable time, CS inactive to PICO high impedance |   |                           |                      | 10                        | ns   |
| t <sub>SU.CI</sub>    | POCI input data setup time <sup>(1)</sup>           | 2.7 < VDD < 3.6V, delayed sampling enabled                      | 1                         |                      |                           | ns   |
|                       |   | 1.62 < VDD < 2.7V, delayed sampling enabled                     | 1                         |                      |                           |      |
| t <sub>SU.CI</sub>    | POCI input data setup time <sup>(1)</sup>           | 2.7 < VDD < 3.6V, no delayed sampling                           | 27                        |                      |                           | ns   |
|                       |   | 1.62 < VDD < 2.7V, no delayed sampling                          | 35                        |                      |                           |      |
| t <sub>HD.CI</sub>    | POCI input data hold time                           |   | 9                         |                      |                           | ns   |
| t <sub>VALID.CO</sub> | PICO output data valid time <sup>(2)</sup>          |   |                           |                      | 10                        | ns   |
| t <sub>HD.CO</sub>    | PICO output data hold time <sup>(3)</sup>           |   | 1                         |                      |                           | ns   |
| <b>Peripheral</b>     |   |   |                           |                      |                           |      |
| t <sub>CS.LEAD</sub>  | CS lead-time, CS active to clock                    |   | 8                         |                      |                           | ns   |
| t <sub>CS.LAG</sub>   | CS lag time, Last clock to CS inactive              |   | 0                         |                      |                           | ns   |
| t <sub>CS.ACC</sub>   | CS access time, CS active to POCI data out          |   |                           |                      | 50                        | ns   |
| t <sub>CS.DIS</sub>   | CS disable time, CS inactive to POCI high impedance |   |                           |                      | 50                        | ns   |

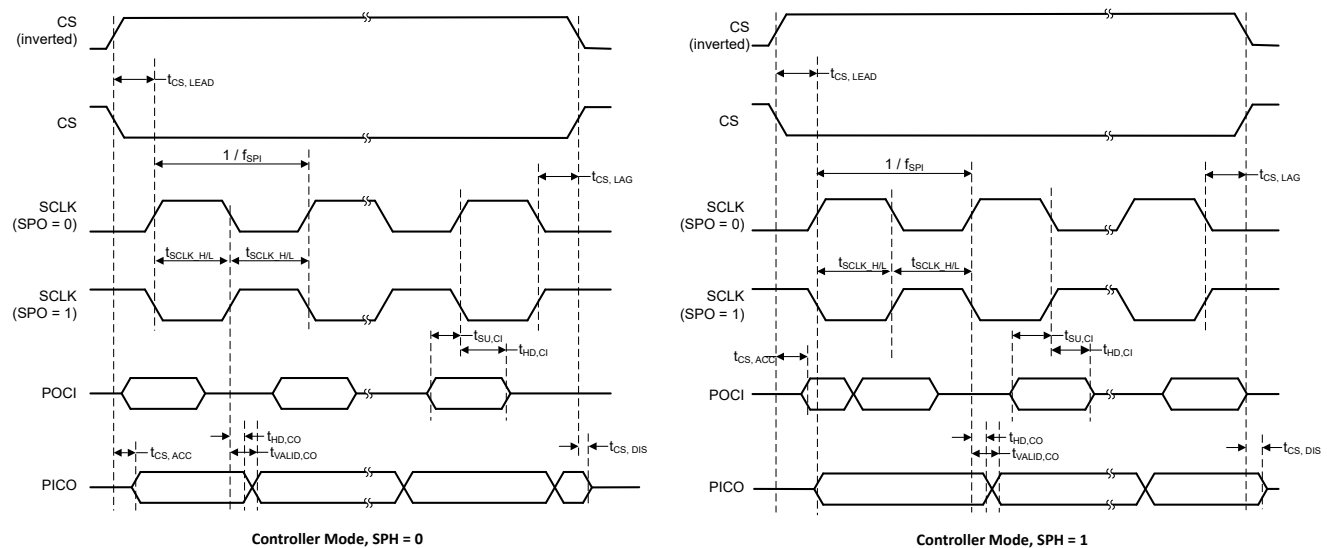
### 7.15.1 SPI (continued)

over operating free-air temperature range (unless otherwise noted)

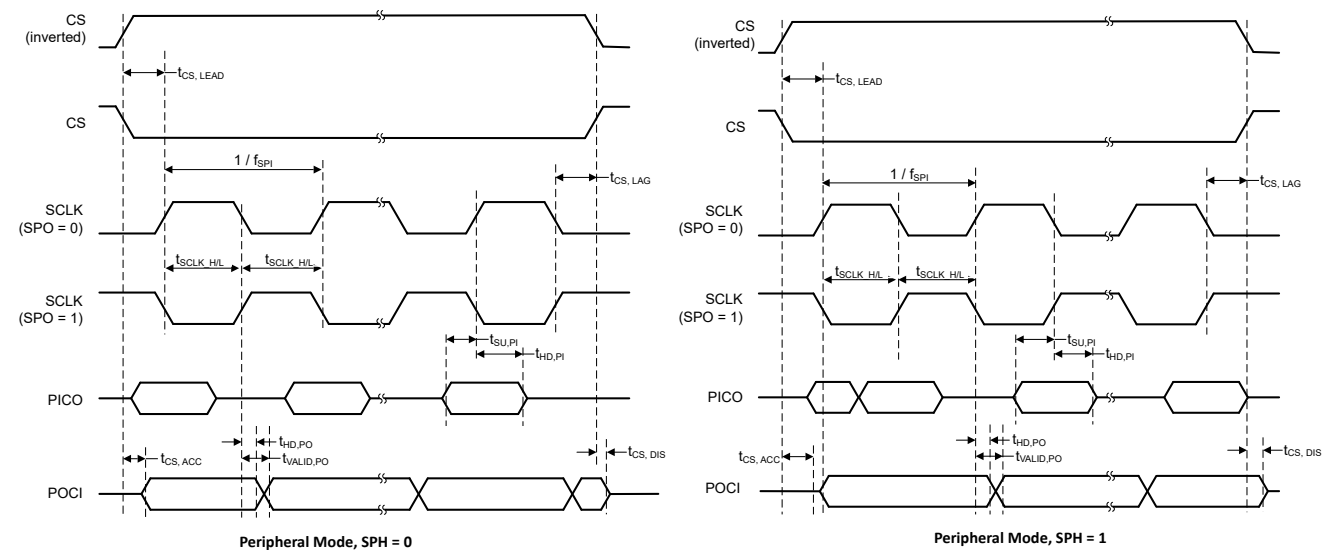
| PARAMETERS     | TEST CONDITIONS                            | MIN | TYP | MAX | UNIT |
|----------------|--|-----|-----|-----|------|
| $t_{SU,PI}$    | PICO input data setup time                 | 2   |     |     | ns   |
| $t_{HD,PI}$    | PICO input data hold time                  | 1   |     |     | ns   |
| $t_{VALID,PO}$ | POCI output data valid time <sup>(2)</sup> |     |     | 34  | ns   |
| $t_{VALID,PO}$ | POCI output data valid time <sup>(2)</sup> |     |     | 41  | ns   |
| $t_{HD,PO}$    | POCI output data hold time <sup>(3)</sup>  | 5   |     |     | ns   |

- (1) The POCI input data setup time can be fully compensated when delayed sampling feature is enabled.  
(2) Specifies the time to drive the next valid data to the output after the output changing SCLK clock edge  
(3) Specifies how long data on the output is valid after the output changing SCLK clock edge

### 7.15.2 SPI Timing Diagrams



**Figure 7-4. SPI Timing Diagram - Controller Mode**



**Figure 7-5. SPI Timing Diagram - Peripheral Mode**

## 7.16 UART

over operating free-air temperature range (unless otherwise noted)

| PARAMETERS          |   | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------|---|-----------------|-----|-----|-----|------|
| $f_{\text{UART}}$   | UART input clock frequency                          |                 |     |     | 24  | MHz  |
| $f_{\text{BITCLK}}$ | BITCLK clock frequency(equals baud rate in MBaud)   |                 |     |     | 3   | MHz  |
| $t_{\text{SP}}$     | Pulse duration of spikes suppressed by input filter | AGFSELx = 0     |     | 11  | 35  | ns   |
|                     |   | AGFSELx = 1     |     | 14  | 35  | ns   |
|                     |   | AGFSELx = 2     |     | 22  | 60  | ns   |
|                     |   | AGFSELx = 3     |     | 35  | 90  | ns   |

## 7.17 TIMx

over operating free-air temperature range (unless otherwise noted)

| PARAMETERS       |                       | TEST CONDITIONS                     | MIN   | TYP | MAX | UNIT                 |
|------------------|-----------------------|-------------------------------------|-------|-----|-----|----------------------|
| $t_{\text{res}}$ | Timer resolution time | $f_{\text{TIMxCLK}} = 24\text{MHz}$ | 41.67 |     |     | ns                   |
|                  |                       |                                     | 1     |     |     | $t_{\text{TIMxCLK}}$ |
| $t_{\text{res}}$ | Timer resolution time | TIMx with 16bit counter             |       |     | 16  | bit                  |

## 7.18 Windowed Watchdog Characteristics

over operating free-air temperature range (unless otherwise noted)

| PARAMETER                |                           | TEST CONDITIONS   | MIN | TYP    | MAX  | UNIT |
|--------------------------|---------------------------|---|-----|--------|------|------|
| WWDT <sub>FREQ</sub>     | WWDT operating frequency  |   |     | 32.768 |      | kHz  |
| WWDT <sub>Tstart</sub>   | WWDT counter start time   | Write to WWDTCTL0 until WWDT counter starts (WWDT <sub>FREQ</sub> = 32.768kHz)    |     |        | 30.5 | μs   |
| WWDT <sub>Trestart</sub> | WWDT counter restart time | Write to WWDCNTRST until WWDT counter restarts (WWDT <sub>FREQ</sub> = 32.768kHz) |     |        | 30.5 | μs   |

## 7.19 Emulation and Debug

### 7.19.1 SWD Timing

over operating free-air temperature range (unless otherwise noted)

| PARAMETER        |               | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------|---------------|-----------------|-----|-----|-----|------|
| $f_{\text{SWD}}$ | SWD frequency |                 |     |     | 10  | MHz  |



## 8 Detailed Description

The following sections describe all of the components that make up the devices in this data sheet. The peripherals integrated into these devices are configured by software through Memory Mapped Registers (MMRs). For more details, see the corresponding chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

### 8.1 CPU

The CPU subsystem (MCPUSS) implements an Arm Cortex-M0+ CPU, a system timer, and interrupt management features. The Arm Cortex-M0+ is a cost-optimized 32-bit CPU that delivers high performance and low power to embedded applications. Key features of the CPU Sub System include:

- Arm Cortex-M0+ CPU supports clock frequencies from 32kHz to 24MHz
  - ARMv6-M Thumb instruction set (little endian) with 32-cycle 32x32 slow multiply instruction
- Nested vectored interrupt controller (NVIC) with 4 programmable priority levels and tail chaining

### 8.2 Operating Modes

MSPM0C MCUs provide five main operating modes (power modes) to allow for optimization of the device power consumption based on application requirements. In order of decreasing power, the modes are: RUN, SLEEP, STOP, STANDBY, and SHUTDOWN. The CPU is active executing code in RUN mode. Peripheral interrupt events can wake the device from SLEEP, STOP, or STANDBY mode to the RUN mode. SHUTDOWN mode completely disables the internal core regulator to minimize power consumption, and wake is only possible via NRST or SWD. RUN, SLEEP, STOP, and STANDBY modes also include several configurable policy options (for example, RUN.x) for balancing performance with power consumption.

To further balance performance and power consumption, MSPM0C devices implement two power domains: **PD1** (for the CPU, memories, and high performance peripherals), and **PD0** (for low speed, low power peripherals).

- **PD1** is always powered in RUN and SLEEP modes, but is disabled in all other modes.
- **PD0** is always powered in RUN, SLEEP, STOP, and STANDBY modes.
- PD1 and PD0 are both disabled in SHUTDOWN mode.

#### 8.2.1 Functionality by Operating Mode (MSPM0C110x)

[Table 8-1](#) lists the supported functionality in each operating mode.

Functional key:

- **EN**: The function is enabled in the specified mode.
- **DIS**: The function is disabled (either clock or power gated) in the specified mode, but the function's configuration is retained.
- **OPT**: The function is optional in the specified mode, and remains enabled if configured to be enabled.
- **NS**: The function is not automatically disabled in the specified mode, but use of the function is not supported.
- **OFF**: The function is fully powered off in the specified mode, and no configuration information is retained.

