

# MSP430F5510、MSP430F550x 混合信号微控制器

## 1 器件概述

### 1.1 特性

- 低电源电压范围：  
3.6V 到 1.8V
- 超低功耗
  - 激活模式 (AM)
    - 所有系统时钟激活
      - 在 8MHz, 3V, 闪存程序执行时为  
195μA/MHz (典型值)
      - 在 8MHz, 3V, RAM 程序执行时为  
115μA/MHz (典型值)
  - 待机模式 (LPM3)
    - 实时时钟 (RTC) (采用晶振)、看门狗和电源  
监控器工作, 完全 RAM 保持, 快速唤醒:  
2.2V 时为 1.9μA, 3V 时为 2.1μA (典型值)
    - 低功耗振荡器 (VLO)、通用计数器、看门狗和  
电源监控器工作, 完全 RAM 保持、快速唤  
醒:  
3V 时为 1.4μA (典型值)
  - 关闭模式 (LPM4)
    - 完全 RAM 保持, 电源监控器工作, 快速唤醒:  
3V 时为 1.1μA (典型值)
  - 关断模式 (LPM4.5)
    - 3V 时为 0.18μA (典型值)
- 可在不到 5μs 的时间内从待机模式唤醒
- 16 位精简指令集计算机 (RISC) 架构, 扩展内存,  
高达 25MHz 的系统时钟
- 灵活的电源管理系统
  - 内置可编程的低压降稳压器 (LDO)
  - 电源电压监控、监视和临时限电
- 统一时钟系统
  - 针对频率稳定的锁相环 (FLL) 控制环路
  - 低功耗低频内部时钟源 (VLO)
  - 低频修整内部基准源 (REFO)
- 32kHz 手表晶振 (XT1)
- 高达 32MHz 的高频晶振 (XT2)
- 具有 5 个捕捉/比较寄存器的 16 位定时器  
TA0, Timer\_A
- 具有 3 个捕捉/比较寄存器的 16 位定时器  
TA1, Timer\_A
- 具有 3 个捕捉/比较寄存器的 16 位定时器  
TA2, Timer\_A
- 具有 7 个捕捉/比较影子寄存器的 16 位定时器  
TB0, Timer\_B
- 两个通用串行通信接口 (USCI)
  - USCI\_A0 和 USCI\_A1 均支持:
    - 具有自动波特率检测功能的增强型通用异步收  
发器 (UART)
    - IrDA 编码和解码
    - 同步串行外设接口 (SPI)
  - USCI\_B0 和 USCI\_B1 每个都支持:
    - I<sup>2</sup>C
    - 同步串行外设接口 (SPI)
- 全速通用串行总线 (USB)
  - 集成的 USB - 物理层 (PHY)
  - 集成 3.3V 和 1.8V USB 电源系统
  - 集成 USB- 锁相环 (PLL)
  - 8 输入和 8 输出端点
- 具有窗口比较器的 10 位模数转换器 (ADC)
- 比较器
- 硬件乘法器支持 32 位运算
- 串行板上编程, 无需外部编程电压
- 3 通道内部直接内存访问 (DMA)
- 具有 RTC 特性的基本计时器
- [器件比较](#) 汇总了可用的产品系列成员

### 1.2 应用范围

- 模拟和数字传感器系统
- 数据记录器
- 与 USB 主机的互连
- 无线耳机

### 1.3 说明

TI MSP 系列超低功耗微控制器种类繁多, 各成员器件配备不同的外设集以满足各类应用。此架构与多种低功耗模式配合使用, 是延长便携式测量应用电池寿命的最优选择。该器件具有一个强大的 16 位精简指令集 (RISC) CPU, 使用 16 位寄存器以及常数发生器, 以便获得最高编码效率。此数控振荡器 (DCO) 可使器件在不到 5μs 的时间内从低功耗模式唤醒至激活模式。

MSP430F5510、MSP430F5509 和 MSP430F5508 器件为微控制器配置, 具有支持 USB 2.0 的集成 USB 和 PHY、4 个 16 位计时器、1 个高性能 10 位 ADC、2 个 USCI<sup>(1)</sup>、1 个硬件乘法器、DMA、具有警报功能的 RTC 模块以及 31 或 47 个 I/O 引脚。

(1) 在 48 引脚封装内, USCI 功能是否可用取决于用户使用端口映射控制器对端口 4 进行的配置。可能无法同时实现全部功能。



MSP430F5507、MSP430F5506、MSP430F5505 和 MSP430F5504 器件属于微控制器，配有支持 USB 2.0 的集成 USB 和 PHY、四个 16 位定时器、一个高性能 10 位 ADC、一个 USCI、一个硬件乘法器、DMA、具有报警功能的 RTC 模块以及 31 个 I/O 引脚。

MSP430F5503、MSP430F5502、MSP430F5501 和 MSP430F5500 器件的外设与 MSP430F5507、MSP430F5506、MSP430F5505 和 MSP430F5504 器件几乎相同，只是其中的 10 位 ADC 替换成了比较器。

典型应用包括需要与多种 USB 主机连接的模拟和数字传感器系统和数据记录器。

要获得完整的模块说明，请参阅《MSP430F5xx 和 MSP430F6xx 系列用户指南》

器件信息<sup>(1)</sup>

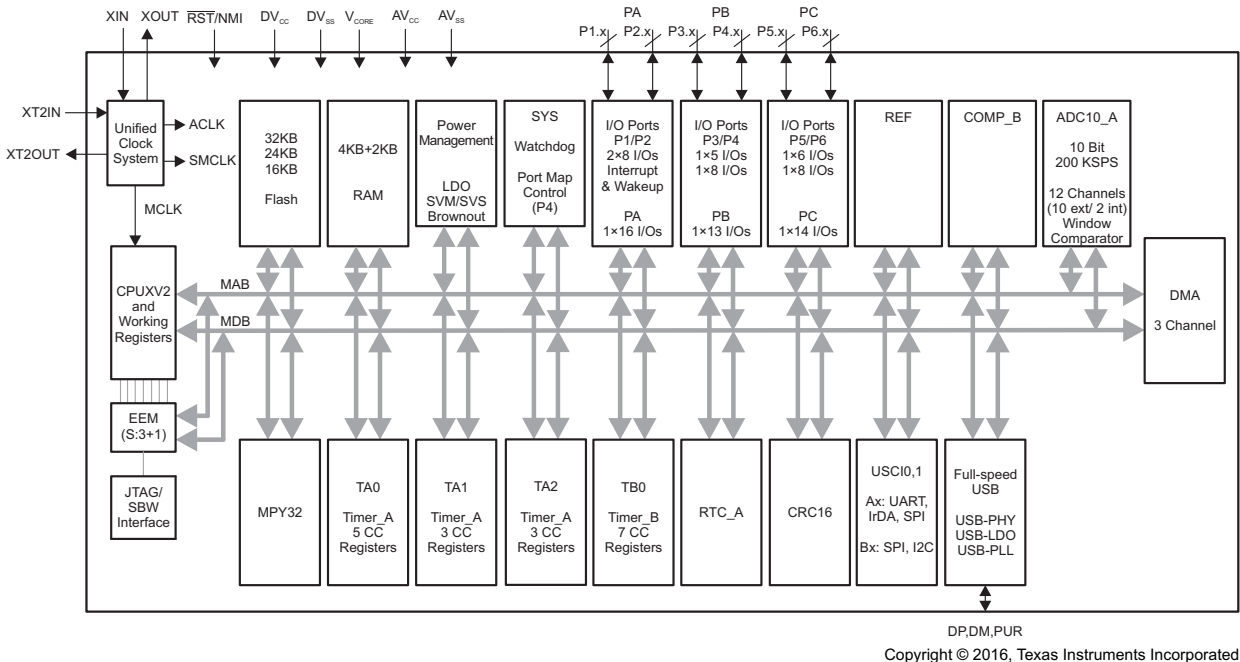
| 器件型号            | 封装        | 封装尺寸 <sup>(2)</sup> |
|-----------------|-----------|---------------------|
| MSP430F5510IRGC | VQFN (64) | 9mm x 9mm           |
| MSP430F5510IZQE | BGA (80)  | 5mm x 5mm           |
| MSP430F5510IPT  | LQFP (48) | 7mm x 7mm           |
| MSP430F5510IRGZ | VQFN (48) | 7mm x 7mm           |

(1) 要获得所有可用器件的最新部件、封装和订购信息，请参见封装选项附录（节 8）或浏览 TI 网站 [www.ti.com.cn](http://www.ti.com.cn)。

(2) 这里显示的尺寸为近似值。要获得包含误差值的封装尺寸，请参见机械数据（节 8）。

## 1.4 功能方框图

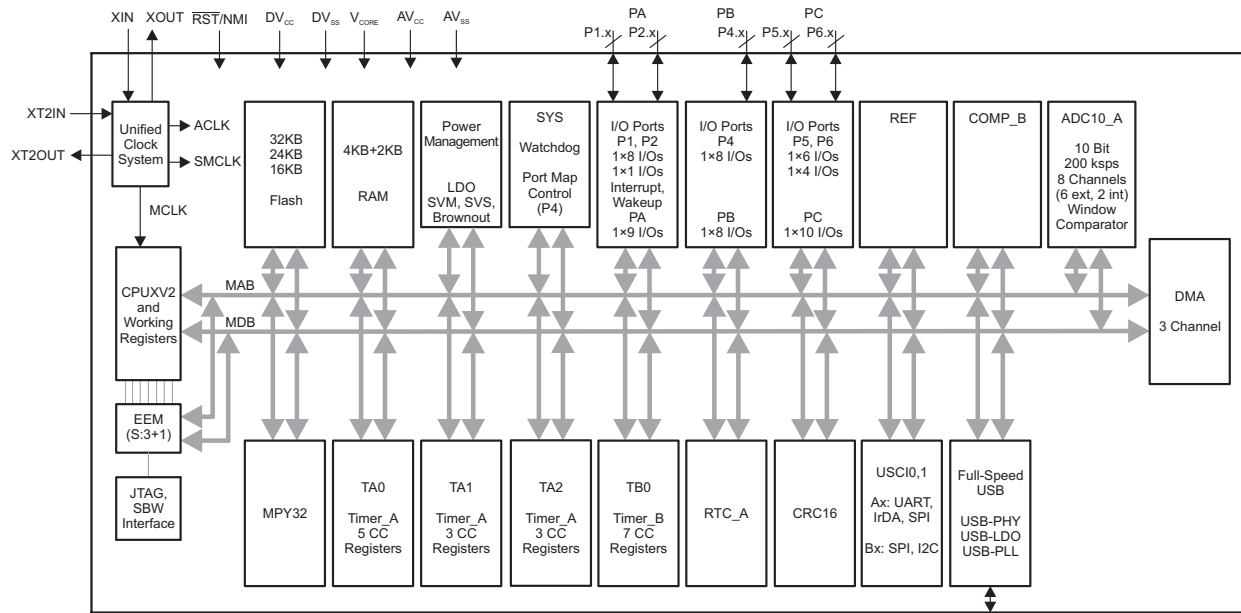
图 1-1 给出了采用 RGC 和 ZQE 封装的 MSP430F5510、MSP430F5509 和 MSP430F5508 器件的功能方框图。



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图 1-1. 功能方框图 - MSP430F5510IRGC、MSP430F5509IRGC、MSP430F5508IRGC、MSP430F5510IZQE、MSP430F5509IZQE、MSP430F5508IZQE

图 1-2 给出了采用 RGZ 和 PT 封装的 MSP430F5510、MSP430F5509 和 MSP430F5508 器件的功能方框图。

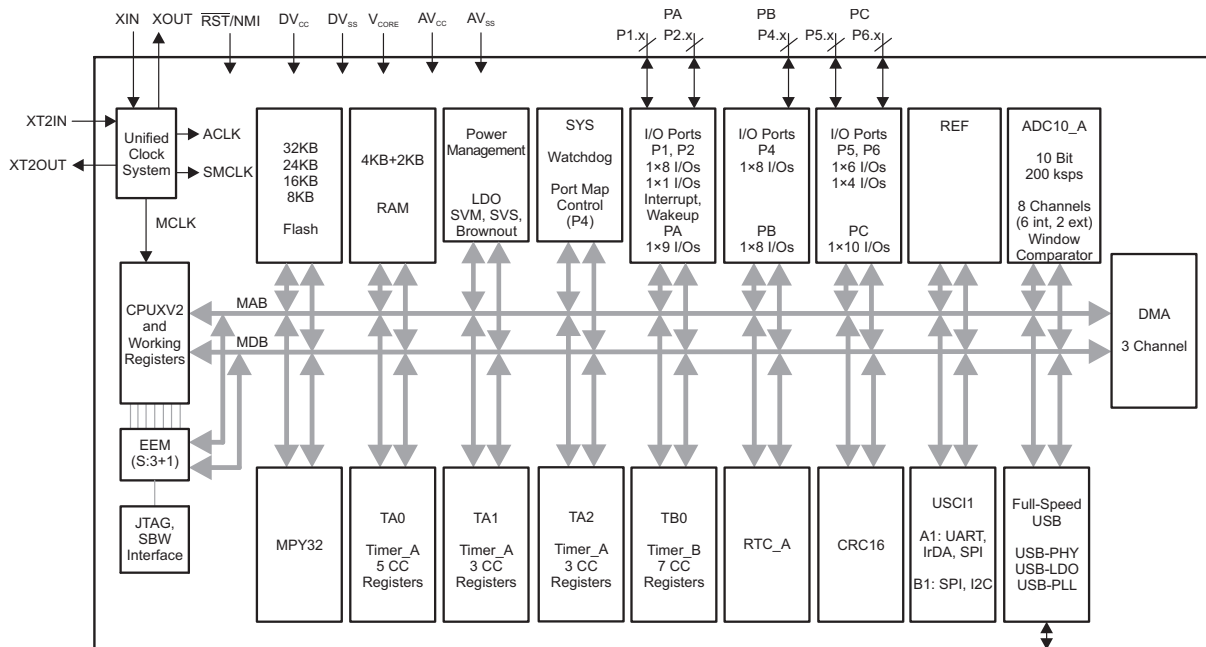


DP,DM,PUR  
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NOTE: 有关 USCIO 模块信号同时可用的限制条件, 请参见 Table 3-1。

图 1-2. 功能方框图 - MSP430F5510IRGZ、MSP430F5509IRGZ、MSP430F5508IRGZ、MSP430F5510IPT、MSP430F5509IPT、MSP430F5508IPT

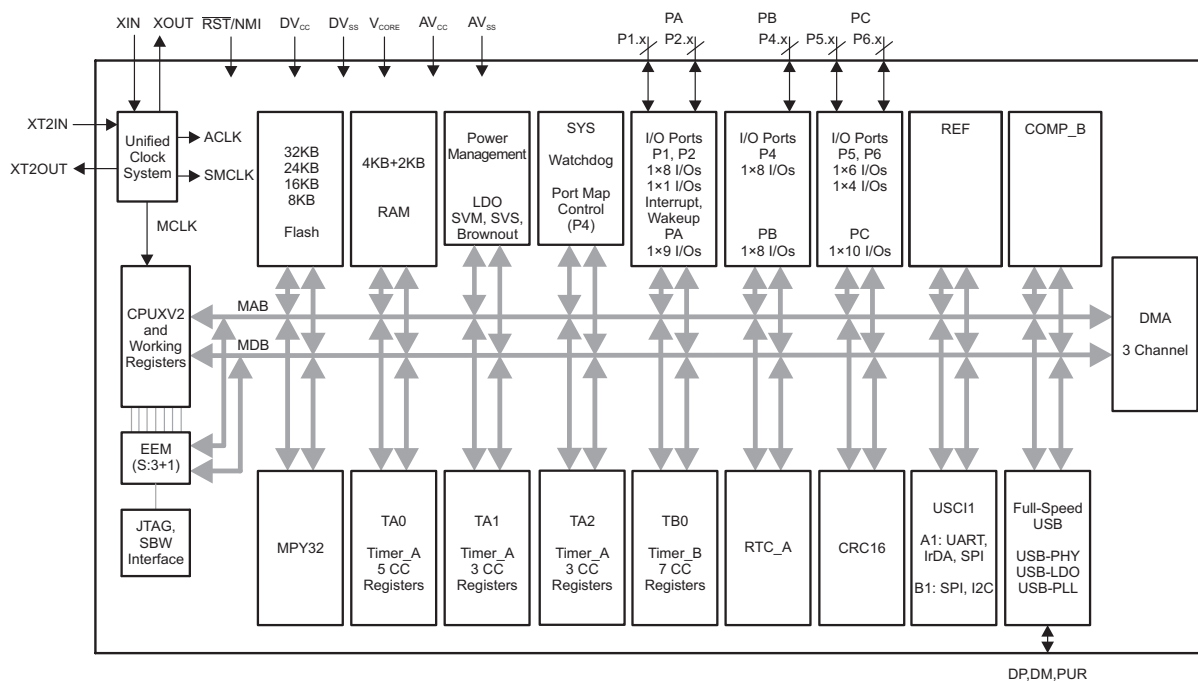
图 1-3 给出了采用 RGZ 封装的 MSP430F5507、MSP430F5506 和 MSP430F5505 器件的功能方框图以及采用 RGZ 和 PT 封装的 MSP430F5504 器件的功能方框图。



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图 1-3. 功能方框图 - MSP430F5507IRGZ、MSP430F5506IRGZ、MSP430F5505IRGZ、MSP430F5504IRGZ、MSP430F5504IPT

图 1-4 给出了采用 RGZ 封装的 MSP430F5503、MSP430F5502、MSP430F5501 和 MSP430F5500 器件的功能方框图。



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图 1-4. 功能方框图 - MSP430F5503IRGZ、MSP430F5502IRGZ、MSP430F5501IRGZ、MSP430F5500IRGZ

## 内容

|          |                                                                                                                                                           |           |          |                                                       |            |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------|-------------------------------------------------------|------------|
| <b>1</b> | <b>器件概述</b>                                                                                                                                               | <b>1</b>  | 5.26     | Wake-up Times From Low-Power Modes and Reset          | <b>35</b>  |
| 1.1      | 特性                                                                                                                                                        | 1         | 5.27     | Timer_A                                               | 35         |
| 1.2      | 应用范围                                                                                                                                                      | 1         | 5.28     | Timer_B                                               | 35         |
| 1.3      | 说明                                                                                                                                                        | 1         | 5.29     | USCI (UART Mode) Clock Frequency                      | 36         |
| 1.4      | 功能方框图                                                                                                                                                     | 2         | 5.30     | USCI (UART Mode)                                      | 36         |
| <b>2</b> | <b>修订历史记录</b>                                                                                                                                             | <b>6</b>  | 5.31     | USCI (SPI Master Mode) Clock Frequency                | 36         |
| <b>3</b> | <b>Device Comparison</b>                                                                                                                                  | <b>7</b>  | 5.32     | USCI (SPI Master Mode)                                | 36         |
| 3.1      | Related Products                                                                                                                                          | 8         | 5.33     | USCI (SPI Slave Mode)                                 | 38         |
| <b>4</b> | <b>Terminal Configuration and Functions</b>                                                                                                               | <b>9</b>  | 5.34     | USCI (I <sup>2</sup> C Mode)                          | 40         |
| 4.1      | Pin Diagrams                                                                                                                                              | 9         | 5.35     | 10-Bit ADC, Power Supply and Input Range Conditions   | 41         |
| 4.2      | Signal Descriptions                                                                                                                                       | 14        | 5.36     | 10-Bit ADC, Timing Parameters                         | 41         |
| <b>5</b> | <b>Specifications</b>                                                                                                                                     | <b>19</b> | 5.37     | 10-Bit ADC, Linearity Parameters                      | 42         |
| 5.1      | Absolute Maximum Ratings                                                                                                                                  | 19        | 5.38     | REF, External Reference                               | 42         |
| 5.2      | ESD Ratings                                                                                                                                               | 19        | 5.39     | REF, Built-In Reference                               | 43         |
| 5.3      | Recommended Operating Conditions                                                                                                                          | 19        | 5.40     | Comparator B                                          | 44         |
| 5.4      | Active Mode Supply Current Into V <sub>CC</sub> Excluding External Current                                                                                | 21        | 5.41     | Ports PU.0 and PU.1                                   | 45         |
| 5.5      | Low-Power Mode Supply Currents (Into V <sub>CC</sub> ) Excluding External Current                                                                         | 22        | 5.42     | USB Output Ports (DP and DM)                          | 47         |
| 5.6      | Thermal Resistance Characteristics                                                                                                                        | 23        | 5.43     | USB Input Ports (DP and DM)                           | 47         |
| 5.7      | Schmitt-Trigger Inputs – General-Purpose I/O (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7) (P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3, RST/NMI) | 24        | 5.44     | USB-PWR (USB Power System)                            | 47         |
| 5.8      | Inputs – Ports P1 and P2 (P1.0 to P1.7, P2.0 to P2.7)                                                                                                     | 24        | 5.45     | USB-PLL (USB Phase-Locked Loop)                       | 48         |
| 5.9      | Leakage Current – General-Purpose I/O (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7) (P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3, RST/NMI)        | 24        | 5.46     | Flash Memory                                          | 48         |
| 5.10     | Outputs – General-Purpose I/O (Full Drive Strength) (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7, P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3)    | 24        | 5.47     | JTAG and Spy-Bi-Wire Interface                        | 48         |
| 5.11     | Outputs – General-Purpose I/O (Reduced Drive Strength) (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7, P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3) | 25        | <b>6</b> | <b>Detailed Description</b>                           | <b>49</b>  |
| 5.12     | Output Frequency – General-Purpose I/O (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7, P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3)                 | 25        | 6.1      | CPU ( <a href="#">Link to User's Guide</a> )          | 49         |
| 5.13     | Typical Characteristics – Outputs, Reduced Drive Strength (PxDS.y = 0)                                                                                    | 26        | 6.2      | Operating Modes                                       | 50         |
| 5.14     | Typical Characteristics – Outputs, Full Drive Strength (PxDS.y = 1)                                                                                       | 27        | 6.3      | Interrupt Vector Addresses                            | 51         |
| 5.15     | Crystal Oscillator, XT1, Low-Frequency Mode                                                                                                               | 28        | 6.4      | Memory Organization                                   | 52         |
| 5.16     | Crystal Oscillator, XT2                                                                                                                                   | 29        | 6.5      | Bootloader (BSL)                                      | 53         |
| 5.17     | Internal Very-Low-Power Low-Frequency Oscillator (VLO)                                                                                                    | 30        | 6.6      | JTAG Operation                                        | 54         |
| 5.18     | Internal Reference, Low-Frequency Oscillator (REFO)                                                                                                       | 30        | 6.7      | Flash Memory ( <a href="#">Link to User's Guide</a> ) | 54         |
| 5.19     | DCO Frequency                                                                                                                                             | 31        | 6.8      | RAM ( <a href="#">Link to User's Guide</a> )          | 55         |
| 5.20     | PMM, Brownout Reset (BOR)                                                                                                                                 | 32        | 6.9      | Peripherals                                           | 55         |
| 5.21     | PMM, Core Voltage                                                                                                                                         | 32        | 6.10     | Peripheral File Map                                   | 65         |
| 5.22     | PMM, SVS High Side                                                                                                                                        | 33        | 6.11     | Input/Output Diagrams                                 | 77         |
| 5.23     | PMM, SVM High Side                                                                                                                                        | 34        | 6.12     | Device Descriptors                                    | 94         |
| 5.24     | PMM, SVS Low Side                                                                                                                                         | 34        | <b>7</b> | <b>器件和文档支持</b>                                        | <b>100</b> |
| 5.25     | PMM, SVM Low Side                                                                                                                                         | 35        | 7.1      | 入门和后续步骤                                               | 100        |
|          |                                                                                                                                                           |           | 7.2      | Device Nomenclature                                   | 100        |
|          |                                                                                                                                                           |           | 7.3      | 工具与软件                                                 | 102        |
|          |                                                                                                                                                           |           | 7.4      | 文档支持                                                  | 104        |
|          |                                                                                                                                                           |           | 7.5      | 相关链接                                                  | 105        |
|          |                                                                                                                                                           |           | 7.6      | 社区资源                                                  | 105        |
|          |                                                                                                                                                           |           | 7.7      | 商标                                                    | 106        |
|          |                                                                                                                                                           |           | 7.8      | 静电放电警告                                                | 106        |
|          |                                                                                                                                                           |           | 7.9      | Export Control Notice                                 | 106        |
|          |                                                                                                                                                           |           | 7.10     | Glossary                                              | 106        |
|          |                                                                                                                                                           |           | <b>8</b> | <b>机械, 封装和可订购信息</b>                                   | <b>107</b> |

## 2 修订历史记录

| Changes from May 1, 2015 to September 20, 2018                                                                                                                                                                   | Page                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| • Updated <a href="#">Section 3.1, Related Products</a> .....                                                                                                                                                    | <a href="#">8</a>   |
| • Added typical conditions statements at the beginning of <a href="#">Section 5, Specifications</a> .....                                                                                                        | <a href="#">19</a>  |
| • Changed the MIN value of the $V_{(DVCC\_BOR\_hys)}$ parameter from 60 mV to 50 mV in <a href="#">Section 5.20, PMM, Brownout Reset (BOR)</a> .....                                                             | <a href="#">32</a>  |
| • Updated notes (1) and (2) and added note (3) in , <i>Wake-up Times From Low-Power Modes and Reset</i> .....                                                                                                    | <a href="#">35</a>  |
| • Removed ADC10DIV from the formula for the TYP value in the second row of the $t_{CONVERT}$ parameter in <a href="#">Section 5.36, 10-Bit ADC, Timing Parameters</a> , because ADC10CLK is after division ..... | <a href="#">41</a>  |
| • Changed the MAX value of the $t_{EN\_CMP}$ parameter with Test Conditions of "CBPWRMD = 10" from 1.5 $\mu$ s to 100 $\mu$ s in <a href="#">Section 5.40, Comparator_B</a> .....                                | <a href="#">44</a>  |
| • Updated note (1) on <a href="#">Section 5.47, JTAG and Spy-Bi-Wire Interface</a> .....                                                                                                                         | <a href="#">48</a>  |
| • Throughout document, changed all instances of "bootstrap loader" to "bootloader".....                                                                                                                          | <a href="#">53</a>  |
| • Corrected spelling of NMIFG in <a href="#">Table 6-9, System Module Interrupt Vector Registers</a> .....                                                                                                       | <a href="#">58</a>  |
| • Corrected register acronyms in <a href="#">Table 6-43, USB Configuration Registers</a> , and <a href="#">Table 6-44, USB Control Registers</a> .                                                               | <a href="#">76</a>  |
| • 将先前的开发工具支持 部分替换为节 7.3“工具与软件” .....                                                                                                                                                                             | <a href="#">102</a> |
| • 更新了节 7.4文档支持 .....                                                                                                                                                                                             | <a href="#">104</a> |

### 3 Device Comparison

Table 3-1 summarizes the available family members.

**Table 3-1. Device Comparison<sup>(1)(2)</sup>**

| DEVICE      | PROGRAM<br>MEMORY<br>(KB) | SRAM<br>(KB) <sup>(3)</sup> | Timer_A <sup>(4)</sup> | Timer_B <sup>(5)</sup> | USCI                                  |                                     | ADC10_A<br>(CH) | Comp_B<br>(CH) | I/Os | PACKAGE           |
|-------------|---------------------------|-----------------------------|------------------------|------------------------|---------------------------------------|-------------------------------------|-----------------|----------------|------|-------------------|
|             |                           |                             |                        |                        | CHANNEL A:<br>UART, LIN,<br>IrDA, SPI | CHANNEL B:<br>SPI, I <sup>2</sup> C |                 |                |      |                   |
| MSP430F5510 | 32                        | 4 + 2                       | 5, 3, 3                | 7                      | 2                                     | 2                                   | 10 ext, 2 int   | 8              | 47   | 64 RGC,<br>80 ZQE |
|             |                           |                             |                        |                        | 2 <sup>(6)</sup>                      | 2 <sup>(6)</sup>                    | 6 ext, 2 int    | 4              | 31   | 48 PT,<br>48 RGZ  |
| MSP430F5509 | 24                        | 4 + 2                       | 5, 3, 3                | 7                      | 2                                     | 2                                   | 10 ext, 2 int   | 8              | 47   | 64 RGC,<br>80 ZQE |
|             |                           |                             |                        |                        | 2 <sup>(6)</sup>                      | 2 <sup>(6)</sup>                    | 6 ext, 2 int    | 4              | 31   | 48 PT,<br>48 RGZ  |
| MSP430F5508 | 16                        | 4 + 2                       | 5, 3, 3                | 7                      | 2                                     | 2                                   | 10 ext, 2 int   | 8              | 47   | 64 RGC,<br>80 ZQE |
|             |                           |                             |                        |                        | 2 <sup>(6)</sup>                      | 2 <sup>(6)</sup>                    | 6 ext, 2 int    | 4              | 31   | 48 PT,<br>48 RGZ  |
| MSP430F5507 | 32                        | 4 + 2                       | 5, 3, 3                | 7                      | 1                                     | 1                                   | 6 ext, 2 int    | –              | 31   | 48 RGZ            |
| MSP430F5506 | 24                        | 4 + 2                       | 5, 3, 3                | 7                      | 1                                     | 1                                   | 6 ext, 2 int    | –              | 31   | 48 RGZ            |
| MSP430F5505 | 16                        | 4 + 2                       | 5, 3, 3                | 7                      | 1                                     | 1                                   | 6 ext, 2 int    | –              | 31   | 48 RGZ            |
| MSP430F5504 | 8                         | 4 + 2                       | 5, 3, 3                | 7                      | 1                                     | 1                                   | 6 ext, 2 int    | –              | 31   | 48 PT,<br>48 RGZ  |
| MSP430F5503 | 32                        | 4 + 2                       | 5, 3, 3                | 7                      | 1                                     | 1                                   | –               | 4              | 31   | 48 RGZ            |
| MSP430F5502 | 24                        | 4 + 2                       | 5, 3, 3                | 7                      | 1                                     | 1                                   | –               | 4              | 31   | 48 RGZ            |
| MSP430F5501 | 16                        | 4 + 2                       | 5, 3, 3                | 7                      | 1                                     | 1                                   | –               | 4              | 31   | 48 RGZ            |
| MSP430F5500 | 8                         | 4 + 2                       | 5, 3, 3                | 7                      | 1                                     | 1                                   | –               | 4              | 31   | 48 RGZ            |

- (1) For the most current part, package, and ordering information for all available devices, see the *Package Option Addendum* in [Section 8](#), or see the TI website at [www.ti.com](http://www.ti.com).
- (2) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/packaging](http://www.ti.com/packaging).
- (3) The additional 2KB USB SRAM that is listed can be used as general-purpose SRAM when USB is not in use.
- (4) Each number in the sequence represents an instantiation of Timer\_A with its associated number of capture/compare registers and PWM output generators available. For example, a number sequence of 3, 5 would represent two instantiations of Timer\_A, the first instantiation having 3 and the second instantiation having 5 capture/compare registers and PWM output generators, respectively.
- (5) Each number in the sequence represents an instantiation of Timer\_B with its associated number of capture/compare registers and PWM output generators available. For example, a number sequence of 3, 5 would represent two instantiations of Timer\_B, the first instantiation having 3 and the second instantiation having 5 capture/compare registers and PWM output generators, respectively.
- (6) Two USCIs are available; however, pinned out functions are limited to what the user configures on port 4 with the port mapping controller (see [Section 6.9.2](#)). It may not be possible to bring out all functions simultaneously.

### 3.1 Related Products

For information about other devices in this family of products or related products, see the following links.

**Products for TI Microcontrollers** TI's low-power and high-performance MCUs, with wired and wireless connectivity options, are optimized for a broad range of applications.

**Products for MSP430 Ultra-Low-Power Microcontrollers** One platform. One ecosystem. Endless possibilities. Enabling the connected world with innovations in ultra-low-power microcontrollers with advanced peripherals for precise sensing and measurement.

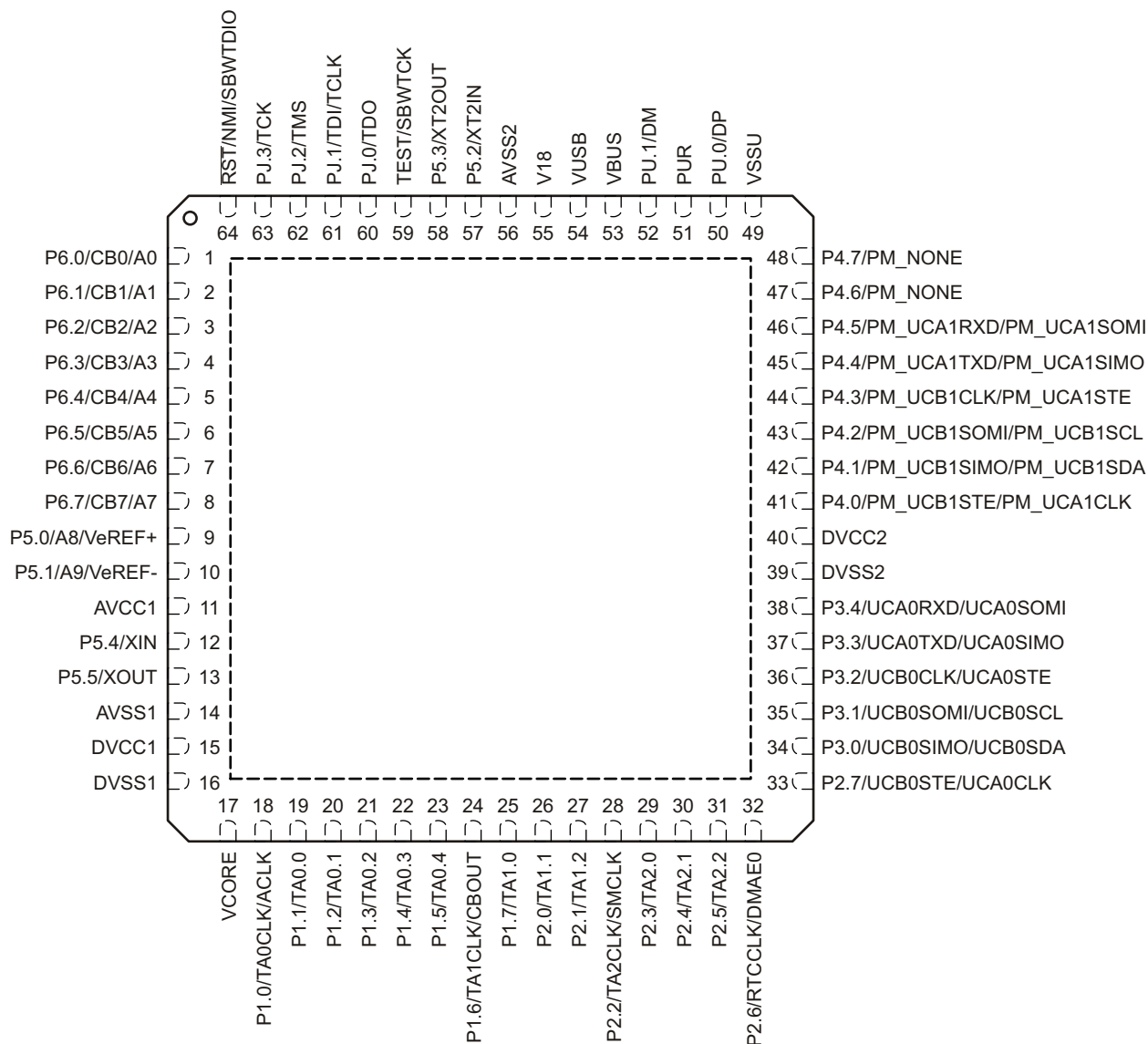
**Companion Products for MSP430F5510** Review products that are frequently purchased or used in conjunction with this product.

**Reference Designs for MSP430F5510** TI Designs Reference Design Library is a robust reference design library that spans analog, embedded processor, and connectivity. Created by TI experts to help you jump start your system design, all TI Designs include schematic or block diagrams, BOMs, and design files to speed your time to market.

## 4 Terminal Configuration and Functions

### 4.1 Pin Diagrams

Figure 4-1 shows the pinout for the 64-pin RGC package of the MSP430F5510, MSP430F5509, and MSP430F5508 MCUs.



NOTE: TI recommends connection of the exposed thermal pad to V<sub>SS</sub>.

**Figure 4-1. 64-Pin RGC Package (Top View) – F5510, F5509, F5508**

Figure 4-2 shows the pinout for the 80-pin ZQE package of the MSP430F5510, MSP430F5509, and MSP430F5508 MCUs. See Section 4.2 for the pin assignments.

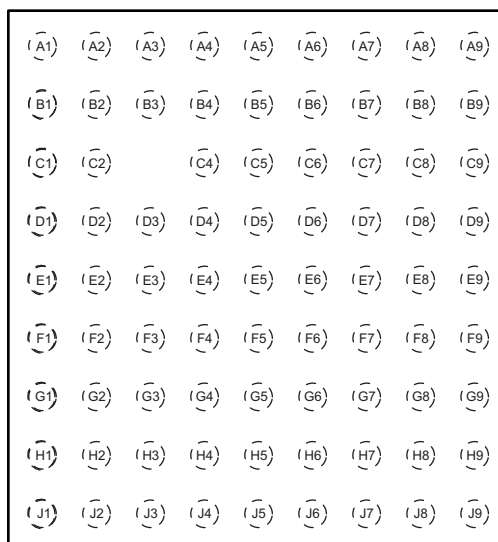
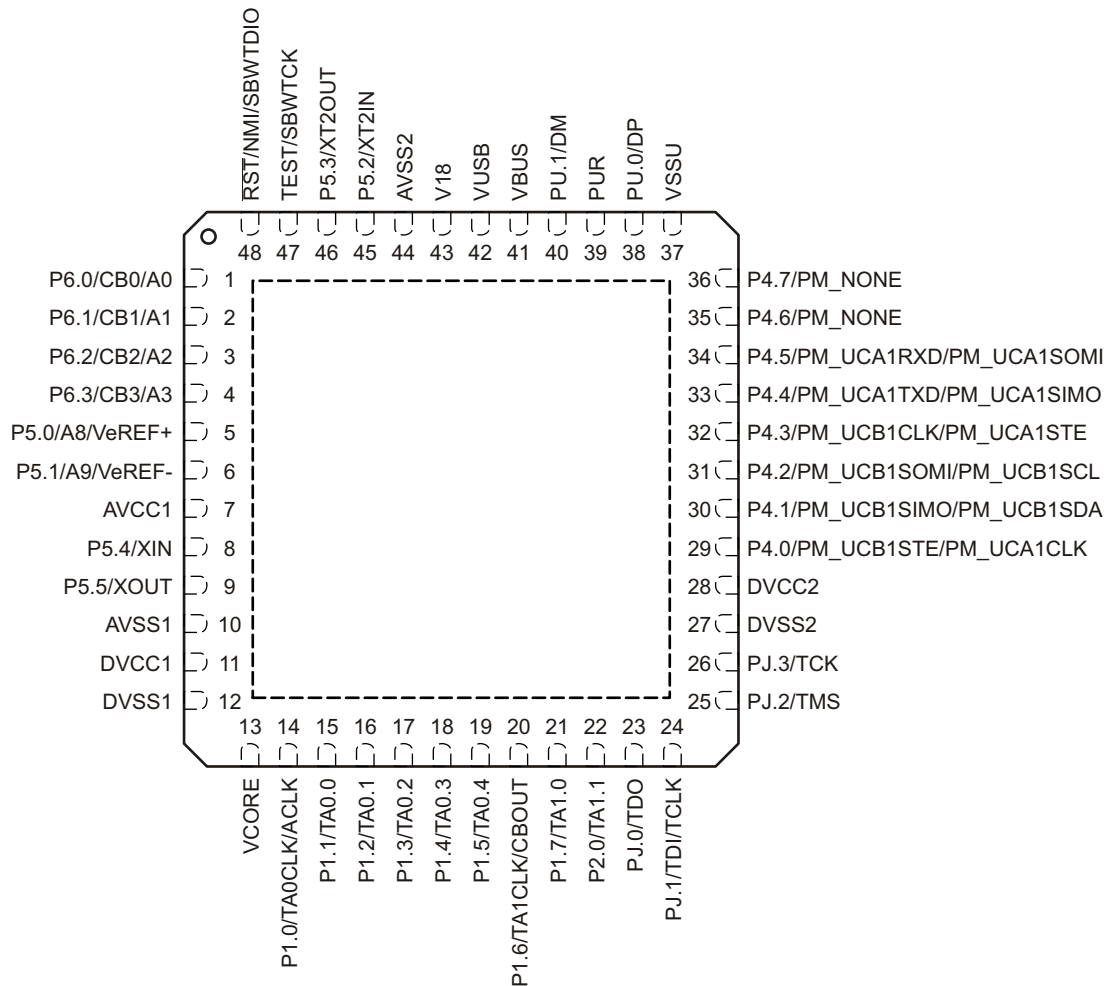


Figure 4-2. 80-Pin ZQE Package (Top View) – F5510, F5509, F5508

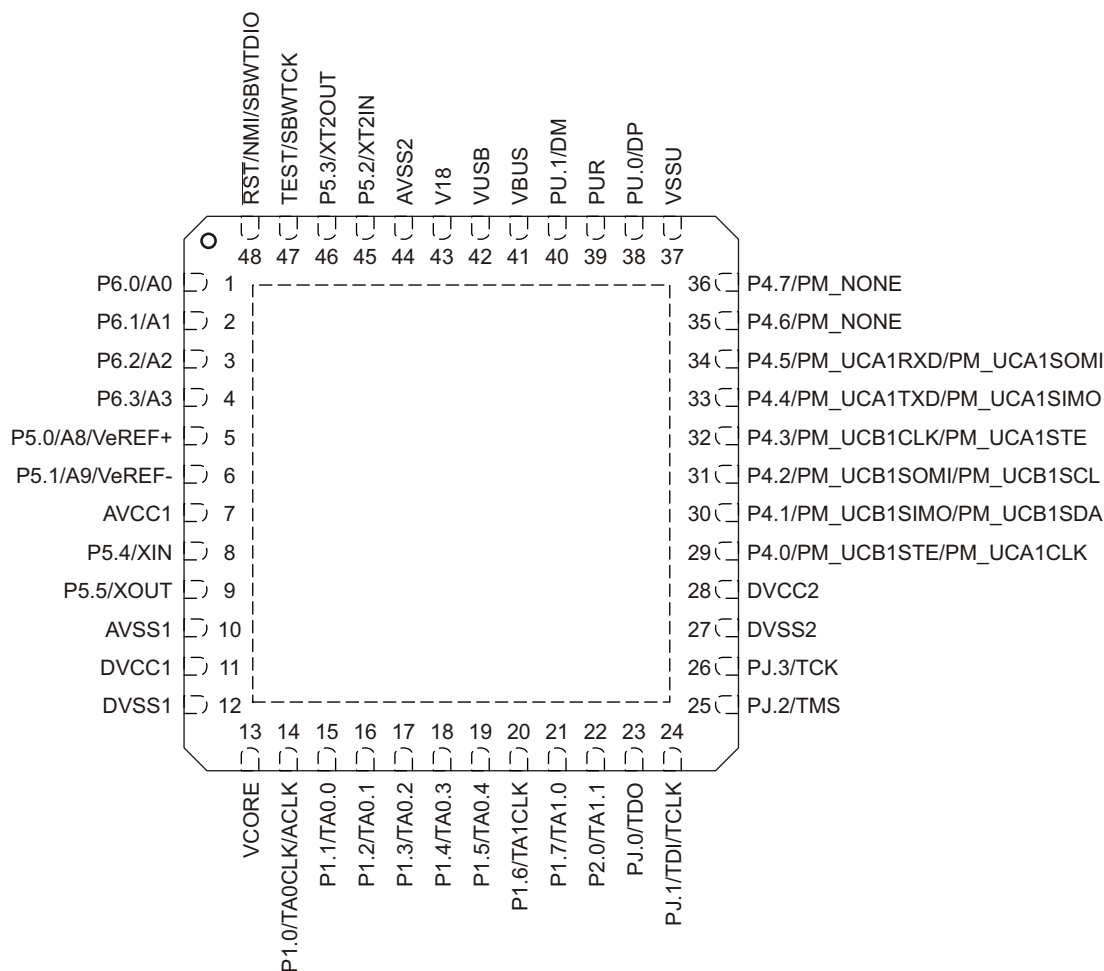
Figure 4-3 shows the pinout for 48-pin RGZ and PT packages of the MSP430F5510, MSP430F5509, and MSP430F5508 MCUs.



NOTE: TI recommends connection of the exposed thermal pad to V<sub>SS</sub>.

**Figure 4-3. 48-Pin RGZ or PT Package (Top View) – F5510, F5509, F5508**

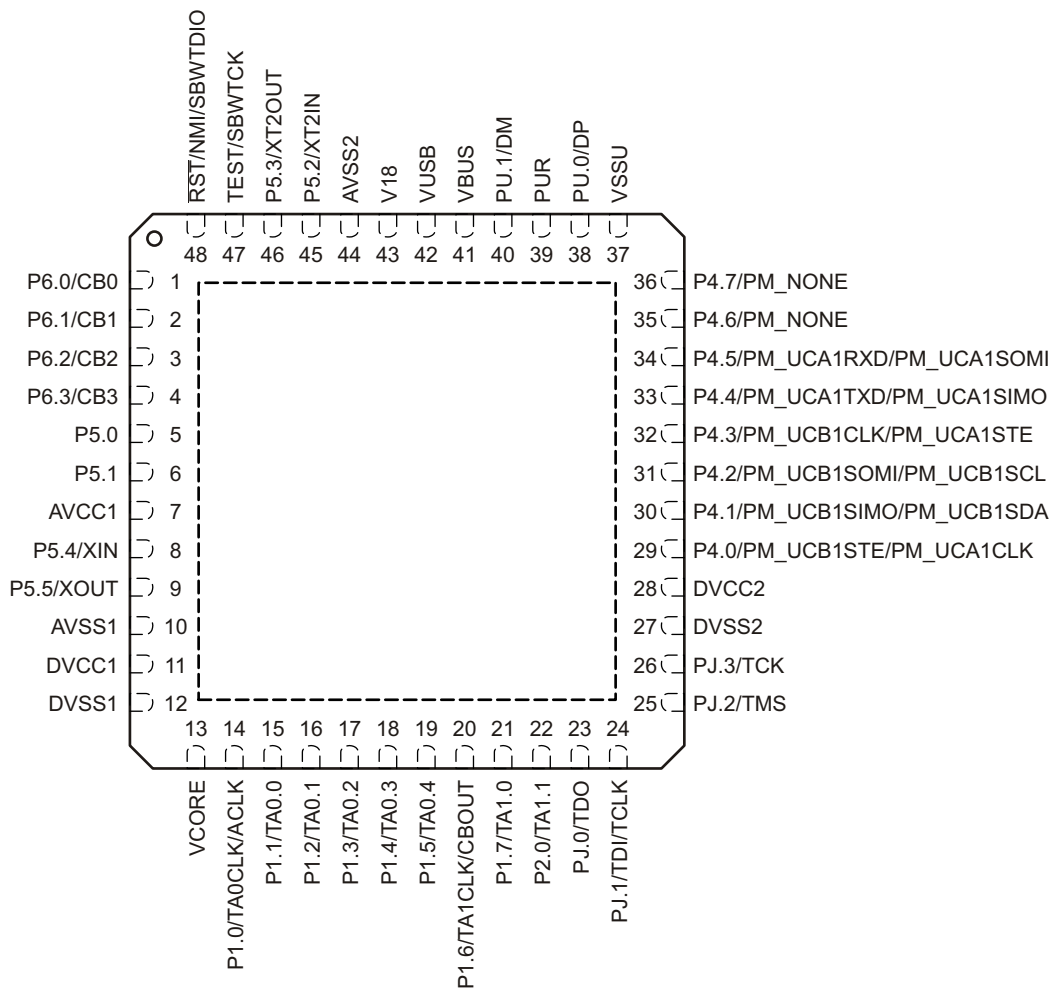
Figure 4-4 shows the pinout for the 48-pin RGZ and PT packages of the MSP430F5507, MSP430F5506, MSP430F5505, and MSP430F5504 MCUs.



NOTE: TI recommends connection of the exposed thermal pad to V<sub>SS</sub>.

**Figure 4-4. 48-Pin RGZ or PT Package (Top View) – F5507, F5506, F5505, F5504**

Figure 4-5 shows the pinout for the 48-pin RGZ package of the MSP430F5503, MSP430F5502, MSP430F5501, and MSP430F5500 MCUs.



NOTE: TI recommends connection of the exposed thermal pad to V<sub>SS</sub>.

**Figure 4-5. 48-Pin RGZ Package (Top View) – F5503, F5502, F5501, F5500**

## 4.2 Signal Descriptions

Table 4-1 describes the signals for all device variants and package options.

**Table 4-1. Terminal Functions**

| NAME                 | NO. |            |     | I/O <sup>(1)</sup> | DESCRIPTION                                                                                                                                                                                                                    |
|----------------------|-----|------------|-----|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      | RGZ | RGZ,<br>PT | ZQE |                    |                                                                                                                                                                                                                                |
| P6.4/CB4/A4          | 5   | N/A        | C1  | I/O                | General-purpose digital I/O<br>Comparator_B input CB4 (not available on PT and RGZ package devices)<br>Analog input A4 – ADC (not available on PT and RGZ package devices)                                                     |
| P6.5/CB5/A5          | 6   | N/A        | D2  | I/O                | General-purpose digital I/O<br>Comparator_B input CB5 (not available on PT and RGZ package devices)<br>Analog input A5 – ADC (not available on PT and RGZ package devices)                                                     |
| P6.6/CB6/A6          | 7   | N/A        | D1  | I/O                | General-purpose digital I/O<br>Comparator_B input CB6 (not available on PT and RGZ package devices)<br>Analog input A6 – ADC (not available on PT and RGZ package devices)                                                     |
| P6.7/CB7/A7          | 8   | N/A        | D3  | I/O                | General-purpose digital I/O<br>Comparator_B input CB7 (not available on PT and RGZ package devices)<br>Analog input A7 – ADC (not available on PT and RGZ package devices)                                                     |
| P5.0/A8/VeREF+       | 9   | 5          | E1  | I/O                | General-purpose digital I/O<br>Analog input A8 – ADC (not available on F5503, F5502, F5501, F5500 devices)<br>Input for an external reference voltage to the ADC (not available on F5503, F5502, F5501, F5500 devices)         |
| P5.1/A9/VeREF-       | 10  | 6          | E2  | I/O                | General-purpose digital I/O<br>Analog input A9 – ADC (not available on F5503, F5502, F5501, F5500 devices)<br>Negative terminal for an externally provided ADC reference (not available on F5503, F5502, F5501, F5500 devices) |
| AVCC1                | 11  | 7          | F2  |                    | Analog power supply                                                                                                                                                                                                            |
| P5.4/XIN             | 12  | 8          | F1  | I/O                | General-purpose digital I/O<br>Input terminal for crystal oscillator XT1                                                                                                                                                       |
| P5.5/XOUT            | 13  | 9          | G1  | I/O                | General-purpose digital I/O<br>Output terminal of crystal oscillator XT1                                                                                                                                                       |
| AVSS1                | 14  | 10         | G2  |                    | Analog ground supply                                                                                                                                                                                                           |
| DVCC1                | 15  | 11         | H1  |                    | Digital power supply                                                                                                                                                                                                           |
| DVSS1                | 16  | 12         | J1  |                    | Digital ground supply                                                                                                                                                                                                          |
| VCORE <sup>(2)</sup> | 17  | 13         | J2  |                    | Regulated core power supply output (internal use only, no external current loading)                                                                                                                                            |
| P1.0/TA0CLK/ACLK     | 18  | 14         | H2  | I/O                | General-purpose digital I/O with port interrupt<br>TA0 clock signal TA0CLK input<br>ACLK output (divided by 1, 2, 4, 8, 16, or 32)                                                                                             |
| P1.1/TA0.0           | 19  | 15         | H3  | I/O                | General-purpose digital I/O with port interrupt<br>TA0 CCR0 capture: CCI0A input, compare: Out0 output<br>BSL transmit output                                                                                                  |
| P1.2/TA0.1           | 20  | 16         | J3  | I/O                | General-purpose digital I/O with port interrupt<br>TA0 CCR1 capture: CCI1A input, compare: Out1 output<br>BSL receive input                                                                                                    |

(1) I = input, O = output, N/A = not available

(2) VCore is for internal use only. No external current loading is possible. VCore should only be connected to the recommended capacitor value, C<sub>VCore</sub> (see [Section 5.3](#)).

