

# TMS320F2837xD 双核 Delfino™ 微控制器

## 1 器件概述

### 1.1 特性

- 双核架构
    - 两个 TMS320C28x 32 位 CPU
    - 200MHz
    - IEEE-754 单精度浮点单元 (FPU)
    - 三角法数学单元 (TMU)
    - Viterbi / 复杂数学单元 (VCU-II)
  - 两个可编程控制律加速器 (CLA)
    - 200MHz
    - IEEE 754 单精度浮点指令
    - 独立于主 CPU 之外执行代码
  - 片上存储器
    - 512KB (256KW) 或 1MB (512KW) 闪存 (ECC 保护)
    - 172KB (86KW) 或 204KB (102KW) RAM (ECC 保护或奇偶校验保护)
    - 支持第三方开发的双区安全
  - 时钟和系统控制
    - 两个内部零引脚 10MHz 振荡器
    - 片上晶体振荡器
    - 窗口化看门狗定时器模块
    - 丢失时钟检测电路
  - 1.2V 内核, 3.3V I/O 设计
  - 系统外设
    - 两个支持 ASRAM 和 SDRAM 的外部存储器接口 (EMIF)
    - 双 6 通道直接存储器存取 (DMA) 控制器
    - 多达 169 个支持输入滤波的独立可编程、复用通用输入/输出 (GPIO) 引脚
    - 扩展外设中断控制器 (ePIE)
    - 多个支持外部唤醒的低功耗模式 (LPM)
  - 通信外设
    - USB 2.0 (MAC + PHY)
    - 支持 12 引脚 3.3V 兼容通用并行端口 (uPP) 接口
    - 两个控制器局域网 (CAN) 模块 (引脚可引导)
    - 三个高速 (最高 50MHz) SPI 端口 (引脚可引导)
  - 两个多通道缓冲串行端口 (McBSP)
  - 四个串行通信接口 (SCI/UART) (引脚可引导)
  - 两个 I<sup>2</sup>C 接口 (引脚可引导)
  - 模拟子系统
    - 多达四个模数转换器 (ADC)
      - 16 位模式
        - 每个转换器的吞吐量为 1.1MSPS (系统吞吐量高达 4.4MSPS)
        - 差分输入
        - 多达 12 个外部通道
      - 12 位模式
        - 每个转换器的吞吐量为 3.5MSPS (系统吞吐量高达 14MSPS)
        - 单端输入
        - 多达 24 个外部通道
    - 每个 ADC 上有单个采样与保持 (S/H) 电路
    - ADC 转换的硬件集成后置处理
      - 饱和偏移校准
      - 定点计算误差
      - 具有中断功能的高、低和过零比较
      - 触发至采样延迟捕捉
  - 八个具有 12 位数模转换器 (DAC) 参考的窗口化比较器
  - 3 个 12 位缓冲 DAC 输出
- 增强型控制外设
  - 24 条具有增强功能的脉宽调制器 (PWM) 通道
  - 16 条高分辨率脉宽调制器 (HRPWM) 通道
    - 8 个 PWM 模块的 A 和 B 通道均可实现高分辨率
    - 死区支持 (对于标准和高分辨率均支持)
  - 6 个增强型捕捉 (eCAP) 模块
  - 3 个增强型正交编码器脉冲 (eQEP) 模块
  - 八条  $\Delta$ - $\Sigma$  滤波器模块 (SDFM) 输入通道, 每条通道 2 个并联滤波器
    - 标准 SDFM 数据滤波
    - 用于快速响应超范围情况的比较器滤波器



- 封装选项：
  - 无铅，绿色环保封装
  - 337 焊球全新细间距球栅阵列 (nFBGA) [后缀 ZWT]
  - 176 引脚 PowerPAD™ 散热增强型半高四方扁平 (HLQFP) [PTP 后缀]
  - 100 引脚 PowerPAD 耐热增强型薄型四方扁平封装 (HTQFP) [PZP 后缀]
- 温度选项：
  - T: -40°C 至 105°C (结温)
  - S: -40°C 到 125°C (结温)
  - Q: -40°C 到 125°C (自然通风)  
(针对汽车应用的 Q100 认证)

## 1.2 应用

- 工业驱动产品
- 太阳能微型逆变器和转换器
- 雷达
- 数字电源
- 智能计量
- 汽车运输
- 电力线通信

## 1.3 说明

本示例中使用的 Delfino™TMS320F2837xD 是一款功能强大的 32 位浮点微控制器单元 (MCU)，针对高级闭环控制应用而设计，例如工业驱动器和伺服电机控制、太阳能逆变器和转换器、数字电源、电力输送以及电力线通信。数字电源和工业驱动器的完整开发包作为 powerSUITE 和 DesignDRIVE 方案的一部分提供。而 Delfino 产品系列并不是 TMS320C2000™ 产品组合的新成员，F2837xD 支持新型双核 C28x 架构，显著提升了系统性能；同时集成有模拟和控制外设，允许设计人员整合控制架构，消除了高端系统中使用多处理器的需求。

双实时控制子系统基于 TI 的 32 位 C28x 浮点 CPU，每个内核中可提供 200MHz 的信号处理性能。C28x CPU 的性能通过新型 TMU 加速器和 VCU 加速器得到了进一步提升，TMU 加速器可快速执行包含变换和转矩环路计算中常见的三角运算的算法；VCU 加速器可缩短编码应用中常见的复杂数学运算的时间。

F2837xD 微控制器系列采用两个 CLA 实时控制协处理器。CLA 是一款独立的 32 位浮点处理器，运行速度与主 CPU 相同。该 CLA 会对外设触发器作出响应，并与主 C28x CPU 同时执行代码。这种并行处理能力可有效加倍实时控制系统的计算性能。通过利用 CLA 执行时间关键型功能，主 C28x CPU 可以得到释放，以便用于执行通信和诊断等其他任务。双 C28x+CLA 架构可在各种系统任务之间实现智能分区。例如，一个 C28x+CLA 内核可用于跟踪速度和位置，而另一个 C28x+CLA 内核则可用于控制转矩和电流环路。

TMS320F2837xD 支持高达 1MB (512KW) 的板载闪存（含纠错码 (ECC)）以及高达 204KB (102KW) 的 SRAM。每个 CPU 上还提供两个 128 位安全区，以实现代码保护。

F2837xD MCU 上还集成了性能模拟和控制外设，进一步实现系统整合。四个独立的 16 位 ADC 可准确、高效地管理多个模拟信号，从而最终提高系统吞吐量。新型  $\Sigma$ - $\Delta$  滤波器模块 (SDFM) 与  $\Sigma$ - $\Delta$  调制器配合使用可实现隔离分流测量。包含窗口化比较器的比较器子系统 (CMPSS) 可在超过或未满足电流限制条件的情况下保护功率级。其他模拟和控制外设包括 DAC、PWM、eCAPs、eQEP 以及其他外设。

凭借可配置逻辑模块 (CLB)，德州仪器 (TI) 可为所选的 C2000 器件提供附加的接口和™控制功能。请参见 Table 3-1 以了解支持 CLB 功能的器件。

EMIF、CAN 模块（符合 ISO11898-1/CAN 2.0B）等外设以及新型 uPP 接口扩展了 F2837xD 的连接功能。uPP 接口是 C2000 MCU 的新功能，支持利用相似的 uPP 接口与 FPGA 或其他处理器实现高速并行连接。最后，具有 MAC 和 PHY 的 USB 2.0 端口使用户能够轻松地将通用串行总线 (USB) 连接功能添加到其应用中。

器件信息<sup>(1)</sup>

产品型号	封装	封装尺寸
TMS320F28379DZWT	nFBGA (337)	16.0mm x 16.0mm
TMS320F28377DZWT	nFBGA (337)	16.0mm x 16.0mm

(1) 有关这些器件的更多信息，请参见节 9，机械、封装和可订购信息。

**器件信息<sup>(1)</sup> (continued)**

产品型号	封装	封装尺寸
TMS320F28376DZWT	nFBGA (337)	16.0mm x 16.0mm
TMS320F28375DZWT	nFBGA (337)	16.0mm x 16.0mm
TMS320F28374DZWT	nFBGA (337)	16.0mm x 16.0mm
TMS320F28379DPTP	HLQFP (176)	24.0mm x 24.0mm
TMS320F28377DPTP	HLQFP (176)	24.0mm x 24.0mm
TMS320F28376DPTP	HLQFP (176)	24.0mm x 24.0mm
TMS320F28375DPTP	HLQFP (176)	24.0mm x 24.0mm
TMS320F28374DPTP	HLQFP (176)	24.0mm x 24.0mm
TMS320F28375DPZP	HTQFP (100)	14.0mm x 14.0mm

## 1.4 功能框图

图 1-1 显示了 CPU 系统及相关外设。

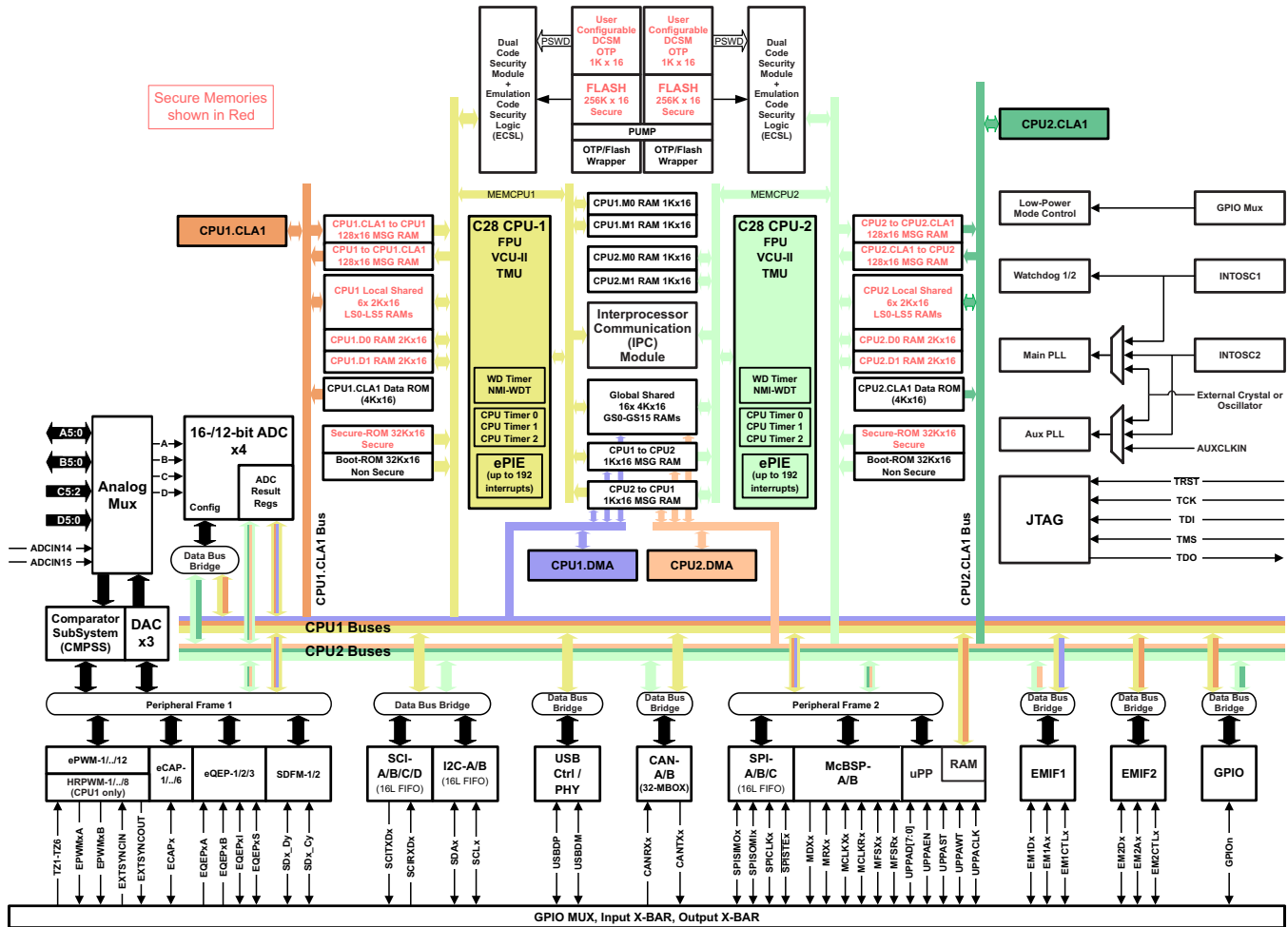


图 1-1. 功能方框图

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## 2 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

Changes from September 25, 2015 to November 9, 2015 (from E Revision (September 2015) to F Revision)	Page
• 全局：已添加 TMS320F28379D。 .....	<a href="#">1</a>
• 节 1.3 (说明)：已添加 可配置逻辑模块 (CLB) 的说明。 .....	<a href="#">2</a>
• Table 3-1 (Device Comparison): Added TMS320F28379D. ....	<a href="#">7</a>
• Table 3-1: Added Configurable Logic Block (CLB). ....	<a href="#">7</a>
• Section 4.5.3 (Output X-BAR and ePWM X-BAR): Changed section title from "Output X-BAR" to "Output X-BAR and ePWM X-BAR". ....	<a href="#">44</a>
• Section 4.5.3: Updated section. ....	<a href="#">44</a>
• Figure 4-8 (Output X-BAR and ePWM X-BAR): Replaced "Output X-BAR" figure with "Output X-BAR and ePWM X-BAR" figure. ....	<a href="#">44</a>
• Table 5-1 (Device Current Consumption at 200-MHz SYSCLK): Updated TEST CONDITIONS for Flash Erase/Program mode. ....	<a href="#">48</a>
• Section 5.5.1 (Current Consumption Graphs): Changed section title from "Operational Current Consumption Graphs" to "Current Consumption Graphs". ....	<a href="#">49</a>
• Section 5.5.1: Added information about leakage current and temperature. ....	<a href="#">49</a>
• Figure 5-3 (I <sub>DD</sub> Leakage Current Versus Temperature): Added graph. ....	<a href="#">50</a>
• 图 5-7 (Clocking System): Changed figure title from "Device Clocking" to "Clocking System". ....	<a href="#">58</a>
• 表 5-12 (Internal Clock Frequencies): Updated table. ....	<a href="#">60</a>
• Table 5-18 (Internal Oscillator Electrical Characteristics): Updated table. ....	<a href="#">63</a>
• 节 5.7.4 (Flash Parameters): Updated "The on-chip flash memory is tightly integrated ..." paragraph. ....	<a href="#">64</a>
• Table 5-42 (ADC Characteristics (16-Bit Differential Mode)): Added "IO activity is minimized on pins ..." footnote. ...	<a href="#">97</a>
• Table 5-44 (ADC Characteristics (12-Bit Single-Ended Mode)): Updated table. ....	<a href="#">99</a>
• Table 5-44: Added "IO activity is minimized on pins ..." footnote. ....	<a href="#">99</a>
• 节 5.8.1.1.2 (ADC Timing Diagrams): Removed "ADC Timings for 12-Bit Mode in Early Interrupt Mode" figure. ...	<a href="#">102</a>
• 节 5.8.1.1.2: Removed "ADC Timings for 16-Bit Mode in Early Interrupt Mode" figure. ....	<a href="#">102</a>
• 表 5-49 (ADC Timings in 12-Bit Mode (SYSCLK Cycles)): Updated table. ....	<a href="#">103</a>
• 图 5-32 (ADC Timings for 12-Bit Mode): Changed figure title from "ADC Timings for 12-Bit Mode in Late Interrupt Mode" to "ADC Timings for 12-Bit Mode". ....	<a href="#">103</a>
• 表 5-50 (ADC Timings in 16-Bit Mode): Updated table. ....	<a href="#">104</a>
• 图 5-33 (ADC Timings for 16-Bit Mode): Changed figure title from "ADC Timings for 16-Bit Mode in Late Interrupt Mode (SYSCLK Cycles)" to "ADC Timings for 16-Bit Mode". ....	<a href="#">104</a>
• Table 5-53 (CMPSS DAC Static Electrical Characteristics): Added "Per active CMPSS module" footnote. ....	<a href="#">109</a>
• Table 5-54 (Buffered DAC Electrical Characteristics): Added "Per active Buffered DAC module" footnote. ....	<a href="#">112</a>
• 图 5-66 (SPI CPU Interface): Changed figure title from "SPI" to "SPI CPU Interface". ....	<a href="#">149</a>
• 节 6.1 (Overview): Added description of Configurable Logic Block (CLB). ....	<a href="#">174</a>
• 表 6-9 (Device Identification Registers): Added PARTIDH for TMS320F28379D. ....	<a href="#">184</a>
• 节 6.15 (Configurable Logic Block (CLB)): Added section. ....	<a href="#">196</a>
• 节 7.1 (TI Design or Reference Design): Added section. ....	<a href="#">197</a>
• 节 7.3.3 (Pin Mux Tool): Changed section title from "Pin Mux Utility for ARM® and F2837xD Microcontrollers" to "Pin Mux Tool". ....	<a href="#">198</a>

### 3 Device Comparison

Table 3-1 lists the features of each 2837xD device.

**Table 3-1. Device Comparison**

FEATURE <sup>(1)</sup>		28379D		28377D		28376D		28375D			28374D		
Package Type (ZWT is an nFBGA package. PTP is an HLQFP package. PZP is an HTQFP package.)		337-Ball ZWT	176-Pin PTP	337-Ball ZWT	176-Pin PTP	337-Ball ZWT	176-Pin PTP	337-Ball ZWT	176-Pin PTP	100-Pin PZP	337-Ball ZWT	176-Pin PTP	
<b>Processor and Accelerators</b>													
C28x	Number	2											
	Frequency (MHz)	200											
	Floating-Point Unit (FPU)	Yes											
	VCU-II	Yes											
CLA – Type 1	TMU – Type 0	Yes											
	Number	2											
	Frequency (MHz)	200											
6-Channel DMA – Type 0		2											
<b>Memory</b>													
Flash (16-bit words)		1MB (512KW) [512KB (256KW) per CPU]		1MB (512KW) [512KB (256KW) per CPU]		512KB (256KW) [256KB (128KW) per CPU]		1MB (512KW) [512KB (256KW) per CPU]			512KB (256KW) [256KB (128KW) per CPU]		
RAM (16-bit words)	Dedicated and Local Shared RAM	72KB (36KW) [36KB (18KW) per CPU]											
	Global Shared RAM	128KB (64KW)		128KB (64KW)		96KB (48KW)		128KB (64KW)			96KB (48KW)		
	Message RAM	4KB (2KW) [2KB (1KW) per CPU]											
	<b>Total RAM</b>	<b>204KB (102KW)</b>		<b>204KB (102KW)</b>		<b>172KB (86KW)</b>		<b>204KB (102KW)</b>			<b>172KB (86KW)</b>		
Code security for on-chip Flash, RAM, and OTP blocks		Yes											
Boot ROM		Yes											
<b>System</b>													
Configurable Logic Block (CLB)		Yes					No						
32-bit CPU timers		6 (3 per CPU)											
Watchdog timers		2 (1 per CPU)											
Nonmaskable Interrupt Watchdog (NMIWD) timers		2 (1 per CPU)											
Crystal oscillator/External clock input		1											
0-pin internal oscillator		2											
I/O pins (shared)	GPIO	169	97	169	97	169	97	169	97	41	169	97	
External interrupts		5											
EMIF	EMIF1 16/32-bit	1					1			–		1	
	EMIF2 16-bit	1	–	1	–	1	–	1	–	–	1	–	
<b>Analog Peripherals</b>													
ADC 16-bit mode	MSPS	1.1											
	Conversion Time (ns) <sup>(2)</sup>	915											
	Input pins	24	20	24	20	24	20	–					
	Channels (differential)	12	9	12	9	12	9	–					
ADC 12-bit mode	MSPS	3.5											
	Conversion Time (ns) <sup>(2)</sup>	290											
	Input pins	24	20	24	20	24	20	24	20	14	24	20	
	Channels (single-ended)	24	20	24	20	24	20	24	20	14	24	20	
Number of 16-bit or 12-bit ADCs		4											
Number of 12-bit only ADCs		–											
Temperature sensor		1											
CMPSS (each CMPSS has two Comparators and two internal DACs)		8											
Buffered DAC		3											



**Table 3-1. Device Comparison (continued)**

FEATURE <sup>(1)</sup>		28379D		28377D		28376D		28375D			28374D			
Package Type (ZWT is an nFBGA package. PTP is an HLQFP package. PZP is an HTQFP package.)		337-Ball ZWT	176-Pin PTP	337-Ball ZWT	176-Pin PTP	337-Ball ZWT	176-Pin PTP	337-Ball ZWT	176-Pin PTP	100-Pin PZP	337-Ball ZWT	176-Pin PTP		
<b>Control Peripherals<sup>(3)</sup></b>														
eCAP inputs – Type 0		6												
Enhanced Pulse Width Modulator (ePWM) channels – Type-4		24					24		15		24			
eQEP modules – Type 0		3					3		2		3			
High-resolution ePWM channels – Type-4		16					16		9		16			
SDFM channels – Type-0		8					8		6		8			
<b>Communication Peripherals<sup>(3)</sup></b>														
Controller Area Network (CAN) – Type 0 <sup>(4)</sup>		2												
Inter-Integrated Circuit (I <sup>2</sup> C) – Type 0		2												
Multichannel Buffered Serial Port (McBSP) – Type 1		2												
SCI – Type 0		4					4		3		4			
Serial Peripheral Interface (SPI) – Type 2		3												
USB – Type 0		1												
uPP – Type 0		1												
<b>Temperature and Qualification</b>														
Junction Temperature (T <sub>J</sub> )		T: –40°C to 105°C		Yes				Yes		No		Yes		
		S: –40°C to 125°C		Yes										
		Q: –40°C to 150°C <sup>(5)</sup>		No		Yes		No						
Free-Air Temperature (T <sub>A</sub> )		Q: –40°C to 125°C <sup>(5)</sup>		No		Yes		No						

- (1) A type change represents a major functional feature difference in a peripheral module. Within a peripheral type, there may be minor differences between devices that do not affect the basic functionality of the module. For more information, see the *C2000 Real-Time Control Peripherals Reference Guide* (SPRU566).
- (2) Time between start of sample-and-hold window to start of sample-and-hold window of the next conversion.
- (3) For devices that are available in more than one package, the peripheral count listed in the smaller package is reduced because the smaller package has less device pins available. The number of peripherals internally present on the device is not reduced compared to the largest package offered within a part number. See [Section 4](#) to identify which peripheral instances are accessible on pins in the smaller package.
- (4) The CAN module uses the IP known as D\_CAN. This document uses the names “CAN” and “D\_CAN” interchangeably to reference this peripheral.
- (5) The letter Q refers to Q100 qualification for automotive applications.



## 4 Terminal Configuration and Functions

### 4.1 Pin Diagrams

Figure 4-1 to Figure 4-4 show the terminal assignments on the 337-ball ZWT New Fine Pitch Ball Grid Array. Each figure shows a quadrant of the terminal assignments. Figure 4-5 shows the pin assignments on the 176-pin PTP PowerPAD Thermally Enhanced Low-Profile Quad Flatpack. Figure 4-6 shows the pin assignments on the 100-pin PZP PowerPAD Thermally Enhanced Thin Quad Flatpack.

	1	2	3	4	5	6	7	8	9	10	
W	V <sub>SSA</sub>	ADCINB1	ADCINB3	ADCINB5	V <sub>REFHIB</sub>	V <sub>REFLOD</sub>	V <sub>SS</sub>	V <sub>DDIO</sub>	GPIO128	GPIO116	W
V	V <sub>REFHIA</sub>	ADCINB0	ADCINB2	ADCINB4	V <sub>REFHID</sub>	V <sub>REFLOB</sub>	V <sub>SSA</sub>	GPIO124	GPIO127	GPIO131	V
U	ADCINA0	ADCINA2	ADCINA4	ADCIN15	ADCIND1	ADCIND3	ADCIND5	GPIO123	GPIO126	GPIO130	U
T	ADCINA1	ADCINA3	ADCINA5	ADCIN14	ADCIND0	ADCIND2	ADCIND4	GPIO122	GPIO125	GPIO129	T
R	V <sub>REFHIC</sub>	V <sub>REFLOA</sub>	ADCINC2	ADCINC4	V <sub>SSA</sub>	V <sub>DDA</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DDIO</sub>	V <sub>DD</sub>	R
P	V <sub>SSA</sub>	V <sub>REFLOC</sub>	ADCINC3	ADCINC5	V <sub>SSA</sub>	V <sub>DDA</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DDIO</sub>	V <sub>DD</sub>	P
N	V <sub>SS</sub>	GPIO109	GPIO114	GPIO113	V <sub>SS</sub>	V <sub>SS</sub>	7 N	8	9	10	N
M	V <sub>DDIO</sub>	GPIO110	GPIO112	GPIO111	V <sub>DDIO</sub>	V <sub>DDIO</sub>	M	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	M
L	GPIO27	GPIO106	GPIO107	GPIO108	V <sub>SS</sub>	V <sub>SS</sub>	L	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	L
K	GPIO26	GPIO25	GPIO24	GPIO23	V <sub>DD</sub>	V <sub>DD</sub>	K	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	K
	1	2	3	4	5	6		8	9	10	

A. Only the GPIO function is shown on GPIO terminals. See Table 4-1 for the complete, muxed signal name.

**Figure 4-1. 337-Ball ZWT New Fine Pitch Ball Grid Array (Bottom View) – [Quadrant A]**

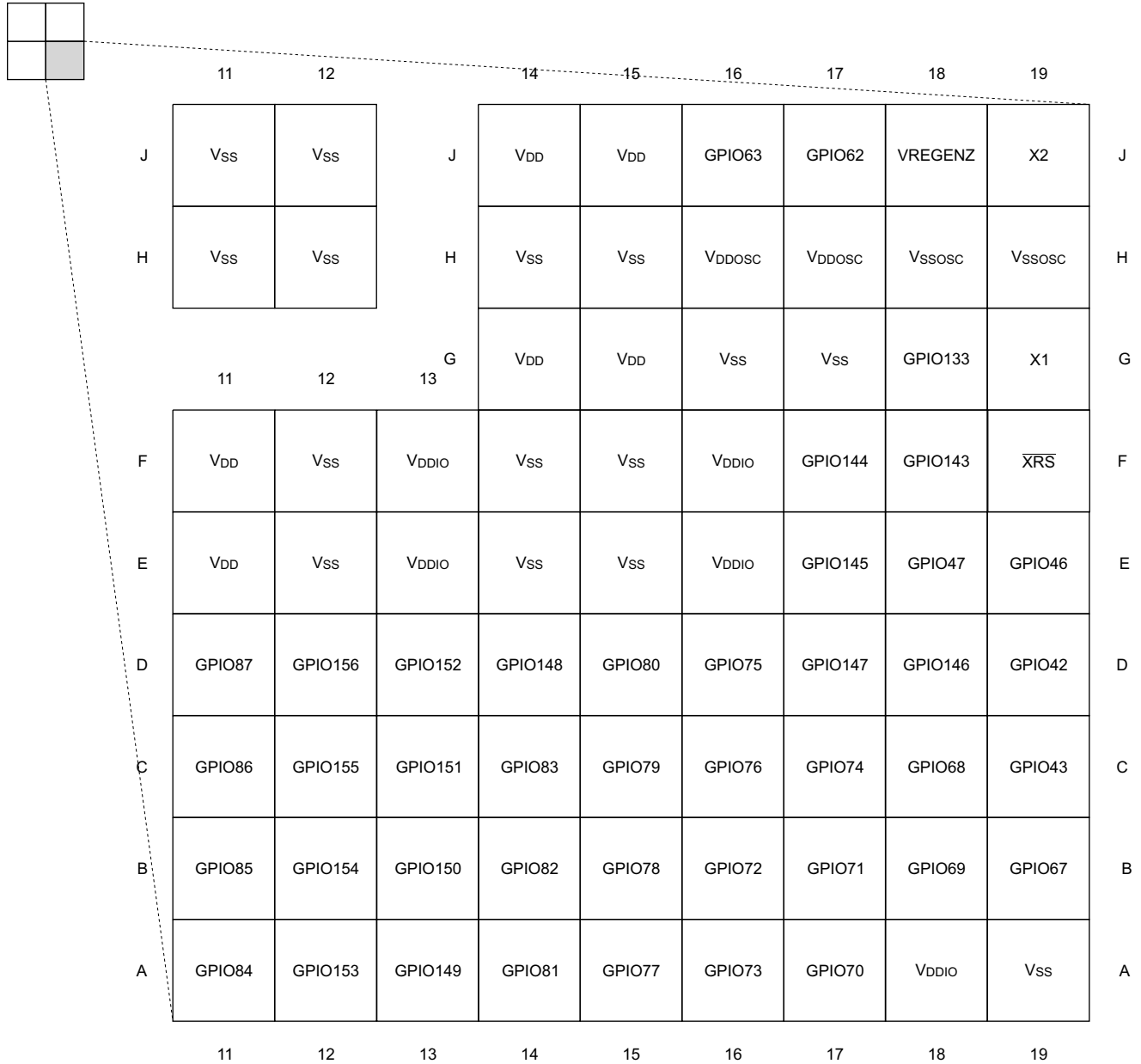
	11	12	13	14	15	16	17	18	19		
W	GPIO29	FLT1	TDI	TMS	TDO	GPIO121	GPIO39	GPIO132	V <sub>SS</sub>	W	
V	GPIO28	GPIO115	FLT2	$\overline{\text{TRST}}$	TCK	GPIO36	GPIO40	GPIO134	V <sub>DDIO</sub>	V	
U	GPIO31	GPIO117	GPIO32	GPIO34	GPIO120	GPIO37	GPIO41	GPIO135	ERRORSTS	U	
T	GPIO30	GPIO118	GPIO33	GPIO35	GPIO119	GPIO38	GPIO136	GPIO137	GPIO138	T	
R	V <sub>DD3VFL</sub>	V <sub>DD3VFL</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	GPIO48	GPIO49	GPIO50	GPIO51	R	
P	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	GPIO52	GPIO53	GPIO54	GPIO55	P	
	11	12	13	N	V <sub>DDIO</sub>	V <sub>DDIO</sub>	GPIO56	GPIO58	GPIO57	GPIO139	N
M	V <sub>SS</sub>	V <sub>SS</sub>	M	V <sub>SS</sub>	V <sub>SS</sub>	GPIO59	GPIO60	GPIO141	GPIO140	M	
L	V <sub>SS</sub>	V <sub>SS</sub>	L	V <sub>DDIO</sub>	V <sub>DDIO</sub>	GPIO61	GPIO64	V <sub>SS</sub>	GPIO142	L	
K	V <sub>SS</sub>	V <sub>SS</sub>	K	V <sub>SS</sub>	V <sub>SS</sub>	GPIO65	GPIO66	GPIO44	GPIO45	K	

	11	12	14	15	16	17	18	19

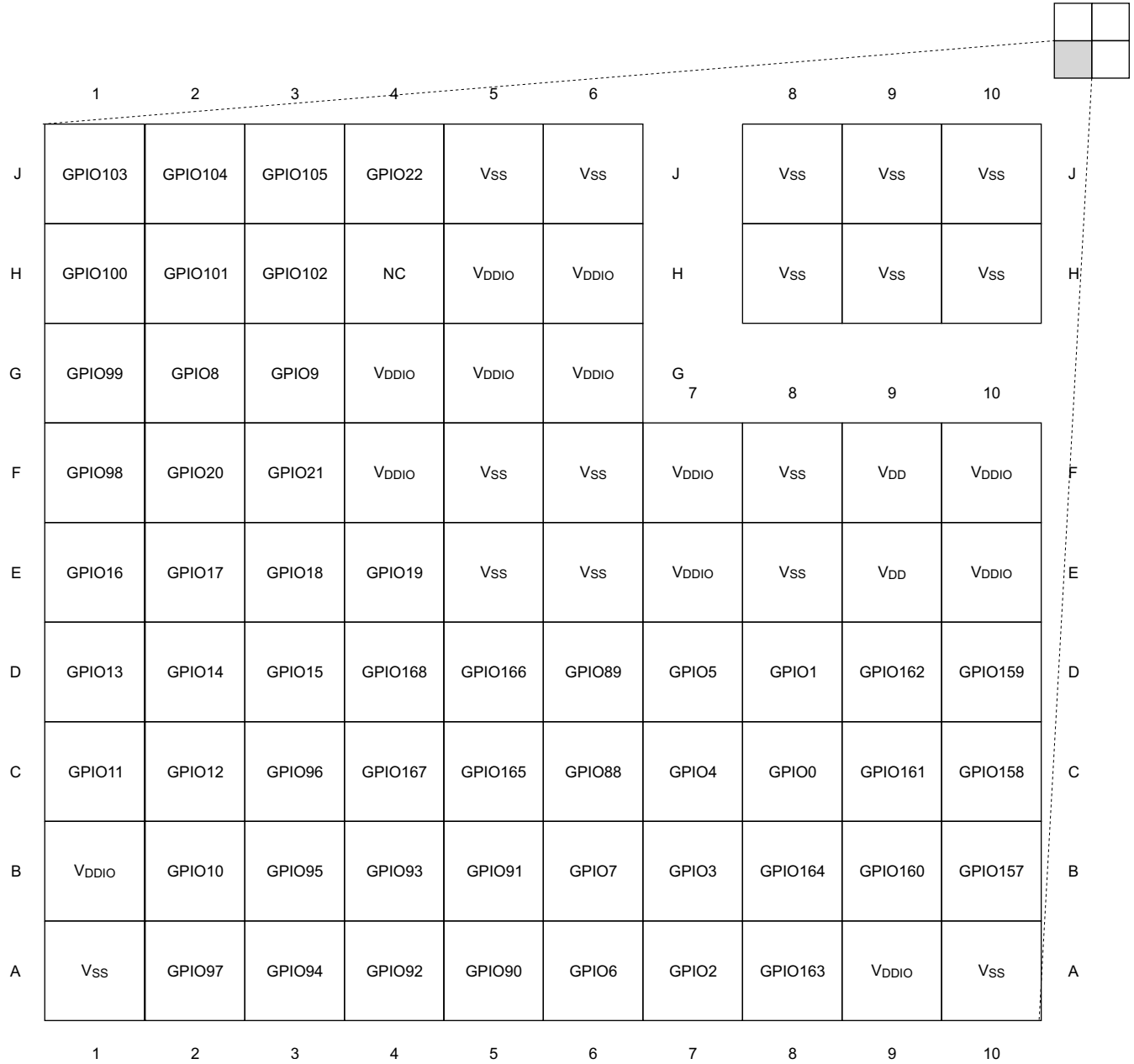
A. Only the GPIO function is shown on GPIO terminals. See [Table 4-1](#) for the complete, muxed signal name.