**Table 8-1. Supported Functionality by Operating Mode**

| Operating Mode |        | RUN  |      |      | SLEEP  |        |        | STOP               |       | STANDBY  |          | SHUTDOWN |
|----------------|--------|------|------|------|--------|--------|--------|--------------------|-------|----------|----------|----------|
|                |        | RUN0 | RUN1 | RUN2 | SLEEP0 | SLEEP1 | SLEEP2 | STOP0              | STOP2 | STANDBY0 | STANDBY1 |          |
| Oscillators    | SYSOSC | EN   | EN   | DIS  | EN     | EN     | DIS    | OPT <sup>(1)</sup> | DIS   | DIS      | DIS      | OFF      |
|                | LFOSC  | EN   |      |      |        |        |        |                    |       |          |          | OFF      |

**Table 8-1. Supported Functionality by Operating Mode (continued)**

| Operating Mode      |                         | RUN        |      |      | SLEEP   |        |        | STOP                    |                         | STANDBY   |                    | SHUTDOWN  |
|---------------------|-------------------------|------------|------|------|---------|--------|--------|-------------------------|-------------------------|-----------|--------------------|-----------|
|                     |                         | RUN0       | RUN1 | RUN2 | SLEEP0  | SLEEP1 | SLEEP2 | STOP0                   | STOP2                   | STANDBY0  | STANDBY1           |           |
| Clocks              | CPUCLK                  | 24M        | 32k  | 32k  | DIS     |        |        |                         |                         |           |                    | OFF       |
|                     | MCLK to PD1             | 24M        | 32k  | 32k  | 24M     | 32k    | 32k    | DIS                     |                         |           |                    | OFF       |
|                     | ULPCLK to PD0           | 24M        | 32k  | 32k  | 24M     | 32k    | 32k    | 4M <sup>(1)</sup>       | 32k                     | DIS       | OFF                |           |
|                     | ULPCLK to TIMG14, TIMG8 | 24M        | 32k  | 32k  | 24M     | 32k    | 32k    | 4M <sup>(1)</sup>       | 32k                     |           | OFF                |           |
|                     | MFCLK                   | OPT        | DIS  |      | OPT     | DIS    |        | OPT                     | DIS                     |           | OFF                |           |
|                     | LFCLK                   | 32k        |      |      |         |        |        |                         |                         |           | DIS                | OFF       |
|                     | LFCLK to TIMG14, TIMG8  | 32k        |      |      |         |        |        |                         |                         |           |                    | OFF       |
|                     | MCLK Monitor            | OPT        |      |      |         |        |        |                         |                         |           | DIS                | OFF       |
| PMU                 | POR Monitor             | EN         |      |      |         |        |        |                         |                         |           |                    |           |
|                     | BOR Monitor             | EN         |      |      |         |        |        |                         |                         |           |                    | OFF       |
|                     | Core Regulator          | Full drive |      |      |         |        |        |                         |                         | Low drive |                    | OFF       |
| Core Functions      | CPU                     | EN         |      |      | DIS     |        |        |                         |                         |           |                    | OFF       |
|                     | DMA                     | OPT        |      |      |         |        |        | NS (triggers supported) |                         |           |                    | OFF       |
|                     | Flash                   | EN         |      |      |         |        |        | OPT                     |                         | DIS       |                    | OFF       |
|                     | SRAM                    | EN         |      |      |         |        |        | OPT                     |                         | DIS       |                    | OFF       |
| PD1 Peripherals     | SPI0                    | OPT        |      |      |         |        |        | DIS                     |                         |           |                    | OFF       |
|                     | CRC                     | OPT        |      |      |         |        |        | DIS                     |                         |           |                    | OFF       |
| PD0 Peripherals     | TIMA0                   | OPT        |      |      |         |        |        |                         |                         |           |                    | OFF       |
|                     | TIMG8                   | OPT        |      |      |         |        |        |                         |                         |           |                    | OFF       |
|                     | TIMG14                  | OPT        |      |      |         |        |        |                         |                         |           |                    | OFF       |
|                     | UART0                   | OPT        |      |      |         |        |        |                         |                         |           | OPT <sup>(2)</sup> | OFF       |
|                     | I2C0                    | OPT        |      |      |         |        |        |                         |                         |           | OPT <sup>(2)</sup> | OFF       |
|                     | GPIOA                   | OPT        |      |      |         |        |        |                         |                         |           | OPT <sup>(2)</sup> | OFF       |
|                     | WWDT0                   | OPT        |      |      |         |        |        |                         |                         |           | DIS                | OFF       |
| Analog              | ADC0                    | OPT        |      |      |         |        |        |                         | NS (triggers supported) |           |                    | OFF       |
|                     | VREF                    | OPT        |      |      |         |        |        |                         | NS                      |           |                    | OFF       |
| IOMUX and IO Wakeup |                         | EN         |      |      |         |        |        |                         |                         |           |                    | DIS       |
| Wake Sources        |                         | N/A        |      |      | ANY IRQ |        |        | PD0 IRQ                 |                         |           |                    | NRST, SWD |

(1) If STOP0 is entered from RUN1 (SYSOSC enabled but MCLK sourced from LFCLK), SYSOSC remains enabled as it was in RUN1, and ULPCLK remains at 32kHz as it was in RUN1. If STOP0 is entered from RUN2 (SYSOSC was disabled and MCLK was sourced from LFCLK), SYSOSC remains disabled as it was in RUN2, and ULPCLK remains at 32kHz as it was in RUN2.

(2) When using the STANDBY1 policy for STANDBY, only TIMG8, TIMG14 and TIMA0 are clocked. Other PD0 peripherals can generate an asynchronous fast clock request upon external activity but are not actively clocked.

### 8.3 Power Management Unit (PMU)

The power management unit (PMU) generates the internally regulated core supplies for the device and provides supervision of the external supply (VDD). The PMU also contains the bandgap voltage reference used by the PMU itself as well as analog peripherals. Key features of the PMU include:

- Power-on reset (POR) supply monitor
- Brown-out reset (BOR) supply monitor with early warning capability using three programmable thresholds

- Core regulator with support for RUN, SLEEP, STOP, and STANDBY operating modes to dynamically balance performance with power consumption
- Parity-protected trim to immediately generate a power-on reset (POR) in the event that a power management trim is corrupted

For more details, see the PMU chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.4 Clock Module (CKM)

The clock module provides the following oscillators:

- **LFOSC**: Internal low-frequency oscillator (32kHz)
- **SYSOSC**: Internal high-frequency oscillator (24MHz)
- **LFCKIN** : low-frequency digital clock input (32KHz)
- **HFCKIN**: high-frequency digital clock input (4 to 24MHz)

The following clocks are distributed by the clock module for use by the processor, bus, and peripherals:

- **MCLK**: Main system clock for PD1 peripherals, derived from SYSOSC or LFCLK, active in RUN and SLEEP modes
- **CPUCLK**: Clock for the processor (derived from MCLK), active in RUN mode
- **ULPCLK**: Ultra-low power clock for PD0 peripherals, active in RUN, SLEEP, STOP, and STANDBY modes
- **MFCLK**: 4MHz fixed mid-frequency clock for peripherals, available in RUN, SLEEP, and STOP modes
- **LFCLK**: 32kHz fixed low-frequency clock for peripherals or MCLK, active in RUN, SLEEP, STOP, and STANDBY modes
- **ADCCLK**: ADC clock, available in RUN, SLEEP and STOP modes
- **CLK\_OUT**: Used to output a clock externally, available in RUN, SLEEP, STOP, and STANDBY modes

For more details, see the CKM chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.5 DMA

The direct memory access (DMA) controller allows movement of data from one memory address to another without CPU intervention. For example, the DMA can be used to move data from ADC conversion memory to SRAM. The DMA reduces system power consumption by allowing the CPU to remain in low power mode, without having to awaken to move data to or from a peripheral.

The DMA in these devices support the following key features:

- 1 DMA transfer channel
- Direct peripheral to DMA trigger is supported only from ADC.
- Byte (8-bit), short word (16-bit), word (32-bit) and long word (64-bit) or mixed byte and word transfer capability
- Transfer counter block size supports up to 64k transfers of any data type
- Configurable DMA transfer trigger selection

[Table 8-2](#) lists the available triggers for the DMA which are configured using the DMATCTL.DMATSEL control bits in the DMA memory mapped registers.

**Table 8-2. DMA Trigger Mapping**

| TRIGGER 0:6 | SOURCE                        |
|-------------|-------------------------------|
| 0           | Software                      |
| 1           | Generic Subscriber 0 (FSUB_0) |
| 2           | Generic Subscriber 1 (FSUB_1) |
| 3           | ADC0 Publisher 2              |

## 8.6 Events

The event manager transfers digital events from one entity (for example, a peripheral) to another (for example, a second peripheral, the DMA or the CPU). The event manager implements event transfer through a defined set of event publishers (generators) and subscribers (receivers) that are interconnected through an event fabric containing a combination of static and programmable routes.

Events that are transferred by the event manager include:

- Peripheral event transferred to the CPU as an interrupt request (IRQ) (Static Event)
  - Example: GPIO interrupt is sent to the CPU
- Peripheral event transferred to the DMA as a DMA trigger (DMA Event)
  - Example: ADC trigger to DMA to request a DMA transfer
- Peripheral event transferred to another peripheral to directly trigger an action in hardware (Generic Event)
  - Example: TIMx timer peripheral publishes a periodic event to the ADC subscriber port, and the ADC uses the event to trigger start-of-sampling

For more details, see the Event chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

**Table 8-3. Generic Event Channels**

A generic route is a point-to-point (1:1) route in which the peripheral publishing the event is configured to use the available generic route channel to publish the event to another entity. An entity can be another peripheral, a generic DMA trigger event, or a generic CPU event.

| CHANID | Generic Route Channel Selection   | Channel Type |
|--------|-----------------------------------|--------------|
| 0      | No generic event channel selected | N/A          |
| 1      | Generic event channel 1 selected  | 1 : 1        |

## 8.7 Memory

### 8.7.1 Memory Organization

[Table 8-4](#) summarizes the memory map of the devices. For more information about the memory region detail, see the *Platform Memory Map* section in the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

**Table 8-4. Memory Organization**

| Memory Region | Subregion         | MSPM0C1103, MSPS003F3                            | MSPM0C1104, MSPS003F4                             |
|---------------|-------------------|--|---|
| Code (Flash)  | Flash             | 8KB <sup>(1)</sup><br>0x0000.0000 to 0x0000.1FFF | 16KB <sup>(1)</sup><br>0x0000.0000 to 0x0000.3FFF |
| SRAM (SRAM)   | SRAM              | 1KB<br>0x2000.0000 to 0x2000.03FF                | 1KB<br>0x2000.0000 to 0x2000.03FF                 |
| Peripheral    | Peripherals       | 0x4000.0000 to 0x40FF.FFFF                       | 0x4000.0000 to 0x40FF.FFFF                        |
|               | Flash             | 0x0040.0000 to 0x0040.1FFF                       | 0x0040.0000 to 0x0040.3FFF                        |
|               | Configuration NVM | 512 bytes<br>0x41C0.0000 to 0x41C0.0200          | 512 bytes<br>0x41C0.0000 to 0x41C0.0200           |
|               | FACTORY           | 0x41C4.0000 to 0x41C4.0080                       | 0x41C4.0000 to 0x41C4.0080                        |
| Subsystem     |                   | 0x6000.0000 to 0x7FFF.FFFF                       | 0x6000.0000 to 0x7FFF.FFFF                        |
| System PPB    |                   | 0xE000.0000 to 0xE00F.FFFF                       | 0xE000.0000 to 0xE00F.FFFF                        |

(1) Up to 100000 program and erase cycles.

### 8.7.2 Peripheral File Map

[Table 8-5](#) lists the available peripherals and the register base address for each.

**Table 8-5. Peripherals Summary**

| PERIPHERAL NAME     | BASE ADDRESS | SIZE   |
|---------------------|--------------|--------|
| VREF                | 0x40030000   | 0x2000 |
| WWDT0               | 0x40080000   | 0x2000 |
| TIMG14              | 0x40084000   | 0x2000 |
| TIMG8               | 0x40090000   | 0x2000 |
| GPIO0               | 0x400A0000   | 0x2000 |
| SYSCTL              | 0x400AF000   | 0x3000 |
| DEBUGSS             | 0x400C7000   | 0x2000 |
| EVENT               | 0x400C9000   | 0x3000 |
| NVMNW               | 0x400CD000   | 0x2000 |
| I2C0                | 0x400F0000   | 0x2000 |
| UART0               | 0x40108000   | 0x2000 |
| MCPUSS              | 0x40400000   | 0x2000 |
| WUC                 | 0x40424000   | 0x1000 |
| IOMUX               | 0x40428000   | 0x2000 |
| DMA                 | 0x4042A000   | 0x2000 |
| CRC                 | 0x40440000   | 0x2000 |
| SPI0                | 0x40468000   | 0x2000 |
| ADC0                | 0x40004000   | 0x2000 |
| TIMA0               | 0x40860000   | 0x2000 |
| ADC0 <sup>(1)</sup> | 0x4055A000   | 0x2000 |

(1) Aliased region of ADC0 memory-mapped registers

### 8.7.3 Peripheral Interrupt Vector

Table 8-6 shows the IRQ number and the interrupt group number for each peripherals. There is only one group GROUP0 in this device.

**Table 8-6. Interrupt Vector Number**

| PERIPHERAL NAME | NVIC IRQ | GROUP0 IIDX |
|-----------------|----------|-------------|
| WWDTO           | 0        | 0           |
| DEBUGSS         | 0        | 2           |
| NVMNW           | 0        | 3           |
| SYSCTL          | 0        | 6           |
| GPIO0           | 1        | -           |
| TIMG8           | 2        | -           |
| ADC             | 4        | -           |
| SPI0            | 9        | -           |
| UART0           | 15       | -           |
| TIMG14          | 16       | -           |
| TIMA0           | 18       | -           |
| I2C0            | 24       | -           |
| DMA             | 31       | -           |

## 8.8 Flash Memory

A single bank of nonvolatile flash memory is provided for storing executable program code and application data.

Key features of the flash include:

- In-circuit program and erase operations supported across the entire recommended supply range
- Small 1KB sector sizes (minimum erase resolution of 1KB)
- Up to 100000 program and erase cycles

For a complete description of the flash memory, see the NVM chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.9 SRAM

MSPM0Cxx MCUs include a low-power high-performance SRAM memory with zero wait state access across the supported CPU frequency range of the device. SRAM memory can be used for storing volatile information such as the call stack, heap, global data, and code. The SRAM memory content is fully retained in RUN, SLEEP, STOP, and STANDBY operating modes and is lost in SHUTDOWN mode. A write protection mechanism is provided to allow the application to dynamically write protect the SRAM memory with 1KB resolution. Write protection is useful when placing executable code into SRAM to provide a level of protection against unintentional overwrites of code by either the CPU or DMA. Placing code in SRAM can improve performance of critical loops by enabling zero wait state operation and lower power consumption.