**Table 4-1. Terminal Functions (continued)**

| TERMINAL              |     |            |     | I/O <sup>(1)</sup> | DESCRIPTION                                                                                                                                                                                 |
|-----------------------|-----|------------|-----|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME                  | NO. |            |     |                    |                                                                                                                                                                                             |
|                       | RGC | RGZ,<br>PT | ZQE |                    |                                                                                                                                                                                             |
| P1.3/TA0.2            | 21  | 17         | G4  | I/O                | General-purpose digital I/O with port interrupt<br>TA0 CCR2 capture: CCI2A input, compare: Out2 output                                                                                      |
| P1.4/TA0.3            | 22  | 18         | H4  | I/O                | General-purpose digital I/O with port interrupt<br>TA0 CCR3 capture: CCI3A input compare: Out3 output                                                                                       |
| P1.5/TA0.4            | 23  | 19         | J4  | I/O                | General-purpose digital I/O with port interrupt<br>TA0 CCR4 capture: CCI4A input, compare: Out4 output                                                                                      |
| P1.6/TA1CLK/CBOUT     | 24  | 20         | G5  | I/O                | General-purpose digital I/O with port interrupt<br>TA1 clock signal TA1CLK input<br>Comparator_B output                                                                                     |
| P1.7/TA1.0            | 25  | 21         | H5  | I/O                | General-purpose digital I/O with port interrupt<br>TA1 CCR0 capture: CCI0A input, compare: Out0 output                                                                                      |
| P2.0/TA1.1            | 26  | 22         | J5  | I/O                | General-purpose digital I/O with port interrupt<br>TA1 CCR1 capture: CCI1A input, compare: Out1 output                                                                                      |
| P2.1/TA1.2            | 27  | N/A        | G6  | I/O                | General-purpose digital I/O with port interrupt<br>TA1 CCR2 capture: CCI2A input, compare: Out2 output                                                                                      |
| P2.2/TA2CLK/SMCLK     | 28  | N/A        | J6  | I/O                | General-purpose digital I/O with port interrupt<br>TA2 clock signal TA2CLK input<br>SMCLK output                                                                                            |
| P2.3/TA2.0            | 29  | N/A        | H6  | I/O                | General-purpose digital I/O with port interrupt<br>TA2 CCR0 capture: CCI0A input, compare: Out0 output                                                                                      |
| P2.4/TA2.1            | 30  | N/A        | J7  | I/O                | General-purpose digital I/O with port interrupt<br>TA2 CCR1 capture: CCI1A input, compare: Out1 output                                                                                      |
| P2.5/TA2.2            | 31  | N/A        | J8  | I/O                | General-purpose digital I/O with port interrupt<br>TA2 CCR2 capture: CCI2A input, compare: Out2 output                                                                                      |
| P2.6/RTCCLK/DMAE0     | 32  | N/A        | J9  | I/O                | General-purpose digital I/O with port interrupt<br>RTC clock output for calibration<br>DMA external trigger input                                                                           |
| P2.7/UCB0STE/UCA0CLK  | 33  | N/A        | H7  | I/O                | General-purpose digital I/O with port interrupt<br>Slave transmit enable – USCI_B0 SPI mode<br>Clock signal input – USCI_A0 SPI slave mode<br>Clock signal output – USCI_A0 SPI master mode |
| P3.0/UCB0SIMO/UCB0SDA | 34  | N/A        | H8  | I/O                | General-purpose digital I/O<br>Slave in, master out – USCI_B0 SPI mode<br>I <sup>2</sup> C data – USCI_B0 I <sup>2</sup> C mode                                                             |
| P3.1/UCB0SOMI/UCB0SCL | 35  | N/A        | H9  | I/O                | General-purpose digital I/O<br>Slave out, master in – USCI_B0 SPI mode<br>I <sup>2</sup> C clock – USCI_B0 I <sup>2</sup> C mode                                                            |
| P3.2/UCB0CLK/UCA0STE  | 36  | N/A        | G8  | I/O                | General-purpose digital I/O<br>Clock signal input – USCI_B0 SPI slave mode<br>Clock signal output – USCI_B0 SPI master mode<br>Slave transmit enable – USCI_A0 SPI mode                     |
| P3.3/UCA0TXD/UCA0SIMO | 37  | N/A        | G9  | I/O                | General-purpose digital I/O<br>Transmit data – USCI_A0 UART mode<br>Slave in, master out – USCI_A0 SPI mode                                                                                 |

**Table 4-1. Terminal Functions (continued)**

| TERMINAL                        |     |            |           | I/O <sup>(1)</sup> | DESCRIPTION                                                                                                                                                                                                                                                                    |
|---------------------------------|-----|------------|-----------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME                            | NO. |            |           |                    |                                                                                                                                                                                                                                                                                |
|                                 | RGC | RGZ,<br>PT | ZQE       |                    |                                                                                                                                                                                                                                                                                |
| P3.4/UCA0RXD/UCA0SOMI           | 38  | N/A        | G7        | I/O                | General-purpose digital I/O<br>Receive data – USCI_A0 UART mode<br>Slave out, master in – USCI_A0 SPI mode                                                                                                                                                                     |
| P4.0/PM_UCB1STE/<br>PM_UCA1CLK  | 41  | 29         | E8        | I/O                | General-purpose digital I/O with reconfigurable port mapping secondary function<br>Default mapping: Slave transmit enable – USCI_B1 SPI mode<br>Default mapping: Clock signal input – USCI_A1 SPI slave mode<br>Default mapping: Clock signal output – USCI_A1 SPI master mode |
| P4.1/PM_UCB1SIMO/<br>PM_UCB1SDA | 42  | 30         | E7        | I/O                | General-purpose digital I/O with reconfigurable port mapping secondary function<br>Default mapping: Slave in, master out – USCI_B1 SPI mode<br>Default mapping: I <sup>2</sup> C data – USCI_B1 I <sup>2</sup> C mode                                                          |
| P4.2/PM_UCB1SOMI/<br>PM_UCB1SCL | 43  | 31         | D9        | I/O                | General-purpose digital I/O with reconfigurable port mapping secondary function<br>Default mapping: Slave out, master in – USCI_B1 SPI mode<br>Default mapping: I <sup>2</sup> C clock – USCI_B1 I <sup>2</sup> C mode                                                         |
| P4.3/PM_UCB1CLK/<br>PM_UCA1STE  | 44  | 32         | D8        | I/O                | General-purpose digital I/O with reconfigurable port mapping secondary function<br>Default mapping: Clock signal input – USCI_B1 SPI slave mode<br>Default mapping: Clock signal output – USCI_B1 SPI master mode<br>Default mapping: Slave transmit enable – USCI_A1 SPI mode |
| DVSS2                           | 39  | 27         | F9        |                    | Digital ground supply                                                                                                                                                                                                                                                          |
| DVCC2                           | 40  | 28         | E9        |                    | Digital power supply                                                                                                                                                                                                                                                           |
| P4.4/PM_UCA1TXD/<br>PM_UCA1SIMO | 45  | 33         | D7        | I/O                | General-purpose digital I/O with reconfigurable port mapping secondary function<br>Default mapping: Transmit data – USCI_A1 UART mode<br>Default mapping: Slave in, master out – USCI_A1 SPI mode                                                                              |
| P4.5/PM_UCA1RXD/<br>PM_UCA1SOMI | 46  | 34         | C9        | I/O                | General-purpose digital I/O with reconfigurable port mapping secondary function<br>Default mapping: Receive data – USCI_A1 UART mode<br>Default mapping: Slave out, master in – USCI_A1 SPI mode                                                                               |
| P4.6/PM_NONE                    | 47  | 35         | C8        | I/O                | General-purpose digital I/O with reconfigurable port mapping secondary function<br>Default mapping: no secondary function                                                                                                                                                      |
| P4.7/PM_NONE                    | 48  | 36         | C7        | I/O                | General-purpose digital I/O with reconfigurable port mapping secondary function<br>Default mapping: no secondary function                                                                                                                                                      |
| VSSU                            | 49  | 37         | B8,<br>B9 |                    | USB PHY ground supply                                                                                                                                                                                                                                                          |
| PU.0/DP                         | 50  | 38         | A9        | I/O                | General-purpose digital I/O - controlled by USB control register<br>USB data terminal DP                                                                                                                                                                                       |
| PUR                             | 51  | 39         | B7        | I/O                | USB pullup resistor pin (open drain). The voltage level at the PUR pin is used to invoke the default USB BSL. Recommended 1-MΩ resistor to ground. See <a href="#">Section 6.5.1</a> for more information.                                                                     |
| PU.1/DM                         | 52  | 40         | A8        | I/O                | General-purpose digital I/O - controlled by USB control register<br>USB data terminal DM                                                                                                                                                                                       |
| VBUS                            | 53  | 41         | A7        |                    | USB LDO input (connect to USB power source)                                                                                                                                                                                                                                    |
| VUSB                            | 54  | 42         | A6        |                    | USB LDO output                                                                                                                                                                                                                                                                 |

**Table 4-1. Terminal Functions (continued)**

| TERMINAL                             |     |            |                | I/O <sup>(1)</sup> | DESCRIPTION                                                                                                                                                                                |
|--------------------------------------|-----|------------|----------------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME                                 | NO. |            |                |                    |                                                                                                                                                                                            |
|                                      | RGC | RGZ,<br>PT | ZQE            |                    |                                                                                                                                                                                            |
| V18                                  | 55  | 43         | B6             |                    | USB regulated power (internal use only, no external current loading)                                                                                                                       |
| AVSS2                                | 56  | 44         | A5             |                    | Analog ground supply                                                                                                                                                                       |
| P5.2/XT2IN                           | 57  | 45         | B5             | I/O                | General-purpose digital I/O<br>Input terminal for crystal oscillator XT2                                                                                                                   |
| P5.3/XT2OUT                          | 58  | 46         | B4             | I/O                | General-purpose digital I/O<br>Output terminal of crystal oscillator XT2                                                                                                                   |
| TEST/SBWTCK                          | 59  | 47         | A4             | I                  | Test mode pin – select digital I/O on JTAG pins<br>Spy-By-Wire input clock                                                                                                                 |
| PJ.0/TDO                             | 60  | 23         | C5             | I/O                | General-purpose digital I/O<br>Test data output port                                                                                                                                       |
| PJ.1/TDI/TCLK                        | 61  | 24         | C4             | I/O                | General-purpose digital I/O<br>Test data input<br>Test clock input                                                                                                                         |
| PJ.2/TMS                             | 62  | 25         | A3             | I/O                | General-purpose digital I/O<br>Test mode select                                                                                                                                            |
| PJ.3/TCK                             | 63  | 26         | B3             | I/O                | General-purpose digital I/O<br>Test clock                                                                                                                                                  |
| $\overline{\text{RST}}$ /NMI/SBWTDIO | 64  | 48         | A2             | I/O                | Reset input, active low <sup>(3)</sup><br>Nonmaskable interrupt input<br>Spy-By-Wire data input/output                                                                                     |
| P6.0/CB0/A0                          | 1   | 1          | A1             | I/O                | General-purpose digital I/O<br>Comparator_B input CB0 (not available on F5507, F5506, F5505, F5504 devices)<br>Analog input A0 – ADC (not available on F5503, F5502, F5501, F5500 devices) |
| P6.1/CB1/A1                          | 2   | 2          | B2             | I/O                | General-purpose digital I/O<br>Comparator_B input CB1 (not available on F5507, F5506, F5505, F5504 devices)<br>Analog input A1 – ADC (not available on F5503, F5502, F5501, F5500 devices) |
| P6.2/CB2/A2                          | 3   | 3          | B1             | I/O                | General-purpose digital I/O<br>Comparator_B input CB2 (not available on F5507, F5506, F5505, F5504 devices)<br>Analog input A2 – ADC (not available on F5503, F5502, F5501, F5500 devices) |
| P6.3/CB3/A3                          | 4   | 4          | C2             | I/O                | General-purpose digital I/O<br>Comparator_B input CB3 (not available on F5507, F5506, F5505, F5504 devices)<br>Analog input A3 – ADC (not available on F5503, F5502, F5501, F5500 devices) |
| Reserved                             | N/A | N/A        | <sup>(4)</sup> |                    | Reserved. Connect to ground.                                                                                                                                                               |
| QFN Pad                              | Pad | Pad        | N/A            |                    | Exposed QFN package pad (not available on PT package devices). TI recommends connecting to V <sub>SS</sub> .                                                                               |

(3) When this pin is configured as reset, the internal pullup resistor is enabled by default.

(4) C6, D4, D5, D6, E3, E4, E5, E6, F3, F4, F5, F6, F7, F8, G3 are reserved and should be connected to ground.



## 5 Specifications

All graphs in this section are for typical conditions, unless otherwise noted.

Typical (TYP) values are specified at  $V_{CC} = 3.3\text{ V}$  and  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

### 5.1 Absolute Maximum Ratings<sup>(1)</sup>

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

|                                                                                                               | MIN  | MAX            | UNIT |
|---------------------------------------------------------------------------------------------------------------|------|----------------|------|
| Voltage applied at $V_{CC}$ to $V_{SS}$                                                                       | -0.3 | 4.1            | V    |
| Voltage applied to any pin (excluding V <sub>CORE</sub> , V <sub>BUS</sub> , V <sub>18</sub> ) <sup>(2)</sup> | -0.3 | $V_{CC} + 0.3$ | V    |
| Diode current at any device pin                                                                               |      | ±2             | mA   |
| Maximum junction temperature, $T_J$                                                                           |      | 95             | °C   |
| Storage temperature, $T_{stg}$ <sup>(3)</sup>                                                                 | -55  | 150            | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages referenced to  $V_{SS}$ . V<sub>CORE</sub> is for internal device use only. No external DC loading or voltage should be applied.
- (3) Higher temperature may be applied during board soldering according to the current JEDEC J-STD-020 specification with peak reflow temperatures not higher than classified on the device label on the shipping boxes or reels.

### 5.2 ESD Ratings

|                                     |                                                                                | VALUE | UNIT |
|-------------------------------------|--------------------------------------------------------------------------------|-------|------|
| $V_{(ESD)}$ Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | ±1000 | V    |
|                                     | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> | ±250  |      |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Pins listed as ±1000 V may actually have higher performance.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. Pins listed as ±250 V may actually have higher performance.

### 5.3 Recommended Operating Conditions

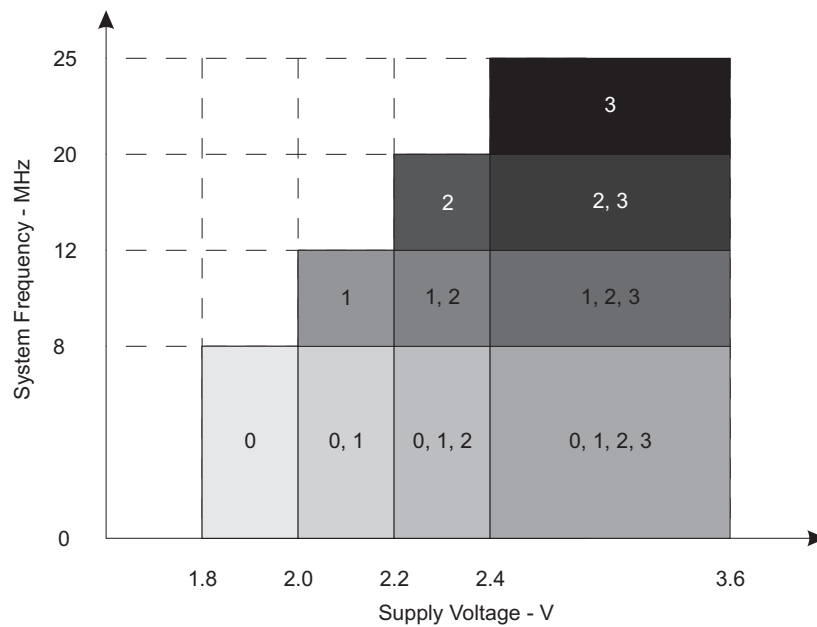
|                      |                                                                                                        | MIN                    | NOM | MAX | UNIT |
|----------------------|--------------------------------------------------------------------------------------------------------|------------------------|-----|-----|------|
| $V_{CC}$             | Supply voltage during program execution and flash programming( $AV_{CC} = DV_{CC}$ ) <sup>(1)(2)</sup> | PMMCOREVx = 0          | 1.8 | 3.6 | V    |
|                      |                                                                                                        | PMMCOREVx = 0, 1       | 2.0 | 3.6 |      |
|                      |                                                                                                        | PMMCOREVx = 0, 1, 2    | 2.2 | 3.6 |      |
|                      |                                                                                                        | PMMCOREVx = 0, 1, 2, 3 | 2.4 | 3.6 |      |
| $V_{CC,USB}$         | Supply voltage during USB operation, USB PLL disabled, USB_EN = 1, UPLLEN = 0                          | PMMCOREVx = 0          | 1.8 | 3.6 | V    |
|                      |                                                                                                        | PMMCOREVx = 0, 1       | 2.0 | 3.6 |      |
|                      |                                                                                                        | PMMCOREVx = 0, 1, 2    | 2.2 | 3.6 |      |
|                      |                                                                                                        | PMMCOREVx = 0, 1, 2, 3 | 2.4 | 3.6 |      |
|                      | Supply voltage during USB operation, USB PLL enabled <sup>(3)</sup> , USB_EN = 1, UPLLEN = 1           | PMMCOREVx = 2          | 2.2 | 3.6 |      |
|                      |                                                                                                        | PMMCOREVx = 2, 3       | 2.4 | 3.6 |      |
| $V_{SS}$             | Supply voltage ( $AV_{SS} = DV_{SS1} = DV_{SS2} = DV_{SS}$ )                                           |                        | 0   |     | V    |
| $T_A$                | Operating free-air temperature                                                                         | I version              | -40 | 85  | °C   |
| $T_J$                | Operating junction temperature                                                                         | I version              | -40 | 85  | °C   |
| $C_{VCORE}$          | Capacitor at V <sub>CORE</sub> <sup>(4)</sup>                                                          |                        | 470 |     | nF   |
| $C_{DVCC}/C_{VCORE}$ | Capacitor ratio of DVCC to V <sub>CORE</sub>                                                           |                        | 10  |     |      |

- (1) TI recommends powering AVCC and DVCC from the same source. A maximum difference of 0.3 V between AVCC and DVCC can be tolerated during power up and operation.
- (2) The minimum supply voltage is defined by the supervisor SVS levels when it is enabled. See the [Section 5.22](#) threshold parameters for the exact values and further details.
- (3) USB operation with USB PLL enabled requires PMMCOREVx ≥ 2 for proper operation.
- (4) A capacitor tolerance of ±20% or better is required.

## Recommended Operating Conditions (continued)

|                          |                                                                                                  | MIN | NOM | MAX  | UNIT   |
|--------------------------|--------------------------------------------------------------------------------------------------|-----|-----|------|--------|
| $f_{\text{SYSTEM}}$      | Processor frequency (maximum MCLK frequency) <sup>(5)</sup><br>(see <a href="#">Figure 5-1</a> ) |     |     |      | MHz    |
|                          | PMMCOREVx = 0,<br>1.8 V $\leq$ V <sub>CC</sub> $\leq$ 3.6 V<br>(default condition)               | 0   |     | 8.0  |        |
|                          | PMMCOREVx = 1,<br>2.0 V $\leq$ V <sub>CC</sub> $\leq$ 3.6 V                                      | 0   |     | 12.0 |        |
|                          | PMMCOREVx = 2,<br>2.2 V $\leq$ V <sub>CC</sub> $\leq$ 3.6 V                                      | 0   |     | 20.0 |        |
|                          | PMMCOREVx = 3,<br>2.4 V $\leq$ V <sub>CC</sub> $\leq$ 3.6 V                                      | 0   |     | 25.0 |        |
| $f_{\text{SYSTEM\_USB}}$ | Minimum processor frequency for USB operation                                                    | 1.5 |     |      | MHz    |
| USB_wait                 | Wait state cycles during USB operation                                                           |     | 16  |      | cycles |

(5) Modules may have a different maximum input clock specification. See the specification of the respective module in this data sheet.



NOTE: The numbers within the fields denote the supported PMMCOREVx settings.

**Figure 5-1. Maximum System Frequency**

## 5.4 Active Mode Supply Current Into $V_{CC}$ Excluding External Current

over recommended operating free-air temperature (unless otherwise noted)<sup>(1)</sup> <sup>(2)</sup> <sup>(3)</sup>

| PARAMETER              | EXECUTION MEMORY | V <sub>CC</sub> | PMMCOREVx | FREQUENCY (f <sub>DCO</sub> = f <sub>MCLK</sub> = f <sub>SMCLK</sub> ) |      |       |      |        |      |        |      |        |     | UNIT |
|------------------------|------------------|-----------------|-----------|------------------------------------------------------------------------|------|-------|------|--------|------|--------|------|--------|-----|------|
|                        |                  |                 |           | 1 MHz                                                                  |      | 8 MHz |      | 12 MHz |      | 20 MHz |      | 25 MHz |     |      |
|                        |                  |                 |           | TYP                                                                    | MAX  | TYP   | MAX  | TYP    | MAX  | TYP    | MAX  | TYP    | MAX |      |
| I <sub>AM, Flash</sub> | Flash            | 3 V             | 0         | 0.25                                                                   | 0.27 | 1.55  | 1.68 |        |      |        |      |        |     | mA   |
|                        |                  |                 | 1         | 0.28                                                                   |      | 1.74  |      | 2.58   | 2.78 |        |      |        |     |      |
|                        |                  |                 | 2         | 0.30                                                                   |      | 1.91  |      | 2.84   |      | 4.68   | 5.06 |        |     |      |
|                        |                  |                 | 3         | 0.32                                                                   |      | 2.09  |      | 3.10   |      | 5.13   |      | 6.0    | 6.5 |      |
| I <sub>AM, RAM</sub>   | RAM              | 3 V             | 0         | 0.17                                                                   | 0.19 | 0.91  | 1.00 |        |      |        |      |        |     | mA   |
|                        |                  |                 | 1         | 0.19                                                                   |      | 1.03  |      | 1.54   | 1.67 |        |      |        |     |      |
|                        |                  |                 | 2         | 0.20                                                                   |      | 1.16  |      | 1.73   |      | 2.84   | 3.11 |        |     |      |
|                        |                  |                 | 3         | 0.21                                                                   |      | 1.24  |      | 1.87   |      | 3.1    |      | 3.9    | 4.3 |      |

(1) All inputs are tied to 0 V or to  $V_{CC}$ . Outputs do not source or sink any current.

(2) The currents are characterized with a Micro Crystal MS1V-T1K crystal with a load capacitance of 12.5 pF. The internal and external load capacitance are chosen to closely match the required 12.5 pF.

(3) Characterized with program executing typical data processing. USB disabled ( $V_{USBEN} = 0$ ,  $SLDOEN = 0$ ).

$f_{ACLK} = 32786 \text{ Hz}$ ,  $f_{DCO} = f_{MCLK} = f_{SMCLK}$  at specified frequency.

$XTS = CPUOFF = SCG0 = SCG1 = OSCOFF = SMCLKOFF = 0$ .

## 5.5 Low-Power Mode Supply Currents (Into $V_{CC}$ ) Excluding External Current

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1) (2)</sup>

| PARAMETER               |                                                  | V <sub>CC</sub> | PMMCOREVx | TEMPERATURE (T <sub>A</sub> ) |     |      |      |      |     |      |      | UNIT |
|-------------------------|--------------------------------------------------|-----------------|-----------|-------------------------------|-----|------|------|------|-----|------|------|------|
|                         |                                                  |                 |           | −40°C                         |     | 25°C |      | 60°C |     | 85°C |      |      |
|                         |                                                  |                 |           | TYP                           | MAX | TYP  | MAX  | TYP  | MAX | TYP  | MAX  |      |
| I <sub>LPM0,1MHz</sub>  | Low-power mode 0 <sup>(3)(4)</sup>               | 2.2 V           | 0         | 73                            |     | 77   | 85   | 80   |     | 85   | 97   | μA   |
|                         |                                                  | 3 V             | 3         | 79                            |     | 83   | 92   | 88   |     | 95   | 105  |      |
| I <sub>LPM2</sub>       | Low-power mode 2 <sup>(5)(4)</sup>               | 2.2 V           | 0         | 6.5                           |     | 6.5  | 8    | 7.5  |     | 8    | 11   | μA   |
|                         |                                                  | 3 V             | 3         | 7.0                           |     | 7.0  | 9    | 7.9  |     | 8.9  | 13   |      |
| I <sub>LPM3,XT1LF</sub> | Low-power mode 3, crystal mode <sup>(6)(4)</sup> | 2.2 V           | 0         | 1.60                          |     | 1.90 |      | 2.6  |     | 3.4  |      | μA   |
|                         |                                                  |                 | 1         | 1.65                          |     | 2.00 |      | 2.7  |     | 3.6  |      |      |
|                         |                                                  |                 | 2         | 1.75                          |     | 2.15 |      | 2.9  |     | 3.8  |      |      |
|                         |                                                  | 3 V             | 0         | 1.8                           |     | 2.1  | 2.6  | 2.8  |     | 3.6  | 6.0  |      |
|                         |                                                  |                 | 1         | 1.9                           |     | 2.3  |      | 2.9  |     | 3.8  |      |      |
|                         |                                                  |                 | 2         | 2.0                           |     | 2.4  |      | 3.0  |     | 4.0  |      |      |
|                         |                                                  |                 | 3         | 2.0                           |     | 2.5  | 3.0  | 3.1  |     | 4.0  | 6.5  |      |
| I <sub>LPM3,VLO</sub>   | 3 V                                              | 0               | 1.1       |                               | 1.3 | 1.8  | 1.9  |      | 2.7 | 5.0  | μA   |      |
|                         |                                                  | 1               | 1.1       |                               | 1.4 |      | 2.0  |      | 2.8 |      |      |      |
|                         |                                                  | 2               | 1.2       |                               | 1.5 |      | 2.1  |      | 2.9 |      |      |      |
|                         |                                                  | 3               | 1.3       |                               | 1.5 | 2.0  | 2.2  |      | 3.0 | 5.5  |      |      |
| I <sub>LPM4</sub>       | Low-power mode 4 <sup>(8)(4)</sup>               | 3 V             | 0         | 0.9                           |     | 1.1  | 1.5  | 1.8  |     | 2.5  | 4.8  | μA   |
|                         |                                                  |                 | 1         | 1.1                           |     | 1.2  |      | 2.0  |     | 2.6  |      |      |
|                         |                                                  |                 | 2         | 1.2                           |     | 1.2  |      | 2.1  |     | 2.7  |      |      |
|                         |                                                  |                 | 3         | 1.3                           |     | 1.3  | 1.6  | 2.2  |     | 2.8  | 5.0  |      |
| I <sub>LPM4.5</sub>     | Low-power mode 4.5 <sup>(9)</sup>                | 3 V             |           | 0.15                          |     | 0.18 | 0.35 | 0.26 |     | 0.45 | 0.80 | μA   |

- (1) All inputs are tied to 0 V or to  $V_{CC}$ . Outputs do not source or sink any current.
- (2) The currents are characterized with a Micro Crystal MS1V-T1K crystal with a load capacitance of 12.5 pF. The internal and external load capacitance are chosen to closely match the required 12.5 pF.
- (3) Current for watchdog timer clocked by SMCLK included. ACLK = low-frequency crystal operation (XTS = 0, XT1DRIVE<sub>x</sub> = 0). CPUOFF = 1, SCG0 = 0, SCG1 = 0, OSCOFF = 0 (LPM0),  $f_{ACLK}$  = 32768 Hz,  $f_{MCLK}$  = 0 MHz,  $f_{SMCLK}$  =  $f_{DCO}$  = 1 MHz USB disabled (VUSBEN = 0, SLDOEN = 0).
- (4) Current for brownout, high-side supervisor (SVSH) normal mode included. Low-side supervisor (SVSL) and low-side monitor (SVM<sub>L</sub>) disabled. High-side monitor (SVM<sub>H</sub>) disabled. RAM retention enabled.
- (5) Current for watchdog timer and RTC clocked by ACLK included. ACLK = low-frequency crystal operation (XTS = 0, XT1DRIVE<sub>x</sub> = 0). CPUOFF = 1, SCG0 = 0, SCG1 = 1, OSCOFF = 0 (LPM2),  $f_{ACLK}$  = 32768 Hz,  $f_{MCLK}$  = 0 MHz,  $f_{SMCLK}$  =  $f_{DCO}$  = 0 MHz, DCO setting = 1 MHz operation, DCO bias generator enabled. USB disabled (VUSBEN = 0, SLDOEN = 0).
- (6) Current for watchdog timer and RTC clocked by ACLK included. ACLK = low-frequency crystal operation (XTS = 0, XT1DRIVE<sub>x</sub> = 0). CPUOFF = 1, SCG0 = 1, SCG1 = 1, OSCOFF = 0 (LPM3),  $f_{ACLK}$  = 32768 Hz,  $f_{MCLK}$  =  $f_{SMCLK}$  =  $f_{DCO}$  = 0 MHz USB disabled (VUSBEN = 0, SLDOEN = 0).
- (7) Current for watchdog timer and RTC clocked by ACLK included. ACLK = VLO. CPUOFF = 1, SCG0 = 1, SCG1 = 1, OSCOFF = 0 (LPM3),  $f_{ACLK}$  =  $f_{VLO}$ ,  $f_{MCLK}$  =  $f_{SMCLK}$  =  $f_{DCO}$  = 0 MHz USB disabled (VUSBEN = 0, SLDOEN = 0).
- (8) CPUOFF = 1, SCG0 = 1, SCG1 = 1, OSCOFF = 1 (LPM4),  $f_{DCO}$  =  $f_{ACLK}$  =  $f_{MCLK}$  =  $f_{SMCLK}$  = 0 MHz USB disabled (VUSBEN = 0, SLDOEN = 0).
- (9) Internal regulator disabled. No data retention. CPUOFF = 1, SCG0 = 1, SCG1 = 1, OSCOFF = 1, PMMREGOFF = 1 (LPM4.5),  $f_{DCO}$  =  $f_{ACLK}$  =  $f_{MCLK}$  =  $f_{SMCLK}$  = 0 MHz

## 5.6 Thermal Resistance Characteristics

|                       |                                                                  | VALUE <sup>(1)</sup> | UNIT |      |
|-----------------------|------------------------------------------------------------------|----------------------|------|------|
| $\theta_{JA}$         | Junction-to-ambient thermal resistance, still air <sup>(2)</sup> | VQFN (RGC)           | 30   | °C/W |
|                       |                                                                  | VQFN (RGZ)           | 28.6 |      |
|                       |                                                                  | LQFP (PT)            | 62.8 |      |
|                       |                                                                  | BGA (ZQE)            | 55.5 |      |
| $\theta_{JC(TOP)}$    | Junction-to-case (top) thermal resistance <sup>(3)</sup>         | VQFN (RGC)           | 15.6 | °C/W |
|                       |                                                                  | VQFN (RGZ)           | 14.4 |      |
|                       |                                                                  | LQFP (PT)            | 18.2 |      |
|                       |                                                                  | BGA (ZQE)            | 21.2 |      |
| $\theta_{JC(BOTTOM)}$ | Junction-to-case (bottom) thermal resistance <sup>(4)</sup>      | VQFN(RGC)            | 1.6  | °C/W |
|                       |                                                                  | VQFN (RGZ)           | 1.6  |      |
|                       |                                                                  | LQFP (PT)            | N/A  |      |
|                       |                                                                  | BGA (ZQE)            | N/A  |      |
| $\theta_{JB}$         | Junction-to-board thermal resistance <sup>(5)</sup>              | VQFN (RGC)           | 8.9  | °C/W |
|                       |                                                                  | VQFN (RGZ)           | 5.5  |      |
|                       |                                                                  | LQFP (PT)            | 28.3 |      |
|                       |                                                                  | BGA (ZQE)            | 19.3 |      |

(1) N/A = not applicable

(2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, High-K board, as specified in JESD51-7, in an environment described in JESD51-2a.

(3) The junction-to-case(top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

(4) The junction-to-case(bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

(5) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.

## 5.7 Schmitt-Trigger Inputs – General-Purpose I/O <sup>(1)</sup> (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7) (P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3, RST/NMI)

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

| PARAMETER                                                                        | TEST CONDITIONS                                                                                  | V <sub>CC</sub> | MIN  | TYP | MAX  | UNIT |
|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------------|------|-----|------|------|
| V <sub>IT+</sub> Positive-going input threshold voltage                          |                                                                                                  | 1.8 V           | 0.80 |     | 1.40 | V    |
|                                                                                  |                                                                                                  | 3 V             | 1.50 |     | 2.10 |      |
| V <sub>IT-</sub> Negative-going input threshold voltage                          |                                                                                                  | 1.8 V           | 0.45 |     | 1.00 | V    |
|                                                                                  |                                                                                                  | 3 V             | 0.75 |     | 1.65 |      |
| V <sub>hys</sub> Input voltage hysteresis (V <sub>IT+</sub> – V <sub>IT-</sub> ) |                                                                                                  | 1.8 V           | 0.3  |     | 0.85 | V    |
|                                                                                  |                                                                                                  | 3 V             | 0.4  |     | 1.0  |      |
| R <sub>Pull</sub> Pullup or pulldown resistor <sup>(2)</sup>                     | For pullup: V <sub>IN</sub> = V <sub>SS</sub><br>For pulldown: V <sub>IN</sub> = V <sub>CC</sub> |                 | 20   | 35  | 50   | kΩ   |
| C <sub>I</sub> Input capacitance                                                 | V <sub>IN</sub> = V <sub>SS</sub> or V <sub>CC</sub>                                             |                 |      | 5   |      | pF   |

(1) Same parametrics apply to clock input pin when crystal bypass mode is used on XT1 (XIN) or XT2 (XT2IN).

(2) Also applies to the RST pin when its pullup or pulldown resistor is enabled.

## 5.8 Inputs – Ports P1 and P2<sup>(1)</sup> (P1.0 to P1.7, P2.0 to P2.7)

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

| PARAMETER                                                   | TEST CONDITIONS                                                                  | V <sub>CC</sub> | MIN | MAX | UNIT |
|-------------------------------------------------------------|----------------------------------------------------------------------------------|-----------------|-----|-----|------|
| t <sub>(int)</sub> External interrupt timing <sup>(2)</sup> | Port P1, P2: P1.x to P2.x, External trigger pulse duration to set interrupt flag | 2.2 V, 3 V      | 20  |     | ns   |

(1) Some devices may contain additional ports with interrupts. See the block diagram and terminal function descriptions.

(2) An external signal sets the interrupt flag every time the minimum interrupt pulse duration t<sub>(int)</sub> is met. It may be set by trigger signals shorter than t<sub>(int)</sub>.

## 5.9 Leakage Current – General-Purpose I/O (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7) (P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3, RST/NMI)

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

| PARAMETER                                                           | TEST CONDITIONS               | V <sub>CC</sub> | MIN | MAX | UNIT |
|---------------------------------------------------------------------|-------------------------------|-----------------|-----|-----|------|
| I <sub>lkg</sub> (P <sub>x.y</sub> ) High-impedance leakage current | <sup>(1)</sup> <sup>(2)</sup> | 1.8 V, 3 V      |     | ±50 | nA   |

(1) The leakage current is measured with V<sub>SS</sub> or V<sub>CC</sub> applied to the corresponding pins, unless otherwise noted.

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

## 5.10 Outputs – General-Purpose I/O (Full Drive Strength) (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7, P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3)

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

| PARAMETER                                 | TEST CONDITIONS                              | V <sub>CC</sub> | MIN                    | MAX                    | UNIT |
|-------------------------------------------|----------------------------------------------|-----------------|------------------------|------------------------|------|
| V <sub>OH</sub> High-level output voltage | I <sub>(OHmax)</sub> = –3 mA <sup>(1)</sup>  | 1.8 V           | V <sub>CC</sub> – 0.25 | V <sub>CC</sub>        | V    |
|                                           | I <sub>(OHmax)</sub> = –10 mA <sup>(2)</sup> |                 | V <sub>CC</sub> – 0.60 | V <sub>CC</sub>        |      |
|                                           | I <sub>(OHmax)</sub> = –5 mA <sup>(1)</sup>  | 3 V             | V <sub>CC</sub> – 0.25 | V <sub>CC</sub>        |      |
|                                           | I <sub>(OHmax)</sub> = –15 mA <sup>(2)</sup> |                 | V <sub>CC</sub> – 0.60 | V <sub>CC</sub>        |      |
| V <sub>OL</sub> Low-level output voltage  | I <sub>(OLmax)</sub> = 3 mA <sup>(1)</sup>   | 1.8 V           | V <sub>SS</sub>        | V <sub>SS</sub> + 0.25 | V    |
|                                           | I <sub>(OLmax)</sub> = 10 mA <sup>(2)</sup>  |                 | V <sub>SS</sub>        | V <sub>SS</sub> + 0.60 |      |
|                                           | I <sub>(OLmax)</sub> = 5 mA <sup>(1)</sup>   | 3 V             | V <sub>SS</sub>        | V <sub>SS</sub> + 0.25 |      |
|                                           | I <sub>(OLmax)</sub> = 15 mA <sup>(2)</sup>  |                 | V <sub>SS</sub>        | V <sub>SS</sub> + 0.60 |      |

(1) The maximum total current, I<sub>(OHmax)</sub> and I<sub>(OLmax)</sub>, for all outputs combined should not exceed ±48 mA to hold the maximum voltage drop specified.

(2) The maximum total current, I<sub>(OHmax)</sub> and I<sub>(OLmax)</sub>, for all outputs combined should not exceed ±100 mA to hold the maximum voltage drop specified.

### 5.11 Outputs – General-Purpose I/O (Reduced Drive Strength) (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7, P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

| PARAMETER                                 | TEST CONDITIONS                             | V <sub>CC</sub> | MIN                    | MAX                    | UNIT |
|-------------------------------------------|---------------------------------------------|-----------------|------------------------|------------------------|------|
| V <sub>OH</sub> High-level output voltage | I <sub>(OHmax)</sub> = –1 mA <sup>(2)</sup> | 1.8 V           | V <sub>CC</sub> – 0.25 | V <sub>CC</sub>        | V    |
|                                           | I <sub>(OHmax)</sub> = –3 mA <sup>(3)</sup> |                 | V <sub>CC</sub> – 0.60 | V <sub>CC</sub>        |      |
|                                           | I <sub>(OHmax)</sub> = –2 mA <sup>(2)</sup> | 3 V             | V <sub>CC</sub> – 0.25 | V <sub>CC</sub>        |      |
|                                           | I <sub>(OHmax)</sub> = –6 mA <sup>(3)</sup> |                 | V <sub>CC</sub> – 0.60 | V <sub>CC</sub>        |      |
| V <sub>OL</sub> Low-level output voltage  | I <sub>(OLmax)</sub> = 1 mA <sup>(2)</sup>  | 1.8 V           | V <sub>SS</sub>        | V <sub>SS</sub> + 0.25 | V    |
|                                           | I <sub>(OLmax)</sub> = 3 mA <sup>(3)</sup>  |                 | V <sub>SS</sub>        | V <sub>SS</sub> + 0.60 |      |
|                                           | I <sub>(OLmax)</sub> = 2 mA <sup>(2)</sup>  | 3 V             | V <sub>SS</sub>        | V <sub>SS</sub> + 0.25 |      |
|                                           | I <sub>(OLmax)</sub> = 6 mA <sup>(3)</sup>  |                 | V <sub>SS</sub>        | V <sub>SS</sub> + 0.60 |      |

(1) Selecting reduced drive strength may reduce EMI.

(2) The maximum total current, I<sub>(OHmax)</sub> and I<sub>(OLmax)</sub>, for all outputs combined, should not exceed ±48 mA to hold the maximum voltage drop specified.

(3) The maximum total current, I<sub>(OHmax)</sub> and I<sub>(OLmax)</sub>, for all outputs combined, should not exceed ±100 mA to hold the maximum voltage drop specified.

### 5.12 Output Frequency – General-Purpose I/O (P1.0 to P1.7, P2.0 to P2.7, P3.0 to P3.4, P4.0 to P4.7, P5.0 to P5.5, P6.0 to P6.7, PJ.0 to PJ.3)

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

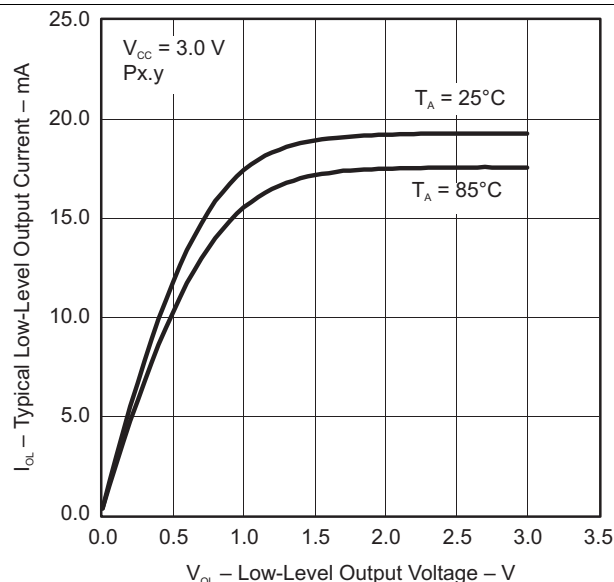
| PARAMETER                                           | TEST CONDITIONS                                                | MIN                                      | MAX | UNIT |
|-----------------------------------------------------|----------------------------------------------------------------|------------------------------------------|-----|------|
| f <sub>Px,y</sub> Port output frequency (with load) | (1)(2) V <sub>CC</sub> = 1.8 V<br>PMMCOREVx = 0                |                                          | 16  | MHz  |
|                                                     | V <sub>CC</sub> = 3 V<br>PMMCOREVx = 3                         |                                          | 25  |      |
| f <sub>Port_CLK</sub> Clock output frequency        | ACLK<br>SMCLK<br>MCLK<br>C <sub>L</sub> = 20 pF <sup>(2)</sup> | V <sub>CC</sub> = 1.8 V<br>PMMCOREVx = 0 | 16  | MHz  |
|                                                     |                                                                | V <sub>CC</sub> = 3 V<br>PMMCOREVx = 3   | 25  |      |

(1) A resistive divider with 2 × R1 between V<sub>CC</sub> and V<sub>SS</sub> is used as load. The output is connected to the center tap of the divider. For full drive strength, R1 = 550 Ω. For reduced drive strength, R1 = 1.6 kΩ. C<sub>L</sub> = 20 pF is connected to the output to V<sub>SS</sub>.

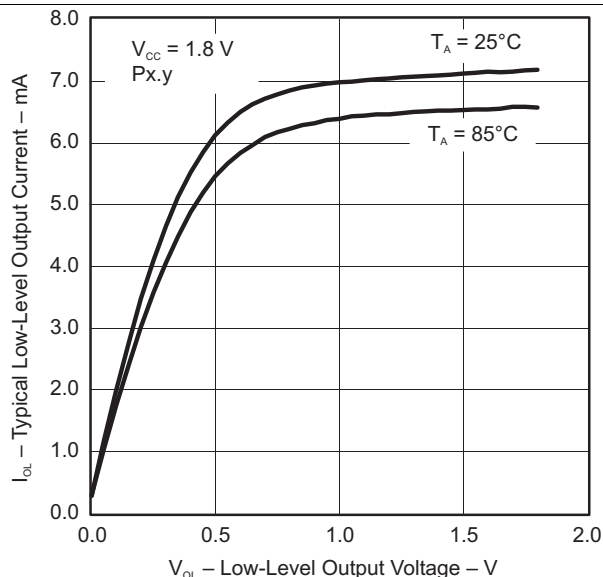
(2) The output voltage reaches at least 10% and 90% V<sub>CC</sub> at the specified toggle frequency.

### 5.13 Typical Characteristics – Outputs, Reduced Drive Strength (PxDS.y = 0)

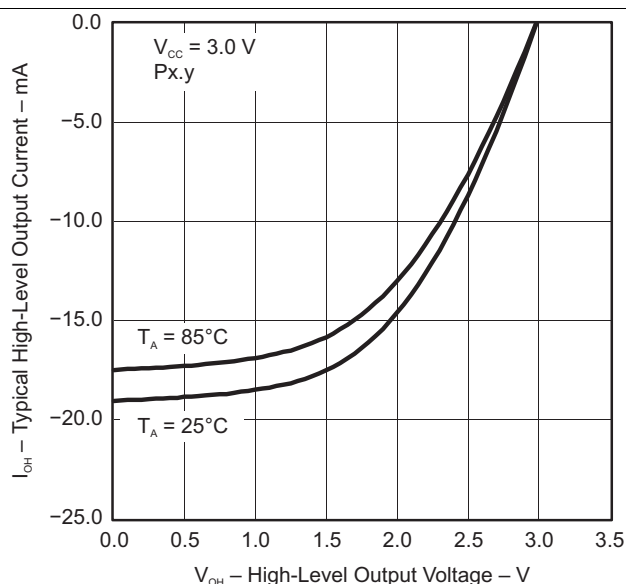
over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)



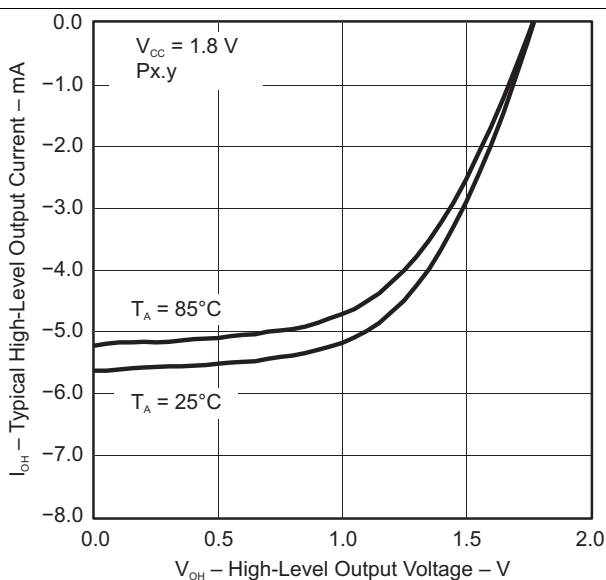
**Figure 5-2. Typical Low-Level Output Current vs Low-Level Output Voltage**



**Figure 5-3. Typical Low-Level Output Current vs Low-Level Output Voltage**



**Figure 5-4. Typical High-Level Output Current vs High-Level Output Voltage**



**Figure 5-5. Typical High-Level Output Current vs High-Level Output Voltage**

## 5.14 Typical Characteristics – Outputs, Full Drive Strength (PxDS.y = 1)

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

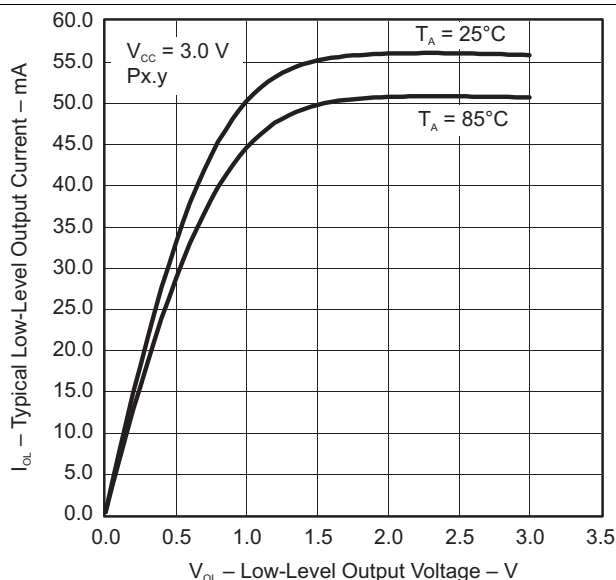


Figure 5-6. Typical Low-Level Output Current vs Low-Level Output Voltage

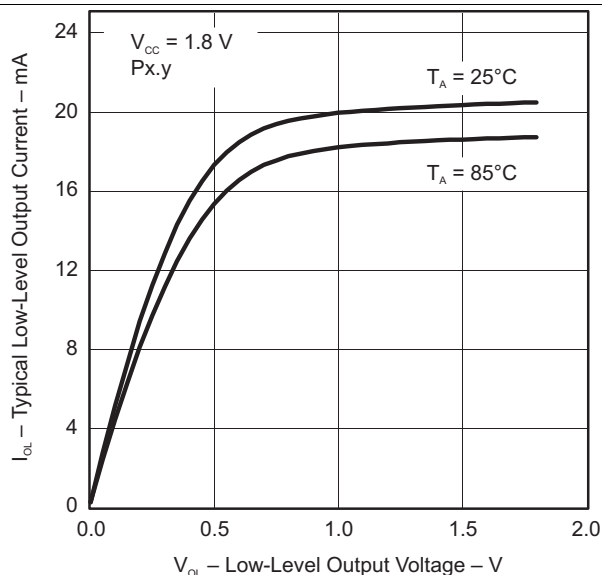


Figure 5-7. Typical Low-Level Output Current vs Low-Level Output Voltage

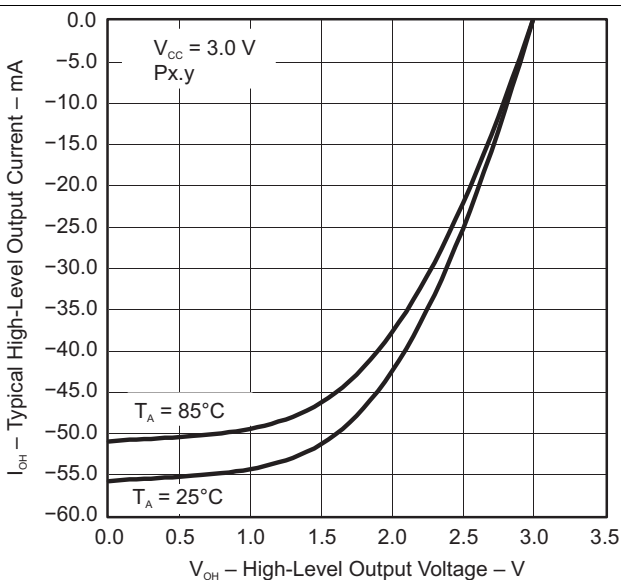


Figure 5-8. Typical High-Level Output Current vs High-Level Output Voltage

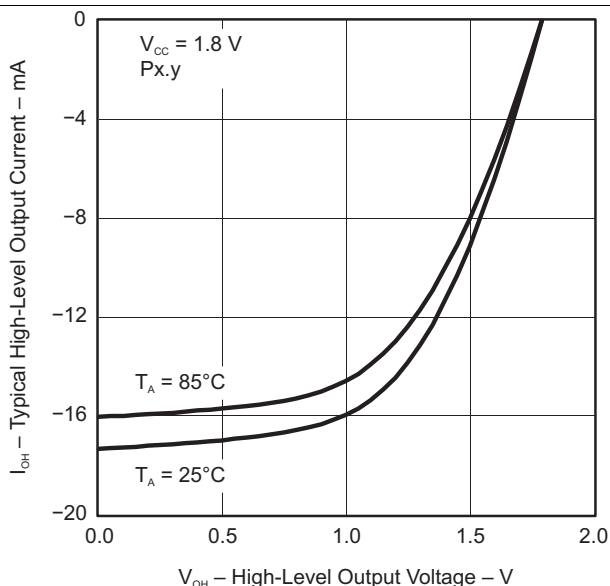


Figure 5-9. Typical High-Level Output Current vs High-Level Output Voltage

## 5.15 Crystal Oscillator, XT1, Low-Frequency Mode<sup>(1)</sup>

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

| PARAMETER              |                                                                                            | TEST CONDITIONS                                                                                                                   | V <sub>CC</sub> | MIN   | TYP    | MAX | UNIT |
|------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|--------|-----|------|
| ΔI <sub>DVCC,LF</sub>  | Differential XT1 oscillator crystal current consumption from lowest drive setting, LF mode | f <sub>OSC</sub> = 32768 Hz, XTS = 0, XT1BYPASS = 0, XT1DRIVE <sub>x</sub> = 1, T <sub>A</sub> = 25°C                             | 3 V             | 0.075 |        |     | μA   |
|                        |                                                                                            | f <sub>OSC</sub> = 32768 Hz, XTS = 0, XT1BYPASS = 0, XT1DRIVE <sub>x</sub> = 2, T <sub>A</sub> = 25°C                             |                 | 0.170 |        |     |      |
|                        |                                                                                            | f <sub>OSC</sub> = 32768 Hz, XTS = 0, XT1BYPASS = 0, XT1DRIVE <sub>x</sub> = 3, T <sub>A</sub> = 25°C                             |                 | 0.290 |        |     |      |
| f <sub>XT1,LF0</sub>   | XT1 oscillator crystal frequency, LF mode                                                  | XTS = 0, XT1BYPASS = 0                                                                                                            |                 | 32768 |        |     | Hz   |
| f <sub>XT1,LF,SW</sub> | XT1 oscillator logic-level square-wave input frequency, LF mode                            | XTS = 0, XT1BYPASS = 1 <sup>(2)</sup> <sup>(3)</sup>                                                                              |                 | 10    | 32.768 | 50  | kHz  |
| OA <sub>LF</sub>       | Oscillation allowance for LF crystals <sup>(4)</sup>                                       | XTS = 0, XT1BYPASS = 0, XT1DRIVE <sub>x</sub> = 0, f <sub>XT1,LF</sub> = 32768 Hz, C <sub>L,eff</sub> = 6 pF                      |                 | 210   |        |     | kΩ   |
|                        |                                                                                            | XTS = 0, XT1BYPASS = 0, XT1DRIVE <sub>x</sub> = 1, f <sub>XT1,LF</sub> = 32768 Hz, C <sub>L,eff</sub> = 12 pF                     |                 | 300   |        |     |      |
| C <sub>L,eff</sub>     | Integrated effective load capacitance, LF mode <sup>(5)</sup>                              | XTS = 0, XCAP <sub>x</sub> = 0 <sup>(6)</sup>                                                                                     |                 | 1     |        |     | pF   |
|                        |                                                                                            | XTS = 0, XCAP <sub>x</sub> = 1                                                                                                    |                 | 5.5   |        |     |      |
|                        |                                                                                            | XTS = 0, XCAP <sub>x</sub> = 2                                                                                                    |                 | 8.5   |        |     |      |
|                        |                                                                                            | XTS = 0, XCAP <sub>x</sub> = 3                                                                                                    |                 | 12.0  |        |     |      |
| Duty cycle, LF mode    |                                                                                            | XTS = 0, Measured at ACLK, f <sub>XT1,LF</sub> = 32768 Hz                                                                         |                 | 30%   | 70%    |     |      |
| f <sub>Fault,LF</sub>  | Oscillator fault frequency, LF mode <sup>(7)</sup>                                         | XTS = 0 <sup>(8)</sup>                                                                                                            |                 | 10    | 10000  |     | Hz   |
| t <sub>START,LF</sub>  | Start-up time, LF mode                                                                     | f <sub>OSC</sub> = 32768 Hz, XTS = 0, XT1BYPASS = 0, XT1DRIVE <sub>x</sub> = 0, T <sub>A</sub> = 25°C, C <sub>L,eff</sub> = 6 pF  | 3 V             | 1000  |        |     | ms   |
|                        |                                                                                            | f <sub>OSC</sub> = 32768 Hz, XTS = 0, XT1BYPASS = 0, XT1DRIVE <sub>x</sub> = 3, T <sub>A</sub> = 25°C, C <sub>L,eff</sub> = 12 pF |                 | 500   |        |     |      |

- (1) To improve EMI on the XT1 oscillator, the following guidelines should be observed.
  - Keep the trace between the device and the crystal as short as possible.
  - Design a good ground plane around the oscillator pins.
  - Prevent crosstalk from other clock or data lines into oscillator pins XIN and XOUT.
  - Avoid running PCB traces underneath or adjacent to the XIN and XOUT pins.
  - Use assembly materials and processes that avoid any parasitic load on the oscillator XIN and XOUT pins.
  - If conformal coating is used, make sure that it does not induce capacitive or resistive leakage between the oscillator pins.
- (2) When XT1BYPASS is set, XT1 circuits are automatically powered down. Input signal is a digital square wave with parametrics defined in the Schmitt-trigger Inputs section of this datasheet.
- (3) Maximum frequency of operation of the entire device cannot be exceeded.
- (4) Oscillation allowance is based on a safety factor of 5 for recommended crystals. The oscillation allowance is a function of the XT1DRIVE<sub>x</sub> settings and the effective load. In general, comparable oscillator allowance can be achieved based on the following guidelines, but should be evaluated based on the actual crystal selected for the application:
  - For XT1DRIVE<sub>x</sub> = 0, C<sub>L,eff</sub> ≤ 6 pF
  - For XT1DRIVE<sub>x</sub> = 1, 6 pF ≤ C<sub>L,eff</sub> ≤ 9 pF
  - For XT1DRIVE<sub>x</sub> = 2, 6 pF ≤ C<sub>L,eff</sub> ≤ 10 pF
  - For XT1DRIVE<sub>x</sub> = 3, C<sub>L,eff</sub> ≥ 6 pF
- (5) Includes parasitic bond and package capacitance (approximately 2 pF per pin). Because the PCB adds additional capacitance, verify the correct load by measuring the ACLK frequency. For a correct setup, the effective load capacitance should always match the specification of the used crystal.
- (6) Requires external capacitors at both terminals. Values are specified by crystal manufacturers.
- (7) Frequencies below the MIN specification set the fault flag. Frequencies above the MAX specification do not set the fault flag. Frequencies between the MIN and MAX specifications might set the flag.
- (8) Measured with logic-level input frequency but also applies to operation with crystals.

## 5.16 Crystal Oscillator, XT2

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1) (2)</sup>

| PARAMETER              |                                                                     | TEST CONDITIONS                                                                                                       | V <sub>CC</sub> | MIN | TYP | MAX | UNIT |
|------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-----------------|-----|-----|-----|------|
| I <sub>DVCC.XT2</sub>  | XT2 oscillator crystal current consumption                          | f <sub>OSC</sub> = 4 MHz, XT2OFF = 0, XT2BYPASS = 0, XT2DRIVE <sub>x</sub> = 0, T <sub>A</sub> = 25°C                 | 3 V             | 200 |     |     | μA   |
|                        |                                                                     | f <sub>OSC</sub> = 12 MHz, XT2OFF = 0, XT2BYPASS = 0, XT2DRIVE <sub>x</sub> = 1, T <sub>A</sub> = 25°C                |                 | 260 |     |     |      |
|                        |                                                                     | f <sub>OSC</sub> = 20 MHz, XT2OFF = 0, XT2BYPASS = 0, XT2DRIVE <sub>x</sub> = 2, T <sub>A</sub> = 25°C                |                 | 325 |     |     |      |
|                        |                                                                     | f <sub>OSC</sub> = 32 MHz, XT2OFF = 0, XT2BYPASS = 0, XT2DRIVE <sub>x</sub> = 3, T <sub>A</sub> = 25°C                |                 | 450 |     |     |      |
| f <sub>XT2,HF0</sub>   | XT2 oscillator crystal frequency, mode 0                            | XT2DRIVE <sub>x</sub> = 0, XT2BYPASS = 0 <sup>(3)</sup>                                                               |                 | 4   |     | 8   | MHz  |
| f <sub>XT2,HF1</sub>   | XT2 oscillator crystal frequency, mode 1                            | XT2DRIVE <sub>x</sub> = 1, XT2BYPASS = 0 <sup>(3)</sup>                                                               |                 | 8   |     | 16  | MHz  |
| f <sub>XT2,HF2</sub>   | XT2 oscillator crystal frequency, mode 2                            | XT2DRIVE <sub>x</sub> = 2, XT2BYPASS = 0 <sup>(3)</sup>                                                               |                 | 16  |     | 24  | MHz  |
| f <sub>XT2,HF3</sub>   | XT2 oscillator crystal frequency, mode 3                            | XT2DRIVE <sub>x</sub> = 3, XT2BYPASS = 0 <sup>(3)</sup>                                                               |                 | 24  |     | 32  | MHz  |
| f <sub>XT2,HF,SW</sub> | XT2 oscillator logic-level square-wave input frequency, bypass mode | XT2BYPASS = 1 <sup>(4)</sup> (3)                                                                                      |                 | 0.7 |     | 32  | MHz  |
| O <sub>AHF</sub>       | Oscillation allowance for HF crystals <sup>(5)</sup>                | XT2DRIVE <sub>x</sub> = 0, XT2BYPASS = 0, f <sub>XT2,HF0</sub> = 6 MHz, C <sub>L,eff</sub> = 15 pF                    |                 | 450 |     |     | Ω    |
|                        |                                                                     | XT2DRIVE <sub>x</sub> = 1, XT2BYPASS = 0, f <sub>XT2,HF1</sub> = 12 MHz, C <sub>L,eff</sub> = 15 pF                   |                 | 320 |     |     |      |
|                        |                                                                     | XT2DRIVE <sub>x</sub> = 2, XT2BYPASS = 0, f <sub>XT2,HF2</sub> = 20 MHz, C <sub>L,eff</sub> = 15 pF                   |                 | 200 |     |     |      |
|                        |                                                                     | XT2DRIVE <sub>x</sub> = 3, XT2BYPASS = 0, f <sub>XT2,HF3</sub> = 32 MHz, C <sub>L,eff</sub> = 15 pF                   |                 | 200 |     |     |      |
| t <sub>START,HF</sub>  | Start-up time                                                       | f <sub>OSC</sub> = 6 MHz, XT2BYPASS = 0, XT2DRIVE <sub>x</sub> = 0, T <sub>A</sub> = 25°C, C <sub>L,eff</sub> = 15 pF | 3 V             | 0.5 |     |     | ms   |
|                        |                                                                     | f <sub>OSC</sub> = 20 MHz XT2BYPASS = 0, XT2DRIVE <sub>x</sub> = 2, T <sub>A</sub> = 25°C, C <sub>L,eff</sub> = 15 pF |                 | 0.3 |     |     |      |
| C <sub>L,eff</sub>     | Integrated effective load capacitance, HF mode <sup>(6)</sup> (1)   |                                                                                                                       |                 | 1   |     |     | pF   |
|                        | Duty cycle                                                          | Measured at ACLK, f <sub>XT2,HF2</sub> = 20 MHz                                                                       |                 | 40% | 50% | 60% |      |
| f <sub>Fault,HF</sub>  | Oscillator fault frequency <sup>(7)</sup>                           | XT2BYPASS = 1 <sup>(8)</sup>                                                                                          |                 | 30  |     | 300 | kHz  |

- (1) Requires external capacitors at both terminals. Values are specified by crystal manufacturers.
- (2) To improve EMI on the XT2 oscillator the following guidelines should be observed.
  - Keep the traces between the device and the crystal as short as possible.
  - Design a good ground plane around the oscillator pins.
  - Prevent crosstalk from other clock or data lines into oscillator pins XT2IN and XT2OUT.
  - Avoid running PCB traces underneath or adjacent to the XT2IN and XT2OUT pins.
  - Use assembly materials and processes that avoid any parasitic load on the oscillator XT2IN and XT2OUT pins.
  - If conformal coating is used, make sure that it does not induce capacitive or resistive leakage between the oscillator pins.
- (3) This represents the maximum frequency that can be input to the device externally. Maximum frequency achievable on the device operation is based on the frequencies present on ACLK, MCLK, and SMCLK cannot be exceed for a given range of operation.
- (4) When XT2BYPASS is set, the XT2 circuit is automatically powered down. Input signal is a digital square wave with parametrics defined in the Schmitt-trigger Inputs section of this datasheet.
- (5) Oscillation allowance is based on a safety factor of 5 for recommended crystals.
- (6) Includes parasitic bond and package capacitance (approximately 2 pF per pin). Because the PCB adds additional capacitance, verify the correct load by measuring the ACLK frequency. For a correct setup, the effective load capacitance should always match the specification of the used crystal.
- (7) Frequencies below the MIN specification set the fault flag. Frequencies above the MAX specification do not set the fault flag. Frequencies between the MIN and MAX specifications might set the flag.
- (8) Measured with logic-level input frequency but also applies to operation with crystals.