**Figure 4-2. 337-Ball ZWT New Fine Pitch Ball Grid Array (Bottom View) – [Quadrant B]**



A. Only the GPIO function is shown on GPIO terminals. See Table 4-1 for the complete, muxed signal name.

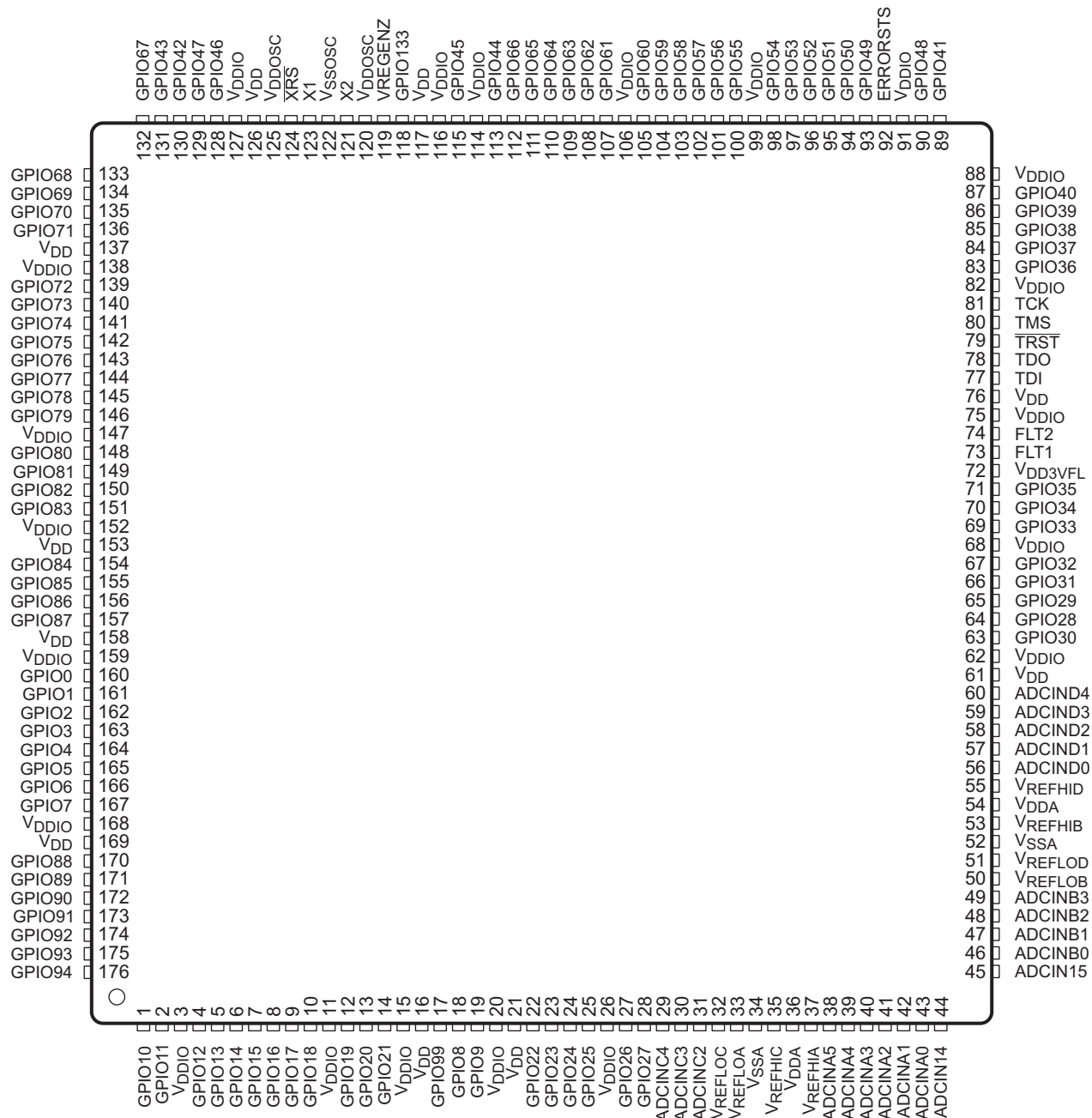
**Figure 4-3. 337-Ball ZWT New Fine Pitch Ball Grid Array (Bottom View) – [Quadrant C]**



	1	2	3	4	5	6		8	9	10	
J	GPIO103	GPIO104	GPIO105	GPIO22	Vss	Vss	J	Vss	Vss	Vss	J
H	GPIO100	GPIO101	GPIO102	NC	VDDIO	VDDIO	H	Vss	Vss	Vss	H
G	GPIO99	GPIO8	GPIO9	VDDIO	VDDIO	VDDIO	G	7	8	9	10
F	GPIO98	GPIO20	GPIO21	VDDIO	Vss	Vss	VDDIO	Vss	VDD	VDDIO	F
E	GPIO16	GPIO17	GPIO18	GPIO19	Vss	Vss	VDDIO	Vss	VDD	VDDIO	E
D	GPIO13	GPIO14	GPIO15	GPIO168	GPIO166	GPIO89	GPIO5	GPIO1	GPIO162	GPIO159	D
C	GPIO11	GPIO12	GPIO96	GPIO167	GPIO165	GPIO88	GPIO4	GPIO0	GPIO161	GPIO158	C
B	VDDIO	GPIO10	GPIO95	GPIO93	GPIO91	GPIO7	GPIO3	GPIO164	GPIO160	GPIO157	B
A	Vss	GPIO97	GPIO94	GPIO92	GPIO90	GPIO6	GPIO2	GPIO163	VDDIO	Vss	A

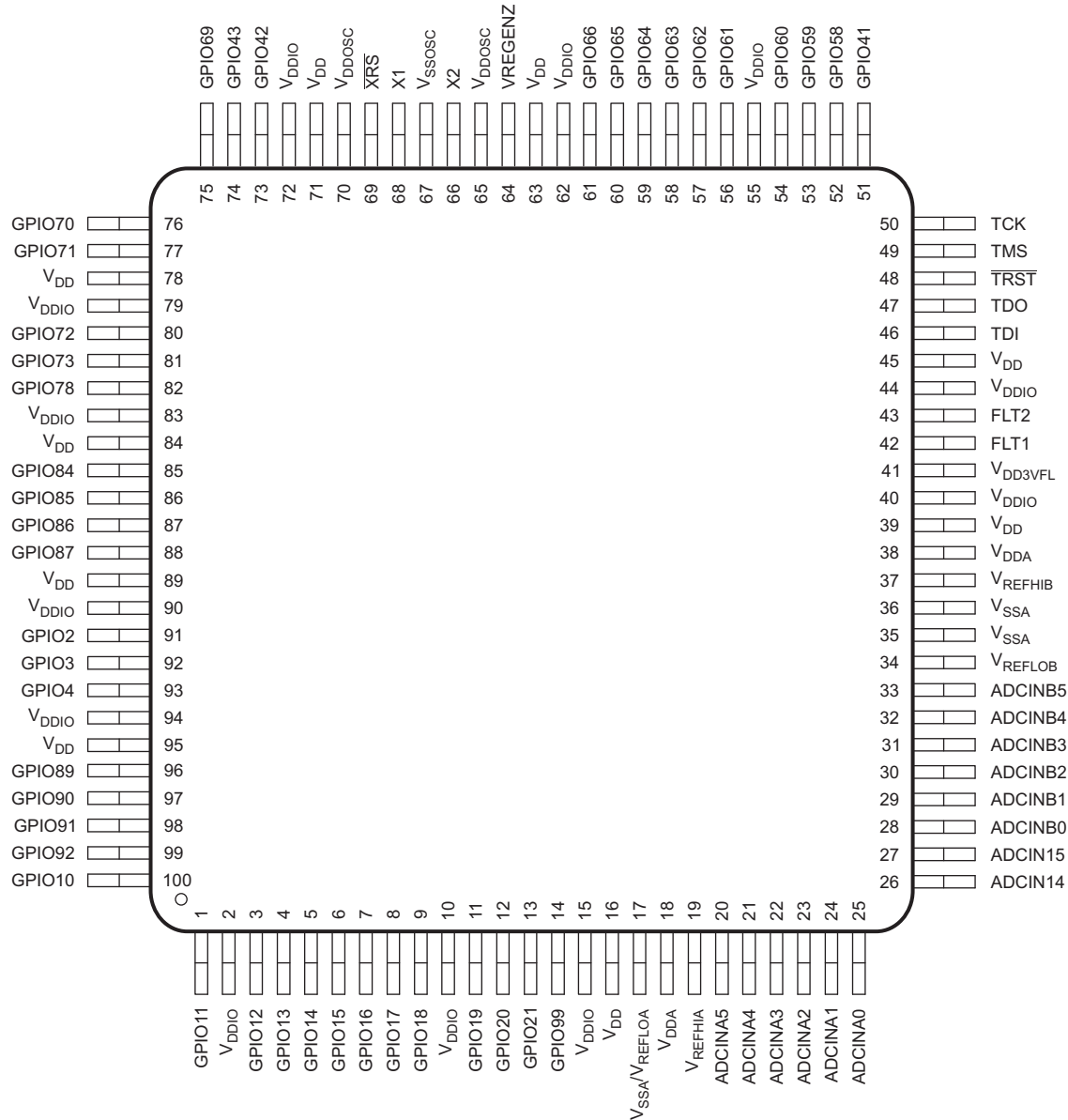
A. Only the GPIO function is shown on GPIO terminals. See [Table 4-1](#) for the complete, muxed signal name.

**Figure 4-4. 337-Ball ZWT New Fine Pitch Ball Grid Array (Bottom View) – [Quadrant D]**



A. Only the GPIO function is shown on GPIO pins. See Table 4-1 for the complete, muxed signal name.

**Figure 4-5. 176-Pin PTP PowerPAD Thermally Enhanced Low-Profile Quad Flatpack (Top View)**



A. Only the GPIO function is shown on GPIO pins. See [Table 4-1](#) for the complete, muxed signal name.

**Figure 4-6. 100-Pin PZP PowerPAD HTQFP (Top View)**

**NOTE**

PCB footprints and schematic symbols are available for download in a vendor-neutral format, which can be exported to the leading EDA CAD/CAE design tools. See the “CAD/CAE symbols” section in each device’s product folder, under the Packaging section. These can also be searched for at <http://webench.ti.com/cad/>.

## 4.2 Signal Descriptions

Table 4-1 describes the signals. The GPIO function is the default at reset, unless otherwise mentioned. The peripheral signals that are listed under them are alternate functions. Some peripheral functions may not be available in all devices. See Table 3-1 for details. All GPIO pins are I/O/Z and have an internal pullup, which can be selectively enabled or disabled on a per-pin basis. This feature only applies to the GPIO pins. The pullups are not enabled at reset.

**Table 4-1. Signal Descriptions**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
<b>ADC, DAC, AND COMPARATOR SIGNALS</b>						
V <sub>REFHIA</sub>		V1	37	19	I	ADC-A high reference. Place at least a 1-μF capacitor on this pin for the 12-bit mode, or at least a 22-μF capacitor for the 16-bit mode. This capacitor should be placed as close to the device as possible between the V <sub>REFHIA</sub> and V <sub>REFLOA</sub> pins.
V <sub>REFHIB</sub>		W5	53	37	I	ADC-B high reference. Place at least a 1-μF capacitor on this pin for the 12-bit mode, or at least a 22-μF capacitor for the 16-bit mode. This capacitor should be placed as close to the device as possible between the V <sub>REFHIB</sub> and V <sub>REFLOB</sub> pins.
V <sub>REFHIC</sub>		R1	35	–	I	ADC-C high reference. Place at least a 1-μF capacitor on this pin for the 12-bit mode, or at least a 22-μF capacitor for the 16-bit mode. This capacitor should be placed as close to the device as possible between the V <sub>REFHIC</sub> and V <sub>REFLOC</sub> pins.
V <sub>REFHID</sub>		V5	55	–	I	ADC-D high reference. Place at least a 1-μF capacitor on this pin for the 12-bit mode, or at least a 22-μF capacitor for the 16-bit mode. This capacitor should be placed as close to the device as possible between the V <sub>REFHID</sub> and V <sub>REFLOD</sub> pins.
V <sub>REFLOA</sub>		R2	33	17	I	ADC-A low reference. On the PZP package, pin 17 is double-bonded to V <sub>SSA</sub> and V <sub>REFLOA</sub> . On the PZP package, pin 17 must be connected to V <sub>SSA</sub> on the system board.
V <sub>REFLOB</sub>		V6	50	34	I	ADC-B low reference
V <sub>REFLOC</sub>		P2	32	–	I	ADC-C low reference
V <sub>REFLOD</sub>		W6	51	–	I	ADC-D low reference
ADCIN14		T4	44	26	I	Input 14 to all ADCs. This pin can be used as a general-purpose ADCIN pin or it can be used to calibrate all ADCs together (either single-ended or differential) from an external reference.
CMPIN4P					I	Comparator 4 positive input
ADCIN15		U4	45	27	I	Input 15 to all ADCs. This pin can be used as a general-purpose ADCIN pin or it can be used to calibrate all ADCs together (either single-ended or differential) from an external reference.
CMPIN4N					I	Comparator 4 negative input
ADCINA0		U1	43	25	I	ADC-A input 0. There is a 50-kΩ internal pulldown on this pin in both an ADC input or DAC output mode which cannot be disabled.
DACOUTA					O	DAC-A output
ADCINA1		T1	42	24	I	ADC-A input 1. There is a 50-kΩ internal pulldown on this pin in both an ADC input or DAC output mode which cannot be disabled.
DACOUTB					O	DAC-B output



Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
ADCINA2 CMPIN1P		U2	41	23	I I	ADC-A input 2 Comparator 1 positive input
ADCINA3 CMPIN1N		T2	40	22	I I	ADC-A input 3 Comparator 1 negative input
ADCINA4 CMPIN2P		U3	39	21	I I	ADC-A input 4 Comparator 2 positive input
ADCINA5 CMPIN2N		T3	38	20	I I	ADC-A input 5 Comparator 2 negative input
ADCINB0  VDAC		V2	46	28	I I	ADC-B input 0. There is a 100-pF capacitor to V <sub>SSA</sub> on this pin in both ADC input or DAC reference mode which cannot be disabled. If this pin is being used as a reference for the on-chip DACs, place at least a 1-μF capacitor on this pin.  Optional external reference voltage for on-chip DACs. There is a 100-pF capacitor to V <sub>SSA</sub> on this pin in both ADC input or DAC reference mode which cannot be disabled. If this pin is being used as a reference for the on-chip DACs, place at least a 1-μF capacitor on this pin.
ADCINB1  DACOUTC		W2	47	29	I O	ADC-B input 1. There is a 50-kΩ internal pulldown on this pin in both an ADC input or DAC output mode which cannot be disabled.  DAC-C output
ADCINB2 CMPIN3P		V3	48	30	I I	ADC-B input 2 Comparator 3 positive input
ADCINB3 CMPIN3N		W3	49	31	I I	ADC-B input 3 Comparator 3 negative input
ADCINB4		V4	–	32	I	ADC-B input 4
ADCINB5		W4	–	33	I	ADC-B input 5
ADCINC2 CMPIN6P		R3	31	–	I I	ADC-C input 2 Comparator 6 positive input
ADCINC3 CMPIN6N		P3	30	–	I I	ADC-C input 3 Comparator 6 negative input
ADCINC4 CMPIN5P		R4	29	–	I I	ADC-C input 4 Comparator 5 positive input
ADCINC5 CMPIN5N		P4	–	–	I I	ADC-C input 5 Comparator 5 negative input
ADCIND0 CMPIN7P		T5	56	–	I I	ADC-D input 0 Comparator 7 positive input
ADCIND1 CMPIN7N		U5	57	–	I I	ADC-D input 1 Comparator 7 negative input
ADCIND2 CMPIN8P		T6	58	–	I I	ADC-D input 2 Comparator 8 positive input
ADCIND3 CMPIN8N		U6	59	–	I I	ADC-D input 3 Comparator 8 negative input
ADCIND4		T7	60	–	I	ADC-D input 4
ADCIND5		U7	–	–	I	ADC-D input 5

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
<b>GPIO AND PERIPHERAL SIGNALS</b>						
GPIO0	0, 4, 8, 12				I/O	General-purpose input/output 0
EPWM1A	1	C8	160	–	O	Enhanced PWM1 output A (HRPWM-capable)
SDAA	6				I/OD	I2C-A data open-drain bidirectional port
GPIO1	0, 4, 8, 12				I/O	General-purpose input/output 1
EPWM1B	1	D8	161	–	O	Enhanced PWM1 output B (HRPWM-capable)
MFSRB	3				I/O	McBSP-B receive frame synch
SCLA	6				I/OD	I2C-A clock open-drain bidirectional port
GPIO2	0, 4, 8, 12				I/O	General-purpose input/output 2
EPWM2A	1	A7	162	91	O	Enhanced PWM2 output A (HRPWM-capable)
OUTPUTXBAR1	5				O	Output 1 of the output XBAR
SDAB	6				I/OD	I2C-B data open-drain bidirectional port
GPIO3	0, 4, 8, 12				I/O	General-purpose input/output 3
EPWM2B	1				O	Enhanced PWM2 output B (HRPWM-capable)
OUTPUTXBAR2	2	B7	163	92	O	Output 2 of the output XBAR
MCLKRB	3				I/O	McBSP-B receive clock
OUTPUTXBAR2	5				O	Output 2 of the output XBAR
SCLB	6				I/OD	I2C-B clock open-drain bidirectional port
GPIO4	0, 4, 8, 12				I/O	General-purpose input/output 4
EPWM3A	1	C7	164	93	O	Enhanced PWM3 output A (HRPWM-capable)
OUTPUTXBAR3	5				O	Output 3 of the output XBAR
CANTXA	6				O	CAN-A transmit
GPIO5	0, 4, 8, 12				I/O	General-purpose input/output 5
EPWM3B	1	D7	165	–	O	Enhanced PWM3 output B (HRPWM-capable)
MFSRA	2				I/O	McBSP-A receive frame synch
OUTPUTXBAR3	3				O	Output 3 of the output XBAR
CANRXA	6				I	CAN-A receive
GPIO6	0, 4, 8, 12				I/O	General-purpose input/output 6
EPWM4A	1	A6	166	–	O	Enhanced PWM4 output A (HRPWM-capable)
OUTPUTXBAR4	2				O	Output 4 of the output XBAR
EXTSYNCOUT	3				O	External ePWM synch pulse output
EQEP3A	5				I	Enhanced QEP3 input A
CANTXB	6				O	CAN-B transmit
GPIO7	0, 4, 8, 12				I/O	General-purpose input/output 7
EPWM4B	1	B6	167	–	O	Enhanced PWM4 output B (HRPWM-capable)
MCLKRA	2				I/O	McBSP-A receive clock
OUTPUTXBAR5	3				O	Output 5 of the output XBAR
EQEP3B	5				I	Enhanced QEP3 input B
CANRXB	6				I	CAN-B receive
GPIO8	0, 4, 8, 12				I/O	General-purpose input/output 8
EPWM5A	1	G2	18	–	O	Enhanced PWM5 output A (HRPWM-capable)
CANTXB	2				O	CAN-B transmit
ADCSOCOA0	3				O	ADC start-of-conversion A output for external ADC
EQEP3S	5				I/O	Enhanced QEP3 strobe
SCITXDA	6				O	SCI-A transmit data

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO9	0, 4, 8, 12				I/O	General-purpose input/output 9
EPWM5B	1				O	Enhanced PWM5 output B (HRPWM-capable)
SCITXDB	2	G3	19	–	O	SCI-B transmit data
OUTPUTXBAR6	3				O	Output 6 of the output XBAR
EQEP3I	5				I/O	Enhanced QEP3 index
SCIRXDA	6				I	SCI-A receive data
GPIO10	0, 4, 8, 12				I/O	General-purpose input/output 10
EPWM6A	1				O	Enhanced PWM6 output A (HRPWM-capable)
CANRXB	2				I	CAN-B receive
ADCSOCBO	3	B2	1	100	O	ADC start-of-conversion B output for external ADC
EQEP1A	5				I	Enhanced QEP1 input A
SCITXDB	6				O	SCI-B transmit data
UPP-WAIT	15				I/O	Universal parallel port wait. Receiver asserts to request a pause in transfer.
GPIO11	0, 4, 8, 12				I/O	General-purpose input/output 11
EPWM6B	1				O	Enhanced PWM6 output B (HRPWM-capable)
SCIRXDB	2, 6				I	SCI-B receive data
OUTPUTXBAR7	3	C1	2	1	O	Output 7 of the output XBAR
EQEP1B	5				I	Enhanced QEP1 input B
UPP-START	15				I/O	Universal parallel port start. Transmitter asserts at start of DMA line.
GPIO12	0, 4, 8, 12				I/O	General-purpose input/output 12
EPWM7A	1				O	Enhanced PWM7 output A (HRPWM-capable)
CANTXB	2				O	CAN-B transmit
MDXB	3	C2	4	3	O	McBSP-B transmit serial data
EQEP1S	5				I/O	Enhanced QEP1 strobe
SCITXDC	6				O	SCI-C transmit data
UPP-ENA	15				I/O	Universal parallel port enable. Transmitter asserts while data bus is active.
GPIO13	0, 4, 8, 12				I/O	General-purpose input/output 13
EPWM7B	1				O	Enhanced PWM7 output B (HRPWM-capable)
CANRXB	2				I	CAN-B receive
MDRB	3	D1	5	4	I	McBSP-B receive serial data
EQEP1I	5				I/O	Enhanced QEP1 index
SCIRXDC	6				I	SCI-C receive data
UPP-D7	15				I/O	Universal parallel port data line 7
GPIO14	0, 4, 8, 12				I/O	General-purpose input/output 14
EPWM8A	1				O	Enhanced PWM8 output A (HRPWM-capable)
SCITXDB	2				O	SCI-B transmit data
MCLKXB	3	D2	6	5	I/O	McBSP-B transmit clock
OUTPUTXBAR3	6				O	Output 3 of the output XBAR
UPP-D6	15				I/O	Universal parallel port data line 6

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO15	0, 4, 8, 12				I/O	General-purpose input/output 15
EPWM8B	1				O	Enhanced PWM8 output B (HRPWM-capable)
SCIRXDB	2	D3	7	6	I	SCI-B receive data
MFSXB	3				I/O	McBSP-B transmit frame synch
OUTPUTXBAR4	6				O	Output 4 of the output XBAR
UPP-D5	15				I/O	Universal parallel port data line 5
GPIO16	0, 4, 8, 12				I/O	General-purpose input/output 16
SPISIMOA	1				I/O	SPI-A slave in, master out
CANTXB	2				O	CAN-B transmit
OUTPUTXBAR7	3	E1	8	7	O	Output 7 of the output XBAR
EPWM9A	5				O	Enhanced PWM9 output A
SD1_D1	7				I	Sigma-Delta 1 channel 1 data input
UPP-D4	15				I/O	Universal parallel port data line 4
GPIO17	0, 4, 8, 12				I/O	General-purpose input/output 17
SPISOMIA	1				I/O	SPI-A slave out, master in
CANRXB	2				I	CAN-B receive
OUTPUTXBAR8	3	E2	9	8	O	Output 8 of the output XBAR
EPWM9B	5				O	Enhanced PWM9 output B
SD1_C1	7				I	Sigma-Delta 1 channel 1 clock input
UPP-D3	15				I/O	Universal parallel port data line 3
GPIO18	0, 4, 8, 12				I/O	General-purpose input/output 18
SPICLKA	1				I/O	SPI-A clock
SCITXDB	2				O	SCI-B transmit data
CANRXA	3	E3	10	9	I	CAN-A receive
EPWM10A	5				O	Enhanced PWM10 output A
SD1_D2	7				I	Sigma-Delta 1 channel 2 data input
UPP-D2	15				I/O	Universal parallel port data line 2
GPIO19	0, 4, 8, 12				I/O	General-purpose input/output 19
SPISTEA	1				I/O	SPI-A slave transmit enable
SCIRXDB	2				I	SCI-B receive data
CANTXA	3	E4	12	11	O	CAN-A transmit
EPWM10B	5				O	Enhanced PWM10 output B
SD1_C2	7				I	Sigma-Delta 1 channel 2 clock input
UPP-D1	15				I/O	Universal parallel port data line 1
GPIO20	0, 4, 8, 12				I/O	General-purpose input/output 20
EQEP1A	1				I	Enhanced QEP1 input A
MDXA	2				O	McBSP-A transmit serial data
CANTXB	3	F2	13	12	O	CAN-B transmit
EPWM11A	5				O	Enhanced PWM11 output A
SD1_D3	7				I	Sigma-Delta 1 channel 3 data input
UPP-D0	15				I/O	Universal parallel port data line 0

Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO21	0, 4, 8, 12				I/O	General-purpose input/output 21
EQEP1B	1				I	Enhanced QEP1 input B
MDRA	2				I	McBSP-A receive serial data
CANRXB	3	F3	14	13	I	CAN-B receive
EPWM11B	5				O	Enhanced PWM11 output B
SD1_C3	7				I	Sigma-Delta 1 channel 3 clock input
UPP-CLK	15				I/O	Universal parallel port transmit clock
GPIO22	0, 2, 4, 8				I/O	General-purpose input/output 22
EQEP1S	1				I/O	Enhanced QEP1 strobe
MCLKXA	2				I/O	McBSP-A transmit clock
SCITXDB	3	J4	22	–	O	SCI-B transmit data
EPWM12A	5				O	Enhanced PWM12 output A
SPICLKB	6				I/O	SPI-B clock
SD1_D4	7				I	Sigma-Delta 1 channel 4 data input
GPIO23	0, 2, 4, 8				I/O	General-purpose input/output 23
EQEP1I	1				I/O	Enhanced QEP1 index
MFSXA	2				I/O	McBSP-A transmit frame synch
SCIRXDB	3	K4	23	–	I	SCI-B receive data
EPWM12B	5				O	Enhanced PWM12 output B
$\overline{\text{SPISTEB}}$	6				I/O	SPI-B slave transmit enable
SD1_C4	7				I	Sigma-Delta 1 channel 4 clock input
GPIO24	0, 4, 8, 12				I/O	General-purpose input/output 24
OUTPUTXBAR1	1				O	Output 1 of the output XBAR
EQEP2A	2				I	Enhanced QEP2 input A
MDXB	3	K3	24	–	O	McBSP-B transmit serial data
SPISIMOB	6				I/O	SPI-B slave in, master out
SD2_D1	7				I	Sigma-Delta 2 channel 1 data input
GPIO25	0, 4, 8, 12				I/O	General-purpose input/output 25
OUTPUTXBAR2	1				O	Output 2 of the output XBAR
EQEP2B	2				I	Enhanced QEP2 input B
MDRB	3	K2	25	–	I	McBSP-B receive serial data
SPISOMIB	6				I/O	SPI-B slave out, master in
SD2_C1	7				I	Sigma-Delta 2 channel 1 clock input
GPIO26	0, 4, 8, 12				I/O	General-purpose input/output 26
OUTPUTXBAR3	1				O	Output 3 of the output XBAR
EQEP2I	2				I/O	Enhanced QEP2 index
MCLKXB	3	K1	27	–	I/O	McBSP-B transmit clock
OUTPUTXBAR3	5				O	Output 3 of the output XBAR
SPICLKB	6				I/O	SPI-B clock
SD2_D2	7				I	Sigma-Delta 2 channel 2 data input

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO27	0, 4, 8, 12				I/O	General-purpose input/output 27
OUTPUTXBAR4	1				O	Output 4 of the output XBAR
EQEP2S	2				I/O	Enhanced QEP2 strobe
MFSXB	3	L1	28	–	I/O	McBSP-B transmit frame synch
OUTPUTXBAR4	5				O	Output 4 of the output XBAR
$\overline{\text{SPISTEB}}$	6				I/O	SPI-B slave transmit enable
SD2_C2	7				I	Sigma-Delta 2 channel 2 clock input
GPIO28	0, 4, 8, 12				I/O	General-purpose input/output 28
SCIRXDA	1				I	SCI-A receive data
$\overline{\text{EM1CS4}}$	2	V11	64	–	O	External memory interface 1 chip select 4
OUTPUTXBAR5	5				O	Output 5 of the output XBAR
EQEP3A	6				I	Enhanced QEP3 input A
SD2_D3	7				I	Sigma-Delta 2 channel 3 data input
GPIO29	0, 4, 8, 12				I/O	General-purpose input/output 29
SCITXDA	1				O	SCI-A transmit data
EM1SDCKE	2	W11	65	–	O	External memory interface 1 SDRAM clock enable
OUTPUTXBAR6	5				O	Output 6 of the output XBAR
EQEP3B	6				I	Enhanced QEP3 input B
SD2_C3	7				I	Sigma-Delta 2 channel 3 clock input
GPIO30	0, 4, 8, 12				I/O	General-purpose input/output 30
CANRXA	1				I	CAN-A receive
EM1CLK	2	T11	63	–	O	External memory interface 1 clock
OUTPUTXBAR7	5				O	Output 7 of the output XBAR
EQEP3S	6				I/O	Enhanced QEP3 strobe
SD2_D4	7				I	Sigma-Delta 2 channel 4 data input
GPIO31	0, 4, 8, 12				I/O	General-purpose input/output 31
CANTXA	1				O	CAN-A transmit
$\overline{\text{EM1WE}}$	2	U11	66	–	O	External memory interface 1 write enable
OUTPUTXBAR8	5				O	Output 8 of the output XBAR
EQEP3I	6				I/O	Enhanced QEP3 index
SD2_C4	7				I	Sigma-Delta 2 channel 4 clock input
GPIO32	0, 4, 8, 12				I/O	General-purpose input/output 32
SDAA	1	U13	67	–	I/OD	I2C-A data open-drain bidirectional port
$\overline{\text{EM1CS0}}$	2				O	External memory interface 1 chip select 0
GPIO33	0, 4, 8, 12				I/O	General-purpose input/output 33
SCLA	1	T13	69	–	I/OD	I2C-A clock open-drain bidirectional port
EM1RNW	2				O	External memory interface 1 read not write
GPIO34	0, 4, 8, 12				I/O	General-purpose input/output 34
OUTPUTXBAR1	1	U14	70	–	O	Output 1 of the output XBAR
$\overline{\text{EM1CS2}}$	2				O	External memory interface 1 chip select 2
SDAB	6				I/OD	I2C-B data open-drain bidirectional port
GPIO35	0, 4, 8, 12				I/O	General-purpose input/output 35
SCIRXDA	1	T14	71	–	I	SCI-A receive data
$\overline{\text{EM1CS3}}$	2				O	External memory interface 1 chip select 3
SCLB	6				I/OD	I2C-B clock open-drain bidirectional port

Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO36	0, 4, 8, 12	V16	83	–	I/O	General-purpose input/output 36
SCITXDA	1				O	SCI-A transmit data
EM1WAIT	2				I	External memory interface 1 Asynchronous SRAM WAIT
CANRXA	6				I	CAN-A receive
GPIO37	0, 4, 8, 12	U16	84	–	I/O	General-purpose input/output 37
OUTPUTXBAR2	1				O	Output 2 of the output XBAR
EM1OE	2				O	External memory interface 1 output enable
CANTXA	6				O	CAN-A transmit
GPIO38	0, 4, 8, 12	T16	85	–	I/O	General-purpose input/output 38
EM1A0	2				O	External memory interface 1 address line 0
SCITXDC	5				O	SCI-C transmit data
CANTXB	6				O	CAN-B transmit
GPIO39	0, 4, 8, 12	W17	86	–	I/O	General-purpose input/output 39
EM1A1	2				O	External memory interface 1 address line 1
SCIRXDC	5				I	SCI-C receive data
CANRXB	6				I	CAN-B receive
GPIO40	0, 4, 8, 12	V17	87	–	I/O	General-purpose input/output 40
EM1A2	2				O	External memory interface 1 address line 2
SDAB	6				I/OD	I2C-B data open-drain bidirectional port
GPIO41	0, 4, 8, 12	U17	89	51	I/O	General-purpose input/output 41. For applications using the Hibernate low-power mode, this pin serves as the GPIOHIBWAKE signal. For details, see the "Low Power Modes" section of the System Control chapter in the <i>TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)</i> .
EM1A3	2				O	External memory interface 1 address line 3
SCLB	6				I/OD	I2C-B clock open-drain bidirectional port
GPIO42	0, 4, 8, 12	D19	130	73	I/O	General-purpose input/output 42
SDAA	6				I/OD	I2C-A data open-drain bidirectional port
SCITXDA	15				O	SCI-A transmit data
USB0DM	Analog				I/O	USB PHY differential data
GPIO43	0, 4, 8, 12	C19	131	74	I/O	General-purpose input/output 43
SCLA	6				I/OD	I2C-A clock open-drain bidirectional port
SCIRXDA	15				I	SCI-A receive data
USB0DP	Analog				I/O	USB PHY differential data
GPIO44	0, 4, 8, 12	K18	113	–	I/O	General-purpose input/output 44
EM1A4	2				O	External memory interface 1 address line 4
GPIO45	0, 4, 8, 12	K19	115	–	I/O	General-purpose input/output 45
EM1A5	2				O	External memory interface 1 address line 5
GPIO46	0, 4, 8, 12	E19	128	–	I/O	General-purpose input/output 46
EM1A6	2				O	External memory interface 1 address line 6
SCIRXDD	6				I	SCI-D receive data
GPIO47	0, 4, 8, 12	E18	129	–	I/O	General-purpose input/output 47
EM1A7	2				O	External memory interface 1 address line 7
SCITXDD	6				O	SCI-D transmit data



**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO48	0, 4, 8, 12				I/O	General-purpose input/output 48
OUTPUTXBAR3	1				O	Output 3 of the output XBAR
EM1A8	2	R16	90	–	O	External memory interface 1 address line 8
SCITXDA	6				O	SCI-A transmit data
SD1_D1	7				I	Sigma-Delta 1 channel 1 data input
GPIO49	0, 4, 8, 12				I/O	General-purpose input/output 49
OUTPUTXBAR4	1				O	Output 4 of the output XBAR
EM1A9	2	R17	93	–	O	External memory interface 1 address line 9
SCIRXDA	6				I	SCI-A receive data
SD1_C1	7				I	Sigma-Delta 1 channel 1 clock input
GPIO50	0, 4, 8, 12				I/O	General-purpose input/output 50
EQEP1A	1				I	Enhanced QEP1 input A
EM1A10	2	R18	94	–	O	External memory interface 1 address line 10
SPISIMOC	6				I/O	SPI-C slave in, master out
SD1_D2	7				I	Sigma-Delta 1 channel 2 data input
GPIO51	0, 4, 8, 12				I/O	General-purpose input/output 51
EQEP1B	1				I	Enhanced QEP1 input B
EM1A11	2	R19	95	–	O	External memory interface 1 address line 11
SPISOMIC	6				I/O	SPI-C slave out, master in
SD1_C2	7				I	Sigma-Delta 1 channel 2 clock input
GPIO52	0, 4, 8, 12				I/O	General-purpose input/output 52
EQEP1S	1				I/O	Enhanced QEP1 strobe
EM1A12	2	P16	96	–	O	External memory interface 1 address line 12
SPICLK	6				I/O	SPI-C clock
SD1_D3	7				I	Sigma-Delta 1 channel 3 data input
GPIO53	0, 4, 8, 12				I/O	General-purpose input/output 53
EQEP1I	1				I/O	Enhanced QEP1 index
EM1D31	2	P17	97	–	I/O	External memory interface 1 data line 31
EM2D15	3				I/O	External memory interface 2 data line 15
$\overline{\text{SPISTEC}}$	6				I/O	SPI-C slave transmit enable
SD1_C3	7				I	Sigma-Delta 1 channel 3 clock input
GPIO54	0, 4, 8, 12				I/O	General-purpose input/output 54
SPISIMOA	1				I/O	SPI-A slave in, master out
EM1D30	2				I/O	External memory interface 1 data line 30
EM2D14	3	P18	98	–	I/O	External memory interface 2 data line 14
EQEP2A	5				I	Enhanced QEP2 input A
SCITXDB	6				O	SCI-B transmit data
SD1_D4	7				I	Sigma-Delta 1 channel 4 data input
GPIO55	0, 4, 8, 12				I/O	General-purpose input/output 55
SPISOMIA	1				I/O	SPI-A slave out, master in
EM1D29	2				I/O	External memory interface 1 data line 29
EM2D13	3	P19	100	–	I/O	External memory interface 2 data line 13
EQEP2B	5				I	Enhanced QEP2 input B
SCIRXDB	6				I	SCI-B receive data
SD1_C4	7				I	Sigma-Delta 1 channel 4 clock input

Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO56	0, 4, 8, 12				I/O	General-purpose input/output 56
SPICLKA	1				I/O	SPI-A clock
EM1D28	2				I/O	External memory interface 1 data line 28
EM2D12	3	N16	101	–	I/O	External memory interface 2 data line 12
EQEP2S	5				I/O	Enhanced QEP2 strobe
SCITXDC	6				O	SCI-C transmit data
SD2_D1	7				I	Sigma-Delta 2 channel 1 data input
GPIO57	0, 4, 8, 12				I/O	General-purpose input/output 57
SPISTEA	1				I/O	SPI-A slave transmit enable
EM1D27	2				I/O	External memory interface 1 data line 27
EM2D11	3	N18	102	–	I/O	External memory interface 2 data line 11
EQEP2I	5				I/O	Enhanced QEP2 index
SCIRXDC	6				I	SCI-C receive data
SD2_C1	7				I	Sigma-Delta 2 channel 1 clock input
GPIO58	0, 4, 8, 12				I/O	General-purpose input/output 58
MCLKRA	1				I/O	McBSP-A receive clock
EM1D26	2				I/O	External memory interface 1 data line 26
EM2D10	3				I/O	External memory interface 2 data line 10
OUTPUTXBAR1	5	N17	103	52	O	Output 1 of the output XBAR
SPICLKB	6				I/O	SPI-B clock
SD2_D2	7				I	Sigma-Delta 2 channel 2 data input
SPISIMOA	15				I/O	SPI-A slave in, master out <sup>(2)</sup>
GPIO59	0, 4, 8, 12				I/O	General-purpose input/output 59 <sup>(3)</sup>
MFSRA	1				I/O	McBSP-A receive frame synch
EM1D25	2				I/O	External memory interface 1 data line 25
EM2D9	3				I/O	External memory interface 2 data line 9
OUTPUTXBAR2	5	M16	104	53	O	Output 2 of the output XBAR
SPISTEB	6				I/O	SPI-B slave transmit enable
SD2_C2	7				I	Sigma-Delta 2 channel 2 clock input
SPISOMIA	15				I/O	SPI-A slave out, master in <sup>(2)</sup>
GPIO60	0, 4, 8, 12				I/O	General-purpose input/output 60
MCLKRB	1				I/O	McBSP-B receive clock
EM1D24	2				I/O	External memory interface 1 data line 24
EM2D8	3				I/O	External memory interface 2 data line 8
OUTPUTXBAR3	5	M17	105	54	O	Output 3 of the output XBAR
SPISIMOB	6				I/O	SPI-B slave in, master out
SD2_D3	7				I	Sigma-Delta 2 channel 3 data input
SPICLKA	15				I/O	SPI-A clock <sup>(2)</sup>

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO61	0, 4, 8, 12	L16	107	56	I/O	General-purpose input/output 61 <sup>(3)</sup>
MFSRB	1				I/O	McBSP-B receive frame synch
EM1D23	2				I/O	External memory interface 1 data line 23
EM2D7	3				I/O	External memory interface 2 data line 7
OUTPUTXBAR4	5				O	Output 4 of the output XBAR
SPISOMIB	6				I/O	SPI-B slave out, master in
SD2_C3	7				I	Sigma-Delta 2 channel 3 clock input
SPISTEA	15				I/O	SPI-A slave transmit enable <sup>(2)</sup>
GPIO62	0, 4, 8, 12	J17	108	57	I/O	General-purpose input/output 62
SCIRXDC	1				I	SCI-C receive data
EM1D22	2				I/O	External memory interface 1 data line 22
EM2D6	3				I/O	External memory interface 2 data line 6
EQEP3A	5				I	Enhanced QEP3 input A
CANRXA	6				I	CAN-A receive
SD2_D4	7				I	Sigma-Delta 2 channel 4 data input
GPIO63	0, 4, 8, 12	J16	109	58	I/O	General-purpose input/output 63
SCITXDC	1				O	SCI-C transmit data
EM1D21	2				I/O	External memory interface 1 data line 21
EM2D5	3				I/O	External memory interface 2 data line 5
EQEP3B	5				I	Enhanced QEP3 input B
CANTXA	6				O	CAN-A transmit
SD2_C4	7				I	Sigma-Delta 2 channel 4 clock input
SPISIMOB	15				I/O	SPI-B slave in, master out <sup>(2)</sup>
GPIO64	0, 4, 8, 12	L17	110	59	I/O	General-purpose input/output 64 <sup>(3)</sup>
EM1D20	2				I/O	External memory interface 1 data line 20
EM2D4	3				I/O	External memory interface 2 data line 4
EQEP3S	5				I/O	Enhanced QEP3 strobe
SCIRXDA	6				I	SCI-A receive data
SPISOMIB	15				I/O	SPI-B slave out, master in <sup>(2)</sup>
GPIO65	0, 4, 8, 12	K16	111	60	I/O	General-purpose input/output 65
EM1D19	2				I/O	External memory interface 1 data line 19
EM2D3	3				I/O	External memory interface 2 data line 3
EQEP3I	5				I/O	Enhanced QEP3 index
SCITXDA	6				O	SCI-A transmit data
SPICLKB	15				I/O	SPI-B clock <sup>(2)</sup>
GPIO66	0, 4, 8, 12	K17	112	61	I/O	General-purpose input/output 66 <sup>(3)</sup>
EM1D18	2				I/O	External memory interface 1 data line 18
EM2D2	3				I/O	External memory interface 2 data line 2
SDAB	6				I/OD	I2C-B data open-drain bidirectional port
SPISTEB	15				I/O	SPI-B slave transmit enable <sup>(2)</sup>
GPIO67	0, 4, 8, 12	B19	132	–	I/O	General-purpose input/output 67
EM1D17	2				I/O	External memory interface 1 data line 17
EM2D1	3				I/O	External memory interface 2 data line 1

Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO68	0, 4, 8, 12				I/O	General-purpose input/output 68
EM1D16	2	C18	133	–	I/O	External memory interface 1 data line 16
EM2D0	3				I/O	External memory interface 2 data line 0
GPIO69	0, 4, 8, 12				I/O	General-purpose input/output 69
EM1D15	2	B18	134	75	I/O	External memory interface 1 data line 15
SCLB	6				I/OD	I2C-B clock open-drain bidirectional port
SPISIMOC	15				I/O	SPI-C slave in, master out <sup>(2)</sup>
GPIO70	0, 4, 8, 12				I/O	General-purpose input/output 70 <sup>(3)</sup>
EM1D14	2				I/O	External memory interface 1 data line 14
CANRXA	5	A17	135	76	I	CAN-A receive
SCITXDB	6				O	SCI-B transmit data
SPISOMIC	15				I/O	SPI-C slave out, master in <sup>(2)</sup>
GPIO71	0, 4, 8, 12				I/O	General-purpose input/output 71
EM1D13	2				I/O	External memory interface 1 data line 13
CANTXA	5	B17	136	77	O	CAN-A transmit
SCIRXDB	6				I	SCI-B receive data
SPICLK	15				I/O	SPI-C clock <sup>(2)</sup>
GPIO72	0, 4, 8, 12				I/O	General-purpose input/output 72. <sup>(3)</sup> This is the factory default boot mode select pin 1.
EM1D12	2	B16	139	80	I/O	External memory interface 1 data line 12
CANTXB	5				O	CAN-B transmit
SCITXDC	6				O	SCI-C transmit data
SPISTEC	15				I/O	SPI-C slave transmit enable <sup>(2)</sup>
GPIO73	0, 4, 8, 12				I/O	General-purpose input/output 73
EM1D11	2				I/O	External memory interface 1 data line 11
XCLKOUT	3	A16	140	81	O/Z	External clock output. This pin outputs a divided-down version of a chosen clock signal from within the device. The clock signal is chosen using the CLKSRCCTL3.XCLKOUTSEL bit field while the divide ratio is chosen using the XCLKOUTDIVSEL.XCLKOUTDIV bit field.
CANRXB	5				I	CAN-B receive
SCIRXDC	6				I	SCI-C receive
GPIO74	0, 4, 8, 12				I/O	General-purpose input/output 74
EM1D10	2	C17	141	–	I/O	External memory interface 1 data line 10
GPIO75	0, 4, 8, 12				I/O	General-purpose input/output 75
EM1D9	2	D16	142	–	I/O	External memory interface 1 data line 9
GPIO76	0, 4, 8, 12				I/O	General-purpose input/output 76
EM1D8	2	C16	143	–	I/O	External memory interface 1 data line 8
SCITXDD	6				O	SCI-D transmit data
GPIO77	0, 4, 8, 12				I/O	General-purpose input/output 77
EM1D7	2	A15	144	–	I/O	External memory interface 1 data line 7
SCIRXDD	6				I	SCI-D receive data
GPIO78	0, 4, 8, 12				I/O	General-purpose input/output 78
EM1D6	2	B15	145	82	I/O	External memory interface 1 data line 6
EQEP2A	6				I	Enhanced QEP2 input A

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO79	0, 4, 8, 12				I/O	General-purpose input/output 79
EM1D5	2	C15	146	–	I/O	External memory interface 1 data line 5
EQEP2B	6				I	Enhanced QEP2 input B
GPIO80	0, 4, 8, 12				I/O	General-purpose input/output 80
EM1D4	2	D15	148	–	I/O	External memory interface 1 data line 4
EQEP2S	6				I/O	Enhanced QEP2 strobe
GPIO81	0, 4, 8, 12				I/O	General-purpose input/output 81
EM1D3	2	A14	149	–	I/O	External memory interface 1 data line 3
EQEP2I	6				I/O	Enhanced QEP2 index
GPIO82	0, 4, 8, 12				I/O	General-purpose input/output 82
EM1D2	2	B14	150	–	I/O	External memory interface 1 data line 2
GPIO83	0, 4, 8, 12				I/O	General-purpose input/output 83
EM1D1	2	C14	151	–	I/O	External memory interface 1 data line 1
GPIO84	0, 4, 8, 12				I/O	General-purpose input/output 84. This is the factory default boot mode select pin 0.
SCITXDA	5	A11	154	85	O	SCI-A transmit data
MDXB	6				O	McBSP-B transmit serial data
MDXA	15				O	McBSP-A transmit serial data
GPIO85	0, 4, 8, 12				I/O	General-purpose input/output 85
EM1D0	2				I/O	External memory interface 1 data line 0
SCIRXDA	5	B11	155	86	I	SCI-A receive data
MDRB	6				I	McBSP-B receive serial data
MDRA	15				I	McBSP-A receive serial data
GPIO86	0, 4, 8, 12				I/O	General-purpose input/output 86
EM1A13	2				O	External memory interface 1 address line 13
EM1CAS	3	C11	156	87	O	External memory interface 1 column address strobe
SCITXDB	5				O	SCI-B transmit data
MCLKXB	6				I/O	McBSP-B transmit clock
MCLKXA	15				I/O	McBSP-A transmit clock
GPIO87	0, 2, 4, 8				I/O	General-purpose input/output 87
EM1A14	2				O	External memory interface 1 address line 14
EM1RAS	3	D11	157	88	O	External memory interface 1 row address strobe
SCIRXDB	5				I	SCI-B receive data
MFSXB	6				I/O	McBSP-B transmit frame synch
MFSXA	15				I/O	McBSP-A transmit frame synch
GPIO88	0, 2, 4, 8				I/O	General-purpose input/output 88
EM1A15	2	C6	170	–	O	External memory interface 1 address line 15
EM1DQM0	3				O	External memory interface 1 Input/output mask for byte 0
GPIO89	0, 2, 4, 8				I/O	General-purpose input/output 89
EM1A16	2	D6	171	96	O	External memory interface 1 address line 16
EM1DQM1	3				O	External memory interface 1 Input/output mask for byte 1
SCITXDC	6				O	SCI-C transmit data

Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO90	0, 2, 4, 8				I/O	General-purpose input/output 90
EM1A17	2	A5	172	97	O	External memory interface 1 address line 17
EM1DQM2	3				O	External memory interface 1 Input/output mask for byte 2
SCIRXDC	6				I	SCI-C receive data
GPIO91	0, 2, 4, 8				I/O	General-purpose input/output 91
EM1A18	2	B5	173	98	O	External memory interface 1 address line 18
EM1DQM3	3				O	External memory interface 1 Input/output mask for byte 3
SDAA	6				I/OD	I2C-A data open-drain bidirectional port
GPIO92	0, 2, 4, 8				I/O	General-purpose input/output 92
EM1A19	2	A4	174	99	O	External memory interface 1 address line 19
EM1BA1	3				O	External memory interface 1 bank address 1
SCLA	6				I/OD	I2C-A clock open-drain bidirectional port
GPIO93	0, 2, 4, 8				I/O	General-purpose input/output 93
EM1BA0	3	B4	175	–	O	External memory interface 1 bank address 0
SCITXDD	6				O	SCI-D transmit data
GPIO94	0, 2, 4, 8				I/O	General-purpose input/output 94
SCIRXDD	6	A3	176	–	I	SCI-D receive data
GPIO95	0, 2, 4, 8	B3	–	–	I/O	General-purpose input/output 95
GPIO96	0, 2, 4, 8				I/O	General-purpose input/output 96
EM2DQM1	3	C3	–	–	O	External memory interface 2 Input/output mask for byte 1
EQEP1A	5				I	Enhanced QEP1 input A
GPIO97	0, 2, 4, 8				I/O	General-purpose input/output 97
EM2DQM0	3	A2	–	–	O	External memory interface 2 Input/output mask for byte 0
EQEP1B	5				I	Enhanced QEP1 input B
GPIO98	0, 2, 4, 8				I/O	General-purpose input/output 98
EM2A0	3	F1	–	–	O	External memory interface 2 address line 0
EQEP1S	5				I/O	Enhanced QEP1 strobe
GPIO99	0, 2, 4, 8				I/O	General-purpose input/output 99
EM2A1	3	G1	17	14	O	External memory interface 2 address line 1
EQEP1I	5				I/O	Enhanced QEP1 index
GPIO100	0, 4, 8, 12				I/O	General-purpose input/output 100
EM2A2	3	H1	–	–	O	External memory interface 2 address line 2
EQEP2A	5				I	Enhanced QEP2 input A
SPISIMOC	6				I/O	SPI-C slave in, master out
GPIO101	0, 4, 8, 12				I/O	General-purpose input/output 101
EM2A3	3	H2	–	–	O	External memory interface 2 address line 3
EQEP2B	5				I	Enhanced QEP2 input B
SPISOMIC	6				I/O	SPI-C slave out, master in
GPIO102	0, 4, 8, 12				I/O	General-purpose input/output 102
EM2A4	3	H3	–	–	O	External memory interface 2 address line 4
EQEP2S	5				I/O	Enhanced QEP2 strobe
SPICLK	6				I/O	SPI-C clock

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO103	0, 4, 8, 12	J1	–	–	I/O	General-purpose input/output 103
EM2A5	3				O	External memory interface 2 address line 5
EQEP2I	5				I/O	Enhanced QEP2 index
$\overline{\text{SPISTEC}}$	6				I/O	SPI-C slave transmit enable
GPIO104	0, 4, 8, 12	J2	–	–	I/O	General-purpose input/output 104
SDAA	1				I/OD	I2C-A data open-drain bidirectional port
EM2A6	3				O	External memory interface 2 address line 6
EQEP3A	5				I	Enhanced QEP3 input A
SCITXDD	6				O	SCI-D transmit data
GPIO105	0, 4, 8, 12	J3	–	–	I/O	General-purpose input/output 105
SCLA	1				I/OD	I2C-A clock open-drain bidirectional port
EM2A7	3				O	External memory interface 2 address line 7
EQEP3B	5				I	Enhanced QEP3 input B
SCIRXDD	6				I	SCI-D receive data
GPIO106	0, 4, 8, 12	L2	–	–	I/O	General-purpose input/output 106
EM2A8	3				O	External memory interface 2 address line 8
EQEP3S	5				I/O	Enhanced QEP3 strobe
SCITXDC	6				O	SCI-C transmit data
GPIO107	0, 4, 8, 12	L3	–	–	I/O	General-purpose input/output 107
EM2A9	3				O	External memory interface 2 address line 9
EQEP3I	5				I/O	Enhanced QEP3 index
SCIRXDC	6				I	SCI-C receive data
GPIO108	0, 4, 8, 12	L4	–	–	I/O	General-purpose input/output 108
EM2A10	3				O	External memory interface 2 address line 10
GPIO109	0, 4, 8, 12	N2	–	–	I/O	General-purpose input/output 109
EM2A11	3				O	External memory interface 2 address line 11
GPIO110	0, 4, 8, 12	M2	–	–	I/O	General-purpose input/output 110
EM2WAIT	3				I	External memory interface 2 Asynchronous SRAM WAIT
GPIO111	0, 4, 8, 12	M4	–	–	I/O	General-purpose input/output 111
EM2BA0	3				O	External memory interface 2 bank address 0
GPIO112	0, 4, 8, 12	M3	–	–	I/O	General-purpose input/output 112
EM2BA1	3				O	External memory interface 2 bank address 1
GPIO113	0, 4, 8, 12	N4	–	–	I/O	General-purpose input/output 113
EM2CAS	3				O	External memory interface 2 column address strobe
GPIO114	0, 4, 8, 12	N3	–	–	I/O	General-purpose input/output 114
EM2RAS	3				O	External memory interface 2 row address strobe
GPIO115	0, 4, 8, 12	V12	–	–	I/O	General-purpose input/output 115
$\overline{\text{EM2CS0}}$	3				O	External memory interface 2 chip select 0
GPIO116	0, 4, 8, 12	W10	–	–	I/O	General-purpose input/output 116
$\overline{\text{EM2CS2}}$	3				O	External memory interface 2 chip select 2
GPIO117	0, 4, 8, 12	U12	–	–	I/O	General-purpose input/output 117
EM2SDCKE	3				O	External memory interface 2 SDRAM clock enable
GPIO118	0, 4, 8, 12	T12	–	–	I/O	General-purpose input/output 118
EM2CLK	3				O	External memory interface 2 clock



Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO119 EM2RNV	0, 4, 8, 12 3	T15	–	–	I/O O	General-purpose input/output 119 External memory interface 2 read not write
GPIO120 EM2WE USB0PFLT	0, 4, 8, 12 3 15	U15	–	–	I/O O I/O	General-purpose input/output 120 External memory interface 2 write enable USB external regulator power fault indicator
GPIO121 EM2OE USB0EPEN	0, 4, 8, 12 3 15	W16	–	–	I/O O I/O	General-purpose input/output 121 External memory interface 2 output enable USB external regulator enable
GPIO122 SPISIMOC SD1_D1	0, 4, 8, 12 6 7	T8	–	–	I/O I/O I	General-purpose input/output 122 SPI-C slave in, master out Sigma-Delta 1 channel 1 data input
GPIO123 SPISOMIC SD1_C1	0, 4, 8, 12 6 7	U8	–	–	I/O I/O I	General-purpose input/output 123 SPI-C slave out, master in Sigma-Delta 1 channel 1 clock input
GPIO124 SPICLK SD1_D2	0, 4, 8, 12 6 7	V8	–	–	I/O I/O I	General-purpose input/output 124 SPI-C clock Sigma-Delta 1 channel 2 data input
GPIO125 SPISTEC SD1_C2	0, 4, 8, 12 6 7	T9	–	–	I/O I/O I	General-purpose input/output 125 SPI-C slave transmit enable Sigma-Delta 1 channel 2 clock input
GPIO126 SD1_D3	0, 4, 8, 12 7	U9	–	–	I/O I	General-purpose input/output 126 Sigma-Delta 1 channel 3 data input
GPIO127 SD1_C3	0, 4, 8, 12 7	V9	–	–	I/O I	General-purpose input/output 127 Sigma-Delta 1 channel 3 clock input
GPIO128 SD1_D4	0, 4, 8, 12 7	W9	–	–	I/O I	General-purpose input/output 128 Sigma-Delta 1 channel 4 data input
GPIO129 SD1_C4	0, 4, 8, 12 7	T10	–	–	I/O I	General-purpose input/output 129 Sigma-Delta 1 channel 4 clock input
GPIO130 SD2_D1	0, 4, 8, 12 7	U10	–	–	I/O I	General-purpose input/output 130 Sigma-Delta 2 channel 1 data input
GPIO131 SD2_C1	0, 4, 8, 12 7	V10	–	–	I/O I	General-purpose input/output 131 Sigma-Delta 2 channel 1 clock input
GPIO132 SD2_D2	0, 4, 8, 12 7	W18	–	–	I/O I	General-purpose input/output 132 Sigma-Delta 2 channel 2 data input
GPIO133/AUXCLKIN  SD2_C2	0, 4, 8, 12  7	G18	118	–	I/O  I	General-purpose input/output 133. The AUXCLKIN function of this GPIO pin could be used to provide a single-ended 3.3-V level clock signal to the Auxiliary Phase-Locked Loop (AUXPLL), whose output is used for the USB module. The AUXCLKIN clock may also be used for the CAN module.  Sigma-Delta 2 channel 2 clock input
GPIO134 SD2_D3	0, 4, 8, 12 7	V18	–	–	I/O I	General-purpose input/output 134 Sigma-Delta 2 channel 3 data input
GPIO135 SCITXDA SD2_C3	0, 4, 8, 12 6 7	U18	–	–	I/O O I	General-purpose input/output 135 SCI-A transmit data Sigma-Delta 2 channel 3 clock input

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO136 SCIRXDA SD2_D4	0, 4, 8, 12 6 7	T17	–	–	I/O I I	General-purpose input/output 136 SCI-A receive data Sigma-Delta 2 channel 4 data input
GPIO137 SCITXDB SD2_C4	0, 4, 8, 12 6 7	T18	–	–	I/O O I	General-purpose input/output 137 SCI-B transmit data Sigma-Delta 2 channel 4 clock input
GPIO138 SCIRXDB	0, 4, 8, 12 6	T19	–	–	I/O I	General-purpose input/output 138 SCI-B receive data
GPIO139 SCIRXDC	0, 4, 8, 12 6	N19	–	–	I/O I	General-purpose input/output 139 SCI-C receive data
GPIO140 SCITXDC	0, 4, 8, 12 6	M19	–	–	I/O O	General-purpose input/output 140 SCI-C transmit data
GPIO141 SCIRXDD	0, 4, 8, 12 6	M18	–	–	I/O I	General-purpose input/output 141 SCI-D receive data
GPIO142 SCITXDD	0, 4, 8, 12 6	L19	–	–	I/O O	General-purpose input/output 142 SCI-D transmit data
GPIO143	0, 4, 8, 12	F18	–	–	I/O	General-purpose input/output 143
GPIO144	0, 4, 8, 12	F17	–	–	I/O	General-purpose input/output 144
GPIO145 EPWM1A	0, 4, 8, 12 1	E17	–	–	I/O O	General-purpose input/output 145 Enhanced PWM1 output A (HRPWM-capable)
GPIO146 EPWM1B	0, 4, 8, 12 1	D18	–	–	I/O O	General-purpose input/output 146 Enhanced PWM1 output B (HRPWM-capable)
GPIO147 EPWM2A	0, 4, 8, 12 1	D17	–	–	I/O O	General-purpose input/output 147 Enhanced PWM2 output A (HRPWM-capable)
GPIO148 EPWM2B	0, 4, 8, 12 1	D14	–	–	I/O O	General-purpose input/output 148 Enhanced PWM2 output B (HRPWM-capable)
GPIO149 EPWM3A	0, 4, 8, 12 1	A13	–	–	I/O O	General-purpose input/output 149 Enhanced PWM3 output A (HRPWM-capable)
GPIO150 EPWM3B	0, 4, 8, 12 1	B13	–	–	I/O O	General-purpose input/output 150 Enhanced PWM3 output B (HRPWM-capable)
GPIO151 EPWM4A	0, 4, 8, 12 1	C13	–	–	I/O O	General-purpose input/output 151 Enhanced PWM4 output A (HRPWM-capable)
GPIO152 EPWM4B	0, 4, 8, 12 1	D13	–	–	I/O O	General-purpose input/output 152 Enhanced PWM4 output B (HRPWM-capable)
GPIO153 EPWM5A	0, 4, 8, 12 1	A12	–	–	I/O O	General-purpose input/output 153 Enhanced PWM5 output A (HRPWM-capable)
GPIO154 EPWM5B	0, 4, 8, 12 1	B12	–	–	I/O O	General-purpose input/output 154 Enhanced PWM5 output B (HRPWM-capable)
GPIO155 EPWM6A	0, 4, 8, 12 1	C12	–	–	I/O O	General-purpose input/output 155 Enhanced PWM6 output A (HRPWM-capable)
GPIO156 EPWM6B	0, 4, 8, 12 1	D12	–	–	I/O O	General-purpose input/output 156 Enhanced PWM6 output B (HRPWM-capable)
GPIO157 EPWM7A	0, 4, 8, 12 1	B10	–	–	I/O O	General-purpose input/output 157 Enhanced PWM7 output A (HRPWM-capable)

Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
GPIO158 EPWM7B	0, 4, 8, 12 1	C10	–	–	I/O O	General-purpose input/output 158 Enhanced PWM7 output B (HRPWM-capable)
GPIO159 EPWM8A	0, 4, 8, 12 1	D10	–	–	I/O O	General-purpose input/output 159 Enhanced PWM8 output A (HRPWM-capable)
GPIO160 EPWM8B	0, 4, 8, 12 1	B9	–	–	I/O O	General-purpose input/output 160 Enhanced PWM8 output B (HRPWM-capable)
GPIO161 EPWM9A	0, 4, 8, 12 1	C9	–	–	I/O O	General-purpose input/output 161 Enhanced PWM9 output A
GPIO162 EPWM9B	0, 4, 8, 12 1	D9	–	–	I/O O	General-purpose input/output 162 Enhanced PWM9 output B
GPIO163 EPWM10A	0, 4, 8, 12 1	A8	–	–	I/O O	General-purpose input/output 163 Enhanced PWM10 output A
GPIO164 EPWM10B	0, 4, 8, 12 1	B8	–	–	I/O O	General-purpose input/output 164 Enhanced PWM10 output B
GPIO165 EPWM11A	0, 4, 8, 12 1	C5	–	–	I/O O	General-purpose input/output 165 Enhanced PWM11 output A
GPIO166 EPWM11B	0, 4, 8, 12 1	D5	–	–	I/O O	General-purpose input/output 166 Enhanced PWM11 output B
GPIO167 EPWM12A	0, 4, 8, 12 1	C4	–	–	I/O O	General-purpose input/output 167 Enhanced PWM12 output A
GPIO168 EPWM12B	0, 4, 8, 12 1	D4	–	–	I/O O	General-purpose input/output 168 Enhanced PWM12 output B
<b>RESET</b>						
$\overline{\text{XRS}}$		F19	124	69	I/OD	Device Reset (in) and Watchdog Reset (out). The devices have a built-in power-on reset (POR) circuit. During a power-on condition, this pin is driven low by the device. An external circuit may also drive this pin to assert a device reset. This pin is also driven low by the MCU when a watchdog reset or NMI watchdog reset occurs. During watchdog reset, the $\overline{\text{XRS}}$ pin is driven low for the watchdog reset duration of 512 OSCCLK cycles. A resistor with a value from 2.2 k $\Omega$ to 10 k $\Omega$ should be placed between $\overline{\text{XRS}}$ and $V_{\text{DDIO}}$ . If a capacitor is placed between $\overline{\text{XRS}}$ and $V_{\text{SS}}$ for noise filtering, it should be 100 nF or smaller. These values will allow the watchdog to properly drive the $\overline{\text{XRS}}$ pin to $V_{\text{OL}}$ within 512 OSCCLK cycles when the watchdog reset is asserted. The output buffer of this pin is an open drain with an internal pullup.
<b>CLOCKS</b>						
X1		G19	123	68	I	On-chip crystal-oscillator input. To use this oscillator, a quartz crystal must be connected across X1 and X2. If this pin is not used, it must be tied to GND. This pin can also be used to feed a single-ended 3.3-V level clock. In this case, X2 is a No Connect (NC).
X2		J19	121	66	O	On-chip crystal-oscillator output. A quartz crystal may be connected across X1 and X2. If X2 is not used, it must be left unconnected.
<b>NO CONNECT</b>						
NC		H4	–	–		No connect. BGA ball is electrically open and not connected to the die.

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
<b>JTAG</b>						
TCK		V15	81	50	I	JTAG test clock with internal pullup (see <a href="#">Section 5.4</a> )
TDI		W13	77	46	I	JTAG test data input (TDI) with internal pullup. TDI is clocked into the selected register (instruction or data) on a rising edge of TCK.
TDO		W15	78	47	O/Z	JTAG scan out, test data output (TDO). The contents of the selected register (instruction or data) are shifted out of TDO on the falling edge of TCK. <sup>(3)</sup>
TMS		W14	80	49	I	JTAG test-mode select (TMS) with internal pullup. This serial control input is clocked into the TAP controller on the rising edge of TCK.
$\overline{\text{TRST}}$		V14	79	48	I	JTAG test reset with internal pulldown. $\overline{\text{TRST}}$ , when driven high, gives the scan system control of the operations of the device. If this signal is driven low, the device operates in its functional mode, and the test reset signals are ignored. NOTE: $\overline{\text{TRST}}$ must be maintained low at all times during normal device operation. An external pulldown resistor is required on this pin. The value of this resistor should be based on drive strength of the debugger pods applicable to the design. A 2.2-k $\Omega$ or smaller resistor generally offers adequate protection. The value of the resistor is application-specific. TI recommends that each target board be validated for proper operation of the debugger and the application. This pin has an internal 50-ns (nominal) glitch filter.
<b>INTERNAL VOLTAGE REGULATOR CONTROL</b>						
VREGENZ		J18	119	64	I	Internal voltage regulator enable with internal pulldown. The internal VREG is not supported and must be disabled. Connect VREGENZ to V <sub>DDIO</sub> .
<b>ANALOG, DIGITAL, AND I/O POWER</b>						
V <sub>DD</sub>		E9	16	16		1.2-V digital logic power pins. TI recommends placing a decoupling capacitor near each V <sub>DD</sub> pin with a minimum total capacitance of approximately 20 $\mu\text{F}$ . The exact value of the decoupling capacitance should be determined by your system voltage regulation solution.
		E11	21	39		
		F9	61	45		
		F11	76	63		
		G14	117	71		
		G15	126	78		
		J14	137	84		
		J15	153	89		
		K5	158	95		
		K6	169	–		
		P10	–	–		
		P13	–	–		
V <sub>DD3VFL</sub>		R11	72	41		3.3-V Flash power pin. Place a minimum 0.1- $\mu\text{F}$ decoupling capacitor on each pin.
		R12	–	–		
V <sub>DDA</sub>		P6	36	18		3.3-V analog power pins. Place a minimum 2.2- $\mu\text{F}$ decoupling capacitor on each pin.
		R6	54	38		

Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
V <sub>DDIO</sub>		A9	3	2		3.3-V digital I/O power pins. Place a minimum 0.1-μF decoupling capacitor on each pin. The exact value of the decoupling capacitance should be determined by your system voltage regulation solution.
		A18	11	10		
		B1	15	15		
		E7	20	40		
		E10	26	44		
		E13	62	55		
		E16	68	62		
		F4	75	72		
		F7	82	79		
		F10	88	83		
		F13	91	90		
		F16	99	94		
		G4	106	–		
		G5	114	–		
		G6	116	–		
		H5	127	–		
		H6	138	–		
		L14	147	–		
		L15	152	–		
		M1	159	–		
		M5	168	–		
	M6	–	–			
	N14	–	–			
	N15	–	–			
	P9	–	–			
	R9	–	–			
	V19	–	–			
	W8	–	–			
V <sub>DDOSC</sub>		H16	120	65		Power pins for the 3.3-V on-chip crystal oscillator (X1 and X2) and the two zero-pin internal oscillators (INTOSC). Place a 0.1-μF (minimum) decoupling capacitor on each pin.
		H17	125	70		

**Table 4-1. Signal Descriptions (continued)**

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
V <sub>SS</sub>		A1	PWR PAD	PWR PAD		Analog and digital ground. For Quad Flatpacks (QFPs), the PowerPAD on the bottom of the package must be soldered to the ground plane of the PCB.
		A10				
		A19				
		E5				
		E6				
		E8				
		E12				
		E14				
		E15				
		F5				
		F6				
		F8				
		F12				
		F14				
		F15				
		G16				
		G17				
		H8				
		H9				
		H10				
		H11				
		H12				
		H14				
		H15				
		J5				
		J6				
		J8				
		J9				
		J10				
		J11				
	J12					
	K8					
	K9					
	K10					
	K11					
	K12					
	K14					
	K15					
	L5					
	L6					
	L8					
	L9					

Table 4-1. Signal Descriptions (continued)

NAME	TERMINAL				I/O/Z <sup>(1)</sup>	DESCRIPTION
	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
V <sub>SS</sub>		L10	PWR PAD	PWR PAD		Analog and digital ground. For Quad Flatpacks (QFPs), the PowerPAD on the bottom of the package must be soldered to the ground plane of the PCB.
		L11				
		L12				
		L18				
		M8				
		M9				
		M10				
		M11				
		M12				
		M14				
		M15				
		N1				
		N5				
		N6				
		P7				
		P8				
		P11				
		P12				
		P14				
		P15				
	R7					
	R8					
	R14					
	R15					
	W7					
	W19					
V <sub>SSOSC</sub>		H18	122	67		Crystal oscillator (X1 and X2) ground pin. When using an external crystal, do not connect this pin to the board ground. Instead, connect it to the ground reference of the external crystal oscillator circuit. If an external crystal is not used, this pin may be connected to the board ground.
		H19	–	–		
V <sub>SSA</sub>		P1	34	17		Analog module ground pins. On the PZP package, pin 17 is double-bonded to V <sub>SSA</sub> and V <sub>REFLOA</sub> . This pin must be connect to V <sub>SSA</sub> .
		P5	52	35		
		R5	–	36		
		V7	–	–		
		W1	–	–		

**Table 4-1. Signal Descriptions (continued)**

TERMINAL					I/O/Z <sup>(1)</sup>	DESCRIPTION
NAME	MUX POSITION	ZWT BALL NO.	PTP PIN NO.	PZP PIN NO.		
<b>SPECIAL FUNCTIONS</b>						
ERRORSTS		U19	92	–	O	Error status output. This pin has an internal pulldown.
<b>TEST PINS</b>						
FLT1		W12	73	42	I/O	Flash test pin 1. Reserved for TI. Must be left unconnected.
FLT2		V13	74	43	I/O	Flash test pin 2. Reserved for TI. Must be left unconnected.

(1) I = Input, O = Output, OD = Open Drain, Z = High Impedance

(2) High-Speed SPI-enabled GPIO mux option. This pin mux option is required when using the SPI in High-Speed Mode (HS\_MODE = 1 in SPICCR). This mux option is still available when not using the SPI in High-Speed Mode (HS\_MODE = 0 in SPICCR).

(3) This pin has output impedance that can be as low as 22 Ω. This output could have fast edges and ringing depending on the system PCB characteristics. If this is a concern, the user should take precautions such as adding a 39Ω (10% tolerance) series termination resistor or implement some other termination scheme. It is also recommended that a system-level signal integrity analysis be performed with the provided IBIS models. The termination is not required if this pin is used for input function.

### 4.3 Pins With Internal Pullup and Pulldown

Some pins on the device have internal pullups or pulldowns. [Table 4-2](#) lists the pull direction and when it is active. The pullups on GPIO pins are disabled by default and can be enabled through software. In order to avoid any floating unbonded inputs, the Boot ROM will enable internal pullups on GPIO pins that are not bonded out in a particular package. Other pins noted in [Table 4-2](#) with pullups and pulldowns are always on and cannot be disabled.

**Table 4-2. Pins With Internal Pullup and Pulldown**

PIN	RESET ( $\overline{XRS} = 0$ )	DEVICE BOOT	APPLICATION SOFTWARE
GPIOx	Pullup disabled	Pullup disabled <sup>(1)</sup>	Pullup enable is application-defined
$\overline{TRST}$		Pulldown active	
TCK		Pullup active	
TMS		Pullup active	
TDI		Pullup active	
$\overline{XRS}$		Pullup active	
VREGENZ		Pulldown active	
ERRORSTS		Pulldown active	
Other pins		No pullup or pulldown present	

(1) Pins not bonded out in a given package will have the internal pullups enabled by the Boot ROM.



#### 4.4 Connections for Unused Pins

For applications that do not need to use all functions of the device, [Table 4-3](#) lists acceptable conditioning for any unused pins. When multiple options are listed in [Table 4-3](#), any are acceptable. Pins not listed in [Table 4-3](#) must be connected according to [Table 4-1](#).