## 8.10 GPIO

The general purpose input/output (GPIO) peripheral lets the application write data out and read data in through the device pins. Through the use of the Port A GPIO peripheral, these devices support up to 18 GPIO pins.

The key features of the GPIO module include:

- 0 wait state MMR access from CPU
- Set, clear, or toggle multiple bits without the need of a read-modify-write construct in software
- "FastWake" feature enables low-power wakeup from STOP and STANDBY modes for any GPIO port
- User controlled input filtering

## 8.11 IOMUX

The IOMUX peripheral enables IO pad configuration and controls digital data flow to and from the device pins. The key features of the IOMUX include:

- IO pad configuration registers allow for programmable drive strength, speed, pullup or pulldown, and more
- Digital pin muxing allows for multiple peripheral signals to be routed to the same IO pad
- Pin functions and capabilities are user-configured using the PINCM register

For more details, see the IOMUX chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.12 ADC

The 12-bit analog-to-digital converter (ADC) module in these devices support fast 12-bit conversions with single-ended inputs.

ADC features include:

- 12-bit output resolution at up to 1.5-Msps with greater than 10-bit ENOB
- Up to 10 external input channels
- Internal channels for temperature sensing, supply monitoring, and analog signal chain
- Software selectable reference:
  - Configurable internal dedicated ADC reference voltage of 1.4V and 2.5V (VREF)
  - MCU supply voltage (VDD)
- Operates in RUN, SLEEP, and STOP modes and supports triggers from STANDBY mode

**Table 8-7. ADC0 Channel Mapping**

| CHANNEL[0:7] | SIGNAL NAME | CHANNEL[8:15] | SIGNAL NAME                   |
|--------------|-------------|---------------|-------------------------------|
| 0            | A0          | 8             | A8                            |
| 1            | A1          | 9             | A9                            |
| 2            | A2          | 10            | -                             |
| 3            | A3          | 11            | <i>Temperature Sensor</i>     |
| 4            | A4          | 12            | -                             |
| 5            | A5          | 13            | -                             |
| 6            | A6          | 14            | -                             |
| 7            | A7          | 15            | <i>Supply/Battery Monitor</i> |

*Italicized* signal names are internal to the SoC. These signals are used for internal peripheral interconnections.

For more details, see the ADC chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.13 Temperature Sensor

The temperature sensor provides a voltage output that changes linearly with device temperature. The temperature sensor output is internally connected to one of ADC input channels to enable a temperature-to-digital conversion.

A unit-specific single-point calibration value for the temperature sensor is provided in the factory constants memory region. This calibration value represents the ADC conversion result (in ADC code format) corresponding to the temperature sensor being measured in 12-bit mode with the 1.4V internal VREF at the factory trim temperature ( $TS_{TRIM}$ ). This calibration value can be used with the temperature sensor temperature coefficient ( $TS_C$ ) to estimate the device temperature. See the temperature sensor section of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#) for guidance on estimating the device temperature with the factory trim value.

## 8.14 VREF

The voltage reference module (VREF) in these devices contains a configurable voltage reference buffer dedicated for the on-board ADC.

VREF features include:

- 1.4V and 2.5V user-selectable internal references
- Internal reference supports ADC operation up to 1Msps at 10-bit mode

For more details, see the VREF chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.15 CRC

The cyclical redundancy check (CRC) module provides a signature for an input data sequence. Key features of the CRC module include:

- Support for 16-bit CRC based on CRC16-CCITT
- Support for bit reversal

For more details, see the CRC chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.16 UART

The UART peripherals provide the following key features:

- Standard asynchronous communication bits for start, stop, and parity
- Fully programmable serial interface
  - 5, 6, 7, or 8 data bits
  - Even, odd, stick, or no-parity bit generation and detection
  - 1 or 2 stop bit generation
  - Line-break detection
  - Glitch filter on the input signals
  - Programmable baud rate generation with oversampling by 16, 8, or 3
  - Local Interconnect Network (LIN) mode support
- Separated transmit and receive FIFOs
- Support transmit and receive loopback mode operation
- See [Table 8-8](#) for detail information on supported protocols

**Table 8-8. UART Features**

| UART FEATURES                       | UART0 (Extend) |
|-------------------------------------|----------------|
| Active in stop and standby modes    | Yes            |
| Separate transmit and receive FIFOs | Yes            |
| Support hardware flow control       | Yes            |
| Support 9-bit configuration         | Yes            |
| Support LIN mode                    | Yes            |
| Support DALI                        | Yes            |
| Support IrDA                        | Yes            |
| Support ISO7816 Smart Card          | Yes            |
| Support Manchester coding           | Yes            |

For more details, see the UART chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.17 SPI

The serial peripheral interface (SPI) peripherals in these devices support the following key features:



- Support ULPClk/2 bit rate and up to 12 Mbits/s in both controller and peripheral modes
- Configurable as a controller or a peripheral
- Configurable chip select for both controller and peripheral
- Programmable clock prescaler and bit rate
- Programmable data frame size from 4 bits to 16 bits (controller mode)
- Programmable data frame size from 7 bits to 16 bits (peripheral mode)
- Separated transmit and receive FIFOs
- Supports TI mode, Motorola mode, and National Microwire format

For more details, see the SPI chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.18 I2C

The inter-integrated circuit interface (I<sup>2</sup>C) peripherals in these devices provide bidirectional data transfer with other I2C devices on the bus and support the following key features:

- 7-bit and 10-bit addressing mode with multiple 7-bit target addresses
- Multiple-controller transmitter or receiver mode
- Target receiver or transmitter mode with configurable clock stretching
- Support Standard-mode (Sm), with a bit rate up to 100 kbit/s
- Support Fast-mode (Fm), with a bit rate up to 400 kbit/s
- Support Fast-mode Plus (Fm+), with a bit rate up to 1 Mbit/s
- Separated transmit and receive FIFOs
- Support SMBus 3.0 with PEC, ARP, timeout detection, and host support
- Wakeup from low-power mode on address match
- Support analog and digital glitch filter for input signal glitch suppression

For more details, see the I2C chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.19 WWDT

The windowed watchdog timer (WWDT) can be used to supervise the operation of the device, specifically code execution. The WWDT can be used to generate a reset or an interrupt if the application software does not successfully reset the watchdog within a specified window of time. Key features of the WWDT include:

- 25-bit counter
- Programmable clock divider
- Eight software selectable watchdog timer periods
- Eight software selectable window sizes
- Support for stopping the WWDT automatically when entering a sleep mode
- Interval timer mode for applications which do not require watchdog functionality

For more details, see the WWDT chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.20 Timers (TIMx)

The timer peripherals in these devices support the following key features. For specific configuration, see [Table 8-9](#).

Specific features for the **general-purpose timer (TIMGx)** include:

- 16-bit down, up/down, or up counter with repeat-reload mode
- Selectable and configurable clock source
- 8-bit programmable prescaler to divide the counter clock frequency
- Two independent channels for
  - Output compare
  - Input capture

- PWM output
- One-shot mode
- Support quadrature encoder interface (QEI) for positioning and movement sensing
- Support synchronization and cross trigger among different TIMx instances in the same power domain
- Support interrupt trigger generation and cross peripherals (such as ADC) trigger capability
- Cross-trigger event logic for Hall sensor inputs

Specific features for the **advanced timer (TIMAx)** include:

- 16-bit down or up-down counter, with repeat-reload mode
- Selectable and configurable clock source
- 8-bit programmable prescaler to divide the counter clock frequency
- Repeat counter to generate an interrupt or event only after a given number of cycles of the counter
- Up to four independent channels for
  - Output compare
  - Input capture
  - PWM output
  - One-shot mode
- Shadow register for load and CC register available
- Complementary output PWM
- Asymmetric PWM with programmable dead band insertion
- Fault handling mechanism to keep the output signals in a safe user-defined state when a fault condition is encountered
- Support synchronization and cross trigger among different TIMx instances in the same power domain
- Support interrupt trigger generation and cross peripherals (such as ADC) trigger capability
- Two additional capture/compare channels for internal events

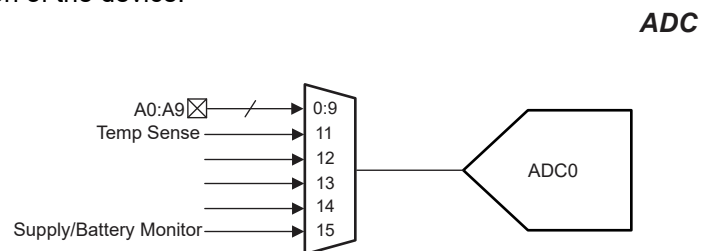
**Table 8-9. TIMx Configurations**

| TIMER NAME | POWER DOMAIN | RESOLUTION | PRESCALER | REPEAT COUNTER | CAPTURE / COMPARE CHANNELS | PHASE LOAD | SHADOW LOAD | SHADOW CC | DEAD-BAND | FAULT | QEI |
|------------|--------------|------------|-----------|----------------|----------------------------|------------|-------------|-----------|-----------|-------|-----|
| TIMG14     | PD0          | 16 bit     | 8 bit     | –              | 4                          | –          | –           | –         | –         | –     | –   |
| TIMG8      | PD0          | 16 bit     | 8 bit     | –              | 2                          | –          | –           | –         | –         | –     | Yes |
| TIMA0      | PD1          | 16 bit     | 8 bit     | 8-bit          | 4                          | Yes        | Yes         | Yes       | Yes       | Yes   | –   |

For more details, see the timer chapters of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

## 8.21 Device Analog Connections

Figure 8-1 shows the internal analog connection of the device.

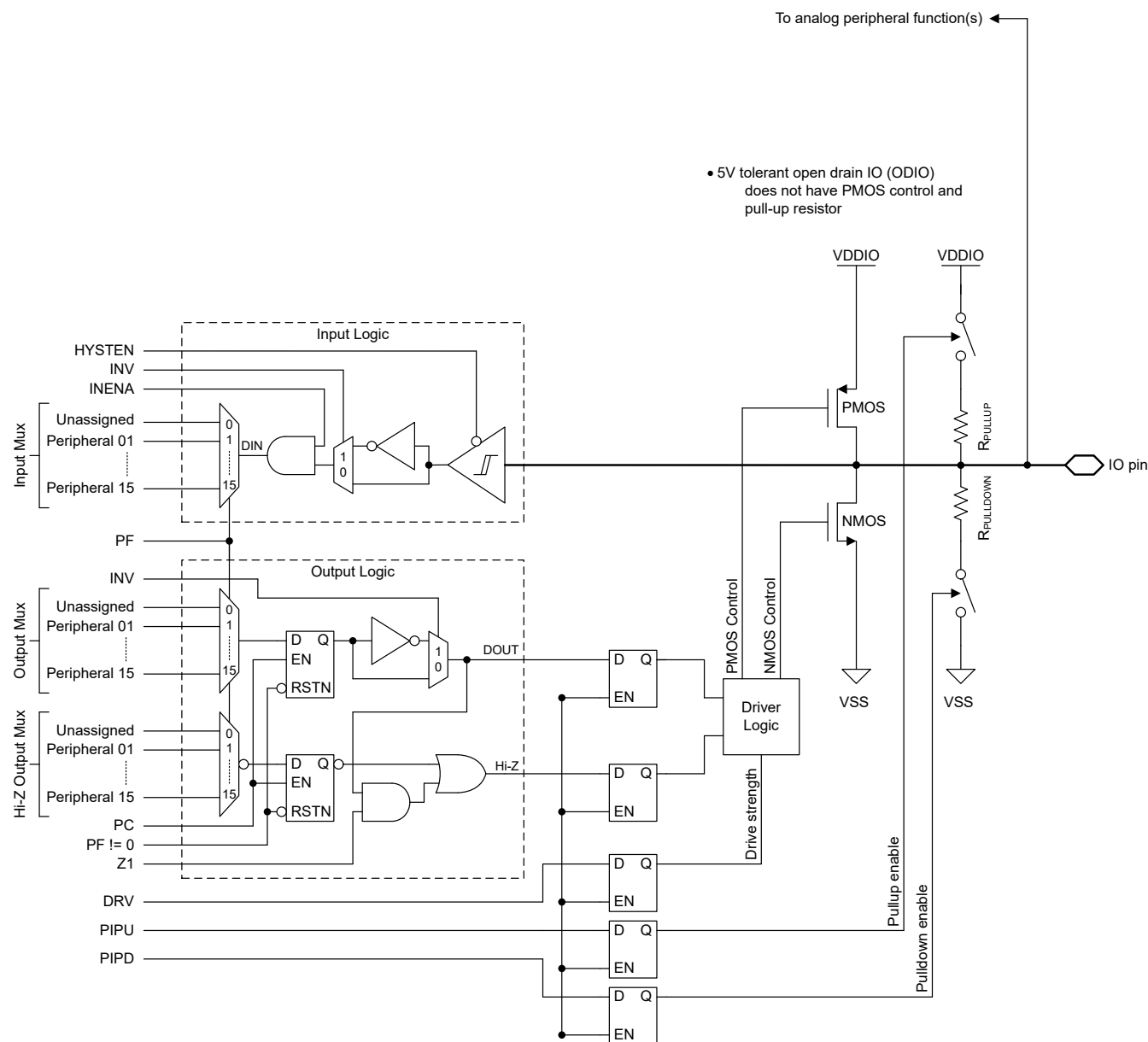


**Figure 8-1. Analog Connections**

## 8.22 Input/Output Diagrams

The IOMUX manages the selection of which peripheral function is to be used on a digital IO and provides the controls for the output driver and input path. For more information, see the IOMUX section of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

The mixed-signal IO pin slice diagram for a full featured IO pin is shown in [Figure 8-2](#). Not all pins have analog functions, drive strength control, and pullup or pulldown resistors available.