## 5.17 Internal Very-Low-Power Low-Frequency Oscillator (VLO)

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

| PARAMETER                                                              | TEST CONDITIONS                 | V <sub>CC</sub> | MIN | TYP | MAX | UNIT |
|------------------------------------------------------------------------|---------------------------------|-----------------|-----|-----|-----|------|
| f <sub>VLO</sub> VLO frequency                                         | Measured at ACLK                | 1.8 V to 3.6 V  | 6   | 9.4 | 14  | kHz  |
| df <sub>VLO</sub> /dT VLO frequency temperature drift                  | Measured at ACLK <sup>(1)</sup> | 1.8 V to 3.6 V  |     | 0.5 |     | %/°C |
| df <sub>VLO</sub> /dV <sub>CC</sub> VLO frequency supply voltage drift | Measured at ACLK <sup>(2)</sup> | 1.8 V to 3.6 V  |     | 4   |     | %/V  |
| Duty cycle                                                             | Measured at ACLK                | 1.8 V to 3.6 V  | 40% | 50% | 60% |      |

(1) Calculated using the box method: (MAX(–40°C to 85°C) – MIN(–40°C to 85°C)) / MIN(–40°C to 85°C) / (85°C – (–40°C))

(2) Calculated using the box method: (MAX(1.8 V to 3.6 V) – MIN(1.8 V to 3.6 V)) / MIN(1.8 V to 3.6 V) / (3.6 V – 1.8 V)

## 5.18 Internal Reference, Low-Frequency Oscillator (REFO)

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

| PARAMETER                                                                | TEST CONDITIONS                 | V <sub>CC</sub> | MIN | TYP   | MAX   | UNIT |
|--------------------------------------------------------------------------|---------------------------------|-----------------|-----|-------|-------|------|
| I <sub>REFO</sub> REFO oscillator current consumption                    | T <sub>A</sub> = 25°C           | 1.8 V to 3.6 V  |     | 3     |       | μA   |
| REFO frequency calibrated                                                | Measured at ACLK                | 1.8 V to 3.6 V  |     | 32768 |       | Hz   |
| f <sub>REFO</sub> REFO absolute tolerance calibrated                     | Full temperature range          | 1.8 V to 3.6 V  |     |       | ±3.5% |      |
|                                                                          | T <sub>A</sub> = 25°C           | 3 V             |     |       | ±1.5% |      |
| df <sub>REFO</sub> /dT REFO frequency temperature drift                  | Measured at ACLK <sup>(1)</sup> | 1.8 V to 3.6 V  |     | 0.01  |       | %/°C |
| df <sub>REFO</sub> /dV <sub>CC</sub> REFO frequency supply voltage drift | Measured at ACLK <sup>(2)</sup> | 1.8 V to 3.6 V  |     | 1.0   |       | %/V  |
| Duty cycle                                                               | Measured at ACLK                | 1.8 V to 3.6 V  | 40% | 50%   | 60%   |      |
| t <sub>START</sub> REFO start-up time                                    | 40%/60% duty cycle              | 1.8 V to 3.6 V  |     | 25    |       | μs   |

(1) Calculated using the box method: (MAX(–40°C to 85°C) – MIN(–40°C to 85°C)) / MIN(–40°C to 85°C) / (85°C – (–40°C))

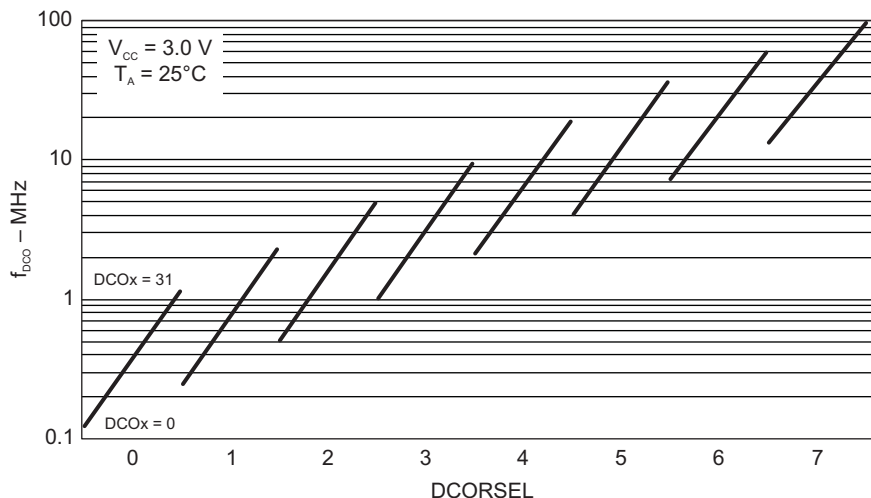
(2) Calculated using the box method: (MAX(1.8 V to 3.6 V) – MIN(1.8 V to 3.6 V)) / MIN(1.8 V to 3.6 V) / (3.6 V – 1.8 V)

## 5.19 DCO Frequency

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

| PARAMETER                                                                   | TEST CONDITIONS                                                                                               | MIN  | TYP | MAX  | UNIT  |
|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|------|-----|------|-------|
| $f_{\text{DCO}(0,0)}$ DCO frequency (0, 0) <sup>(1)</sup>                   | DCORSELx = 0, DCOx = 0, MODx = 0                                                                              | 0.07 |     | 0.20 | MHz   |
| $f_{\text{DCO}(0,31)}$ DCO frequency (0, 31) <sup>(1)</sup>                 | DCORSELx = 0, DCOx = 31, MODx = 0                                                                             | 0.70 |     | 1.70 | MHz   |
| $f_{\text{DCO}(1,0)}$ DCO frequency (1, 0) <sup>(1)</sup>                   | DCORSELx = 1, DCOx = 0, MODx = 0                                                                              | 0.15 |     | 0.36 | MHz   |
| $f_{\text{DCO}(1,31)}$ DCO frequency (1, 31) <sup>(1)</sup>                 | DCORSELx = 1, DCOx = 31, MODx = 0                                                                             | 1.47 |     | 3.45 | MHz   |
| $f_{\text{DCO}(2,0)}$ DCO frequency (2, 0) <sup>(1)</sup>                   | DCORSELx = 2, DCOx = 0, MODx = 0                                                                              | 0.32 |     | 0.75 | MHz   |
| $f_{\text{DCO}(2,31)}$ DCO frequency (2, 31) <sup>(1)</sup>                 | DCORSELx = 2, DCOx = 31, MODx = 0                                                                             | 3.17 |     | 7.38 | MHz   |
| $f_{\text{DCO}(3,0)}$ DCO frequency (3, 0) <sup>(1)</sup>                   | DCORSELx = 3, DCOx = 0, MODx = 0                                                                              | 0.64 |     | 1.51 | MHz   |
| $f_{\text{DCO}(3,31)}$ DCO frequency (3, 31) <sup>(1)</sup>                 | DCORSELx = 3, DCOx = 31, MODx = 0                                                                             | 6.07 |     | 14.0 | MHz   |
| $f_{\text{DCO}(4,0)}$ DCO frequency (4, 0) <sup>(1)</sup>                   | DCORSELx = 4, DCOx = 0, MODx = 0                                                                              | 1.3  |     | 3.2  | MHz   |
| $f_{\text{DCO}(4,31)}$ DCO frequency (4, 31) <sup>(1)</sup>                 | DCORSELx = 4, DCOx = 31, MODx = 0                                                                             | 12.3 |     | 28.2 | MHz   |
| $f_{\text{DCO}(5,0)}$ DCO frequency (5, 0) <sup>(1)</sup>                   | DCORSELx = 5, DCOx = 0, MODx = 0                                                                              | 2.5  |     | 6.0  | MHz   |
| $f_{\text{DCO}(5,31)}$ DCO frequency (5, 31) <sup>(1)</sup>                 | DCORSELx = 5, DCOx = 31, MODx = 0                                                                             | 23.7 |     | 54.1 | MHz   |
| $f_{\text{DCO}(6,0)}$ DCO frequency (6, 0) <sup>(1)</sup>                   | DCORSELx = 6, DCOx = 0, MODx = 0                                                                              | 4.6  |     | 10.7 | MHz   |
| $f_{\text{DCO}(6,31)}$ DCO frequency (6, 31) <sup>(1)</sup>                 | DCORSELx = 6, DCOx = 31, MODx = 0                                                                             | 39.0 |     | 88.0 | MHz   |
| $f_{\text{DCO}(7,0)}$ DCO frequency (7, 0) <sup>(1)</sup>                   | DCORSELx = 7, DCOx = 0, MODx = 0                                                                              | 8.5  |     | 19.6 | MHz   |
| $f_{\text{DCO}(7,31)}$ DCO frequency (7, 31) <sup>(1)</sup>                 | DCORSELx = 7, DCOx = 31, MODx = 0                                                                             | 60   |     | 135  | MHz   |
| $S_{\text{DCORSEL}}$ Frequency step between range DCORSEL and DCORSEL + 1   | $S_{\text{RSEL}} = f_{\text{DCO}(\text{DCORSEL}+1, \text{DCO})} / f_{\text{DCO}(\text{DCORSEL}, \text{DCO})}$ | 1.2  |     | 2.3  | ratio |
| $S_{\text{DCO}}$ Frequency step between tap DCO and DCO + 1                 | $S_{\text{DCO}} = f_{\text{DCO}(\text{DCORSEL}, \text{DCO}+1)} / f_{\text{DCO}(\text{DCORSEL}, \text{DCO})}$  | 1.02 |     | 1.12 | ratio |
| Duty cycle                                                                  | Measured at SMCLK                                                                                             | 40%  | 50% | 60%  |       |
| $df_{\text{DCO}}/dT$ DCO frequency temperature drift <sup>(2)</sup>         | $f_{\text{DCO}} = 1 \text{ MHz}$                                                                              |      | 0.1 |      | %/°C  |
| $df_{\text{DCO}}/dV_{\text{CC}}$ DCO frequency voltage drift <sup>(3)</sup> | $f_{\text{DCO}} = 1 \text{ MHz}$                                                                              |      | 1.9 |      | %/V   |

- (1) When selecting the proper DCO frequency range (DCORSELx), the target DCO frequency,  $f_{\text{DCO}}$ , should be set to reside within the range of  $f_{\text{DCO}(n, 0), \text{MAX}} \leq f_{\text{DCO}} \leq f_{\text{DCO}(n, 31), \text{MIN}}$ , where  $f_{\text{DCO}(n, 0), \text{MAX}}$  represents the maximum frequency specified for the DCO frequency, range n, tap 0 (DCOx = 0) and  $f_{\text{DCO}(n, 31), \text{MIN}}$  represents the minimum frequency specified for the DCO frequency, range n, tap 31 (DCOx = 31). This ensures that the target DCO frequency resides within the range selected. It should also be noted that if the actual  $f_{\text{DCO}}$  frequency for the selected range causes the FLL or the application to select tap 0 or 31, the DCO fault flag is set to report that the selected range is at its minimum or maximum tap setting.
- (2) Calculated using the box method:  $(\text{MAX}(-40^\circ\text{C to } 85^\circ\text{C}) - \text{MIN}(-40^\circ\text{C to } 85^\circ\text{C})) / \text{MIN}(-40^\circ\text{C to } 85^\circ\text{C}) / (85^\circ\text{C} - (-40^\circ\text{C}))$
- (3) Calculated using the box method:  $(\text{MAX}(1.8 \text{ V to } 3.6 \text{ V}) - \text{MIN}(1.8 \text{ V to } 3.6 \text{ V})) / \text{MIN}(1.8 \text{ V to } 3.6 \text{ V}) / (3.6 \text{ V} - 1.8 \text{ V})$



**Figure 5-10. Typical DCO Frequency**

## 5.20 PMM, Brownout Reset (BOR)

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

| PARAMETER              |                                                             | TEST CONDITIONS                 | MIN  | TYP  | MAX  | UNIT |
|------------------------|-------------------------------------------------------------|---------------------------------|------|------|------|------|
| $V_{(DVCC\_BOR\_IT-)}$ | BOR <sub>H</sub> on voltage, DV <sub>CC</sub> falling level | $ dDV_{CC}/dt  < 3 \text{ V/s}$ |      |      | 1.45 | V    |
| $V_{(DVCC\_BOR\_IT+)}$ | BOR <sub>H</sub> off voltage, DV <sub>CC</sub> rising level | $ dDV_{CC}/dt  < 3 \text{ V/s}$ | 0.80 | 1.30 | 1.50 | V    |
| $V_{(DVCC\_BOR\_hys)}$ | BOR <sub>H</sub> hysteresis                                 |                                 | 50   |      | 250  | mV   |
| $t_{\text{RESET}}$     | Pulse duration required at RST/NMI pin to accept a reset    |                                 | 2    |      |      | μs   |

## 5.21 PMM, Core Voltage

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

| PARAMETER               |                                              | TEST CONDITIONS                                 | MIN | TYP  | MAX | UNIT |
|-------------------------|----------------------------------------------|-------------------------------------------------|-----|------|-----|------|
| $V_{\text{CORE3(AM)}}$  | Core voltage, active mode, PMMCOREV = 3      | $2.4 \text{ V} \leq DV_{CC} \leq 3.6 \text{ V}$ |     | 1.90 |     | V    |
| $V_{\text{CORE2(AM)}}$  | Core voltage, active mode, PMMCOREV = 2      | $2.2 \text{ V} \leq DV_{CC} \leq 3.6 \text{ V}$ |     | 1.80 |     | V    |
| $V_{\text{CORE1(AM)}}$  | Core voltage, active mode, PMMCOREV = 1      | $2.0 \text{ V} \leq DV_{CC} \leq 3.6 \text{ V}$ |     | 1.60 |     | V    |
| $V_{\text{CORE0(AM)}}$  | Core voltage, active mode, PMMCOREV = 0      | $1.8 \text{ V} \leq DV_{CC} \leq 3.6 \text{ V}$ |     | 1.40 |     | V    |
| $V_{\text{CORE3(LPM)}}$ | Core voltage, low-current mode, PMMCOREV = 3 | $2.4 \text{ V} \leq DV_{CC} \leq 3.6 \text{ V}$ |     | 1.94 |     | V    |
| $V_{\text{CORE2(LPM)}}$ | Core voltage, low-current mode, PMMCOREV = 2 | $2.2 \text{ V} \leq DV_{CC} \leq 3.6 \text{ V}$ |     | 1.84 |     | V    |
| $V_{\text{CORE1(LPM)}}$ | Core voltage, low-current mode, PMMCOREV = 1 | $2.0 \text{ V} \leq DV_{CC} \leq 3.6 \text{ V}$ |     | 1.64 |     | V    |
| $V_{\text{CORE0(LPM)}}$ | Core voltage, low-current mode, PMMCOREV = 0 | $1.8 \text{ V} \leq DV_{CC} \leq 3.6 \text{ V}$ |     | 1.44 |     | V    |

## 5.22 PMM, SVS High Side

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

| PARAMETER         |                                                   | TEST CONDITIONS                                                   | MIN  | TYP  | MAX  | UNIT          |
|-------------------|---------------------------------------------------|-------------------------------------------------------------------|------|------|------|---------------|
| $I_{(SVSH)}$      | SVS current consumption                           | SVSHE = 0, $DV_{CC} = 3.6\text{ V}$                               |      | 0    |      | nA            |
|                   |                                                   | SVSHE = 1, $DV_{CC} = 3.6\text{ V}$ , SVSHFP = 0                  |      | 200  |      |               |
|                   |                                                   | SVSHE = 1, $DV_{CC} = 3.6\text{ V}$ , SVSHFP = 1                  |      | 1.5  |      | $\mu\text{A}$ |
| $V_{(SVSH\_IT-)}$ | SVS <sub>H</sub> on voltage level <sup>(1)</sup>  | SVSHE = 1, SVSHRVL = 0                                            | 1.57 | 1.68 | 1.78 | V             |
|                   |                                                   | SVSHE = 1, SVSHRVL = 1                                            | 1.79 | 1.88 | 1.98 |               |
|                   |                                                   | SVSHE = 1, SVSHRVL = 2                                            | 1.98 | 2.08 | 2.21 |               |
|                   |                                                   | SVSHE = 1, SVSHRVL = 3                                            | 2.10 | 2.18 | 2.31 |               |
| $V_{(SVSH\_IT+)}$ | SVS <sub>H</sub> off voltage level <sup>(1)</sup> | SVSHE = 1, SVSMHRRRL = 0                                          | 1.62 | 1.74 | 1.85 | V             |
|                   |                                                   | SVSHE = 1, SVSMHRRRL = 1                                          | 1.88 | 1.94 | 2.07 |               |
|                   |                                                   | SVSHE = 1, SVSMHRRRL = 2                                          | 2.07 | 2.14 | 2.28 |               |
|                   |                                                   | SVSHE = 1, SVSMHRRRL = 3                                          | 2.20 | 2.30 | 2.42 |               |
|                   |                                                   | SVSHE = 1, SVSMHRRRL = 4                                          | 2.32 | 2.40 | 2.55 |               |
|                   |                                                   | SVSHE = 1, SVSMHRRRL = 5                                          | 2.52 | 2.70 | 2.88 |               |
|                   |                                                   | SVSHE = 1, SVSMHRRRL = 6                                          | 2.90 | 3.10 | 3.23 |               |
|                   |                                                   | SVSHE = 1, SVSMHRRRL = 7                                          | 2.90 | 3.10 | 3.23 |               |
| $t_{pd(SVSH)}$    | SVS <sub>H</sub> propagation delay                | SVSHE = 1, $dV_{DVCC}/dt = 10\text{ mV}/\mu\text{s}$ , SVSHFP = 1 |      | 2.5  |      | $\mu\text{s}$ |
|                   |                                                   | SVSHE = 1, $dV_{DVCC}/dt = 1\text{ mV}/\mu\text{s}$ , SVSHFP = 0  |      | 20   |      |               |
| $t_{(SVSH)}$      | SVS <sub>H</sub> on or off delay time             | SVSHE = 0 → 1, SVSHFP = 1                                         |      | 12.5 |      | $\mu\text{s}$ |
|                   |                                                   | SVSHE = 0 → 1, SVSHFP = 0                                         |      | 100  |      |               |
| $dV_{DVCC}/dt$    | DVCC rise time                                    |                                                                   | 0    |      | 1000 | V/s           |

(1) The SVS<sub>H</sub> settings available depend on the VCore (PMMCOREVx) setting. See the *Power Management Module and Supply Voltage Supervisor* chapter in the [MSP430F5xx and MSP430F6xx Family User's Guide](#) on recommended settings and use.

## 5.23 PMM, SVM High Side

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

| PARAMETER                                                            | TEST CONDITIONS                                          | MIN  | TYP  | MAX  | UNIT |
|----------------------------------------------------------------------|----------------------------------------------------------|------|------|------|------|
| $I_{(SVMH)}$ SVM <sub>H</sub> current consumption                    | SVMHE = 0, DV <sub>CC</sub> = 3.6 V                      |      | 0    |      | nA   |
|                                                                      | SVMHE = 1, DV <sub>CC</sub> = 3.6 V, SVMHFP = 0          |      | 200  |      |      |
|                                                                      | SVMHE = 1, DV <sub>CC</sub> = 3.6 V, SVMHFP = 1          |      | 1.5  |      | μA   |
| $V_{(SVMH)}$ SVM <sub>H</sub> on or off voltage level <sup>(1)</sup> | SVMHE = 1, SVSMHRRRL = 0                                 | 1.62 | 1.74 | 1.85 | V    |
|                                                                      | SVMHE = 1, SVSMHRRRL = 1                                 | 1.88 | 1.94 | 2.07 |      |
|                                                                      | SVMHE = 1, SVSMHRRRL = 2                                 | 2.07 | 2.14 | 2.28 |      |
|                                                                      | SVMHE = 1, SVSMHRRRL = 3                                 | 2.20 | 2.30 | 2.42 |      |
|                                                                      | SVMHE = 1, SVSMHRRRL = 4                                 | 2.32 | 2.40 | 2.55 |      |
|                                                                      | SVMHE = 1, SVSMHRRRL = 5                                 | 2.52 | 2.70 | 2.88 |      |
|                                                                      | SVMHE = 1, SVSMHRRRL = 6                                 | 2.90 | 3.10 | 3.23 |      |
|                                                                      | SVMHE = 1, SVSMHRRRL = 7                                 | 2.90 | 3.10 | 3.23 |      |
| $t_{pd(SVMH)}$ SVM <sub>H</sub> propagation delay                    | SVMHE = 1, dV <sub>DVCC</sub> /dt = 10 mV/μs, SVMHFP = 1 |      | 2.5  |      | μs   |
|                                                                      | SVMHE = 1, dV <sub>DVCC</sub> /dt = 1 mV/μs, SVMHFP = 0  |      | 20   |      |      |
| $t_{(SVMH)}$ SVM <sub>H</sub> on or off delay time                   | SVMHE = 0 → 1, SVMHFP = 1                                |      | 12.5 |      | μs   |
|                                                                      | SVMHE = 0 → 1, SVMHFP = 0                                |      | 100  |      |      |

(1) The SVM<sub>H</sub> settings available depend on the VCORE (PMMCOREVx) setting. See the *Power Management Module and Supply Voltage Supervisor* chapter in the [MSP430F5xx and MSP430F6xx Family User's Guide](#) on recommended settings and use.

## 5.24 PMM, SVS Low Side

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

| PARAMETER                                          | TEST CONDITIONS                                          | MIN | TYP  | MAX | UNIT |
|----------------------------------------------------|----------------------------------------------------------|-----|------|-----|------|
| $I_{(SVSL)}$ SVS <sub>L</sub> current consumption  | SVSLE = 0, PMMCOREV = 2                                  |     | 0    |     | nA   |
|                                                    | SVSLE = 1, PMMCOREV = 2, SVSLFP = 0                      |     | 200  |     |      |
|                                                    | SVSLE = 1, PMMCOREV = 2, SVSLFP = 1                      |     | 2.0  |     | μA   |
| $t_{pd(SVSL)}$ SVS <sub>L</sub> propagation delay  | SVSLE = 1, dV <sub>CORE</sub> /dt = 10 mV/μs, SVSLFP = 1 |     | 2.5  |     | μs   |
|                                                    | SVSLE = 1, dV <sub>CORE</sub> /dt = 1 mV/μs, SVSLFP = 0  |     | 20   |     |      |
| $t_{(SVSL)}$ SVS <sub>L</sub> on or off delay time | SVSLE = 0 → 1, SVSLFP = 1                                |     | 12.5 |     | μs   |
|                                                    | SVSLE = 0 → 1, SVSLFP = 0                                |     | 100  |     |      |

## 5.25 PMM, SVM Low Side

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

| PARAMETER                                          | TEST CONDITIONS                                                    | MIN | TYP  | MAX | UNIT |
|----------------------------------------------------|--------------------------------------------------------------------|-----|------|-----|------|
| $I_{(SVML)}$ SVM <sub>L</sub> current consumption  | SVMLE = 0, PMMCOREV = 2                                            |     | 0    |     | nA   |
|                                                    | SVMLE = 1, PMMCOREV = 2, SVMLFP = 0                                |     | 200  |     |      |
|                                                    | SVMLE = 1, PMMCOREV = 2, SVMLFP = 1                                |     | 1.5  |     | μA   |
| $t_{pd(SVML)}$ SVM <sub>L</sub> propagation delay  | SVMLE = 1, $dV_{CORE}/dt = 10 \text{ mV}/\mu\text{s}$ , SVMLFP = 1 |     | 2.5  |     | μs   |
|                                                    | SVMLE = 1, $dV_{CORE}/dt = 1 \text{ mV}/\mu\text{s}$ , SVMLFP = 0  |     | 20   |     |      |
| $t_{(SVML)}$ SVM <sub>L</sub> on or off delay time | SVMLE = 0 → 1, SVMLFP = 1                                          |     | 12.5 |     | μs   |
|                                                    | SVMLE = 0 → 1, SVMLFP = 0                                          |     | 100  |     |      |

## 5.26 Wake-up Times From Low-Power Modes and Reset

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

| PARAMETER                                                                                         | TEST CONDITIONS                                                                                        | MIN | TYP | MAX | UNIT |
|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-----|-----|-----|------|
| $t_{WAKE-UP-FAST}$ Wake-up time from LPM2, LPM3, or LPM4 to active mode <sup>(1)</sup>            | PMMCOREV = SVSMLRRL = n<br>(where n = 0, 1, 2, or 3),<br>SVSLFP = 1<br>$f_{MCLK} \geq 4.0 \text{ MHz}$ |     |     | 5   | μs   |
|                                                                                                   | $f_{MCLK} < 4.0 \text{ MHz}$                                                                           |     |     | 6   |      |
| $t_{WAKE-UP-SLOW}$ Wake-up time from LPM2, LPM3, or LPM4 to active mode <sup>(2)(3)</sup>         | PMMCOREV = SVSMLRRL = n<br>(where n = 0, 1, 2, or 3), SVSLFP = 0                                       |     | 150 | 165 | μs   |
| $t_{WAKE-UP-LPM5}$ Wake-up time from LPM4.5 to active mode <sup>(4)</sup>                         |                                                                                                        |     | 2   | 3   | ms   |
| $t_{WAKE-UP-RESET}$ Wake-up time from $\overline{RST}$ or BOR event to active mode <sup>(4)</sup> |                                                                                                        |     | 2   | 3   | ms   |

- (1) This value represents the time from the wake-up event to the first active edge of MCLK. The wake-up time depends on the performance mode of the low-side supervisor (SVS<sub>L</sub>) and low-side monitor (SVM<sub>L</sub>).  $t_{WAKE-UP-FAST}$  is possible with SVS<sub>L</sub> and SVM<sub>L</sub> in full performance mode or disabled. For specific register settings, see the *Low-Side SVS and SVM Control and Performance Mode Selection* section in the *Power Management Module and Supply Voltage Supervisor* chapter of the [MSP430F5xx and MSP430F6xx Family User's Guide](#).
- (2) This value represents the time from the wake-up event to the first active edge of MCLK. The wake-up time depends on the performance mode of the low-side supervisor (SVS<sub>L</sub>) and low-side monitor (SVM<sub>L</sub>).  $t_{WAKE-UP-SLOW}$  is set with SVS<sub>L</sub> and SVM<sub>L</sub> in normal mode (low current mode). For specific register settings, see the *Low-Side SVS and SVM Control and Performance Mode Selection* section in the *Power Management Module and Supply Voltage Supervisor* chapter of the [MSP430F5xx and MSP430F6xx Family User's Guide](#).
- (3) The wake-up times from LPM0 and LPM1 to AM are not specified. They are proportional to MCLK cycle time but are not affected by the performance mode settings as for LPM2, LPM3, and LPM4.
- (4) This value represents the time from the wake-up event to the reset vector execution.

## 5.27 Timer\_A

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

| PARAMETER                              | TEST CONDITIONS                                                       | V <sub>CC</sub> | MIN | MAX | UNIT |
|----------------------------------------|-----------------------------------------------------------------------|-----------------|-----|-----|------|
| $f_{TA}$ Timer_A input clock frequency | Internal: SMCLK or ACLK,<br>External: TACLK,<br>Duty cycle = 50% ±10% | 1.8 V, 3 V      |     | 25  | MHz  |
| $t_{TA,cap}$ Timer_A capture timing    | All capture inputs,<br>Minimum pulse duration required for capture.   | 1.8 V, 3 V      | 20  |     | ns   |

## 5.28 Timer\_B

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

| PARAMETER                              | TEST CONDITIONS                                                       | V <sub>CC</sub> | MIN | MAX | UNIT |
|----------------------------------------|-----------------------------------------------------------------------|-----------------|-----|-----|------|
| $f_{TB}$ Timer_B input clock frequency | Internal: SMCLK or ACLK,<br>External: TBCLK,<br>Duty cycle = 50% ±10% | 1.8 V, 3 V      |     | 25  | MHz  |
| $t_{TB,cap}$ Timer_B capture timing    | All capture inputs, Minimum pulse duration required for capture       | 1.8 V, 3 V      | 20  |     | ns   |

## 5.29 USCI (UART Mode) Clock Frequency

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

| PARAMETER                                                       | TEST CONDITIONS                                                           | MIN          | MAX | UNIT |
|-----------------------------------------------------------------|---------------------------------------------------------------------------|--------------|-----|------|
| $f_{USCI}$ USCI input clock frequency                           | Internal: SMCLK or ACLK,<br>External: UCLK,<br>Duty cycle = 50% $\pm$ 10% | $f_{SYSTEM}$ |     | MHz  |
| $f_{BITCLK}$ BITCLK clock frequency (equals baud rate in MBaud) |                                                                           | 1            |     | MHz  |

## 5.30 USCI (UART Mode)

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

| PARAMETER                                       | $V_{CC}$ | MIN | MAX | UNIT |
|-------------------------------------------------|----------|-----|-----|------|
| $t_t$ UART receive deglitch time <sup>(1)</sup> | 2.2 V    | 50  | 600 | ns   |
|                                                 | 3 V      | 50  | 600 |      |

- (1) Pulses on the UART receive input (UCxRX) shorter than the UART receive deglitch time are suppressed. To ensure that pulses are correctly recognized, their duration should exceed the maximum specification of the deglitch time.

## 5.31 USCI (SPI Master Mode) Clock Frequency

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

| PARAMETER                             | CONDITIONS                                             | MIN          | MAX | UNIT |
|---------------------------------------|--------------------------------------------------------|--------------|-----|------|
| $f_{USCI}$ USCI input clock frequency | Internal: SMCLK or ACLK,<br>Duty cycle = 50% $\pm$ 10% | $f_{SYSTEM}$ |     | MHz  |

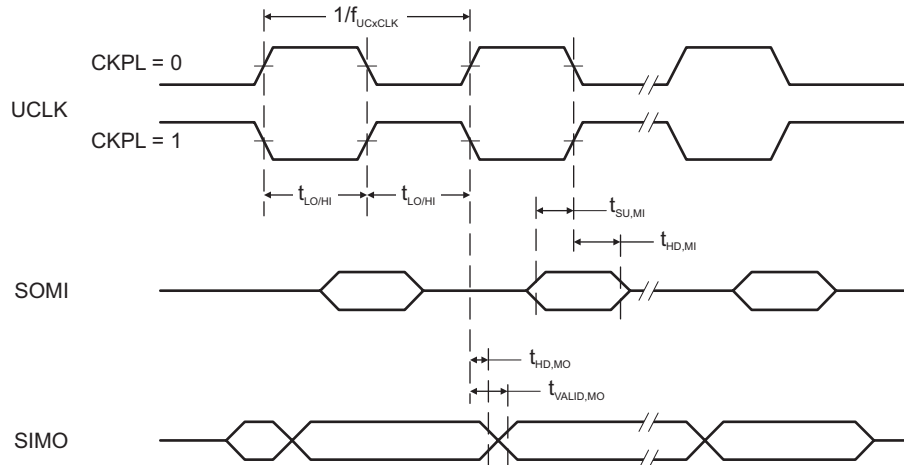
## 5.32 USCI (SPI Master Mode)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

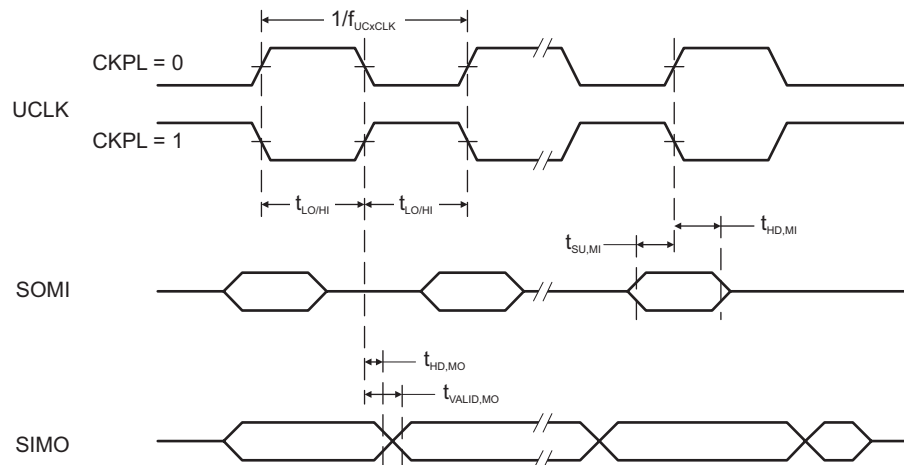
(see [Figure 5-11](#) and [Figure 5-12](#))

| PARAMETER                                                 | TEST CONDITIONS                                         | $V_{CC}$ | MIN          | MAX | UNIT |
|-----------------------------------------------------------|---------------------------------------------------------|----------|--------------|-----|------|
| $f_{USCI}$ USCI input clock frequency                     | SMCLK, ACLK<br>Duty cycle = 50% $\pm$ 10%               |          | $f_{SYSTEM}$ |     | MHz  |
| $t_{SU,MI}$ SOMI input data setup time                    | PMMCOREV = 0                                            | 1.8 V    | 55           |     | ns   |
|                                                           |                                                         | 3 V      | 38           |     |      |
|                                                           | PMMCOREV = 3                                            | 2.4 V    | 30           |     |      |
|                                                           |                                                         | 3 V      | 25           |     |      |
| $t_{HD,MI}$ SOMI input data hold time                     | PMMCOREV = 0                                            | 1.8 V    | 0            |     | ns   |
|                                                           |                                                         | 3 V      | 0            |     |      |
|                                                           | PMMCOREV = 3                                            | 2.4 V    | 0            |     |      |
|                                                           |                                                         | 3 V      | 0            |     |      |
| $t_{VALID,MO}$ SIMO output data valid time <sup>(2)</sup> | UCLK edge to SIMO valid,<br>$C_L$ = 20 pF, PMMCOREV = 0 | 1.8 V    |              | 20  | ns   |
|                                                           |                                                         | 3 V      |              | 18  |      |
|                                                           | UCLK edge to SIMO valid,<br>$C_L$ = 20 pF, PMMCOREV = 3 | 2.4 V    |              | 16  |      |
|                                                           |                                                         | 3 V      |              | 15  |      |
| $t_{HD,MO}$ SIMO output data hold time <sup>(3)</sup>     | $C_L$ = 20 pF, PMMCOREV = 0                             | 1.8 V    | –10          |     | ns   |
|                                                           |                                                         | 3 V      | –8           |     |      |
|                                                           | $C_L$ = 20 pF, PMMCOREV = 3                             | 2.4 V    | –10          |     |      |
|                                                           |                                                         | 3 V      | –8           |     |      |

- (1)  $f_{UCXCLK} = 1/2t_{LO/HI}$  with  $t_{LO/HI} \geq \max(t_{VALID,MO}(USCI) + t_{SU,SI}(Slave), t_{SU,MI}(USCI) + t_{VALID,SO}(Slave))$   
For the slave parameters  $t_{SU,SI}(Slave)$  and  $t_{VALID,SO}(Slave)$ , see the SPI parameters of the attached slave.
- (2) Specifies the time to drive the next valid data to the SIMO output after the output changing UCLK clock edge. See the timing diagrams in [Figure 5-11](#) and [Figure 5-12](#).
- (3) Specifies how long data on the SIMO output is valid after the output changing UCLK clock edge. Negative values indicate that the data on the SIMO output can become invalid before the output changing clock edge observed on UCLK. See the timing diagrams in [Figure 5-11](#) and [Figure 5-12](#).



**Figure 5-11. SPI Master Mode, CKPH = 0**



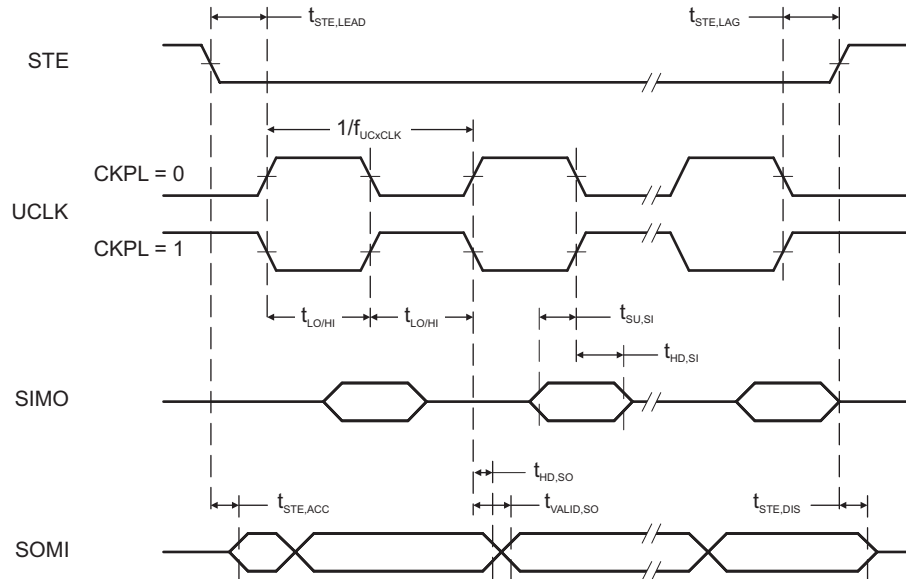
**Figure 5-12. SPI Master Mode, CKPH = 1**

### 5.33 USCI (SPI Slave Mode)

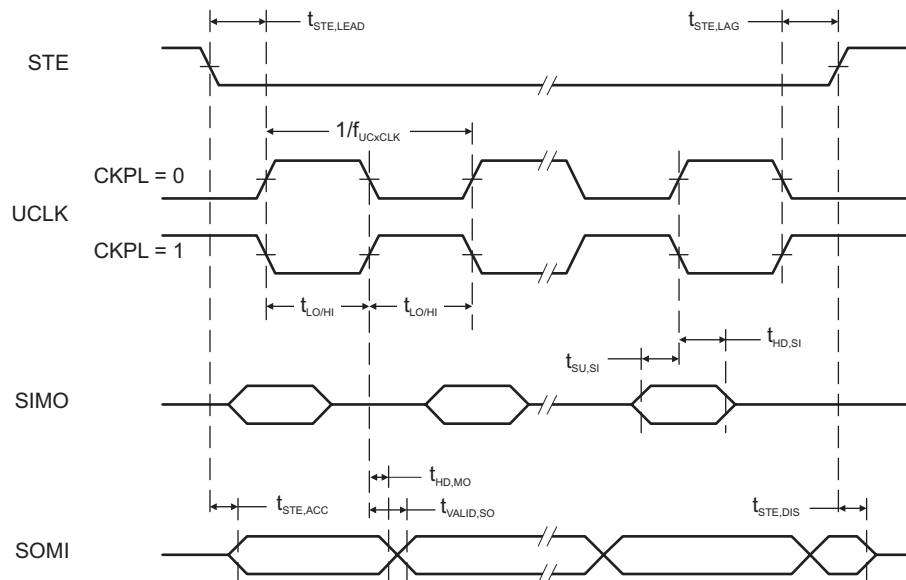
over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>  
(see [Figure 5-13](#) and [Figure 5-14](#))

| PARAMETER                                                       | TEST CONDITIONS                                               | V <sub>CC</sub> | MIN | MAX | UNIT |
|-----------------------------------------------------------------|---------------------------------------------------------------|-----------------|-----|-----|------|
| $t_{STE,LEAD}$ STE lead time, STE low to clock                  | PMMCOREV = 0                                                  | 1.8 V           | 11  |     | ns   |
|                                                                 |                                                               | 3 V             | 8   |     |      |
|                                                                 | PMMCOREV = 3                                                  | 2.4 V           | 7   |     |      |
|                                                                 |                                                               | 3 V             | 6   |     |      |
| $t_{STE,LAG}$ STE lag time, Last clock to STE high              | PMMCOREV = 0                                                  | 1.8 V           | 3   |     | ns   |
|                                                                 |                                                               | 3 V             | 3   |     |      |
|                                                                 | PMMCOREV = 3                                                  | 2.4 V           | 3   |     |      |
|                                                                 |                                                               | 3 V             | 3   |     |      |
| $t_{STE,ACC}$ STE access time, STE low to SOMI data out         | PMMCOREV = 0                                                  | 1.8 V           |     | 66  | ns   |
|                                                                 |                                                               | 3 V             |     | 50  |      |
|                                                                 | PMMCOREV = 3                                                  | 2.4 V           |     | 36  |      |
|                                                                 |                                                               | 3 V             |     | 30  |      |
| $t_{STE,DIS}$ STE disable time, STE high to SOMI high impedance | PMMCOREV = 0                                                  | 1.8 V           |     | 30  | ns   |
|                                                                 |                                                               | 3 V             |     | 23  |      |
|                                                                 | PMMCOREV = 3                                                  | 2.4 V           |     | 16  |      |
|                                                                 |                                                               | 3 V             |     | 13  |      |
| $t_{SU,SI}$ SIMO input data setup time                          | PMMCOREV = 0                                                  | 1.8 V           | 5   |     | ns   |
|                                                                 |                                                               | 3 V             | 5   |     |      |
|                                                                 | PMMCOREV = 3                                                  | 2.4 V           | 2   |     |      |
|                                                                 |                                                               | 3 V             | 2   |     |      |
| $t_{HD,SI}$ SIMO input data hold time                           | PMMCOREV = 0                                                  | 1.8 V           | 5   |     | ns   |
|                                                                 |                                                               | 3 V             | 5   |     |      |
|                                                                 | PMMCOREV = 3                                                  | 2.4 V           | 5   |     |      |
|                                                                 |                                                               | 3 V             | 5   |     |      |
| $t_{VALID,SO}$ SOMI output data valid time <sup>(2)</sup>       | UCLK edge to SOMI valid, C <sub>L</sub> = 20 pF, PMMCOREV = 0 | 1.8 V           |     | 76  | ns   |
|                                                                 |                                                               | 3 V             |     | 60  |      |
|                                                                 | UCLK edge to SOMI valid, C <sub>L</sub> = 20 pF, PMMCOREV = 3 | 2.4 V           |     | 44  |      |
|                                                                 |                                                               | 3 V             |     | 40  |      |
| $t_{HD,SO}$ SOMI output data hold time <sup>(3)</sup>           | C <sub>L</sub> = 20 pF, PMMCOREV = 0                          | 1.8 V           | 18  |     | ns   |
|                                                                 |                                                               | 3 V             | 12  |     |      |
|                                                                 | C <sub>L</sub> = 20 pF, PMMCOREV = 3                          | 2.4 V           | 10  |     |      |
|                                                                 |                                                               | 3 V             | 8   |     |      |

- (1)  $f_{UCXCLK} = 1/2t_{LO/HI}$  with  $t_{LO/HI} \geq \max(t_{VALID,MO(Master)} + t_{SU,SI(USCI)}, t_{SU,MI(Master)} + t_{VALID,SO(USCI)})$   
For the master parameters  $t_{SU,MI(Master)}$  and  $t_{VALID,MO(Master)}$ , see the SPI parameters of the attached master.
- (2) Specifies the time to drive the next valid data to the SOMI output after the output changing UCLK clock edge. See the timing diagrams in [Figure 5-13](#) and [Figure 5-14](#).
- (3) Specifies how long data on the SOMI output is valid after the output changing UCLK clock edge. See the timing diagrams in [Figure 5-13](#) and [Figure 5-14](#).



**Figure 5-13. SPI Slave Mode, CKPH = 0**

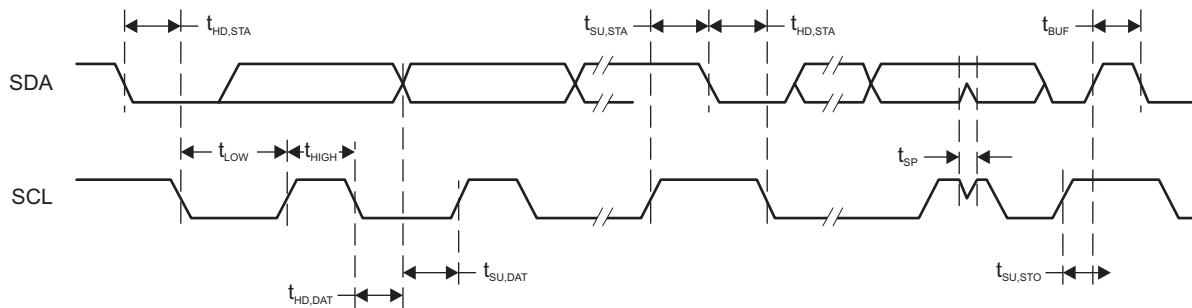


**Figure 5-14. SPI Slave Mode, CKPH = 1**

### 5.34 USCI (I<sup>2</sup>C Mode)

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 5-15](#))

| PARAMETER                                                           | TEST CONDITIONS                                                     | V <sub>CC</sub> | MIN                 | MAX | UNIT |
|---------------------------------------------------------------------|---------------------------------------------------------------------|-----------------|---------------------|-----|------|
| f <sub>USCI</sub> USCI input clock frequency                        | Internal: SMCLK or ACLK,<br>External: UCLK<br>Duty cycle = 50% ±10% |                 | f <sub>SYSTEM</sub> |     | MHz  |
| f <sub>SCL</sub> SCL clock frequency                                |                                                                     | 2.2 V, 3 V      | 0                   | 400 | kHz  |
| t <sub>HD,STA</sub> Hold time (repeated) START                      | f <sub>SCL</sub> ≤ 100 kHz                                          | 2.2 V, 3 V      | 4.0                 |     | μs   |
|                                                                     | f <sub>SCL</sub> > 100 kHz                                          |                 | 0.6                 |     |      |
| t <sub>SU,STA</sub> Setup time for a repeated START                 | f <sub>SCL</sub> ≤ 100 kHz                                          | 2.2 V, 3 V      | 4.7                 |     | μs   |
|                                                                     | f <sub>SCL</sub> > 100 kHz                                          |                 | 0.6                 |     |      |
| t <sub>HD,DAT</sub> Data hold time                                  |                                                                     | 2.2 V, 3 V      | 0                   |     | ns   |
| t <sub>SU,DAT</sub> Data setup time                                 |                                                                     | 2.2 V, 3 V      | 250                 |     | ns   |
| t <sub>SU,STO</sub> Setup time for STOP                             | f <sub>SCL</sub> ≤ 100 kHz                                          | 2.2 V, 3 V      | 4.0                 |     | μs   |
|                                                                     | f <sub>SCL</sub> > 100 kHz                                          |                 | 0.6                 |     |      |
| t <sub>SP</sub> Pulse duration of spikes suppressed by input filter |                                                                     | 2.2 V           | 50                  | 600 | ns   |
|                                                                     |                                                                     | 3 V             | 50                  | 600 |      |



**Figure 5-15. I<sup>2</sup>C Mode Timing**

### 5.35 10-Bit ADC, Power Supply and Input Range Conditions

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

| PARAMETER            |                                                                                               | TEST CONDITIONS                                                                                                                                                             | V <sub>CC</sub> | MIN | TYP | MAX              | UNIT |
|----------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----|-----|------------------|------|
| AV <sub>CC</sub>     | Analog supply voltage                                                                         | AV <sub>CC</sub> and DV <sub>CC</sub> are connected together, AV <sub>SS</sub> and DV <sub>SS</sub> are connected together, V <sub>(AVSS)</sub> = V <sub>(DVSS)</sub> = 0 V |                 | 1.8 |     | 3.6              | V    |
| V <sub>(Ax)</sub>    | Analog input voltage range <sup>(2)</sup>                                                     | All ADC10_A pins: P1.0 to P1.5 and P3.6 and P3.7 terminals                                                                                                                  |                 | 0   |     | AV <sub>CC</sub> | V    |
| I <sub>ADC10_A</sub> | Operating supply current into AV <sub>CC</sub> terminal, REF module and reference buffer off  | f <sub>ADC10CLK</sub> = 5 MHz, ADC10ON = 1, REFON = 0, SHT0 = 0, SHT1 = 0, ADC10DIV = 0, ADC10SREF = 00                                                                     | 2.2 V           |     | 60  | 100              | μA   |
|                      |                                                                                               |                                                                                                                                                                             | 3 V             |     | 75  | 110              |      |
|                      | Operating supply current into AV <sub>CC</sub> terminal, REF module on, reference buffer on   | f <sub>ADC10CLK</sub> = 5 MHz, ADC10ON = 1, REFON = 1, SHT0 = 0, SHT1 = 0, ADC10DIV = 0, ADC10SREF = 01                                                                     | 3 V             |     | 113 | 150              |      |
|                      | Operating supply current into AV <sub>CC</sub> terminal, REF module off, reference buffer on  | f <sub>ADC10CLK</sub> = 5 MHz, ADC10ON = 1, REFON = 0, SHT0 = 0, SHT1 = 0, ADC10DIV = 0, ADC10SREF = 10, VREF = 2.5 V                                                       | 3 V             |     | 105 | 140              |      |
| I <sub>ADC10_A</sub> | Operating supply current into AV <sub>CC</sub> terminal, REF module off, reference buffer off | f <sub>ADC10CLK</sub> = 5 MHz, ADC10ON = 1, REFON = 0, SHT0 = 0, SHT1 = 0, ADC10DIV = 0, ADC10SREF = 11, VREF = 2.5 V                                                       | 3 V             |     | 70  | 110              | μA   |
|                      |                                                                                               |                                                                                                                                                                             |                 |     |     |                  |      |
| C <sub>I</sub>       | Input capacitance                                                                             | Only one terminal Ax can be selected at one time from the pad to the ADC10_A capacitor array including wiring and pad.                                                      | 2.2 V           |     | 3.5 |                  | pF   |
| R <sub>I</sub>       | Input MUX ON resistance                                                                       | AV <sub>CC</sub> > 2.0 V, 0 V ≤ V <sub>Ax</sub> ≤ AV <sub>CC</sub>                                                                                                          |                 |     |     | 36               | kΩ   |
|                      |                                                                                               | 1.8V < AV <sub>CC</sub> < 2.0 V, 0 V ≤ V <sub>Ax</sub> ≤ AV <sub>CC</sub>                                                                                                   |                 |     |     | 96               |      |

(1) The leakage current is defined in the leakage current table with P6.x/Ax parameter.

(2) The analog input voltage range must be within the selected reference voltage range V<sub>R+</sub> to V<sub>R-</sub> for valid conversion results. The external reference voltage requires decoupling capacitors. Two decoupling capacitors, 10 μF and 100 nF, should be connected to V<sub>REF</sub> to decouple the dynamic current required for an external reference source if it is used for the ADC10\_A. Also see the [MSP430F5xx and MSP430F6xx Family User's Guide](#).

### 5.36 10-Bit ADC, Timing Parameters

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

| PARAMETER             |                                            | TEST CONDITIONS                                                                                         | V <sub>CC</sub> | MIN  | TYP                               | MAX | UNIT |
|-----------------------|--------------------------------------------|---------------------------------------------------------------------------------------------------------|-----------------|------|-----------------------------------|-----|------|
| f <sub>ADC10CLK</sub> |                                            | For specified performance of ADC10_A linearity parameters                                               | 2.2 V, 3 V      | 0.45 | 5                                 | 5.5 | MHz  |
| f <sub>ADC10OSC</sub> | Internal ADC10_A oscillator <sup>(1)</sup> | ADC10DIV = 0, f <sub>ADC10CLK</sub> = f <sub>ADC10OSC</sub>                                             | 2.2 V, 3 V      | 4.2  | 4.8                               | 5.4 | MHz  |
| t <sub>CONVERT</sub>  | Conversion time                            | REFON = 0, Internal oscillator, 12 ADC10CLK cycles, 10-bit mode, f <sub>ADC10OSC</sub> = 4 MHz to 5 MHz | 2.2 V, 3 V      | 2.4  |                                   | 3.0 | μs   |
|                       |                                            | External f <sub>ADC10CLK</sub> from ACLK, MCLK, or SMCLK, ADC10SSEL ≠ 0                                 |                 |      | 12 ×<br>1 / f <sub>ADC10CLK</sub> |     |      |
| t <sub>ADC10ON</sub>  | Turn-on settling time of the ADC           | See <sup>(2)</sup>                                                                                      |                 |      |                                   | 100 | ns   |
| t <sub>Sample</sub>   | Sampling time                              | R <sub>S</sub> = 1000 Ω, R <sub>I</sub> = 96 kΩ, C <sub>I</sub> = 3.5 pF <sup>(3)</sup>                 | 1.8 V           | 3    |                                   |     | μs   |
|                       |                                            | R <sub>S</sub> = 1000 Ω, R <sub>I</sub> = 36 kΩ, C <sub>I</sub> = 3.5 pF <sup>(3)</sup>                 | 3 V             | 1    |                                   |     |      |

(1) The ADC10OSC is sourced directly from MODOSC in the UCS.

(2) The condition is that the error in a conversion started after t<sub>ADC10ON</sub> is less than ±0.5 LSB. The reference and input signal are already settled.

(3) Approximately 8 Tau (τ) are required for an error of less than ±0.5 LSB

### 5.37 10-Bit ADC, Linearity Parameters

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

| PARAMETER      |                              | TEST CONDITIONS                                                                                                                                      | V <sub>CC</sub> | MIN | TYP  | MAX  | UNIT |
|----------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----|------|------|------|
| E <sub>I</sub> | Integral linearity error     | $1.4\text{ V} \leq (V_{\text{eREF+}} - V_{\text{eREF-}}) \leq 1.6\text{ V}$ , $C_{\text{VeREF+}} = 20\text{ pF}$                                     | 2.2 V, 3 V      |     |      | ±1.0 | LSB  |
|                |                              | $1.6\text{ V} < (V_{\text{eREF+}} - V_{\text{eREF-}}) \leq V_{\text{AVCC}}$ , $C_{\text{VeREF+}} = 20\text{ pF}$                                     |                 |     |      | ±1.0 |      |
| E <sub>D</sub> | Differential linearity error | $1.4\text{ V} \leq (V_{\text{eREF+}} - V_{\text{eREF-}})$ , $C_{\text{VeREF+}} = 20\text{ pF}$                                                       | 2.2 V, 3 V      |     |      | ±1.0 | LSB  |
| E <sub>O</sub> | Offset error                 | $1.4\text{ V} \leq (V_{\text{eREF+}} - V_{\text{eREF-}})$ , $C_{\text{VeREF+}} = 20\text{ pF}$ ,<br>Internal impedance of source $R_S < 100\ \Omega$ | 2.2 V, 3 V      |     |      | ±1.0 | LSB  |
| E <sub>G</sub> | Gain error                   | $1.4\text{ V} \leq (V_{\text{eREF+}} - V_{\text{eREF-}})$ , $C_{\text{VeREF+}} = 20\text{ pF}$ ,<br>ADC10SREFx = 11b                                 | 2.2 V, 3 V      |     |      | ±1.0 | LSB  |
| E <sub>T</sub> | Total unadjusted error       | $1.4\text{ V} \leq (V_{\text{eREF+}} - V_{\text{eREF-}})$ , $C_{\text{VeREF+}} = 20\text{ pF}$ ,<br>ADC10SREFx = 11b                                 | 2.2 V, 3 V      |     | ±1.0 | ±2.0 | LSB  |

### 5.38 REF, External Reference

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

| PARAMETER                                  |                                               | TEST CONDITIONS                                                                                                                                                                          | V <sub>CC</sub> | MIN | TYP  | MAX              | UNIT |
|--------------------------------------------|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----|------|------------------|------|
| V <sub>eREF+</sub>                         | Positive external reference voltage input     | $V_{\text{eREF+}} > V_{\text{eREF-}}$ <sup>(2)</sup>                                                                                                                                     |                 | 1.4 |      | AV <sub>CC</sub> | V    |
| V <sub>eREF-</sub>                         | Negative external reference voltage input     | $V_{\text{eREF+}} > V_{\text{eREF-}}$ <sup>(3)</sup>                                                                                                                                     |                 | 0   |      | 1.2              | V    |
| (V <sub>eREF+</sub> – V <sub>eREF-</sub> ) | Differential external reference voltage input | $V_{\text{eREF+}} > V_{\text{eREF-}}$ <sup>(4)</sup>                                                                                                                                     |                 | 1.4 |      | AV <sub>CC</sub> | V    |
| I <sub>VeREF+</sub><br>I <sub>VeREF-</sub> | Static input current                          | $1.4\text{ V} \leq V_{\text{eREF+}} \leq V_{\text{AVCC}}$ , $V_{\text{eREF-}} = 0\text{ V}$ ,<br>$f_{\text{ADC10CLK}} = 5\text{ MHz}$ , ADC10SHTx = 0x0001,<br>Conversion rate 200 kpsps | 2.2 V, 3 V      |     | ±8.5 | ±26              | μA   |
|                                            |                                               | $1.4\text{ V} \leq V_{\text{eREF+}} \leq V_{\text{AVCC}}$ , $V_{\text{eREF-}} = 0\text{ V}$ ,<br>$f_{\text{ADC10CLK}} = 5\text{ MHz}$ , ADC10SHTx = 0x1000,<br>Conversion rate 20 kpsps  | 2.2 V, 3 V      |     |      | ±1               |      |
| C <sub>VeREF+/-</sub>                      | Capacitance at VeREF+ or VeREF- terminal      | <sup>(5)</sup>                                                                                                                                                                           |                 | 10  |      |                  | μF   |

- (1) The external reference is used during ADC conversion to charge and discharge the capacitance array. The input capacitance, C<sub>I</sub>, is also the dynamic load for an external reference during conversion. The dynamic impedance of the reference supply should follow the recommendations on analog-source impedance to allow the charge to settle for 10-bit accuracy.
- (2) The accuracy limits the minimum positive external reference voltage. Lower reference voltage levels may be applied with reduced accuracy requirements.
- (3) The accuracy limits the maximum negative external reference voltage. Higher reference voltage levels may be applied with reduced accuracy requirements.
- (4) The accuracy limits minimum external differential reference voltage. Lower differential reference voltage levels may be applied with reduced accuracy requirements.
- (5) Two decoupling capacitors, 10 μF and 100 nF, should be connected to VeREF to decouple the dynamic current required for an external reference source if it is used for the ADC10\_A. Also see the [MSP430F5xx and MSP430F6xx Family User's Guide](#).