**Table 4-3. Connections for Unused Pins**

SIGNAL NAME	ACCEPTABLE PRACTICE
<b>Analog</b>	
V <sub>REFHIX</sub>	Tie to V <sub>DDA</sub>
V <sub>REFLOX</sub>	Tie to V <sub>SSA</sub>
ADCIN <sub>x</sub>	<ul style="list-style-type: none"> <li>• No Connect</li> <li>• Tie to V<sub>SSA</sub></li> </ul>
<b>Digital</b>	
GPIO <sub>x</sub>	<ul style="list-style-type: none"> <li>• Input mode with internal pullup enabled</li> <li>• Input mode with external pullup or pulldown resistor</li> <li>• Output mode with internal pullup disabled</li> </ul>
X1	Tie to V <sub>SS</sub>
X2	No Connect
TCK	<ul style="list-style-type: none"> <li>• No Connect</li> <li>• Pullup resistor</li> </ul>
TDI	<ul style="list-style-type: none"> <li>• No Connect</li> <li>• Pullup resistor</li> </ul>
TDO	No Connect
TMS	No Connect
$\overline{\text{TRST}}$	Pulldown resistor (2.2 kΩ or smaller)
V <sub>REGENZ</sub>	Tie to V <sub>DDIO</sub>
ERRORSTS	No Connect
FLT1	No Connect
FLT2	No Connect
<b>Power and Ground</b>	
V <sub>DD</sub>	All V <sub>DD</sub> pins must be connected per <a href="#">Table 4-1</a> .
V <sub>DDA</sub>	If a separate analog supply is not used, tie to V <sub>DDIO</sub> .
V <sub>DDIO</sub>	All V <sub>DDIO</sub> pins must be connected per <a href="#">Table 4-1</a> .
V <sub>DD3VFL</sub>	Must be tied to V <sub>DDIO</sub>
V <sub>DDOSC</sub>	Must be tied to V <sub>DDIO</sub>
V <sub>SS</sub>	All V <sub>SS</sub> pins must be connected to board ground.
V <sub>SSA</sub>	If a separate analog ground is not used, tie to V <sub>SS</sub> .
V <sub>SSOSC</sub>	If an external crystal is not used, this pin may be connected to the board ground.

## 4.5 Pin Multiplexing

### 4.5.1 GPIO Muxed Pins

Table 4-4 shows the GPIO muxed pins. The default for each pin is the GPIO function, secondary functions can be selected by setting both the GPyGMUXn.GPIOz and GPyMUXn.GPIOz register bits. The GPyGMUXn register should be configured prior to the GPyMUXn to avoid transient pulses on GPIO's from alternate mux selections. Columns not shown and blank cells are reserved GPIO Mux settings.

**Table 4-4. GPIO Muxed Pins<sup>(1)(2)</sup>**

GPIO Index	GPIO Mux Selection							
	0, 4, 8, 12	1	2	3	5	6	7	15
	GPyGMUXn. GPIOz = 00b, 01b, 10b, 11b	00b			01b			11b
GPyMUXn. GPIOz =	00b	01b	10b	11b	01b	10b	11b	11b
GPIO0	EPWM1A (O)					SDAA (I/OD)		
GPIO1	EPWM1B (O)			MFSRB (I/O)		SCLA (I/OD)		
GPIO2	EPWM2A (O)				OUTPUTXBAR1 (O)	SDAB (I/OD)		
GPIO3	EPWM2B (O)	OUTPUTXBAR2 (O)		MCLKRB (I/O)	OUTPUTXBAR2 (O)	SCLB (I/OD)		
GPIO4	EPWM3A (O)				OUTPUTXBAR3 (O)	CANTXA (O)		
GPIO5	EPWM3B (O)	MFSRA (I/O)		OUTPUTXBAR3 (O)		CANRXA (I)		
GPIO6	EPWM4A (O)	OUTPUTXBAR4 (O)		EXTSYNCO (O)	EQEP3A (I)	CANTXB (O)		
GPIO7	EPWM4B (O)	MCLKRA (I/O)		OUTPUTXBAR5 (O)	EQEP3B (I)	CANRXB (I)		
GPIO8	EPWM5A (O)	CANTXB (O)		ADCSO (O)	EQEP3S (I/O)	SCITXDA (O)		
GPIO9	EPWM5B (O)	SCITXDB (O)		OUTPUTXBAR6 (O)	EQEP3I (I/O)	SCIRXDA (I)		
GPIO10	EPWM6A (O)	CANRXB (I)		ADCSOCBO (O)	EQEP1A (I)	SCITXDB (O)		UPP-WAIT (I/O)
GPIO11	EPWM6B (O)	SCIRXDB (I)		OUTPUTXBAR7 (O)	EQEP1B (I)	SCIRXDB (I)		UPP-START (I/O)
GPIO12	EPWM7A (O)	CANTXB (O)		MDXB (O)	EQEP1S (I/O)	SCITXDC (O)		UPP-ENA (I/O)
GPIO13	EPWM7B (O)	CANRXB (I)		MDRB (I)	EQEP11 (I/O)	SCIRXDC (I)		UPP-D7 (I/O)
GPIO14	EPWM8A (O)	SCITXDB (O)		MCLKXB (I/O)		OUTPUTXBAR3 (O)		UPP-D6 (I/O)
GPIO15	EPWM8B (O)	SCIRXDB (I)		MFSXB (I/O)		OUTPUTXBAR4 (O)		UPP-D5 (I/O)
GPIO16	SPISIMOA (I/O)	CANTXB (O)		OUTPUTXBAR7 (O)	EPWM9A (O)		SD1_D1 (I)	UPP-D4 (I/O)
GPIO17	SPISOMIA (I/O)	CANRXB (I)		OUTPUTXBAR8 (O)	EPWM9B (O)		SD1_C1 (I)	UPP-D3 (I/O)
GPIO18	SPICLKA (I/O)	SCITXDB (O)		CANRXA (I)	EPWM10A (O)		SD1_D2 (I)	UPP-D2 (I/O)
GPIO19	SPISTEA (I/O)	SCIRXDB (I)		CANTXA (O)	EPWM10B (O)		SD1_C2 (I)	UPP-D1 (I/O)
GPIO20	EQEP1A (I)	MDXA (O)		CANTXB (O)	EPWM11A (O)		SD1_D3 (I)	UPP-D0 (I/O)
GPIO21	EQEP1B (I)	MDRA (I)		CANRXB (I)	EPWM11B (O)		SD1_C3 (I)	UPP-CLK (I/O)
GPIO22	EQEP1S (I/O)	MCLKXA (I/O)		SCITXDB (O)	EPWM12A (O)	SPICLKB (I/O)	SD1_D4 (I)	
GPIO23	EQEP1I (I/O)	MFSXA (I/O)		SCIRXDB (I)	EPWM12B (O)	SPISTEB (I/O)	SD1_C4 (I)	
GPIO24	OUTPUTXBAR1 (O)	EQEP2A (I)		MDXB (O)		SPISIMOB (I/O)	SD2_D1 (I)	
GPIO25	OUTPUTXBAR2 (O)	EQEP2B (I)		MDRB (I)		SPISOMIB (I/O)	SD2_C1 (I)	
GPIO26	OUTPUTXBAR3 (O)	EQEP2I (I/O)		MCLKXB (I/O)	OUTPUTXBAR3 (O)	SPICLKB (I/O)	SD2_D2 (I)	
GPIO27	OUTPUTXBAR4 (O)	EQEP2S (I/O)		MFSXB (I/O)	OUTPUTXBAR4 (O)	SPISTEB (I/O)	SD2_C2 (I)	
GPIO28	SCIRXDA (I)	EM1CS4 (O)			OUTPUTXBAR5 (O)	EQEP3A (I)	SD2_D3 (I)	
GPIO29	SCITXDA (O)	EM1SDCKE (O)			OUTPUTXBAR6 (O)	EQEP3B (I)	SD2_C3 (I)	
GPIO30	CANRXA (I)	EM1CLK (O)			OUTPUTXBAR7 (O)	EQEP3S (I/O)	SD2_D4 (I)	
GPIO31	CANTXA (O)	EM1WE (O)			OUTPUTXBAR8 (O)	EQEP3I (I/O)	SD2_C4 (I)	
GPIO32	SDAA (I/OD)	EM1CS0 (O)						
GPIO33	SCLA (I/OD)	EM1RNW (O)						
GPIO34	OUTPUTXBAR1 (O)	EM1CS2 (O)				SDAB (I/OD)		
GPIO35	SCIRXDA (I)	EM1CS3 (O)				SCLB (I/OD)		
GPIO36	SCITXDA (O)	EM1WAIT (I)				CANRXA (I)		
GPIO37	OUTPUTXBAR2 (O)	EM1OE (O)				CANTXA (O)		
GPIO38		EM1A0 (O)			SCITXDC (O)	CANTXB (O)		
GPIO39		EM1A1 (O)			SCIRXDC (I)	CANRXB (I)		

(1) I = Input, O = Output, OD = Open Drain

(2) GPIO Index settings of 9, 10, 11, 13, and 14 are reserved.

**Table 4-4. GPIO Muxed Pins<sup>(1)(2)</sup> (continued)**

GPIO Index	GPIO Mux Selection							
	0, 4, 8, 12	1	2	3	5	6	7	15
GPyGMUXn. GPIOz =	00b, 01b, 10b, 11b	00b			01b			11b
GPyMUXn. GPIOz =	00b	01b	10b	11b	01b	10b	11b	11b
GPIO40			EM1A2 (O)			SDAB (I/OD)		
GPIO41			EM1A3 (O)			SCLB (I/OD)		
GPIO42						SDAA (I/OD)		SCITXDA (O)
GPIO43						SCLA (I/OD)		SCIRXDA (I)
GPIO44			EM1A4 (O)					
GPIO45			EM1A5 (O)					
GPIO46			EM1A6 (O)			SCIRXDD (I)		
GPIO47			EM1A7 (O)			SCITXDD (O)		
GPIO48	OUTPUTXBAR3 (O)		EM1A8 (O)			SCITXDA (O)	SD1_D1 (I)	
GPIO49	OUTPUTXBAR4 (O)		EM1A9 (O)			SCIRXDA (I)	SD1_C1 (I)	
GPIO50	EQEP1A (I)		EM1A10 (O)			SPISIMOC (I/O)	SD1_D2 (I)	
GPIO51	EQEP1B (I)		EM1A11 (O)			SPISOMIC (I/O)	SD1_C2 (I)	
GPIO52	EQEP1S (I/O)		EM1A12 (O)			SPICLK (I/O)	SD1_D3 (I)	
GPIO53	EQEP1I (I/O)		EM1D31 (I/O)	EM2D15 (I/O)		SPISTEC (I/O)	SD1_C3 (I)	
GPIO54	SPISIMOA (I/O)		EM1D30 (I/O)	EM2D14 (I/O)	EQEP2A (I)	SCITXDB (O)	SD1_D4 (I)	
GPIO55	SPISOMIA (I/O)		EM1D29 (I/O)	EM2D13 (I/O)	EQEP2B (I)	SCIRXDB (I)	SD1_C4 (I)	
GPIO56	SPICLKA (I/O)		EM1D28 (I/O)	EM2D12 (I/O)	EQEP2S (I/O)	SCITXDC (O)	SD2_D1 (I)	
GPIO57	SPISTEA (I/O)		EM1D27 (I/O)	EM2D11 (I/O)	EQEP2I (I/O)	SCIRXDC (I)	SD2_C1 (I)	
GPIO58	MCLKRA (I/O)		EM1D26 (I/O)	EM2D10 (I/O)	OUTPUTXBAR1 (O)	SPICLKB (I/O)	SD2_D2 (I)	SPISIMOA <sup>(3)</sup> (I/O)
GPIO59	MFSRA (I/O)		EM1D25 (I/O)	EM2D9 (I/O)	OUTPUTXBAR2 (O)	SPISTEB (I/O)	SD2_C2 (I)	SPISOMIA <sup>(3)</sup> (I/O)
GPIO60	MCLKRB (I/O)		EM1D24 (I/O)	EM2D8 (I/O)	OUTPUTXBAR3 (O)	SPISIMOB (I/O)	SD2_D3 (I)	SPICLKA <sup>(3)</sup> (I/O)
GPIO61	MFSRB (I/O)		EM1D23 (I/O)	EM2D7 (I/O)	OUTPUTXBAR4 (O)	SPISOMIB (I/O)	SD2_C3 (I)	SPISTEA <sup>(3)</sup> (I/O)
GPIO62	SCIRXDC (I)		EM1D22 (I/O)	EM2D6 (I/O)	EQEP3A (I)	CANRXA (I)	SD2_D4 (I)	
GPIO63	SCITXDC (O)		EM1D21 (I/O)	EM2D5 (I/O)	EQEP3B (I)	CANTXA (O)	SD2_C4 (I)	SPISIMOB <sup>(3)</sup> (I/O)
GPIO64			EM1D20 (I/O)	EM2D4 (I/O)	EQEP3S (I/O)	SCIRXDA (I)		SPISOMIB <sup>(3)</sup> (I/O)
GPIO65			EM1D19 (I/O)	EM2D3 (I/O)	EQEP3I (I/O)	SCITXDA (O)		SPICLKB <sup>(3)</sup> (I/O)
GPIO66			EM1D18 (I/O)	EM2D2 (I/O)		SDAB (I/OD)		SPISTEB <sup>(3)</sup> (I/O)
GPIO67			EM1D17 (I/O)	EM2D1 (I/O)				
GPIO68			EM1D16 (I/O)	EM2D0 (I/O)				
GPIO69			EM1D15 (I/O)			SCLB (I/OD)		SPISIMOC <sup>(3)</sup> (I/O)
GPIO70			EM1D14 (I/O)		CANRXA (I)	SCITXDB (O)		SPISOMIC <sup>(3)</sup> (I/O)
GPIO71			EM1D13 (I/O)		CANTXA (O)	SCIRXDB (I)		SPICLK <sup>(3)</sup> (I/O)
GPIO72			EM1D12 (I/O)		CANTXB (O)	SCITXDC (O)		SPISTEC <sup>(3)</sup> (I/O)
GPIO73			EM1D11 (I/O)	XCLKOUT (O)	CANRXB (I)	SCIRXDC (I)		
GPIO74			EM1D10 (I/O)					
GPIO75			EM1D9 (I/O)					
GPIO76			EM1D8 (I/O)			SCITXDD (O)		
GPIO77			EM1D7 (I/O)			SCIRXDD (I)		
GPIO78			EM1D6 (I/O)			EQEP2A (I)		
GPIO79			EM1D5 (I/O)			EQEP2B (I)		
GPIO80			EM1D4 (I/O)			EQEP2S (I/O)		
GPIO81			EM1D3 (I/O)			EQEP2I (I/O)		
GPIO82			EM1D2 (I/O)					
GPIO83			EM1D1 (I/O)					
GPIO84					SCITXDA (O)	MDXB (O)		MDXA (O)
GPIO85			EM1D0 (I/O)		SCIRXDA (I)	MDRB (I)		MDRA (I)
GPIO86			EM1A13 (O)	EM1CAS (O)	SCITXDB (O)	MCLKXB (I/O)		MCLKXA (I/O)
GPIO87			EM1A14 (O)	EM1RAS (O)	SCIRXDB (I)	MFSXB (I/O)		MFSXA (I/O)
GPIO88			EM1A15 (O)	EM1DQM0 (O)				
GPIO89			EM1A16 (O)	EM1DQM1 (O)		SCITXDC (O)		

(3) High-Speed SPI-enabled GPIO mux option. This pin mux option is required when using the SPI in High-Speed Mode (HS\_MODE = 1 in SPICCR). This mux option is still available when not using the SPI in High-Speed Mode (HS\_MODE = 0 in SPICCR).

**Table 4-4. GPIO Muxed Pins<sup>(1)(2)</sup> (continued)**

GPIO Index	GPIO Mux Selection							
	0, 4, 8, 12	1	2	3	5	6	7	15
GPyGMUXn. GPIOz =	00b, 01b, 10b, 11b	00b			01b			11b
GPyMUXn. GPIOz =	00b	01b	10b	11b	01b	10b	11b	11b
GPIO90			EM1A17 (O)	EM1DQM2 (O)		SCIRXDC (I)		
GPIO91			EM1A18 (O)	EM1DQM3 (O)		SDAA (I/OD)		
GPIO92			EM1A19 (O)	EM1BA1 (O)		SCLA (I/OD)		
GPIO93				EM1BA0 (O)		SCITXDD (O)		
GPIO94						SCIRXDD (I)		
GPIO95								
GPIO96				EM2DQM1 (O)	EQEP1A (I)			
GPIO97				EM2DQM0 (O)	EQEP1B (I)			
GPIO98				EM2A0 (O)	EQEP1S (I/O)			
GPIO99				EM2A1 (O)	EQEP1I (I/O)			
GPIO100				EM2A2 (O)	EQEP2A (I)	SPISIMOC (I/O)		
GPIO101				EM2A3 (O)	EQEP2B (I)	SPISOMIC (I/O)		
GPIO102				EM2A4 (O)	EQEP2S (I/O)	SPICLK (I/O)		
GPIO103				EM2A5 (O)	EQEP2I (I/O)	SPISTEC (I/O)		
GPIO104	SDAA (I/OD)			EM2A6 (O)	EQEP3A (I)	SCITXDD (O)		
GPIO105	SCLA (I/OD)			EM2A7 (O)	EQEP3B (I)	SCIRXDD (I)		
GPIO106				EM2A8 (O)	EQEP3S (I/O)	SCITXDC (O)		
GPIO107				EM2A9 (O)	EQEP3I (I/O)	SCIRXDC (I)		
GPIO108				EM2A10 (O)				
GPIO109				EM2A11 (O)				
GPIO110				EM2WAIT (I)				
GPIO111				EM2BA0 (O)				
GPIO112				EM2BA1 (O)				
GPIO113				EM2CAS (O)				
GPIO114				EM2RAS (O)				
GPIO115				EM2CS0 (O)				
GPIO116				EM2CS2 (O)				
GPIO117				EM2SDCKE (O)				
GPIO118				EM2CLK (O)				
GPIO119				EM2RNW (O)				
GPIO120				EM2WE (O)				USB0PFLT
GPIO121				EM2OE (O)				USB0EPEN
GPIO122						SPISIMOC (I/O)	SD1_D1 (I)	
GPIO123						SPISOMIC (I/O)	SD1_C1 (I)	
GPIO124						SPICLK (I/O)	SD1_D2 (I)	
GPIO125						SPISTEC (I/O)	SD1_C2 (I)	
GPIO126							SD1_D3 (I)	
GPIO127							SD1_C3 (I)	
GPIO128							SD1_D4 (I)	
GPIO129							SD1_C4 (I)	
GPIO130							SD2_D1 (I)	
GPIO131							SD2_C1 (I)	
GPIO132							SD2_D2 (I)	
GPIO133/ AUXCLKIN							SD2_C2 (I)	
GPIO134							SD2_D3 (I)	
GPIO135						SCITXDA (O)	SD2_C3 (I)	
GPIO136						SCIRXDA (I)	SD2_D4 (I)	
GPIO137						SCITXDB (O)	SD2_C4 (I)	
GPIO138						SCIRXDB (I)		
GPIO139						SCIRXDC (I)		
GPIO140						SCITXDC (O)		

**Table 4-4. GPIO Muxed Pins<sup>(1)(2)</sup> (continued)**

GPIO Index	GPIO Mux Selection							
	0, 4, 8, 12	1	2	3	5	6	7	15
GPyGMUXn. GPIOz =	00b, 01b, 10b, 11b	00b			01b			11b
GPyMUXn. GPIOz =	00b	01b	10b	11b	01b	10b	11b	11b
GPIO141						SCIRXDD (I)		
GPIO142						SCITXDD (O)		
GPIO143								
GPIO144								
GPIO145		EPWM1A (O)						
GPIO146		EPWM1B (O)						
GPIO147		EPWM2A (O)						
GPIO148		EPWM2B (O)						
GPIO149		EPWM3A (O)						
GPIO150		EPWM3B (O)						
GPIO151		EPWM4A (O)						
GPIO152		EPWM4B (O)						
GPIO153		EPWM5A (O)						
GPIO154		EPWM5B (O)						
GPIO155		EPWM6A (O)						
GPIO156		EPWM6B (O)						
GPIO157		EPWM7A (O)						
GPIO158		EPWM7B (O)						
GPIO159		EPWM8A (O)						
GPIO160		EPWM8B (O)						
GPIO161		EPWM9A (O)						
GPIO162		EPWM9B (O)						
GPIO163		EPWM10A (O)						
GPIO164		EPWM10B (O)						
GPIO165		EPWM11A (O)						
GPIO166		EPWM11B (O)						
GPIO167		EPWM12A (O)						
GPIO168		EPWM12B (O)						

### 4.5.2 Input X-BAR

The Input X-BAR is used to route any GPIO input to the ADC, eCAP, and ePWM peripherals as well as to external interrupts (XINT) (see Figure 4-7). Table 4-5 shows the input X-BAR destinations. For details on configuring the Input X-BAR, see the "Crossbar (X-BAR)" chapter of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)*.

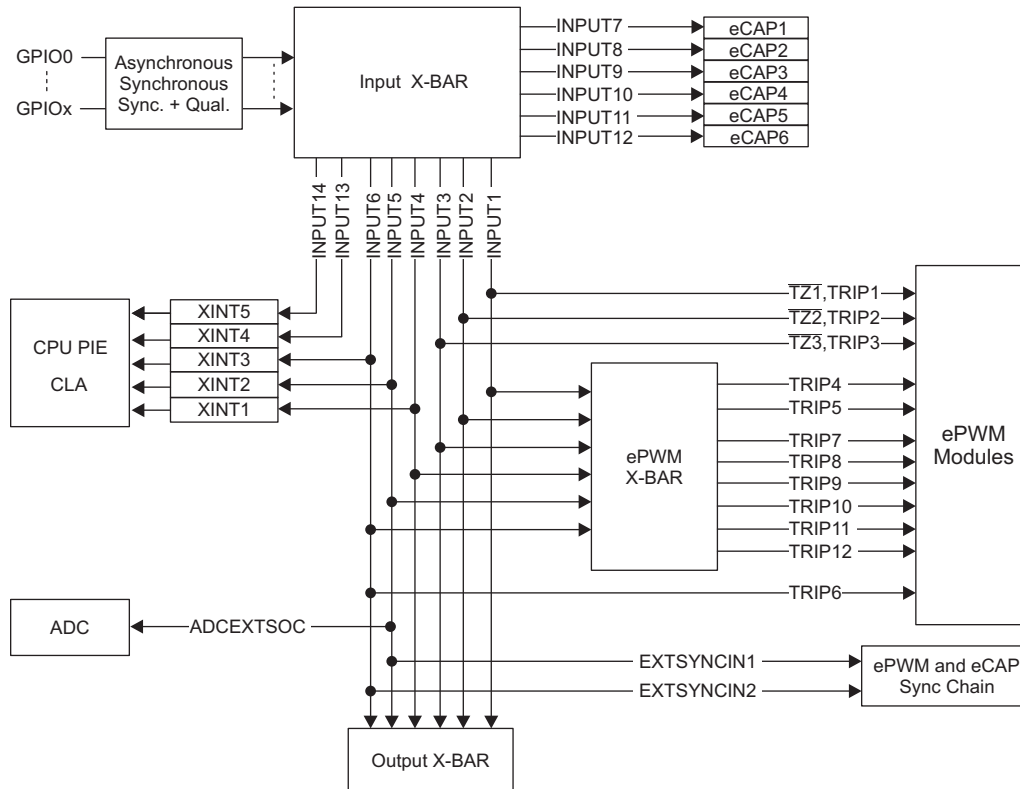


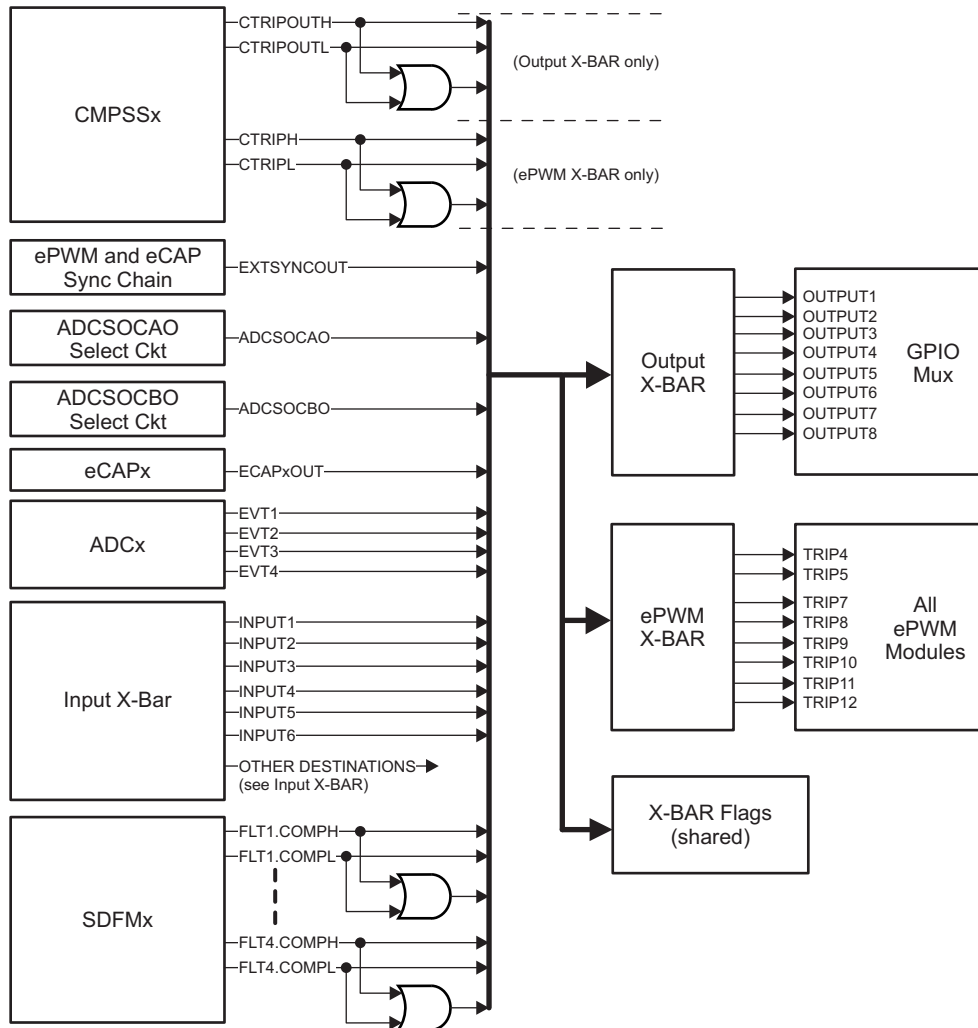
Figure 4-7. Input X-BAR

Table 4-5. Input X-BAR Destinations

INPUT	DESTINATIONS
INPUT1	EPWM[TZ1,TRIP1], EPWM X-BAR, Output X-BAR
INPUT2	EPWM[TZ2,TRIP2], EPWM X-BAR, Output X-BAR
INPUT3	EPWM[TZ3,TRIP3], EPWM X-BAR, Output X-BAR
INPUT4	XINT1, EPWM X-BAR, Output X-BAR
INPUT5	XINT2, ADCEXTSOC, EXTSYNCIN1, EPWM X-BAR, Output X-BAR
INPUT6	XINT3, EPWM[TRIP6], EXTSYNCIN2, EPWM X-BAR, Output X-BAR
INPUT7	ECAP1
INPUT8	ECAP2
INPUT9	ECAP3
INPUT10	ECAP4
INPUT11	ECAP5
INPUT12	ECAP6
INPUT13	XINT4
INPUT14	XINT5

### 4.5.3 Output X-BAR and ePWM X-BAR

The Output X-BAR has eight outputs which can be selected on the GPIO mux as OUTPUTXBARx. The ePWM X-BAR has eight outputs which are connected to the TRIPx inputs of the ePWM. The sources for both the Output X-BAR and ePWM X-BAR are shown in Figure 4-8. For details on the Output X-BAR and ePWM X-BAR, see the "Crossbar (X-BAR)" chapter of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)*.



**Figure 4-8. Output X-BAR and ePWM X-BAR**

#### 4.5.4 USB Pin Muxing

Table 4-6 shows assignment of the alternate USB function mapping. These can be configured with the GPBAMSEL register.

**Table 4-6. Alternate USB Function**

GPIO	GPBAMSEL SETTING	USB FUNCTION
GPIO42	GPBAMSEL[10] = 1b	USB0DM
GPIO43	GPBAMSEL[11] = 1b	USB0DP

#### 4.5.5 High-Speed SPI Pin Muxing

The SPI module on this device has a high-speed mode. To achieve the highest possible speed, a special GPIO configuration is used on a single GPIO mux option for each SPI. These GPIOs may also be used by the SPI when not in high-speed mode (HS\_MODE = 0).

To select the mux options that enable the SPI high-speed mode, configure the GPyGMUX and GPyMUX registers as shown in Table 4-7.

**Table 4-7. GPIO Configuration for High-Speed SPI**

GPIO	SPI SIGNAL	MUX CONFIGURATION	
<b>SPIA</b>			
GPIO58	SPISIMOA	GPBGMUX2[21:20]=11b	GPBMUX2[21:20]=11b
GPIO59	SPISOMIA	GPBGMUX2[23:22]=11b	GPBMUX2[23:22]=11b
GPIO60	SPICLKA	GPBGMUX2[25:24]=11b	GPBMUX2[25:24]=11b
GPIO61	$\overline{\text{SPISTEA}}$	GPBGMUX2[27:26]=11b	GPBMUX2[27:26]=11b
<b>SPIB</b>			
GPIO63	SPISIMOB	GPBGMUX2[31:30]=11b	GPBMUX2[31:30]=11b
GPIO64	SPISOMIB	GPCGMUX1[1:0]=11b	GPCMUX1[1:0]=11b
GPIO65	SPICLKB	GPCGMUX1[3:2]=11b	GPCMUX1[3:2]=11b
GPIO66	$\overline{\text{SPISTEB}}$	GPCGMUX1[5:4]=11b	GPCMUX1[5:4]=11b
<b>SPIC</b>			
GPIO69	SPISIMOC	GPCGMUX1[11:10]=11b	GPCMUX1[11:10]=11b
GPIO70	SPISOMIC	GPCGMUX1[13:12]=11b	GPCMUX1[13:12]=11b
GPIO71	SPICLKC	GPCGMUX1[15:14]=11b	GPCMUX1[15:14]=11b
GPIO72	$\overline{\text{SPISTEC}}$	GPCGMUX1[17:16]=11b	GPCMUX1[17:16]=11b



## 5 Specifications

### 5.1 Absolute Maximum Ratings<sup>(1)(2)</sup>

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

		MIN	MAX	UNIT
Supply voltage	$V_{DDIO}$ with respect to $V_{SS}$	-0.3	4.6	V
	$V_{DD3VFL}$ with respect to $V_{SS}$	-0.3	4.6	
	$V_{DDOSC}$ with respect to $V_{SS}$	-0.3	4.6	
	$V_{DD}$ with respect to $V_{SS}$	-0.3	1.5	
Analog voltage	$V_{DDA}$ with respect to $V_{SSA}$	-0.3	4.6	V
Input voltage	$V_{IN}$ (3.3 V)	-0.3	4.6	V
Output voltage	$V_O$	-0.3	4.6	V
Input clamp current	Digital input (per pin), $I_{IK}$ ( $V_{IN} < V_{SS}$ or $V_{IN} > V_{DDIO}$ )	-20	20	mA
	Analog input (per pin), $I_{IKANALOG}$ ( $V_{IN} < V_{SSA}$ or $V_{IN} > V_{DDA}$ )	-20	20	
	Total for all inputs, $I_{IKTOTAL}$ ( $V_{IN} < V_{SS}/V_{SSA}$ or $V_{IN} > V_{DDIO}/V_{DDA}$ )	-20	20	
Output current	Digital output (per pin), $I_{OUT}$	-20	20	mA
Free-Air temperature	$T_A$	-40	125	°C
Operating junction temperature	$T_J$	-40	150	°C
Storage temperature <sup>(3)</sup>	$T_{stg}$	-65	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 [Section 5.3](#) is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values are with respect to  $V_{SS}$ , unless otherwise noted.
- (3) Long-term high-temperature storage or extended use at maximum temperature conditions may result in a reduction of overall device life. For additional information, see the *IC Package Thermal Metrics Application Report (SPRA953)*.

### 5.2 ESD Ratings

			VALUE	UNIT
TMS320F2837xD in 337-ball ZWT package				
$V_{(ESD)}$ Electrostatic discharge	Human body model (HBM), per AEC Q100-002 <sup>(1)</sup> Charged device model (CDM), per AEC Q100-011	All pins	±2000	V
		All pins	±500	
		Corner balls on 337-ball ZWT: A1, A19, W1, W19	±750	
TMS320F2837xD in 176-pin PTP package				
$V_{(ESD)}$ Electrostatic discharge	Human body model (HBM), per AEC Q100-002 <sup>(1)</sup> Charged device model (CDM), per AEC Q100-011	All pins	±2000	V
		All pins	±500	
		Corner pins on 176-pin PTP: 1, 44, 45, 88, 89, 132, 133, 176	±750	
TMS320F2837xD in 100-pin PZP package				
$V_{(ESD)}$ Electrostatic discharge	Human body model (HBM), per AEC Q100-002 <sup>(1)</sup> Charged device model (CDM), per AEC Q100-011	All pins	±2000	V
		All pins	±500	
		Corner pins on 100-pin PZP: 1, 25, 26, 50, 51, 75, 76, 100	±750	

- (1) AEC Q100-002 indicates HBM stressing is done in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

### 5.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
Device supply voltage, I/O, $V_{DDIO}^{(1)}$		3.14	3.3	3.47	V
Device supply voltage, $V_{DD}$		1.14	1.2	1.26	V
Supply ground, $V_{SS}$			0		V
Analog supply voltage, $V_{DDA}$		3.14	3.3	3.47	V
Analog ground, $V_{SSA}$			0		V
Junction temperature, $T_J$	T version	-40		105	°C
	S version <sup>(2)</sup>	-40		125	
	Q version (Q100 qualification) <sup>(2)</sup>	-40		150	
Free-Air temperature, $T_A$	Q version (Q100 qualification)	-40		125	°C

(1)  $V_{DDIO}$ ,  $V_{DD3VFL}$ , and  $V_{DDOSC}$  should be maintained within 0.3 V of each other.

(2) Operation above  $T_J = 105^\circ\text{C}$  for extended duration will reduce the lifetime of the device. See the *Calculating Useful Lifetimes of Embedded Processors Application Report (SPRABX4)* for more information.

### 5.4 Electrical Characteristics

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{OH}$	High-level output voltage	$I_{OH} = I_{OH\ MIN}$	$V_{DDIO} * 0.8$			V
		$I_{OH} = -100\ \mu\text{A}$	$V_{DDIO} - 0.2$			
$V_{OL}$	Low-level output voltage	$I_{OL} = I_{OL\ MAX}$			0.4	V
		$I_{OL} = 100\ \mu\text{A}$			0.2	
$I_{OH}$	High-level output source current for all output pins		-4			mA
$I_{OL}$	Low-level output sink current for all output pins				4	mA
$V_{IH}$	High-level input voltage (3.3 V)	GPIO0–GPIO7, GPIO42–GPIO43, GPIO46–GPIO47	$V_{DDIO} * 0.7$		$V_{DDIO} + 0.3$	V
		All other pins	2.0		$V_{DDIO} + 0.3$	
$V_{IL}$	Low-level input voltage (3.3 V)		$V_{SS} - 0.3$		0.8	V
$I_{pull\ down}$	Input current	Digital inputs with pulldown <sup>(1)</sup>	$V_{DDIO} = 3.3\ \text{V}$ $V_{IN} = V_{DDIO}$		120	$\mu\text{A}$
$I_{pull\ up}$	Input current	Digital inputs with pullup enabled <sup>(1)</sup>	$V_{DDIO} = 3.3\ \text{V}$ $V_{IN} = 0\ \text{V}$		150	$\mu\text{A}$
$I_{LEAK}$	Pin leakage	Digital	Pullups disabled $0\ \text{V} \leq V_{IN} \leq V_{DDIO}$		2	$\mu\text{A}$
		Analog (except ADCINB0 or DACOUTx)	$0\ \text{V} \leq V_{IN} \leq V_{DDA}$		2	
		ADCINB0			11 <sup>(2)</sup>	
		DACOUTx			66	
$C_I$	Input capacitance				2	pF

(1) See Table 4-2 for a list of pins with a pullup or pulldown.