**Figure 8-2. Superset Input/Output Diagram**

## 8.23 Serial Wire Debug Interface

A serial wire debug (SWD) two-wire interface is provided via an Arm compatible serial wire debug port (SW-DP) to enable access to multiple debug functions within the device. For a complete description of the debug functionality offered on MSPM0 devices, see the debug chapter of the technical reference manual.

**Table 8-10. Serial Wire Debug Pin Requirements and Functions**

| DEVICE SIGNAL | DIRECTION    | SWD FUNCTION                             |
|---------------|--------------|--|
| SWCLK         | Input        | Serial wire clock from debug probe       |
| SWDIO         | Input/Output | Bi-directional (shared) serial wire data |

## 8.24 Device Factory Constants

All devices include a memory-mapped FACTORY region which provides read-only data describing the capabilities of a device as well as any factory-provided trim information for use by application software. See the *Factory Constants* section of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

**Table 8-11. DEVICEID**

DEVICEID address is 0x41C4.0004, PARTNUM is bit 12 to 27, MANUFACTURER is bit 1 to 11.

| Device     | DEVICEID.PARTNUM | DEVICEID.MANUFACTURER |
|------------|------------------|-----------------------|
| MSPM0C1103 | 0xBBA1           | 0x17                  |
| MSPM0C1104 | 0xBBA1           | 0x17                  |

**Table 8-12. USERID**

USERID address is 0x41C4.0008, PART is bit 0 to 15, VARIANT is bit 16 to 23

| Device            | PART   | VARIANT | Device            | PART   | VARIANT |
|-------------------|--------|---------|-------------------|--------|---------|
| MSPS003F4SPW20R   | 0x57B3 | 0x70    | MSPS003F3SPW20R   | 0xD2B6 | 0x2     |
| MSPM0C1104SDGS20R | 0x57B3 | 0x71    | MSPM0C1103SDGS20R | 0xD2B6 | 0x4     |
| MSPM0C1104SRUKR   | 0x57B3 | 0x73    | MSPM0C1103SRUKR   | 0xD2B6 | 0x7     |
| MSPM0C1104SDYYR   | 0x57B3 | 0x75    | MSPM0C1103SDYYR   | 0xD2B6 | 0xA     |
| MSPM0C1104SDDFR   | 0x57B3 | 0x77    | MSPM0C1103SDDFR   | 0xD2B6 | 0xC     |
| MSPM0C1104SDSGR   | 0x57B3 | 0x79    | MSPM0C1103SDSGR   | 0xD2B6 | 0xE     |

## 8.25 Identification

### Revision and Device Identification

The hardware revision and device identification values are stored in the memory-mapped FACTORY region (see the Device Factory Constants section) which provides read-only data describing the capabilities of a device as well as any factory-provided trim information for use by application software. For more information, see the *Factory Constants* chapter of the [MSPM0 C-Series 24MHz Microcontrollers Technical Reference Manual](#).

The device revision and identification information are also included as part of the top-side marking on the device package. The device-specific errata describes these markings.

## 9 Applications, Implementation, and Layout

### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 9.1 Typical Application

#### 9.1.1 Schematic

TI recommends connecting a combination of a 10- $\mu$ F and a 0.1- $\mu$ F low-ESR ceramic decoupling capacitor to the VDD and VSS pins. Higher-value capacitors can be used but can affect the supply rail ramp-up time. Decoupling capacitors must be placed as close as possible to the pins (within a few millimeters).

PA1 and NRST are double bonded for some variants. If it's used as a NRST, it must connect an external 47-k $\Omega$  pullup resistor with a 10-nF pulldown capacitor.

For 5V-tolerant open drain (ODIO), a pullup resistor is required to output high for I2C and UART functions if the ODIO are used.

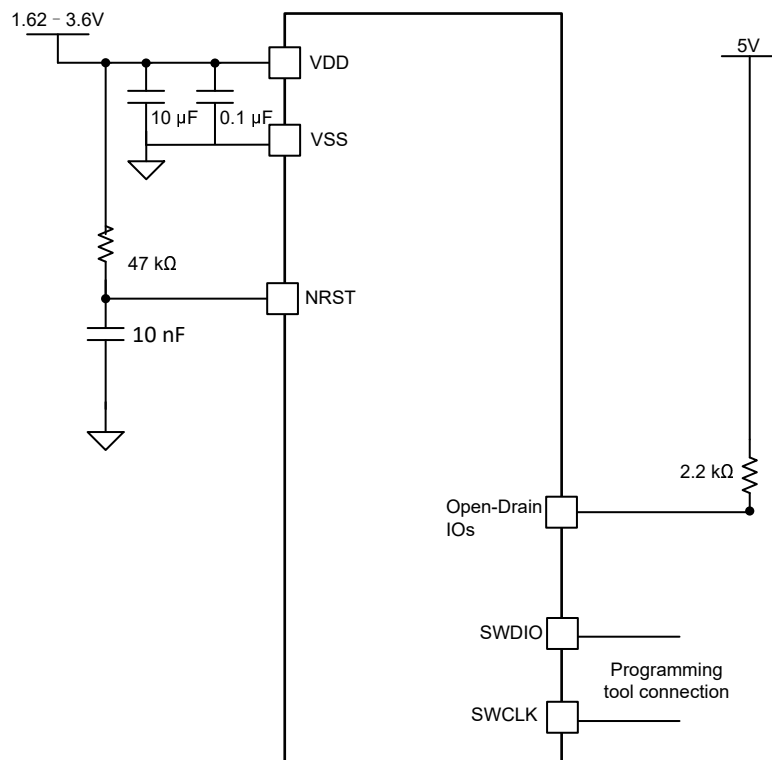


Figure 9-1. Typical Application Schematic

## 10 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

### 10.1 Device Nomenclature

To designate the stages in the product development cycle, TI assigns prefixes to the part numbers of all MSP MCU devices and support tools. Each MSP MCU commercial family member has one of two prefixes: MSP or X. These prefixes represent evolutionary stages of product development from engineering prototypes (X) through fully qualified production devices (MSP).

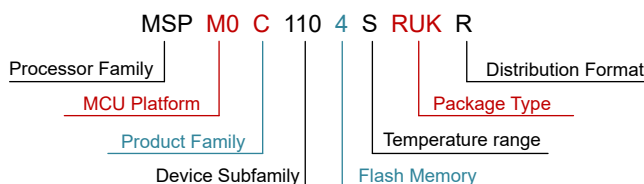
**X** – Experimental device that is not necessarily representative of the final device's electrical specifications

**MSP** – Fully qualified production device

**X** devices are shipped against the following disclaimer:

"Developmental product is intended for internal evaluation purposes." MSP devices have been characterized fully, and the quality and reliability of the device have been demonstrated fully. TI's standard warranty applies. Predictions show that prototype devices (X) have a greater failure rate than the standard production devices. TI recommends that these devices not be used in any production system because their expected end-use failure rate still is undefined. Only qualified production devices are to be used.

TI device nomenclature also includes a suffix with the device family name. This suffix indicates the temperature range, package type, and distribution format. [Figure 10-1](#) provides a legend for reading the complete device name.



**Figure 10-1. Device Nomenclature**

**Table 10-1. Device Nomenclature**

|                            |  |
|----------------------------|--|
| <b>Processor Family</b>    | MSP = Mixed-signal processor<br>X= Experimental silicon  |
| <b>MCU Platform</b>        | M0 = Arm-based 32-bit M0+  |
| <b>Product Family</b>      | C = 24MHz frequency  |
| <b>Device Subfamily</b>    | 110 = ADC  |
| <b>Flash Memory</b>        | 3 = 8KB<br>4 = 16KB  |
| <b>Temperature Range</b>   | S = –40°C to 125°C   |
| <b>Package Type</b>        | See <a href="#">Table 5-1</a> and <a href="http://www.ti.com/packaging">www.ti.com/packaging</a> |
| <b>Distribution Format</b> | T = Small reel<br>R = Large reel<br>No marking = Tube or tray                                    |

For orderable part numbers of MSP devices in different package types, see the Package Option Addendum of this document, [ti.com](http://ti.com), or contact your TI sales representative.

## 10.2 Tools and Software

### Design Kits and Evaluation Modules

#### MSPM0 LaunchPad (LP) Boards: LP-MSPM0C1104

Empowers you to immediately start developing on the industry's best integrated analog and most cost-optimized general purpose MSPM0 MCU family. Exposes all device pins and functionality; includes some built-in circuitry, out-of-box software demos, and on-board XDS110 debug probe for programming, debugging, and EnergyTrace™ technology.

The LP ecosystem includes dozens of [BoosterPack™](#) stackable plug-in modules to extend functionality.

### Embedded Software

#### MSPM0 Software Development Kit (SDK)

Contains software drivers, middleware libraries, documentation, tools, and code examples that create a familiar and easy user experience for all MSPM0 devices.

### Software Development Tools

#### TI Cloud Tools

Start your evaluation and development on a web browser without any installation. Cloud tools also have a downloadable, offline version.

#### TI Resource Explorer SysConfig

Online portal to TI SDKs. Accessible in CCS IDE or in TI Cloud Tools.

Intuitive GUI to configure device and peripherals, resolve system conflicts, generate configuration code, and automate pin mux settings. Accessible in CCS IDE or in TI Cloud Tools. ([offline version](#))

#### MSP Academy

Great starting point for all developers to learn about the MSPM0 MCU Platform with training modules that span a wide range of topics. Part of TIRex.

#### GUI Composer

GUIs that simplify evaluation of certain MSPM0 features, such as configuring and monitoring a fully integrated analog signal chain without any code needed.

### IDE and compiler tool chains

#### Code Composer Studio™ (CCS)

Includes [TI Arm-Clang](#) compiler. Supports all TI Arm Cortex MCUs and boasts competitive code size performance advantages, fast compile time, code coverage support, safety certification support, and completely free to use.

#### IAR Embedded Workbench® IDE

#### Keil® MDK IDE

#### GNU Arm Embedded Tool Chain

## 10.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

## 10.4 Trademarks

LaunchPad™, Code Composer Studio™, TI E2E™, EnergyTrace™, and BoosterPack™ are trademarks of Texas Instruments.

Arm® and Cortex® are registered trademarks of Arm Limited.

All trademarks are the property of their respective owners.



## 10.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## 10.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 11 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from April 3, 2024 to May 24, 2024  | Page |
|---|------|
| <ul style="list-style-type: none"> <li>Changed the status of this data sheet to Production Data; Updates throughout document for final characterization.....</li> </ul> | 1    |