### 5.39 REF, Built-In Reference

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)<sup>(1)</sup>

| PARAMETER                   | TEST CONDITIONS                                                                                                                                                                                               | V <sub>CC</sub> | MIN  | TYP   | MAX  | UNIT       |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|------|-------|------|------------|
| V <sub>REF+</sub>           | REFVSEL = {2} for 2.5 V, REFON = 1                                                                                                                                                                            | 3 V             | 2.51 | ±1.5% |      | V          |
|                             | REFVSEL = {1} for 2.0 V, REFON = 1                                                                                                                                                                            | 3 V             | 1.99 | ±1.5% |      |            |
|                             | REFVSEL = {0} for 1.5 V, REFON = 1                                                                                                                                                                            | 2.2 V, 3 V      | 1.5  | ±1.5% |      |            |
| AV <sub>CC(min)</sub>       | REFVSEL = {0} for 1.5 V                                                                                                                                                                                       |                 | 1.8  |       |      | V          |
|                             | REFVSEL = {1} for 2.0 V                                                                                                                                                                                       |                 | 2.2  |       |      |            |
|                             | REFVSEL = {2} for 2.5 V                                                                                                                                                                                       |                 | 2.7  |       |      |            |
| I <sub>REF+</sub>           | f <sub>ADC10CLK</sub> = 5.0 MHz,<br>REFON = 1, REFBURST = 0,<br>REFVSEL = {2} for 2.5 V                                                                                                                       | 3 V             | 18   |       | 24   | μA         |
|                             | f <sub>ADC10CLK</sub> = 5.0 MHz,<br>REFON = 1, REFBURST = 0,<br>REFVSEL = {1} for 2.0 V                                                                                                                       | 3 V             | 15.5 |       | 21   |            |
|                             | f <sub>ADC10CLK</sub> = 5.0 MHz,<br>REFON = 1, REFBURST = 0,<br>REFVSEL = {0} for 1.5 V                                                                                                                       | 3 V             | 13.5 |       | 21   |            |
| TC <sub>REF+</sub>          | Temperature coefficient of<br>built-in reference <sup>(3)</sup><br>I <sub>VREF+</sub> = 0 A,<br>REFVSEL = {0, 1, 2}, REFON = 1                                                                                |                 |      | 30    | 50   | ppm/<br>°C |
| I <sub>SENSOR</sub>         | Operating supply current<br>into AVCC terminal <sup>(4)</sup><br>REFON = 0, INCH = 0Ah,<br>ADC10ON = N/A, T <sub>A</sub> = 30°C                                                                               | 2.2 V           | 20   |       | 22   | μA         |
|                             |                                                                                                                                                                                                               | 3 V             | 20   |       | 22   |            |
| V <sub>SENSOR</sub>         | See <sup>(5)</sup><br>ADC10ON = 1, INCH = 0Ah, T <sub>A</sub> = 30°C                                                                                                                                          | 2.2 V           | 770  |       |      | mV         |
|                             |                                                                                                                                                                                                               | 3 V             | 770  |       |      |            |
| V <sub>MID</sub>            | AVCC divider at channel 11<br>ADC10ON = 1, INCH = 0Bh,<br>V <sub>MID</sub> ≈ 0.5 × V <sub>AVCC</sub>                                                                                                          | 2.2 V           | 1.06 | 1.1   | 1.14 | V          |
|                             |                                                                                                                                                                                                               | 3 V             | 1.46 | 1.5   | 1.54 |            |
| t <sub>SENSOR(sample)</sub> | Sample time required if<br>channel 10 is selected <sup>(6)</sup><br>ADC10ON = 1, INCH = 0Ah,<br>Error of conversion result ≤ 1 LSB                                                                            |                 | 30   |       |      | μs         |
| t <sub>VMID(sample)</sub>   | Sample time required if<br>channel 11 is selected <sup>(7)</sup><br>ADC10ON = 1, INCH = 0Bh,<br>Error of conversion result ≤ 1 LSB                                                                            |                 | 1    |       |      | μs         |
| PSRR <sub>DC</sub>          | Power supply rejection ratio<br>(DC)<br>AV <sub>CC</sub> = AV <sub>CC(min)</sub> to AV <sub>CC(max)</sub> ,<br>T <sub>A</sub> = 25°C,<br>REFVSEL = {0, 1, 2}, REFON = 1                                       |                 |      | 120   |      | μV/V       |
| PSRR <sub>AC</sub>          | Power supply rejection ratio<br>(AC)<br>AV <sub>CC</sub> = AV <sub>CC(min)</sub> to AV <sub>CC(max)</sub> ,<br>T <sub>A</sub> = 25°C, f = 1 kHz, ΔV <sub>pp</sub> = 100 mV,<br>REFVSEL = {0, 1, 2}, REFON = 1 |                 |      | 6.4   |      | mV/V       |
| t <sub>SETTLE</sub>         | Settling time of reference<br>voltage <sup>(8)</sup><br>AV <sub>CC</sub> = AV <sub>CC(min)</sub> to AV <sub>CC(max)</sub> ,<br>REFVSEL = {0, 1, 2}, REFON = 0 → 1                                             |                 |      | 75    |      | μs         |

(1) The leakage current is defined in the leakage current table with P6.x/Ax parameter.

(2) The internal reference current is supplied from terminal AVCC. Consumption is independent of the ADC10ON control bit, unless a conversion is active. The REFON bit enables to settle the built-in reference before starting an A/D conversion.

(3) Calculated using the box method: (MAX(−40°C to 85°C) − MIN(−40°C to 85°C)) / MIN(−40°C to 85°C)/(85°C − (−40°C)).

(4) The sensor current I<sub>SENSOR</sub> is consumed if (ADC10ON = 1 and REFON = 1) or (ADC10ON = 1 and INCH = 0Ah and sample signal is high). When REFON = 1, I<sub>SENSOR</sub> is already included in I<sub>REF+</sub>.

(5) The temperature sensor offset can be significant. TI recommends a single-point calibration to minimize the offset error of the built-in temperature sensor.

(6) The typical equivalent impedance of the sensor is 51 kΩ. The sample time required includes the sensor on-time t<sub>SENSOR(on)</sub>.

(7) The on-time t<sub>VMID(on)</sub> is included in the sampling time t<sub>VMID(sample)</sub>; no additional on time is needed.

(8) The condition is that the error in a conversion started after t<sub>REFON</sub> is less than ±0.5 LSB.

## 5.40 Comparator B

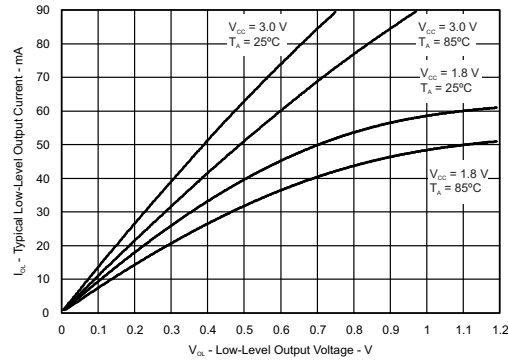
over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

| PARAMETER              | TEST CONDITIONS                                                                   | V <sub>CC</sub>                                               | MIN                                  | TYP                                | MAX                                  | UNIT |
|------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------|------------------------------------|--------------------------------------|------|
| V <sub>CC</sub>        | Supply voltage                                                                    |                                                               | 1.8                                  |                                    | 3.6                                  | V    |
| I <sub>AVCC_COMP</sub> | Comparator operating supply current into AVCC, Excludes reference resistor ladder | 1.8 V                                                         |                                      |                                    | 40                                   | μA   |
|                        |                                                                                   | 2.2 V                                                         |                                      | 30                                 | 50                                   |      |
|                        |                                                                                   | 3 V                                                           |                                      | 40                                 | 65                                   |      |
|                        |                                                                                   | 2.2 V, 3 V                                                    |                                      | 10                                 | 17                                   |      |
| I <sub>AVCC_REF</sub>  | Quiescent current of resistor ladder into AVCC, Includes REF module current       | 2.2 V, 3 V                                                    |                                      | 10                                 | 17                                   | μA   |
|                        |                                                                                   | 2.2 V, 3 V                                                    |                                      |                                    | 22                                   |      |
| V <sub>IC</sub>        | Common mode input range                                                           |                                                               | 0                                    |                                    | V <sub>CC</sub> – 1                  | V    |
| V <sub>OFFSET</sub>    | Input offset voltage                                                              | CBPWRMD = 00                                                  |                                      |                                    | ±20                                  | mV   |
|                        |                                                                                   | CBPWRMD = 01 or 10                                            |                                      |                                    | ±10                                  |      |
| C <sub>IN</sub>        | Input capacitance                                                                 |                                                               |                                      | 5                                  |                                      | pF   |
| R <sub>SIN</sub>       | Series input resistance                                                           | On (switch closed)                                            |                                      | 3                                  | 4                                    | kΩ   |
|                        |                                                                                   | Off (switch open)                                             | 50                                   |                                    |                                      | MΩ   |
| t <sub>PD</sub>        | Propagation delay, response time                                                  | CBPWRMD = 00, CBF = 0                                         |                                      |                                    | 450                                  | ns   |
|                        |                                                                                   | CBPWRMD = 01, CBF = 0                                         |                                      |                                    | 600                                  |      |
|                        |                                                                                   | CBPWRMD = 10, CBF = 0                                         |                                      |                                    | 50                                   | μs   |
| t <sub>PD,filter</sub> | Propagation delay with filter active                                              | CBPWRMD = 00, CBON = 1, CBF = 1, CBF <sub>DLY</sub> = 00      | 0.35                                 | 0.6                                | 1.0                                  | μs   |
|                        |                                                                                   | CBPWRMD = 00, CBON = 1, CBF = 1, CBF <sub>DLY</sub> = 01      | 0.6                                  | 1.0                                | 1.8                                  |      |
|                        |                                                                                   | CBPWRMD = 00, CBON = 1, CBF = 1, CBF <sub>DLY</sub> = 10      | 1.0                                  | 1.8                                | 3.4                                  |      |
|                        |                                                                                   | CBPWRMD = 00, CBON = 1, CBF = 1, CBF <sub>DLY</sub> = 11      | 1.8                                  | 3.4                                | 6.5                                  |      |
| t <sub>EN_CMP</sub>    | Comparator enable time                                                            | CBON = 0 to CBON = 1<br>CBPWRMD = 00 or 01                    |                                      | 1                                  | 2                                    | μs   |
|                        |                                                                                   | CBON = 0 to CBON = 1<br>CBPWRMD = 10                          |                                      |                                    | 100                                  |      |
| t <sub>EN_REF</sub>    | Resistor reference enable time                                                    | CBON = 0 to CBON = 1                                          |                                      | 1                                  | 1.5                                  | μs   |
| V <sub>CB_REF</sub>    | Reference voltage for a given tap                                                 | V <sub>IN</sub> = reference into resistor ladder, n = 0 to 31 | $\frac{V_{IN} \times (n + 0.5)}{32}$ | $\frac{V_{IN} \times (n + 1)}{32}$ | $\frac{V_{IN} \times (n + 1.5)}{32}$ | V    |

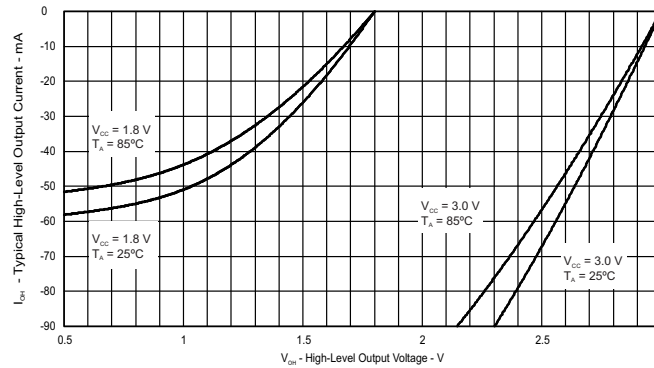
## 5.41 Ports PU.0 and PU.1

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

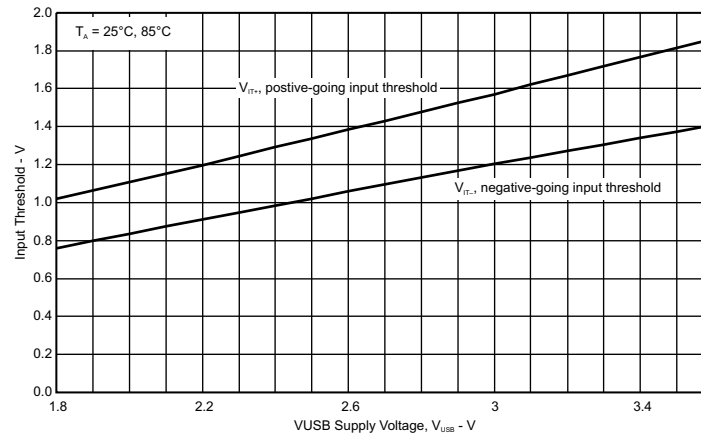
| PARAMETER       |                           | TEST CONDITIONS                                                                                                         | MIN | MAX | UNIT |
|-----------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------|-----|-----|------|
| V <sub>OH</sub> | High-level output voltage | V <sub>USB</sub> = 3.3 V ±10%, I <sub>OH</sub> = –25 mA.<br>See <a href="#">Figure 5-17</a> for typical characteristics | 2.4 |     | V    |
| V <sub>OL</sub> | Low-level output voltage  | V <sub>USB</sub> = 3.3 V ±10%, I <sub>OL</sub> = 25 mA.<br>See <a href="#">Figure 5-16</a> for typical characteristics  |     | 0.4 | V    |
| V <sub>IH</sub> | High-level input voltage  | V <sub>USB</sub> = 3.3 V ±10%<br>See <a href="#">Figure 5-18</a> for typical characteristics                            | 2.0 |     | V    |
| V <sub>IL</sub> | Low-level input voltage   | V <sub>USB</sub> = 3.3 V ±10%<br>See <a href="#">Figure 5-18</a> for typical characteristics                            |     | 0.8 | V    |



**Figure 5-16. Ports PU.0, PU.1 Typical Low-Level Output Characteristics**



**Figure 5-17. Ports PU.0, PU.1 Typical High-Level Output Characteristics**



**Figure 5-18. Ports PU.0, PU.1 Typical Input Threshold Characteristics**

## 5.42 USB Output Ports (DP and DM)

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

| PARAMETER         |                     | TEST CONDITIONS                                                      | MIN | MAX | UNIT     |
|-------------------|---------------------|----------------------------------------------------------------------|-----|-----|----------|
| V <sub>OH</sub>   | D+, D- single ended | USB 2.0 load conditions                                              | 2.8 | 3.6 | V        |
| V <sub>OL</sub>   | D+, D- single ended | USB 2.0 load conditions                                              | 0   | 0.3 | V        |
| Z(DRV)            | D+, D- impedance    | Including external series resistor of 27 $\Omega$                    | 28  | 44  | $\Omega$ |
| t <sub>RISE</sub> | Rise time           | Full speed, differential, C <sub>L</sub> = 50 pF, 10%/90%, Rpu on D+ | 4   | 20  | ns       |
| t <sub>FALL</sub> | Fall time           | Full speed, differential, C <sub>L</sub> = 50 pF, 10%/90%, Rpu on D+ | 4   | 20  | ns       |

## 5.43 USB Input Ports (DP and DM)

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

| PARAMETER        |                                      | MIN | MAX | UNIT       |
|------------------|--------------------------------------|-----|-----|------------|
| V <sub>CM</sub>  | Differential input common mode range | 0.8 | 2.5 | V          |
| Z <sub>IN</sub>  | Input impedance                      | 300 |     | k $\Omega$ |
| V <sub>CRS</sub> | Crossover voltage                    | 1.3 | 2.0 | V          |
| V <sub>IL</sub>  | Static SE input logic low level      |     | 0.8 | V          |
| V <sub>IH</sub>  | Static SE input logic high level     | 2.0 |     | V          |
| V <sub>DI</sub>  | Differential input voltage           |     | 0.2 | V          |

## 5.44 USB-PWR (USB Power System)

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

| PARAMETER                |                                                                                                 | TEST CONDITIONS                                                                                 | V <sub>CC</sub> | MIN  | TYP       | MAX  | UNIT     |
|--------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-----------------|------|-----------|------|----------|
| V <sub>LAUNCH</sub>      | V <sub>BUS</sub> detection threshold                                                            |                                                                                                 |                 |      |           | 3.75 | V        |
| V <sub>BUS</sub>         | USB bus voltage                                                                                 | Normal operation                                                                                |                 | 3.76 |           | 5.5  | V        |
| V <sub>USB</sub>         | USB LDO output voltage                                                                          |                                                                                                 |                 | 3.3  | $\pm 9\%$ |      | V        |
| V <sub>18</sub>          | Internal USB voltage <sup>(1)</sup>                                                             |                                                                                                 |                 | 1.8  |           |      | V        |
| I <sub>USB_EXT</sub>     | Maximum external current from VUSB terminal <sup>(2)</sup>                                      | USB LDO is on                                                                                   |                 |      |           | 12   | mA       |
| I <sub>DET</sub>         | USB LDO current overload detection <sup>(3)</sup>                                               |                                                                                                 |                 | 60   |           | 100  | mA       |
| I <sub>SUSPEND</sub>     | Operating supply current into VBUS terminal <sup>(4)</sup>                                      | USB LDO on, USB PLL disabled                                                                    |                 |      |           | 250  | $\mu$ A  |
| I <sub>USB_LDO</sub>     | Operating supply current into VBUS terminal, Represents the current of the 3.3-V LDO only       | USB LDO on, USB 1.8-V LDO disabled, V <sub>BUS</sub> = 5 V, USBDETEN = 0 or 1                   | 1.8 V, 3 V      |      | 60        |      | $\mu$ A  |
| I <sub>VBUS_DETECT</sub> | Operating supply current into VBUS terminal, Represents the current of the VBUS detection logic | USB LDO disabled, USB 1.8-V LDO disabled, V <sub>BUS</sub> > V <sub>LAUNCH</sub> , USBDETEN = 1 | 1.8 V, 3 V      |      | 30        |      | $\mu$ A  |
| C <sub>BUS</sub>         | VBUS terminal recommended capacitance                                                           |                                                                                                 |                 |      | 4.7       |      | $\mu$ F  |
| C <sub>USB</sub>         | VUSB terminal recommended capacitance                                                           |                                                                                                 |                 |      | 220       |      | nF       |
| C <sub>18</sub>          | V18 terminal recommended capacitance                                                            |                                                                                                 |                 |      | 220       |      | nF       |
| t <sub>ENABLE</sub>      | Settling time V <sub>USB</sub> and V <sub>18</sub>                                              | Within 2%, recommended capacitances                                                             |                 |      |           | 2    | ms       |
| R <sub>PUR</sub>         | Pullup resistance of PUR terminal <sup>(5)</sup>                                                |                                                                                                 |                 | 70   | 110       | 150  | $\Omega$ |

(1) This voltage is for internal use only. No external DC loading should be applied.

(2) This represents additional current that can be supplied to the application from the VUSB terminal beyond the needs of the USB operation.

(3) A current overload is detected when the total current supplied from the USB LDO, including I<sub>USB\_EXT</sub>, exceeds this value.

(4) Does not include current contribution of Rpu and Rpd as outlined in the USB specification.

(5) This value, in series with an external resistor between PUR and D+, produces the Rpu as outlined in the USB specification.

## 5.45 USB-PLL (USB Phase-Locked Loop)

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

| PARAMETER    |                          | MIN | TYP  | MAX | UNIT |
|--------------|--------------------------|-----|------|-----|------|
| $I_{PLL}$    | Operating supply current |     |      | 7   | mA   |
| $f_{PLL}$    | PLL frequency            |     | 48   |     | MHz  |
| $f_{UPD}$    | PLL reference frequency  | 1.5 |      | 3   | MHz  |
| $t_{LOCK}$   | PLL lock time            |     |      | 2   | ms   |
| $t_{Jitter}$ | PLL jitter               |     | 1000 |     | ps   |

## 5.46 Flash Memory

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

| PARAMETER              |                                                                                                  | $T_J$ | MIN    | TYP    | MAX | UNIT   |
|------------------------|--------------------------------------------------------------------------------------------------|-------|--------|--------|-----|--------|
| $DV_{CC(PGM/ERASE)}$   | Program and erase supply voltage                                                                 |       | 1.8    |        | 3.6 | V      |
| $t_{READMARGIN}$       | Read access time during marginal mode                                                            |       |        |        | 200 | ns     |
| $I_{PGM}$              | Supply current from $DV_{CC}$ during program                                                     |       |        | 3      | 5   | mA     |
| $I_{ERASE}$            | Supply current from $DV_{CC}$ during erase                                                       |       |        | 2      | 6.5 | mA     |
| $I_{MERASE}, I_{BANK}$ | Supply current from $DV_{CC}$ during mass erase or bank erase                                    |       |        | 2      | 6.5 | mA     |
| $t_{CPT}$              | Cumulative program time <sup>(1)</sup>                                                           |       |        |        | 16  | ms     |
|                        | Program and erase endurance                                                                      |       | $10^4$ | $10^5$ |     | cycles |
| $t_{Retention}$        | Data retention duration                                                                          | 25°C  | 100    |        |     | years  |
| $t_{Word}$             | Word or byte program time <sup>(2)</sup>                                                         |       | 64     |        | 85  | μs     |
| $t_{Block, 0}$         | Block program time for first byte or word <sup>(2)</sup>                                         |       | 49     |        | 65  | μs     |
| $t_{Block, 1-(N-1)}$   | Block program time for each additional byte or word, except for last byte or word <sup>(2)</sup> |       | 37     |        | 49  | μs     |
| $t_{Block, N}$         | Block program time for last byte or word <sup>(2)</sup>                                          |       | 55     |        | 73  | μs     |
| $t_{Erase}$            | Erase time for segment, mass erase, and bank erase when available <sup>(2)</sup>                 |       | 23     |        | 32  | ms     |

(1) The cumulative program time must not be exceeded when writing to a 128-byte flash block. This parameter applies to all programming methods: individual word write, individual byte write, and block write modes.

(2) These values are hardwired into the state machine of the flash controller.

## 5.47 JTAG and Spy-Bi-Wire Interface

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

| PARAMETER      |                                                                                      | $V_{CC}$   | MIN   | TYP | MAX | UNIT |
|----------------|--------------------------------------------------------------------------------------|------------|-------|-----|-----|------|
| $f_{SBW}$      | Spy-Bi-Wire input frequency                                                          | 2.2 V, 3 V | 0     |     | 20  | MHz  |
| $t_{SBW, Low}$ | Spy-Bi-Wire low clock pulse duration                                                 | 2.2 V, 3 V | 0.025 |     | 15  | μs   |
| $t_{SBW, En}$  | Spy-Bi-Wire enable time (TEST high to acceptance of first clock edge) <sup>(1)</sup> | 2.2 V, 3 V |       |     | 1   | μs   |
| $t_{SBW, Rst}$ | Spy-Bi-Wire return to normal operation time                                          |            | 15    |     | 100 | μs   |
| $f_{TCK}$      | TCK input frequency for 4-wire JTAG <sup>(2)</sup>                                   | 2.2 V      | 0     |     | 5   | MHz  |
|                |                                                                                      | 3 V        | 0     |     | 10  | MHz  |
| $R_{internal}$ | Internal pulldown resistance on TEST                                                 | 2.2 V, 3 V | 45    | 60  | 80  | kΩ   |

(1) Tools that access the Spy-Bi-Wire and BSL interfaces must wait for the  $t_{SBW, En}$  time after the first transition of the TEST/SBW TCK pin (low to high), before the second transition of the pin (high to low) during the entry sequence.

(2)  $f_{TCK}$  may be restricted to meet the timing requirements of the module selected.

## 6 Detailed Description

### 6.1 CPU ([Link to User's Guide](#))

The MSP430 CPU has a 16-bit RISC architecture that is highly transparent to the application. All operations, other than program-flow instructions, are performed as register operations in conjunction with seven addressing modes for source operand and four addressing modes for destination operand.

The CPU is integrated with 16 registers that provide reduced instruction execution time. The register-to-register operation execution time is one cycle of the CPU clock. Four of the registers, R0 to R3, are dedicated as program counter, stack pointer, status register, and constant generator, respectively. The remaining registers are general-purpose registers (see [Figure 6-1](#)).

Peripherals are connected to the CPU using data, address, and control buses. Peripherals can be managed with all instructions.

The instruction set consists of the original 51 instructions with three formats and seven address modes and additional instructions for the expanded address range. Each instruction can operate on word and byte data.

|                          |           |
|--------------------------|-----------|
| Program Counter          | PC/R0     |
| Stack Pointer            | SP/R1     |
| Status Register          | SR/CG1/R2 |
| Constant Generator       | CG2/R3    |
| General-Purpose Register | R4        |
| General-Purpose Register | R5        |
| General-Purpose Register | R6        |
| General-Purpose Register | R7        |
| General-Purpose Register | R8        |
| General-Purpose Register | R9        |
| General-Purpose Register | R10       |
| General-Purpose Register | R11       |
| General-Purpose Register | R12       |
| General-Purpose Register | R13       |
| General-Purpose Register | R14       |
| General-Purpose Register | R15       |

**Figure 6-1. Integrated CPU Registers**

## 6.2 Operating Modes

These microcontrollers have one active mode and six software-selectable low-power modes of operation. An interrupt event can wake up the device from any of the low-power modes, service the request, and restore back to the low-power mode on return from the interrupt program.

Software can configure the following seven operating modes:

- Active mode (AM)
  - All clocks are active
- Low-power mode 0 (LPM0)
  - CPU is disabled
  - ACLK and SMCLK remain active
  - MCLK is disabled
  - FLL loop control remains active
- Low-power mode 1 (LPM1)
  - CPU is disabled
  - FLL loop control is disabled
  - ACLK and SMCLK remain active
  - MCLK is disabled
- Low-power mode 2 (LPM2)
  - CPU is disabled
  - MCLK, FLL loop control, and DCOCLK are disabled
  - DC generator of the DCO remains enabled
  - ACLK remains active
- Low-power mode 3 (LPM3)
  - CPU is disabled
  - MCLK, FLL loop control, and DCOCLK are disabled
  - DC generator of the DCO is disabled
  - ACLK remains active
- Low-power mode 4 (LPM4)
  - CPU is disabled
  - ACLK is disabled
  - MCLK, FLL loop control, and DCOCLK are disabled
  - DC generator of the DCO is disabled
  - Crystal oscillator is stopped
  - Complete data retention
- Low-power mode 4.5 (LPM4.5)
  - Internal regulator disabled
  - No data retention
  - Wake-up input from  $\overline{\text{RST}}$ /NMI, P1, and P2.

### 6.3 Interrupt Vector Addresses

The interrupt vectors and the power-up start address are in the address range 0FFFFh to 0FF80h (see [Table 6-1](#)). The vector contains the 16-bit address of the interrupt-handler instruction sequence.

**Table 6-1. Interrupt Sources, Flags, and Vectors**

| INTERRUPT SOURCE                                                                                                              | INTERRUPT FLAG                                                                                            | SYSTEM INTERRUPT | WORD ADDRESS | PRIORITY    |
|-------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------------|--------------|-------------|
| <b>System Reset</b><br>Power up<br>External reset<br>Watchdog time-out, password violation<br>Flash memory password violation | WDTIFG, KEYV (SYSRSTIV) <sup>(1) (2)</sup>                                                                | Reset            | 0FFFEh       | 63, highest |
| <b>System NMI</b><br>PMM<br>Vacant memory access<br>JTAG mailbox                                                              | SVMLIFG, SVMHIFG, DLYLIFG, DLYHIFG, VLRIFG, VLRHIFG, VMAIFG, JMBINIFG, JMBOUTIFG (SYSSNIV) <sup>(1)</sup> | (Non)maskable    | 0FFFCh       | 62          |
| <b>User NMI</b><br>NMI<br>Oscillator fault<br>Flash memory access violation                                                   | NMIIFG, OFIFG, ACCVIFG, BUSIFG (SYSUNIV) <sup>(1) (2)</sup>                                               | (Non)maskable    | 0FFFAh       | 61          |
| Comp_B                                                                                                                        | Comparator B interrupt flags (CBIV) <sup>(1) (3)</sup>                                                    | Maskable         | 0FFF8h       | 60          |
| TB0                                                                                                                           | TB0CCR0 CCIFG0 <sup>(3)</sup>                                                                             | Maskable         | 0FFF6h       | 59          |
| TB0                                                                                                                           | TB0CCR1 CCIFG1 to TB0CCR6 CCIFG6, TB0IFG (TB0IV) <sup>(1) (3)</sup>                                       | Maskable         | 0FFF4h       | 58          |
| Watchdog Timer_A interval timer mode                                                                                          | WDTIFG                                                                                                    | Maskable         | 0FFF2h       | 57          |
| USCI_A0 receive or transmit                                                                                                   | UCA0RXIFG, UCA0TXIFG (UCA0IV) <sup>(1) (3)</sup>                                                          | Maskable         | 0FFF0h       | 56          |
| USCI_B0 receive or transmit                                                                                                   | UCB0RXIFG, UCB0TXIFG (UCB0IV) <sup>(1) (3)</sup>                                                          | Maskable         | 0FFEEh       | 55          |
| ADC10_A                                                                                                                       | ADC10IFG0 <sup>(1) (3) (4)</sup>                                                                          | Maskable         | 0FFECCh      | 54          |
| TA0                                                                                                                           | TA0CCR0 CCIFG0 <sup>(3)</sup>                                                                             | Maskable         | 0FFEAh       | 53          |
| TA0                                                                                                                           | TA0CCR1 CCIFG1 to TA0CCR4 CCIFG4, TA0IFG (TA0IV) <sup>(1) (3)</sup>                                       | Maskable         | 0FFE8h       | 52          |
| USB_UBM                                                                                                                       | USB interrupts (USBIV) <sup>(1) (3)</sup>                                                                 | Maskable         | 0FFE6h       | 51          |
| DMA                                                                                                                           | DMA0IFG, DMA1IFG, DMA2IFG (DMAIV) <sup>(1) (3)</sup>                                                      | Maskable         | 0FFE4h       | 50          |
| TA1                                                                                                                           | TA1CCR0 CCIFG0 <sup>(3)</sup>                                                                             | Maskable         | 0FFE2h       | 49          |
| TA1                                                                                                                           | TA1CCR1 CCIFG1 to TA1CCR2 CCIFG2, TA1IFG (TA1IV) <sup>(1) (3)</sup>                                       | Maskable         | 0FFE0h       | 48          |
| I/O port P1                                                                                                                   | P1IFG.0 to P1IFG.7 (P1IV) <sup>(1) (3)</sup>                                                              | Maskable         | 0FFDEh       | 47          |
| USCI_A1 receive or transmit                                                                                                   | UCA1RXIFG, UCA1TXIFG (UCA1IV) <sup>(1) (3)</sup>                                                          | Maskable         | 0FFDCh       | 46          |
| USCI_B1 receive or transmit                                                                                                   | UCB1RXIFG, UCB1TXIFG (UCB1IV) <sup>(1) (3)</sup>                                                          | Maskable         | 0FFDAh       | 45          |
| TA2                                                                                                                           | TA2CCR0 CCIFG0 <sup>(3)</sup>                                                                             | Maskable         | 0FFD8h       | 44          |
| TA2                                                                                                                           | TA2CCR1 CCIFG1 to TA2CCR2 CCIFG2, TA2IFG (TA2IV) <sup>(1) (3)</sup>                                       | Maskable         | 0FFD6h       | 43          |
| I/O port P2                                                                                                                   | P2IFG.0 to P2IFG.7 (P2IV) <sup>(1) (3)</sup>                                                              | Maskable         | 0FFD4h       | 42          |
| RTC_A                                                                                                                         | RTCRDYIFG, RTCTEVIFG, RTCAIFG, RT0PSIFG, RT1PSIFG (RTCIV) <sup>(1) (3)</sup>                              | Maskable         | 0FFD2h       | 41          |
| Reserved                                                                                                                      | Reserved <sup>(5)</sup>                                                                                   |                  | 0FFD0h       | 40          |
|                                                                                                                               |                                                                                                           |                  | ⋮            | ⋮           |
|                                                                                                                               |                                                                                                           |                  | 0FF80h       | 0, lowest   |

(1) Multiple source flags

(2) A reset is generated if the CPU tries to fetch instructions from within peripheral space or vacant memory space.

(Non)maskable: the individual interrupt enable bit can disable an interrupt event, but the general interrupt enable bit cannot disable it.

(3) Interrupt flags are in the module.

(4) Only on devices with ADC, otherwise reserved.

(5) Reserved interrupt vectors at addresses are not used in this device and can be used for regular program code if necessary. To maintain compatibility with other devices, TI recommends reserving these locations.

## 6.4 Memory Organization

Table 6-2 summarizes the memory map of all device variants.

**Table 6-2. Memory Organization<sup>(1)</sup>**

|                                                               |            | MSP430F5504<br>MSP430F5500                | MSP430F5508<br>MSP430F5505<br>MSP430F5501  | MSP430F5509<br>MSP430F5506<br>MSP430F5502  | MSP430F5510<br>MSP430F5507<br>MSP430F5503  |
|---------------------------------------------------------------|------------|-------------------------------------------|--------------------------------------------|--------------------------------------------|--------------------------------------------|
| Memory (flash)<br>Main: interrupt vector<br>Main: code memory | Total Size | 8KB<br>00FFFFh–00FF80h<br>00FFFFh–00E000h | 16KB<br>00FFFFh–00FF80h<br>00FFFFh–00C000h | 24KB<br>00FFFFh–00FF80h<br>00FFFFh–00A000h | 32KB<br>00FFFFh–00FF80h<br>00FFFFh–008000h |
| RAM                                                           | Sector 1   | 2KB<br>0033FFh–002C00h                    | 2KB<br>0033FFh–002C00h                     | 2KB<br>0033FFh–002C00h                     | 2KB<br>0033FFh–002C00h                     |
|                                                               | Sector 0   | 2KB<br>002BFFh–002400h                    | 2KB<br>002BFFh–002400h                     | 2KB<br>002BFFh–002400h                     | 2KB<br>002BFFh–002400h                     |
| USB RAM <sup>(2)</sup>                                        |            | 2KB<br>0023FFh–001C00h                    | 2KB<br>0023FFh–001C00h                     | 2KB<br>0023FFh–001C00h                     | 2KB<br>0023FFh–001C00h                     |
| Information memory<br>(flash)                                 | Info A     | 128 B<br>0019FFh–001980h                  | 128 B<br>0019FFh–001980h                   | 128 B<br>0019FFh–001980h                   | 128 B<br>0019FFh–001980h                   |
|                                                               | Info B     | 128 B<br>00197Fh–001900h                  | 128 B<br>00197Fh–001900h                   | 128 B<br>00197Fh–001900h                   | 128 B<br>00197Fh–001900h                   |
|                                                               | Info C     | 128 B<br>0018FFh–001880h                  | 128 B<br>0018FFh–001880h                   | 128 B<br>0018FFh–001880h                   | 128 B<br>0018FFh–001880h                   |
|                                                               | Info D     | 128 B<br>00187Fh–001800h                  | 128 B<br>00187Fh–001800h                   | 128 B<br>00187Fh–001800h                   | 128 B<br>00187Fh–001800h                   |
| Bootloader (BSL)<br>memory (flash)                            | BSL 3      | 512 B<br>0017FFh–001600h                  | 512 B<br>0017FFh–001600h                   | 512 B<br>0017FFh–001600h                   | 512 B<br>0017FFh–001600h                   |
|                                                               | BSL 2      | 512 B<br>0015FFh–001400h                  | 512 B<br>0015FFh–001400h                   | 512 B<br>0015FFh–001400h                   | 512 B<br>0015FFh–001400h                   |
|                                                               | BSL 1      | 512 B<br>0013FFh–001200h                  | 512 B<br>0013FFh–001200h                   | 512 B<br>0013FFh–001200h                   | 512 B<br>0013FFh–001200h                   |
|                                                               | BSL 0      | 512 B<br>0011FFh–001000h                  | 512 B<br>0011FFh–001000h                   | 512 B<br>0011FFh–001000h                   | 512 B<br>0011FFh–001000h                   |
| Peripherals                                                   | Size       | 4KB<br>000FFFh–0h                         | 4KB<br>000FFFh–0h                          | 4KB<br>000FFFh–0h                          | 4KB<br>000FFFh–0h                          |

(1) N/A = Not available

(2) USB RAM can be used as general purpose RAM when not used for USB operation.

## 6.5 Bootloader (BSL)

The BSL enables users to program the flash memory or RAM using various serial interfaces. Access to the device memory through the BSL is protected by an user-defined password. For complete description of the features of the BSL and its implementation, see [MSP430 Programming With the Bootloader \(BSL\)](#).

### 6.5.1 USB BSL

All devices come preprogrammed with the USB BSL. Use of the USB BSL requires external access to six pins (see [Table 6-3](#)). In addition to these pins, the application must support external components necessary for normal USB operation (for example, proper crystal on XT2IN and XT2OUT and proper decoupling). For further details on interfacing to development tools and device programmers, see the [MSP430 Hardware Tools User's Guide](#).

**Table 6-3. USB BSL Pin Requirements and Functions**

| DEVICE SIGNAL                                     | BSL FUNCTION                 |
|---------------------------------------------------|------------------------------|
| $\overline{\text{RST}}/\text{NMI}/\text{SBWTDIO}$ | Entry sequence signal        |
| PU.0/DP                                           | USB data terminal DP         |
| PU.1/DM                                           | USB data terminal DM         |
| PUR                                               | USB pullup resistor terminal |
| VBUS                                              | USB bus power supply         |
| VSSU                                              | USB ground supply            |

#### NOTE

The default USB BSL evaluates the logic level of the PUR pin after a BOR reset. If it is pulled high externally, then the BSL is invoked. Therefore, unless the BSL should be invoked, it is important to keep PUR pulled low after a BOR reset, even if BSL or USB is never used. TI recommends applying a 1-M $\Omega$  resistor to ground.

### 6.5.2 UART BSL

A UART BSL is also available that can be programmed by the user into the BSL memory by replacing the pre-programmed factory-supplied USB BSL. Use of the UART BSL requires external access to six pins (see [Table 6-4](#)). For further details on interfacing to development tools and device programmers, see the [MSP430 Hardware Tools User's Guide](#).

**Table 6-4. UART BSL Pin Requirements and Functions**

| DEVICE SIGNAL                                     | BSL FUNCTION          |
|---------------------------------------------------|-----------------------|
| $\overline{\text{RST}}/\text{NMI}/\text{SBWTDIO}$ | Entry sequence signal |
| TEST/SBWTK                                        | Entry sequence signal |
| P1.1                                              | Data transmit         |
| P1.2                                              | Data receive          |
| VCC                                               | Power supply          |
| VSS                                               | Ground supply         |

## 6.6 JTAG Operation

### 6.6.1 JTAG Standard Interface

The MSP430 family supports the standard JTAG interface, which requires four signals for sending and receiving data. The JTAG signals are shared with general-purpose I/Os. The TEST/SBWTCK pin is used to enable the JTAG signals. In addition to these signals, the  $\overline{\text{RST}}$ /NMI/SBWDIO is required to interface with MSP430 development tools and device programmers. [Table 6-5](#) lists the JTAG pin requirements. For further details on interfacing to development tools and device programmers, see the [MSP430 Hardware Tools User's Guide](#). For complete description of the features of the JTAG interface and its implementation, see the [MSP430 Memory Programming With the JTAG Interface](#).

**Table 6-5. JTAG Pin Requirements and Functions**

| DEVICE SIGNAL                       | DIRECTION | FUNCTION                    |
|-------------------------------------|-----------|-----------------------------|
| PJ.3/TCK                            | IN        | JTAG clock input            |
| PJ.2/TMS                            | IN        | JTAG state control          |
| PJ.1/TDI/TCLK                       | IN        | JTAG data input, TCLK input |
| PJ.0/TDO                            | OUT       | JTAG data output            |
| TEST/SBWTCK                         | IN        | Enable JTAG pins            |
| $\overline{\text{RST}}$ /NMI/SBWDIO | IN        | External reset              |
| VCC                                 |           | Power supply                |
| VSS                                 |           | Ground supply               |

### 6.6.2 Spy-Bi-Wire Interface

In addition to the standard JTAG interface, the MSP430 family supports the two-wire Spy-Bi-Wire interface. Spy-Bi-Wire can be used to interface with MSP430 development tools and device programmers. [Table 6-6](#) lists the Spy-Bi-Wire interface pin requirements. For further details on interfacing to development tools and device programmers, see the [MSP430 Hardware Tools User's Guide](#). For complete description of the features of the JTAG interface and its implementation, see the [MSP430 Memory Programming With the JTAG Interface](#).

**Table 6-6. Spy-Bi-Wire Pin Requirements and Functions**

| DEVICE SIGNAL                       | DIRECTION | FUNCTION                      |
|-------------------------------------|-----------|-------------------------------|
| TEST/SBWTCK                         | IN        | Spy-Bi-Wire clock input       |
| $\overline{\text{RST}}$ /NMI/SBWDIO | IN, OUT   | Spy-Bi-Wire data input/output |
| VCC                                 |           | Power supply                  |
| VSS                                 |           | Ground supply                 |

## 6.7 Flash Memory ([Link to User's Guide](#))

The flash memory can be programmed through the JTAG port, Spy-Bi-Wire (SBW), the BSL, or in-system by the CPU. The CPU can perform single-byte, single-word, and long-word writes to the flash memory. Features of the flash memory include:

- Flash memory has n segments of main memory and four segments of information memory (A to D) of 128 bytes each. Each segment in main memory is 512 bytes in size.
- Segments 0 to n may be erased in one step, or each segment may be individually erased.
- Segments A to D can be erased individually, or as a group with segments 0 to n. Segments A to D are also called *information memory*.
- Segment A can be locked separately.

## 6.8 RAM ([Link to User's Guide](#))

The RAM is made up of n sectors. Each sector can be completely powered down to save leakage; however, all data are lost. Features of the RAM include:

- RAM has n sectors. The size of a sector can be found in [Section 6.4](#).
- Each sector 0 to n can be completely disabled; however, data retention is lost.
- Each sector 0 to n automatically enters low-power retention mode when possible.
- For devices that contain USB memory, the USB memory can be used as normal RAM if USB is not required.

## 6.9 Peripherals

Peripherals are connected to the CPU through data, address, and control buses. Peripherals can be handled using all instructions. For complete module descriptions, see the [MSP430F5xx and MSP430F6xx Family User's Guide](#).

### 6.9.1 Digital I/O ([Link to User's Guide](#))

Up to six 8-bit I/O ports are implemented: for 64-pin options, P1, P2, P4, P6, and are complete, P5 is reduced to 6-bit I/O, and P3 to 5-bit I/O. For 48-pin options, P6 is reduced to 4-bit I/O, P2 to 1-bit I/O, and P3 is completely removed. Port PJ contains four individual I/O ports, common to all devices.

- All individual I/O bits are independently programmable.
- Any combination of input, output, and interrupt conditions is possible.
- Pullup or pulldown on all ports is programmable.
- Drive strength on all ports is programmable.
- Edge-selectable interrupt and LPM4.5 wake-up input capability is available for all bits of ports P1 and P2.
- Read and write access to port-control registers is supported by all instructions.
- Ports can be accessed byte-wise (P1 through P6) or word-wise in pairs (PA through PC).

### 6.9.2 Port Mapping Controller ([Link to User's Guide](#))

The port mapping controller allows the flexible and reconfigurable mapping of digital functions to port P4 (see [Table 6-7](#)). [Table 6-8](#) lists the default settings for all pins that support port mapping.

**Table 6-7. Port Mapping Mnemonics and Functions**

| VALUE | PxMAPy MNEMONIC | INPUT PIN FUNCTION               | OUTPUT PIN FUNCTION          |
|-------|-----------------|----------------------------------|------------------------------|
| 0     | PM_NONE         | None                             | DVSS                         |
| 1     | PM_CBOUT0       | –                                | Comparator_B output          |
|       | PM_TB0CLK       | TB0 clock input                  | –                            |
| 2     | PM_ADC10CLK     | –                                | ADC10CLK                     |
|       | PM_DMAE0        | DMAE0 input                      | –                            |
| 3     | PM_SVMOUT       | –                                | SVM output                   |
|       | PM_TB0OUTH      | TB0 high impedance input TB0OUTH | –                            |
| 4     | PM_TB0CCR0A     | TB0 CCR0 capture input CCI0A     | TB0 CCR0 compare output Out0 |
| 5     | PM_TB0CCR1A     | TB0 CCR1 capture input CCI1A     | TB0 CCR1 compare output Out1 |
| 6     | PM_TB0CCR2A     | TB0 CCR2 capture input CCI2A     | TB0 CCR2 compare output Out2 |
| 7     | PM_TB0CCR3A     | TB0 CCR3 capture input CCI3A     | TB0 CCR3 compare output Out3 |
| 8     | PM_TB0CCR4A     | TB0 CCR4 capture input CCI4A     | TB0 CCR4 compare output Out4 |
| 9     | PM_TB0CCR5A     | TB0 CCR5 capture input CCI5A     | TB0 CCR5 compare output Out5 |
| 10    | PM_TB0CCR6A     | TB0 CCR6 capture input CCI6A     | TB0 CCR6 compare output Out6 |

**Table 6-7. Port Mapping Mnemonics and Functions (continued)**

| VALUE                    | PxMAPy MNEMONIC | INPUT PIN FUNCTION                                                                                                         | OUTPUT PIN FUNCTION |
|--------------------------|-----------------|----------------------------------------------------------------------------------------------------------------------------|---------------------|
| 11                       | PM_UCA1RXD      | USCI_A1 UART RXD (Direction controlled by USCI – input)                                                                    |                     |
|                          | PM_UCA1SOMI     | USCI_A1 SPI slave out master in (direction controlled by USCI)                                                             |                     |
| 12                       | PM_UCA1TXD      | USCI_A1 UART TXD (Direction controlled by USCI – output)                                                                   |                     |
|                          | PM_UCA1SIMO     | USCI_A1 SPI slave in master out (direction controlled by USCI)                                                             |                     |
| 13                       | PM_UCA1CLK      | USCI_A1 clock input/output (direction controlled by USCI)                                                                  |                     |
|                          | PM_UCB1STE      | USCI_B1 SPI slave transmit enable (direction controlled by USCI)                                                           |                     |
| 14                       | PM_UCB1SOMI     | USCI_B1 SPI slave out master in (direction controlled by USCI)                                                             |                     |
|                          | PM_UCB1SCL      | USCI_B1 I2C clock (open drain and direction controlled by USCI)                                                            |                     |
| 15                       | PM_UCB1SIMO     | USCI_B1 SPI slave in master out (direction controlled by USCI)                                                             |                     |
|                          | PM_UCB1SDA      | USCI_B1 I2C data (open drain and direction controlled by USCI)                                                             |                     |
| 16                       | PM_UCB1CLK      | USCI_B1 clock input/output (direction controlled by USCI)                                                                  |                     |
|                          | PM_UCA1STE      | USCI_A1 SPI slave transmit enable (direction controlled by USCI)                                                           |                     |
| 17                       | PM_CBOUT1       | None                                                                                                                       | Comparator_B output |
| 18                       | PM_MCLK         | None                                                                                                                       | MCLK                |
| 19                       | PM_RTCCLK       | None                                                                                                                       | RTCCLK output       |
| 20                       | PM_UCA0RXD      | USCI_A0 UART RXD (Direction controlled by USCI – input)                                                                    |                     |
|                          | PM_UCA0SOMI     | USCI_A0 SPI slave out master in (direction controlled by USCI)                                                             |                     |
| 21                       | PM_UCA0TXD      | USCI_A0 UART TXD (Direction controlled by USCI – output)                                                                   |                     |
|                          | PM_UCA0SIMO     | USCI_A0 SPI slave in master out (direction controlled by USCI)                                                             |                     |
| 22                       | PM_UCA0CLK      | USCI_A0 clock input/output (direction controlled by USCI)                                                                  |                     |
|                          | PM_UCB0STE      | USCI_B0 SPI slave transmit enable (direction controlled by USCI)                                                           |                     |
| 23                       | PM_UCB0SOMI     | USCI_B0 SPI slave out master in (direction controlled by USCI)                                                             |                     |
|                          | PM_UCB0SCL      | USCI_B0 I2C clock (open drain and direction controlled by USCI)                                                            |                     |
| 24                       | PM_UCB0SIMO     | USCI_B0 SPI slave in master out (direction controlled by USCI)                                                             |                     |
|                          | PM_UCB0SDA      | USCI_B0 I2C data (open drain and direction controlled by USCI)                                                             |                     |
| 25                       | PM_UCB0CLK      | USCI_B0 clock input/output (direction controlled by USCI)                                                                  |                     |
|                          | PM_UCA0STE      | USCI_A0 SPI slave transmit enable (direction controlled by USCI)                                                           |                     |
| 26–30                    | Reserved        | None                                                                                                                       | DVSS                |
| 31 (0FFh) <sup>(1)</sup> | PM_ANALOG       | Disables the output driver and the input Schmitt-trigger to prevent parasitic cross currents when applying analog signals. |                     |

(1) The value of the PM\_ANALOG mnemonic is set to 0FFh. The port mapping registers are only 5 bits wide, and the upper bits are ignored, which results in a read value of 31.

**Table 6-8. Default Mapping**

| PIN         | PxMAPy MNEMONIC        | INPUT PIN FUNCTION                                                                                                                | OUTPUT PIN FUNCTION |
|-------------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------|
| P4.0/P4MAP0 | PM_UCB1STE/PM_UCA1CLK  | USCI_B1 SPI slave transmit enable (direction controlled by USCI)<br>USCI_A1 clock input/output (direction controlled by USCI)     |                     |
| P4.1/P4MAP1 | PM_UCB1SIMO/PM_UCB1SDA | USCI_B1 SPI slave in master out (direction controlled by USCI)<br>USCI_B1 I2C data (open drain and direction controlled by USCI)  |                     |
| P4.2/P4MAP2 | PM_UCB1SOMI/PM_UCB1SCL | USCI_B1 SPI slave out master in (direction controlled by USCI)<br>USCI_B1 I2C clock (open drain and direction controlled by USCI) |                     |
| P4.3/P4MAP3 | PM_UCB1CLK/PM_UCA1STE  | USCI_A1 SPI slave transmit enable (direction controlled by USCI)<br>USCI_B1 clock input/output (direction controlled by USCI)     |                     |
| P4.4/P4MAP4 | PM_UCA1TXD/PM_UCA1SIMO | USCI_A1 UART TXD (Direction controlled by USCI – output)<br>USCI_A1 SPI slave in master out (direction controlled by USCI)        |                     |
| P4.5/P4MAP5 | PM_UCA1RXD/PM_UCA1SOMI | USCI_A1 UART RXD (Direction controlled by USCI – input)<br>USCI_A1 SPI slave out master in (direction controlled by USCI)         |                     |
| P4.6/P4MAP6 | PM_NONE                | None                                                                                                                              | DVSS                |
| P4.7/P4MAP7 | PM_NONE                | None                                                                                                                              | DVSS                |

### 6.9.3 Oscillator and System Clock ([Link to User's Guide](#))

The clock system is supported by the Unified Clock System (UCS) module that includes support for a 32-kHz watch crystal oscillator (XT1 LF mode; XT1 HF mode is not supported), an internal very-low-power low-frequency oscillator (VLO), an internal trimmed low-frequency oscillator (REFO), an integrated internal digitally controlled oscillator (DCO), and a high-frequency crystal oscillator (XT2). The UCS module is designed to meet the requirements of both low system cost and low power consumption. The UCS module features digital frequency locked loop (FLL) hardware that, in conjunction with a digital modulator, stabilizes the DCO frequency to a programmable multiple of the selected FLL reference frequency. The internal DCO provides a fast turnon clock source and stabilizes in less than 5  $\mu$ s. The UCS module provides the following clock signals:

- Auxiliary clock (ACLK), sourced from the XT1, XT2, VLO, REFO, or DCO.
- Main clock (MCLK), the system clock used by the CPU. MCLK can be sourced by same sources made available to ACLK.
- Sub-Main clock (SMCLK), the subsystem clock used by the peripheral modules. SMCLK can be sourced by same sources made available to ACLK.
- ACLK/n, the buffered output of ACLK, ACLK/2, ACLK/4, ACLK/8, ACLK/16, ACLK/32.

### 6.9.4 Power-Management Module (PMM) ([Link to User's Guide](#))

The PMM includes an integrated voltage regulator that supplies the core voltage to the device and contains programmable output levels to provide for power optimization. The PMM also includes supply voltage supervisor (SVS) and supply voltage monitoring (SVM) circuitry, as well as brownout protection. The brownout circuit is implemented to provide the proper internal reset signal to the device during power-on and power-off. The SVS and SVM circuitry detects if the supply voltage drops below a user-selectable level and supports both supply voltage supervision (the device is automatically reset) and supply voltage monitoring (the device is not automatically reset). SVS and SVM circuitry is available on the primary supply and core supply.

### 6.9.5 Hardware Multiplier (MPY) ([Link to User's Guide](#))

The multiplication operation is supported by a dedicated peripheral module. The module performs operations with 32-, 24-, 16-, and 8-bit operands. The module supports signed and unsigned multiplication as well as signed and unsigned multiply-and-accumulate operations.

### 6.9.6 Real-Time Clock (RTC\_A) ([Link to User's Guide](#))

The RTC\_A module can be used as a general-purpose 32-bit counter (counter mode) or as an integrated real-time clock (RTC) (calendar mode). In counter mode, the RTC\_A also includes two independent 8-bit timers that can be cascaded to form a 16-bit timer or counter. Both timers can be read and written by software. Calendar mode integrates an internal calendar that compensates for months with less than 31 days and includes leap year correction. The RTC\_A also supports flexible alarm functions and offset-calibration hardware.

### 6.9.7 Watchdog Timer (WDT\_A) ([Link to User's Guide](#))

The primary function of the WDT\_A module is to perform a controlled system restart after a software problem occurs. If the selected time interval expires, a system reset is generated. If the watchdog function is not needed in an application, the module can be configured as an interval timer and can generate interrupts at selected time intervals.

### 6.9.8 System Module (SYS) ([Link to User's Guide](#))

The SYS module handles many of the system functions within the device. These include power on reset and power up clear handling, NMI source selection and management, reset interrupt vector generators, bootloader entry mechanisms, and configuration management (device descriptors). It also includes a data exchange mechanism through JTAG called a JTAG mailbox that can be used in the application. [Table 6-9](#) lists the SYS module interrupt vector registers.

**Table 6-9. System Module Interrupt Vector Registers**

| INTERRUPT VECTOR REGISTER | ADDRESS | INTERRUPT EVENT                     | VALUE      | PRIORITY |
|---------------------------|---------|-------------------------------------|------------|----------|
| SYSRSTIV, System Reset    | 019Eh   | No interrupt pending                | 00h        |          |
|                           |         | Brownout (BOR)                      | 02h        | Highest  |
|                           |         | $\overline{\text{RST}}$ /NMI (POR)  | 04h        |          |
|                           |         | PMMSWBOR (BOR)                      | 06h        |          |
|                           |         | Wake up from LPMx.5                 | 08h        |          |
|                           |         | Security violation (BOR)            | 0Ah        |          |
|                           |         | SVSL (POR)                          | 0Ch        |          |
|                           |         | SVSH (POR)                          | 0Eh        |          |
|                           |         | SVML_OVP (POR)                      | 10h        |          |
|                           |         | SVMH_OVP (POR)                      | 12h        |          |
|                           |         | PMMSWPOR (POR)                      | 14h        |          |
|                           |         | WDT time-out (PUC)                  | 16h        |          |
|                           |         | WDT password violation (PUC)        | 18h        |          |
|                           |         | KEYV flash password violation (PUC) | 1Ah        |          |
|                           |         | Reserved                            | 1Ch        |          |
|                           |         | Peripheral area fetch (PUC)         | 1Eh        |          |
|                           |         | PMM password violation (PUC)        | 20h        |          |
|                           |         | Reserved                            | 22h to 3Eh | Lowest   |
| SYSSNIV, System NMI       | 019Ch   | No interrupt pending                | 00h        |          |
|                           |         | SVMLIFG                             | 02h        | Highest  |
|                           |         | SVMHIFG                             | 04h        |          |
|                           |         | SVSMLDLYIFG                         | 06h        |          |
|                           |         | SVSMHDLYIFG                         | 08h        |          |
|                           |         | VMAIFG                              | 0Ah        |          |
|                           |         | JMBINIFG                            | 0Ch        |          |
|                           |         | JMBOUTIFG                           | 0Eh        |          |
|                           |         | SVMLVLRIFG                          | 10h        |          |
|                           |         | SVMHVLRIFG                          | 12h        |          |
|                           |         | Reserved                            | 14h to 1Eh | Lowest   |
|                           |         |                                     |            |          |
| SYSUNIV, User NMI         | 019Ah   | No interrupt pending                | 00h        |          |
|                           |         | NMIIFG                              | 02h        | Highest  |
|                           |         | OFIFG                               | 04h        |          |
|                           |         | ACCVIFG                             | 06h        |          |
|                           |         | Reserved                            | 08h        |          |
|                           |         | Reserved                            | 0Ah to 1Eh | Lowest   |

### 6.9.9 DMA Controller ([Link to User's Guide](#))

The DMA controller allows movement of data from one memory address to another without CPU intervention. For example, the DMA controller can be used to move data from the ADC10\_A conversion register to RAM. Using the DMA controller can increase the throughput of peripheral modules. The DMA controller reduces system power consumption by allowing the CPU to remain in sleep mode, without having to awaken to move data to or from a peripheral.