(2) The MAX input leakage shown on ADCINB0 is at high temperature.

## 5.5 Power Consumption Summary

Current values listed in this section are representative for the test conditions given and not the absolute maximum possible. The actual device currents in an application will vary with application code and pin configurations. [Table 5-1](#) shows the device current consumption at 200-MHz SYSCLK.

**Table 5-1. Device Current Consumption at 200-MHz SYSCLK**

MODE	TEST CONDITIONS	I <sub>DD</sub>		I <sub>DDIO</sub> <sup>(1)</sup>		I <sub>DDA</sub>		I <sub>DD3VFL</sub>	
		TYP <sup>(2)</sup>	MAX <sup>(3)</sup>	TYP <sup>(2)</sup>	MAX <sup>(3)</sup>	TYP <sup>(2)</sup>	MAX <sup>(3)</sup>	TYP <sup>(2)</sup>	MAX <sup>(3)</sup>
Operational (RAM)	<ul style="list-style-type: none"> <li>Code is running out of RAM.<sup>(4)</sup></li> <li>All I/O pins are left unconnected.</li> <li>Peripherals not active have their clocks disabled.</li> <li>FLASH is read and in active state.</li> <li>XCLKOUT is enabled at SYSCLK/4.</li> </ul>	325 mA	440 mA	30 mA		13 mA	20 mA	33 mA	40 mA
IDLE	<ul style="list-style-type: none"> <li>Both CPU1 and CPU2 are in IDLE mode.</li> <li>Flash is powered down.</li> <li>XCLKOUT is turned off.</li> </ul>	105 mA	210 mA	3 mA	10 mA	10 μA	150 μA	10 μA	150 μA
STANDBY	<ul style="list-style-type: none"> <li>Both CPU1 and CPU2 are in STANDBY mode.</li> <li>Flash is powered down.</li> <li>XCLKOUT is turned off.</li> </ul>	30 mA	135 mA	3 mA	10 mA	5 μA	150 μA	10 μA	150 μA
HALT <sup>(5)</sup>	<ul style="list-style-type: none"> <li>CPU1 watchdog is running.</li> <li>Flash is powered down.</li> <li>XCLKOUT is turned off.</li> </ul>	1.5 mA	110 mA	750 μA	2 mA	5 μA	150 μA	10 μA	150 μA
HIBERNATE <sup>(6)</sup>	<ul style="list-style-type: none"> <li>CPU1.M0 and CPU1.M1 RAMs are in low-power data retention mode.</li> <li>CPU2.M0 and CPU2.M1 RAMs are in low-power data retention mode.</li> </ul>	300 μA	4 mA	750 μA	2 mA	5 μA	75 μA	1 μA	50 μA
Flash Erase/Program	<ul style="list-style-type: none"> <li>CPU1 is running from RAM.</li> <li>CPU2 is running from Flash.</li> <li>All I/O pins are left unconnected.</li> <li>Peripheral clocks are disabled.</li> <li>CPU1 is performing Flash Erase and Programming.</li> <li>CPU2 is accessing Flash locations to keep bank active.</li> <li>XCLKOUT is turned off.</li> </ul>	242 mA	360 mA	3 mA	10 mA	10 μA	150 μA	53 mA	65 mA

(1) I<sub>DDIO</sub> current is dependent on the electrical loading on the I/O pins.

(2) TYP: V<sub>nom</sub>, 30°C

(3) MAX: V<sub>max</sub>, 125°C

(4) The following is executed in a loop on CPU1:

- All of the communication peripherals are exercised in loop-back mode: CAN-A to CAN-B; SPI-A to SPI-C; SCI-A to SCI-D; I<sup>2</sup>C-A to I<sup>2</sup>C-B; McBSP-A to McBSP-B; USB
- SDFM1 to SDFM4 active
- ePWM1 to ePWM12 generate 400-kHz PWM output on 24 pins
- CPU TIMERS active
- DMA does 32-bit burst transfers
- CLA1 does multiply-accumulate tasks
- All ADCs perform continuous conversion
- All DACs ramp voltage up/down at 150 kHz
- CMPSS1 to CMPSS8 active

The following is executed in a loop on CPU2:

- CPU TIMERS active
- CLA1 does multiply-accumulate tasks
- VCU does complex multiply/accumulate with parallel load
- TMU calculates a cosine
- FPU does multiply/accumulate with parallel load

(5) CPU2 must go into IDLE mode before CPU1 enters HALT mode.

(6) CPU2 must go into reset/IDLE/STANDBY mode before CPU1 enters HIBERNATE mode.

### 5.5.1 Current Consumption Graphs

Figure 5-1 and Figure 5-2 are a typical representation of the relationship between frequency and current consumption/power on the device. The operational test from Table 5-1 was run across frequency at  $V_{max}$  and high temperature. Actual results will vary based on the system implementation and conditions.

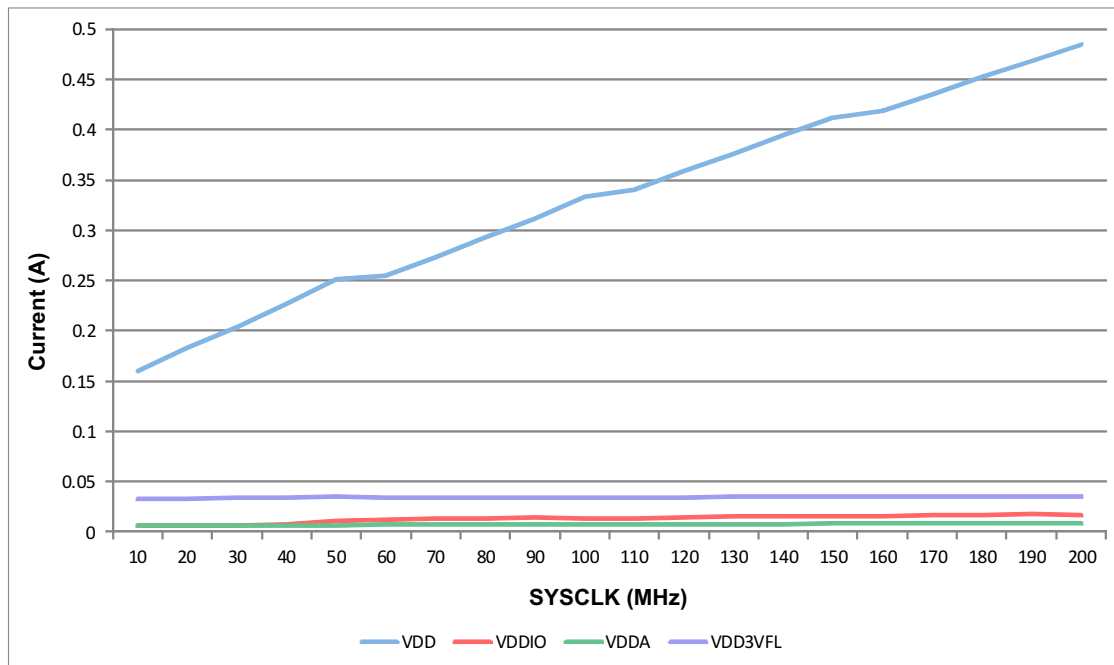


Figure 5-1. Operational Current Versus Frequency

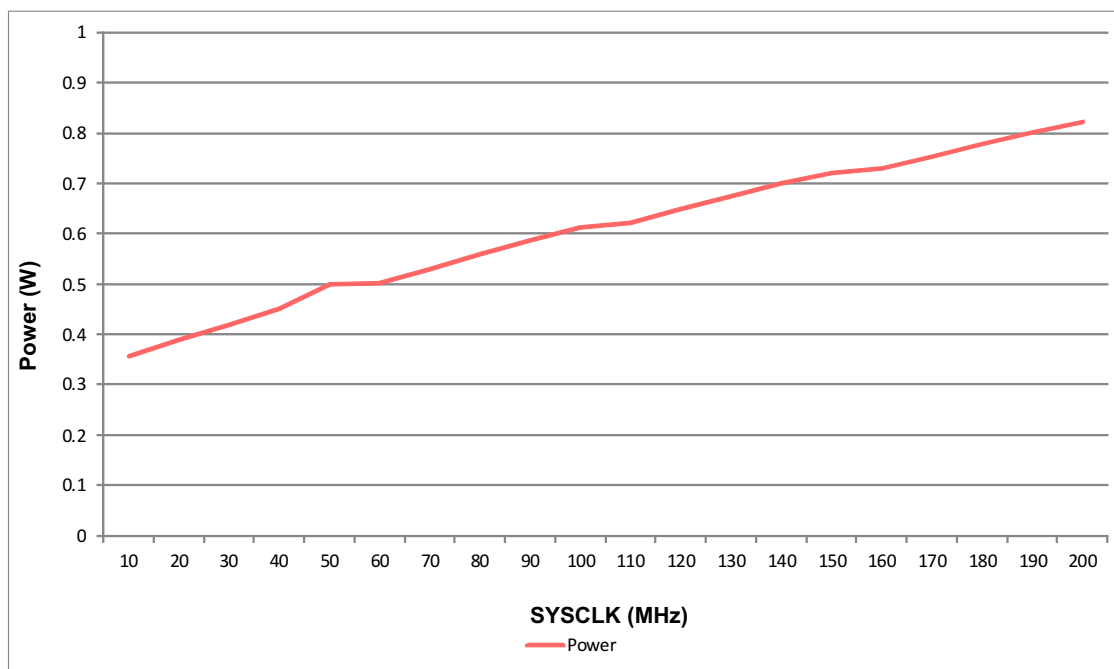
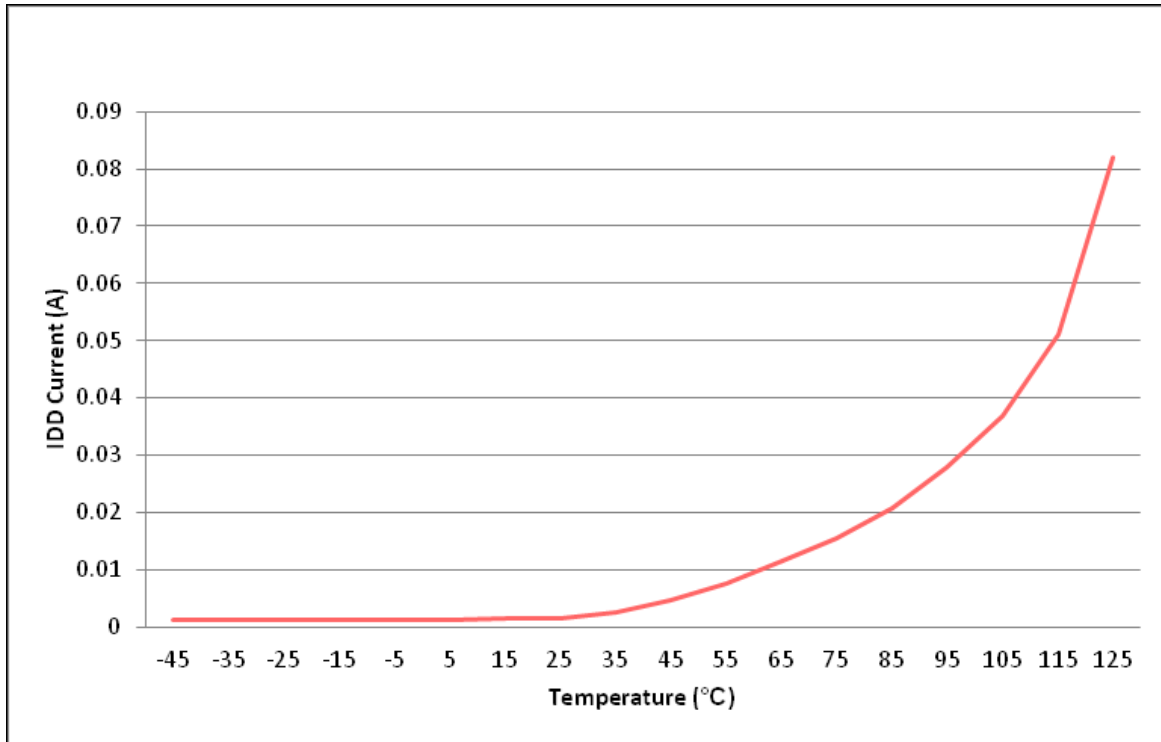


Figure 5-2. Power Versus Frequency

Leakage current will increase with operating temperature in a nonlinear manner. The difference in  $V_{DD}$  current between TYP and MAX conditions can be seen in [Figure 5-3](#). The current consumption in HALT mode is primarily leakage current as there is no active switching if the internal oscillator has been powered down.

[Figure 5-3](#) shows the typical leakage current across temperature. The device was placed into HALT mode under nominal voltage conditions.



**Figure 5-3.  $I_{DD}$  Leakage Current Versus Temperature**

### 5.5.2 Reducing Current Consumption

The F2837xD devices provide some methods to reduce the device current consumption:

- Any one of the four low-power modes—IDLE, STANDBY, HALT, and HIBERNATE—could be entered during idle periods in the application.
- The flash module may be powered down if the code is run from RAM.
- Disable the pullups on pins that assume an output function.
- Each peripheral has an individual clock-enable bit (PCLKCRx). Reduced current consumption may be achieved by turning off the clock to any peripheral that is not used in a given application. [Table 5-2](#) indicates the typical current reduction that may be achieved by disabling the clocks using the PCLKCRx register.

**Table 5-2. Current on V<sub>DD</sub> Supply by Various Peripherals (at 200 MHz)<sup>(1)</sup>**

PERIPHERAL MODULE <sup>(2)</sup>	I <sub>DD</sub> CURRENT REDUCTION (mA)
ADC <sup>(3)</sup>	3.3
CAN	3.3
CLA	1.4
CMPSS <sup>(3)</sup>	1.4
CPUTIMER	0.3
DAC <sup>(3)</sup>	0.6
DMA	2.9
eCAP	0.6
EMIF1	2.9
EMIF2	2.6
ePWM1 to ePWM4 <sup>(4)</sup>	4.5
ePWM5 to ePWM12 <sup>(4)</sup>	1.7
HRPWM <sup>(4)</sup>	1.7
I <sup>2</sup> C	1.3
McBSP	1.6
SCI	0.9
SDFM	2
SPI	0.5
uPP	7.3
USB and AUXPLL at 60 MHz	23.8

(1) At V<sub>max</sub> and 125°C.

(2) All peripherals are disabled upon reset. Use the PCLKCRx register to individually enable peripherals. For peripherals with multiple instances, the current quoted is for a single module.

(3) This number represents the current drawn by the digital portion of the ADC, CMPSS, and DAC modules.

(4) The ePWM is at /2 of SYSCLK.

## 5.6 Thermal Resistance Characteristics

### 5.6.1 ZWT Package

		°C/W <sup>(1)</sup>	AIR FLOW (lfm) <sup>(2)</sup>
R <sub>θJC</sub>	Junction-to-case thermal resistance	8.3	N/A
R <sub>θJB</sub>	Junction-to-board thermal resistance	11.6	N/A
R <sub>θJA</sub> (High k PCB)	Junction-to-free air thermal resistance	21.5	0
R <sub>θJMA</sub>	Junction-to-moving air thermal resistance	19.0	150
		17.8	250
		16.5	500
Psi <sub>JT</sub>	Junction-to-package top	0.2	0
		0.3	150
		0.4	250
		0.5	500
Psi <sub>JB</sub>	Junction-to-board	11.4	0
		11.3	150
		11.2	250
		11.0	500

(1) These values are based on a JEDEC-defined 2S2P system (with the exception of the Theta JC [R<sub>θJC</sub>] value, which is based on a JEDEC-defined 1S0P system) and will change based on environment as well as application. For more information, see these EIA/JEDEC standards:

- JESD51-2, *Integrated Circuits Thermal Test Method Environmental Conditions - Natural Convection (Still Air)*
- JESD51-3, *Low Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages*
- JESD51-7, *High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages*
- JESD51-9, *Test Boards for Area Array Surface Mount Package Thermal Measurements*

(2) lfm = linear feet per minute

### 5.6.2 PTP Package

		°C/W <sup>(1)</sup>	AIR FLOW (lfm) <sup>(2)</sup>
R <sub>θJC</sub>	Junction-to-case thermal resistance	6.97	N/A
R <sub>θJB</sub>	Junction-to-board thermal resistance	6.05	N/A
R <sub>θJA</sub> (High k PCB)	Junction-to-free air thermal resistance	17.8	0
R <sub>θJMA</sub>	Junction-to-moving air thermal resistance	12.8	150
		11.4	250
		10.1	500
Psi <sub>JT</sub>	Junction-to-package top	0.11	0
		0.24	150
		0.33	250
		0.42	500
Psi <sub>JB</sub>	Junction-to-board	6.1	0
		5.5	150
		5.4	250
		5.3	500

(1) These values are based on a JEDEC-defined 2S2P system (with the exception of the Theta JC [R<sub>θJC</sub>] value, which is based on a JEDEC-defined 1S0P system) and will change based on environment as well as application. For more information, see these EIA/JEDEC standards:

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- JESD51-7, *High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages*
- JESD51-9, *Test Boards for Area Array Surface Mount Package Thermal Measurements*

(2) lfm = linear feet per minute

### 5.6.3 PZP Package

		°C/W <sup>(1)</sup>	AIR FLOW (lfm) <sup>(2)</sup>
R $\theta$ <sub>JC</sub>	Junction-to-case thermal resistance	4.3	N/A
R $\theta$ <sub>JB</sub>	Junction-to-board thermal resistance	5.9	N/A
R $\theta$ <sub>JA</sub> (High k PCB)	Junction-to-free air thermal resistance	19.1	0
R $\theta$ <sub>JMA</sub>	Junction-to-moving air thermal resistance	14.3	150
		12.8	250
		11.4	500
Psi <sub>JT</sub>	Junction-to-package top	0.03	0
		0.09	150
		0.12	250
		0.20	500
Psi <sub>JB</sub>	Junction-to-board	6.0	0
		5.5	150
		5.5	250
		5.3	500

- (1) These values are based on a JEDEC-defined 2S2P system (with the exception of the Theta JC [R $\theta$ <sub>JC</sub>] value, which is based on a JEDEC-defined 1S0P system) and will change based on environment as well as application. For more information, see these EIA/JEDEC standards:
- JESD51-2, *Integrated Circuits Thermal Test Method Environmental Conditions - Natural Convection (Still Air)*
  - JESD51-3, *Low Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages*
  - JESD51-7, *High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages*
  - JESD51-9, *Test Boards for Area Array Surface Mount Package Thermal Measurements*
- (2) lfm = linear feet per minute



## 5.7 System

### 5.7.1 Power Sequencing

An external power supply must be used to supply 3.3 V to  $V_{DDIO}$ ,  $V_{DD3VFL}$ ,  $V_{DDOSC}$ , and  $V_{DDA}$  and to provide 1.2 V to  $V_{DD}$ . The internal VREG is not supported; therefore, the VREGENZ pin must be tied high to 3.3 V. The supplies should ramp to full rail within 10 ms. Table 5-3 shows the supply ramp rate.

**Table 5-3. Supply Ramp Rate**

		MIN	MAX	UNIT
Supply ramp rate	$V_{DDIO}$ , $V_{DD}$ , $V_{DDA}$ , $V_{DD3VFL}$ , $V_{DDOSC}$ with respect to $V_{SS}$	330	$10^5$	V/s

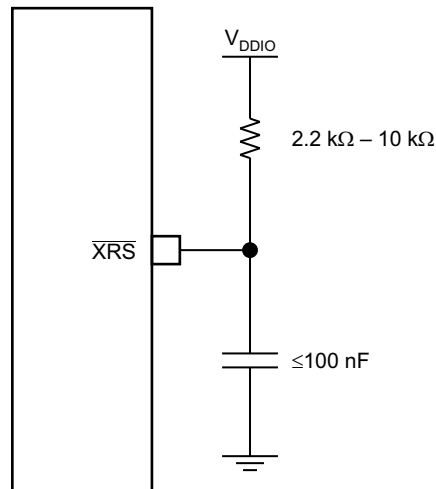
The voltage on  $V_{DDIO}$  should be greater than  $V_{DD}$  or no less than 0.3 V below  $V_{DD}$  at all times.  $V_{DDIO}$ ,  $V_{DD3VFL}$ ,  $V_{DDOSC}$ , and  $V_{DDA}$  should be powered up together and be kept within 0.3 V of each other during operation. Before powering the device, no voltage larger than 0.3 V above  $V_{DDIO}$  should be applied to any digital pin, and no voltage larger than 0.3 V above  $V_{DDA}$  should be applied to any analog pin.

An internal power-on-reset (POR) circuit holds the device in reset and keeps the I/Os in a high-impedance state during power up. External supply voltage supervisors (SVS) can be used to monitor the voltage on the 3.3-V and 1.2-V rails and drive XRS low should supplies fall outside operational specifications.

### 5.7.2 Reset Timing

$\overline{XRS}$  is the device reset pin. It functions as an input and open-drain output. The device has a built-in power-on reset (POR). During power up, the POR circuit drives the  $\overline{XRS}$  pin low. A watchdog or NMI watchdog reset also drives the pin low. An external circuit may drive the pin to assert a device reset.

A resistor with a value from 2.2 k $\Omega$  to 10 k $\Omega$  should be placed between  $\overline{XRS}$  and  $V_{DDIO}$ . A capacitor should be placed between  $\overline{XRS}$  and  $V_{SS}$  for noise filtering; the capacitance should be 100 nF or smaller. These values will allow the watchdog to properly drive the  $\overline{XRS}$  pin to  $V_{OL}$  within 512 OSCCLK cycles when the watchdog reset is asserted. Figure 5-4 shows the recommended reset circuit.



**Figure 5-4. Reset Circuit**

### 5.7.2.1 Reset Sources

The following reset sources exist on this device:  $\overline{XRS}$ ,  $\overline{WDRS}$ ,  $\overline{NMIWDRS}$ ,  $\overline{SYSRS}$ ,  $\overline{SCCRESET}$ , and  $\overline{HIBRESET}$ . See the "Reset Signals" table in the "System Control" chapter of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual* ([SPRUHM8](#)).

The parameter  $t_{h(\text{boot-mode})}$  must account for a reset initiated from any of these sources.

#### CAUTION

Some reset sources are internally driven by the device. Some of these sources will drive  $\overline{XRS}$  low. Use this to disable any other devices driving the boot pins. The  $\overline{SCCRESET}$  and debugger reset sources do not drive  $\overline{XRS}$ ; therefore, the pins used for boot mode should not be actively driven by other devices in the system. The boot configuration has a provision for changing the boot pins in OTP; for more details, see the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual* ([SPRUHM8](#)).

### 5.7.2.2 Reset Electrical Data and Timing

[Table 5-4](#) shows the reset ( $\overline{XRS}$ ) timing requirements. [Table 5-5](#) shows the reset ( $\overline{XRS}$ ) switching characteristics. [Figure 5-5](#) shows the power-on reset. [Figure 5-6](#) shows the warm reset.

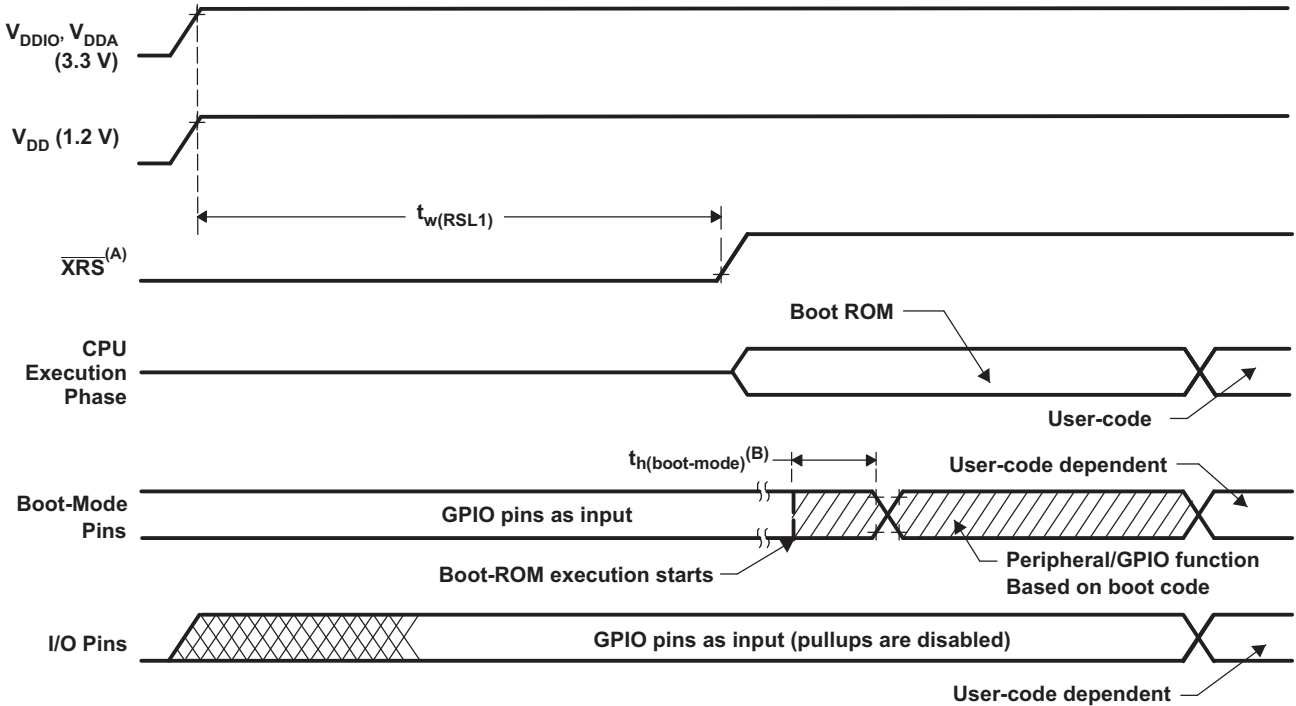
**Table 5-4. Reset ( $\overline{XRS}$ ) Timing Requirements**

		MIN	MAX	UNIT
$t_{h(\text{boot-mode})}$	Hold time for boot-mode pins	1.5		ms
$t_{w(\text{RSL2})}$	Pulse duration, $\overline{XRS}$ low on warm reset	3.2		$\mu\text{s}$

**Table 5-5. Reset ( $\overline{XRS}$ ) Switching Characteristics**

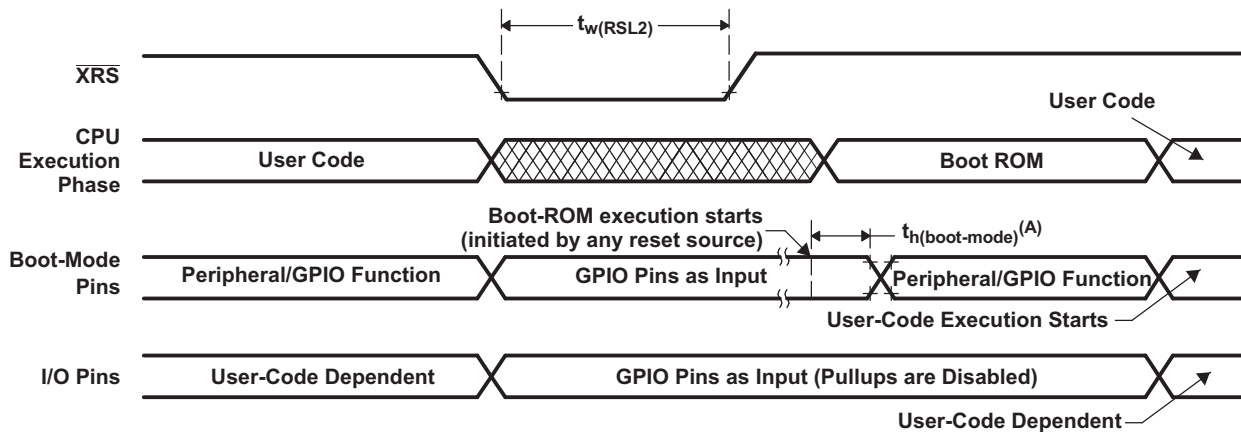
over recommended operating conditions (unless otherwise noted)

PARAMETER		MIN	TYP	MAX	UNIT
$t_{w(\text{RSL1})}$	Pulse duration, $\overline{XRS}$ driven low by device after supplies are stable		100		$\mu\text{s}$
$t_{w(\text{WDRS})}$	Pulse duration, reset pulse generated by watchdog		$512t_{c(\text{OSCCLOCK})}$		cycles



- A. The  $\overline{\text{XRS}}$  pin can be driven externally by a supervisor or an external pullup resistor, see [Table 4-1](#). On-chip POR logic will hold this pin low until the supplies are in a valid range.
- B. After reset from any source (see [Section 5.7.2.1](#)), the boot ROM code samples Boot Mode pins. Based on the status of the Boot Mode pin, the boot code branches to destination memory or boot code function. If boot ROM code executes after power-on conditions (in debugger environment), the boot code execution time is based on the current SYSCLK speed. The SYSCLK will be based on user environment and could be with or without PLL enabled.

Figure 5-5. Power-on Reset



- A. After reset from any source (see [Section 5.7.2.1](#)), the Boot ROM code samples BOOT Mode pins. Based on the status of the Boot Mode pin, the boot code branches to destination memory or boot code function. If Boot ROM code executes after power-on conditions (in debugger environment), the Boot code execution time is based on the current SYSCLK speed. The SYSCLK will be based on user environment and could be with or without PLL enabled.

Figure 5-6. Warm Reset

## 5.7.3 Clock Specifications

### 5.7.3.1 Clock Sources

表 5-6 lists four possible clock sources. 图 5-7 provides an overview of the device's clocking system.

**表 5-6. Possible Reference Clock Sources**

CLOCK SOURCE	MODULES CLOCKED	COMMENTS
INTOSC1	Can be used to provide clock for: <ul style="list-style-type: none"> <li>• Watchdog block</li> <li>• Main PLL</li> <li>• CPU-Timer 2</li> </ul>	Internal oscillator 1. Zero-pin overhead 10-MHz internal oscillator.
INTOSC2 <sup>(1)</sup>	Can be used to provide clock for: <ul style="list-style-type: none"> <li>• Main PLL</li> <li>• Auxiliary PLL</li> <li>• CPU-Timer 2</li> </ul>	Internal oscillator 2. Zero-pin overhead 10-MHz internal oscillator.
XTAL	Can be used to provide clock for: <ul style="list-style-type: none"> <li>• Main PLL</li> <li>• Auxiliary PLL</li> <li>• CPU-Timer 2</li> </ul>	External crystal or resonator connected between the X1 and X2 pins or single-ended clock connected to the X1 pin.
AUXCLKIN	Can be used to provide clock for: <ul style="list-style-type: none"> <li>• Auxiliary PLL</li> <li>• CPU-Timer 2</li> </ul>	Single-ended 3.3-V level clock source. GPIO133/AUXCLKIN pin should be used to provide the input clock.

(1) On reset, internal oscillator 2 (INTOSC2) is the default clock source for both system PLL (OSCCLK) and auxiliary PLL (AUXOSCCLK).

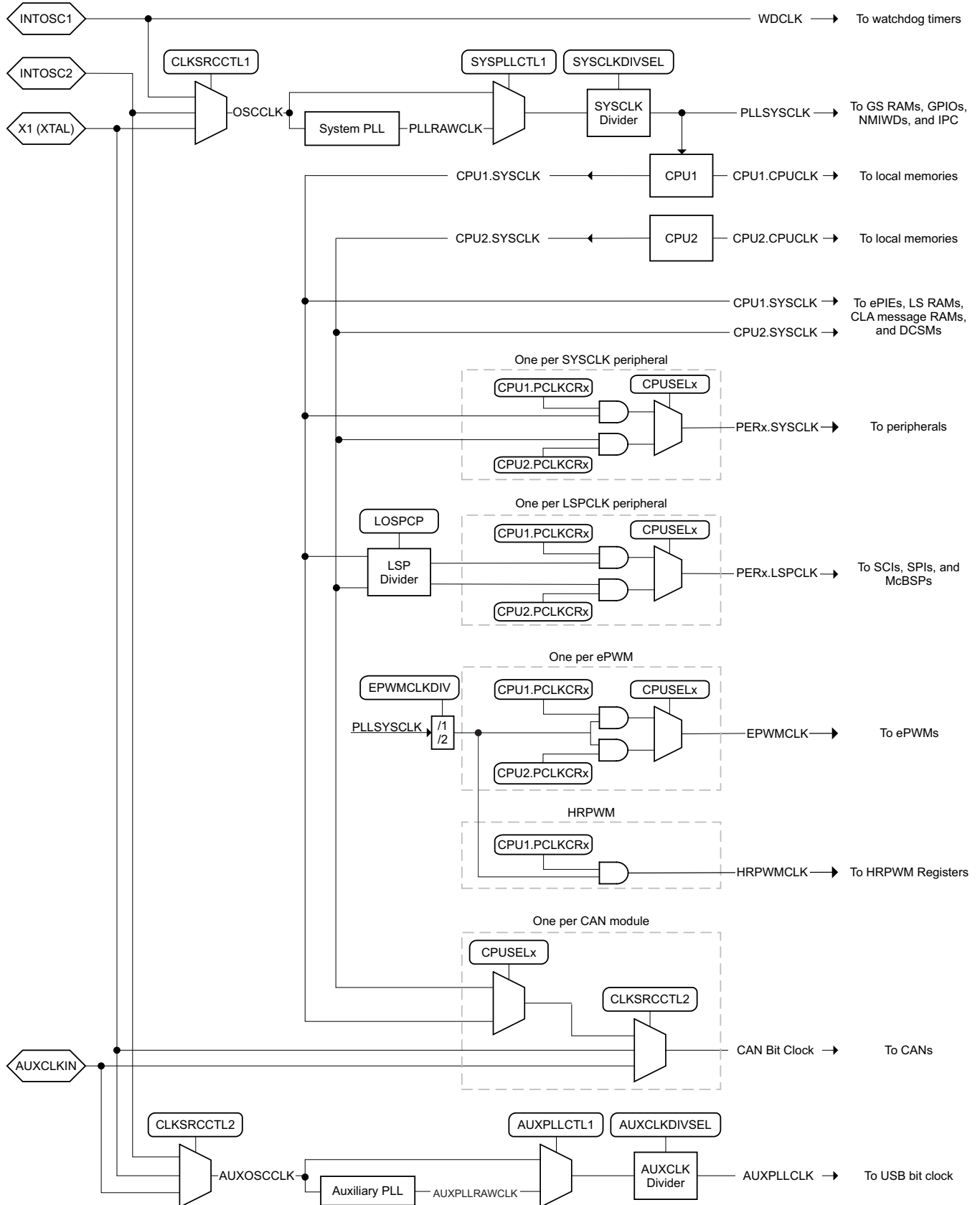


图 5-7. Clocking System

### 5.7.3.2 Clock Frequencies, Requirements, and Characteristics

This section provides the frequencies and timing requirements of the input clocks, PLL lock times, frequencies of the internal clocks, and the frequency and switching characteristics of the output clock.

#### 5.7.3.2.1 Input Clock Frequency and Timing Requirements, PLL Lock Times

表 5-7 shows the frequency requirements for the input clocks. 表 5-16 shows the crystal equivalent series resistance requirements. 表 5-8 shows the X1 input level characteristics when using an external clock source. 表 5-9 and 表 5-10 show the timing requirements for the input clocks. 表 5-11 shows the PLL lock times for the Main PLL and the USB PLL.