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

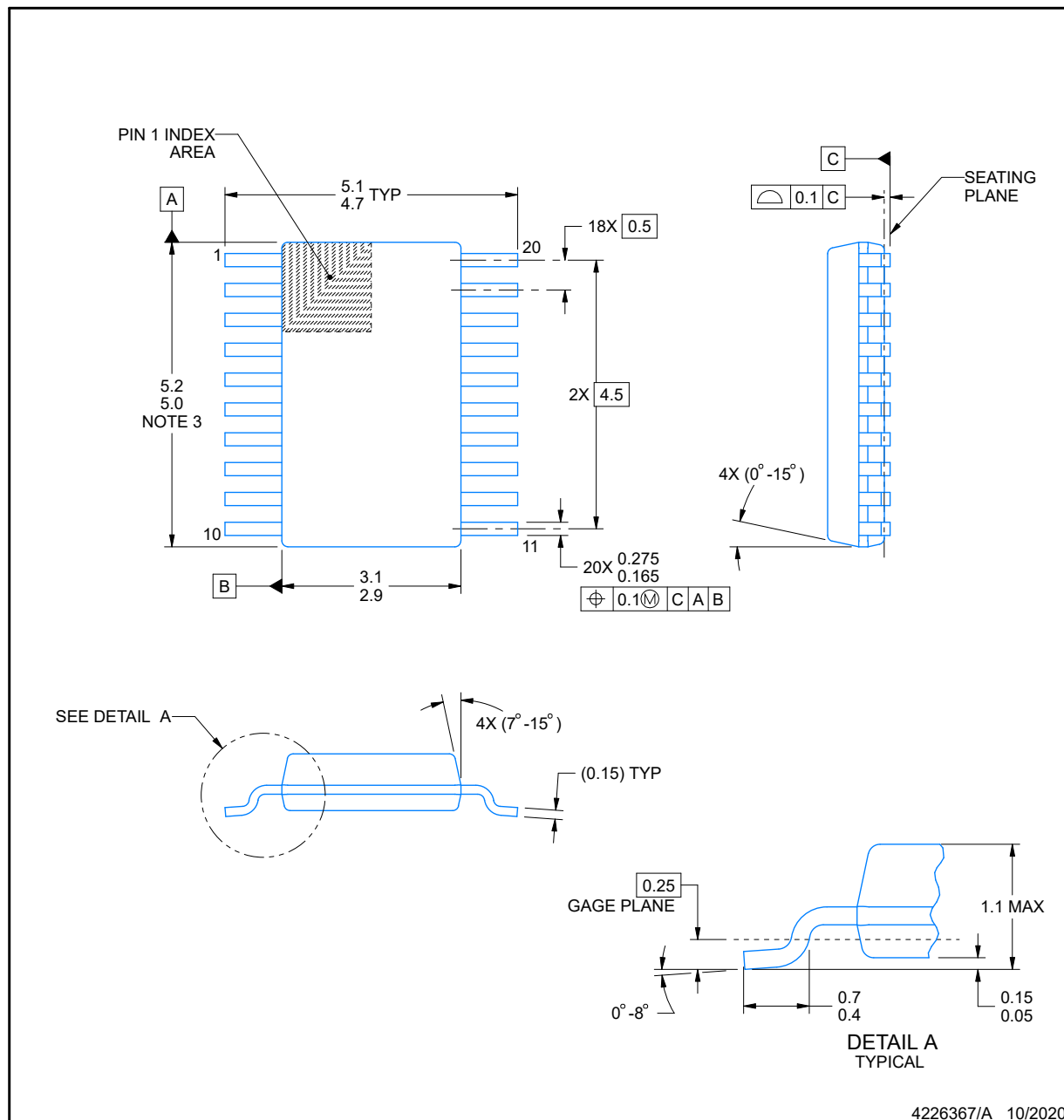


## DGS0020A

## PACKAGE OUTLINE

**VSSOP - 1.1 mm max height**

SMALL OUTLINE PACKAGE



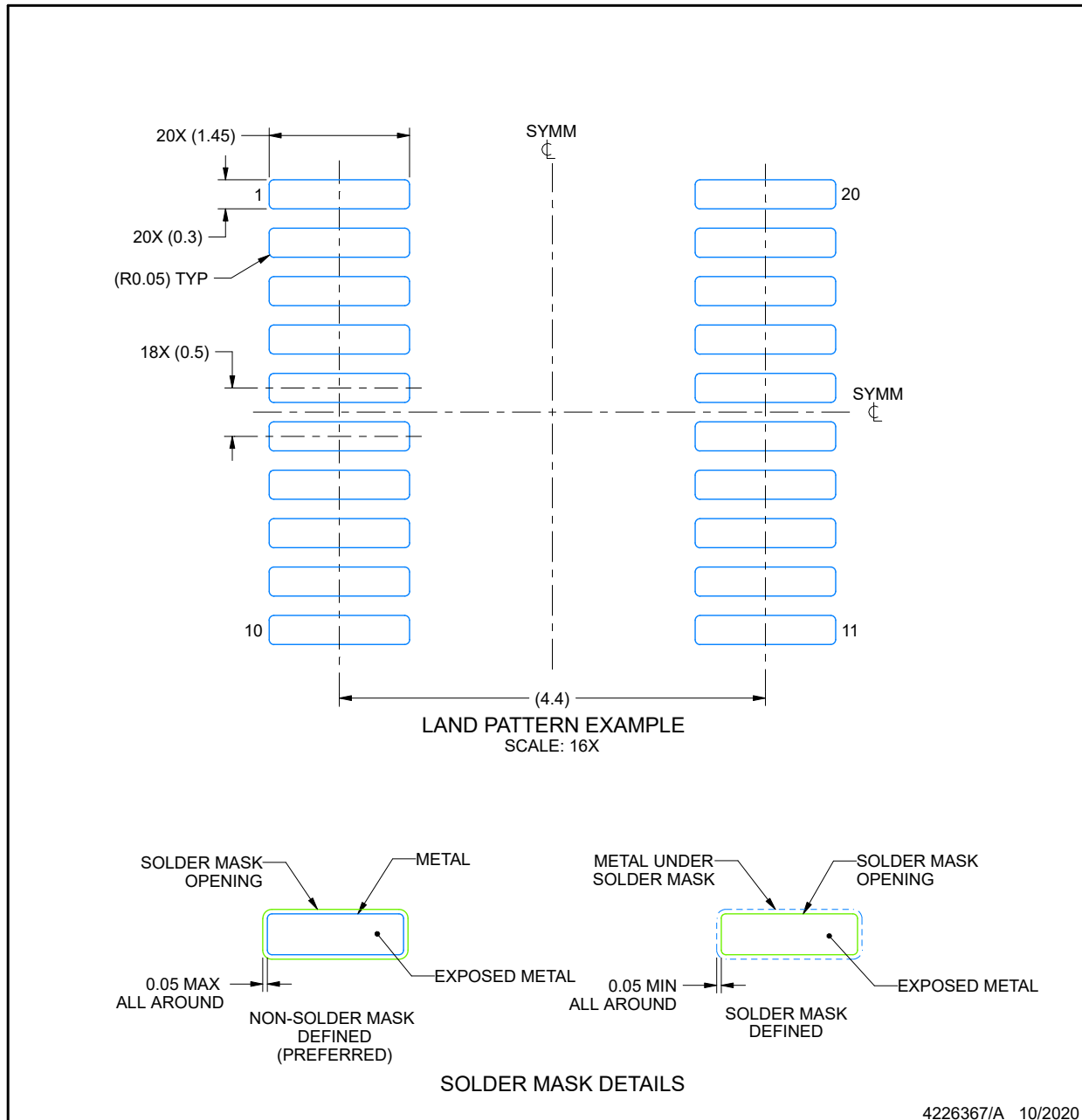
### NOTES:

PowerPAD is a trademark of Texas Instruments.

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. No JEDEC registration as of September 2020.
5. Features may differ or may not be present.

**EXAMPLE BOARD LAYOUT****DGS0020A****VSSOP - 1.1 mm max height**

SMALL OUTLINE PACKAGE



NOTES: (continued)

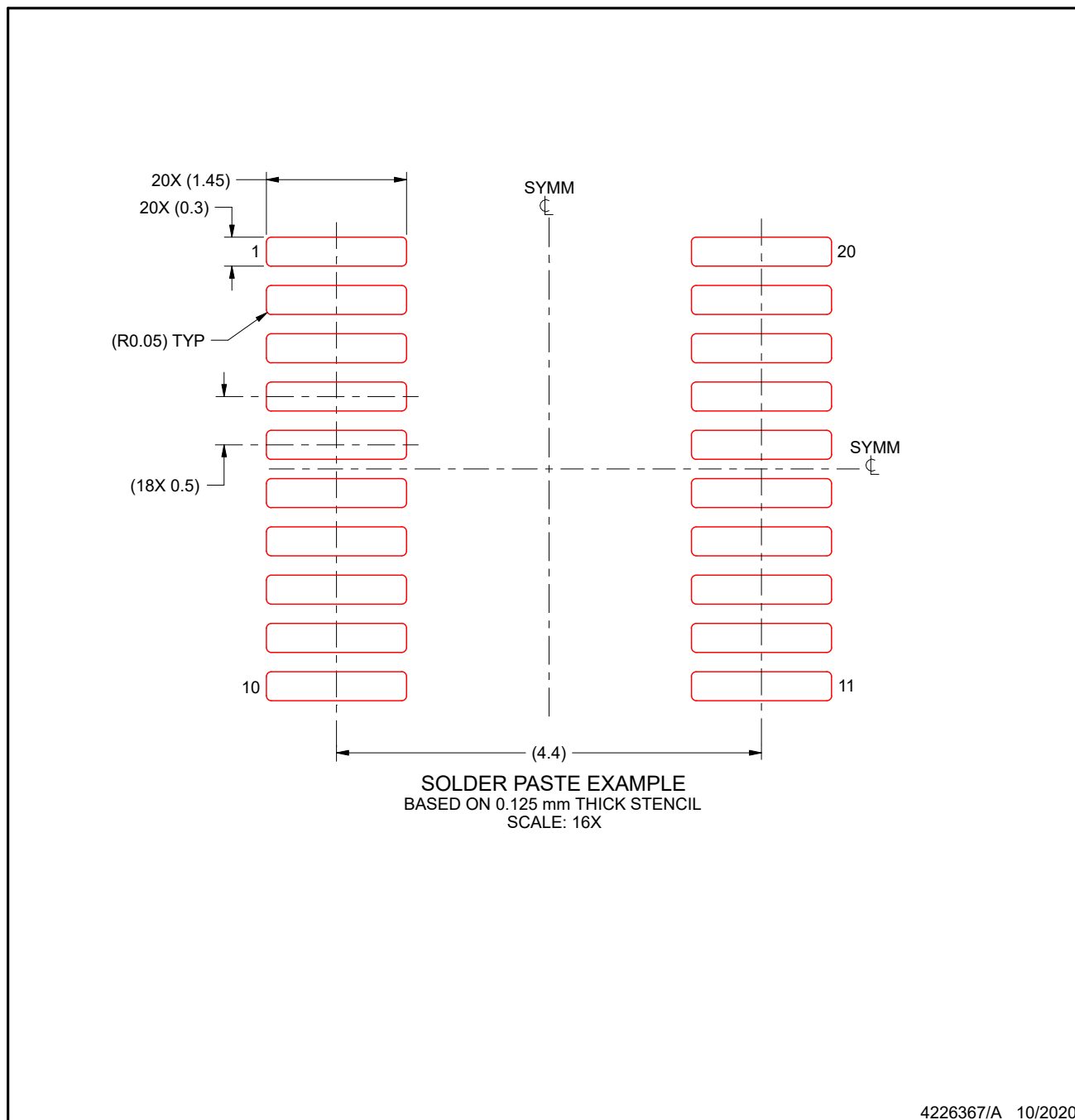
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 ([www.ti.com/lit/slma002](http://www.ti.com/lit/slma002)) and SLMA004 ([www.ti.com/lit/slma004](http://www.ti.com/lit/slma004)).
9. Size of metal pad may vary due to creepage requirement.
10. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.

## EXAMPLE STENCIL DESIGN

**DGS0020A**

**VSSOP - 1.1 mm max height**

SMALL OUTLINE PACKAGE

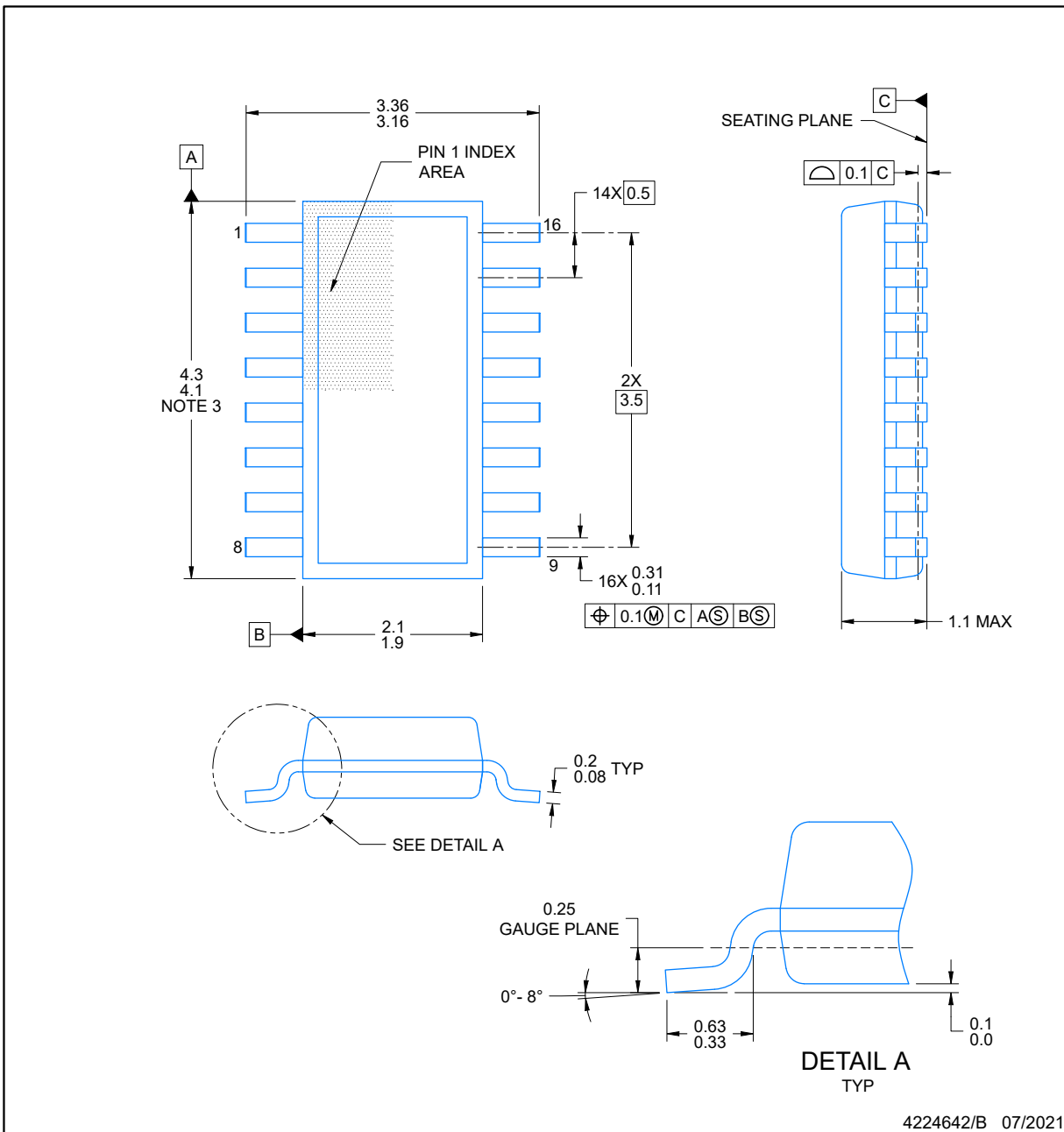


NOTES: (continued)

11. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
12. Board assembly site may have different recommendations for stencil design.