[Table 6-10](#) lists the DMA trigger assignments, which are also used by the USB timestamp generator.

**Table 6-10. DMA Trigger Assignments<sup>(1)</sup>**

| TRIGGER | CHANNEL                  |                          |                          |
|---------|--------------------------|--------------------------|--------------------------|
|         | 0                        | 1                        | 2                        |
| 0       | DMAREQ                   | DMAREQ                   | DMAREQ                   |
| 1       | TA0CCR0 CCIFG            | TA0CCR0 CCIFG            | TA0CCR0 CCIFG            |
| 2       | TA0CCR2 CCIFG            | TA0CCR2 CCIFG            | TA0CCR2 CCIFG            |
| 3       | TA1CCR0 CCIFG            | TA1CCR0 CCIFG            | TA1CCR0 CCIFG            |
| 4       | TA1CCR2 CCIFG            | TA1CCR2 CCIFG            | TA1CCR2 CCIFG            |
| 5       | TA2CCR0 CCIFG            | TA2CCR0 CCIFG            | TA2CCR0 CCIFG            |
| 6       | TA2CCR2 CCIFG            | TA2CCR2 CCIFG            | TA2CCR2 CCIFG            |
| 7       | TB0CCR0 CCIFG            | TB0CCR0 CCIFG            | TB0CCR0 CCIFG            |
| 8       | TB0CCR2 CCIFG            | TB0CCR2 CCIFG            | TB0CCR2 CCIFG            |
| 9       | Reserved                 | Reserved                 | Reserved                 |
| 10      | Reserved                 | Reserved                 | Reserved                 |
| 11      | Reserved                 | Reserved                 | Reserved                 |
| 12      | Reserved                 | Reserved                 | Reserved                 |
| 13      | Reserved                 | Reserved                 | Reserved                 |
| 14      | Reserved                 | Reserved                 | Reserved                 |
| 15      | Reserved                 | Reserved                 | Reserved                 |
| 16      | UCA0RXIFG                | UCA0RXIFG                | UCA0RXIFG                |
| 17      | UCA0TXIFG                | UCA0TXIFG                | UCA0TXIFG                |
| 18      | UCB0RXIFG                | UCB0RXIFG                | UCB0RXIFG                |
| 19      | UCB0TXIFG                | UCB0TXIFG                | UCB0TXIFG                |
| 20      | UCA1RXIFG                | UCA1RXIFG                | UCA1RXIFG                |
| 21      | UCA1TXIFG                | UCA1TXIFG                | UCA1TXIFG                |
| 22      | UCB1RXIFG                | UCB1RXIFG                | UCB1RXIFG                |
| 23      | UCB1TXIFG                | UCB1TXIFG                | UCB1TXIFG                |
| 24      | ADC10IFG0 <sup>(2)</sup> | ADC10IFG0 <sup>(2)</sup> | ADC10IFG0 <sup>(2)</sup> |
| 25      | Reserved                 | Reserved                 | Reserved                 |
| 26      | Reserved                 | Reserved                 | Reserved                 |
| 27      | USB FNRXD                | USB FNRXD                | USB FNRXD                |
| 28      | USB ready                | USB ready                | USB ready                |
| 29      | MPY ready                | MPY ready                | MPY ready                |
| 30      | DMA2IFG                  | DMA0IFG                  | DMA1IFG                  |
| 31      | DMAE0                    | DMAE0                    | DMAE0                    |

(1) If a reserved trigger source is selected, no Trigger1 is generated.

(2) Only on devices with ADC. Reserved on devices without ADC.

## 6.9.10 Universal Serial Communication Interface (USCI) (Links to User's Guide: [UART Mode](#), [SPI Mode](#), [I<sup>2</sup>C Mode](#))

The USCI modules are used for serial data communication. The USCI module supports synchronous communication protocols such as SPI (3- or 4-pin) and I<sup>2</sup>C, and asynchronous communication protocols such as UART, enhanced UART with automatic baud-rate detection, and IrDA. Each USCI module contains two portions, A and B.

The USCI\_An module provides support for SPI (3- or 4-pin), UART, enhanced UART, or IrDA.

The USCI\_Bn module provides support for SPI (3- or 4-pin) or I<sup>2</sup>C.

The MSP430F55xx series includes two complete USCI modules (n = 0, 1).

## 6.9.11 TA0 (Link to User's Guide)

TA0 is a 16-bit timer/counter (Timer\_A type) with five capture/compare registers. TA0 can support multiple capture/compares, PWM outputs, and interval timing (see [Table 6-11](#)). TA0 also has extensive interrupt capabilities. Interrupts may be generated from the counter on overflow conditions and from each of the capture/compare registers.

**Table 6-11. TA0 Signal Connections**

| INPUT PIN NUMBER |         | DEVICE INPUT SIGNAL | MODULE INPUT SIGNAL       | MODULE BLOCK | MODULE OUTPUT SIGNAL | DEVICE OUTPUT SIGNAL | OUTPUT PIN NUMBER                                  |                                                    |
|------------------|---------|---------------------|---------------------------|--------------|----------------------|----------------------|----------------------------------------------------|----------------------------------------------------|
| RGC, ZQE         | RGZ, PT |                     |                           |              |                      |                      | RGC, ZQE                                           | RGZ, PT                                            |
| 18, H2-P1.0      | 14-P1.0 | TA0CLK              | TACLK                     | Timer        | NA                   | NA                   |                                                    |                                                    |
|                  |         | ACLK (internal)     | ACLK                      |              |                      |                      |                                                    |                                                    |
|                  |         | SMCLK (internal)    | SMCLK                     |              |                      |                      |                                                    |                                                    |
| 18, H2-P1.0      | 14-P1.0 | TA0CLK              | $\overline{\text{TACLK}}$ |              |                      |                      |                                                    |                                                    |
| 19, H3-P1.1      | 15-P1.1 | TA0.0               | CCI0A                     | CCR0         | TA0                  | TA0.0                | 19, H3-P1.1                                        | 15-P1.1                                            |
|                  |         | DV <sub>SS</sub>    | CCI0B                     |              |                      |                      |                                                    |                                                    |
|                  |         | DV <sub>SS</sub>    | GND                       |              |                      |                      |                                                    |                                                    |
|                  |         | DV <sub>CC</sub>    | V <sub>CC</sub>           |              |                      |                      |                                                    |                                                    |
| 20, J3-P1.2      | 16-P1.2 | TA0.1               | CCI1A                     | CCR1         | TA1                  | TA0.1                | 20, J3-P1.2                                        | 16-P1.2                                            |
|                  |         | CBOUT (internal)    | CCI1B                     |              |                      |                      | ADC10 (internal) <sup>(1)</sup><br>ADC10SHSx = {1} | ADC10 (internal) <sup>(1)</sup><br>ADC10SHSx = {1} |
|                  |         | DV <sub>SS</sub>    | GND                       |              |                      |                      |                                                    |                                                    |
|                  |         | DV <sub>CC</sub>    | V <sub>CC</sub>           |              |                      |                      |                                                    |                                                    |
| 21, G4-P1.3      | 17-P1.3 | TA0.2               | CCI2A                     | CCR2         | TA2                  | TA0.2                | 21, G4-P1.3                                        | 17-P1.3                                            |
|                  |         | ACLK (internal)     | CCI2B                     |              |                      |                      |                                                    |                                                    |
|                  |         | DV <sub>SS</sub>    | GND                       |              |                      |                      |                                                    |                                                    |
|                  |         | DV <sub>CC</sub>    | V <sub>CC</sub>           |              |                      |                      |                                                    |                                                    |
| 22, H4-P1.4      | 18-P1.4 | TA0.3               | CCI3A                     | CCR3         | TA3                  | TA0.3                | 22, H4-P1.4                                        | 18-P1.4                                            |
|                  |         | DV <sub>SS</sub>    | CCI3B                     |              |                      |                      |                                                    |                                                    |
|                  |         | DV <sub>SS</sub>    | GND                       |              |                      |                      |                                                    |                                                    |
|                  |         | DV <sub>CC</sub>    | V <sub>CC</sub>           |              |                      |                      |                                                    |                                                    |
| 23, J4-P1.5      | 19-P1.5 | TA0.4               | CCI4A                     | CCR4         | TA4                  | TA0.4                | 23, J4-P1.5                                        | 19-P1.5                                            |
|                  |         | DV <sub>SS</sub>    | CCI4B                     |              |                      |                      |                                                    |                                                    |
|                  |         | DV <sub>SS</sub>    | GND                       |              |                      |                      |                                                    |                                                    |
|                  |         | DV <sub>CC</sub>    | V <sub>CC</sub>           |              |                      |                      |                                                    |                                                    |

(1) Only on devices with ADC.

### 6.9.12 TA1 [\(Link to User's Guide\)](#)

TA1 is a 16-bit timer/counter (Timer\_A type) with three capture/compare registers. TA1 can support multiple capture/compares, PWM outputs, and interval timing (see [Table 6-12](#)). TA1 also has extensive interrupt capabilities. Interrupts may be generated from the counter on overflow conditions and from each of the capture/compare registers.

**Table 6-12. TA1 Signal Connections**

| INPUT PIN NUMBER |         | DEVICE<br>INPUT<br>SIGNAL | MODULE<br>INPUT<br>SIGNAL | MODULE<br>BLOCK | MODULE<br>OUTPUT<br>SIGNAL | DEVICE<br>OUTPUT<br>SIGNAL | OUTPUT PIN NUMBER |         |
|------------------|---------|---------------------------|---------------------------|-----------------|----------------------------|----------------------------|-------------------|---------|
| RGC, ZQE         | RGZ, PT |                           |                           |                 |                            |                            | RGC, ZQE          | RGZ, PT |
| 24, G5-P1.6      | 20-P1.6 | TA1CLK                    | TACLK                     | Timer           | NA                         | NA                         |                   |         |
|                  |         | ACLK<br>(internal)        | ACLK                      |                 |                            |                            |                   |         |
|                  |         | SMCLK<br>(internal)       | SMCLK                     |                 |                            |                            |                   |         |
| 24, G5-P1.6      | 20-P1.6 | TA1CLK                    | $\overline{\text{TACLK}}$ |                 |                            |                            |                   |         |
| 25, H5-P1.7      | 21-P1.7 | TA1.0                     | CCI0A                     | CCR0            | TA0                        | TA1.0                      | 25, H5-P1.7       | 21-P1.7 |
|                  |         | DV <sub>SS</sub>          | CCI0B                     |                 |                            |                            |                   |         |
|                  |         | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                   |         |
|                  |         | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                   |         |
| 26, J5-P2.0      | 22-P2.0 | TA1.1                     | CCI1A                     | CCR1            | TA1                        | TA1.1                      | 26, J5-P2.0       | 22-P2.0 |
|                  |         | CBOUT<br>(internal)       | CCI1B                     |                 |                            |                            |                   |         |
|                  |         | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                   |         |
|                  |         | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                   |         |
| 27, G6-P2.1      |         | TA1.2                     | CCI2A                     | CCR2            | TA2                        | TA1.2                      | 27, G6-P2.1       |         |
|                  |         | ACLK<br>(internal)        | CCI2B                     |                 |                            |                            |                   |         |
|                  |         | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                   |         |
|                  |         | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                   |         |

### 6.9.13 TA2 [\(Link to User's Guide\)](#)

TA2 is a 16-bit timer/counter (Timer\_A type) with three capture/compare registers. TA2 can support multiple capture/compares, PWM outputs, and interval timing (see [Table 6-13](#)). TA2 also has extensive interrupt capabilities. Interrupts may be generated from the counter on overflow conditions and from each of the capture/compare registers.

**Table 6-13. TA2 Signal Connections**

| INPUT PIN NUMBER |         | DEVICE<br>INPUT<br>SIGNAL | MODULE<br>INPUT<br>SIGNAL | MODULE<br>BLOCK | MODULE<br>OUTPUT<br>SIGNAL | DEVICE<br>OUTPUT<br>SIGNAL | OUTPUT PIN NUMBER |         |
|------------------|---------|---------------------------|---------------------------|-----------------|----------------------------|----------------------------|-------------------|---------|
| RGC, ZQE         | RGZ, PT |                           |                           |                 |                            |                            | RGC, ZQE          | RGZ, PT |
| 28, J6-P2.2      |         | TA2CLK                    | TACLK                     | Timer           | NA                         | NA                         |                   |         |
|                  |         | ACLK<br>(internal)        | ACLK                      |                 |                            |                            |                   |         |
|                  |         | SMCLK<br>(internal)       | SMCLK                     |                 |                            |                            |                   |         |
|                  |         |                           |                           |                 |                            |                            |                   |         |
| 28, J6-P2.2      |         | TA2CLK                    | $\overline{\text{TACLK}}$ | CCR0            | TA0                        | TA2.0                      |                   |         |
| 29, H6-P2.3      |         | TA2.0                     | CCI0A                     |                 |                            |                            | 29, H6-P2.3       |         |
|                  |         | DV <sub>SS</sub>          | CCI0B                     |                 |                            |                            |                   |         |
|                  |         | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                   |         |
|                  |         | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                   |         |
| 30, J7-P2.4      |         | TA2.1                     | CCI1A                     | CCR1            | TA1                        | TA2.1                      | 30, J7-P2.4       |         |
|                  |         | CBOUT<br>(internal)       | CCI1B                     |                 |                            |                            |                   |         |
|                  |         | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                   |         |
|                  |         | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                   |         |
| 31, J8-P2.5      |         | TA2.2                     | CCI2A                     | CCR2            | TA2                        | TA2.2                      | 31, J8-P2.5       |         |
|                  |         | ACLK<br>(internal)        | CCI2B                     |                 |                            |                            |                   |         |
|                  |         | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                   |         |
|                  |         | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                   |         |

### 6.9.14 TB0 (Link to User's Guide)

TB0 is a 16-bit timer/counter (Timer\_B type) with seven capture/compare registers. TB0 can support multiple capture/compares, PWM outputs, and interval timing (see Table 6-14). TB0 also has extensive interrupt capabilities. Interrupts may be generated from the counter on overflow conditions and from each of the capture/compare registers.

**Table 6-14. TB0 Signal Connections**

| INPUT PIN NUMBER        |                        | DEVICE<br>INPUT<br>SIGNAL | MODULE<br>INPUT<br>SIGNAL | MODULE<br>BLOCK | MODULE<br>OUTPUT<br>SIGNAL | DEVICE<br>OUTPUT<br>SIGNAL | OUTPUT PIN NUMBER                                        |                                                          |
|-------------------------|------------------------|---------------------------|---------------------------|-----------------|----------------------------|----------------------------|----------------------------------------------------------|----------------------------------------------------------|
| RGC, ZQE <sup>(1)</sup> | RGZ, PT <sup>(1)</sup> |                           |                           |                 |                            |                            | RGC, ZQE <sup>(1)</sup>                                  | RGZ, PT <sup>(1)</sup>                                   |
|                         |                        | TB0CLK                    | TBCLK                     | Timer           | NA                         | NA                         |                                                          |                                                          |
|                         |                        | ACLK<br>(internal)        | ACLK                      |                 |                            |                            |                                                          |                                                          |
|                         |                        | SMCLK<br>(internal)       | SMCLK                     |                 |                            |                            |                                                          |                                                          |
|                         |                        | TB0CLK                    | $\overline{\text{TBCLK}}$ |                 |                            |                            |                                                          |                                                          |
|                         |                        | TB0.0                     | CCI0A                     | CCR0            | TB0                        | TB0.0                      | ADC10<br>(internal) <sup>(2)</sup><br>ADC10SHSx =<br>{2} | ADC10<br>(internal) <sup>(2)</sup><br>ADC10SHSx =<br>{2} |
|                         |                        | TB0.0                     | CCI0B                     |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                                                          |                                                          |
|                         |                        | TB0.1                     | CCI1A                     | CCR1            | TB1                        | TB0.1                      | ADC10 (internal)<br>ADC10SHSx =<br>{3}                   | ADC10 (internal)<br>ADC10SHSx =<br>{3}                   |
|                         |                        | CBOUT<br>(internal)       | CCI1B                     |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                                                          |                                                          |
|                         |                        | TB0.2                     | CCI2A                     | CCR2            | TB2                        | TB0.2                      |                                                          |                                                          |
|                         |                        | TB0.2                     | CCI2B                     |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                                                          |                                                          |
|                         |                        | TB0.3                     | CCI3A                     | CCR3            | TB3                        | TB0.3                      |                                                          |                                                          |
|                         |                        | TB0.3                     | CCI3B                     |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                                                          |                                                          |
|                         |                        | TB0.4                     | CCI4A                     | CCR4            | TB4                        | TB0.4                      |                                                          |                                                          |
|                         |                        | TB0.4                     | CCI4B                     |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                                                          |                                                          |
|                         |                        | TB0.5                     | CCI5A                     | CCR5            | TB5                        | TB0.5                      |                                                          |                                                          |
|                         |                        | TB0.5                     | CCI5B                     |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                                                          |                                                          |
|                         |                        | TB0.6                     | CCI6A                     | CCR6            | TB6                        | TB0.6                      |                                                          |                                                          |
|                         |                        | ACLK<br>(internal)        | CCI6B                     |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>SS</sub>          | GND                       |                 |                            |                            |                                                          |                                                          |
|                         |                        | DV <sub>CC</sub>          | V <sub>CC</sub>           |                 |                            |                            |                                                          |                                                          |

(1) Timer functions selectable through the port mapping controller.

(2) Only on devices with ADC.

#### **6.9.15 Comparator\_B ([Link to User's Guide](#))**

The primary function of the Comparator\_B module is to support precision slope analog-to-digital conversions, battery voltage supervision, and monitoring of external analog signals.

#### **6.9.16 ADC10\_A ([Link to User's Guide](#))**

The ADC10\_A module supports fast 10-bit analog-to-digital conversions. The module implements a 10-bit SAR core, sample select control, reference generator, and a conversion result buffer. A window comparator with lower and upper limits allows CPU-independent result monitoring with three window comparator interrupt flags.

#### **6.9.17 CRC16 ([Link to User's Guide](#))**

The CRC16 module produces a signature based on a sequence of entered data values and can be used for data checking purposes. The CRC16 module signature is based on the CRC-CCITT standard.

#### **6.9.18 Reference (REF) Voltage Reference ([Link to User's Guide](#))**

The REF module is responsible for generation of all critical reference voltages that can be used by the various analog peripherals in the device.

#### **6.9.19 Universal Serial Bus (USB) ([Link to User's Guide](#))**

The USB module is a fully integrated USB interface that is compliant with the USB 2.0 specification. The module supports full-speed operation of control, interrupt, and bulk transfers. The module includes an integrated LDO, PHY, and PLL. The PLL is highly flexible and supports a wide range of input clock frequencies. USB RAM, when not used for USB communication, can be used by the system.

#### **6.9.20 Embedded Emulation Module (EEM) (S Version) ([Link to User's Guide](#))**

The EEM supports real-time in-system debugging. The S version of the EEM has the following features:

- Three hardware triggers or breakpoints on memory access
- One hardware trigger or breakpoint on CPU register write access
- Up to four hardware triggers can be combined to form complex triggers or breakpoints
- One cycle counter
- Clock control on module level

## 6.10 Peripheral File Map

Table 6-15 lists the base address for the registers of all supported peripherals.

**Table 6-15. Peripherals**

| MODULE NAME                                 | BASE ADDRESS | OFFSET ADDRESS RANGE |
|---------------------------------------------|--------------|----------------------|
| Special Functions (see Table 6-16)          | 0100h        | 000h–01Fh            |
| PMM (see Table 6-17)                        | 0120h        | 000h–010h            |
| Flash Control (see Table 6-18)              | 0140h        | 000h–00Fh            |
| CRC16 (see Table 6-19)                      | 0150h        | 000h–007h            |
| RAM Control (see Table 6-20)                | 0158h        | 000h–001h            |
| Watchdog (see Table 6-21)                   | 015Ch        | 000h–001h            |
| UCS (see Table 6-22)                        | 0160h        | 000h–01Fh            |
| SYS (see Table 6-23)                        | 0180h        | 000h–01Fh            |
| Shared Reference (see Table 6-24)           | 01B0h        | 000h–001h            |
| Port Mapping Control (see Table 6-25)       | 01C0h        | 000h–002h            |
| Port Mapping Port P4 (see Table 6-25)       | 01E0h        | 000h–007h            |
| Port P1, P2 (see Table 6-26)                | 0200h        | 000h–01Fh            |
| Port P3, P4 (see Table 6-27)                | 0220h        | 000h–00Bh            |
| Port P5, P6 (see Table 6-28)                | 0240h        | 000h–00Bh            |
| Port PJ (see Table 6-29)                    | 0320h        | 000h–01Fh            |
| TA0 (see Table 6-30)                        | 0340h        | 000h–02Eh            |
| TA1 (see Table 6-31)                        | 0380h        | 000h–02Eh            |
| TB0 (see Table 6-32)                        | 03C0h        | 000h–02Eh            |
| TA2 (see Table 6-33)                        | 0400h        | 000h–02Eh            |
| Real-Time Clock (RTC_A) (see Table 6-34)    | 04A0h        | 000h–01Bh            |
| 32-Bit Hardware Multiplier (see Table 6-35) | 04C0h        | 000h–02Fh            |
| DMA General Control (see Table 6-36)        | 0500h        | 000h–00Fh            |
| DMA Channel 0 (see Table 6-36)              | 0510h        | 000h–00Ah            |
| DMA Channel 1 (see Table 6-36)              | 0520h        | 000h–00Ah            |
| DMA Channel 2 (see Table 6-36)              | 0530h        | 000h–00Ah            |
| USCI_A0 (see Table 6-37)                    | 05C0h        | 000h–01Fh            |
| USCI_B0 (see Table 6-38)                    | 05E0h        | 000h–01Fh            |
| USCI_A1 (see Table 6-39)                    | 0600h        | 000h–01Fh            |
| USCI_B1 (see Table 6-40)                    | 0620h        | 000h–01Fh            |
| ADC10_A (see Table 6-41)                    | 0740h        | 000h–01Fh            |
| Comparator_B (see Table 6-42)               | 08C0h        | 000h–00Fh            |
| USB configuration (see Table 6-43)          | 0900h        | 000h–014h            |
| USB control (see Table 6-44)                | 0920h        | 000h–01Fh            |

**Table 6-16. Special Function Registers (Base Address: 0100h)**

| REGISTER DESCRIPTION  | REGISTER | OFFSET |
|-----------------------|----------|--------|
| SFR interrupt enable  | SFRIE1   | 00h    |
| SFR interrupt flag    | SFRIFG1  | 02h    |
| SFR reset pin control | SFRRPCR  | 04h    |

**Table 6-17. PMM Registers (Base Address: 0120h)**

| REGISTER DESCRIPTION     | REGISTER | OFFSET |
|--------------------------|----------|--------|
| PMM control 0            | PMMCTL0  | 00h    |
| PMM control 1            | PMMCTL1  | 02h    |
| SVS high-side control    | SVSMHCTL | 04h    |
| SVS low-side control     | SVSMLCTL | 06h    |
| PMM interrupt flags      | PMMIFG   | 0Ch    |
| PMM interrupt enable     | PMMIE    | 0Eh    |
| PMM power mode 5 control | PM5CTL0  | 10h    |

**Table 6-18. Flash Control Registers (Base Address: 0140h)**

| REGISTER DESCRIPTION | REGISTER | OFFSET |
|----------------------|----------|--------|
| Flash control 1      | FCTL1    | 00h    |
| Flash control 3      | FCTL3    | 04h    |
| Flash control 4      | FCTL4    | 06h    |

**Table 6-19. CRC16 Registers (Base Address: 0150h)**

| REGISTER DESCRIPTION          | REGISTER  | OFFSET |
|-------------------------------|-----------|--------|
| CRC data input                | CRC16DI   | 00h    |
| CRC data input reverse byte   | CRCDIRB   | 02h    |
| CRC initialization and result | CRCINIRES | 04h    |
| CRC result reverse byte       | CRCRESR   | 06h    |

**Table 6-20. RAM Control Registers (Base Address: 0158h)**

| REGISTER DESCRIPTION | REGISTER | OFFSET |
|----------------------|----------|--------|
| RAM control 0        | RCCTL0   | 00h    |

**Table 6-21. Watchdog Registers (Base Address: 015Ch)**

| REGISTER DESCRIPTION   | REGISTER | OFFSET |
|------------------------|----------|--------|
| Watchdog timer control | WDTCTL   | 00h    |

**Table 6-22. UCS Registers (Base Address: 0160h)**

| REGISTER DESCRIPTION | REGISTER | OFFSET |
|----------------------|----------|--------|
| UCS control 0        | UCSCTL0  | 00h    |
| UCS control 1        | UCSCTL1  | 02h    |
| UCS control 2        | UCSCTL2  | 04h    |
| UCS control 3        | UCSCTL3  | 06h    |
| UCS control 4        | UCSCTL4  | 08h    |
| UCS control 5        | UCSCTL5  | 0Ah    |
| UCS control 6        | UCSCTL6  | 0Ch    |
| UCS control 7        | UCSCTL7  | 0Eh    |
| UCS control 8        | UCSCTL8  | 10h    |

**Table 6-23. SYS Registers (Base Address: 0180h)**

| REGISTER DESCRIPTION          | REGISTER  | OFFSET |
|-------------------------------|-----------|--------|
| System control                | SYSCTL    | 00h    |
| Bootloader configuration area | SYSBSLC   | 02h    |
| JTAG mailbox control          | SYSJMBC   | 06h    |
| JTAG mailbox input 0          | SYSJMBI0  | 08h    |
| JTAG mailbox input 1          | SYSJMBI1  | 0Ah    |
| JTAG mailbox output 0         | SYSJMBO0  | 0Ch    |
| JTAG mailbox output 1         | SYSJMBO1  | 0Eh    |
| Bus error vector generator    | SYSBERRIV | 18h    |
| User NMI vector generator     | SYSUNIV   | 1Ah    |
| System NMI vector generator   | SYSSNIV   | 1Ch    |
| Reset vector generator        | SYSRSTIV  | 1Eh    |

**Table 6-24. Shared Reference Registers (Base Address: 01B0h)**

| REGISTER DESCRIPTION     | REGISTER | OFFSET |
|--------------------------|----------|--------|
| Shared reference control | REFCTL   | 00h    |

**Table 6-25. Port Mapping Registers  
(Base Address of Port Mapping Control: 01C0h, Port P4: 01E0h)**

| REGISTER DESCRIPTION | REGISTER  | OFFSET |
|----------------------|-----------|--------|
| Port mapping key/ID  | PMAPKEYID | 00h    |
| Port mapping control | PMAPCTL   | 02h    |
| Port P4.0 mapping    | P4MAP0    | 00h    |
| Port P4.1 mapping    | P4MAP1    | 01h    |
| Port P4.2 mapping    | P4MAP2    | 02h    |
| Port P4.3 mapping    | P4MAP3    | 03h    |
| Port P4.4 mapping    | P4MAP4    | 04h    |
| Port P4.5 mapping    | P4MAP5    | 05h    |
| Port P4.6 mapping    | P4MAP6    | 06h    |
| Port P4.7 mapping    | P4MAP7    | 07h    |

**Table 6-26. Port P1, P2 Registers (Base Address: 0200h)**

| REGISTER DESCRIPTION          | REGISTER | OFFSET |
|-------------------------------|----------|--------|
| Port P1 input                 | P1IN     | 00h    |
| Port P1 output                | P1OUT    | 02h    |
| Port P1 direction             | P1DIR    | 04h    |
| Port P1 resistor enable       | P1REN    | 06h    |
| Port P1 drive strength        | P1DS     | 08h    |
| Port P1 selection             | P1SEL    | 0Ah    |
| Port P1 interrupt vector word | P1IV     | 0Eh    |
| Port P1 interrupt edge select | P1IES    | 18h    |
| Port P1 interrupt enable      | P1IE     | 1Ah    |
| Port P1 interrupt flag        | P1IFG    | 1Ch    |
| Port P2 input                 | P2IN     | 01h    |
| Port P2 output                | P2OUT    | 03h    |
| Port P2 direction             | P2DIR    | 05h    |
| Port P2 resistor enable       | P2REN    | 07h    |
| Port P2 drive strength        | P2DS     | 09h    |
| Port P2 selection             | P2SEL    | 0Bh    |
| Port P2 interrupt vector word | P2IV     | 1Eh    |
| Port P2 interrupt edge select | P2IES    | 19h    |
| Port P2 interrupt enable      | P2IE     | 1Bh    |
| Port P2 interrupt flag        | P2IFG    | 1Dh    |

**Table 6-27. Port P3, P4 Registers (Base Address: 0220h)**

| REGISTER DESCRIPTION    | REGISTER | OFFSET |
|-------------------------|----------|--------|
| Port P3 input           | P3IN     | 00h    |
| Port P3 output          | P3OUT    | 02h    |
| Port P3 direction       | P3DIR    | 04h    |
| Port P3 resistor enable | P3REN    | 06h    |
| Port P3 drive strength  | P3DS     | 08h    |
| Port P3 selection       | P3SEL    | 0Ah    |
| Port P4 input           | P4IN     | 01h    |
| Port P4 output          | P4OUT    | 03h    |
| Port P4 direction       | P4DIR    | 05h    |
| Port P4 resistor enable | P4REN    | 07h    |
| Port P4 drive strength  | P4DS     | 09h    |
| Port P4 selection       | P4SEL    | 0Bh    |

**Table 6-28. Port P5, P6 Registers (Base Address: 0240h)**

| REGISTER DESCRIPTION    | REGISTER | OFFSET |
|-------------------------|----------|--------|
| Port P5 input           | P5IN     | 00h    |
| Port P5 output          | P5OUT    | 02h    |
| Port P5 direction       | P5DIR    | 04h    |
| Port P5 resistor enable | P5REN    | 06h    |
| Port P5 drive strength  | P5DS     | 08h    |
| Port P5 selection       | P5SEL    | 0Ah    |
| Port P6 input           | P6IN     | 01h    |
| Port P6 output          | P6OUT    | 03h    |
| Port P6 direction       | P6DIR    | 05h    |
| Port P6 resistor enable | P6REN    | 07h    |
| Port P6 drive strength  | P6DS     | 09h    |
| Port P6 selection       | P6SEL    | 0Bh    |

**Table 6-29. Port J Registers (Base Address: 0320h)**

| REGISTER DESCRIPTION    | REGISTER | OFFSET |
|-------------------------|----------|--------|
| Port PJ input           | PJIN     | 00h    |
| Port PJ output          | PJOUT    | 02h    |
| Port PJ direction       | PJDIR    | 04h    |
| Port PJ resistor enable | PJREN    | 06h    |
| Port PJ drive strength  | PJDS     | 08h    |

**Table 6-30. TA0 Registers (Base Address: 0340h)**

| REGISTER DESCRIPTION      | REGISTER | OFFSET |
|---------------------------|----------|--------|
| TA0 control               | TA0CTL   | 00h    |
| Capture/compare control 0 | TA0CCTL0 | 02h    |
| Capture/compare control 1 | TA0CCTL1 | 04h    |
| Capture/compare control 2 | TA0CCTL2 | 06h    |
| Capture/compare control 3 | TA0CCTL3 | 08h    |
| Capture/compare control 4 | TA0CCTL4 | 0Ah    |
| TA0 counter               | TA0R     | 10h    |
| Capture/compare 0         | TA0CCR0  | 12h    |
| Capture/compare 1         | TA0CCR1  | 14h    |
| Capture/compare 2         | TA0CCR2  | 16h    |
| Capture/compare 3         | TA0CCR3  | 18h    |
| Capture/compare 4         | TA0CCR4  | 1Ah    |
| TA0 expansion 0           | TA0EX0   | 20h    |
| TA0 interrupt vector      | TA0IV    | 2Eh    |

**Table 6-31. TA1 Registers (Base Address: 0380h)**

| REGISTER DESCRIPTION      | REGISTER | OFFSET |
|---------------------------|----------|--------|
| TA1 control               | TA1CTL   | 00h    |
| Capture/compare control 0 | TA1CCTL0 | 02h    |
| Capture/compare control 1 | TA1CCTL1 | 04h    |
| Capture/compare control 2 | TA1CCTL2 | 06h    |
| TA1 counter               | TA1R     | 10h    |
| Capture/compare 0         | TA1CCR0  | 12h    |
| Capture/compare 1         | TA1CCR1  | 14h    |
| Capture/compare 2         | TA1CCR2  | 16h    |
| TA1 expansion 0           | TA1EX0   | 20h    |
| TA1 interrupt vector      | TA1IV    | 2Eh    |

**Table 6-32. TB0 Registers (Base Address: 03C0h)**

| REGISTER DESCRIPTION      | REGISTER | OFFSET |
|---------------------------|----------|--------|
| TB0 control               | TB0CTL   | 00h    |
| Capture/compare control 0 | TB0CCTL0 | 02h    |
| Capture/compare control 1 | TB0CCTL1 | 04h    |
| Capture/compare control 2 | TB0CCTL2 | 06h    |
| Capture/compare control 3 | TB0CCTL3 | 08h    |
| Capture/compare control 4 | TB0CCTL4 | 0Ah    |
| Capture/compare control 5 | TB0CCTL5 | 0Ch    |
| Capture/compare control 6 | TB0CCTL6 | 0Eh    |
| TB0 counter               | TB0R     | 10h    |
| Capture/compare 0         | TB0CCR0  | 12h    |
| Capture/compare 1         | TB0CCR1  | 14h    |
| Capture/compare 2         | TB0CCR2  | 16h    |
| Capture/compare 3         | TB0CCR3  | 18h    |
| Capture/compare 4         | TB0CCR4  | 1Ah    |
| Capture/compare 5         | TB0CCR5  | 1Ch    |
| Capture/compare 6         | TB0CCR6  | 1Eh    |
| TB0 expansion 0           | TB0EX0   | 20h    |
| TB0 interrupt vector      | TB0IV    | 2Eh    |

**Table 6-33. TA2 Registers (Base Address: 0400h)**

| REGISTER DESCRIPTION      | REGISTER | OFFSET |
|---------------------------|----------|--------|
| TA2 control               | TA2CTL   | 00h    |
| Capture/compare control 0 | TA2CCTL0 | 02h    |
| Capture/compare control 1 | TA2CCTL1 | 04h    |
| Capture/compare control 2 | TA2CCTL2 | 06h    |
| TA2 counter               | TA2R     | 10h    |
| Capture/compare 0         | TA2CCR0  | 12h    |
| Capture/compare 1         | TA2CCR1  | 14h    |
| Capture/compare 2         | TA2CCR2  | 16h    |
| TA2 expansion 0           | TA2EX0   | 20h    |
| TA2 interrupt vector      | TA2IV    | 2Eh    |

**Table 6-34. Real-Time Clock Registers (Base Address: 04A0h)**

| REGISTER DESCRIPTION               | REGISTER       | OFFSET |
|------------------------------------|----------------|--------|
| RTC control 0                      | RTCCTL0        | 00h    |
| RTC control 1                      | RTCCTL1        | 01h    |
| RTC control 2                      | RTCCTL2        | 02h    |
| RTC control 3                      | RTCCTL3        | 03h    |
| RTC prescaler 0 control            | RTCPSEL0CTL    | 08h    |
| RTC prescaler 1 control            | RTCPSEL1CTL    | 0Ah    |
| RTC prescaler 0                    | RTCPSEL0       | 0Ch    |
| RTC prescaler 1                    | RTCPSEL1       | 0Dh    |
| RTC interrupt vector word          | RTCIV          | 0Eh    |
| RTC seconds/counter 1              | RTCSEC/RTCNT1  | 10h    |
| RTC minutes/counter 2              | RTCMIN/RTCNT2  | 11h    |
| RTC hours/counter 3                | RTCHOUR/RTCNT3 | 12h    |
| RTC day of week/counter register 4 | RTCDOW/RTCNT4  | 13h    |
| RTC days                           | RTCDAY         | 14h    |
| RTC month                          | RTCMON         | 15h    |
| RTC year low                       | RTCYEARL       | 16h    |
| RTC year high                      | RTCYEARH       | 17h    |
| RTC alarm minutes                  | RTCAMIN        | 18h    |
| RTC alarm hours                    | RTCAHOUR       | 19h    |
| RTC alarm day of week              | RTCADOW        | 1Ah    |
| RTC alarm days                     | RTCADAY        | 1Bh    |

**Table 6-35. 32-Bit Hardware Multiplier Registers (Base Address: 04C0h)**

| REGISTER DESCRIPTION                                    | REGISTER  | OFFSET |
|---------------------------------------------------------|-----------|--------|
| 16-bit operand 1 – multiply                             | MPY       | 00h    |
| 16-bit operand 1 – signed multiply                      | MPYS      | 02h    |
| 16-bit operand 1 – multiply accumulate                  | MAC       | 04h    |
| 16-bit operand 1 – signed multiply accumulate           | MACS      | 06h    |
| 16-bit operand 2                                        | OP2       | 08h    |
| 16 × 16 result low word                                 | RESLO     | 0Ah    |
| 16 × 16 result high word                                | RESHI     | 0Ch    |
| 16 × 16 sum extension register                          | SUMEXT    | 0Eh    |
| 32-bit operand 1 – multiply low word                    | MPY32L    | 10h    |
| 32-bit operand 1 – multiply high word                   | MPY32H    | 12h    |
| 32-bit operand 1 – signed multiply low word             | MPYS32L   | 14h    |
| 32-bit operand 1 – signed multiply high word            | MPYS32H   | 16h    |
| 32-bit operand 1 – multiply accumulate low word         | MAC32L    | 18h    |
| 32-bit operand 1 – multiply accumulate high word        | MAC32H    | 1Ah    |
| 32-bit operand 1 – signed multiply accumulate low word  | MACS32L   | 1Ch    |
| 32-bit operand 1 – signed multiply accumulate high word | MACS32H   | 1Eh    |
| 32-bit operand 2 – low word                             | OP2L      | 20h    |
| 32-bit operand 2 – high word                            | OP2H      | 22h    |
| 32 × 32 result 0 – least significant word               | RES0      | 24h    |
| 32 × 32 result 1                                        | RES1      | 26h    |
| 32 × 32 result 2                                        | RES2      | 28h    |
| 32 × 32 result 3 – most significant word                | RES3      | 2Ah    |
| MPY32 control 0                                         | MPY32CTL0 | 2Ch    |

**Table 6-36. DMA Registers (Base Address DMA General Control: 0500h, DMA Channel 0: 0510h, DMA Channel 1: 0520h, DMA Channel 2: 0530h)**

| REGISTER DESCRIPTION                   | REGISTER | OFFSET |
|----------------------------------------|----------|--------|
| DMA channel 0 control                  | DMA0CTL  | 00h    |
| DMA channel 0 source address low       | DMA0SAL  | 02h    |
| DMA channel 0 source address high      | DMA0SAH  | 04h    |
| DMA channel 0 destination address low  | DMA0DAL  | 06h    |
| DMA channel 0 destination address high | DMA0DAH  | 08h    |
| DMA channel 0 transfer size            | DMA0SZ   | 0Ah    |
| DMA channel 1 control                  | DMA1CTL  | 00h    |
| DMA channel 1 source address low       | DMA1SAL  | 02h    |
| DMA channel 1 source address high      | DMA1SAH  | 04h    |
| DMA channel 1 destination address low  | DMA1DAL  | 06h    |
| DMA channel 1 destination address high | DMA1DAH  | 08h    |
| DMA channel 1 transfer size            | DMA1SZ   | 0Ah    |
| DMA channel 2 control                  | DMA2CTL  | 00h    |
| DMA channel 2 source address low       | DMA2SAL  | 02h    |
| DMA channel 2 source address high      | DMA2SAH  | 04h    |
| DMA channel 2 destination address low  | DMA2DAL  | 06h    |
| DMA channel 2 destination address high | DMA2DAH  | 08h    |
| DMA channel 2 transfer size            | DMA2SZ   | 0Ah    |
| DMA module control 0                   | DMACTL0  | 00h    |
| DMA module control 1                   | DMACTL1  | 02h    |
| DMA module control 2                   | DMACTL2  | 04h    |
| DMA module control 3                   | DMACTL3  | 06h    |
| DMA module control 4                   | DMACTL4  | 08h    |
| DMA interrupt vector                   | DMAIV    | 0Ah    |

**Table 6-37. USCI\_A0 Registers (Base Address: 05C0h)**

| REGISTER DESCRIPTION       | REGISTER   | OFFSET |
|----------------------------|------------|--------|
| USCI control 1             | UCA0CTL1   | 00h    |
| USCI control 0             | UCA0CTL0   | 01h    |
| USCI baud rate 0           | UCA0BR0    | 06h    |
| USCI baud rate 1           | UCA0BR1    | 07h    |
| USCI modulation control    | UCA0MCTL   | 08h    |
| USCI status                | UCA0STAT   | 0Ah    |
| USCI receive buffer        | UCA0RXBUF  | 0Ch    |
| USCI transmit buffer       | UCA0TXBUF  | 0Eh    |
| USCI LIN control           | UCA0ABCTL  | 10h    |
| USCI IrDA transmit control | UCA0IRTCTL | 12h    |
| USCI IrDA receive control  | UCA0IRRCTL | 13h    |
| USCI interrupt enable      | UCA0IE     | 1Ch    |
| USCI interrupt flags       | UCA0IFG    | 1Dh    |
| USCI interrupt vector word | UCA0IV     | 1Eh    |

**Table 6-38. USCI\_B0 Registers (Base Address: 05E0h)**

| REGISTER DESCRIPTION             | REGISTER  | OFFSET |
|----------------------------------|-----------|--------|
| USCI synchronous control 1       | UCB0CTL1  | 00h    |
| USCI synchronous control 0       | UCB0CTL0  | 01h    |
| USCI synchronous bit rate 0      | UCB0BR0   | 06h    |
| USCI synchronous bit rate 1      | UCB0BR1   | 07h    |
| USCI synchronous status          | UCB0STAT  | 0Ah    |
| USCI synchronous receive buffer  | UCB0RXBUF | 0Ch    |
| USCI synchronous transmit buffer | UCB0TXBUF | 0Eh    |
| USCI I2C own address             | UCB0I2COA | 10h    |
| USCI I2C slave address           | UCB0I2CSA | 12h    |
| USCI interrupt enable            | UCB0IE    | 1Ch    |
| USCI interrupt flags             | UCB0IFG   | 1Dh    |
| USCI interrupt vector word       | UCB0IV    | 1Eh    |

**Table 6-39. USCI\_A1 Registers (Base Address: 0600h)**

| REGISTER DESCRIPTION       | REGISTER   | OFFSET |
|----------------------------|------------|--------|
| USCI control 1             | UCA1CTL1   | 00h    |
| USCI control 0             | UCA1CTL0   | 01h    |
| USCI baud rate 0           | UCA1BR0    | 06h    |
| USCI baud rate 1           | UCA1BR1    | 07h    |
| USCI modulation control    | UCA1MCTL   | 08h    |
| USCI status                | UCA1STAT   | 0Ah    |
| USCI receive buffer        | UCA1RXBUF  | 0Ch    |
| USCI transmit buffer       | UCA1TXBUF  | 0Eh    |
| USCI LIN control           | UCA1ABCTL  | 10h    |
| USCI IrDA transmit control | UCA1IRTCTL | 12h    |
| USCI IrDA receive control  | UCA1IRRCTL | 13h    |
| USCI interrupt enable      | UCA1IE     | 1Ch    |
| USCI interrupt flags       | UCA1IFG    | 1Dh    |
| USCI interrupt vector word | UCA1IV     | 1Eh    |

**Table 6-40. USCI\_B1 Registers (Base Address: 0620h)**

| REGISTER DESCRIPTION             | REGISTER  | OFFSET |
|----------------------------------|-----------|--------|
| USCI synchronous control 1       | UCB1CTL1  | 00h    |
| USCI synchronous control 0       | UCB1CTL0  | 01h    |
| USCI synchronous bit rate 0      | UCB1BR0   | 06h    |
| USCI synchronous bit rate 1      | UCB1BR1   | 07h    |
| USCI synchronous status          | UCB1STAT  | 0Ah    |
| USCI synchronous receive buffer  | UCB1RXBUF | 0Ch    |
| USCI synchronous transmit buffer | UCB1TXBUF | 0Eh    |
| USCI I2C own address             | UCB1I2COA | 10h    |
| USCI I2C slave address           | UCB1I2CSA | 12h    |
| USCI interrupt enable            | UCB1IE    | 1Ch    |
| USCI interrupt flags             | UCB1IFG   | 1Dh    |
| USCI interrupt vector word       | UCB1IV    | 1Eh    |

**Table 6-41. ADC10\_A Registers (Base Address: 0740h)**

| REGISTER DESCRIPTION                     | REGISTER   | OFFSET |
|------------------------------------------|------------|--------|
| ADC10_A control 0                        | ADC10CTL0  | 00h    |
| ADC10_A control 1                        | ADC10CTL1  | 02h    |
| ADC10_A control 2                        | ADC10CTL2  | 04h    |
| ADC10_A window comparator low threshold  | ADC10LO    | 06h    |
| ADC10_A window comparator high threshold | ADC10HI    | 08h    |
| ADC10_A memory control 0                 | ADC10MCTL0 | 0Ah    |
| ADC10_A conversion memory                | ADC10MEM0  | 12h    |
| ADC10_A interrupt enable                 | ADC10IE    | 1Ah    |
| ADC10_A interrupt flags                  | ADC10IGH   | 1Ch    |
| ADC10_A interrupt vector word            | ADC10IV    | 1Eh    |

**Table 6-42. Comparator\_B Registers (Base Address: 08C0h)**

| REGISTER DESCRIPTION         | REGISTER | OFFSET |
|------------------------------|----------|--------|
| Comp_B control 0             | CBCTL0   | 00h    |
| Comp_B control 1             | CBCTL1   | 02h    |
| Comp_B control 2             | CBCTL2   | 04h    |
| Comp_B control 3             | CBCTL3   | 06h    |
| Comp_B interrupt             | CBINT    | 0Ch    |
| Comp_B interrupt vector word | CBIV     | 0Eh    |

**Table 6-43. USB Configuration Registers (Base Address: 0900h)**

| REGISTER DESCRIPTION     | REGISTER   | OFFSET |
|--------------------------|------------|--------|
| USB key/ID               | USBKEYPID  | 00h    |
| USB module configuration | USBCNF     | 02h    |
| USB PHY control          | USBPHYCTL  | 04h    |
| USB power control        | USBPWRCTL  | 08h    |
| USB PLL control          | USBPLLCTL  | 10h    |
| USB PLL divider          | USBPLLDIVB | 12h    |
| USB PLL interrupts       | USBPLLIR   | 14h    |

**Table 6-44. USB Control Registers (Base Address: 0920h)**

| REGISTER DESCRIPTION              | REGISTER    | OFFSET |
|-----------------------------------|-------------|--------|
| Input endpoint_0 configuration    | USBIEPCNF_0 | 00h    |
| Input endpoint_0 byte count       | USBIEPCNT_0 | 01h    |
| Output endpoint_0 configuration   | USBOEPCNF_0 | 02h    |
| Output endpoint_0 byte count      | USBOEPCNT_0 | 03h    |
| Input endpoint interrupt enables  | USBIEPIE    | 0Eh    |
| Output endpoint interrupt enables | USBOEPIE    | 0Fh    |
| Input endpoint interrupt flags    | USBIEPIFG   | 10h    |
| Output endpoint interrupt flags   | USBOEPIFG   | 11h    |
| USB interrupt vector              | USBIV       | 12h    |
| USB maintenance                   | USBMAINT    | 16h    |
| Time stamp                        | USBTSREG    | 18h    |
| USB frame number                  | USBFN       | 1Ah    |
| USB control                       | USBCTL      | 1Ch    |
| USB interrupt enables             | USBIE       | 1Dh    |
| USB interrupt flags               | USBIFG      | 1Eh    |
| Function address                  | USBFUNADR   | 1Fh    |

## 6.11 Input/Output Diagrams

### 6.11.1 Port P1 (P1.0 to P1.7) Input/Output With Schmitt Trigger

Figure 6-2 shows the port diagram. Table 6-45 summarizes the selection of the pin functions.

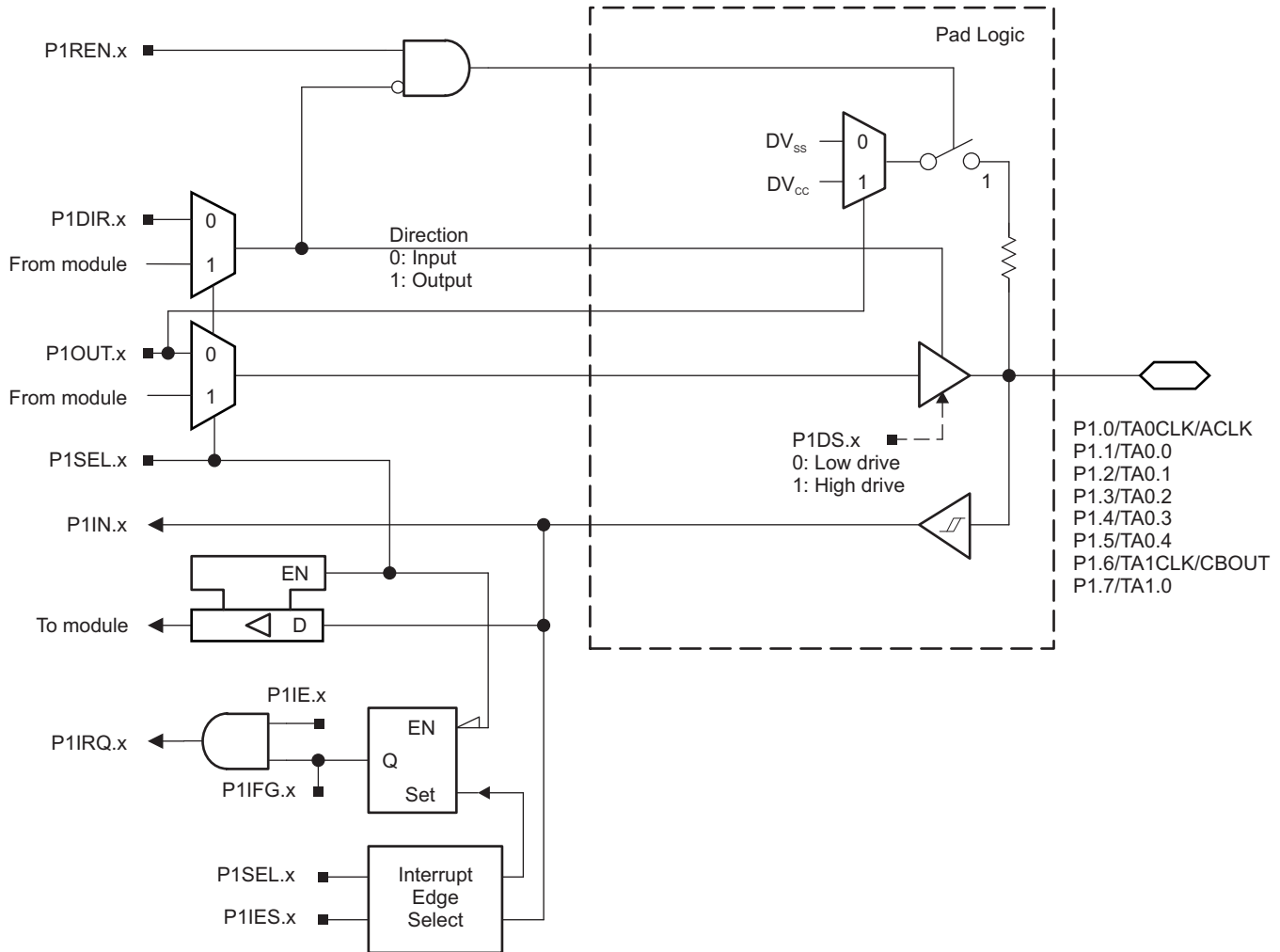


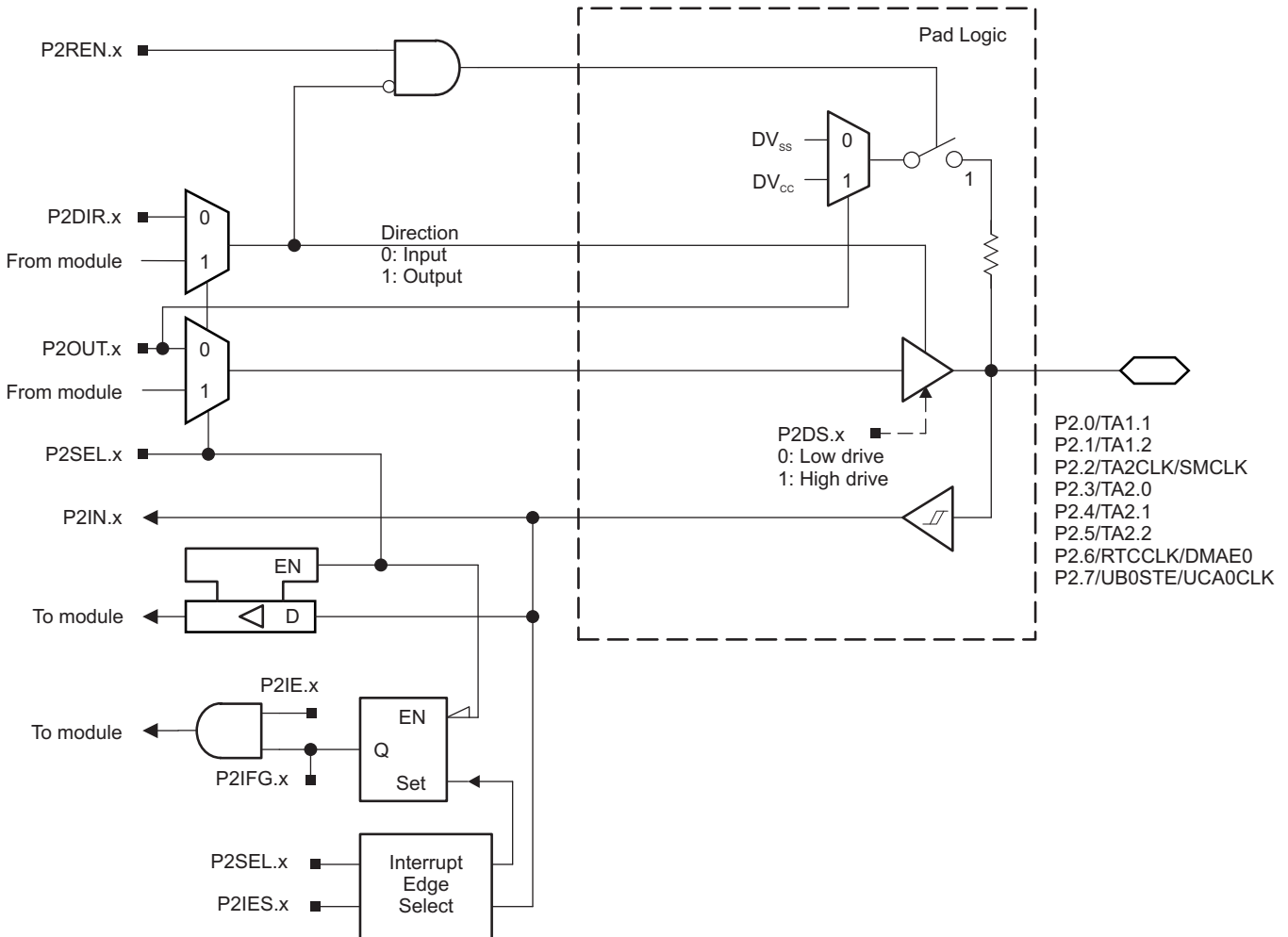
Figure 6-2. Port P1 (P1.0 to P1.7) Diagram

**Table 6-45. Port P1 (P1.0 to P1.7) Pin Functions**

| PIN NAME (P1.x)   | x | FUNCTION           | CONTROL BITS OR SIGNALS |         |
|-------------------|---|--------------------|-------------------------|---------|
|                   |   |                    | P1DIR.x                 | P1SEL.x |
| P1.0/TA0CLK/ACLK  | 0 | P1.0 (I/O)         | I: 0; O: 1              | 0       |
|                   |   | TA0CLK             | 0                       | 1       |
|                   |   | ACLK               | 1                       | 1       |
| P1.1/TA0.0        | 1 | P1.1 (I/O)         | I: 0; O: 1              | 0       |
|                   |   | TA0.CCI0A          | 0                       | 1       |
|                   |   | TA0.0              | 1                       | 1       |
| P1.2/TA0.1        | 2 | P1.2 (I/O)         | I: 0; O: 1              | 0       |
|                   |   | TA0.CCI1A          | 0                       | 1       |
|                   |   | TA0.1              | 1                       | 1       |
| P1.3/TA0.2        | 3 | P1.3 (I/O)         | I: 0; O: 1              | 0       |
|                   |   | TA0.CCI2A          | 0                       | 1       |
|                   |   | TA0.2              | 1                       | 1       |
| P1.4/TA0.3        | 4 | P1.4 (I/O)         | I: 0; O: 1              | 0       |
|                   |   | TA0.CCI3A          | 0                       | 1       |
|                   |   | TA0.3              | 1                       | 1       |
| P1.5/TA0.4        | 5 | P1.5 (I/O)         | I: 0; O: 1              | 0       |
|                   |   | TA0.CCI4A          | 0                       | 1       |
|                   |   | TA0.4              | 1                       | 1       |
| P1.6/TA1CLK/CBOUT | 6 | P1.6 (I/O)         | I: 0; O: 1              | 0       |
|                   |   | TA1CLK             | 0                       | 1       |
|                   |   | CBOUT comparator B | 1                       | 1       |
| P1.7/TA1.0        | 7 | P1.7 (I/O)         | I: 0; O: 1              | 0       |
|                   |   | TA1.CCI0A          | 0                       | 1       |
|                   |   | TA1.0              | 1                       | 1       |

### 6.11.2 Port P2 (P2.0 to P2.7) Input/Output With Schmitt Trigger

Figure 6-3 shows the port diagram. Table 6-46 summarizes the selection of the pin functions.