**表 5-7. Input Clock Frequency**

		MIN	MAX	UNIT
$f_{(XTAL)}$	Frequency, X1/X2, from external crystal or resonator	10	20	MHz
$f_{(X1)}$	Frequency, X1, from external oscillator ( <b>PLL enabled</b> )	2	20	MHz
	Frequency, X1, from external oscillator ( <b>PLL disabled</b> )	2	100	MHz
$f_{(AUXI)}$	Frequency, AUXCLKIN, from external oscillator	2	60	MHz

**表 5-8. X1 Input Level Characteristics When Using an External Clock Source (Not a Crystal)**

over recommended operating conditions (unless otherwise noted)

PARAMETER		MIN	MAX	UNIT
X1 $V_{IL}$	Valid low-level input voltage	-0.3	$0.3 * V_{DDIO}$	V
X1 $V_{IH}$	Valid high-level input voltage	$0.7 * V_{DDIO}$	$V_{DDIO} + 0.3$	V

**表 5-9. X1 Timing Requirements**

		MIN	MAX	UNIT
$t_{f(X1)}$	Fall time, X1		6	ns
$t_{r(X1)}$	Rise time, X1		6	ns
$t_{w(X1L)}$	Pulse duration, X1 low as a percentage of $t_{c(X1)}$	45%	55%	
$t_{w(X1H)}$	Pulse duration, X1 high as a percentage of $t_{c(X1)}$	45%	55%	

**表 5-10. AUXCLKIN Timing Requirements**

		MIN	MAX	UNIT
$t_{f(AUXI)}$	Fall time, AUXCLKIN		6	ns
$t_{r(AUXI)}$	Rise time, AUXCLKIN		6	ns
$t_{w(AUXL)}$	Pulse duration, AUXCLKIN low as a percentage of $t_{c(XCI)}$	45%	55%	
$t_{w(AUXH)}$	Pulse duration, AUXCLKIN high as a percentage of $t_{c(XCI)}$	45%	55%	

**表 5-11. PLL Lock Times**

		MIN	NOM	MAX	UNIT
$t_{(PLL)}$	Lock time, Main PLL (X1, from external oscillator)		$50 \mu s + 2500 * t_{c(OSCCLK)}^{(1)}$		$\mu s$
$t_{(USB)}$	Lock time, USB PLL (AUXCLKIN, from external oscillator)		$50 \mu s + 2500 * t_{c(OSCCLK)}^{(1)}$		$\mu s$

(1) The PLL lock time here includes the two required PLL lock sequences. Cycle count includes code execution of the PLL initialization routine, which could vary depending on compiler optimizations and flash wait states.

### 5.7.3.2.2 Internal Clock Frequencies

表 5-12 provides the clock frequencies for the internal clocks.

表 5-12. Internal Clock Frequencies

		MIN	NOM	MAX	UNIT
$f_{\text{SYSCLK}}$	Frequency, device (system) clock	2		200	MHz
$t_{\text{c(SYSCLK)}}$	Period, device (system) clock	5		500	ns
$f_{\text{(PLLRAWCLK)}}$	Frequency, system PLL output (before SYSCLK divider)	120		400	MHz
$f_{\text{(AUXPLLRAWCLK)}}$	Frequency, auxiliary PLL output (before AUXCLK divider)	120		400	MHz
$f_{\text{(AUXPLL)}}$	Frequency, AUXPLLCLK	60		60	MHz
$f_{\text{(PLL)}}$	Frequency, PLLSYSCLK	2		200	MHz
$f_{\text{(LSP)}}$	Frequency, LSPCLK <sup>(1)</sup>	2		200	MHz
$t_{\text{c(LSPCLK)}}$	Period, LSPCLK	5		500	ns
$f_{\text{(OSCCLK)}}$	Frequency, OSCCLK (INTOSC1 or INTOSC2 or XTAL or X1)	See respective clock			
$f_{\text{(EPWM)}}$	Frequency, EPWMCLK <sup>(2)</sup>			100	MHz
$f_{\text{(HRPWM)}}$	Frequency, HRPWMCLK	60		100	MHz

(1) Lower LSPCLK will reduce device power consumption. The default at reset is SYSCLK/4.

(2) For SYSCLK above 100 MHz, the EPWMCLK must be half of SYSCLK.

### 5.7.3.2.3 Output Clock Frequency and Switching Characteristics

表 5-13 provides the frequency of the output clock. 表 5-14 shows the switching characteristics of the output clock, XCLKOUT.

表 5-13. Output Clock Frequency

		MIN	MAX	UNIT
$f_{\text{(XCO)}}$	Frequency, XCLKOUT		50	MHz

表 5-14. XCLKOUT Switching Characteristics (PLL Bypassed or Enabled)<sup>(1)(2)</sup>

over recommended operating conditions (unless otherwise noted)

	PARAMETER	MIN	MAX	UNIT
$t_{\text{f(XCO)}}$	Fall time, XCLKOUT		5	ns
$t_{\text{r(XCO)}}$	Rise time, XCLKOUT		5	ns
$t_{\text{w(XCOL)}}$	Pulse duration, XCLKOUT low	H – 2	H + 2	ns
$t_{\text{w(XCOH)}}$	Pulse duration, XCLKOUT high	H – 2	H + 2	ns

(1) A load of 40 pF is assumed for these parameters.

(2)  $H = 0.5t_{\text{c(XCO)}}$

### 5.7.3.3 Input Clocks and PLLs

In addition to the internal 0-pin oscillators, multiple external clock source options are available. 图 5-8 shows the recommended methods of connecting crystals, resonators, and oscillators to pins X1/X2 (also referred to as XTAL) and AUXCLKIN.

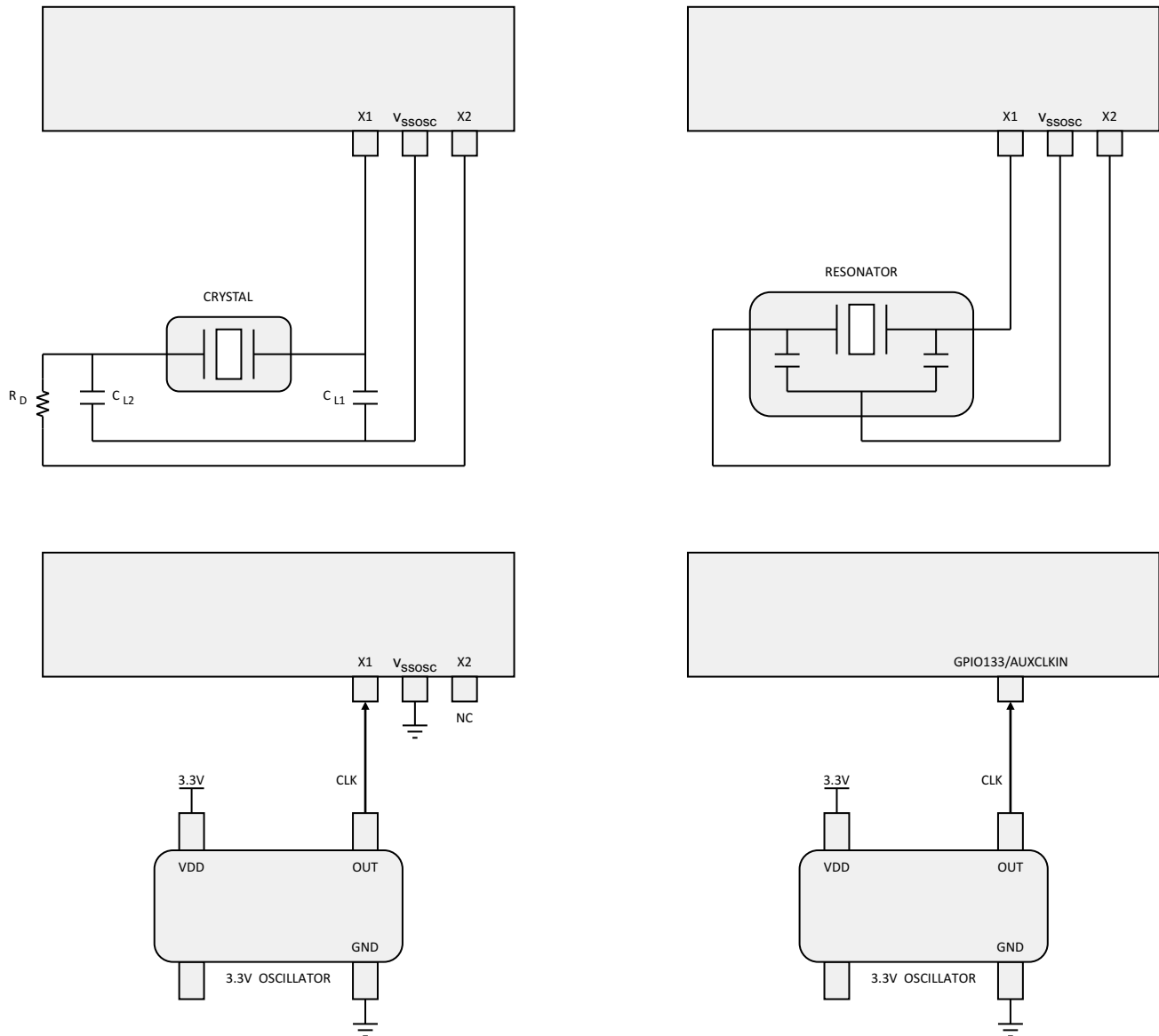


图 5-8. Connecting Input Clocks to a 2837xD Device



### 5.7.3.4 Crystal Oscillator

When using a quartz crystal, it may be necessary to include a damping resistor ( $R_D$ ) in the crystal circuit to prevent over-driving the crystal (drive level can be found in the crystal data sheet). In higher-frequency applications (10 MHz or greater),  $R_D$  is generally not required. If a damping resistor is required,  $R_D$  should be as small as possible because the size of the resistance affects start-up time (smaller  $R_D$  = faster start-up time). It is recommended that the crystal manufacturer characterize the crystal with the application board. 表 5-15 shows the crystal oscillator parameters. 表 5-16 shows the crystal equivalent series resistance (ESR) requirements. 表 5-17 shows the crystal oscillator electrical characteristics.

表 5-15. Crystal Oscillator Parameters

		MIN	MAX	UNIT
CL1, CL2	Load capacitance	12	24	pF
C0	Crystal shunt capacitance		7	pF

表 5-16. Crystal Equivalent Series Resistance (ESR) Requirements<sup>(1)(2)</sup>

CRYSTAL FREQUENCY (MHz)	MAXIMUM ESR ( $\Omega$ ) (CL1 = CL2 = 12 pF)	MAXIMUM ESR ( $\Omega$ ) (CL1 = CL2 = 24 pF)
10	55	110
12	50	95
14	50	90
16	45	75
18	45	65
20	45	50

- (1) Crystal shunt capacitance (C0) should be less than or equal to 7 pF.  
(2) ESR = Negative Resistance/3

表 5-17. Crystal Oscillator Electrical Characteristics

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Start-up time <sup>(1)</sup>	f = 20 MHz ESR MAX = 50 $\Omega$ CL1 = CL2 = 24 pF C0 = 7 pF		2		ms
Crystal drive level (DL)				1	mW

- (1) Start-up time is dependent on the crystal and tank circuit components. It is recommended that the crystal vendor characterize the application with the chosen crystal.

### 5.7.3.5 Internal Oscillators

To reduce production board costs and application development time, all F2837xD devices contain two independent internal oscillators, referred to as INTOSC1 and INTOSC2. By default, both oscillators are enabled at power up. INTOSC2 is set as the source for the system reference clock (OSCCLK) and INTOSC1 is set as the backup clock source. INTOSC1 can also be manually configured as the system reference clock (OSCCLK). [Table 5-18](#) provides the electrical characteristics of the internal oscillators to determine if this module meets the clocking requirements of the application.

[Table 5-18](#) provides the electrical characteristics of the two internal oscillators.

---

#### NOTE

This oscillator cannot be used as the PLL source if the PLLSYSCLK is configured to frequencies above 194 MHz.

---

**Table 5-18. Internal Oscillator Electrical Characteristics**

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{(INTOSC)}$	Frequency, INTOSC1 and INTOSC2		9.7		10.3	MHz
	Frequency stability at room temperature	30°C		±0.1%		
$t_{OSCST}$	Start-up and settling time				22	µs

### 5.7.4 Flash Parameters

The on-chip flash memory is tightly integrated to the CPU, allowing code execution directly from flash through 128-bit-wide prefetch reads and a pipeline buffer. Flash performance for sequential code is equal to execution from RAM. Factoring in discontinuities, most applications will run with an efficiency of approximately 80% relative to code executing from RAM. This flash efficiency lets designers realize a 2x improvement in performance when migrating from the previous generation Delfino MCUs.

This device also has an OTP (One-Time-Programmable) sector used for the dual code security module (DCSM), which cannot be erased after it is programmed.

表 5-19 shows the minimum required flash wait states at different frequencies. 表 5-20 shows the flash parameters at 200 MHz. 表 5-21 shows the flash/OTP endurance. 表 5-22 shows the flash data retention duration.

**表 5-19. Minimum Required Flash Wait States at Different Frequencies**

CPUCLK (MHz) <sup>(1)</sup>	FLASH WAIT STATES (MINIMUM REQUIRED RWAIT)
151–200	3
101–150	2
51–100	1
≤50	0

(1) When using INTOSC (see Table 5-18, Internal Oscillator Electrical Characteristics) as the PLL clock source, the SYSCLK divided by RWAIT + 1 should not exceed 50 MHz after accounting for INTOSC accuracy. For example, instead of configuring the PLL for 100 MHz, configure it for 97 MHz when using INTOSC.

**表 5-20. Flash Parameters at 200 MHz<sup>(1)</sup>**

PARAMETER		MIN	TYP	MAX	UNIT
Program Time <sup>(2)</sup>	128 data bits + 16 ECC bits		40	300	μs
	8KW sector		90	180	ms
	32KW sector		360	720	ms
Erase Time <sup>(3)</sup> at < 25 cycles	8KW sector		25	50	ms
	32KW sector		30	55	
Erase Time <sup>(3)</sup> at 50k cycles	8KW sector		105	4000	ms
	32KW sector		110	4000	

(1) The on-chip flash memory is in an erased state when the device is shipped from TI. As such, erasing the flash memory is not required prior to programming, when programming the device for the first time. However, the erase operation is needed on all subsequent programming operations.

(2) Program time includes overhead of the Flash state machine but does not include the time to transfer the following into RAM:

- Code that uses Flash API to program the Flash
- Flash API itself
- Flash data to be programmed

In other words, the time indicated in this table is applicable after all the required code/data is available in the device RAM, ready for programming. Note that the transfer time will significantly vary depending on the speed of the emulator used.

Program time calculation is based on programming 144 bits at a time at the specified operating frequency. Program time includes Program verify by the CPU. Note that the program time does not degrade with write/erase (W/E) cycling, but the erase time does.

Erase time includes Erase verify by the CPU and does not involve any data transfer.

(3) Erase time includes Erase verify by the CPU.

**表 5-21. Flash/OTP Endurance**

		MIN	TYP	MAX	UNIT
$N_f$	Flash endurance for the array (write/erase cycles)	20000	50000		cycles

**表 5-22. Flash Data Retention Duration**

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$t_{\text{retention}}$	Data retention duration	$T_J = 85^\circ\text{C}$	20		years

### 5.7.5 Emulation/JTAG

The JTAG port has five dedicated pins:  $\overline{\text{TRST}}$ , TMS, TDI, TDO, and TCK. The  $\overline{\text{TRST}}$  signal should always be pulled down through a 2.2-k $\Omega$  pull-down resistor on the board. This MCU does not support the EMU0 and EMU1 signals that are present on 14-pin and 20-pin emulation headers. These signals should always be pulled up at the emulation header through a pair of board pullup resistors ranging from 2.2 k $\Omega$  to 4.7 k $\Omega$  (depending on the drive strength of the debugger ports). Typically, a 2.2-k $\Omega$  value is used.

See [图 5-9](#) to see how the 14-pin JTAG header connects to the MCU's JTAG port signals. [图 5-10](#) shows how to connect to the 20-pin header. The 20-pin JTAG header terminals EMU2, EMU3, and EMU4 are not used and should be grounded.

The PD (Power Detect) terminal of the emulator header should be connected to the board 3.3-V supply. Header GND terminals should be connected to board ground. TDIS (Cable Disconnect Sense) should also be connected to board ground. The JTAG clock should be looped from the header TCK output terminal back to the RTCK input terminal of the header (to sense clock continuity by the emulator). Header terminal  $\overline{\text{RESET}}$  is an open-drain output from the emulator header that enables board components to be reset through emulator commands (available only through the 20-pin header).

Typically, no buffers are needed on the JTAG signals when the distance between the MCU target and the JTAG header is smaller than 6 inches (15.24 cm), and no other devices are present on the JTAG chain. Otherwise, each signal should be buffered. Additionally, for most emulator operations at 10 MHz, no series resistors are needed on the JTAG signals. However, if high emulation speeds are expected (35 MHz or so), 22- $\Omega$  resistors should be placed in series on each JTAG signal.

See the [XDS Target Connection Guide](#) for more information about JTAG emulation.

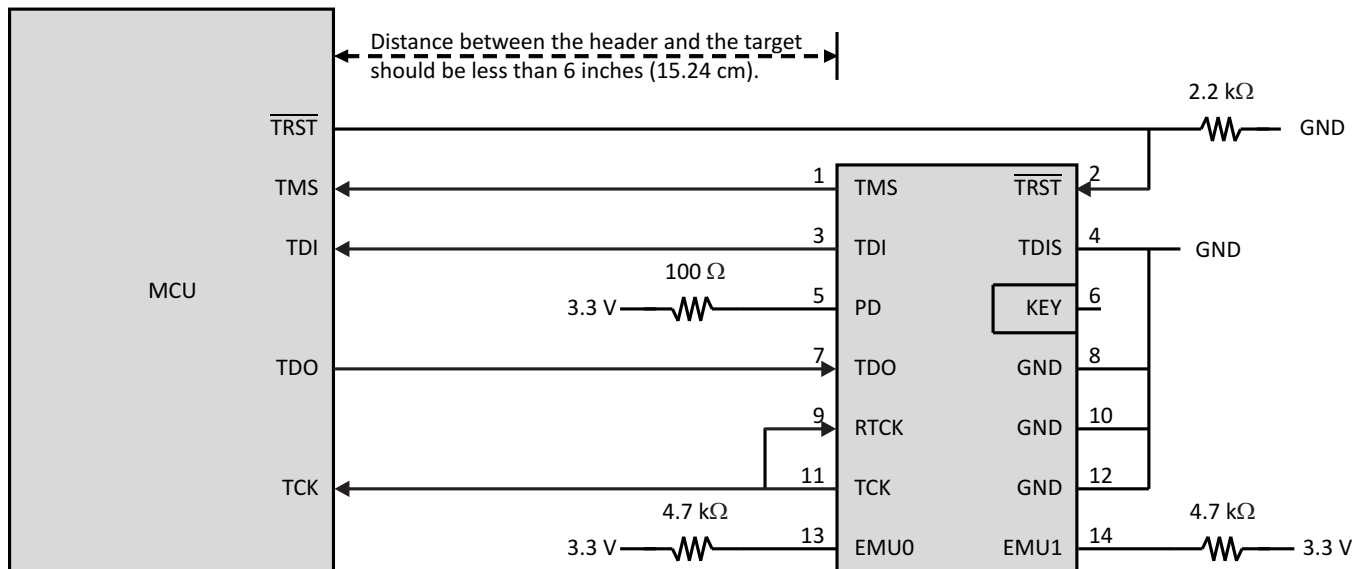


图 5-9. Connecting to the 14-Pin JTAG Header

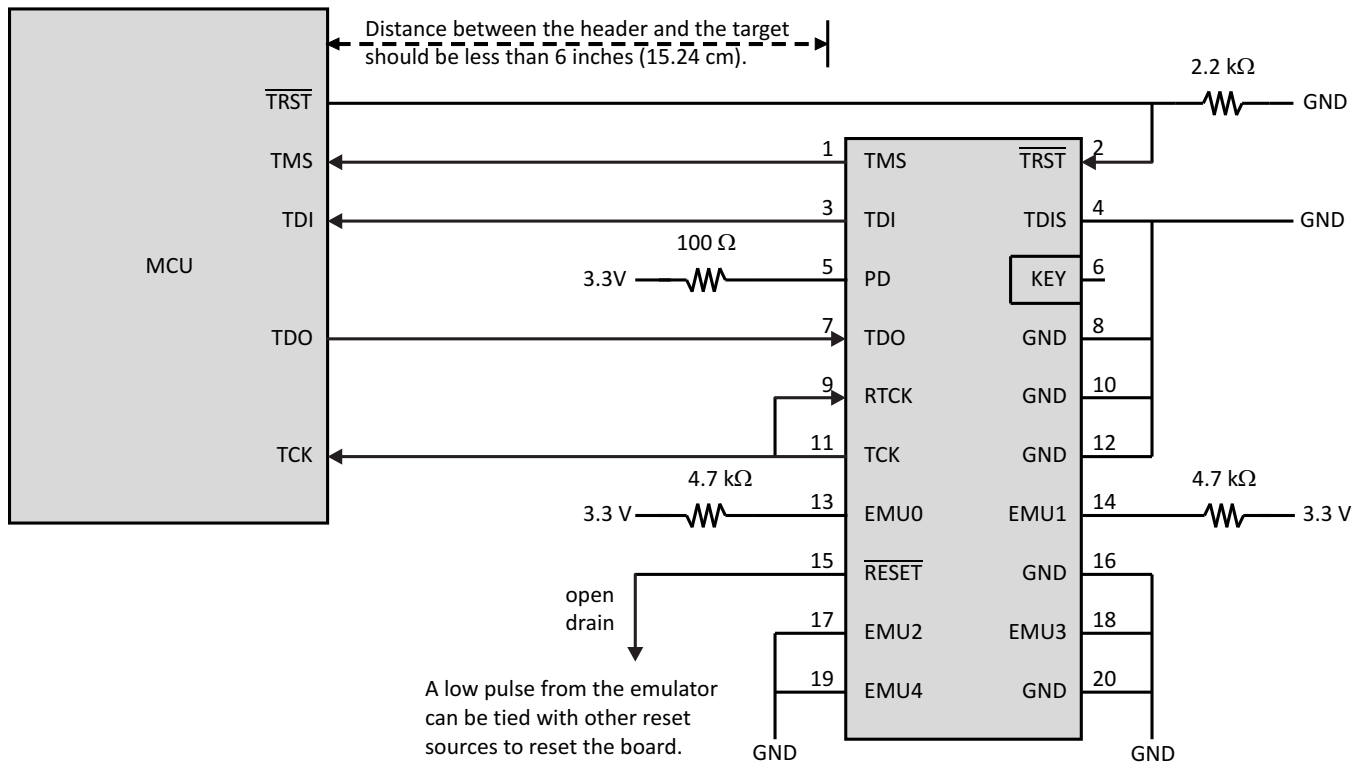


图 5-10. Connecting to the 20-Pin JTAG Header

### 5.7.6 GPIO Electrical Data and Timing

The peripheral signals are multiplexed with general-purpose input/output (GPIO) signals. On reset, GPIO pins are configured as inputs. For specific inputs, the user can also select the number of input qualification cycles to filter unwanted noise glitches.

The GPIO module contains an Output X-BAR which allows an assortment of internal signals to be routed to a GPIO in the GPIO mux positions denoted as OUTPUTXBARx. The GPIO module also contains an Input X-BAR which is used to route signals from any GPIO input to different IP blocks such as the ADC(s), eCAP(s), ePWM(s), and external interrupts. For more details, see the X-BAR chapter in the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)*.

#### 5.7.6.1 GPIO - Output Timing

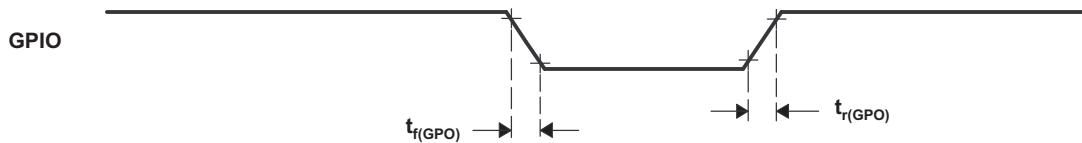
Table 5-23 shows the general-purpose output switching characteristics. Figure 5-11 shows the general-purpose output timing.

**Table 5-23. General-Purpose Output Switching Characteristics**

over recommended operating conditions (unless otherwise noted)

PARAMETER			MIN	MAX	UNIT
$t_{r(GPO)}$	Rise time, GPIO switching low to high	All GPIOs		8 <sup>(1)</sup>	ns
$t_{f(GPO)}$	Fall time, GPIO switching high to low	All GPIOs		8 <sup>(1)</sup>	ns
$t_{fGPO}$	Toggle frequency, GPO pins			25	MHz

(1) Rise time and fall time vary with load. These values assume a 40-pF load.



**Figure 5-11. General-Purpose Output Timing**

### 5.7.6.2 GPIO - Input Timing

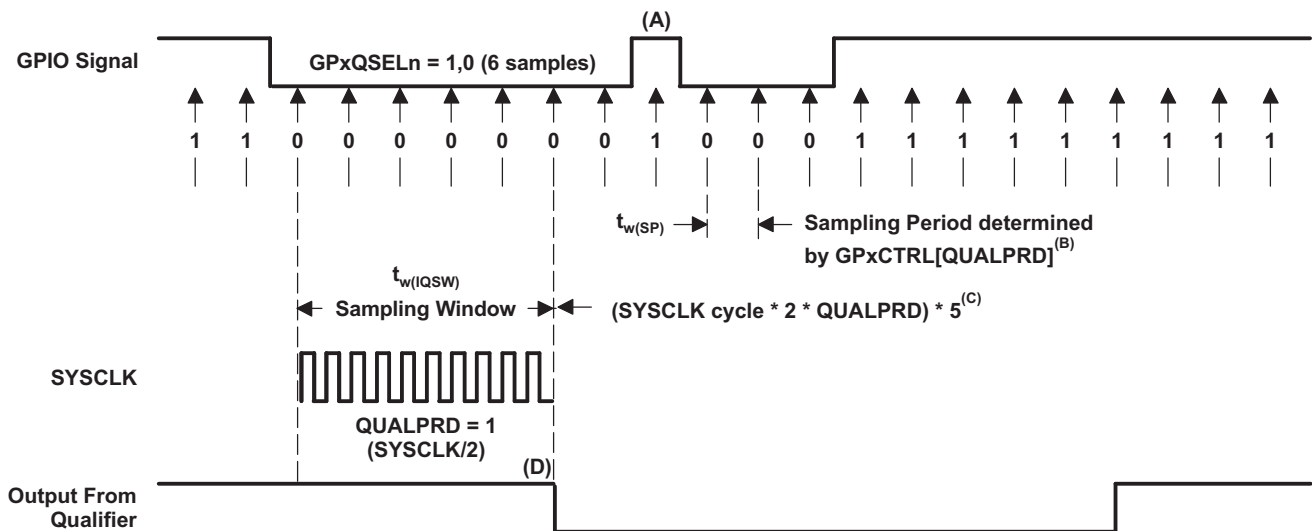
Table 5-24 shows the general-purpose input timing requirements. Figure 5-12 shows the sampling mode.

**Table 5-24. General-Purpose Input Timing Requirements**

			MIN	MAX	UNIT
$t_{w(SP)}$	Sampling period	QUALPRD = 0	$1t_{c(SYCLK)}$		cycles
		QUALPRD $\neq$ 0	$2t_{c(SYCLK)} * QUALPRD$		cycles
$t_{w(IQSW)}$	Input qualifier sampling window		$t_{w(SP)} * (n^{(1)} - 1)$		cycles
$t_{w(GPI)}^{(2)}$	Pulse duration, GPIO low/high	Synchronous mode	$2t_{c(SYCLK)}$		cycles
		With input qualifier	$t_{w(IQSW)} + t_{w(SP)} + 1t_{c(SYCLK)}$		cycles

(1) "n" represents the number of qualification samples as defined by GPxQSELn register.

(2) For  $t_{w(GPI)}$ , pulse width is measured from  $V_{IL}$  to  $V_{IL}$  for an active low signal and  $V_{IH}$  to  $V_{IH}$  for an active high signal.



- A. This glitch will be ignored by the input qualifier. The QUALPRD bit field specifies the qualification sampling period. It can vary from 00 to 0xFF. If QUALPRD = 00, then the sampling period is 1 SYCLK cycle. For any other value "n", the qualification sampling period is 2n SYCLK cycles (that is, at every 2n SYCLK cycles, the GPIO pin will be sampled).
- B. The qualification period selected through the GPxCTRL register applies to groups of 8 GPIO pins.
- C. The qualification block can take either three or six samples. The GPxQSELn Register selects which sample mode is used.
- D. In the example shown, for the qualifier to detect the change, the input should be stable for 10 SYCLK cycles or greater. In other words, the inputs should be stable for (5 x QUALPRD x 2) SYCLK cycles. This would ensure 5 sampling periods for detection to occur. Because external signals are driven asynchronously, a 13-SYCLK-wide pulse ensures reliable recognition.

**Figure 5-12. Sampling Mode**



### 5.7.6.3 Sampling Window Width for Input Signals

The following section summarizes the sampling window width for input signals for various input qualifier configurations.

Sampling frequency denotes how often a signal is sampled with respect to SYSCLK.

Sampling frequency =  $\text{SYSCLK} / (2 \times \text{QUALPRD})$ , if  $\text{QUALPRD} \neq 0$

Sampling frequency =  $\text{SYSCLK}$ , if  $\text{QUALPRD} = 0$

Sampling period =  $\text{SYSCLK cycle} \times 2 \times \text{QUALPRD}$ , if  $\text{QUALPRD} \neq 0$

In the above equations, SYSCLK cycle indicates the time period of SYSCLK.

Sampling period =  $\text{SYSCLK cycle}$ , if  $\text{QUALPRD} = 0$

In a given sampling window, either 3 or 6 samples of the input signal are taken to determine the validity of the signal. This is determined by the value written to GPxQSELn register.

#### Case 1:

Qualification using 3 samples

Sampling window width =  $(\text{SYSCLK cycle} \times 2 \times \text{QUALPRD}) \times 2$ , if  $\text{QUALPRD} \neq 0$

Sampling window width =  $(\text{SYSCLK cycle}) \times 2$ , if  $\text{QUALPRD} = 0$

#### Case 2:

Qualification using 6 samples

Sampling window width =  $(\text{SYSCLK cycle} \times 2 \times \text{QUALPRD}) \times 5$ , if  $\text{QUALPRD} \neq 0$

Sampling window width =  $(\text{SYSCLK cycle}) \times 5$ , if  $\text{QUALPRD} = 0$

Figure 5-13 shows the general-purpose input timing.

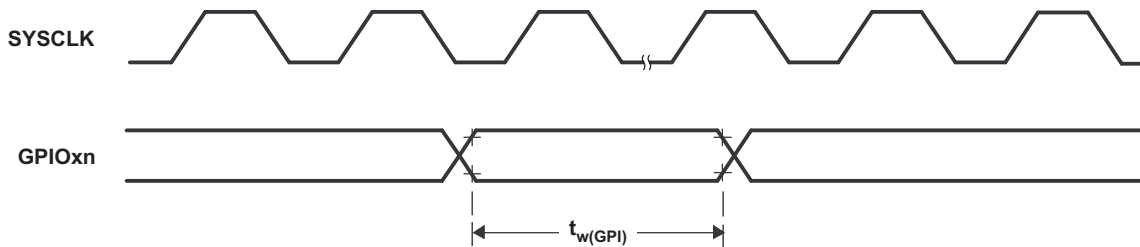


Figure 5-13. General-Purpose Input Timing

### 5.7.7 Interrupts

图 5-14 提供了中断架构的高级别视图。

如所示在 图 5-14, 设备支持五个外部中断 (XINT1 到 XINT5) 可以映射到任意的 GPIO 引脚。

在此设备中, 16 ePIE 块中断被分组为 1 CPU 中断。总共, 有 12 CPU 中断组, 每个组有 16 个中断。

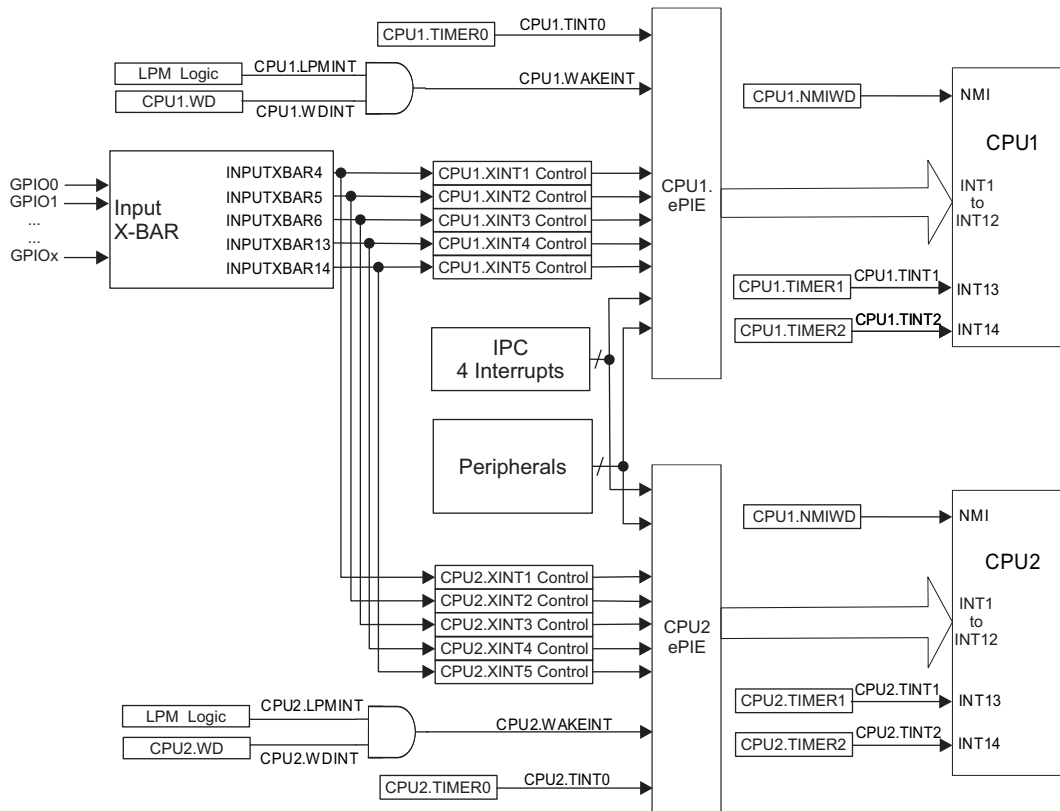


图 5-14. External and ePIE Interrupt Sources

### 5.7.7.1 External Interrupt (XINT) Electrical Data and Timing

Table 5-25 shows the external interrupt timing requirements. Table 5-26 shows the external interrupt switching characteristics. Figure 5-15 shows the external interrupt timing.

**Table 5-25. External Interrupt Timing Requirements<sup>(1)</sup>**

		MIN	MAX	UNIT
$t_{w(INT)}$	Pulse duration, INT input low/high	Synchronous	$2t_{c(SYSCCLK)}$	cycles
		With qualifier	$t_{w(IQSW)} + t_{w(SP)} + 1t_{c(SYSCCLK)}$	cycles

(1) For an explanation of the input qualifier parameters, see Table 5-24.