**DYY0016A**
**PACKAGE OUTLINE**  
**SOT-23-THIN - 1.1 mm max height**

PLASTIC SMALL OUTLINE



4224642/B 07/2021

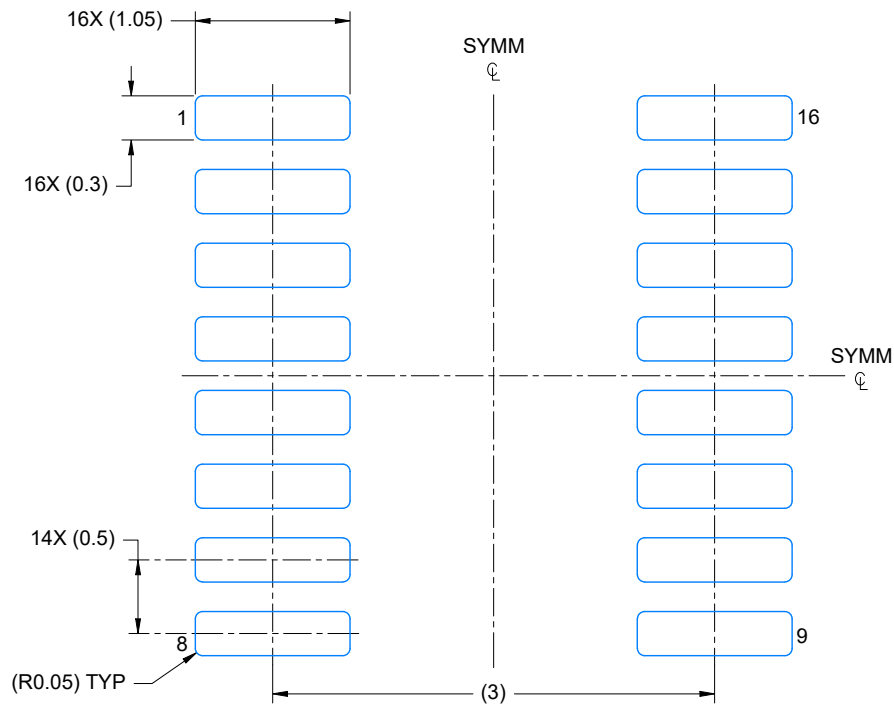
## NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
5. Reference JEDEC Registration MO-345, Variation AA

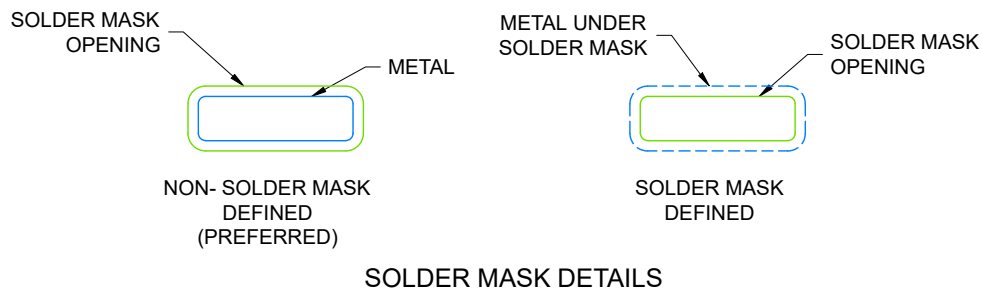
## DYY0016A

## EXAMPLE BOARD LAYOUT SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE



**LAND PATTERN EXAMPLE**  
EXPOSED METAL SHOWN  
SCALE: 20X



4224642/B 07/2021

NOTES: (continued)

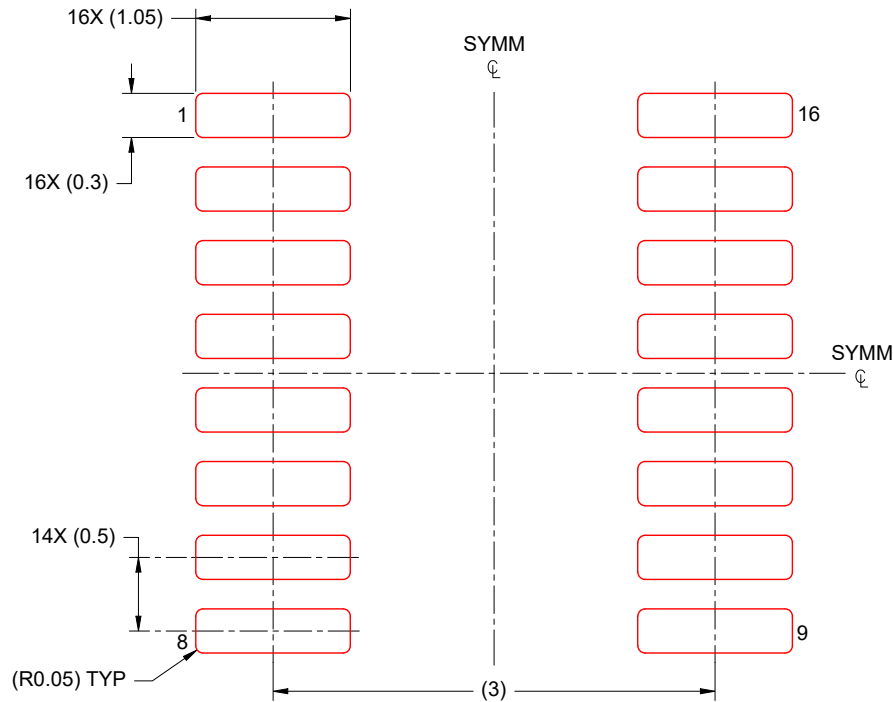
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

### SOT-23-THIN - 1.1 mm max height

DYY0016A

PLASTIC SMALL OUTLINE



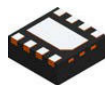
**SOLDER PASTE EXAMPLE**  
 BASED ON 0.125 mm THICK STENCIL  
 SCALE: 20X

4224642/B 07/2021

## NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.



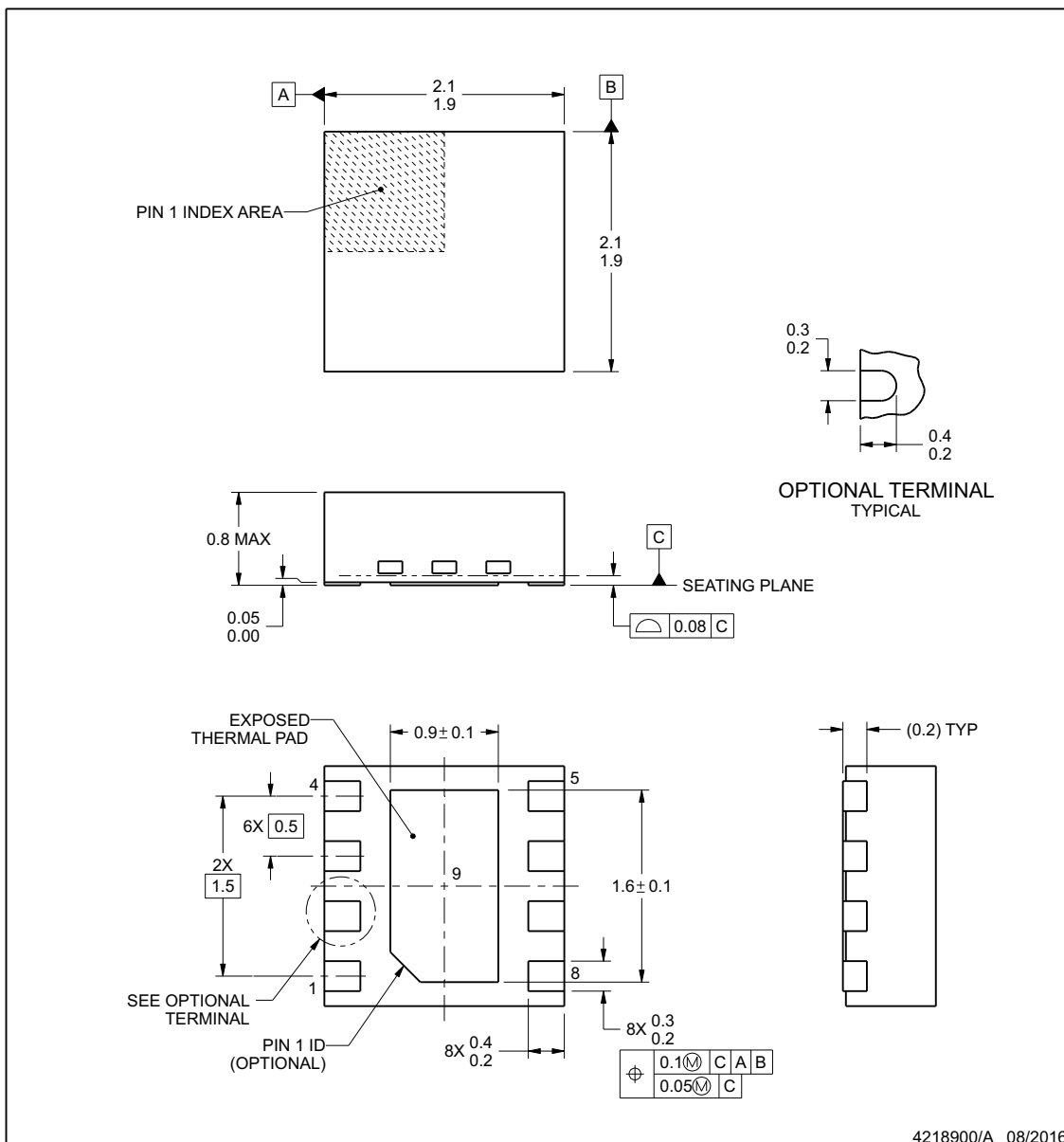


## DSG0008A

## PACKAGE OUTLINE

**WSON - 0.8 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



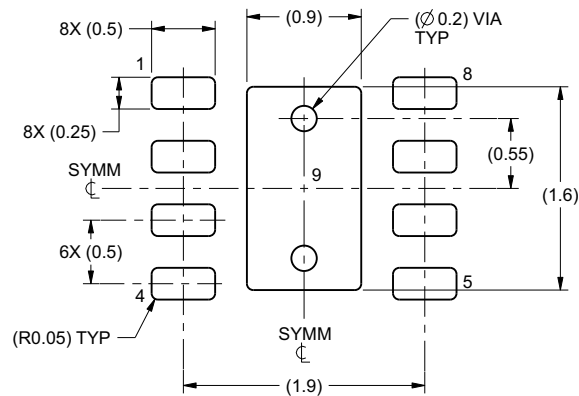
### NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

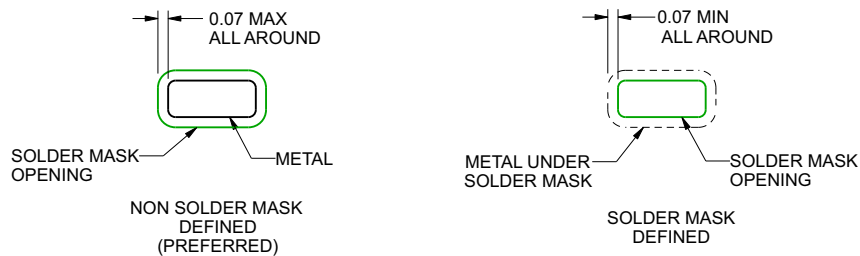
www.ti.com

**EXAMPLE BOARD LAYOUT****DSG0008A****WSN - 0.8 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:20X



SOLDER MASK DETAILS

4218900/A 08/2016

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

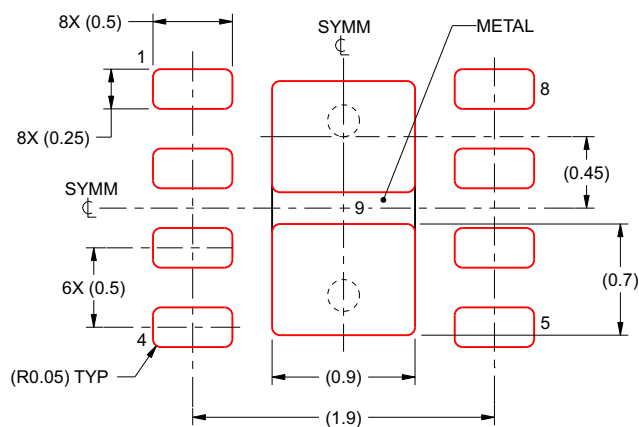
www.ti.com

## EXAMPLE STENCIL DESIGN

**DSG0008A**

**WSN - 0.8 mm max height**

PLASTIC SMALL OUTLINE - NO LEAD



**SOLDER PASTE EXAMPLE**  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 9:  
87% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:25X

4218900/A 08/2016

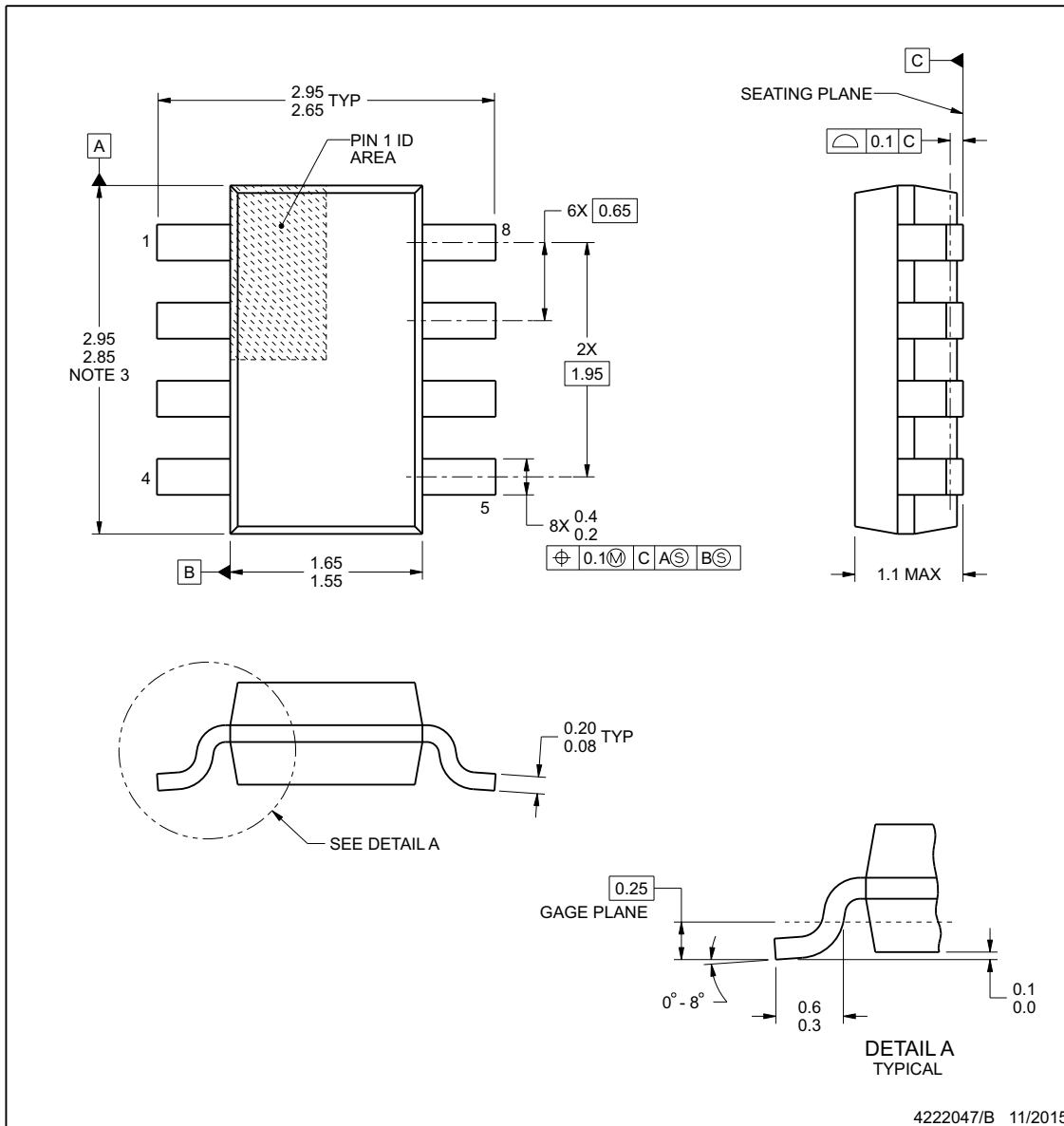
NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