### Figure 6-3. Port P2 (P2.0 to P2.7) Diagram

**Table 6-46. Port P2 (P2.0 to P2.7) Pin Functions**

| PIN NAME (P2.x)      | x | FUNCTION                           | CONTROL BITS OR SIGNALS <sup>(1)</sup> |         |
|----------------------|---|------------------------------------|----------------------------------------|---------|
|                      |   |                                    | P2DIR.x                                | P2SEL.x |
| P2.0/TA1.1           | 0 | P2.0 (I/O)                         | I: 0; O: 1                             | 0       |
|                      |   | TA1.CCI1A                          | 0                                      | 1       |
|                      |   | TA1.1                              | 1                                      | 1       |
| P2.1/TA1.2           | 1 | P2.1 (I/O)                         | I: 0; O: 1                             | 0       |
|                      |   | TA1.CCI2A                          | 0                                      | 1       |
|                      |   | TA1.2                              | 1                                      | 1       |
| P2.2/TA2CLK/SMCLK    | 2 | P2.2 (I/O)                         | I: 0; O: 1                             | 0       |
|                      |   | TA2CLK                             | 0                                      | 1       |
|                      |   | SMCLK                              | 1                                      | 1       |
| P2.3/TA2.0           | 3 | P2.3 (I/O)                         | I: 0; O: 1                             | 0       |
|                      |   | TA2.CCI0A                          | 0                                      | 1       |
|                      |   | TA2.0                              | 1                                      | 1       |
| P2.4/TA2.1           | 4 | P2.4 (I/O)                         | I: 0; O: 1                             | 0       |
|                      |   | TA2.CCI1A                          | 0                                      | 1       |
|                      |   | TA2.1                              | 1                                      | 1       |
| P2.5/TA2.2           | 5 | P2.5 (I/O)                         | I: 0; O: 1                             | 0       |
|                      |   | TA2.CCI2A                          | 0                                      | 1       |
|                      |   | TA2.2                              | 1                                      | 1       |
| P2.6/RTCCLK/DMAE0    | 6 | P2.6 (I/O)                         | I: 0; O: 1                             | 0       |
|                      |   | DMAE0                              | 0                                      | 1       |
|                      |   | RTCCLK                             | 1                                      | 1       |
| P2.7/UCB0STE/UCA0CLK | 7 | P2.7 (I/O)                         | I: 0; O: 1                             | 0       |
|                      |   | UCB0STE/UCA0CLK <sup>(2) (3)</sup> | X                                      | 1       |

(1) X = Don't care

(2) The pin direction is controlled by the USCI module.

(3) UCA0CLK function takes precedence over UCB0STE function. If the pin is required as UCA0CLK input or output, USCI\_B0 is forced to 3-wire SPI mode if 4-wire SPI mode is selected.

### 6.11.3 Port P3 (P3.0 to P3.4) Input/Output With Schmitt Trigger

Figure 6-4 shows the port diagram. Table 6-47 summarizes the selection of the pin functions.

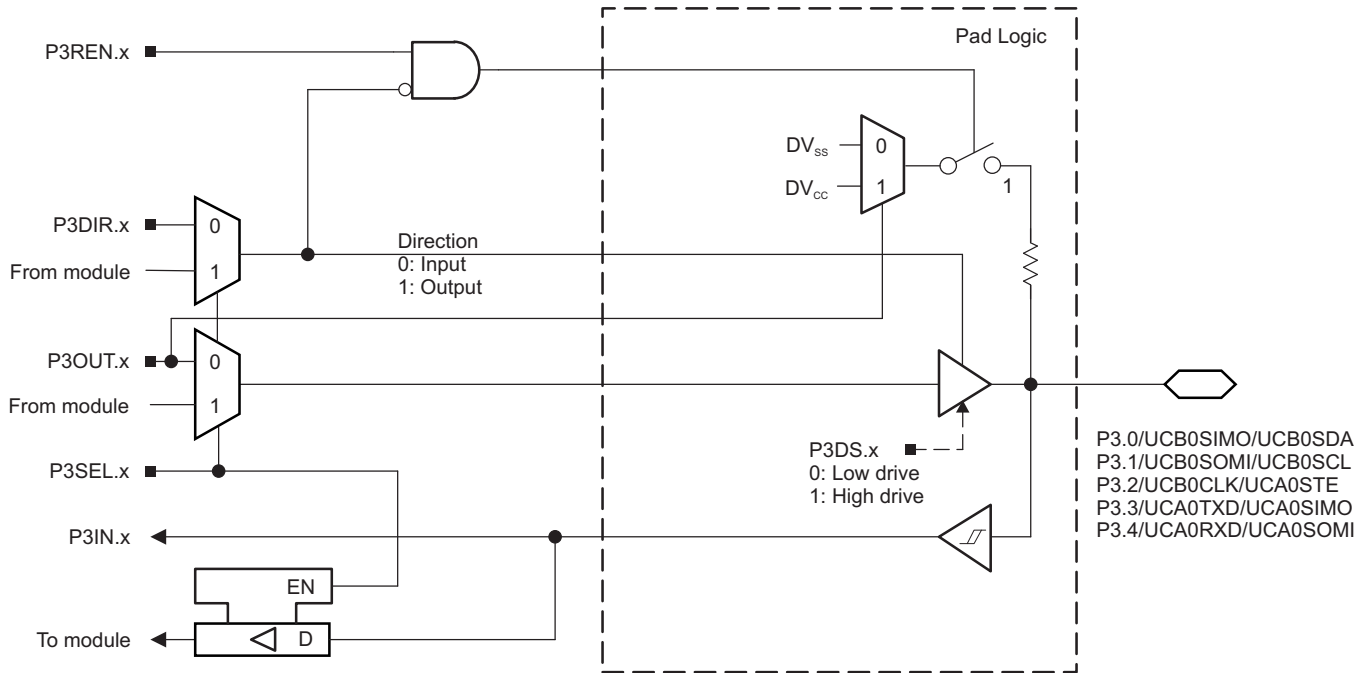


Figure 6-4. Port P3 (P3.0 to P3.7) Diagram

Table 6-47. Port P3 (P3.0 to P3.7) Pin Functions

| PIN NAME (P3.x)       | x | FUNCTION                            | CONTROL BITS OR SIGNALS <sup>(1)</sup> |         |
|-----------------------|---|-------------------------------------|----------------------------------------|---------|
|                       |   |                                     | P3DIR.x                                | P3SEL.x |
| P3.0/UCB0SIMO/UCB0SDA | 0 | P3.0 (I/O)                          | I: 0; O: 1                             | 0       |
|                       |   | UCB0SIMO/UCB0SDA <sup>(2) (3)</sup> | X                                      | 1       |
| P3.1/UCB0SOMI/UCB0SCL | 1 | P3.1 (I/O)                          | I: 0; O: 1                             | 0       |
|                       |   | UCB0SOMI/UCB0SCL <sup>(2) (3)</sup> | X                                      | 1       |
| P3.2/UCB0CLK/UCA0STE  | 2 | P3.2 (I/O)                          | I: 0; O: 1                             | 0       |
|                       |   | UCB0CLK/UCA0STE <sup>(2) (4)</sup>  | X                                      | 1       |
| P3.3/UCA0TXD/UCA0SIMO | 3 | P3.3 (I/O)                          | I: 0; O: 1                             | 0       |
|                       |   | UCA0TXD/UCA0SIMO <sup>(2)</sup>     | X                                      | 1       |
| P3.4/UCA0RXD/UCA0SOMI | 4 | P3.4 (I/O)                          | I: 0; O: 1                             | 0       |
|                       |   | UCA0RXD/UCA0SOMI <sup>(2)</sup>     | X                                      | 1       |

- (1) X = Don't care  
(2) The pin direction is controlled by the USCI module.  
(3) If the I<sup>2</sup>C functionality is selected, the output drives only the logical 0 to V<sub>SS</sub> level.  
(4) UCB0CLK function takes precedence over UCA0STE function. If the pin is required as UCB0CLK input or output, USCI\_A0 is forced to 3-wire SPI mode if 4-wire SPI mode is selected.

#### 6.11.4 Port P4 (P4.0 to P4.7) Input/Output With Schmitt Trigger

Figure 6-5 shows the port diagram. Table 6-48 summarizes the selection of the pin functions.

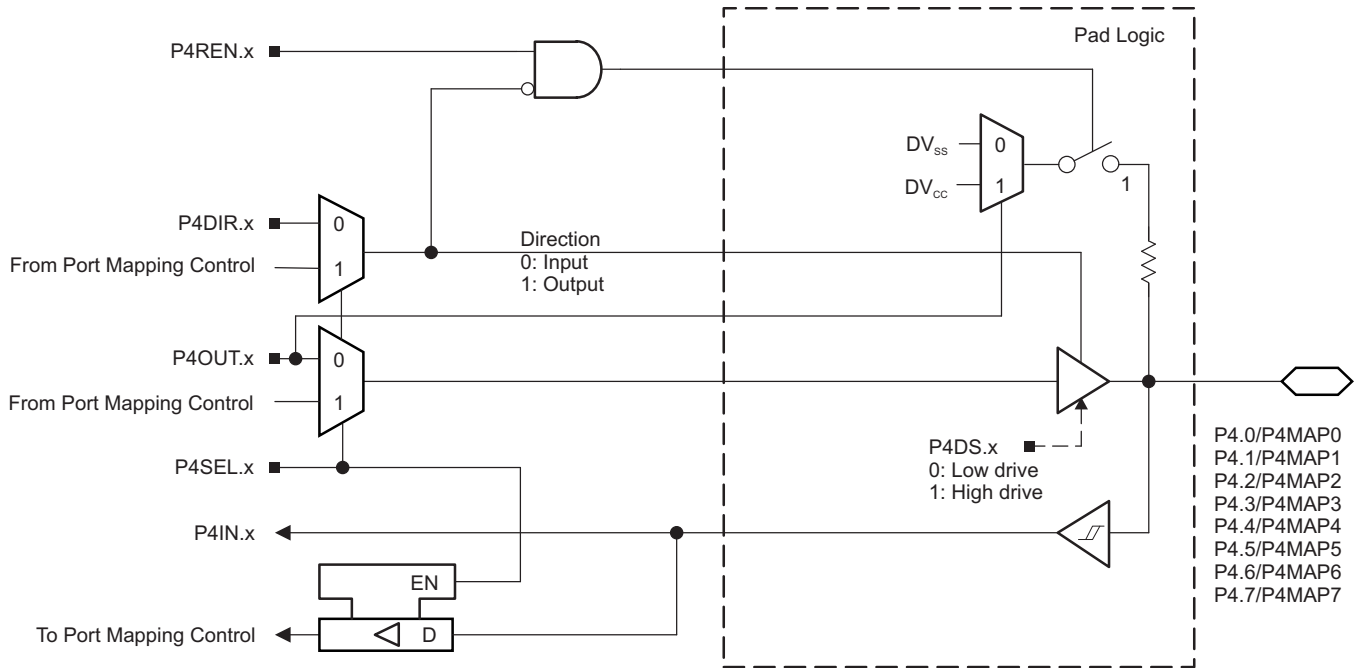


Figure 6-5. Port P4 (P4.0 to P4.7) Diagram

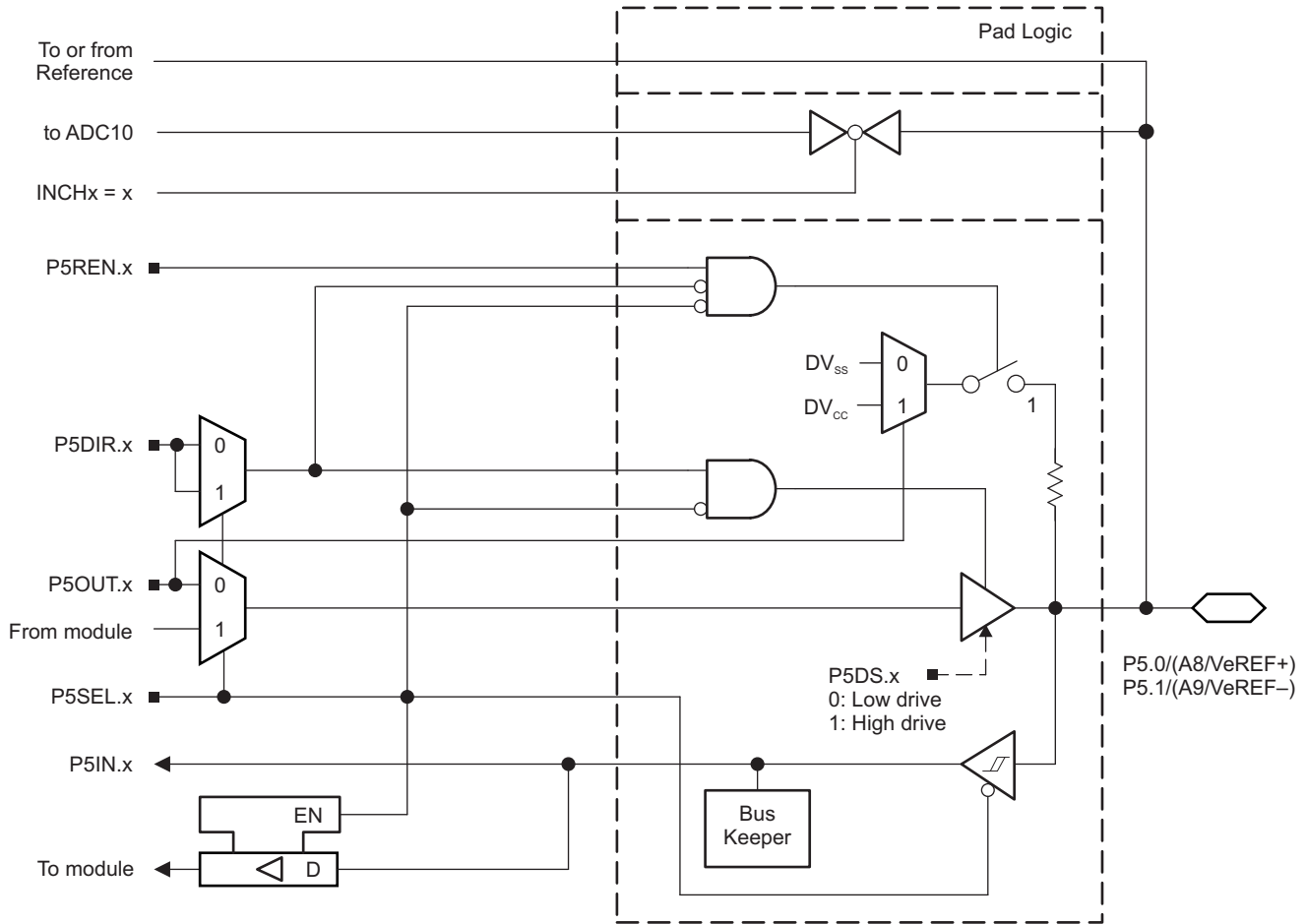
Table 6-48. Port P4 (P4.0 to P4.7) Pin Functions

| PIN NAME (P4.x) | x | FUNCTION                          | CONTROL BITS OR SIGNALS |         |        |
|-----------------|---|-----------------------------------|-------------------------|---------|--------|
|                 |   |                                   | P4DIR.x <sup>(1)</sup>  | P4SEL.x | P4MAPx |
| P4.0/P4MAP0     | 0 | P4.0 (I/O)                        | I: 0; O: 1              | 0       | X      |
|                 |   | Mapped secondary digital function | X                       | 1       | ≤ 30   |
| P4.1/P4MAP1     | 1 | P4.1 (I/O)                        | I: 0; O: 1              | 0       | X      |
|                 |   | Mapped secondary digital function | X                       | 1       | ≤ 30   |
| P4.2/P4MAP2     | 2 | P4.2 (I/O)                        | I: 0; O: 1              | 0       | X      |
|                 |   | Mapped secondary digital function | X                       | 1       | ≤ 30   |
| P4.3/P4MAP3     | 3 | P4.3 (I/O)                        | I: 0; O: 1              | 0       | X      |
|                 |   | Mapped secondary digital function | X                       | 1       | ≤ 30   |
| P4.4/P4MAP4     | 4 | P4.4 (I/O)                        | I: 0; O: 1              | 0       | X      |
|                 |   | Mapped secondary digital function | X                       | 1       | ≤ 30   |
| P4.5/P4MAP5     | 5 | P4.5 (I/O)                        | I: 0; O: 1              | 0       | X      |
|                 |   | Mapped secondary digital function | X                       | 1       | ≤ 30   |
| P4.6/P4MAP6     | 6 | P4.6 (I/O)                        | I: 0; O: 1              | 0       | X      |
|                 |   | Mapped secondary digital function | X                       | 1       | ≤ 30   |
| P4.7/P4MAP7     | 7 | P4.7 (I/O)                        | I: 0; O: 1              | 0       | X      |
|                 |   | Mapped secondary digital function | X                       | 1       | ≤ 30   |

(1) The direction of some mapped secondary functions are controlled directly by the module. See Table 6-7 for specific direction control information of mapped secondary functions.

### 6.11.5 Port P5 (P5.0 and P5.1) Input/Output With Schmitt Trigger

Figure 6-6 shows the port diagram. Table 6-49 summarizes the selection of the pin functions.



**Figure 6-6. Port P5 (P5.0 and P5.1) Diagram**

**Table 6-49. Port P5 (P5.0 and P5.1) Pin Functions**

| PIN NAME (P5.x)               | x | FUNCTION                  | CONTROL BITS OR SIGNALS <sup>(1)</sup> |         |
|-------------------------------|---|---------------------------|----------------------------------------|---------|
|                               |   |                           | P5DIR.x                                | P5SEL.x |
| P5.0/A8/VeREF+ <sup>(2)</sup> | 0 | P5.0 (I/O) <sup>(3)</sup> | I: 0; O: 1                             | 0       |
|                               |   | A8/VeREF+ <sup>(4)</sup>  | X                                      | 1       |
| P5.1/A9/VeREF- <sup>(5)</sup> | 1 | P5.1 (I/O) <sup>(3)</sup> | I: 0; O: 1                             | 0       |
|                               |   | A9/VeREF- <sup>(6)</sup>  | X                                      | 1       |

(1) X = Don't care

(2) VeREF+ available on devices with ADC10\_A.

(3) Default condition

(4) Setting the P5SEL.0 bit disables the output driver and the input Schmitt trigger to prevent parasitic cross currents when applying analog signals. An external voltage can be applied to VeREF+ and used as the reference for the ADC10\_A when available.

(5) VeREF- available on devices with ADC10\_A.

(6) Setting the P5SEL.1 bit disables the output driver and the input Schmitt trigger to prevent parasitic cross currents when applying analog signals. An external voltage can be applied to VeREF- and used as the reference for the ADC10\_A when available.

### 6.11.6 Port P5 (P5.2) Input/Output With Schmitt Trigger

Figure 6-7 shows the port diagram. Table 6-50 summarizes the selection of the pin functions.

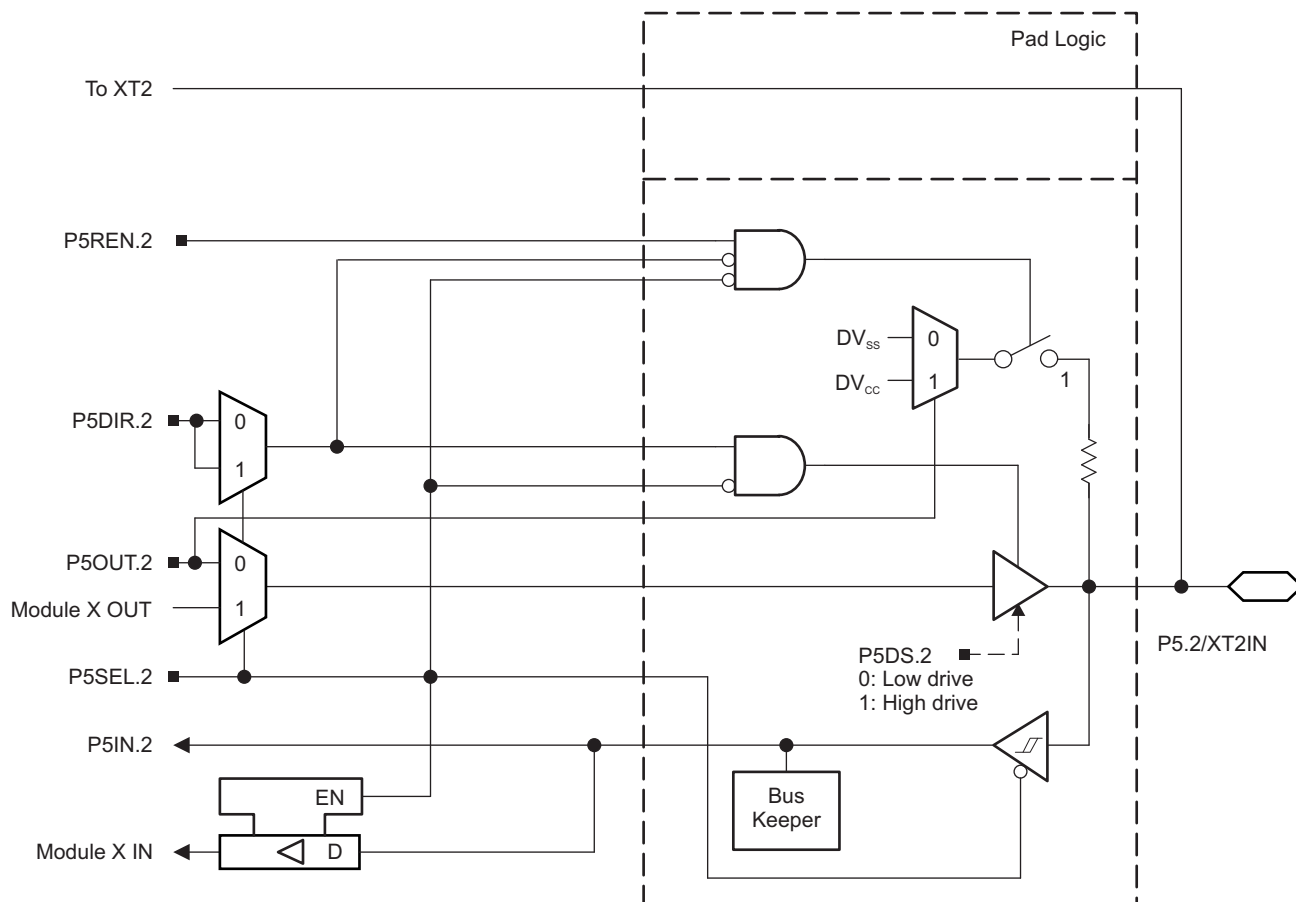


Figure 6-7. Port P5 (P5.2) Diagram

### 6.11.7 Port P5 (P5.3) Input/Output With Schmitt Trigger

Figure 6-8 shows the port diagram. Table 6-50 summarizes the selection of the pin functions.

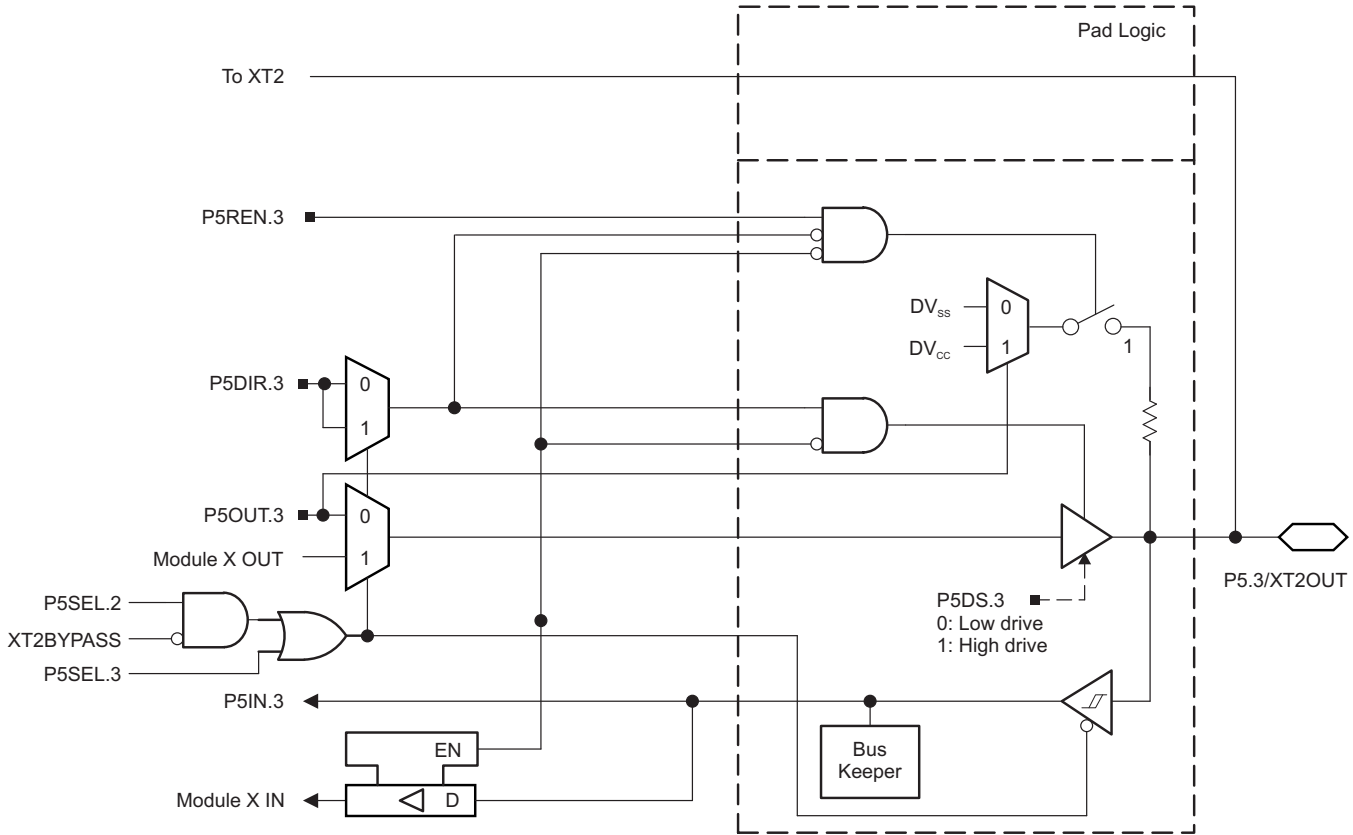


Figure 6-8. Port P5 (P5.3) Diagram

Table 6-50. Port P5 (P5.2 and P5.3) Pin Functions

| PIN NAME (P5.x) | x | FUNCTION                           | CONTROL BITS OR SIGNALS <sup>(1)</sup> |         |         |           |
|-----------------|---|------------------------------------|----------------------------------------|---------|---------|-----------|
|                 |   |                                    | P5DIR.x                                | P5SEL.2 | P5SEL.3 | XT2BYPASS |
| P5.2/XT2IN      | 2 | P5.2 (I/O)                         | I: 0; O: 1                             | 0       | X       | X         |
|                 |   | XT2IN crystal mode <sup>(2)</sup>  | X                                      | 1       | X       | 0         |
|                 |   | XT2IN bypass mode <sup>(2)</sup>   | X                                      | 1       | X       | 1         |
| P5.3/XT2OUT     | 3 | P5.3 (I/O)                         | I: 0; O: 1                             | 0       | 0       | X         |
|                 |   | XT2OUT crystal mode <sup>(3)</sup> | X                                      | 1       | X       | 0         |
|                 |   | P5.3 (I/O) <sup>(3)</sup>          | X                                      | 1       | 0       | 1         |

(1) X = Don't care

(2) Setting P5SEL.2 causes the general-purpose I/O to be disabled. Pending the setting of XT2BYPASS, P5.2 is configured for crystal mode or bypass mode.

(3) Setting P5SEL.2 causes the general-purpose I/O to be disabled in crystal mode. When using bypass mode, P5.3 can be used as general-purpose I/O.

### 6.11.8 Port P5 (P5.4 and P5.5) Input/Output With Schmitt Trigger

Figure 6-9 and Figure 6-10 show the port diagrams. Table 6-51 summarizes the selection of the pin functions.

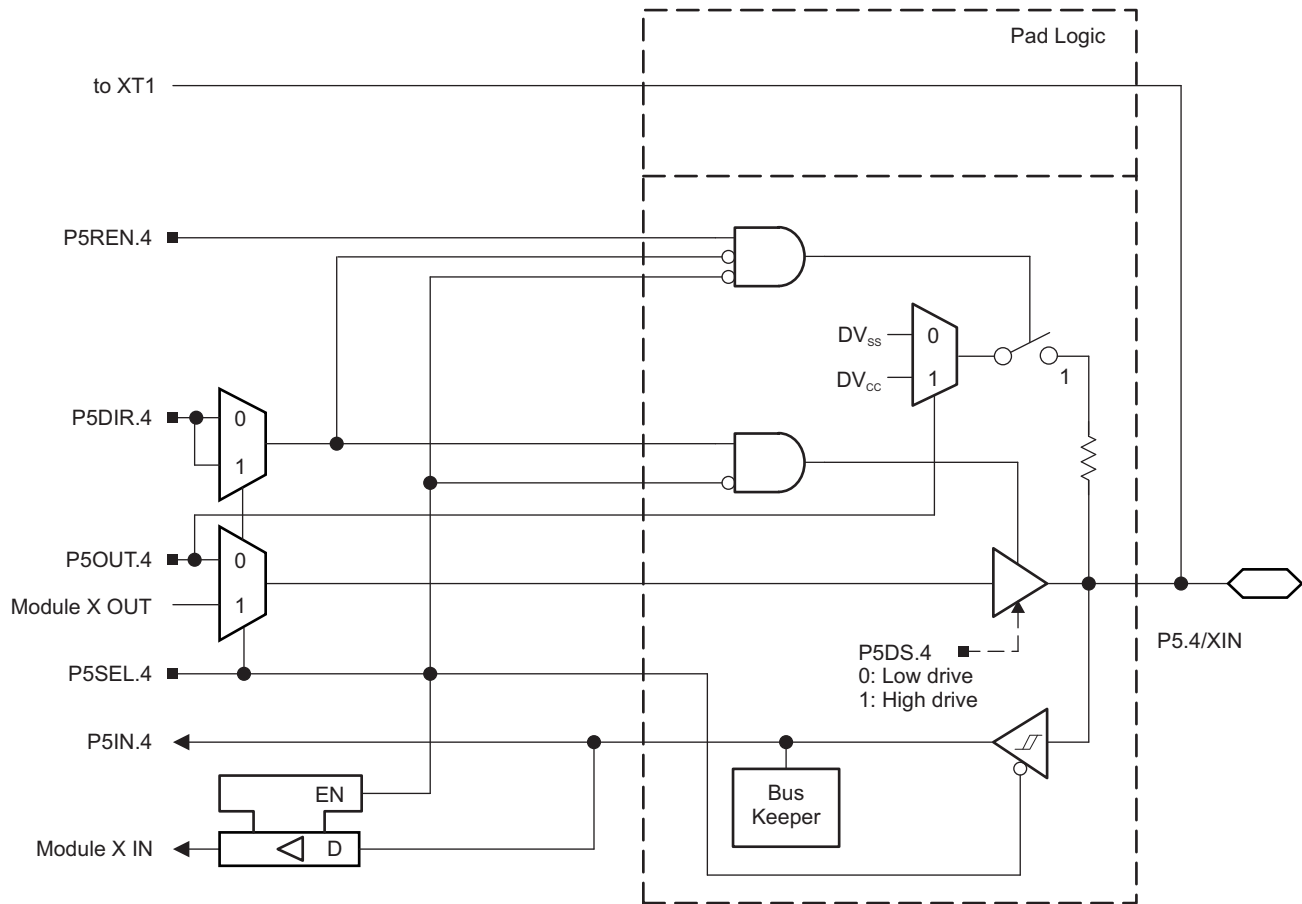
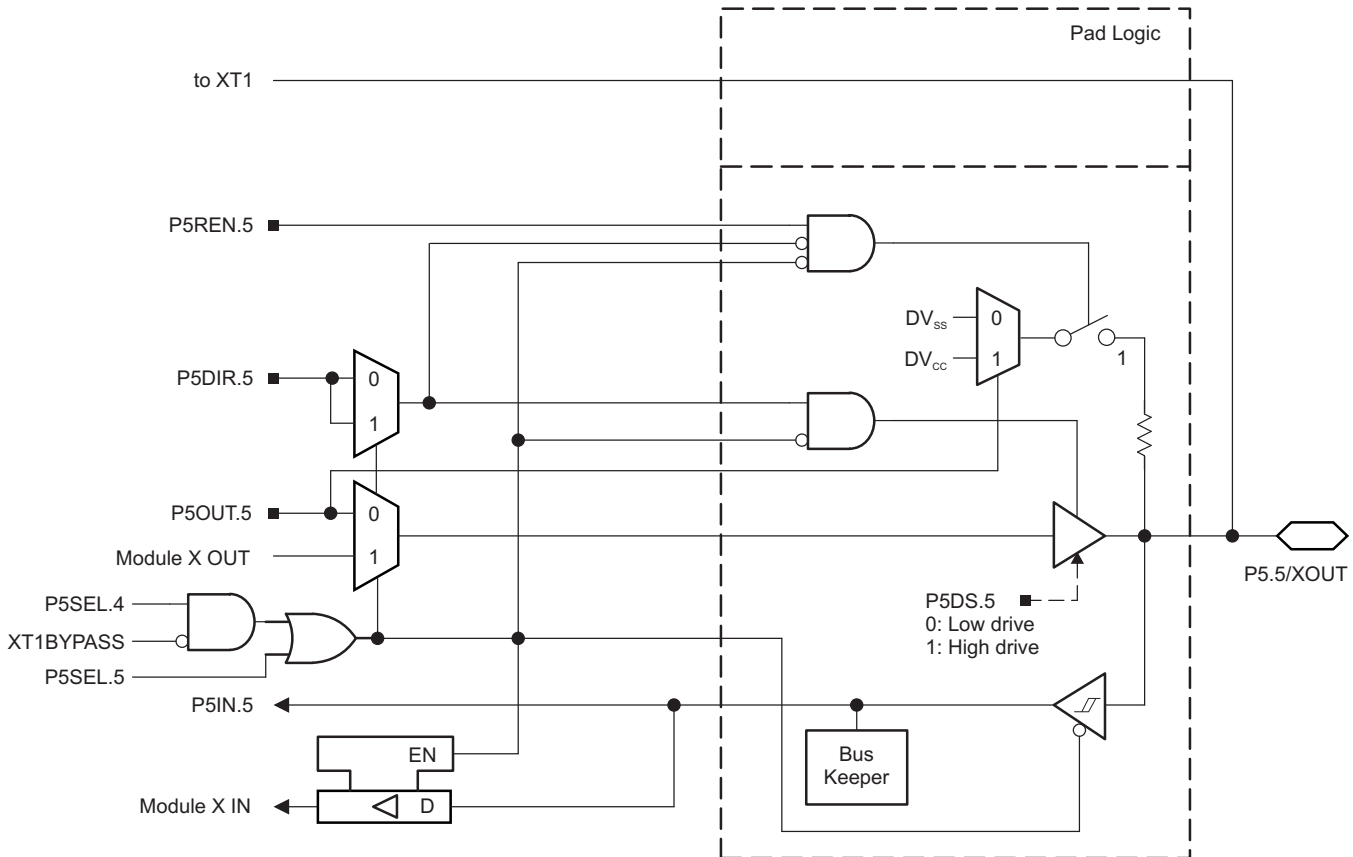


Figure 6-9. Port P5 (P5.4) Diagram



**Figure 6-10. Port P5 (P5.5) Diagram**

**Table 6-51. Port P5 (P5.4 and P5.5) Pin Functions**

| PIN NAME (P7.x) | x | FUNCTION                         | CONTROL BITS OR SIGNALS <sup>(1)</sup> |         |         |           |
|-----------------|---|----------------------------------|----------------------------------------|---------|---------|-----------|
|                 |   |                                  | P5DIR.x                                | P5SEL.4 | P5SEL.5 | XT1BYPASS |
| P5.4/XIN        | 4 | P5.4 (I/O)                       | I: 0; O: 1                             | 0       | X       | X         |
|                 |   | XIN crystal mode <sup>(2)</sup>  | X                                      | 1       | X       | 0         |
|                 |   | XIN bypass mode <sup>(2)</sup>   | X                                      | 1       | X       | 1         |
| P5.5/XOUT       | 5 | P5.5 (I/O)                       | I: 0; O: 1                             | 0       | 0       | X         |
|                 |   | XOUT crystal mode <sup>(3)</sup> | X                                      | 1       | X       | 0         |
|                 |   | P5.5 (I/O) <sup>(3)</sup>        | X                                      | 1       | 0       | 1         |

(1) X = Don't care

(2) Setting P5SEL.4 causes the general-purpose I/O to be disabled. Pending the setting of XT1BYPASS, P5.4 is configured for crystal mode or bypass mode.

(3) Setting P5SEL.4 causes the general-purpose I/O to be disabled in crystal mode. When using bypass mode, P5.5 can be used as general-purpose I/O.

### 6.11.9 Port P6 (P6.0 to P6.7) Input/Output With Schmitt Trigger

Figure 6-11 shows the port diagram. Table 6-52 summarizes the selection of the pin functions.

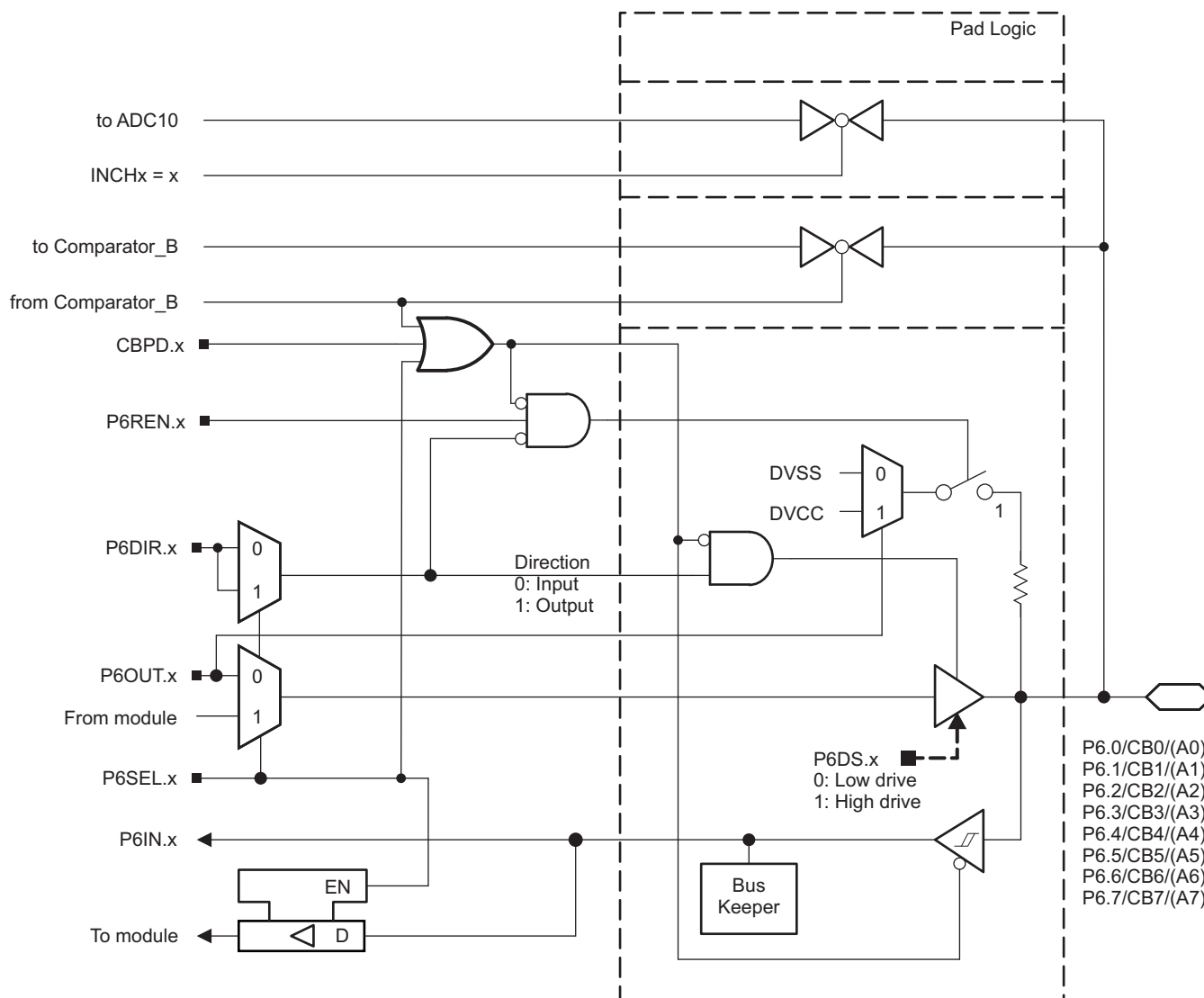


Figure 6-11. Port P6 (P6.0 to P6.7) Diagram

**Table 6-52. Port P6 (P6.0 to P6.7) Pin Functions**

| PIN NAME (P6.x) | x | FUNCTION                      | CONTROL BITS OR SIGNALS |         |       |
|-----------------|---|-------------------------------|-------------------------|---------|-------|
|                 |   |                               | P6DIR.x                 | P6SEL.x | CBPDx |
| P6.0/CB0/(A0)   | 0 | P6.0 (I/O)                    | I: 0; O: 1              | 0       | 0     |
|                 |   | A0 (only on devices with ADC) | X                       | 1       | X     |
|                 |   | CB0 <sup>(1)</sup>            | X                       | X       | 1     |
| P6.1/CB1/(A1)   | 1 | P6.1 (I/O)                    | I: 0; O: 1              | 0       | 0     |
|                 |   | A1 (only on devices with ADC) | X                       | 1       | X     |
|                 |   | CB1 <sup>(1)</sup>            | X                       | X       | 1     |
| P6.2/CB2/(A2)   | 2 | P6.2 (I/O)                    | I: 0; O: 1              | 0       | 0     |
|                 |   | A2 (only on devices with ADC) | X                       | 1       | X     |
|                 |   | CB2 <sup>(1)</sup>            | X                       | X       | 1     |
| P6.3/CB3/(A3)   | 3 | P6.3 (I/O)                    | I: 0; O: 1              | 0       | 0     |
|                 |   | A3 (only on devices with ADC) | X                       | 1       | X     |
|                 |   | CB3 <sup>(1)</sup>            | X                       | X       | 1     |
| P6.4/CB4/(A4)   | 4 | P6.4 (I/O)                    | I: 0; O: 1              | 0       | 0     |
|                 |   | A4 (only on devices with ADC) | X                       | 1       | X     |
|                 |   | CB4 <sup>(1)</sup>            | X                       | X       | 1     |
| P6.5/CB5/(A5)   | 5 | P6.5 (I/O)                    | I: 0; O: 1              | 0       | 0     |
|                 |   | A5 (only on devices with ADC) | X                       | 1       | X     |
|                 |   | CB5 <sup>(1)</sup>            | X                       | X       | 1     |
| P6.6/CB6/(A6)   | 6 | P6.6 (I/O)                    | I: 0; O: 1              | 0       | 0     |
|                 |   | A6 (only on devices with ADC) | X                       | 1       | X     |
|                 |   | CB6 <sup>(1)</sup>            | X                       | X       | 1     |
| P6.7/CB7/(A7)   | 7 | P6.7 (I/O)                    | I: 0; O: 1              | 0       | 0     |
|                 |   | A7 (only on devices with ADC) | X                       | 1       | X     |
|                 |   | CB7 <sup>(1)</sup>            | X                       | X       | 1     |

- (1) Setting the CBPDx bit disables the output driver and the input Schmitt trigger to prevent parasitic cross currents when applying analog signals. Selecting the CBx input pin to the comparator multiplexer with the CBx bits automatically disables output driver and input buffer for that pin, regardless of the state of the associated CBPDx bit.

### 6.11.10 Port U (PU.0/DP, PU.1/DM, PUR) USB Ports

Figure 6-12 shows the port diagram. Table 6-53 through Table 6-55 summarize the selection of the pin functions.

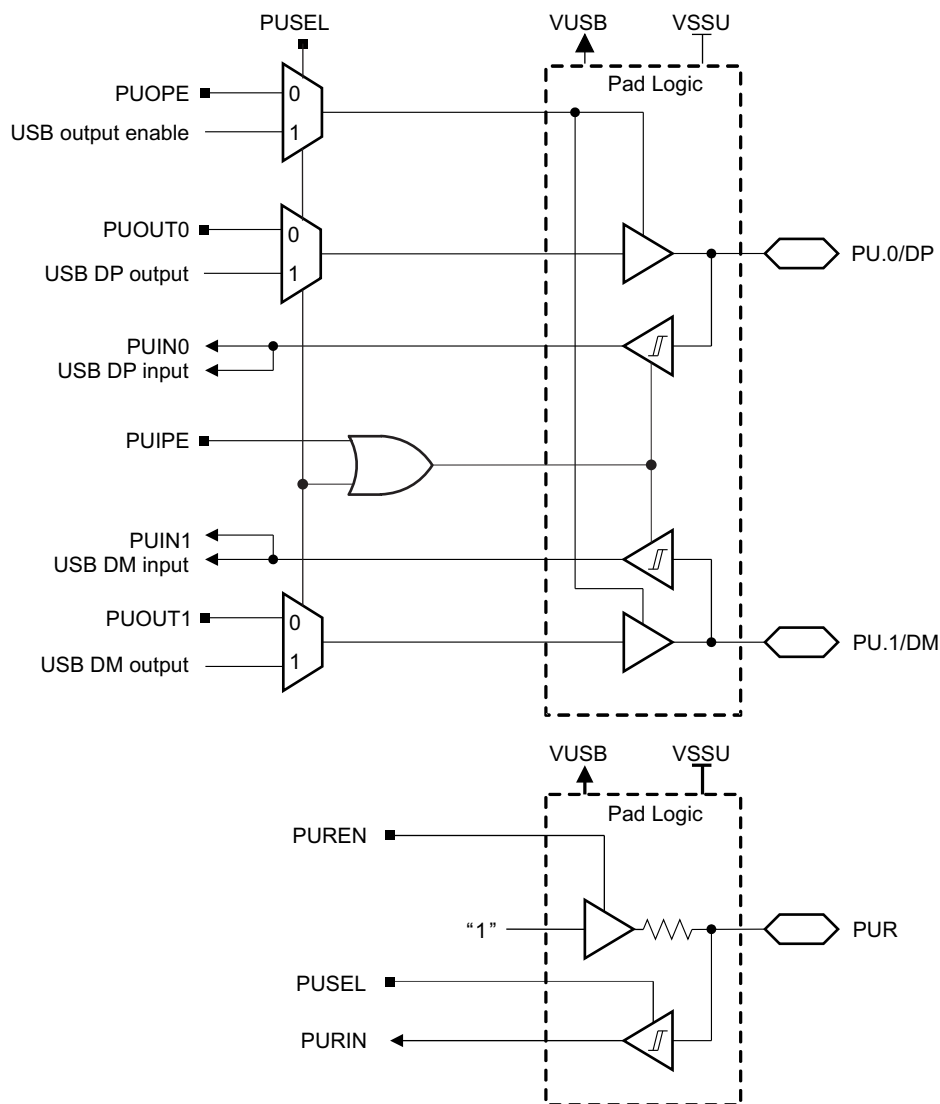


Figure 6-12. Port U (PU.0/DP, PU.1/DM, PUR) Diagram

**Table 6-53. Port U (PU.0/DP and PU.1/DM) Output Functions<sup>(1)</sup>**

| CONTROL BITS |       |        |        | PIN NAME          |                   |
|--------------|-------|--------|--------|-------------------|-------------------|
| PUSEL        | PUOPE | PUOUT1 | PUOUT0 | PU.1/DM           | PU.0/DP           |
| 0            | 0     | X      | X      | Output disabled   | Output disabled   |
| 0            | 1     | 0      | 0      | Output low        | Output low        |
| 0            | 1     | 0      | 1      | Output low        | Output high       |
| 0            | 1     | 1      | 0      | Output high       | Output low        |
| 0            | 1     | 1      | 1      | Output high       | Output high       |
| 1            | X     | X      | X      | DM <sup>(2)</sup> | DP <sup>(2)</sup> |

- (1) PU.1/DM and PU.0/DP inputs and outputs are supplied from VUSB. VUSB can be generated by the device using the integrated 3.3-V LDO when enabled. VUSB can also be supplied externally when the 3.3-V LDO is not being used and is disabled.
- (2) Output state set by the USB module.

**Table 6-54. Port U (PU.0/DP and PU.1/DM) Input Functions<sup>(1)</sup>**

| CONTROL BITS |       | PIN NAME       |                |
|--------------|-------|----------------|----------------|
| PUSEL        | PUIPE | PU.1/DM        | PU.0/DP        |
| 0            | 0     | Input disabled | Input disabled |
| 0            | 1     | Input enabled  | Input enabled  |
| 1            | X     | DM input       | DP input       |

- (1) PU.1/DM and PU.0/DP inputs and outputs are supplied from VUSB. VUSB can be generated by the device using the integrated 3.3-V LDO when enabled. VUSB can also be supplied externally when the 3.3-V LDO is not being used and is disabled.

**Table 6-55. Port U (PUR) Input Functions**

| CONTROL BITS |       | FUNCTION                          |
|--------------|-------|-----------------------------------|
| PUSEL        | PUREN |                                   |
| 0            | 0     | Input disabled<br>Pullup disabled |
| 0            | 1     | Input disabled<br>Pullup enabled  |
| 1            | 0     | Input enabled<br>Pullup disabled  |
| 1            | 1     | Input enabled<br>Pullup enabled   |

### 6.11.11 Port J (PJ.0) JTAG Pin TDO, Input/Output With Schmitt Trigger or Output

Figure 6-13 shows the port diagram. Table 6-56 summarizes the selection of the pin functions.

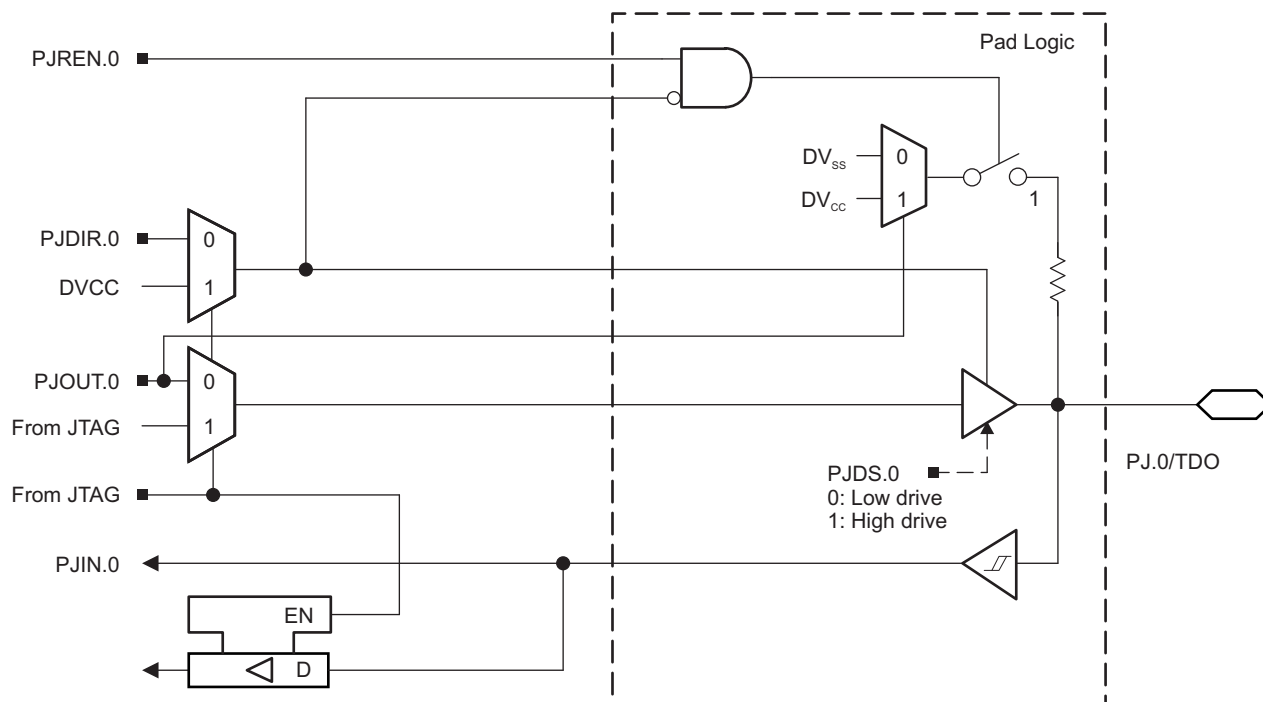
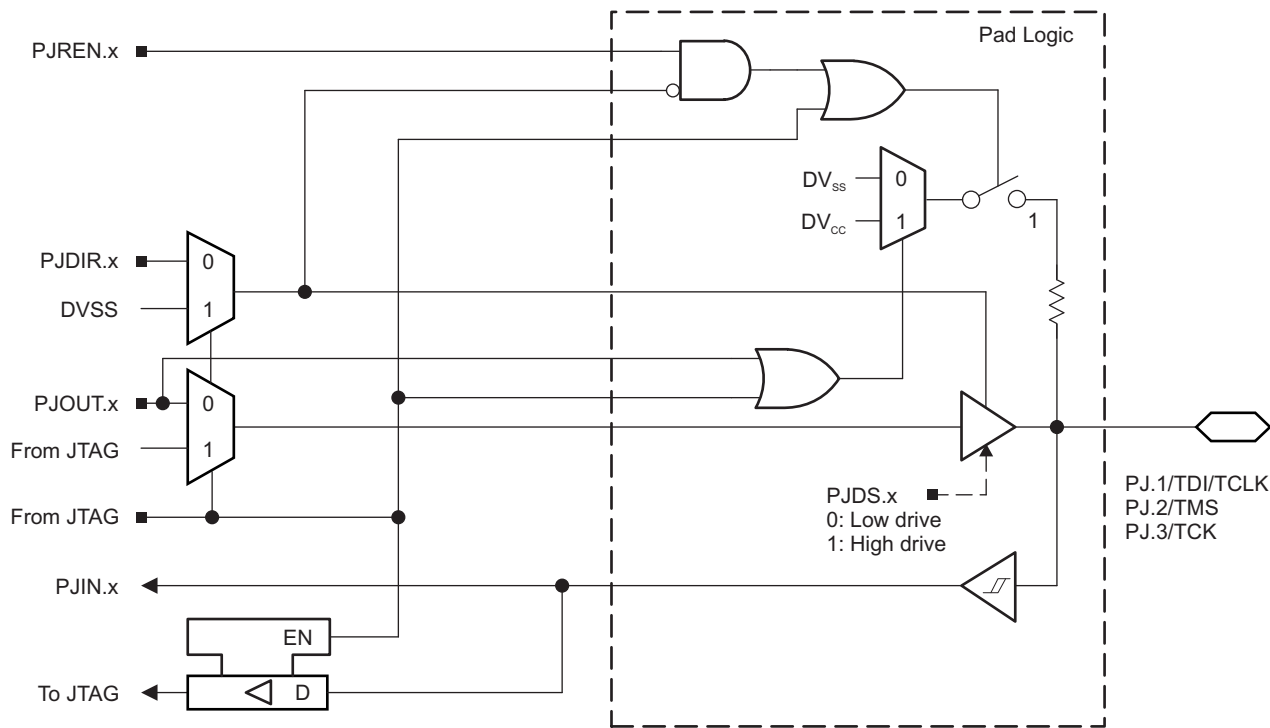


Figure 6-13. Port PJ (PJ.0) Diagram

### 6.11.12 Port J (PJ.1 to PJ.3) JTAG Pins TMS, TCK, TDI/TCLK, Input/Output With Schmitt Trigger or Output

Figure 6-14 shows the port diagram. Table 6-56 summarizes the selection of the pin functions.



**Figure 6-14. Port PJ (PJ.1 to PJ.3) Diagram**

**Table 6-56. Port PJ (PJ.0 to PJ.3) Pin Functions**

| PIN NAME (PJ.x) | x | FUNCTION                    | CONTROL BITS OR SIGNALS <sup>(1)</sup> |
|-----------------|---|-----------------------------|----------------------------------------|
|                 |   |                             | PJDIR.x                                |
| PJ.0/TDO        | 0 | PJ.0 (I/O) <sup>(2)</sup>   | I: 0; O: 1                             |
|                 |   | TDO <sup>(3)</sup>          | X                                      |
| PJ.1/TDI/TCLK   | 1 | PJ.1 (I/O) <sup>(2)</sup>   | I: 0; O: 1                             |
|                 |   | TDI/TCLK <sup>(3) (4)</sup> | X                                      |
| PJ.2/TMS        | 2 | PJ.2 (I/O) <sup>(2)</sup>   | I: 0; O: 1                             |
|                 |   | TMS <sup>(3) (4)</sup>      | X                                      |
| PJ.3/TCK        | 3 | PJ.3 (I/O) <sup>(2)</sup>   | I: 0; O: 1                             |
|                 |   | TCK <sup>(3) (4)</sup>      | X                                      |

(1) X = Don't care

(2) Default condition

(3) The pin direction is controlled by the JTAG module.