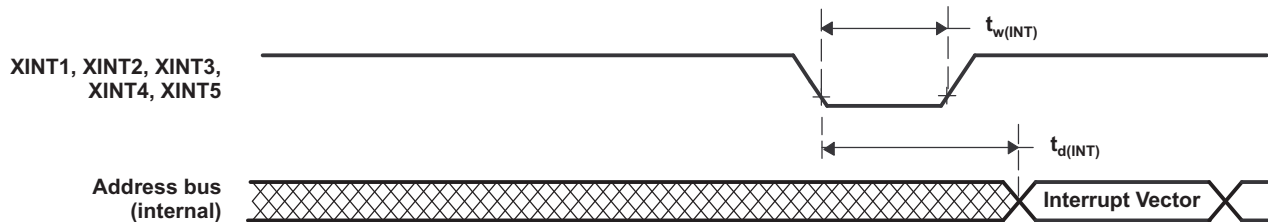
**Table 5-26. External Interrupt Switching Characteristics<sup>(1)</sup>**

over recommended operating conditions (unless otherwise noted)

PARAMETER	MIN	MAX	UNIT
$t_{d(INT)}$ Delay time, INT low/high to interrupt-vector fetch <sup>(2)</sup>	$t_{w(IQSW)} + 14t_{c(SYSCCLK)}$	$t_{w(IQSW)} + t_{w(SP)} + 14t_{c(SYSCCLK)}$	cycles

(1) For an explanation of the input qualifier parameters, see Table 5-24.

(2) This assumes that the ISR is in a single-cycle memory.



**Figure 5-15. External Interrupt Timing**

### 5.7.8 Low-Power Modes

This device has three clock-gating low-power modes and a special power-gating mode.

Further details, as well as the entry and exit procedure, for all of the low-power modes can be found in the "Low Power Modes" section of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)*.

#### 5.7.8.1 Clock-Gating Low-Power Modes

IDLE, STANDBY, and HALT modes on this device are similar to those on other C28x devices. 表 5-27 describes the effect on the system when any of the clock-gating low-power modes are entered.

**表 5-27. Effect of Clock-Gating Low-Power Modes on the Device**

MODULES/ CLOCK DOMAIN	CPU1 IDLE	CPU1 STANDBY	CPU2 IDLE	CPU2 STANDBY	HALT
CPU1.CLKIN	Active	Gated	N/A	N/A	Gated
CPU1.SYSCLK	Active	Gated	N/A	N/A	Gated
CPU1.CPUCLK	Gated	Gated	N/A	N/A	Gated
CPU2.CLKIN	N/A	N/A	Active	Gated	Gated
CPU2.SYSCLK	N/A	N/A	Active	Gated	Gated
CPU2.CPUCLK	N/A	N/A	Gated	Gated	Gated
Clock to modules Connected to PERx.SYSCLK	Active	Gated if CPUSEL.PERx = CPU1	Active	Gated if CPUSEL.PERx = CPU2	Gated
CPU1.WDCLK	Active	Active	N/A	N/A	Gated if CLKSRCCTL1.WDHALTI = 0
CPU2.WDCLK	N/A	N/A	Active	Active	Gated
AUXPLLCLK	Active	Active	Active	Active	Gated
PLL	Powered	Powered	Powered	Powered	Software must power down PLL before entering HALT
INTOSC1	Powered	Powered	Powered	Powered	Powered down if CLKSRCCTL1.WDHALTI = 0
INTOSC2	Powered	Powered	Powered	Powered	Powered down if CLKSRCCTL1.WDHALTI = 0
Flash	Powered	Powered	Powered	Powered	Software-Controlled
X1/X2 Crystal Oscillator	Powered	Powered	Powered	Powered	Powered-Down

#### 5.7.8.2 Power-Gating Low-Power Modes

HIBERNATE mode is the lowest power mode on this device. It is a global low-power mode that gates the supply voltages to most of the system. HIBERNATE is essentially a controlled power-down with remote wakeup capability, and can be used to save power during long periods of inactivity. 表 5-28 describes the effects on the system when the HIBERNATE mode is entered.

**表 5-28. Effect of Power-Gating Low-Power Mode on the Device**

MODULES/POWER DOMAINS	HIBERNATE
M0 and M1 memories	<ul style="list-style-type: none"> <li>Remain on with memory retention if LPMCR.M0M1MODE = 0x00</li> <li>Are off when LPMCR.M0M1MODE = 0x01</li> </ul>
CPU1, CPU2, digital peripherals	Powered down
Dx, LSx, GSx memories	Power down, memory contents are lost
IOs	On with output state preserved
Oscillators, PLL, analog peripherals, Flash	Enters Low-Power Mode

### 5.7.8.3 Low-Power Mode Wakeup Timing

表 5-29 shows the IDLE mode timing requirements, 表 5-30 shows the switching characteristics, and 图 5-16 shows the timing diagram for IDLE mode.

表 5-29. IDLE Mode Timing Requirements<sup>(1)</sup>

		MIN	MAX	UNIT
$t_{w(WAKE)}$	Pulse duration, external wake-up signal	Without input qualifier	$2t_{c(SYCLK)}$	cycles
		With input qualifier	$2t_{c(SYCLK)} + t_{w(IQSW)}$	

(1) For an explanation of the input qualifier parameters, see Table 5-24.

表 5-30. IDLE Mode Switching Characteristics<sup>(1)</sup>

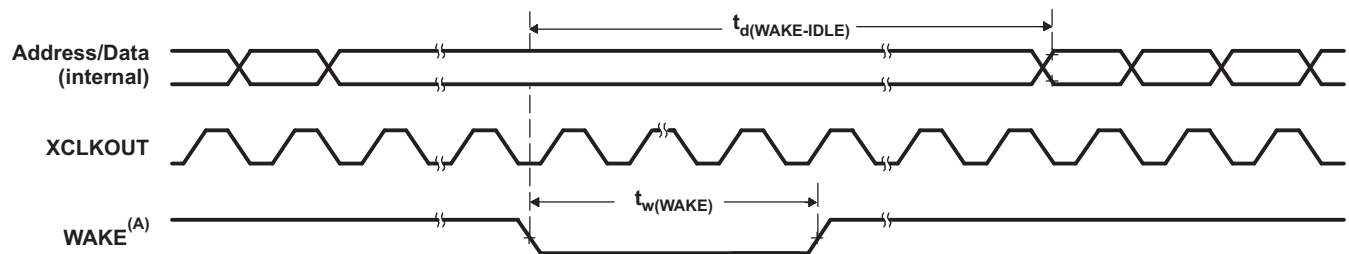
over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
$t_{d(WAKE-IDLE)}$	Delay time, external wake signal to program execution resume <sup>(2)</sup>				cycles
	• Wakeup from Flash – Flash module in active state	Without input qualifier		$40t_{c(SYCLK)}$	
		With input qualifier		$40t_{c(SYCLK)} + t_{w(WAKE)}$	
	• Wakeup from Flash – Flash module in sleep state	Without input qualifier		$6700t_{c(SYCLK)}^{(3)}$	
		With input qualifier		$6700t_{c(SYCLK)}^{(3)} + t_{w(WAKE)}$	
	• Wakeup from RAM	Without input qualifier		$25t_{c(SYCLK)}$	
With input qualifier			$25t_{c(SYCLK)} + t_{w(WAKE)}$		

(1) For an explanation of the input qualifier parameters, see Table 5-24.

(2) This is the time taken to begin execution of the instruction that immediately follows the IDLE instruction. Execution of an ISR (triggered by the wake-up signal) involves additional latency.

(3) This value is based on the flash power-up time, which is a function of the SYCLK frequency, flash wait states (RWAIT), and FPAC1[PSLEEP]. For more information, see the "Flash and OTP Power-Down Modes and Wakeup" section of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)*. This value can be realized when SYCLK is 200 MHz, RWAIT is 3, and FPAC1[PSLEEP] is 0x860.



A. WAKE can be any enabled interrupt,  $\overline{WDINT}$  or  $\overline{XRS}$ . After the IDLE instruction is executed, a delay of five OSCCLK cycles (minimum) is needed before the wake-up signal could be asserted.

图 5-16. IDLE Entry and Exit Timing Diagram

表 5-31 shows the STANDBY mode timing requirements, 表 5-32 shows the switching characteristics, and 图 5-17 shows the timing diagram for STANDBY mode.

**表 5-31. STANDBY Mode Timing Requirements**

		MIN	MAX	UNIT
$t_{w(WAKE-INT)}$	Pulse duration, external wake-up signal	QUALSTDBY = 0   $2t_{c(OSCCLK)}$	$3t_{c(OSCCLK)}$	cycles
		QUALSTDBY > 0   $(2 + QUALSTDBY)t_{c(OSCCLK)}^{(1)}$	$(2 + QUALSTDBY) * t_{c(OSCCLK)}$	

(1) QUALSTDBY is a 6-bit field in the LPMCR register.

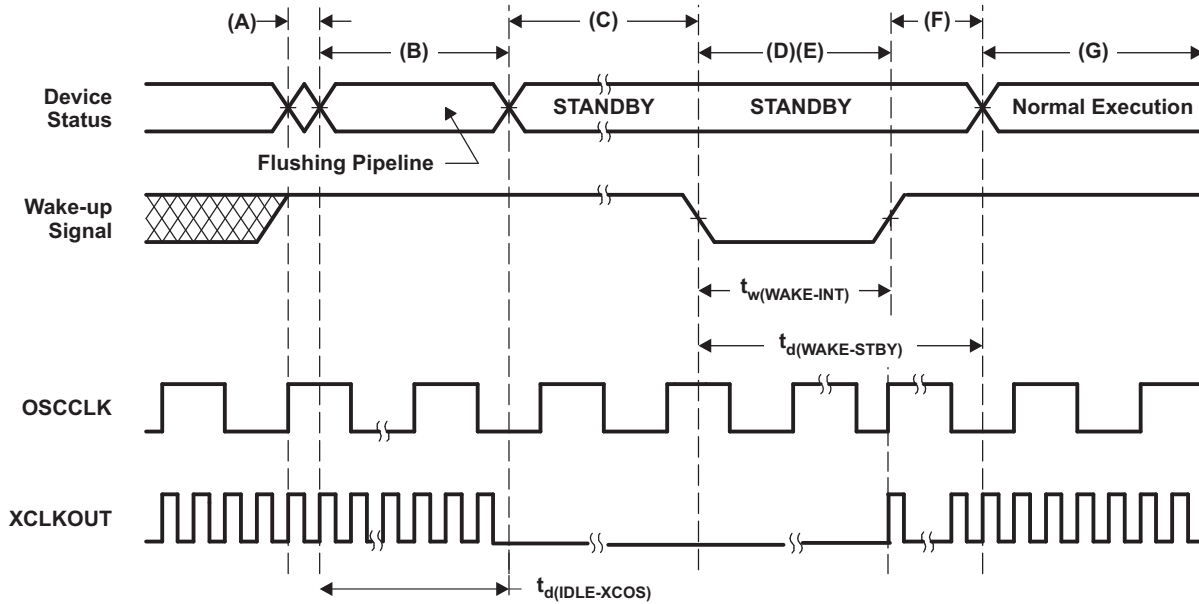
**表 5-32. STANDBY Mode Switching Characteristics**

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
$t_{d(IDLE-XCOS)}$	Delay time, IDLE instruction executed to XCLKOUT stop		$16t_{c(INTOSC1)}$	cycles
$t_{d(WAKE-STBY)}$	Delay time, external wake signal to program execution resume <sup>(1)</sup>			cycles
	<ul style="list-style-type: none"> <li>Wakeup from flash                             <ul style="list-style-type: none"> <li>Flash module in active state</li> </ul> </li> </ul>		$175t_{c(SYSCLK)} + t_{w(WAKE-INT)}$	
	<ul style="list-style-type: none"> <li>Wakeup from flash                             <ul style="list-style-type: none"> <li>Flash module in sleep state</li> </ul> </li> </ul>		$6700t_{c(SYSCLK)}^{(2)} + t_{w(WAKE-INT)}$	
	<ul style="list-style-type: none"> <li>Wakeup from RAM</li> </ul>		$3t_{c(OSC)} + 15t_{c(SYSCLK)} + t_{w(WAKE-INT)}$	

(1) This is the time taken to begin execution of the instruction that immediately follows the IDLE instruction. Execution of an ISR (triggered by the wake-up signal) involves additional latency.

(2) This value is based on the flash power-up time, which is a function of the SYSCLK frequency, flash wait states (RWAIT), and FPAC1[PSLEEP]. For more information, see the "Flash and OTP Power-Down Modes and Wakeup" section of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)*. This value can be realized when SYSCLK is 200 MHz, RWAIT is 3, and FPAC1[PSLEEP] is 0x860.



- A. IDLE instruction is executed to put the device into STANDBY mode.
- B. The LPM block responds to the STANDBY signal, SYSCCLK is held for a maximum 16 INTOSC1 clock cycles before being turned off. This delay enables the CPU pipeline and any other pending operations to flush properly.
- C. Clock to the peripherals are turned off. However, the PLL and watchdog are not shut down. The device is now in STANDBY mode. After the IDLE instruction is executed, a delay of five OSCCLK cycles (minimum) is needed before the wake-up signal could be asserted.
- D. The external wake-up signal is driven active.
- E. The wake-up signal fed to a GPIO pin to wake up the device must meet the minimum pulse width requirement. Furthermore, this signal must be free of glitches. If a noisy signal is fed to a GPIO pin, the wakeup behavior of the device will not be deterministic and the device may not exit low-power mode for subsequent wakeup pulses.
- F. After a latency period, the STANDBY mode is exited.
- G. Normal execution resumes. The device will respond to the interrupt (if enabled).

图 5-17. STANDBY Entry and Exit Timing Diagram

表 5-33 shows the HALT mode timing requirements, 表 5-34 shows the switching characteristics, and 图 5-18 shows the timing diagram for HALT mode.

**表 5-33. HALT Mode Timing Requirements**

		MIN	MAX	UNIT
$t_{w(\text{WAKE-GPIO})}$	Pulse duration, GPIO wake-up signal <sup>(1)</sup>	$t_{\text{oscst}} + 2t_{c(\text{OSCCLK})}$		cycles
$t_{w(\text{WAKE-XRS})}$	Pulse duration, $\overline{\text{XRS}}$ wake-up signal <sup>(1)</sup>	$t_{\text{oscst}} + 8t_{c(\text{OSCCLK})}$		cycles

- (1) For applications using X1/X2 for OSCCLK, the user must characterize their specific oscillator start-up time as it is dependent on circuit/layout external to the device. See 表 5-17 for more information. For applications using INTOSC1 or INTOSC2 for OSCCLK, see 节 5.7.3.5 for  $t_{\text{oscst}}$ . Oscillator start-up time does not apply to applications using a single-ended crystal on the X1 pin, as it is powered externally to the device.

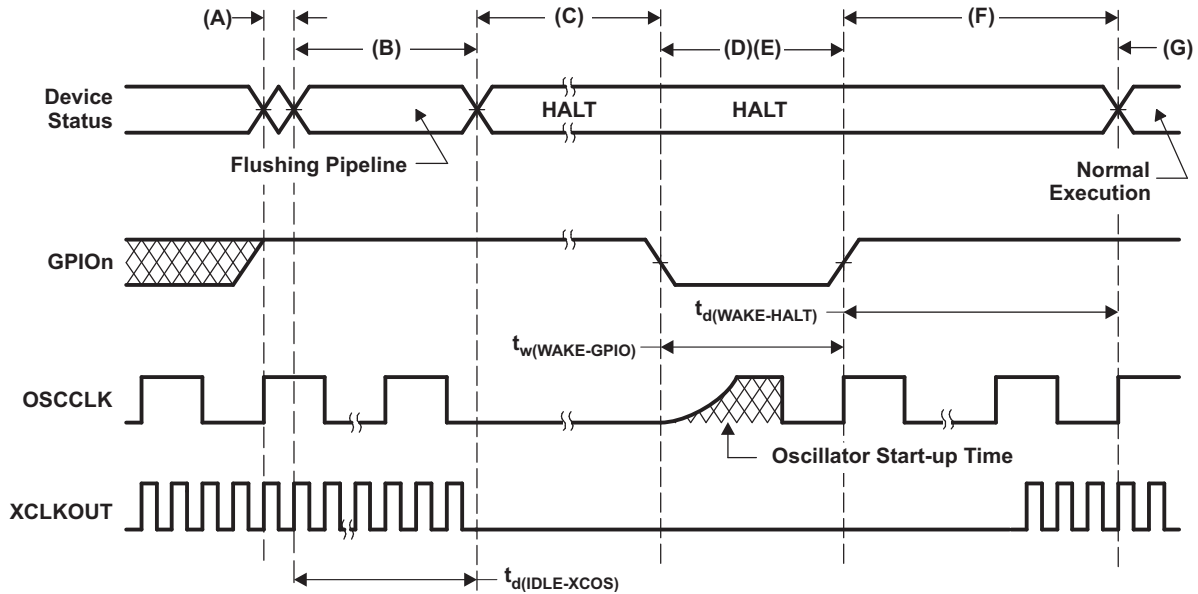
**表 5-34. HALT Mode Switching Characteristics**

over recommended operating conditions (unless otherwise noted)

PARAMETER		MIN	MAX	UNIT
$t_{d(\text{IDLE-XCOS})}$	Delay time, IDLE instruction executed to XCLKOUT stop	$16t_{c(\text{INTOSC1})}$		cycles
$t_{d(\text{WAKE-HALT})}$	Delay time, external wake signal end to CPU1 program execution resume			cycles
	<ul style="list-style-type: none"> <li>Wakeup from flash                             <ul style="list-style-type: none"> <li>Flash module in active state</li> </ul> </li> </ul>	$75t_{c(\text{OSCCLK})}$		
	<ul style="list-style-type: none"> <li>Wakeup from flash                             <ul style="list-style-type: none"> <li>Flash module in sleep state</li> </ul> </li> </ul>	$17500t_{c(\text{OSCCLK})}$ <sup>(1)</sup>		
	<ul style="list-style-type: none"> <li>Wakeup from RAM</li> </ul>	$75t_{c(\text{OSCCLK})}$		

- (1) This value is based on the flash power-up time, which is a function of the SYSCLK frequency, flash wait states (RWAIT), and FPAC1[PSLEEP]. For more information, see the "Flash and OTP Power-Down Modes and Wakeup" section of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)*. This value can be realized when SYSCLK is 200 MHz, RWAIT is 3, and FPAC1[PSLEEP] is 0x860.





- A. IDLE instruction is executed to put the device into HALT mode.
- B. The LPM block responds to the HALT signal, SYSCLK is held for a maximum 16 INTOSC1 clock cycles before being turned off. This delay enables the CPU pipeline and any other pending operations to flush properly.
- C. Clocks to the peripherals are turned off and the PLL is shut down. If a quartz crystal or ceramic resonator is used as the clock source, the internal oscillator is shut down as well. The device is now in HALT mode and consumes very little power. It is possible to keep the zero-pin internal oscillators (INTOSC1 and INTOSC2) and the watchdog alive in HALT MODE. This is done by writing a 1 to CLKSRCCTL1.WDHALTI. After the IDLE instruction is executed, a delay of five OSCCLK cycles (minimum) is needed before the wake-up signal could be asserted.
- D. When the GPIOn pin (used to bring the device out of HALT) is driven low, the oscillator is turned on and the oscillator wakeup sequence is initiated. The GPIO pin should be driven high only after the oscillator has stabilized. This enables the provision of a clean clock signal during the PLL lock sequence. Because the falling edge of the GPIO pin asynchronously begins the wakeup procedure, care should be taken to maintain a low noise environment prior to entering and during HALT mode.
- E. The wake-up signal fed to a GPIO pin to wake up the device must meet the minimum pulse width requirement. Furthermore, this signal must be free of glitches. If a noisy signal is fed to a GPIO pin, the wakeup behavior of the device will not be deterministic and the device may not exit low-power mode for subsequent wakeup pulses.
- F. When CLKIN to the core is enabled, the device will respond to the interrupt (if enabled), after some latency. The HALT mode is now exited.
- G. Normal operation resumes.
- H. The user must relock the PLL upon HALT wakeup to ensure a stable PLL lock.

图 5-18. HALT Entry and Exit Timing Diagram

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CPU2 should enter IDLE mode before CPU1 puts the device into HALT mode. CPU1 should verify that CPU2 has entered IDLE mode using the LPMSTAT register before calling the IDLE instruction to enter HALT.

表 5-35 shows the HIBERNATE mode timing requirements, 表 5-36 shows the switching characteristics, and 图 5-19 shows the timing diagram for HIBERNATE mode.

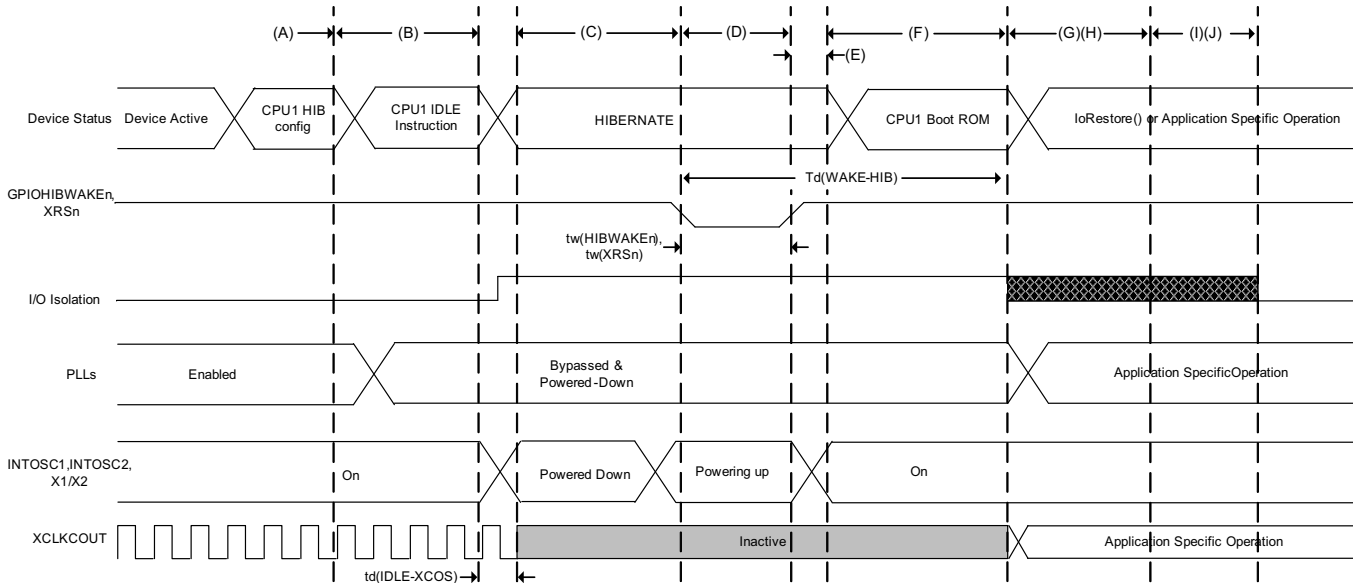
**表 5-35. HIBERNATE Mode Timing Requirements**

		MIN	MAX	UNIT
$t_w(\text{HIBWAKE})$	Pulse duration, $\overline{\text{HIBWAKE}}$ signal	40		$\mu\text{s}$
$t_w(\text{WAKEXRS})$	Pulse duration, $\overline{\text{XRS}}$ wake-up signal	40		$\mu\text{s}$

**表 5-36. HIBERNATE Mode Switching Characteristics**

over recommended operating conditions (unless otherwise noted)

PARAMETER		MIN	MAX	UNIT
$t_d(\text{IDLE-XCOS})$	Delay time, IDLE instruction executed to XCLKOUT stop		$30t_{c(\text{SYSCLK})}$	cycles
$t_d(\text{WAKE-HIB})$	Delay time, external wake signal to IORestore function start		1.5	ms



- A. CPU1 does necessary application-specific context save to M0/M1 memories if required. This includes GPIO state if using I/O Isolation. Configures the LPMCR register of CPU1 for HIBERNATE mode. Powers down Flash Pump/Bank, USB-PHY, CMPSS, DAC, and ADC using their register configurations. The application should also power down the PLL and peripheral clocks before entering HIBERNATE. In dual-core applications, CPU1 should confirm that CPU2 has entered IDLE/STANDBY using the LPMSTAT register.
- B. IDLE instruction is executed to put the device into HIBERNATE mode.
- C. The device is now in HIBERNATE mode. If configured, I/O isolation is turned on, M0 and M1 memories are retained. CPU1 and CPU2 are powered down. Digital peripherals are powered down. The oscillators, PLLs, analog peripherals, and Flash are in their software-controlled Low-Power modes. Dx, LSx, and GSx memories are also powered down, and their memory contents lost.
- D. A falling edge on the GPIOHIBWAKEn pin will drive the wakeup of the devices clock sources INTOSC1, INTOSC2, and X1/X2 OSC. The wakeup source must keep the GPIOHIBWAKEn pin low long enough to ensure full power-up of these clock sources.
- E. After the clock sources are powered up, the GPIOHIBWAKEn must be driven high to trigger the wakeup sequence of the remainder of the device.
- F. The BootROM will then begin to execute. The BootROM can distinguish a HIBERNATE wakeup by reading the CPU1.REC.HIBRESETn bit. After the TI OTP trims are loaded, the BootROM code will branch to the user-defined IoRestore function if it has been configured.
- G. At this point, the device is out of HIBERNATE mode, and the application may continue.
- H. The IoRestore function is a user-defined function where the application may reconfigure GPIO states, disable I/O isolation, reconfigure the PLL, restore peripheral configurations, or branch to application code. This is up to the application requirements.
- I. If the application has not branched to application code, the BootROM will continue after completing IoRestore. It will disable I/O isolation automatically if it was not taken care of inside of IoRestore. CPU2 will be brought out of reset at this point as well.
- J. BootROM will then boot as determined by the HIBBOOTMODE register. Refer to the "ROM Code and Peripheral Booting" chapter of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)* for more information.

图 5-19. HIBERNATE Entry and Exit Timing Diagram

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1. If the IORESTOREADDR is configured as the default value, the BootROM will continue its execution to boot as determined by the HIBBOOTMODE register. Refer to the "ROM Code and Peripheral Booting" chapter of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)* for more information.
2. The user may choose to disable I/O Isolation at any point in the IoRestore function. Regardless if the user has disabled Isolation in the IoRestore function or if IoRestore is not defined, the BootROM will automatically disable isolation before booting as determined by the HIBBOOTMODE register.

**注**

For applications using both CPU1 and CPU2, it is recommended that the application puts CPU2 in either IDLE or STANDBY before entering HIBERNATE mode. If any GPIOs are used and the state is to be preserved, data can be stored in M0/M1 memory of CPU1 to be reconfigured upon wakeup. This should be done before step A of [图 5-19](#).

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## 5.7.9 External Memory Interface (EMIF)

The EMIF provides a means of connecting the CPU to various external storage devices like asynchronous memories (SRAM, NOR flash) or synchronous memory (SDRAM).

### 5.7.9.1 Asynchronous Memory Support

The EMIF supports asynchronous memories:

- SRAMs
- NOR Flash memories

There is an external wait input that allows slower asynchronous memories to extend the memory access. The EMIF module supports up to three chip selects (EMIF\_CS[4:2]). Each chip select has the following individually programmable attributes:

- Data bus width
- Read cycle timings: setup, hold, strobe
- Write cycle timings: setup, hold, strobe
- Bus turnaround time
- Extended wait option with programmable time-out
- Select strobe option

### 5.7.9.2 Synchronous DRAM Support

The EMIF memory controller is compliant with the JESD21-C SDR SDRAMs that use a 32-bit or 16-bit data bus. The EMIF has a single SDRAM chip select (EMIF\_CS[0]).

The address space of the EMIF, for the synchronous memory (SDRAM), lies beyond the 22-bit range of the program address bus and can only be accessed through the data bus, which places a restriction on the C compiler being able to work effectively on data in this space. Therefore, when using SDRAM, the user is advised to copy data (using the DMA) from external memory to RAM before working on it. See the examples in controlSUITE™ ([CONTROLSUITE](#)) and the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual* ([SPRUHM8](#)).

SDRAM configurations supported are:

- One-bank, two-bank, and four-bank SDRAM devices
- Devices with 8, 9, 10, and 11 column addresses
- CAS latency of two or three clock cycles
- 16-bit/32-bit data bus width
- 3.3-V LVCMOS interface

Additionally, the EMIF supports placing the SDRAM in self-refresh and power-down modes. Self-refresh mode allows the SDRAM to be put in a low-power state while still retaining memory contents because the SDRAM will continue to refresh itself even without clocks from the microcontroller. Power-down mode achieves even lower power, except the microcontroller must periodically wake up and issue refreshes if data retention is required. Note that the EMIF module does not support mobile SDRAM devices.

### 5.7.9.3 EMIF Electrical Data and Timing

#### 5.7.9.3.1 Asynchronous RAM

Table 5-37 shows the EMIF asynchronous memory timing requirements. Table 5-38 shows the EMIF asynchronous memory switching characteristics. Figure 5-20 through Figure 5-23 show the EMIF asynchronous memory timing diagrams.

**Table 5-37. EMIF Asynchronous Memory Timing Requirements**

NO.			MIN	MAX	UNIT
<b>Reads and Writes</b>					
	E	EMIF clock period	$t_{c(SYSCLK)}$		ns
2	$t_{w(EM\_WAIT)}$	Pulse duration, EMxWAIT assertion and deassertion	2E		ns
<b>Reads</b>					
12	$t_{su(EMDV-EMOEH)}$	Setup time, EMxD[y:0] valid before $\overline{EMxOE}$ high	15		ns
13	$t_{h(EMOEH-EMDIV)}$	Hold time, EMxD[y:0] valid after $\overline{EMxOE}$ high	0		ns
14	$t_{su(EMOEL-EMWAIT)}$	Setup Time, EMxWAIT asserted before end of Strobe Phase <sup>(1)</sup>	4E		ns
<b>Writes</b>					
28	$t_{su(EMWEL-EMWAIT)}$	Setup Time, EMxWAIT asserted before end of Strobe Phase <sup>(1)</sup>	4E		ns

- (1) Setup before end of STROBE phase (if no extended wait states are inserted) by which EMxWAIT must be asserted to add extended wait states. Figure 5-21 and Figure 5-23 describe EMIF transactions that include extended wait states inserted during the STROBE phase. However, cycles inserted as part of this extended wait period should not be counted; the 4E requirement is to the start of where the HOLD phase would begin if there were no extended wait cycles.

**Table 5-38. EMIF Asynchronous Memory Switching Characteristics<sup>(1)(2)(3)</sup>**

NO.	PARAMETER		MIN	MAX	UNIT
<b>Reads and Writes</b>					
1	$t_d(TURNAROUND)$	Turn around time	(TA)*E-3	(TA)*E+2	ns
<b>Reads</b>					
3	$t_{c(EMRCYCLE)}$	EMIF read cycle time (EW = 0)	(RS+RST+RH+2)*E-3	(RS+RST+RH+2)*E+2	ns
		EMIF read cycle time (EW = 1)	(RS+RST+RH+2+(EWC*16))*E-3	(RS+RST+RH+2+(EWC*16))*E+2	ns
4	$t_{su(EMCEL-EMOEL)}$	Output setup time, $\overline{EMxCS}[y:2]$ low to $\overline{EMxOE}$ low (SS = 0)	(RS)*E-3	(RS)*E+2	ns
		Output setup time, $\overline{EMxCS}[y:2]$ low to $\overline{EMxOE}$ low (SS = 1)	-3	2	ns
5	$t_{h(EMOEH-EMCEH)}$	Output hold time, $\overline{EMxOE}$ high to $\overline{EMxCS}[y:2]$ high (SS = 0)	(RH)*E-3	(RH)*E	ns
		Output hold time, $\overline{EMxOE}$ high to $\overline{EMxCS}[y:2]$ high (SS = 1)	-3	0	ns
6	$t_{su(EMBAV-EMOEL)}$	Output setup time, EMxBA[y:0] valid to $\overline{EMxOE}$ low	(RS)*E-3	(RS)*E+2	ns
7	$t_{h(EMOEH-EMBAIV)}$	Output hold time, $\overline{EMxOE}$ high to EMxBA[y:0] invalid	(RH)*E-3	(RH)*E	ns
8	$t_{su(EMAV-EMOEL)}$	Output setup time, EMxA[y:0] valid to $\overline{EMxOE}$ low	(RS)*E-3	(RS)*E+2	ns

- (1) TA = Turn around, RS = Read setup, RST = Read strobe, RH = Read hold, WS = Write setup, WST = Write strobe, WH = Write hold, MEWC = Maximum external wait cycles. These parameters are programmed through the Asynchronous Bank and Asynchronous Wait Cycle Configuration Registers. These support the following ranges of values: TA[4-1], RS[16-1], RST[64-4], RH[8-1], WS[16-1], WST[64-1], WH[8-1], and MEWC[1-256]. See the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)* for more information.
- (2) E = EMxCLK period in ns.
- (3) EWC = external wait cycles determined by EMxWAIT input signal. EWC supports the following range of values. EWC[256-1]. Note that the maximum wait time before time-out is specified by bit field MEWC in the Asynchronous Wait Cycle Configuration Register. See the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)* for more information.