www.ti.com

**DDF0008A**
**PACKAGE OUTLINE**  
**SOT-23 - 1.1 mm max height**

PLASTIC SMALL OUTLINE

**NOTES:**

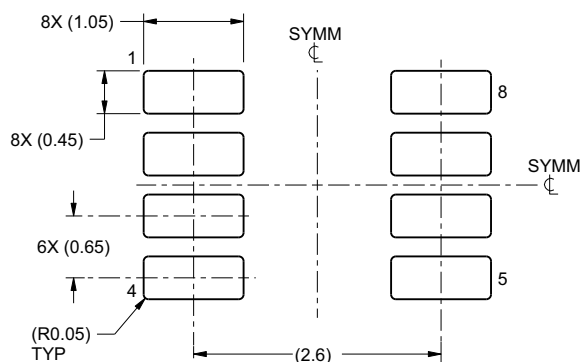
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.

## EXAMPLE BOARD LAYOUT

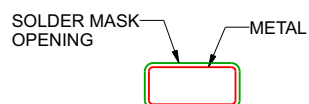
**DDF0008A**

**SOT-23 - 1.1 mm max height**

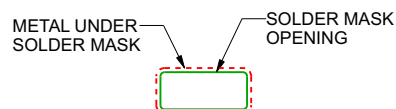
PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE  
SCALE:15X



NON SOLDER MASK  
DEFINED



SOLDER MASK  
DEFINED

SOLDER MASK DETAILS

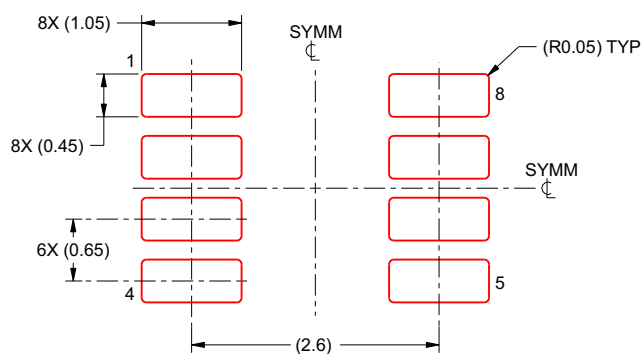
4222047/B 11/2015

NOTES: (continued)

4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

**EXAMPLE STENCIL DESIGN****DDF0008A****SOT-23 - 1.1 mm max height**

PLASTIC SMALL OUTLINE

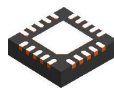


SOLDER PASTE EXAMPLE  
 BASED ON 0.125 mm THICK STENCIL  
 SCALE:15X

4222047/B 11/2015

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
7. Board assembly site may have different recommendations for stencil design.

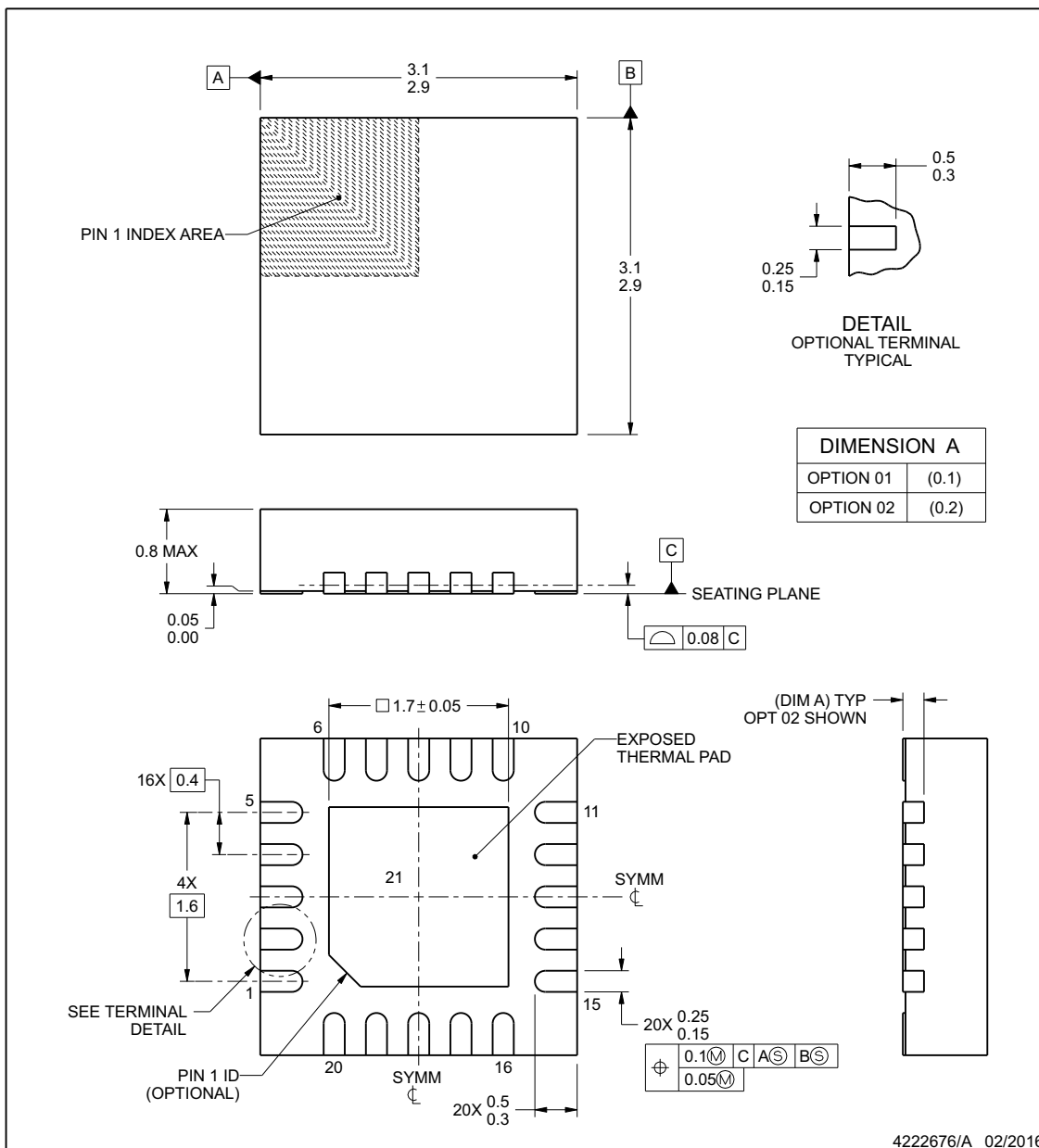


**RUK0020B**

## PACKAGE OUTLINE

**WQFN - 0.8 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



### NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

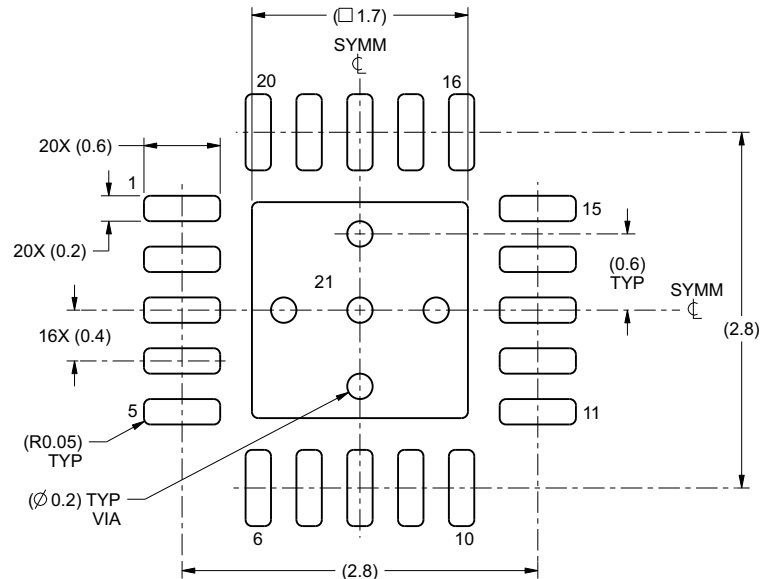
www.ti.com

## EXAMPLE BOARD LAYOUT

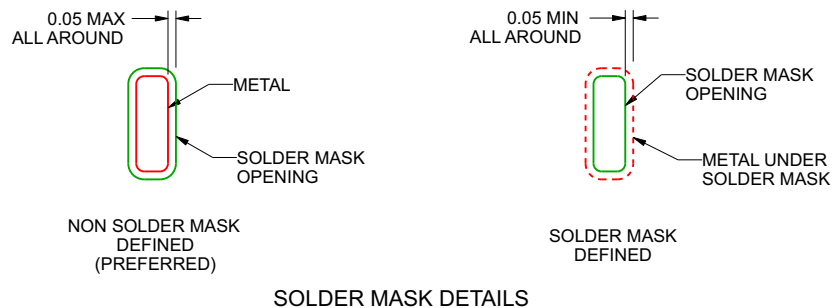
**RUK0020B**

**WQFN - 0.8 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:20X



4222676/A 02/2016

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slue271](http://www.ti.com/lit/slue271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