(4) In JTAG mode, pullups are activated automatically on TMS, TCK, and TDI/TCLK. PJREN.x are do not care.

## 6.12 Device Descriptors

Table 6-57 and Table 6-58 list the complete contents of the device descriptor tag-length-value (TLV) structure for each device type.

**Table 6-57. F5504 to F5510 Device Descriptor Table <sup>(1)</sup>**

| DESCRIPTION       |                                       | ADDRESS | SIZE<br>(bytes) | VALUE       |            |             |            |             |            |          |          |          |          |
|-------------------|---------------------------------------|---------|-----------------|-------------|------------|-------------|------------|-------------|------------|----------|----------|----------|----------|
|                   |                                       |         |                 | F5510       |            | F5509       |            | F5508       |            | F5507    | F5506    | F5505    | F5504    |
|                   |                                       |         |                 | RGC,<br>ZQE | RGZ,<br>PT | RGC,<br>ZQE | RGZ,<br>PT | RGC,<br>ZQE | RGZ,<br>PT |          |          |          |          |
| Info Block        | Info length                           | 01A00h  | 1               | 06h         | 06h        | 06h         | 06h        | 06h         | 06h        | 06h      | 06h      | 06h      | 06h      |
|                   | CRC length                            | 01A01h  | 1               | 06h         | 06h        | 06h         | 06h        | 06h         | 06h        | 06h      | 06h      | 06h      | 06h      |
|                   | CRC value                             | 01A02h  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | Device ID                             | 01A04h  | 1               | 31h         | 31h        | 3Ah         | 3Ah        | 39h         | 39h        | 38h      | 37h      | 36h      | 35h      |
|                   | Device ID                             | 01A05h  | 1               | 80h         | 80h        | 80h         | 80h        | 80h         | 80h        | 80h      | 80h      | 80h      | 80h      |
|                   | Hardware revision                     | 01A06h  | 1               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | Firmware revision                     | 01A07h  | 1               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
| Die Record        | Die record tag                        | 01A08h  | 1               | 08h         | 08h        | 08h         | 08h        | 08h         | 08h        | 08h      | 08h      | 08h      | 08h      |
|                   | Die record length                     | 01A09h  | 1               | 0Ah         | 0Ah        | 0Ah         | 0Ah        | 0Ah         | 0Ah        | 0Ah      | 0Ah      | 0Ah      | 0Ah      |
|                   | Lot/wafer ID                          | 01A0Ah  | 4               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | Die X position                        | 01A0Eh  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | Die Y position                        | 01A10h  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | Test results                          | 01A12h  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
| ADC10 Calibration | ADC10 calibration tag                 | 01A14h  | 1               | 13h         | 13h        | 13h         | 13h        | 13h         | 13h        | 13h      | 13h      | 13h      | 13h      |
|                   | ADC10 calibration length              | 01A15h  | 1               | 10h         | 10h        | 10h         | 10h        | 10h         | 10h        | 10h      | 10h      | 10h      | 10h      |
|                   | ADC gain factor                       | 01A16h  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | ADC offset                            | 01A18h  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | ADC 1.5-V reference Temp. sensor 30°C | 01A1Ah  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | ADC 1.5-V reference Temp. sensor 85°C | 01A1Ch  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | ADC 2.0-V reference Temp. sensor 30°C | 01A1Eh  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | ADC 2.0-V reference Temp. sensor 85°C | 01A20h  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | ADC 2.5-V reference Temp. sensor 30°C | 01A22h  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | ADC 2.5-V reference Temp. sensor 85°C | 01A24h  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
| REF Calibration   | REF calibration tag                   | 01A26h  | 1               | 12h         | 12h        | 12h         | 12h        | 12h         | 12h        | 12h      | 12h      | 12h      | 12h      |
|                   | REF calibration length                | 01A27h  | 1               | 06h         | 06h        | 06h         | 06h        | 06h         | 06h        | 06h      | 06h      | 06h      | 06h      |
|                   | REF 1.5-V reference factor            | 01A28h  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | REF 2.0-V reference factor            | 01A2Ah  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |
|                   | REF 2.5-V reference factor            | 01A2Ch  | 2               | Per unit    | Per unit   | Per unit    | Per unit   | Per unit    | Per unit   | Per unit | Per unit | Per unit | Per unit |

(1) N/A = Not applicable

**Table 6-57. F5504 to F5510 Device Descriptor Table <sup>(1)</sup> (continued)**

| DESCRIPTION              |                              | ADDRESS | SIZE<br>(bytes) | VALUE       |            |             |             |             |            |            |            |            |            |
|--------------------------|------------------------------|---------|-----------------|-------------|------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|
|                          |                              |         |                 | F5510       |            | F5509       |             | F5508       |            | F5507      | F5506      | F5505      | F5504      |
|                          |                              |         |                 | RGC,<br>ZQE | RGZ,<br>PT | RGC,<br>ZQE | RGZ,<br>PT  | RGC,<br>ZQE | RGZ,<br>PT |            |            |            |            |
| Peripheral<br>Descriptor | Peripheral descriptor tag    | 01A2Eh  | 1               | 02h         | 02h        | 02h         | 02h         | 02h         | 02h        | 02h        | 02h        | 02h        | 02h        |
|                          | Peripheral descriptor length | 01A2Fh  | 1               | 61h         | 61h        | 62h         | 62h         | 61h         | 61h        | 5Dh        | 5Eh        | 5Dh        | 5Dh        |
|                          | Memory 1                     |         | 2               | 08h<br>8Ah  | 08h<br>8Ah | 08h<br>8Ah  | 08h<br>8Ah  | 08h<br>8Ah  | 08h<br>8Ah | 08h<br>8Ah | 08h<br>8Ah | 08h<br>8Ah | 08h<br>8Ah |
|                          | Memory 2                     |         | 2               | 0Ch<br>86h  | 0Ch<br>86h | 0Ch<br>86h  | 0Ch<br>86h  | 0Ch<br>86h  | 0Ch<br>86h | 0Ch<br>86h | 0Ch<br>86h | 0Ch<br>86h | 0Ch<br>86h |
|                          | Memory 3                     |         | 2               | 0Eh<br>2Ah  | 0Eh<br>2Ah | 0Eh<br>2Ah  | 00Eh<br>2Ah | 0Eh<br>2Ah  | 0Eh<br>2Ah | 0Eh<br>2Ah | 0Eh<br>2Ah | 0Eh<br>2Ah | 0Eh<br>2Ah |
|                          | Memory 4                     |         | 2               | 12h<br>2Ch  | 12h<br>2Ch | 12h<br>2Ch  | 12h<br>2Ch  | 12h<br>2Ch  | 12h<br>2Ch | 12h<br>2Ch | 12h<br>2Ch | 12h<br>2Ch | 12h<br>2Ch |
|                          | Memory 5                     |         | 2               | 40h<br>92h  | 40h<br>92h | 50h<br>91h  | 50h<br>91h  | 60h<br>90h  | 60h<br>90h | 40h<br>92h | 50h<br>91h | 60h<br>90h | 70h<br>8Eh |
|                          | Memory 6                     |         |                 | N/A         | N/A        | 8Eh         | 8Eh         | N/A         | N/A        | N/A        | 8Eh        | N/A        | N/A        |
|                          | Delimiter                    |         | 1               | 00h         | 00h        | 00h         | 00h         | 00h         | 00h        | 00h        | 00h        | 00h        | 00h        |
|                          | Peripheral count             |         | 1               | 20h         | 20h        | 20h         | 20h         | 20h         | 20h        | 1Eh        | 1Eh        | 1Eh        | 1Eh        |
|                          | MSP430CPUXV2                 |         | 2               | 00h<br>23h  | 00h<br>23h | 00h<br>23h  | 00h<br>23h  | 00h<br>23h  | 00h<br>23h | 00h<br>23h | 00h<br>23h | 00h<br>23h | 00h<br>23h |
|                          | JTAG                         |         | 2               | 00h<br>09h  | 00h<br>09h | 00h<br>09h  | 00h<br>09h  | 00h<br>09h  | 00h<br>09h | 00h<br>09h | 00h<br>09h | 00h<br>09h | 00h<br>09h |
|                          | SBW                          |         | 2               | 00h<br>0Fh  | 00h<br>0Fh | 00h<br>0Fh  | 00h<br>0Fh  | 00h<br>0Fh  | 00h<br>0Fh | 00h<br>0Fh | 00h<br>0Fh | 00h<br>0Fh | 00h<br>0Fh |
|                          | EEM-S                        |         | 2               | 00h<br>03h  | 00h<br>03h | 00h<br>03h  | 00h<br>03h  | 00h<br>03h  | 00h<br>03h | 00h<br>03h | 00h<br>03h | 00h<br>03h | 00h<br>03h |
|                          | TI BSL                       |         | 2               | 00h<br>FCh  | 00h<br>FCh | 00h<br>FCh  | 00h<br>FCh  | 00h<br>FCh  | 00h<br>FCh | 00h<br>FCh | 00h<br>FCh | 00h<br>FCh | 00h<br>FCh |
|                          | SFR                          |         | 2               | 10h<br>41h  | 10h<br>41h | 10h<br>41h  | 10h<br>41h  | 10h<br>41h  | 10h<br>41h | 10h<br>41h | 10h<br>41h | 10h<br>41h | 10h<br>41h |
|                          | PMM                          |         | 2               | 02h<br>30h  | 02h<br>30h | 02h<br>30h  | 02h<br>30h  | 02h<br>30h  | 02h<br>30h | 02h<br>30h | 02h<br>30h | 02h<br>30h | 02h<br>30h |
|                          | FCTL                         |         | 2               | 02h<br>38h  | 02h<br>38h | 02h<br>38h  | 02h<br>38h  | 02h<br>38h  | 02h<br>38h | 02h<br>38h | 02h<br>38h | 02h<br>38h | 02h<br>38h |
|                          | CRC16                        |         | 2               | 01h<br>3Ch  | 01h<br>3Ch | 01h<br>3Ch  | 01h<br>3Ch  | 01h<br>3Ch  | 01h<br>3Ch | 01h<br>3Ch | 01h<br>3Ch | 01h<br>3Ch | 01h<br>3Ch |
|                          | CRC16_RB                     |         | 2               | 00h<br>3Dh  | 00h<br>3Dh | 00h<br>3Dh  | 00h<br>3Dh  | 00h<br>3Dh  | 00h<br>3Dh | 00h<br>3Dh | 00h<br>3Dh | 00h<br>3Dh | 00h<br>3Dh |
|                          | RAMCTL                       |         | 2               | 00h<br>44h  | 00h<br>44h | 00h<br>44h  | 00h<br>44h  | 00h<br>44h  | 00h<br>44h | 00h<br>44h | 00h<br>44h | 00h<br>44h | 00h<br>44h |
|                          | WDT_A                        |         | 2               | 00h<br>40h  | 00h<br>40h | 00h<br>40h  | 00h<br>40h  | 00h<br>40h  | 00h<br>40h | 00h<br>40h | 00h<br>40h | 00h<br>40h | 00h<br>40h |
|                          | UCS                          |         | 2               | 01h<br>48h  | 01h<br>48h | 01h<br>48h  | 01h<br>48h  | 01h<br>48h  | 01h<br>48h | 01h<br>48h | 01h<br>48h | 01h<br>48h | 01h<br>48h |
|                          | SYS                          |         | 2               | 02h<br>42h  | 02h<br>42h | 02h<br>42h  | 02h<br>42h  | 02h<br>42h  | 02h<br>42h | 02h<br>42h | 02h<br>42h | 02h<br>42h | 02h<br>42h |
|                          | REF                          |         | 2               | 03h<br>A0h  | 03h<br>A0h | 03h<br>A0h  | 03h<br>A0h  | 03h<br>A0h  | 03h<br>A0h | 03h<br>A0h | 03h<br>A0h | 03h<br>A0h | 03h<br>A0h |
|                          | Port Mapping                 |         | 2               | 01h<br>10h  | 01h<br>10h | 01h<br>10h  | 01h<br>10h  | 01h<br>10h  | 01h<br>10h | 01h<br>10h | 01h<br>10h | 01h<br>10h | 01h<br>10h |
|                          | Port 1 and 2                 |         | 2               | 04h<br>51h  | 04h<br>51h | 04h<br>51h  | 04h<br>51h  | 04h<br>51h  | 04h<br>51h | 04h<br>51h | 04h<br>51h | 04h<br>51h | 04h<br>51h |
|                          | Port 3 and 4                 |         | 2               | 02h<br>52h  | 02h<br>52h | 02h<br>52h  | 02h<br>52h  | 02h<br>52h  | 02h<br>52h | 02h<br>52h | 02h<br>52h | 02h<br>52h | 02h<br>52h |
|                          | Port 5 and 6                 |         | 2               | 02h<br>53h  | 02h<br>53h | 02h<br>53h  | 02h<br>53h  | 02h<br>53h  | 02h<br>53h | 02h<br>53h | 02h<br>53h | 02h<br>53h | 02h<br>53h |

**Table 6-57. F5504 to F5510 Device Descriptor Table <sup>(1)</sup> (continued)**

| DESCRIPTION                             |                   | ADDRESS | SIZE<br>(bytes) | VALUE       |            |             |            |             |            |            |            |            |            |
|-----------------------------------------|-------------------|---------|-----------------|-------------|------------|-------------|------------|-------------|------------|------------|------------|------------|------------|
|                                         |                   |         |                 | F5510       |            | F5509       |            | F5508       |            | F5507      | F5506      | F5505      | F5504      |
|                                         |                   |         |                 | RGC,<br>ZQE | RGZ,<br>PT | RGC,<br>ZQE | RGZ,<br>PT | RGC,<br>ZQE | RGZ,<br>PT |            |            |            |            |
| Peripheral<br>Descriptor<br>(continued) | JTAG              |         | 2               | 0Eh<br>5Fh  | 0Eh<br>5Fh | 0Eh<br>5Fh  | 0Eh<br>5Fh | 0Eh<br>5Fh  | 0Eh<br>5Fh | 0Eh<br>5Fh | 0Eh<br>5Fh | 0Eh<br>5Fh | 0Eh<br>5Fh |
|                                         | TA0               |         | 2               | 02h<br>62h  | 02h<br>62h | 02h<br>62h  | 02h<br>62h | 02h<br>62h  | 02h<br>62h | 02h<br>62h | 02h<br>62h | 02h<br>62h | 02h<br>62h |
|                                         | TA1               |         | 2               | 04h<br>61h  | 04h<br>61h | 04h<br>61h  | 04h<br>61h | 04h<br>61h  | 04h<br>61h | 04h<br>61h | 04h<br>61h | 04h<br>61h | 04h<br>61h |
|                                         | TB0               |         | 2               | 04h<br>67h  | 04h<br>67h | 04h<br>67h  | 04h<br>67h | 04h<br>67h  | 04h<br>67h | 04h<br>67h | 04h<br>67h | 04h<br>67h | 04h<br>67h |
|                                         | TA2               |         | 2               | 04h<br>61h  | 04h<br>61h | 04h<br>61h  | 04h<br>61h | 04h<br>61h  | 04h<br>61h | 04h<br>61h | 04h<br>61h | 04h<br>61h | 04h<br>61h |
|                                         | RTC               |         | 2               | 0Ah<br>68h  | 0Ah<br>68h | 0Ah<br>68h  | 0Ah<br>68h | 0Ah<br>68h  | 0Ah<br>68h | 0Ah<br>68h | 0Ah<br>68h | 0Ah<br>68h | 0Ah<br>68h |
|                                         | MPY32             |         | 2               | 02h<br>85h  | 02h<br>85h | 02h<br>85h  | 02h<br>85h | 02h<br>85h  | 02h<br>85h | 02h<br>85h | 02h<br>85h | 02h<br>85h | 02h<br>85h |
|                                         | DMA-3             |         | 2               | 04h<br>47h  | 04h<br>47h | 04h<br>47h  | 04h<br>47h | 04h<br>47h  | 04h<br>47h | 04h<br>47h | 04h<br>47h | 04h<br>47h | 04h<br>47h |
|                                         | USCI_A and USCI_B |         | 2               | 0Ch<br>90h  | 0Ch<br>90h | 0Ch<br>90h  | 0Ch<br>90h | 0Ch<br>90h  | 0Ch<br>90h | 10h<br>90h | 10h<br>90h | 10h<br>90h | 10h<br>90h |
|                                         | USCI_A and USCI_B |         | 2               | 04h<br>90h  | 04h<br>90h | 04h<br>90h  | 04h<br>90h | 04h<br>90h  | 04h<br>90h | N/A        | N/A        | N/A        | N/A        |
|                                         | ADC10_A           |         | 2               | 14h<br>D3h  | 14h<br>D3h | 14h<br>D3h  | 14h<br>D3h | 14h<br>D3h  | 14h<br>D3h | 14h<br>D3h | 14h<br>D3h | 14h<br>D3h | 14h<br>D3h |
|                                         | COMP_B            |         | 2               | 18h<br>A8h  | 18h<br>A8h | 18h<br>A8h  | 18h<br>A8h | 18h<br>A8h  | 18h<br>A8h | N/A        | N/A        | N/A        | N/A        |
|                                         | USB               |         | 2               | 04h<br>98h  | 04h<br>98h | 04h<br>98h  | 04h<br>98h | 04h<br>98h  | 04h<br>98h | 1Ch<br>98h | 1Ch<br>98h | 1Ch<br>98h | 1Ch<br>98h |
| Interrupts                              | COMP_B            |         | 1               | A8h         | A8h        | A8h         | A8h        | A8h         | A8h        | 01h        | 01h        | 01h        | 01h        |
|                                         | TB0.CCIFG0        |         | 1               | 64h         | 64h        | 64h         | 64h        | 64h         | 64h        | 64h        | 64h        | 64h        | 64h        |
|                                         | TB0.CCIFG1..6     |         | 1               | 65h         | 65h        | 65h         | 65h        | 65h         | 65h        | 65h        | 65h        | 65h        | 65h        |
|                                         | WDTIFG            |         | 1               | 40h         | 40h        | 40h         | 40h        | 40h         | 40h        | 40h        | 40h        | 40h        | 40h        |
|                                         | USCI_A0           |         | 1               | 90h         | 90h        | 90h         | 90h        | 90h         | 90h        | 01h        | 01h        | 01h        | 01h        |
|                                         | USCI_B0           |         | 1               | 91h         | 91h        | 91h         | 91h        | 91h         | 91h        | 01h        | 01h        | 01h        | 01h        |
|                                         | ADC10_A           |         | 1               | D0h         | D0h        | D0h         | D0h        | D0h         | D0h        | D0h        | D0h        | D0h        | D0h        |
|                                         | TA0.CCIFG0        |         | 1               | 60h         | 60h        | 60h         | 60h        | 60h         | 60h        | 60h        | 60h        | 60h        | 60h        |
|                                         | TA0.CCIFG1..4     |         | 1               | 61h         | 61h        | 61h         | 61h        | 61h         | 61h        | 61h        | 61h        | 61h        | 61h        |
|                                         | USB               |         | 1               | 98h         | 98h        | 98h         | 98h        | 98h         | 98h        | 98h        | 98h        | 98h        | 98h        |
|                                         | DMA               |         | 1               | 46h         | 46h        | 46h         | 46h        | 46h         | 46h        | 46h        | 46h        | 46h        | 46h        |
|                                         | TA1.CCIFG0        |         | 1               | 62h         | 62h        | 62h         | 62h        | 62h         | 62h        | 62h        | 62h        | 62h        | 62h        |
|                                         | TA1.CCIFG1..2     |         | 1               | 63h         | 63h        | 63h         | 63h        | 63h         | 63h        | 63h        | 63h        | 63h        | 63h        |
|                                         | P1                |         | 1               | 50h         | 50h        | 50h         | 50h        | 50h         | 50h        | 50h        | 50h        | 50h        | 50h        |
|                                         | USCI_A1           |         | 1               | 92h         | 92h        | 92h         | 92h        | 92h         | 92h        | 92h        | 92h        | 92h        | 92h        |
|                                         | USCI_B1           |         | 1               | 93h         | 93h        | 93h         | 93h        | 93h         | 93h        | 93h        | 93h        | 93h        | 93h        |
|                                         | TA1.CCIFG0        |         | 1               | 66h         | 66h        | 66h         | 66h        | 66h         | 66h        | 66h        | 66h        | 66h        | 66h        |
|                                         | TA1.CCIFG1..2     |         | 1               | 67h         | 67h        | 67h         | 67h        | 67h         | 67h        | 67h        | 67h        | 67h        | 67h        |
|                                         | P2                |         | 1               | 51h         | 51h        | 51h         | 51h        | 51h         | 51h        | 51h        | 51h        | 51h        | 51h        |
|                                         | RTC_A             |         | 1               | 68h         | 68h        | 68h         | 68h        | 68h         | 68h        | 68h        | 68h        | 68h        | 68h        |
|                                         | Delimiter         |         | 1               | 00h         | 00h        | 00h         | 00h        | 00h         | 00h        | 00h        | 00h        | 00h        | 00h        |

**Table 6-58. F5500 to F5503 Device Descriptor<sup>(1)</sup>**

| DESCRIPTION           |                              | ADDRESS | SIZE<br>(bytes) | VALUE      |            |            |            |
|-----------------------|------------------------------|---------|-----------------|------------|------------|------------|------------|
|                       |                              |         |                 | F5503      | F5502      | F5501      | F5500      |
| Info Block            | Info length                  | 01A00h  | 1               | 06h        | 06h        | 06h        | 06h        |
|                       | CRC length                   | 01A01h  | 1               | 06h        | 06h        | 06h        | 06h        |
|                       | CRC value                    | 01A02h  | 2               | Per unit   | Per unit   | Per unit   | Per unit   |
|                       | Device ID                    | 01A04h  | 1               | 34h        | 33h        | 32h        | 3Bh        |
|                       | Device ID                    | 01A05h  | 1               | 80h        | 80h        | 80h        | 80h        |
|                       | Hardware revision            | 01A06h  | 1               | Per unit   | Per unit   | Per unit   | Per unit   |
|                       | Firmware revision            | 01A07h  | 1               | Per unit   | Per unit   | Per unit   | Per unit   |
| Die Record            | Die record tag               | 01A08h  | 1               | 08h        | 08h        | 08h        | 08h        |
|                       | Die record length            | 01A09h  | 1               | 0Ah        | 0Ah        | 0Ah        | 0Ah        |
|                       | Lot/wafer ID                 | 01A0Ah  | 4               | Per unit   | Per unit   | Per unit   | Per unit   |
|                       | Die X position               | 01A0Eh  | 2               | Per unit   | Per unit   | Per unit   | Per unit   |
|                       | Die Y position               | 01A10h  | 2               | Per unit   | Per unit   | Per unit   | Per unit   |
|                       | Test results                 | 01A12h  | 2               | Per unit   | Per unit   | Per unit   | Per unit   |
| ADC10 Calibration     | Empty tag                    | 01A14h  | 1               | 05h        | 05h        | 05h        | 05h        |
|                       | Empty tag length             | 01A15h  | 1               | 10h        | 10h        | 10h        | 10h        |
| REF Calibration       | REF calibration tag          | 01A26h  | 1               | 12h        | 12h        | 12h        | 12h        |
|                       | REF calibration length       | 01A27h  | 1               | 06h        | 06h        | 06h        | 06h        |
|                       | REF 1.5-V reference factor   | 01A28h  | 2               | Per unit   | Per unit   | Per unit   | Per unit   |
|                       | REF 2.0-V reference factor   | 01A2Ah  | 2               | Per unit   | Per unit   | Per unit   | Per unit   |
|                       | REF 2.5-V reference factor   | 01A2Ch  | 2               | Per unit   | Per unit   | Per unit   | Per unit   |
| Peripheral Descriptor | Peripheral descriptor tag    | 01A2Eh  | 1               | 02h        | 02h        | 02h        | 02h        |
|                       | Peripheral descriptor length | 01A2Fh  | 1               | 5Dh        | 5Eh        | 5Dh        | 5Dh        |
|                       | Memory 1                     |         | 2               | 08h<br>8Ah | 08h<br>8Ah | 08h<br>8Ah | 08h<br>8Ah |
|                       | Memory 2                     |         | 2               | 0Ch<br>86h | 0Ch<br>86h | 0Ch<br>86h | 0Ch<br>86h |
|                       | Memory 3                     |         | 2               | 0Eh<br>2Ah | 0Eh<br>2Ah | 0Eh<br>2Ah | 0Eh<br>2Ah |
|                       | Memory 4                     |         | 2               | 12h<br>2Ch | 12h<br>2Ch | 12h<br>2Ch | 12h<br>2Ch |
|                       | Memory 5                     |         | 2               | 40h<br>92h | 50h<br>91  | 60h<br>90h | 70h<br>8Eh |
|                       | Memory 6                     |         | 1               | N/A        | 8E         | N/A        | N/A        |
|                       | Delimiter                    |         | 1               | 00h        | 00h        | 00h        | 00h        |
|                       | Peripheral count             |         | 1               | 1Eh        | 1Eh        | 1Eh        | 1Eh        |
|                       | MSP430CPUXV2                 |         | 2               | 00h<br>23h | 00h<br>23h | 00h<br>23h | 00h<br>23h |
|                       | JTAG                         |         | 2               | 00h<br>09h | 00h<br>09h | 00h<br>09h | 00h<br>09h |
|                       | SBW                          |         | 2               | 00h<br>0Fh | 00h<br>0Fh | 00h<br>0Fh | 00h<br>0Fh |
|                       | EEM-S                        |         | 2               | 00h<br>03h | 00h<br>03h | 00h<br>03h | 00h<br>03h |
|                       | TI BSL                       |         | 2               | 00h<br>FCh | 00h<br>FCh | 00h<br>FCh | 00h<br>FCh |
|                       | SFR                          |         | 2               | 10h<br>41h | 10h<br>41h | 10h<br>41h | 10h<br>41h |
|                       | PMM                          |         | 2               | 02h<br>30h | 02h<br>30h | 02h<br>30h | 02h<br>30h |
|                       | FCTL                         |         | 2               | 02h<br>38h | 02h<br>38h | 02h<br>38h | 02h<br>38h |

(1) N/A = Not applicable

**Table 6-58. F5500 to F5503 Device Descriptor<sup>(1)</sup> (continued)**

| DESCRIPTION                          | ADDRESS           | SIZE<br>(bytes) | VALUE      |            |            |            |
|--------------------------------------|-------------------|-----------------|------------|------------|------------|------------|
|                                      |                   |                 | F5503      | F5502      | F5501      | F5500      |
| Peripheral Descriptor<br>(continued) | CRC16             | 2               | 01h<br>3Ch | 01h<br>3Ch | 01h<br>3Ch | 01h<br>3Ch |
|                                      | CRC16_RB          | 2               | 00h<br>3Dh | 00h<br>3Dh | 00h<br>3Dh | 00h<br>3Dh |
|                                      | RAMCTL            | 2               | 00h<br>44h | 00h<br>44h | 00h<br>44h | 00h<br>44h |
|                                      | WDT_A             | 2               | 00h<br>40h | 00h<br>40h | 00h<br>40h | 00h<br>40h |
|                                      | UCS               | 2               | 01h<br>48h | 01h<br>48h | 01h<br>48h | 01h<br>48h |
|                                      | SYS               | 2               | 02h<br>42h | 02h<br>42h | 02h<br>42h | 02h<br>42h |
|                                      | REF               | 2               | 03h<br>A0h | 03h<br>A0h | 03h<br>A0h | 03h<br>A0h |
|                                      | Port Mapping      | 2               | 01h<br>10h | 01h<br>10h | 01h<br>10h | 01h<br>10h |
|                                      | Port 1 and 2      | 2               | 04h<br>51h | 04h<br>51h | 04h<br>51h | 04h<br>51h |
|                                      | Port 3 and 4      | 2               | 02h<br>52h | 02h<br>52h | 02h<br>52h | 02h<br>52h |
|                                      | Port 5 and 6      | 2               | 02h<br>53h | 02h<br>53h | 02h<br>53h | 02h<br>53h |
|                                      | JTAG              | 2               | 0Eh<br>5Fh | 0Eh<br>5Fh | 0Eh<br>5Fh | 0Eh<br>5Fh |
|                                      | TA0               | 2               | 02h<br>62h | 02h<br>62h | 02h<br>62h | 02h<br>62h |
|                                      | TA1               | 2               | 04h<br>61h | 04h<br>61h | 04h<br>61h | 04h<br>61h |
|                                      | TB0               | 2               | 04h<br>67h | 04h<br>67h | 04h<br>67h | 04h<br>67h |
|                                      | TA2               | 2               | 04h<br>61h | 04h<br>61h | 04h<br>61h | 04h<br>61h |
|                                      | RTC               | 2               | 0Ah<br>68h | 0Ah<br>68h | 0Ah<br>68h | 0Ah<br>68h |
|                                      | MPY32             | 2               | 02h<br>85h | 02h<br>85h | 02h<br>85h | 02h<br>85h |
|                                      | DMA-3             | 2               | 04h<br>47h | 04h<br>47h | 04h<br>47h | 04h<br>47h |
|                                      | USCI_A and USCI_B | 2               | 10h<br>90h | 10h<br>90h | 10h<br>90h | 10h<br>90h |
|                                      | ADC10_A           | 2               | N/A        | N/A        | N/A        | N/A        |
|                                      | COMP_B            | 2               | 2Ch<br>A8h | 2Ch<br>A8h | 2Ch<br>A8h | 2Ch<br>A8h |
|                                      | USB               | 2               | 04h<br>98h | 04h<br>98h | 04h<br>98h | 04h<br>98h |

**Table 6-58. F5500 to F5503 Device Descriptor<sup>(1)</sup> (continued)**

| DESCRIPTION |               | ADDRESS | SIZE<br>(bytes) | VALUE |       |       |       |
|-------------|---------------|---------|-----------------|-------|-------|-------|-------|
|             |               |         |                 | F5503 | F5502 | F5501 | F5500 |
| Interrupts  | COMP_B        |         | 1               | A8h   | A8h   | A8h   | A8h   |
|             | TB0.CCIFG0    |         | 1               | 64h   | 64h   | 64h   | 64h   |
|             | TB0.CCIFG1..6 |         | 1               | 65h   | 65h   | 65h   | 65h   |
|             | WDTIFG        |         | 1               | 40h   | 40h   | 40h   | 40h   |
|             | USCI_A0       |         | 1               | 01h   | 01h   | 01h   | 01h   |
|             | USCI_B0       |         | 1               | 01h   | 01h   | 01h   | 01h   |
|             | ADC10_A       |         | 1               | 01h   | 01h   | 01h   | 01h   |
|             | TA0.CCIFG0    |         | 1               | 60h   | 60h   | 60h   | 60h   |
|             | TA0.CCIFG1..4 |         | 1               | 61h   | 61h   | 61h   | 61h   |
|             | USB           |         | 1               | 98h   | 98h   | 98h   | 98h   |
|             | DMA           |         | 1               | 46h   | 46h   | 46h   | 46h   |
|             | TA1.CCIFG0    |         | 1               | 62h   | 62h   | 62h   | 62h   |
|             | TA1.CCIFG1..2 |         | 1               | 63h   | 63h   | 63h   | 63h   |
|             | P1            |         | 1               | 50h   | 50h   | 50h   | 50h   |
|             | USCI_A1       |         | 1               | 92h   | 92h   | 92h   | 92h   |
|             | USCI_B1       |         | 1               | 93h   | 93h   | 93h   | 93h   |
|             | TA1.CCIFG0    |         | 1               | 66h   | 66h   | 66h   | 66h   |
|             | TA1.CCIFG1..2 |         | 1               | 67h   | 67h   | 67h   | 67h   |
|             | P2            |         | 1               | 51h   | 51h   | 51h   | 51h   |
|             | RTC_A         |         | 1               | 68h   | 68h   | 68h   | 68h   |
|             | Delimiter     |         | 1               | 00h   | 00h   | 00h   | 00h   |

## 7 器件和文档支持

### 7.1 入门和后续步骤

有关 MSP430™ 系列微控制器以及开发协助工具和库的简介，请访问《[MSP430 超低功耗传感和测量 MCU 概述](#)》。

### 7.2 Device Nomenclature

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

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

**MSP** – Fully qualified production device

XMS 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 (XMS) 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. [图 7-1](#) provides a legend for reading the complete device name.

|                                      |                                                                                                                                |                                                                                                                                                                                             |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>MSP 430 F 5 438 A I ZQW T -EP</b> |                                                                                                                                |                                                                                                                                                                                             |
| Processor Family                     | MCU Platform                                                                                                                   | Optional: Additional Features                                                                                                                                                               |
| Device Type                          | Series                                                                                                                         | Optional: Tape and Reel                                                                                                                                                                     |
| Feature Set                          | Optional: Temperature Range                                                                                                    | Packaging                                                                                                                                                                                   |
| Optional: A = Revision               |                                                                                                                                |                                                                                                                                                                                             |
| <b>Processor Family</b>              | CC = Embedded RF Radio<br>MSP = Mixed-Signal Processor<br>XMS = Experimental Silicon<br>PMS = Prototype Device                 |                                                                                                                                                                                             |
| <b>MCU Platform</b>                  | 430 = MSP430 low-power microcontroller platform                                                                                |                                                                                                                                                                                             |
| <b>Device Type</b>                   | <b>Memory Type</b><br>C = ROM<br>F = Flash<br>FR = FRAM<br>G = Flash or FRAM (Value Line)<br>L = No Nonvolatile Memory         | <b>Specialized Application</b><br>AFE = Analog Front End<br>BQ = Contactless Power<br>CG = ROM Medical<br>FE = Flash Energy Meter<br>FG = Flash Medical<br>FW = Flash Electronic Flow Meter |
| <b>Series</b>                        | 1 = Up to 8 MHz<br>2 = Up to 16 MHz<br>3 = Legacy<br>4 = Up to 16 MHz with LCD                                                 | 5 = Up to 25 MHz<br>6 = Up to 25 MHz with LCD<br>0 = Low-Voltage Series                                                                                                                     |
| <b>Feature Set</b>                   | Various levels of integration within a series                                                                                  |                                                                                                                                                                                             |
| <b>Optional: A = Revision</b>        | N/A                                                                                                                            |                                                                                                                                                                                             |
| <b>Optional: Temperature Range</b>   | S = 0°C to 50°C<br>C = 0°C to 70°C<br>I = –40°C to 85°C<br>T = –40°C to 105°C                                                  |                                                                                                                                                                                             |
| <b>Packaging</b>                     | <a href="http://www.ti.com/packaging">http://www.ti.com/packaging</a>                                                          |                                                                                                                                                                                             |
| <b>Optional: Tape and Reel</b>       | T = Small reel<br>R = Large reel<br>No markings = Tube or tray                                                                 |                                                                                                                                                                                             |
| <b>Optional: Additional Features</b> | -EP = Enhanced Product (–40°C to 105°C)<br>-HT = Extreme Temperature Parts (–55°C to 150°C)<br>-Q1 = Automotive Q100 Qualified |                                                                                                                                                                                             |

图 7-1. Device Nomenclature

### 7.3 工具与软件

所有 MSP 微控制器均受多种软件和硬件开发工具的支持。相关工具由 TI 以及多家第三方供应商提供。请参阅 [MSP430 超低功耗 MCU – 工具与软件](#)，了解所有工具。

表 7-1 列出了 MSP430F5510 和 MSP430F550x MCU 的调试功能。请参阅 [《适用于 MSP430 的 Code Composer Studio IDE 用户指南》](#)，以了解可用特性的详细信息。

表 7-1. 硬件 特性

| MSP430 架构 | 四线制 JTAG | 2 线 JTAG | 断点 (N) | 范围断点 | 时钟控制 | 状态序列发生器 | 跟踪缓冲器 | LPMx.5 调试支持 |
|-----------|----------|----------|--------|------|------|---------|-------|-------------|
| MSP430Xv2 | 有        | 是        | 8      | 是    | 是    | 是       | 是     | 否           |

#### 设计套件与评估模块

**适用于 MSP430F5x MCU 的 64 引脚目标开发板和 MSP-FET 编程器捆绑包** MSP-FET430U64USB 是一款强大的闪存仿真工具，可在 MSP430 MCU 上快速开始应用开发。它包含 USB 调试接口，用于通过 JTAG 接口或节省引脚的 Spy Bi-Wire (2 线 JTAG) 协议在系统内对 MSP430 进行编程和调试。只需使用几个按键即可在数秒钟内擦除闪存并对其进行编程。由于 MSP430 闪存的功耗极低，因此无需外部电源。

**MSP-TS430RGC64USB - 适用于 MSP430F5x MCU 的 64 引脚目标开发板** MSP-TS430RGC64USB 是一款独立的 64 引脚 ZIF 插座目标板，用于通过 JTAG 接口或 Spy Bi-Wire (2 线 JTAG) 协议在系统内对 MSP430 MCU 进行编程和调试。

#### 软件

**MSP430Ware™ 软件** MSP430Ware 软件集合了所有 MSP430 器件的代码示例、产品说明书以及其他设计资源，打包提供给用户。除了提供已有 MSP430 设计资源的完整集合外，MSP430Ware 软件还包含名为 MSP 驱动程序库的高级 API。借助该库可以轻松地对 MSP430 硬件进行编程。MSP430Ware 软件可作为 Code Composer Studio™IDE 的一部分提供，也可以以独立软件包的形式提供。

**MSP430F550x、MSP430F5510 C 代码示例** 根据不同应用需求配置各集成外设的每个 MSP 器件均具备相应的 C 代码示例。

**MSP 驱动程序库** 驱动程序库的抽象化 API 通过提供易于使用的函数调用使您不再拘泥于 MSP430 硬件的细节。完整的文档通过具有帮助意义的 API 指南交付，其中包括有关每个函数调用和经过验证的参数的详细信息。开发人员可以使用驱动程序库功能，以最低开销编写完整项目。

**MSP EnergyTrace™ 技术** MSP430 微控制器的 EnergyTrace 技术是基于能量的代码分析工具，用于测量和显示应用的能量配置，同时协助优化应用以实现超低功耗。

**ULP (超低功耗) Advisor** ULP Advisor™软件是一款辅助工具，旨在指导开发人员编写更为高效的代码，从而充分利用 MSP 和 MSP432 微控制器独特的超低功耗功能。ULP Advisor 的目标人群是微控制器的资深开发者和开发新手，可以根据详尽的 ULP 检验表检查代码，以便最大限度地利用应用程序。在编译时，ULP Advisor 会提供通知和备注以突出显示代码中可以进一步优化的区域，进而实现更低功耗。

**MSP430 USB 开发包** 这款适用于 MSP430 的 USB 开发包是一个软件包，包含开发基于 USB 的 MSP430 项目所需的所有必要源代码和应用示例。此软件包仅支持 MSP430 USB 器件。

**IEC60730 软件包** IEC60730 MSP430 软件包经过专门开发，用于协助客户达到 IEC 60730-1:2010（家用及类似用途的自动化电气控制 - 第 1 部分：一般要求）B 类产品的要求。其中涵盖家用电器、电弧检测器、电源转换器、电动工具、电动自行车及其他诸多产品。IEC60730 MSP430 软件包可以嵌入在 MSP430 中运行的客户应用，从而帮助客户简化其消费类器件在功能安全方面遵循 IEC 60730-1:2010 B 类规范的认证工作。

**适用于 MSP 的定点数学运算库** MSP IQmath 和 Qmath 库是为 C 语言开发者提供的一套经过高度优化的高精度数学运算函数集合，能够将浮点算法无缝嵌入 MSP430 和 MSP432 器件的定点代码中。这些例程通常用于计算密集型实时应用，而优化的执行速度、高精度以及超低能耗通常是影响这些实时应用的关键因素。与使用浮点数学算法编写的同等代码相比，使用 IQmath 和 Qmath 库可以大幅提高执行速度并显著降低能耗。

**适用于 MSP430 的浮点数学运算库** TI 在低功耗和低成本微控制器领域锐意创新，为您提供 MSPMATHLIB。这是标量函数的浮点数学运算库，能够充分利用器件的智能外设，使性能提升高达 26 倍。Mathlib 能够轻松集成到您的设计中。该运算库免费使用并集成在 Code Composer Studio 和 IAR IDE 中。如需深入了解该数学运算库及相关基准，请阅读用户指南。

## 开发工具

**适用于 MSP 微控制器的 Code Composer Studio™ 集成开发环境** Code Composer Studio 是一种集成开发环境 (IDE)，支持所有 MSP 微控制器。Code Composer Studio 包含一整套开发和调试嵌入式应用的嵌入式软件实用程序的工具。它包含了优化的 C/C++ 编译器、源代码编辑器、项目构建环境、调试器、描述器以及其他多种功能。直观的 IDE 提供了单个用户界面，有助于完成应用程序开发流程的每个步骤。熟悉的实用程序和界面可提升用户的入门速度。Code Composer Studio 将 Eclipse 软件框架的优点和 TI 先进的嵌入式调试功能相结合，为嵌入式开发人员提供了一种功能丰富的优异开发环境。当 CCS 与 MSP MCU 搭配使用时，可以使用独特而强大的插件和嵌入式软件实用程序，从而充分利用 MSP 微控制器的功能。

**命令行编程器** MSP Flasher 是一款基于 shell 的开源接口，可使用 JTAG 或 Spy-Bi-Wire (SBW) 通信通过 FET 编程器或 eZ430 对 MSP 微控制器进行编程。MSP Flasher 可用于将二进制文件 (.txt 或 .hex 文件) 直接下载到 MSP 微控制器，而无需使用 IDE。

**MSP MCU 编程器和调试器** MSP-FET 是一款强大的仿真开发工具（通常称为调试探针），可帮助用户在 MSP 低功耗微控制器 (MCU) 中快速开发应用。创建 MCU 软件通常需要将生成的二进制程序下载到 MSP 器件，以进行验证和调试。MSP-FET 在主机和目标 MSP 间提供调试通信通道。此外，MSP-FET 还可在计算机的 USB 接口和 MSP UART 间提供反向通道 UART 连接。这为 MSP 编程器提供了一种在 MSP 和计算机上运行的终端之间进行串行通信的便捷方法。它还支持使用 BSL（引导加载程序）通过 UART 和 I<sup>2</sup>C 通信协议将程序（通常称为固件）加载到 MSP 目标中。

**MSP-GANG 生产编程器** MSP Gang 编程器是一款 MSP430 或 MSP432 器件编程器，可同时对多达八个完全相同的 MSP430 或 MSP432 闪存或 FRAM 器件进行编程。MSP Gang 编程器可使用标准的 RS-232 或 USB 连接与主机 PC 相连并提供灵活的编程选项，允许用户完全自定义流程。MSP Gang 编程器配有扩展板，即“Gang 分离器”，可在 MSP Gang 编程器和多个目标器件间实施互连。提供了八条电缆，用于将扩展板与八个目标器件相连（通过 JTAG 或 SPY-Bi-Wire 连接器）。编程工作可在 PC 或独立设备上完成。PC 端具备基于 DLL 的图形化用户界面。

## 7.4 文档支持

以下文档描述了 MSP430F550x 微控制器。[www.ti.com.cn](http://www.ti.com.cn) 网站上提供了这些文档的副本。

### 接收文档更新通知

要接收文档更新通知（包括芯片勘误表），请转至 [ti.com.cn](http://ti.com.cn) 上您的器件对应的产品文件夹（关于产品文件夹的链接，请参见表 7-2）。请单击右上角的“通知我”按钮。点击注册后，即可收到产品信息更改每周摘要（如有）。有关更改的详细信息，请查阅已修订文档的修订历史记录。

### 勘误

- 《[MSP430F5510 器件勘误表](#)》 说明了针对 MSP430F5510 器件功能技术规格的已知例外情况。
- 《[MSP430F5509 器件勘误表](#)》 说明了针对 MSP430F5509 器件功能技术规格的已知例外情况。
- 《[MSP430F5508 器件勘误表](#)》 说明了针对 MSP430F5508 器件功能技术规格的已知例外情况。
- 《[MSP430F5507 器件勘误表](#)》 说明了针对 MSP430F5507 器件功能技术规格的已知例外情况。
- 《[MSP430F5506 器件勘误表](#)》 说明了针对 MSP430F5506 器件功能技术规格的已知例外情况。
- 《[MSP430F5505 器件勘误表](#)》 说明了针对 MSP430F5505 器件功能技术规格的已知例外情况。
- 《[MSP430F5504 器件勘误表](#)》 说明了针对 MSP430F5504 器件功能技术规格的已知例外情况。
- 《[MSP430F5503 器件勘误表](#)》 说明了针对 MSP430F5503 器件功能技术规格的已知例外情况。
- 《[MSP430F5502 器件勘误表](#)》 说明了针对 MSP430F5502 器件功能技术规格的已知例外情况。
- 《[MSP430F5501 器件勘误表](#)》 说明了针对 MSP430F5501 器件功能技术规格的已知例外情况。
- 《[MSP430F5500 器件勘误表](#)》 说明了针对 MSP430F5500 器件功能技术规格的已知例外情况。

### 用户指南

- 《[MSP430F5xx 和 MSP430F6xx 系列用户指南](#)》 详细介绍了该器件系列提供的模块和外设。
- 《[MSP430 闪存器件引导加载程序 \(BSL\) 用户指南](#)》 MSP430 引导加载程序 (BSL) 允许用户在原型设计、投产和维护等各阶段与 MSP430 微控制器中的嵌入式存储器进行通信。可编程存储器（闪存）和数据存储器（RAM）可根据相关要求进行变更。不要将此处的引导加载程序与某些数字信号处理器 (DSP) 中将外部存储器中的程序代码（和数据）自动加载到 DSP 内部存储器的引导加载程序混为一谈。
- 《[通过 JTAG 接口对 MSP430 进行编程](#)》 此文档介绍了使用 JTAG 通信端口擦除、编程和验证基于 MSP430 闪存和 FRAM 的微控制器系列的存储器模块所需的功能。此外，该文档还介绍了如何编程所有 MSP430 器件上均具备的 JTAG 访问安全保险丝。此文档介绍了使用标准四线制 JTAG 接口和两线制 JTAG 接口（也称为 Spy-Bi-Wire (SBW)）的器件访问。
- 《[MSP430 硬件工具用户指南](#)》 此手册介绍了 TI MSP-FET430 闪存仿真工具 (FET) 的硬件。FET 是针对 MSP430 超低功耗微控制器的程序开发工具。文中对提供的接口类型，即并行端口接口和 USB 接口进行了说明。

## 应用报告

《**MSP430 32kHz 晶体振荡器**》 选择合适的晶体、正确的负载电路和适当的电路板布局是实现稳定的晶体振荡器的关键。该应用报告总结了晶体振荡器的功能，介绍了用于选择合适的晶体以实现 MSP430 超低功耗运行的参数。此外，还给出了正确电路板布局的提示和示例。此外，为了确保振荡器在大规模生产后能够稳定运行，还可能需要进行一些振荡器测试，该文档中提供了有关这些测试的详细信息。

《**MSP430 系统级 ESD 注意事项**》 系统级 ESD 对于低电压下的硅晶技术以及经济高效型和超低功耗组件的需求日益增加。此应用报告重点讨论了三个不同的 ESD 主题，以帮助板卡设计师和原始设备制造商 (OEM) 理解和设计稳健的系统级设计产品：(1) 组件级 ESD 测试和系统级 ESD 测试，二者的差异以及为何组件级 ESD 无法确保达到系统级的稳健性。(2) 系统级 ESD 保护在不同电平下的通用设计指南（包括外壳、电缆、PCB 布局和板载 ESD 防护器件）。(3) 介绍了系统高效 ESD 设计 (SEED)。这是一种板上和片上 ESD 保护协同设计的方法论，用于实现系统级 ESD 的稳健性，配备仿真示例和测试结果。另外，还讨论了一些真实的系统级 ESD 保护设计示例及其成果。

## 7.5 相关链接

表 7-2 列出了快速访问链接。类别包括技术文档、支持与社区资源、工具与软件，以及申请样片或购买产品的快速链接。

表 7-2. 相关链接

| 器件          | 产品文件夹                 | 立即订购                  | 技术文档                  | 工具与软件                 | 支持和社区                 |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| MSP430F5510 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5509 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5508 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5507 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5506 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5505 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5504 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5503 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5502 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5501 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |
| MSP430F5500 | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> | <a href="#">请单击此处</a> |

## 7.6 社区资源

下列链接提供到 TI 社区资源的连接。链接的内容由各个分销商“按照原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参见 TI 的《使用条款》。

### TI E2E™ 社区

TI 的工程师交流 (E2E) 社区。此社区的创建目的是为了促进工程师之间协作。在 [e2e.ti.com](http://e2e.ti.com) 中，您可以提问、共享知识、拓展思路，在同领域工程师的帮助下解决问题。

### TI 嵌入式处理器维基网页

德州仪器 (TI) 嵌入式处理器维基网页。此网站的建立是为了帮助开发人员熟悉德州仪器 (TI) 的嵌入式处理器，并且也为了促进与这些器件相关的硬件和软件的总体知识的创新和增长。

## 7.7 商标

MSP430, MSP430Ware, Code Composer Studio, EnergyTrace, ULP Advisor, 适用于 MSP 微控制器的 Code Composer Studio, E2E are trademarks of Texas Instruments.  
All other trademarks are the property of their respective owners.

## 7.8 静电放电警告



ESD 可能会损坏该集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理措施和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

## 7.9 Export Control Notice

Recipient agrees to not knowingly export or re-export, directly or indirectly, any product or technical data (as defined by the U.S., EU, and other Export Administration Regulations) including software, or any controlled product restricted by other applicable national regulations, received from disclosing party under nondisclosure obligations (if any), or any direct product of such technology, to any destination to which such export or re-export is restricted or prohibited by U.S. or other applicable laws, without obtaining prior authorization from U.S. Department of Commerce and other competent Government authorities to the extent required by those laws.

## 7.10 Glossary

**TI Glossary** This glossary lists and explains terms, acronyms, and definitions.

## 8 机械，封装和可订购信息

以下页中包括机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知，且不会对此文档进行修订。如需获取此数据表的浏览器版本，请查阅左侧的导航栏。

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>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                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| MSP430F5500IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5500           | <a href="#">Samples</a> |
| MSP430F5500IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5500           | <a href="#">Samples</a> |
| MSP430F5501IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5501           | <a href="#">Samples</a> |
| MSP430F5501IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5501           | <a href="#">Samples</a> |
| MSP430F5502IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5502           | <a href="#">Samples</a> |
| MSP430F5502IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5502           | <a href="#">Samples</a> |
| MSP430F5503IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5503           | <a href="#">Samples</a> |
| MSP430F5503IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5503           | <a href="#">Samples</a> |
| MSP430F5504IPT   | ACTIVE        | LQFP         | PT                 | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5504               | <a href="#">Samples</a> |
| MSP430F5504IPTR  | ACTIVE        | LQFP         | PT                 | 48   | 1000           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5504               | <a href="#">Samples</a> |
| MSP430F5504IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5504           | <a href="#">Samples</a> |
| MSP430F5504IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5504           | <a href="#">Samples</a> |
| MSP430F5505IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5505           | <a href="#">Samples</a> |
| MSP430F5505IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5505           | <a href="#">Samples</a> |
| MSP430F5506IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5506           | <a href="#">Samples</a> |
| MSP430F5506IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5506           | <a href="#">Samples</a> |
| MSP430F5507IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5507           | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>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                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| MSP430F5507IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5507           | <a href="#">Samples</a> |
| MSP430F5508IPT   | ACTIVE        | LQFP         | PT                 | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5508               | <a href="#">Samples</a> |
| MSP430F5508IPTR  | ACTIVE        | LQFP         | PT                 | 48   | 1000           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5508               | <a href="#">Samples</a> |
| MSP430F5508IRGCR | ACTIVE        | VQFN         | RGC                | 64   | 2000           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5508               | <a href="#">Samples</a> |
| MSP430F5508IRGCT | ACTIVE        | VQFN         | RGC                | 64   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5508               | <a href="#">Samples</a> |
| MSP430F5508IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5508           | <a href="#">Samples</a> |
| MSP430F5508IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5508           | <a href="#">Samples</a> |
| MSP430F5508IZXH  | ACTIVE        | NFBGA        | ZXH                | 80   | 576            | RoHS & Green    | SNAGCU                               | Level-3-260C-168 HR  | -40 to 85    | F5508                   | <a href="#">Samples</a> |
| MSP430F5509IPT   | ACTIVE        | LQFP         | PT                 | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5509               | <a href="#">Samples</a> |
| MSP430F5509IRGCR | ACTIVE        | VQFN         | RGC                | 64   | 2000           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5509               | <a href="#">Samples</a> |
| MSP430F5509IRGCT | ACTIVE        | VQFN         | RGC                | 64   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5509               | <a href="#">Samples</a> |
| MSP430F5509IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5509           | <a href="#">Samples</a> |
| MSP430F5509IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5509           | <a href="#">Samples</a> |
| MSP430F5509IZXH  | ACTIVE        | NFBGA        | ZXH                | 80   | 576            | RoHS & Green    | SNAGCU                               | Level-3-260C-168 HR  | -40 to 85    | F5509                   | <a href="#">Samples</a> |
| MSP430F5509IZXHR | ACTIVE        | NFBGA        | ZXH                | 80   | 2500           | RoHS & Green    | SNAGCU                               | Level-3-260C-168 HR  | -40 to 85    | F5509                   | <a href="#">Samples</a> |
| MSP430F5510IPT   | ACTIVE        | LQFP         | PT                 | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5510               | <a href="#">Samples</a> |
| MSP430F5510IPTR  | ACTIVE        | LQFP         | PT                 | 48   | 1000           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5510               | <a href="#">Samples</a> |
| MSP430F5510IRGCR | ACTIVE        | VQFN         | RGC                | 64   | 2000           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5510               | <a href="#">Samples</a> |
| MSP430F5510IRGCT | ACTIVE        | VQFN         | RGC                | 64   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430F5510               | <a href="#">Samples</a> |
| MSP430F5510IRGZR | ACTIVE        | VQFN         | RGZ                | 48   | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5510           | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>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                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| MSP430F5510IRGZT | ACTIVE        | VQFN         | RGZ                | 48   | 250            | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 85    | M430<br>F5510           | <a href="#">Samples</a> |
| MSP430F5510IZXH  | ACTIVE        | NFBGA        | ZXH                | 80   | 576            | RoHS & Green    | SNAGCU                               | Level-3-260C-168 HR  | -40 to 85    | F5510                   | <a href="#">Samples</a> |
| MSP430F5510IZXHR | ACTIVE        | NFBGA        | ZXH                | 80   | 2500           | RoHS & Green    | SNAGCU                               | Level-3-260C-168 HR  | -40 to 85    | F5510                   | <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.