www.ti.com

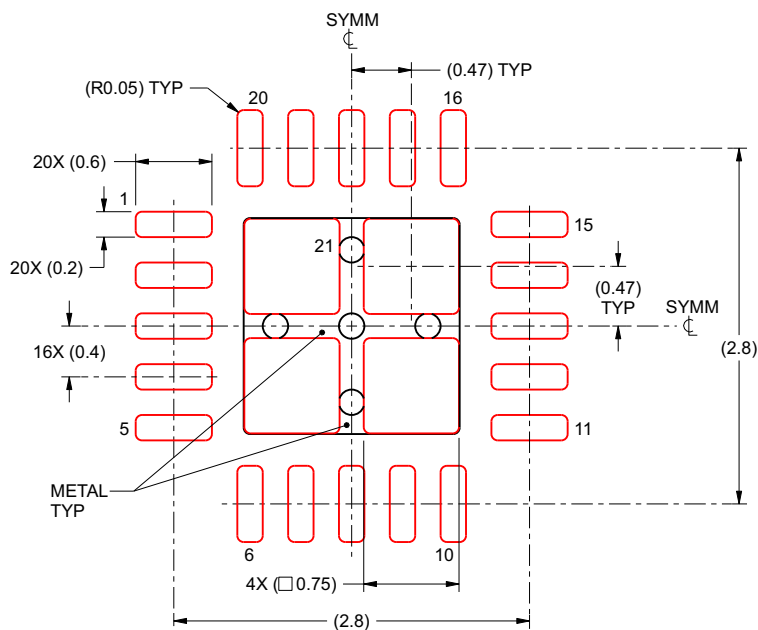


## EXAMPLE STENCIL DESIGN

**RUK0020B**

**WQFN - 0.8 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



**SOLDER PASTE EXAMPLE**  
BASED ON 0.1 mm THICK STENCIL

EXPOSED PAD 21:  
78% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:20X

4222676/A 02/2016

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

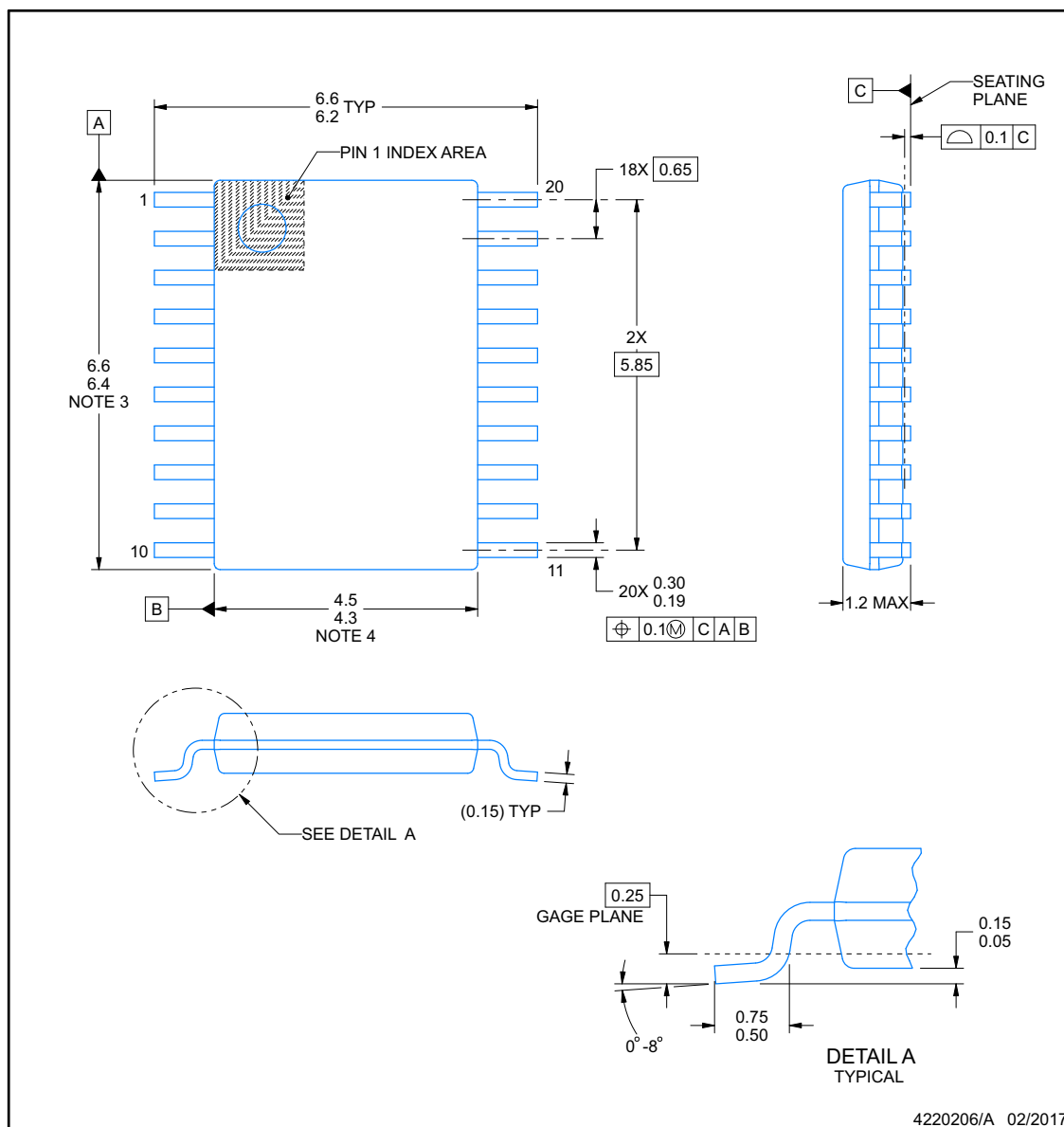
www.ti.com



**PW0020A**

**PACKAGE OUTLINE**  
**TSSOP - 1.2 mm max height**

SMALL OUTLINE PACKAGE



NOTES:

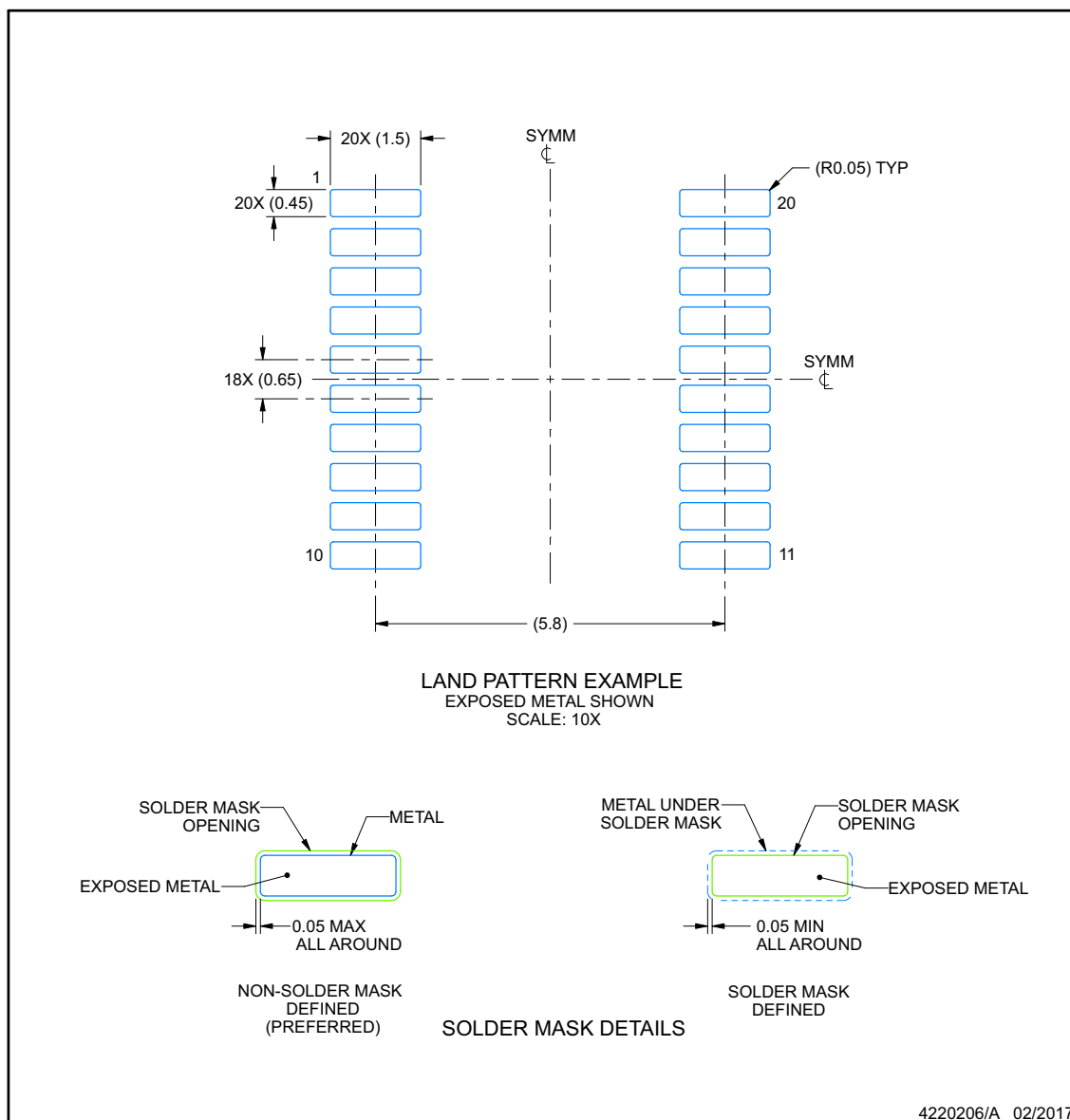
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

## EXAMPLE BOARD LAYOUT

**PW0020A**

**TSSOP - 1.2 mm max height**

SMALL OUTLINE PACKAGE

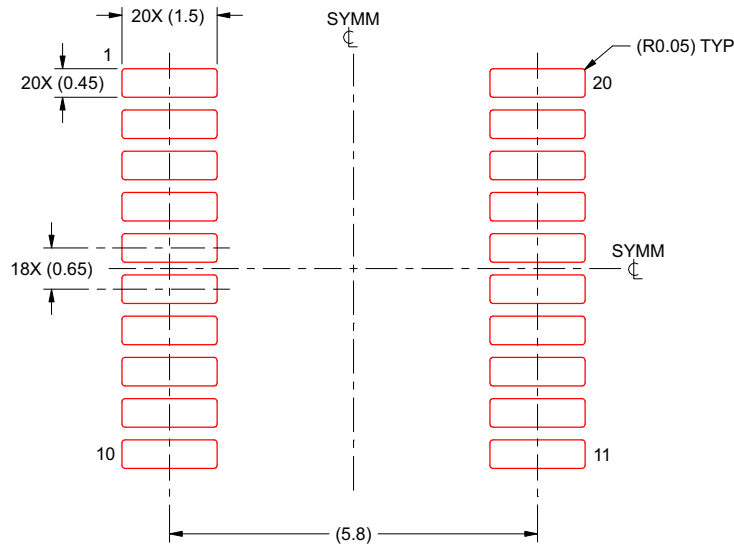


NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

**EXAMPLE STENCIL DESIGN****PW0020A****TSSOP - 1.2 mm max height**

SMALL OUTLINE PACKAGE



**SOLDER PASTE EXAMPLE**  
 BASED ON 0.125 mm THICK STENCIL  
 SCALE: 10X

4220206/A 02/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

## PACKAGING INFORMATION

| Orderable Device  | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|-------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| MSPM0C1103SDDFR   | ACTIVE        | SOT-23-THIN  | DDF             | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | C03S                    | <a href="#">Samples</a> |
| MSPM0C1103SDGS20R | ACTIVE        | VSSOP        | DGS             | 20   | 5000        | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | M0C1103S                | <a href="#">Samples</a> |
| MSPM0C1103SDSGR   | ACTIVE        | WSO          | DSG             | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | C03S                    | <a href="#">Samples</a> |
| MSPM0C1103SDYYR   | ACTIVE        | SOT-23-THIN  | DYY             | 16   | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | M0C1103S                | <a href="#">Samples</a> |
| MSPM0C1103SRUKR   | ACTIVE        | WQFN         | RUK             | 20   | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | C1103S                  | <a href="#">Samples</a> |
| MSPM0C1104SDDFR   | ACTIVE        | SOT-23-THIN  | DDF             | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | C04S                    | <a href="#">Samples</a> |
| MSPM0C1104SDGS20R | ACTIVE        | VSSOP        | DGS             | 20   | 5000        | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | M0C1104S                | <a href="#">Samples</a> |
| MSPM0C1104SDSGR   | ACTIVE        | WSO          | DSG             | 8    | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | C04S                    | <a href="#">Samples</a> |
| MSPM0C1104SDYYR   | ACTIVE        | SOT-23-THIN  | DYY             | 16   | 3000        | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | M0C1104S                | <a href="#">Samples</a> |
| MSPM0C1104SRUKR   | ACTIVE        | WQFN         | RUK             | 20   | 3000        | RoHS & Green    | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | C1104S                  | <a href="#">Samples</a> |
| MSPS003F3SPW20R   | ACTIVE        | TSSOP        | PW              | 20   | 3000        | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | MS003F3                 | <a href="#">Samples</a> |
| MSPS003F4SPW20R   | ACTIVE        | TSSOP        | PW              | 20   | 3000        | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | MS003F4                 | <a href="#">Samples</a> |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

- (3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.
- (4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.
- (5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.
- (6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device            | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| MSPM0C1103SDDFR   | SOT-23-THIN  | DDF             | 8    | 3000 | 180.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| MSPM0C1103SDGS20R | VSSOP        | DGS             | 20   | 5000 | 330.0              | 16.4               | 5.4     | 5.4     | 1.45    | 8.0     | 16.0   | Q1            |
| MSPM0C1103SDSGR   | WSOP         | DSG             | 8    | 3000 | 180.0              | 8.4                | 2.3     | 2.3     | 1.15    | 4.0     | 8.0    | Q2            |
| MSPM0C1103SDYYR   | SOT-23-THIN  | DYY             | 16   | 3000 | 330.0              | 12.4               | 4.8     | 3.6     | 1.6     | 8.0     | 12.0   | Q3            |
| MSPM0C1103SRUKR   | WQFN         | RUK             | 20   | 3000 | 330.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |
| MSPM0C1104SDGS20R | VSSOP        | DGS             | 20   | 5000 | 330.0              | 16.4               | 5.4     | 5.4     | 1.45    | 8.0     | 16.0   | Q1            |
| MSPM0C1104SDSGR   | WSOP         | DSG             | 8    | 3000 | 180.0              | 8.4                | 2.3     | 2.3     | 1.15    | 4.0     | 8.0    | Q2            |
| MSPM0C1104SDYYR   | SOT-23-THIN  | DYY             | 16   | 3000 | 330.0              | 12.4               | 4.8     | 3.6     | 1.6     | 8.0     | 12.0   | Q3            |
| MSPM0C1104SRUKR   | WQFN         | RUK             | 20   | 3000 | 330.0              | 12.4               | 3.3     | 3.3     | 1.1     | 8.0     | 12.0   | Q2            |
| MSPS003F3SPW20R   | TSSOP        | PW              | 20   | 3000 | 330.0              | 16.4               | 6.95    | 7.0     | 1.4     | 8.0     | 16.0   | Q1            |
| MSPS003F4SPW20R   | TSSOP        | PW              | 20   | 3000 | 330.0              | 16.4               | 6.95    | 7.0     | 1.4     | 8.0     | 16.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device            | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| MSPM0C1103SDDFR   | SOT-23-THIN  | DDF             | 8    | 3000 | 210.0       | 185.0      | 35.0        |
| MSPM0C1103SDGS20R | VSSOP        | DGS             | 20   | 5000 | 353.0       | 353.0      | 32.0        |
| MSPM0C1103SDSGR   | WSON         | DSG             | 8    | 3000 | 210.0       | 185.0      | 35.0        |
| MSPM0C1103SDYYR   | SOT-23-THIN  | DYY             | 16   | 3000 | 336.6       | 336.6      | 31.8        |
| MSPM0C1103SRUKR   | WQFN         | RUK             | 20   | 3000 | 367.0       | 367.0      | 35.0        |
| MSPM0C1104SDGS20R | VSSOP        | DGS             | 20   | 5000 | 353.0       | 353.0      | 32.0        |
| MSPM0C1104SDSGR   | WSON         | DSG             | 8    | 3000 | 210.0       | 185.0      | 35.0        |
| MSPM0C1104SDYYR   | SOT-23-THIN  | DYY             | 16   | 3000 | 336.6       | 336.6      | 31.8        |
| MSPM0C1104SRUKR   | WQFN         | RUK             | 20   | 3000 | 367.0       | 367.0      | 35.0        |
| MSPS003F3SPW20R   | TSSOP        | PW              | 20   | 3000 | 353.0       | 353.0      | 32.0        |
| MSPS003F4SPW20R   | TSSOP        | PW              | 20   | 3000 | 353.0       | 353.0      | 32.0        |



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