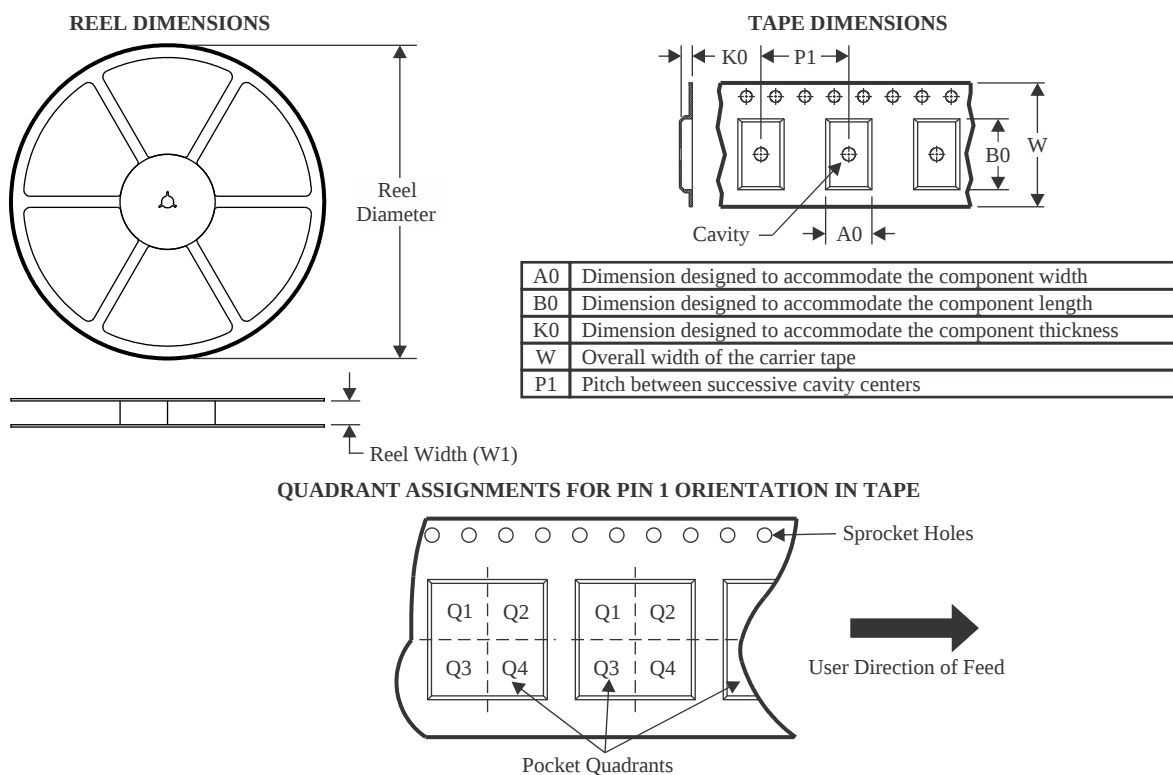
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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## TAPE AND REEL INFORMATION

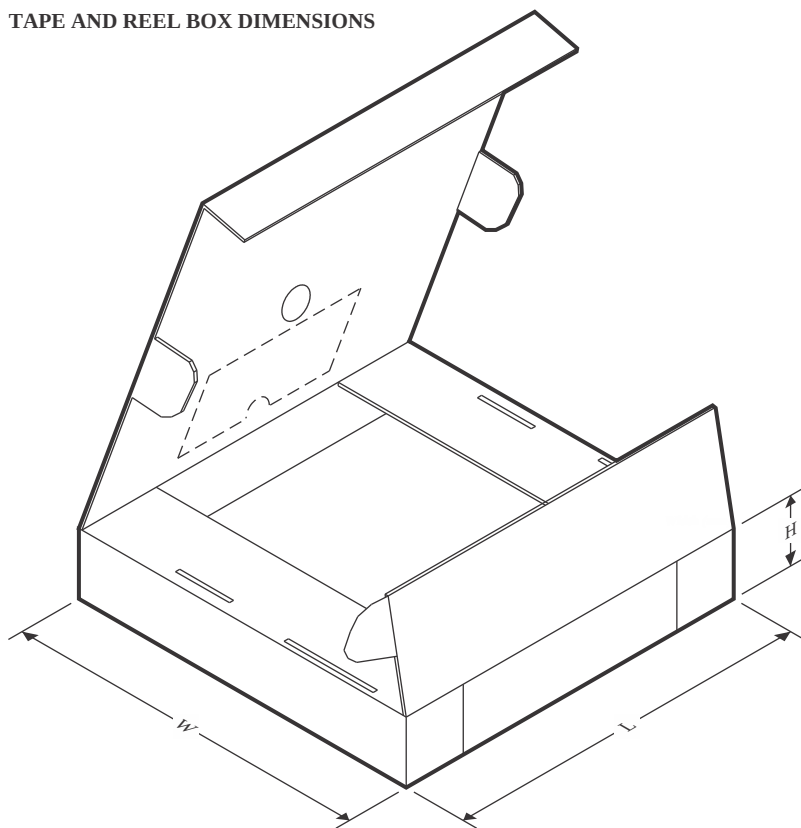


\*All dimensions are nominal

| 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 |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| MSP430F5500IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5500IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5501IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5501IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5502IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5502IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5503IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5503IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5504IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5504IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5505IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5505IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5506IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5506IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5507IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5507IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |

| 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 |
|------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| MSP430F5508IRGCR | VQFN         | RGC             | 64   | 2000 | 330.0              | 16.4               | 9.3     | 9.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5508IRGCT | VQFN         | RGC             | 64   | 250  | 180.0              | 16.4               | 9.3     | 9.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5508IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5508IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5509IRGCR | VQFN         | RGC             | 64   | 2000 | 330.0              | 16.4               | 9.3     | 9.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5509IRGCT | VQFN         | RGC             | 64   | 250  | 180.0              | 16.4               | 9.3     | 9.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5509IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5509IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5509IZXHR | NFBGA        | ZXH             | 80   | 2500 | 330.0              | 12.4               | 5.3     | 5.3     | 1.5     | 8.0     | 12.0   | Q1            |
| MSP430F5510IRGCR | VQFN         | RGC             | 64   | 2000 | 330.0              | 16.4               | 9.3     | 9.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5510IRGCT | VQFN         | RGC             | 64   | 250  | 180.0              | 16.4               | 9.3     | 9.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5510IRGZR | VQFN         | RGZ             | 48   | 2500 | 330.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5510IRGZT | VQFN         | RGZ             | 48   | 250  | 180.0              | 16.4               | 7.3     | 7.3     | 1.5     | 12.0    | 16.0   | Q2            |
| MSP430F5510IZXHR | NFBGA        | ZXH             | 80   | 2500 | 330.0              | 12.4               | 5.3     | 5.3     | 1.5     | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS

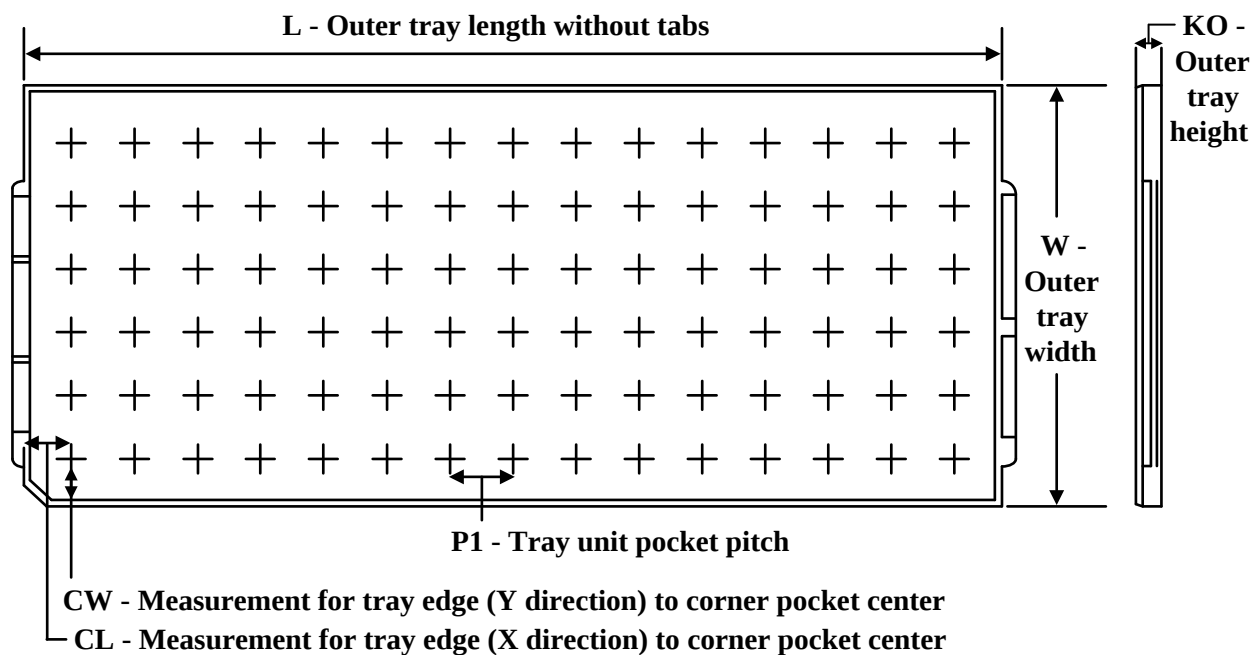


\*All dimensions are nominal

| Device           | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| MSP430F5500IRGZR | VQFN         | RGZ             | 48   | 2500 | 367.0       | 367.0      | 38.0        |
| MSP430F5500IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5501IRGZR | VQFN         | RGZ             | 48   | 2500 | 356.0       | 356.0      | 35.0        |
| MSP430F5501IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5502IRGZR | VQFN         | RGZ             | 48   | 2500 | 356.0       | 356.0      | 35.0        |
| MSP430F5502IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5503IRGZR | VQFN         | RGZ             | 48   | 2500 | 367.0       | 367.0      | 38.0        |
| MSP430F5503IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5504IRGZR | VQFN         | RGZ             | 48   | 2500 | 356.0       | 356.0      | 35.0        |
| MSP430F5504IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5505IRGZR | VQFN         | RGZ             | 48   | 2500 | 356.0       | 356.0      | 35.0        |
| MSP430F5505IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5506IRGZR | VQFN         | RGZ             | 48   | 2500 | 356.0       | 356.0      | 35.0        |
| MSP430F5506IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5507IRGZR | VQFN         | RGZ             | 48   | 2500 | 356.0       | 356.0      | 35.0        |
| MSP430F5507IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5508IRGCR | VQFN         | RGC             | 64   | 2000 | 356.0       | 356.0      | 35.0        |
| MSP430F5508IRGCT | VQFN         | RGC             | 64   | 250  | 210.0       | 185.0      | 35.0        |

| Device           | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| MSP430F5508IRGZR | VQFN         | RGZ             | 48   | 2500 | 356.0       | 356.0      | 35.0        |
| MSP430F5508IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5509IRGCR | VQFN         | RGC             | 64   | 2000 | 356.0       | 356.0      | 35.0        |
| MSP430F5509IRGCT | VQFN         | RGC             | 64   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5509IRGZR | VQFN         | RGZ             | 48   | 2500 | 356.0       | 356.0      | 35.0        |
| MSP430F5509IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5509IZXHR | NFBGA        | ZXH             | 80   | 2500 | 350.0       | 350.0      | 43.0        |
| MSP430F5510IRGCR | VQFN         | RGC             | 64   | 2000 | 356.0       | 356.0      | 35.0        |
| MSP430F5510IRGCT | VQFN         | RGC             | 64   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5510IRGZR | VQFN         | RGZ             | 48   | 2500 | 356.0       | 356.0      | 35.0        |
| MSP430F5510IRGZT | VQFN         | RGZ             | 48   | 250  | 210.0       | 185.0      | 35.0        |
| MSP430F5510IZXHR | NFBGA        | ZXH             | 80   | 2500 | 350.0       | 350.0      | 43.0        |

## TRAY



Chamfer on Tray corner indicates Pin 1 orientation of packed units.

\*All dimensions are nominal

| Device           | Package Name | Package Type | Pins | SPQ  | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (μm) | P1 (mm) | CL (mm) | CW (mm) |
|------------------|--------------|--------------|------|------|-------------------|----------------------|--------|--------|---------|---------|---------|---------|
| MSP430F5504IPT   | PT           | LQFP         | 48   | 250  | 10 x 25           | 150                  | 315    | 135.9  | 7620    | 12.2    | 11.1    | 11.25   |
| MSP430F5508IPT   | PT           | LQFP         | 48   | 250  | 10 x 25           | 150                  | 315    | 135.9  | 7620    | 12.2    | 11.1    | 11.25   |
| MSP430F5508IZXH  | ZXH          | NFBGA        | 80   | 576  | 16 x 36           | 150                  | 315    | 135.9  | 7620    | 8.5     | 8.75    | 8.7     |
| MSP430F5508IZXH  | ZXH          | NFBGA        | 80   | 576  | 16 x 36           | 150                  | 315    | 135.9  | 7620    | 8.5     | 8.75    | 8.7     |
| MSP430F5509IPT   | PT           | LQFP         | 48   | 250  | 10 x 25           | 150                  | 315    | 135.9  | 7620    | 12.2    | 11.1    | 11.25   |
| MSP430F5509IZXH  | ZXH          | NFBGA        | 80   | 576  | 16 x 36           | 150                  | 315    | 135.9  | 7620    | 8.5     | 8.75    | 8.7     |
| MSP430F5509IZXH  | ZXH          | NFBGA        | 80   | 576  | 16 x 36           | 150                  | 315    | 135.9  | 7620    | 8.5     | 8.75    | 8.7     |
| MSP430F5509IZXHR | ZXH          | NFBGA        | 80   | 2500 | 16 x 36           | 150                  | 315    | 135.9  | 7620    | 8.5     | 8.75    | 8.7     |
| MSP430F5510IPT   | PT           | LQFP         | 48   | 250  | 10 x 25           | 150                  | 315    | 135.9  | 7620    | 12.2    | 11.1    | 11.25   |
| MSP430F5510IZXH  | ZXH          | NFBGA        | 80   | 576  | 16 x 36           | 150                  | 315    | 135.9  | 7620    | 8.5     | 8.75    | 8.7     |
| MSP430F5510IZXH  | ZXH          | NFBGA        | 80   | 576  | 16 x 36           | 150                  | 315    | 135.9  | 7620    | 8.5     | 8.75    | 8.7     |
| MSP430F5510IZXHR | ZXH          | NFBGA        | 80   | 2500 | 16 x 36           | 150                  | 315    | 135.9  | 7620    | 8.5     | 8.75    | 8.7     |

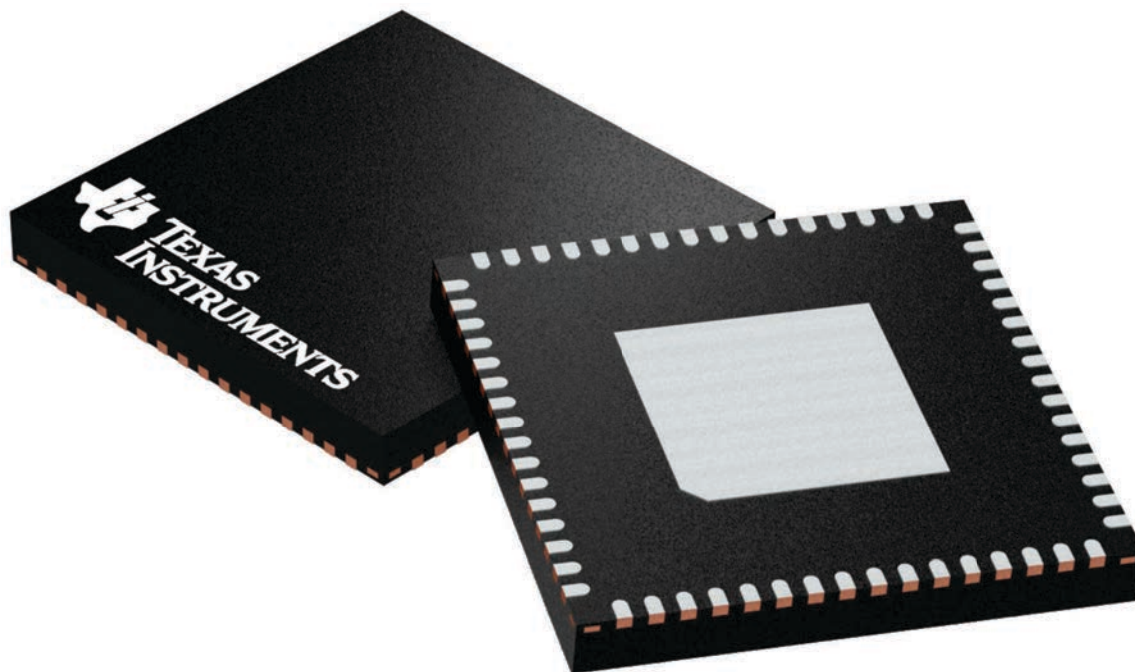
## GENERIC PACKAGE VIEW

**RGC 64**

**VQFN - 1 mm max height**

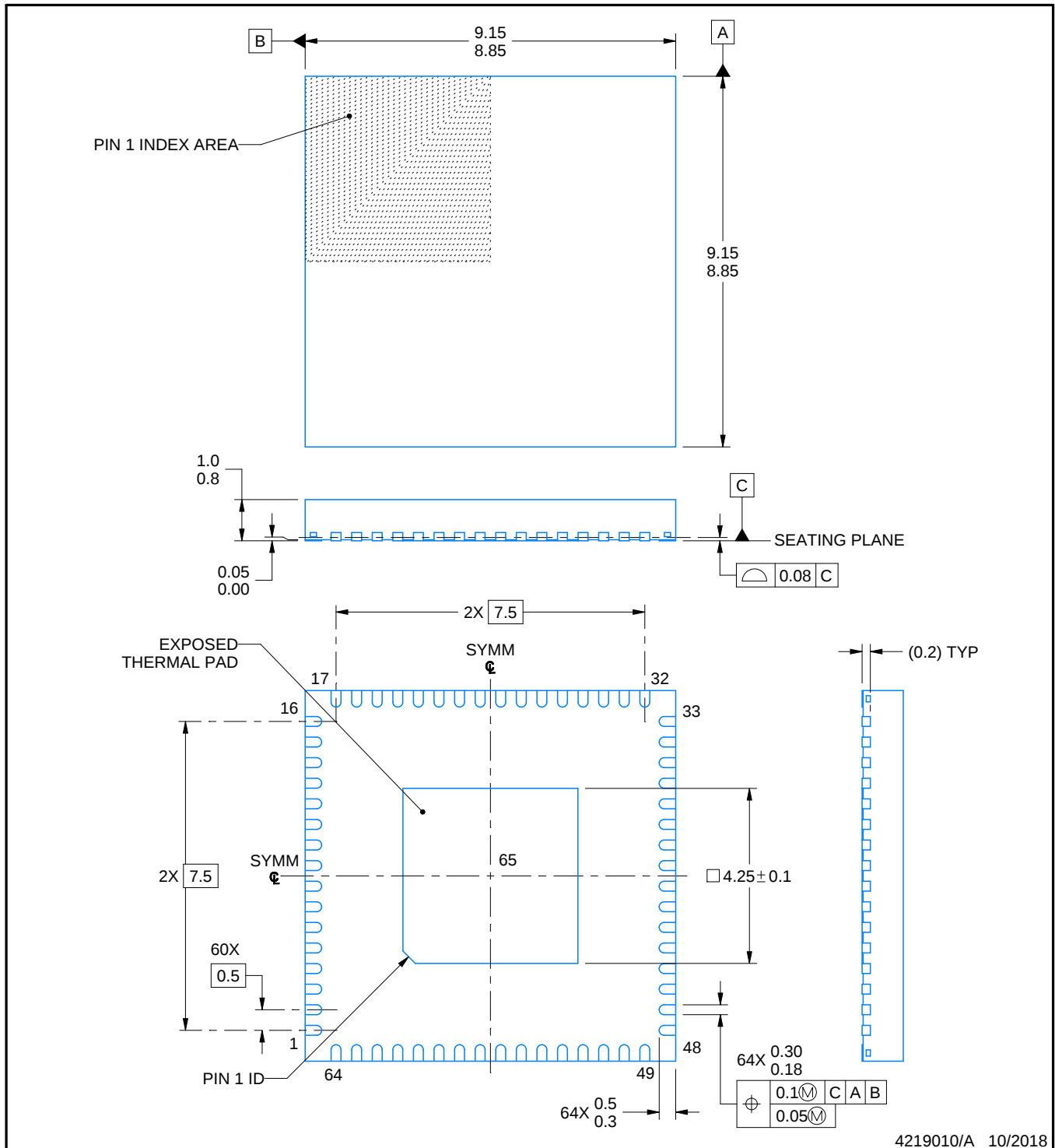
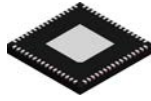
9 x 9, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

4224597/A



4219010/A 10/2018

## 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.

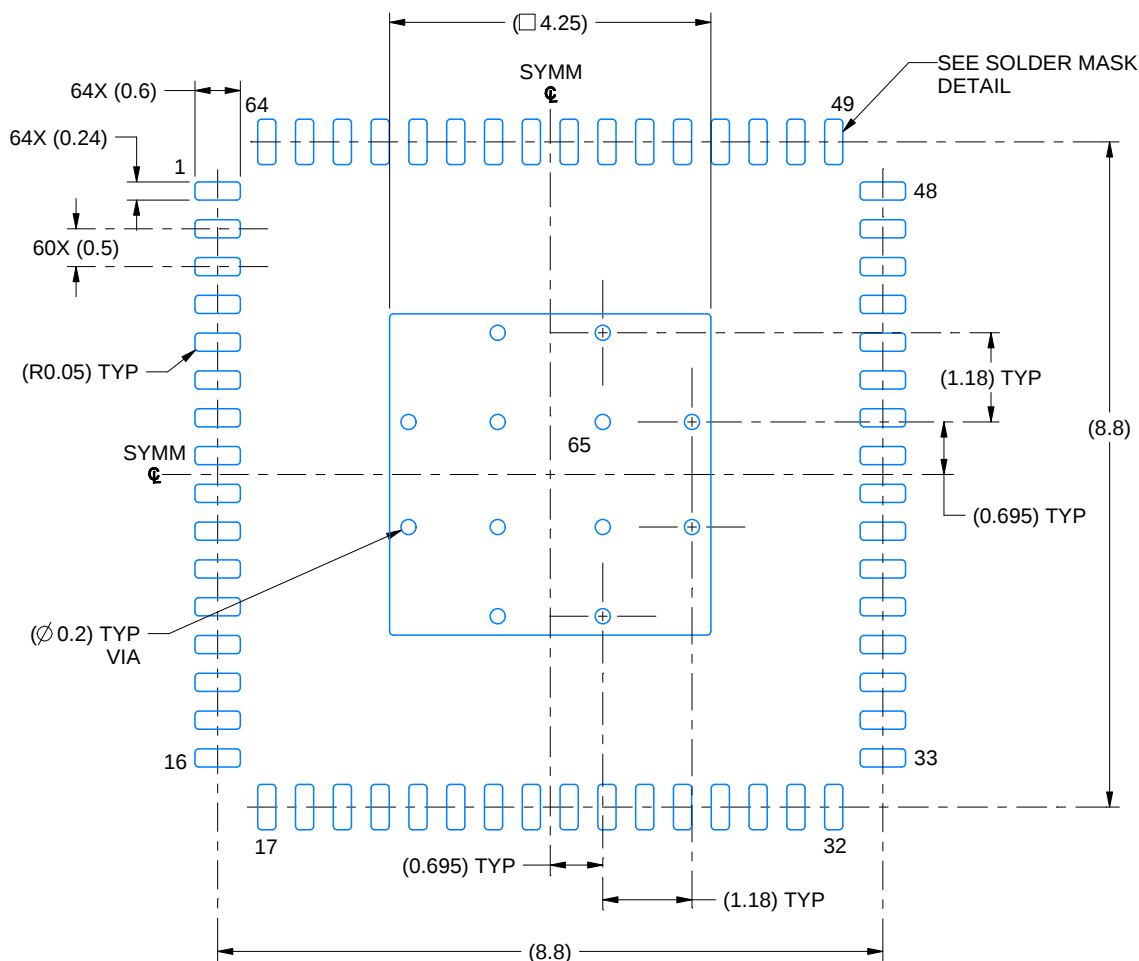


# EXAMPLE BOARD LAYOUT

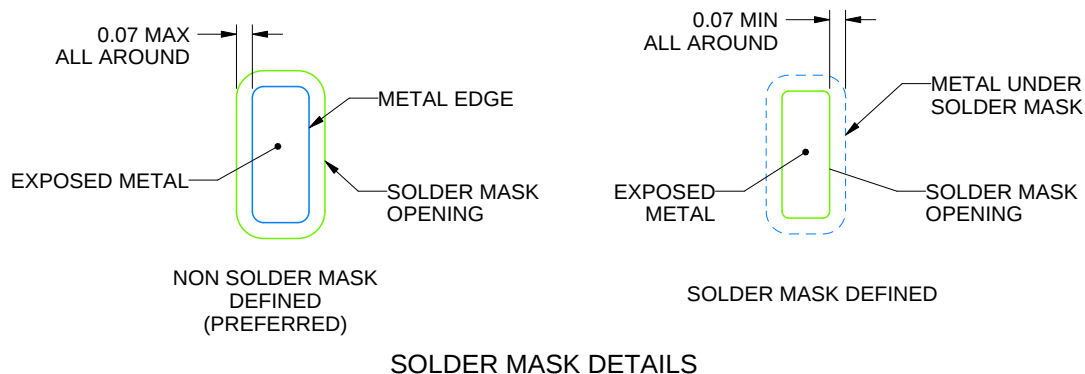
RGC0064B

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



4219010/A 10/2018

NOTES: (continued)

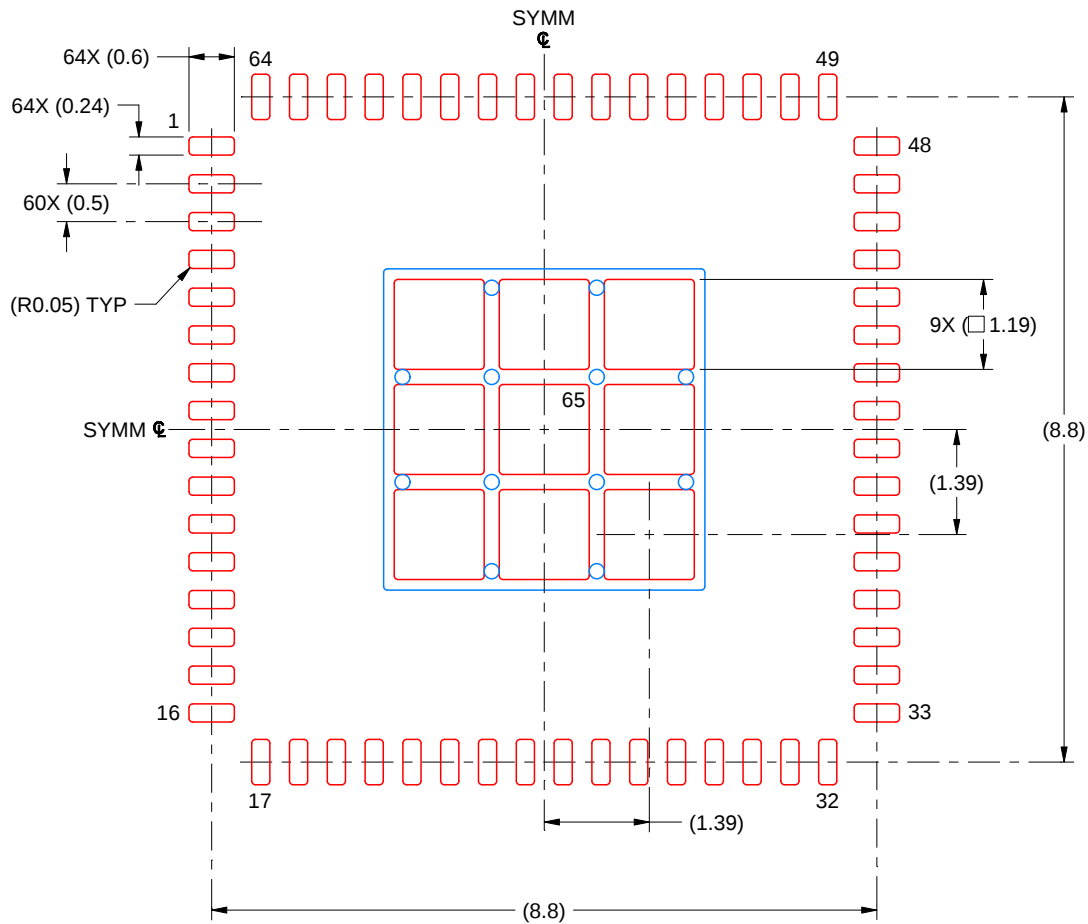
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented,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

# EXAMPLE STENCIL DESIGN

RGC0064B

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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

EXPOSED PAD 65  
 71% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE

4219010/A 10/2018

NOTES: (continued)

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

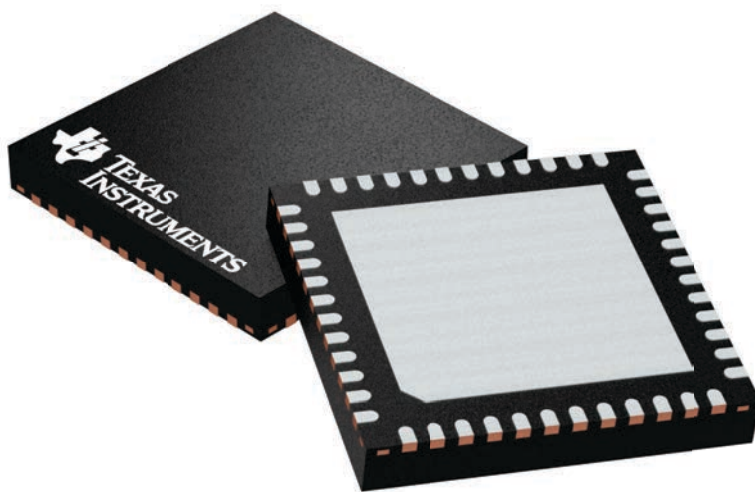
## GENERIC PACKAGE VIEW

**RGZ 48**

**VQFN - 1 mm max height**

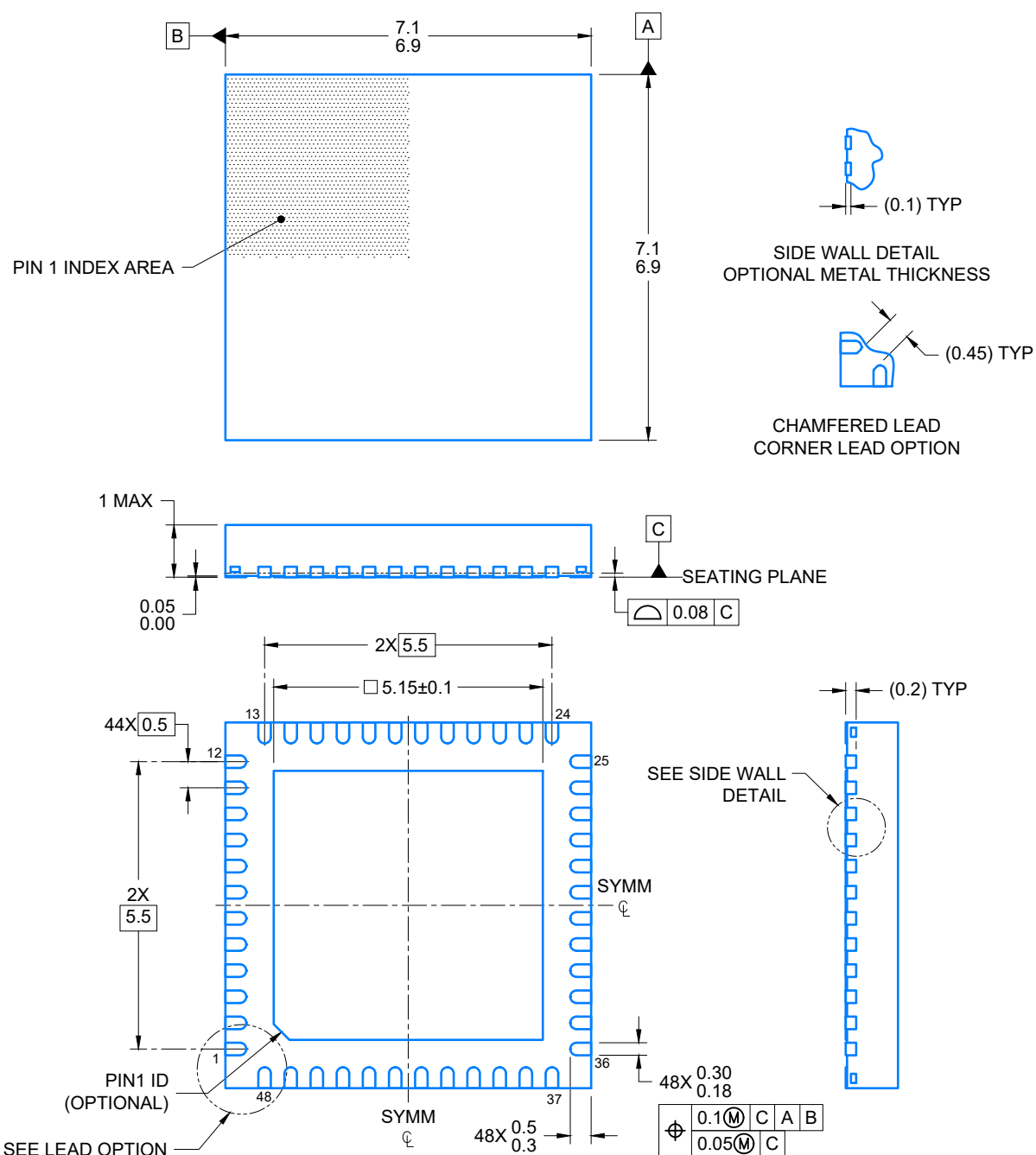
7 x 7, 0.5 mm pitch

PLASTIC QUADFLAT PACK- NO LEAD



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

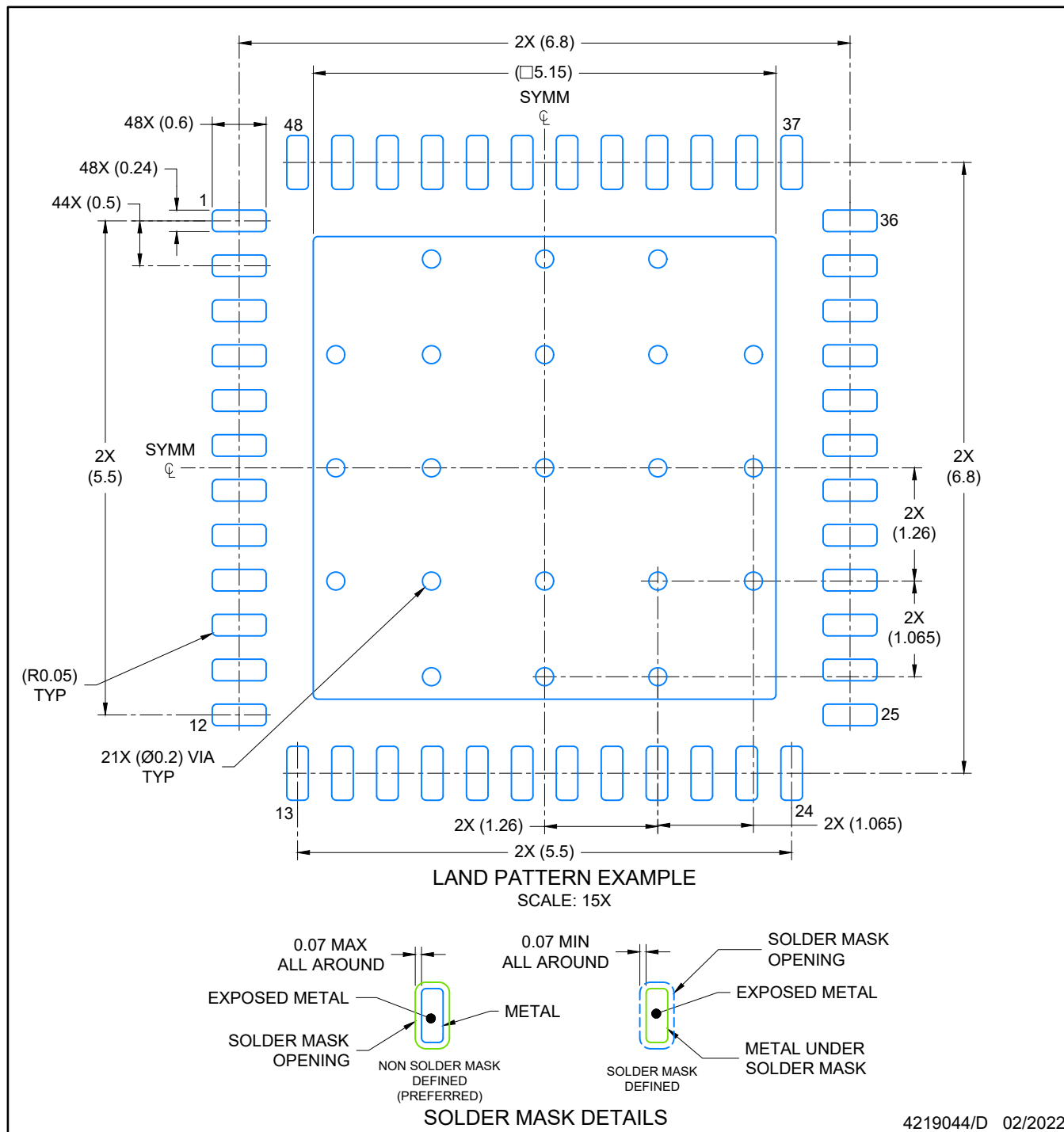
4224671/A



4219044/D 02/2022

## NOTES:

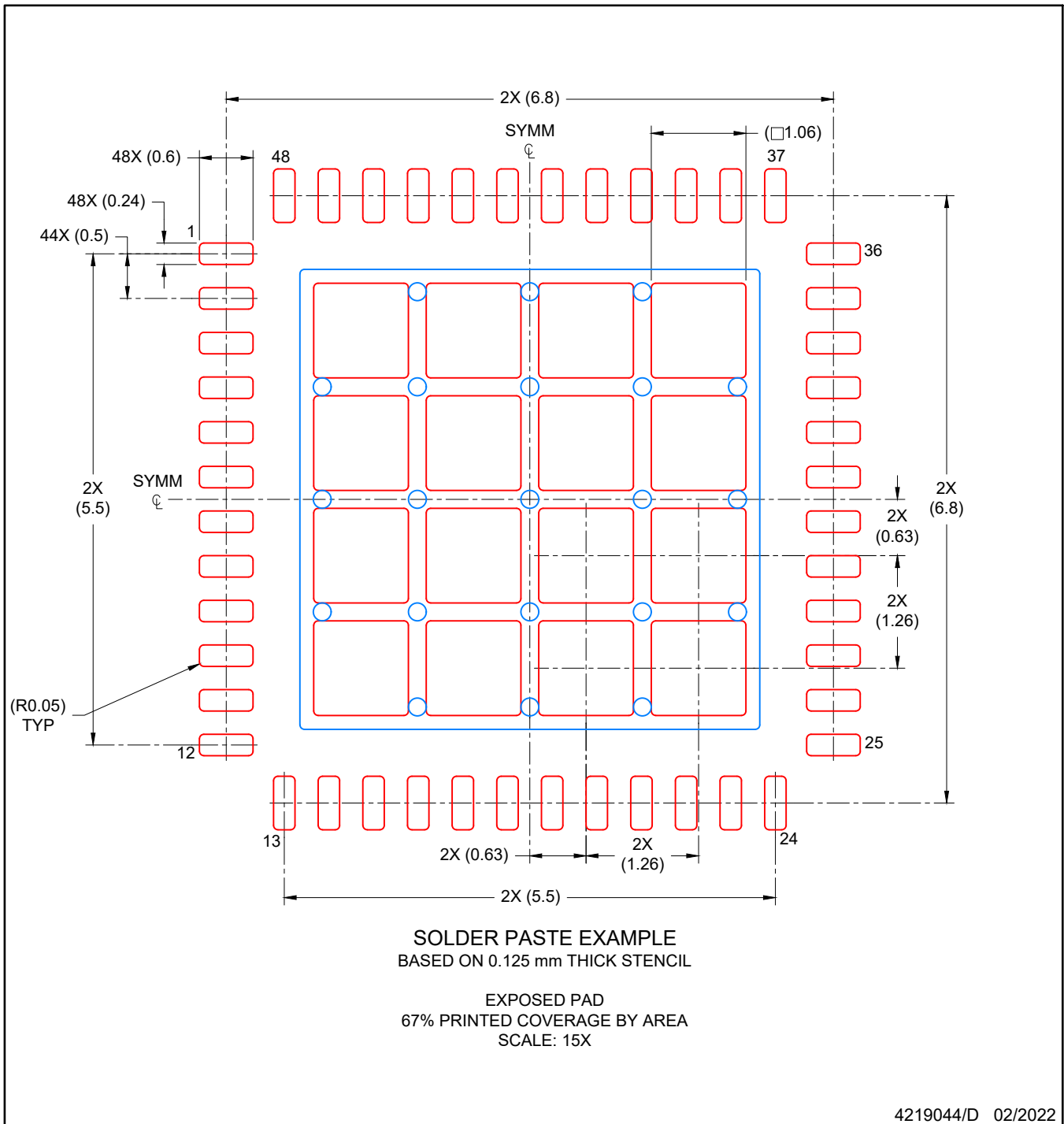
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical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



4219044/D 02/2022

NOTES: (continued)

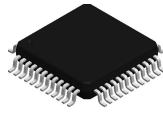
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented,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



NOTES: (continued)

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

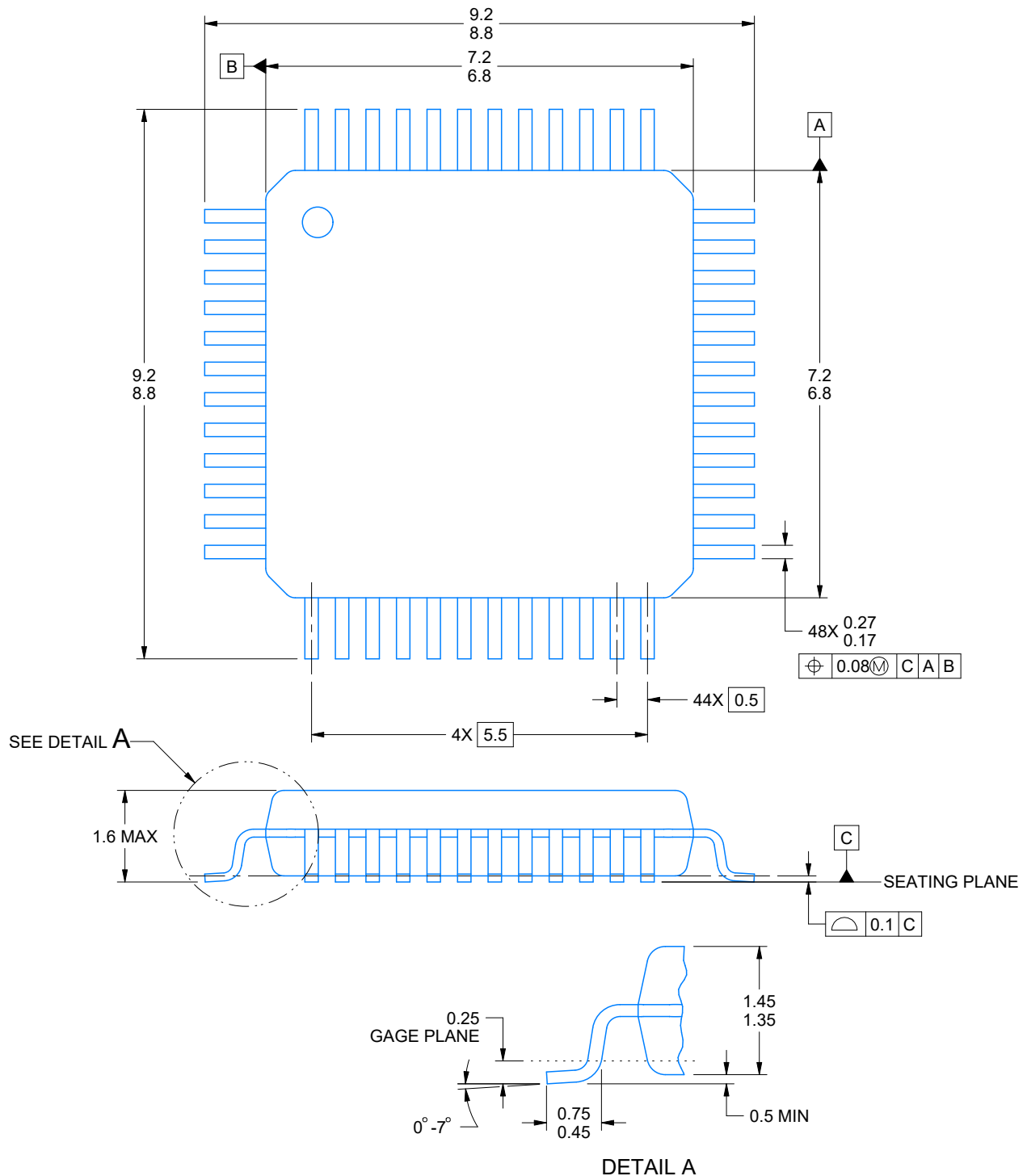
PT0048A



# PACKAGE OUTLINE

LQFP - 1.6 mm max height

LOW PROFILE QUAD FLATPACK



4215159/A 12/2021

## NOTES:

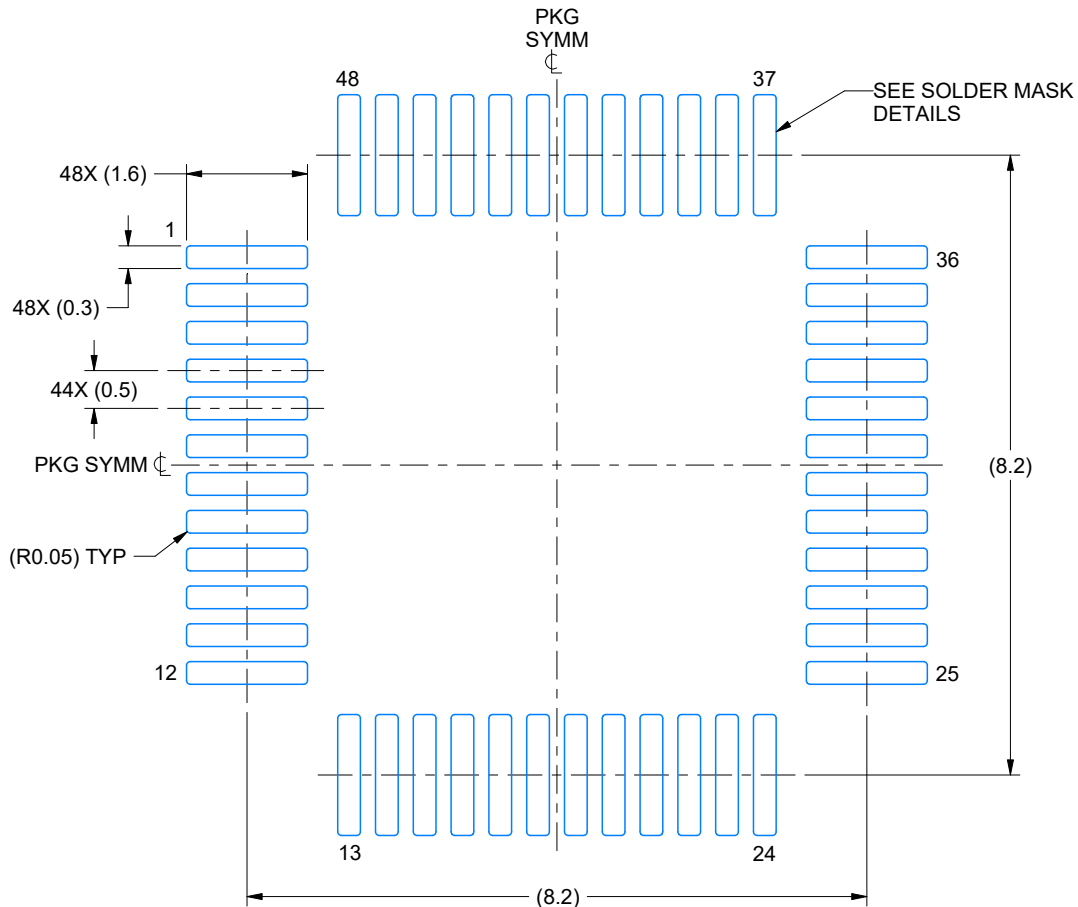
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration MS-026.
4. This may also be a thermally enhanced plastic package with leads connected to the die pads.

# EXAMPLE BOARD LAYOUT

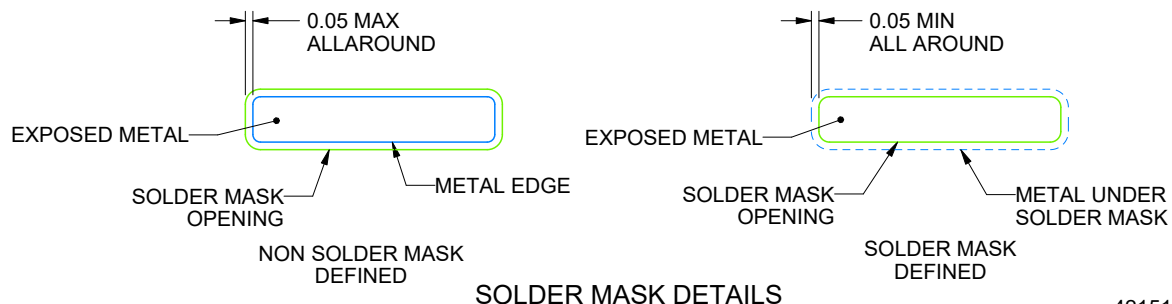
PT0048A

LQFP - 1.6 mm max height

LOW PROFILE QUAD FLATPACK



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE 10.000



SOLDER MASK DETAILS

4215159/A 12/2021

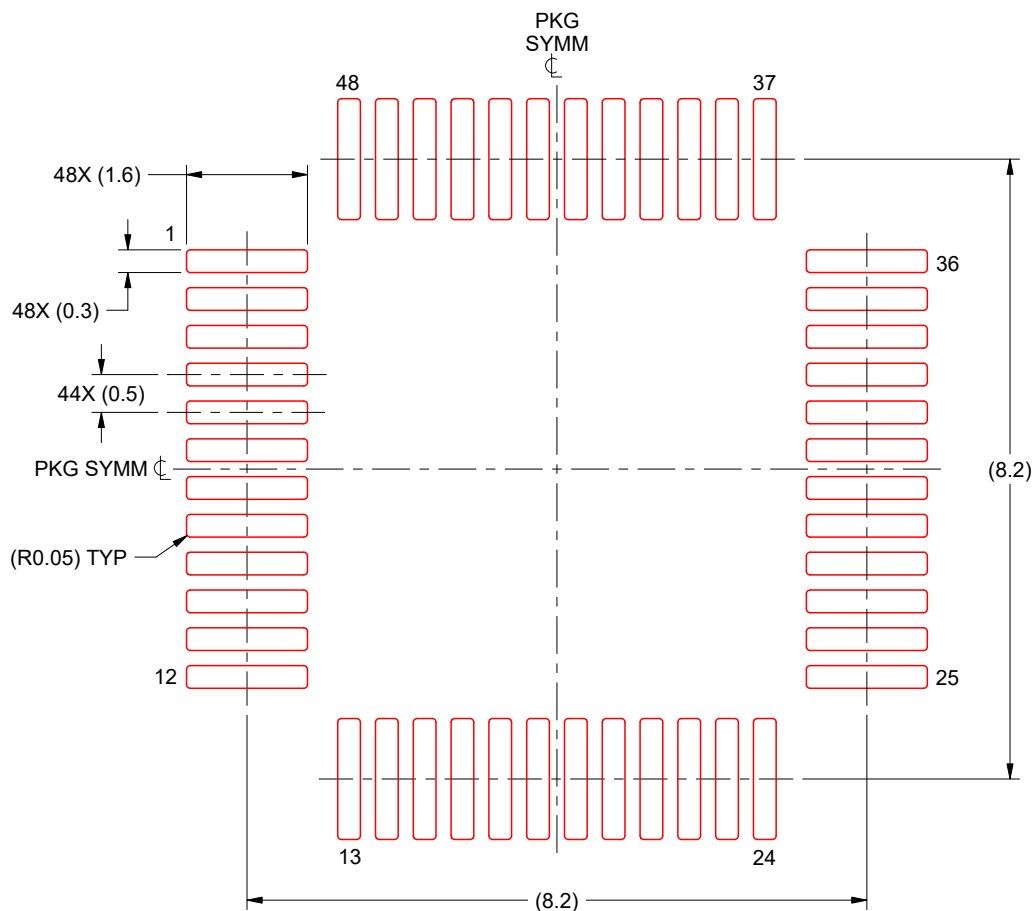
NOTES: (continued)

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

**PT0048A**

**LQFP - 1.6 mm max height**

## LOW PROFILE QUAD FLATPACK



**SOLDER PASTE EXAMPLE**  
**BASED ON 0.1 mm THICK STENCIL**  
**SCALE: 10X**

4215159/A 12/2021

NOTES: (continued)

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



### NFBGA - 1 mm max height

Technical drawing of a 100mm x 100mm square plate with a grid of 80 balls. The drawing includes three views: a top view showing the grid layout with dimensions (5.1/4.9 mm spacing, 0.7/0.6 mm ball height, 1 mm max plate thickness, 0.25/0.15 mm typical ball height), a side view showing the ball profile and seating plane, and a detailed view of the ball grid. The grid is 9x9 with 80 balls (8x10). Dimensions include 4 mm typical spacing, 0.5 mm typical ball diameter, and 80x balls with diameters of 0.15 mm and 0.05 mm. Symmetry is indicated with 'SYMM' and center lines. A 'BALL A1 CORNER INDEX AREA' is marked in the top left corner.

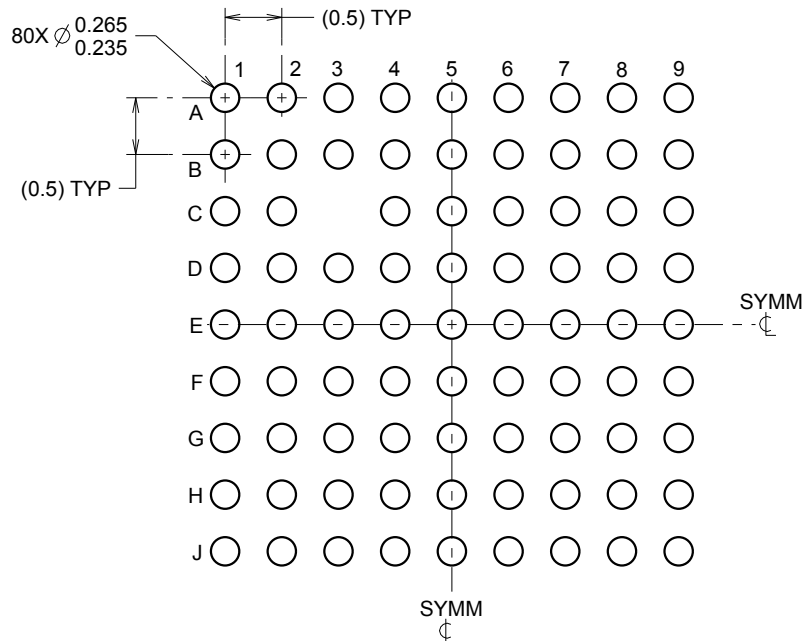
1. All linear dimensions are in millimeters. Any dimensions in parenthesis is for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This is a Pb-free solder ball design.

# EXAMPLE BOARD LAYOUT

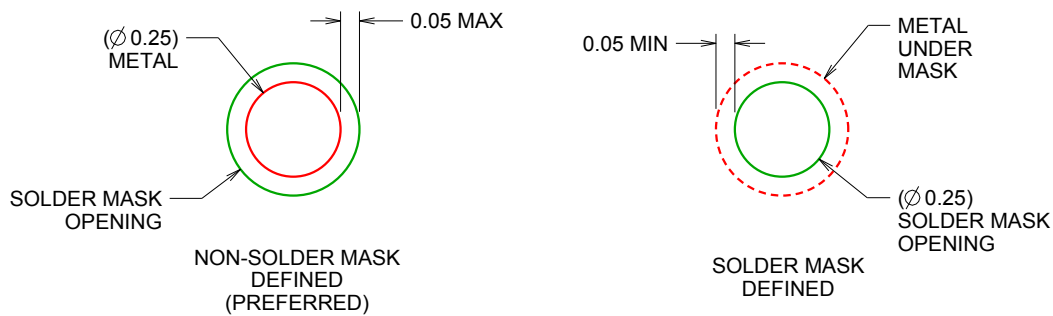
ZXH0080A

NFBGA - 1 mm max height

BALL GRID ARRAY



LAND PATTERN EXAMPLE  
SCALE:15X



SOLDER MASK DETAILS  
NOT TO SCALE

4221325/A 01/2014

NOTES: (continued)

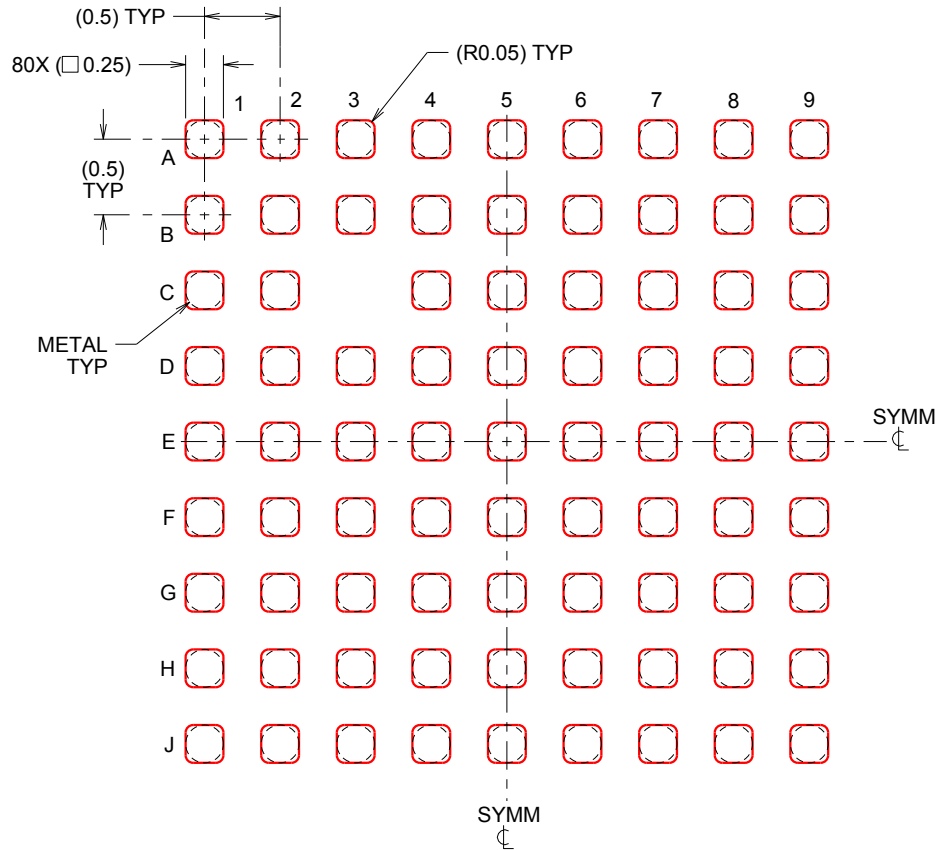
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. See Texas Instruments Literature No. SBVA017 ([www.ti.com/lit/sbva017](http://www.ti.com/lit/sbva017)).

# EXAMPLE STENCIL DESIGN

ZXH0080A

NFBGA - 1 mm max height

BALL GRID ARRAY



SOLDER PASTE EXAMPLE  
 BASED ON 0.1 mm THICK STENCIL  
 SCALE:20X

4221325/A 01/2014

NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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