**Table 5-38. EMIF Asynchronous Memory Switching Characteristics<sup>(1)(2)(3)</sup> (continued)**

NO.	PARAMETER		MIN	MAX	UNIT
9	$t_{h(EMOE\overline{H}-EMAIV)}$	Output hold time, $\overline{EMxOE}$ high to $\overline{EMxA[y:0]}$ invalid	(RH)*E-3	(RH)*E	ns
10	$t_{w(EMOEL)}$	$\overline{EMxOE}$ active low width (EW = 0)	(RST)*E-1	(RST)*E+1	ns
		$\overline{EMxOE}$ active low width (EW = 1)	(RST+(EWC*16))*E-1	(RST+(EWC*16))*E+1	ns
11	$t_{d(EMWAITH-EMOE\overline{H})}$	Delay time from $\overline{EMxWAIT}$ deasserted to $\overline{EMxOE}$ high	3E+8	4E+10	ns
29	$t_{su(EMDQM\overline{V}-EMOEL)}$	Output setup time, $\overline{EMxDQM[y:0]}$ valid to $\overline{EMxOE}$ low	(RS)*E-3	(RS)*E+2	ns
30	$t_{h(EMOE\overline{H}-EMDQM\overline{V})}$	Output hold time, $\overline{EMxOE}$ high to $\overline{EMxDQM[y:0]}$ invalid	(RH)*E-3	(RH)*E	ns
<b>Writes</b>					
15	$t_{c(EMWCYCLE)}$	EMIF write cycle time (EW = 0)	(WS+WST+WH+2)*E-3	(WS+WST+WH+2)*E+1	ns
		EMIF write cycle time (EW = 1)	(WS+WST+WH+2+(EWC*16))*E-3	(WS+WST+WH+2+(EWC*16))*E+1	ns
16	$t_{su(EMCEL-EMWEL)}$	Output setup time, $\overline{EMxCS[y:2]}$ low to $\overline{EMxWE}$ low (SS = 0)	(WS)*E-3	(WS)*E+1	ns
		Output setup time, $\overline{EMxCS[y:2]}$ low to $\overline{EMxWE}$ low (SS = 1)	-3	1	ns
17	$t_{h(EMWE\overline{H}-EMCE\overline{H})}$	Output hold time, $\overline{EMxWE}$ high to $\overline{EMxCS[y:2]}$ high (SS = 0)	(WH)*E-3	(WH)*E	ns
		Output hold time, $\overline{EMxWE}$ high to $\overline{EMxCS[y:2]}$ high (SS = 1)	-3	0	ns
18	$t_{su(EMDQM\overline{V}-EMWEL)}$	Output setup time, $\overline{EMxDQM[y:0]}$ valid to $\overline{EMxWE}$ low	(WS)*E-3	(WS)*E+1	ns
19	$t_{h(EMWE\overline{H}-EMDQM\overline{V})}$	Output hold time, $\overline{EMxWE}$ high to $\overline{EMxDQM[y:0]}$ invalid	(WH)*E-3	(WH)*E	ns
20	$t_{su(EMBA\overline{V}-EMWEL)}$	Output setup time, $\overline{EMxBA[y:0]}$ valid to $\overline{EMxWE}$ low	(WS)*E-3	(WS)*E+1	ns
21	$t_{h(EMWE\overline{H}-EMBA\overline{V})}$	Output hold time, $\overline{EMxWE}$ high to $\overline{EMxBA[y:0]}$ invalid	(WH)*E-3	(WH)*E	ns
22	$t_{su(EMAV-EMWEL)}$	Output setup time, $\overline{EMxA[y:0]}$ valid to $\overline{EMxWE}$ low	(WS)*E-3	(WS)*E+1	ns
23	$t_{h(EMWE\overline{H}-EMAV)}$	Output hold time, $\overline{EMxWE}$ high to $\overline{EMxA[y:0]}$ invalid	(WH)*E-3	(WH)*E	ns
24	$t_{w(EMWEL)}$	$\overline{EMxWE}$ active low width (EW = 0)	(WST)*E-1	(WST)*E+1	ns
		$\overline{EMxWE}$ active low width (EW = 1)	(WST+(EWC*16))*E-1	(WST+(EWC*16))*E+1	ns
25	$t_{d(EMWAITH-EMWE\overline{H})}$	Delay time from $\overline{EMxWAIT}$ deasserted to $\overline{EMxWE}$ high	3E+8	4E+10	ns
26	$t_{su(EMDV-EMWEL)}$	Output setup time, $\overline{EMxD[y:0]}$ valid to $\overline{EMxWE}$ low	(WS)*E-3	(WS)*E+1	ns
27	$t_{h(EMWE\overline{H}-EMDV)}$	Output hold time, $\overline{EMxWE}$ high to $\overline{EMxD[y:0]}$ invalid	(WH)*E-3	(WH)*E	ns

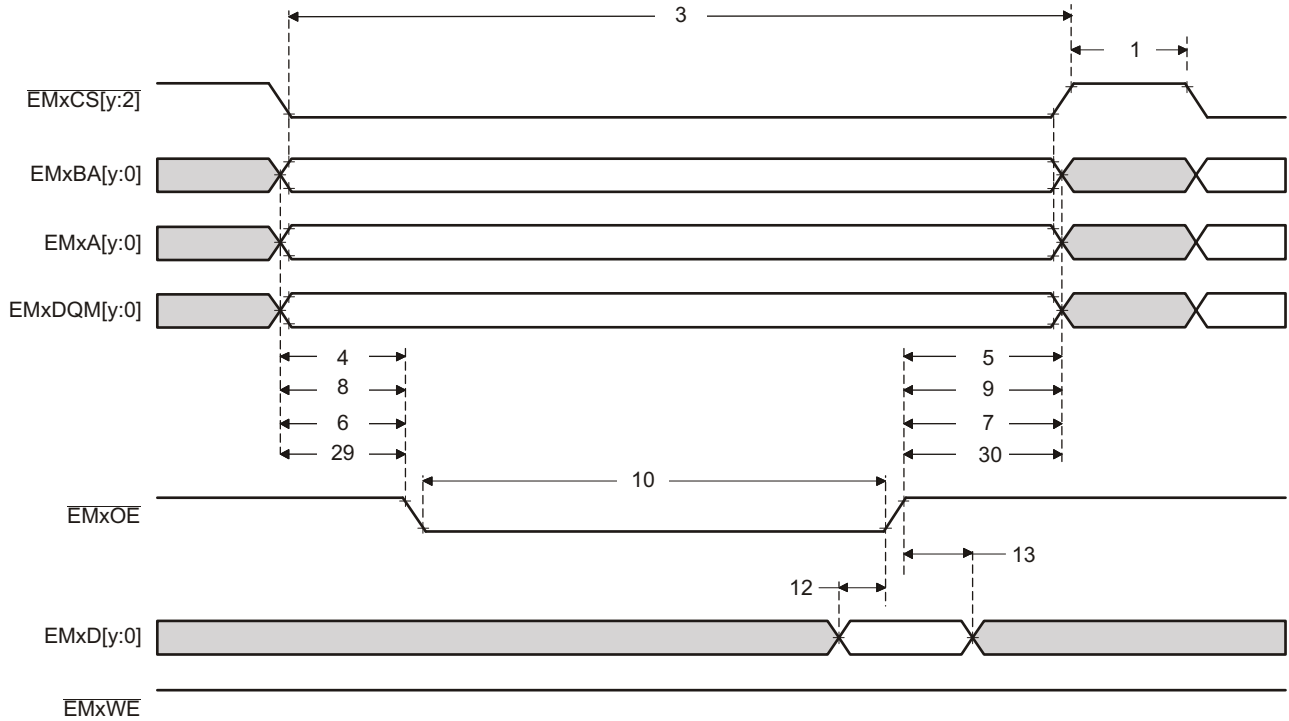


Figure 5-20. Asynchronous Memory Read Timing

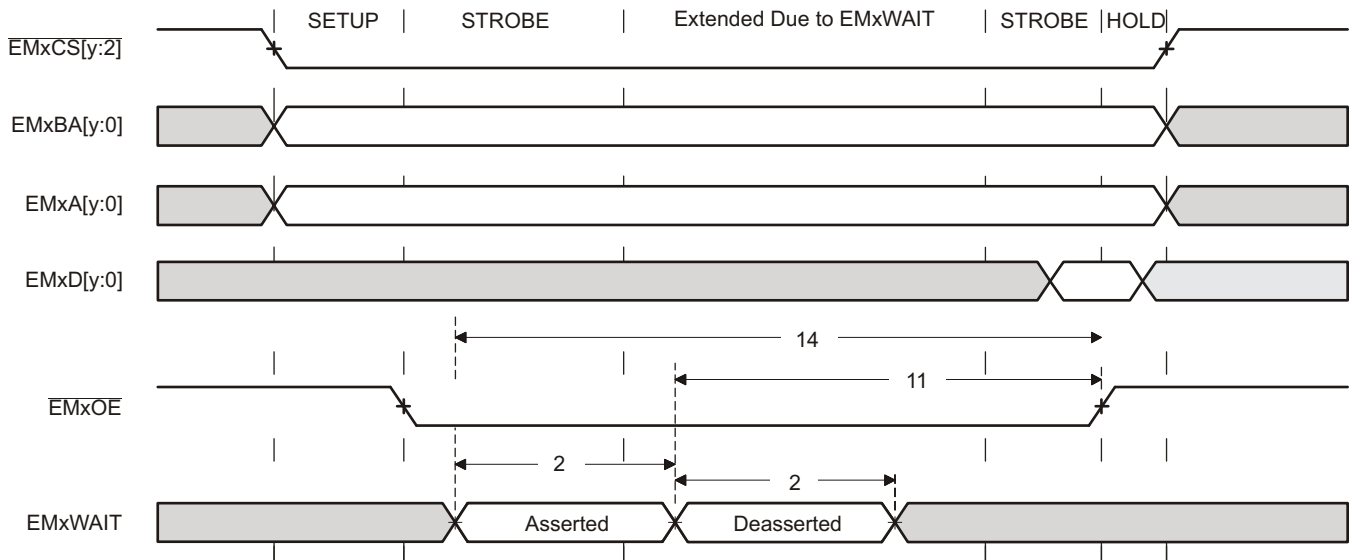
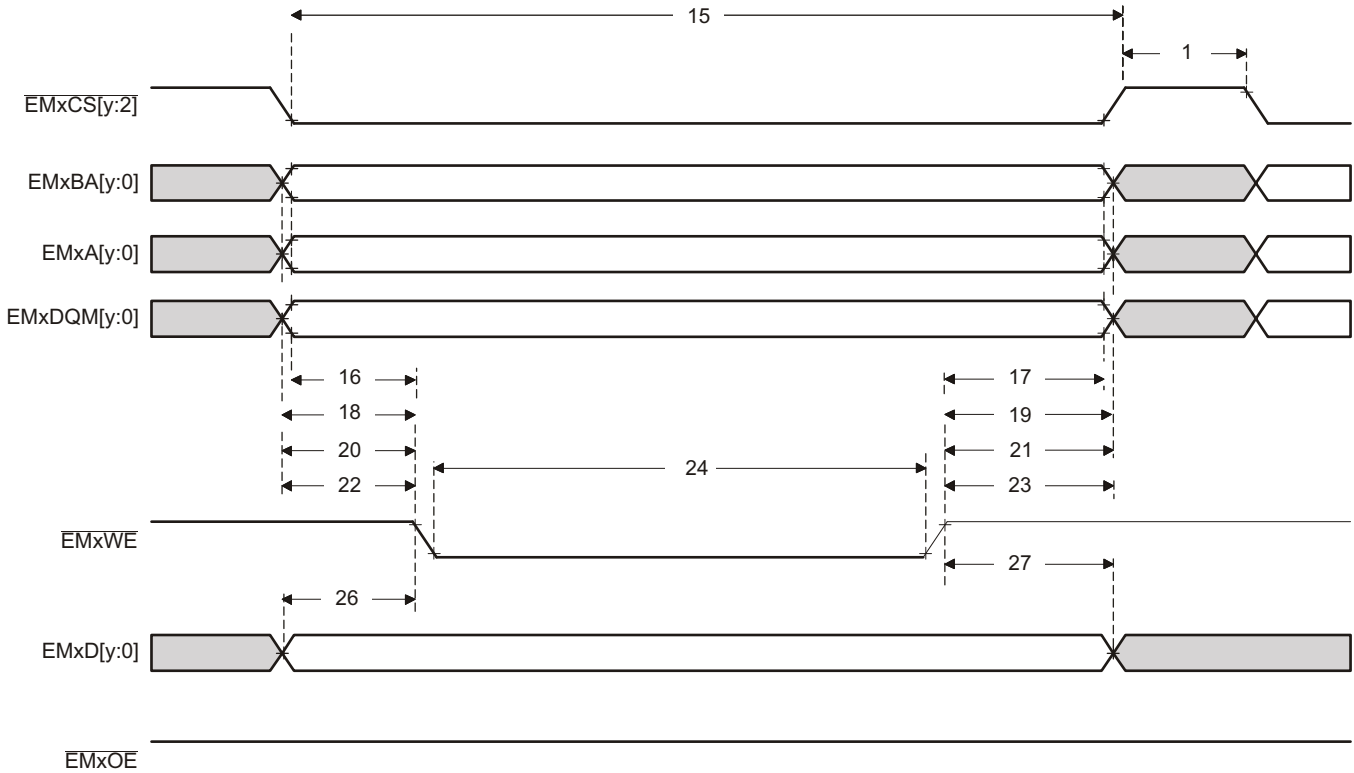
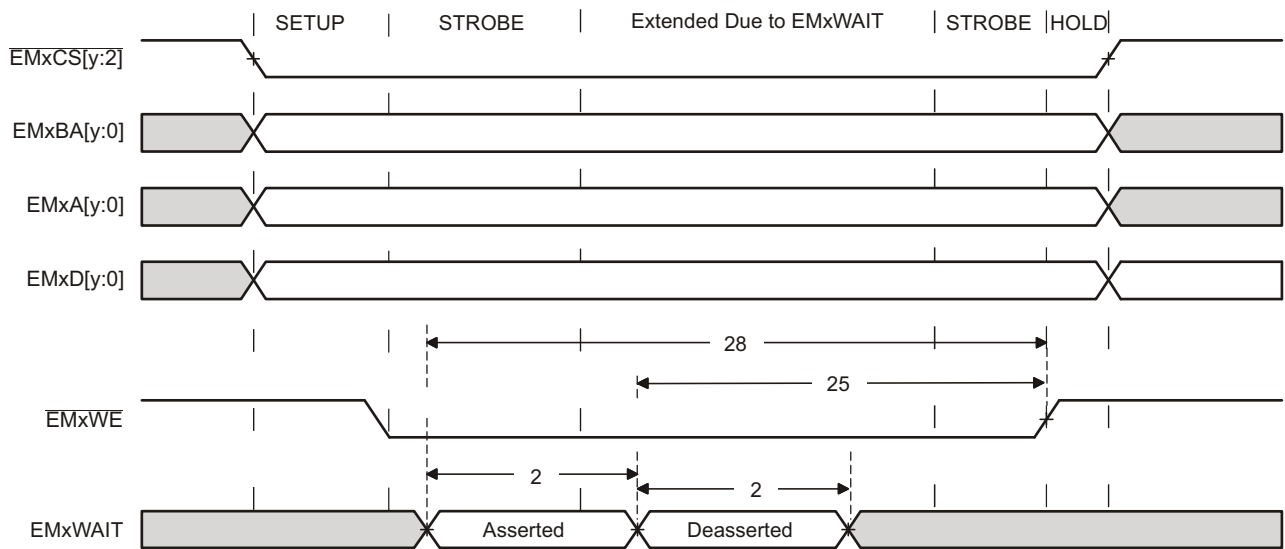


Figure 5-21. EMxWAIT Read Timing Requirements





**Figure 5-22. Asynchronous Memory Write Timing**



**Figure 5-23. EMxWAIT Write Timing Requirements**

### 5.7.9.3.2 Synchronous RAM

Table 5-39 shows the EMIF synchronous memory timing requirements. Table 5-40 shows the EMIF synchronous memory switching characteristics. Figure 5-24 and Figure 5-25 show the synchronous memory timing diagrams.

**Table 5-39. EMIF Synchronous Memory Timing Requirements**

NO.			MIN	MAX	UNIT
19	$t_{su}(EMIFDV-EM\_CLKH)$	Input setup time, read data valid on EMxD[y:0] before EMxCLK rising	2		ns
20	$t_{h}(CLKH-DIV)$	Input hold time, read data valid on EMxD[y:0] after EMxCLK rising	1.5		ns

**Table 5-40. EMIF Synchronous Memory Switching Characteristics**

NO.	PARAMETER		MIN	MAX	UNIT
1	$t_{c}(CLK)$	Cycle time, EMIF clock EMxCLK	10		ns
2	$t_{w}(CLK)$	Pulse width, EMIF clock EMxCLK high or low	3		ns
3	$t_{d}(CLKH-CSV)$	Delay time, EMxCLK rising to $\overline{EMxCS}[y:2]$ valid		8	ns
4	$t_{oh}(CLKH-CSIV)$	Output hold time, EMxCLK rising to $\overline{EMxCS}[y:2]$ invalid	1		ns
5	$t_{d}(CLKH-DQMV)$	Delay time, EMxCLK rising to EMxDQM[y:0] valid		8	ns
6	$t_{oh}(CLKH-DQMIV)$	Output hold time, EMxCLK rising to EMxDQM[y:0] invalid	1		ns
7	$t_{d}(CLKH-AV)$	Delay time, EMxCLK rising to EMxA[y:0] and EMxBA[y:0] valid		8	ns
8	$t_{oh}(CLKH-AIV)$	Output hold time, EMxCLK rising to EMxA[y:0] and EMxBA[y:0] invalid	1		ns
9	$t_{d}(CLKH-DV)$	Delay time, EMxCLK rising to EMxD[y:0] valid		8	ns
10	$t_{oh}(CLKH-DIV)$	Output hold time, EMxCLK rising to EMxD[y:0] invalid	1		ns
11	$t_{d}(CLKH-RASV)$	Delay time, EMxCLK rising to EMxRAS valid		8	ns
12	$t_{oh}(CLKH-RASIV)$	Output hold time, EMxCLK rising to EMxRAS invalid	1		ns
13	$t_{d}(CLKH-CASV)$	Delay time, EMxCLK rising to EMxCAS valid		8	ns
14	$t_{oh}(CLKH-CASIV)$	Output hold time, EMxCLK rising to EMxCAS invalid	1		ns
15	$t_{d}(CLKH-WEV)$	Delay time, EMxCLK rising to $\overline{EMxWE}$ valid		8	ns
16	$t_{oh}(CLKH-WEIV)$	Output hold time, EMxCLK rising to $\overline{EMxWE}$ invalid	1		ns
17	$t_{d}(CLKH-DHZ)$	Delay time, EMxCLK rising to EMxD[y:0] tri-stated		8	ns
18	$t_{oh}(CLKH-DLZ)$	Output hold time, EMxCLK rising to EMxD[y:0] driving	1		ns

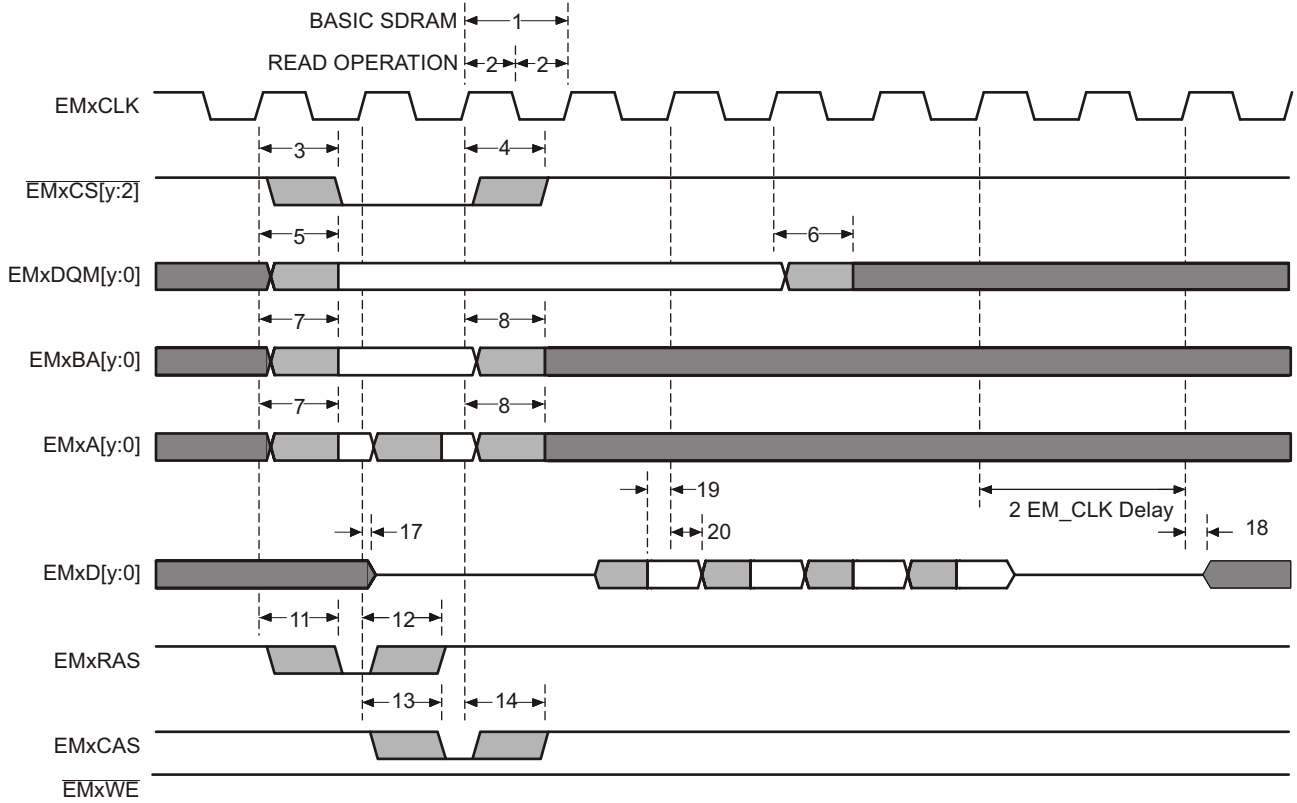


Figure 5-24. Basic SDRAM Read Operation

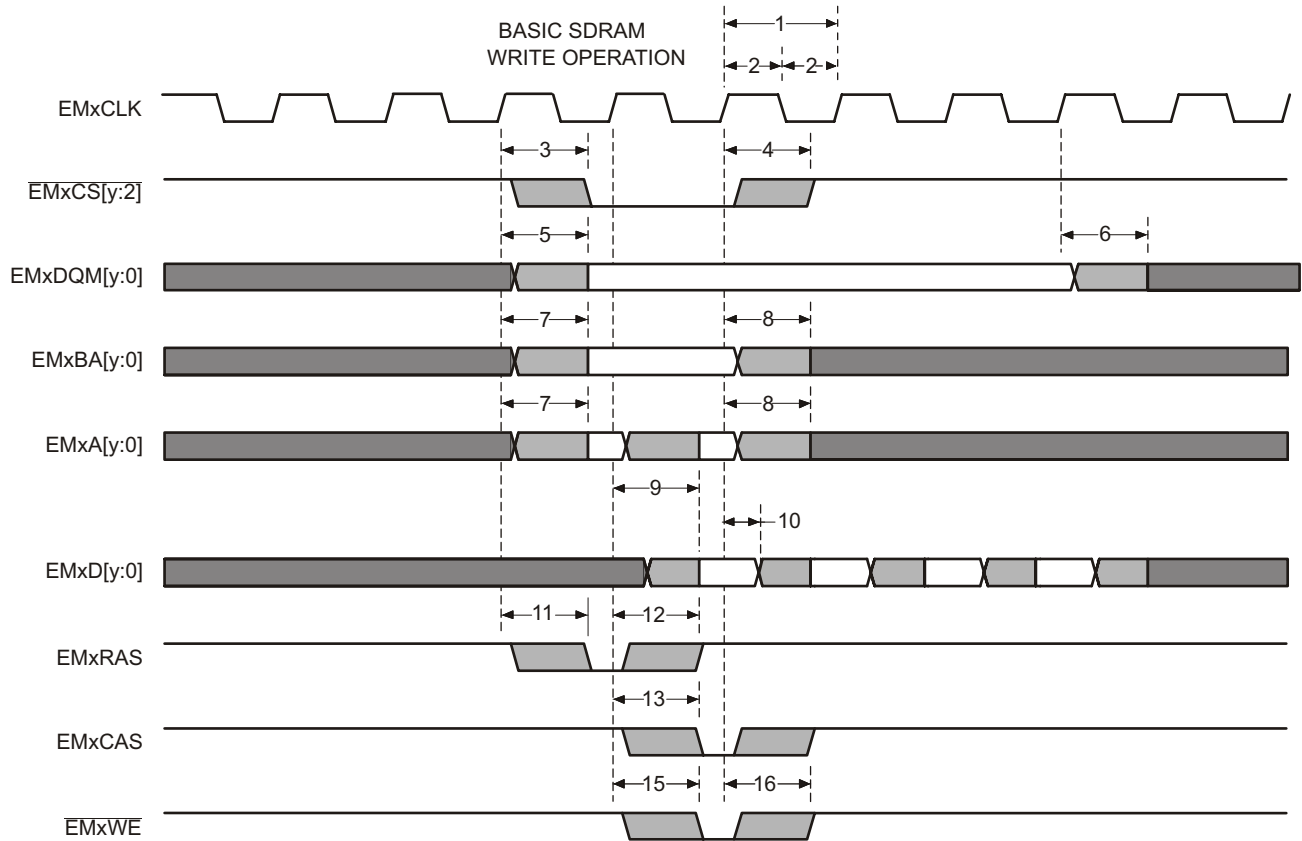


Figure 5-25. Basic SDRAM Write Operation

## 5.8 Analog Peripherals

This analog subsystem module is described in this section.

The analog modules on this device include the ADC, temperature sensor, buffered DAC, and CMPSS.

The analog subsystem has the following features:

- Flexible voltage references
  - $V_{REFHIA}$  and  $V_{REFLOA}$ ,  $V_{REFHIB}$  and  $V_{REFLOB}$ ,  $V_{REFHIC}$  and  $V_{REFLOC}$ , and  $V_{REFHID}$  and  $V_{REFLOD}$  externally supplied reference voltage pins
    - Selectable by ADCs and buffered DACs
  - VDAC externally supplied reference voltage pin
    - Selectable by buffered DACs and comparator subsystem DACs
    - Low reference is  $V_{SSA}$
- Flexible pin usage
  - Buffered DAC and comparator subsystem functions multiplexed with ADC inputs
- Internal connection to  $V_{REFLO}$  on all ADCs for offset self-calibration

[图 5-26](#) shows the Analog Subsystem Block Diagram for the 337-ball ZWT package. [图 5-27](#) shows the Analog Subsystem Block Diagram for the 176-pin PTP package. [图 5-28](#) shows the Analog Subsystem Block Diagram for the 100-pin PZP package.

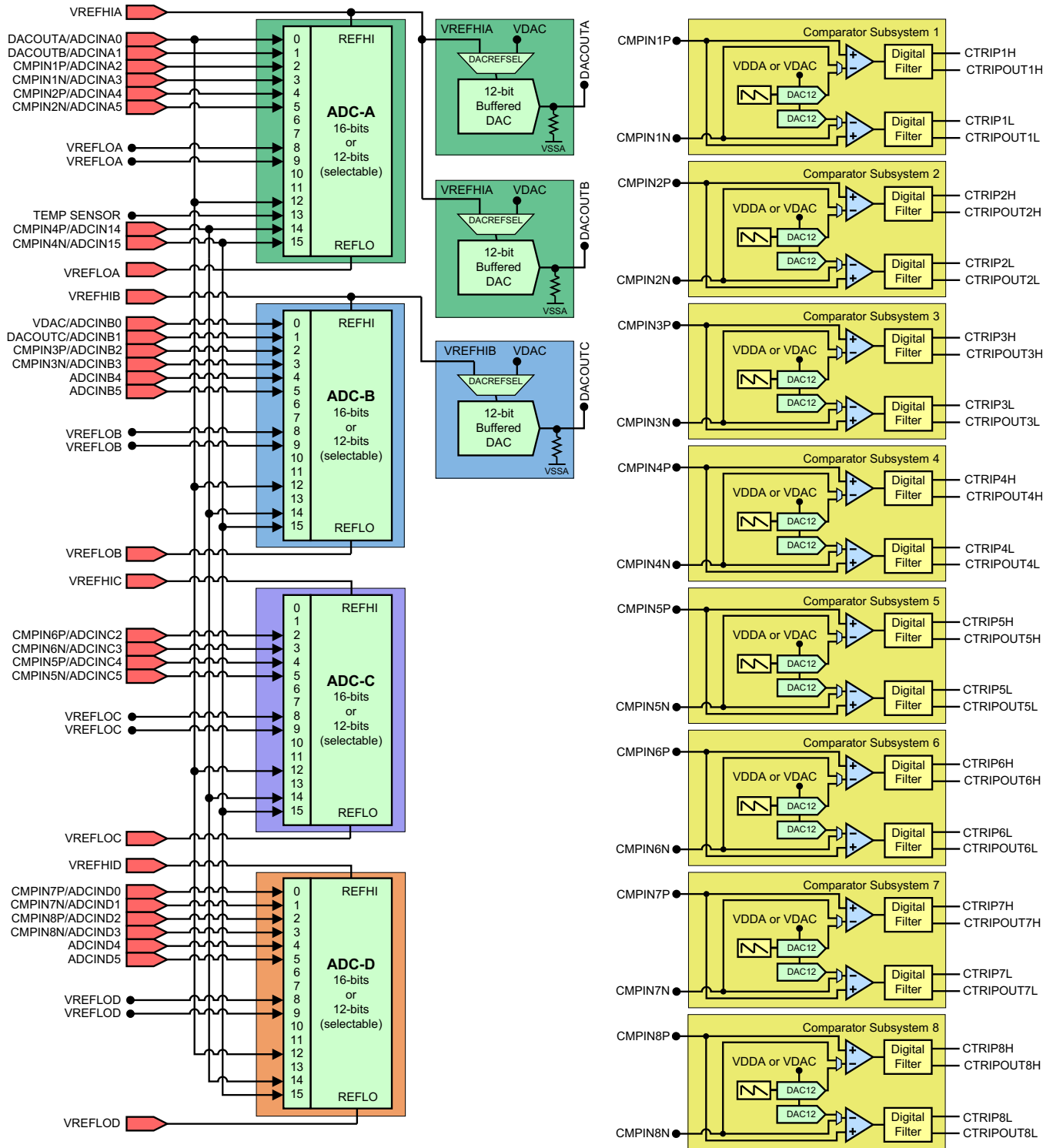


图 5-26. Analog Subsystem Block Diagram (337-Ball ZWT)

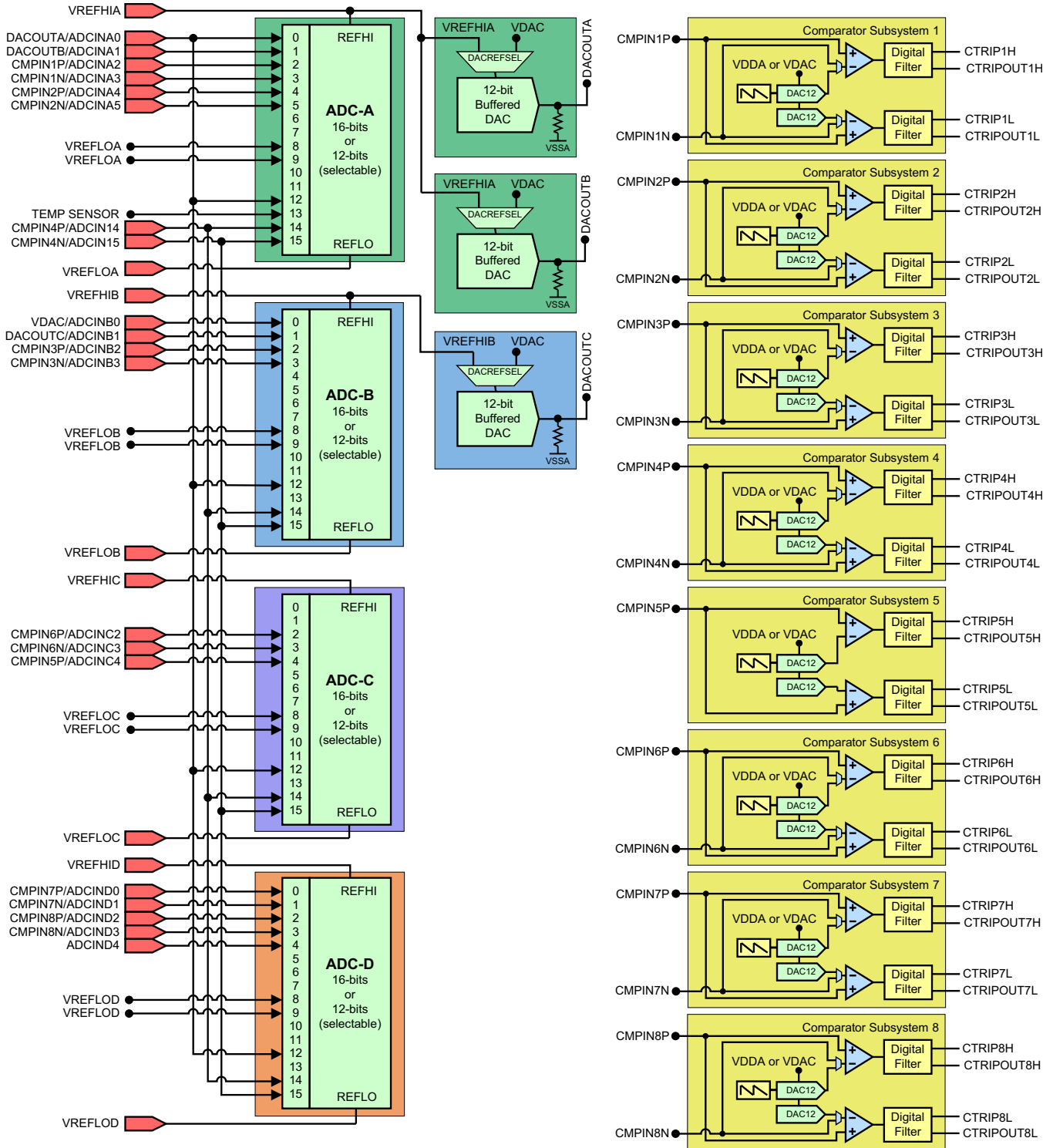


图 5-27. Analog Subsystem Block Diagram (176-Pin PTP)

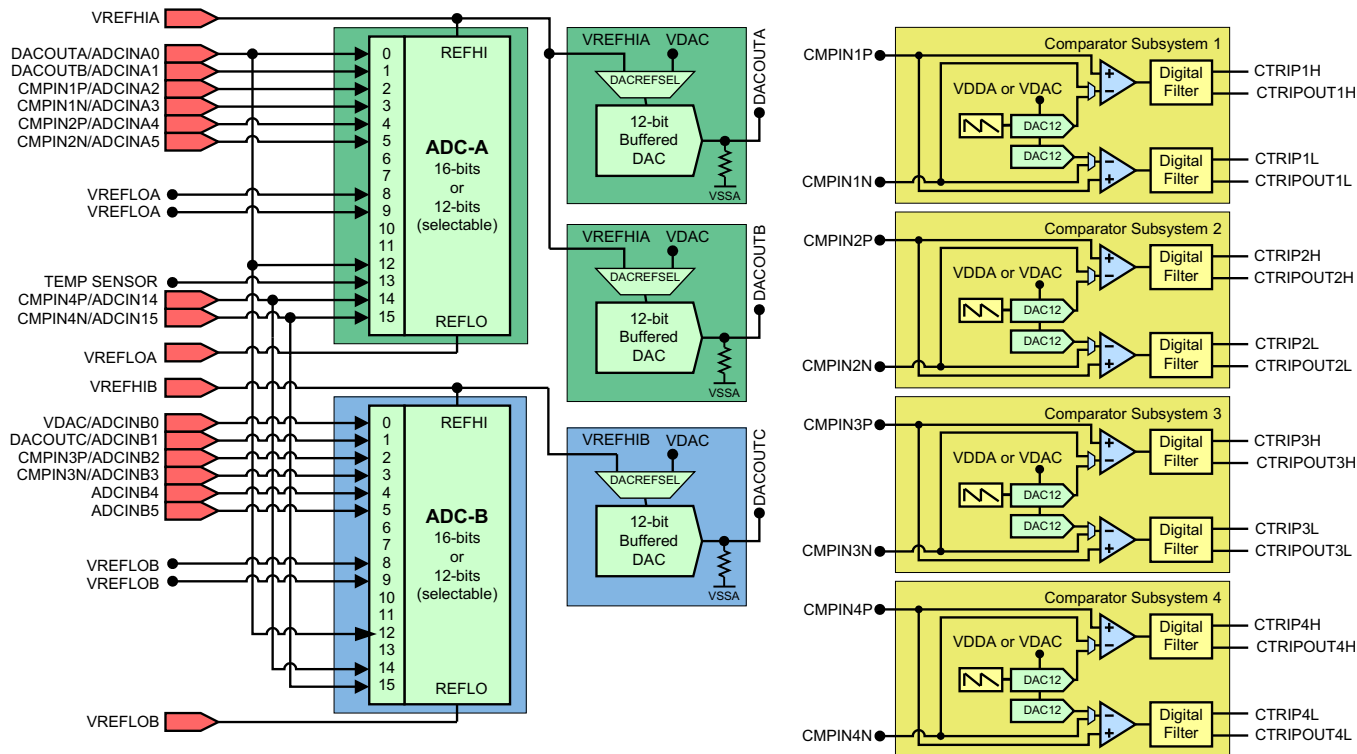


图 5-28. Analog Subsystem Block Diagram (100-Pin PZP)



### 5.8.1 Analog-to-Digital Converter (ADC)

The ADCs on this device are successive approximation (SAR) style ADCs with selectable resolution of either 16 bits or 12 bits. There are multiple ADC modules which allow simultaneous sampling. The ADC wrapper is start-of-conversion (SOC) based [see the "SOC Principle of Operation" section of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)*].

Each ADC has the following features:

- Selectable resolution of 16 bits or 12 bits
- Ratiometric external reference set by  $V_{REFHI}$  and  $V_{REFLO}$
- Differential signal conversions (16-bit mode only)
- Single-ended signal conversions (12-bit mode only)
- Input multiplexer with up to 16 channels (single-ended) or 8 channels (differential)
- 16 configurable SOCs
- 16 individually addressable result registers
- Multiple trigger sources
  - Software immediate start
  - All ePWMs
  - GPIO XINT2
  - CPU timers
  - ADCINT1 or 2
- Four flexible PIE interrupts
- Burst mode
- Four post-processing blocks, each with:
  - Saturating offset calibration
  - Error from setpoint calculation
  - High, low, and zero-crossing compare, with interrupt and ePWM trip capability
  - Trigger-to-sample delay capture

图 5-29 shows the ADC module block diagram.

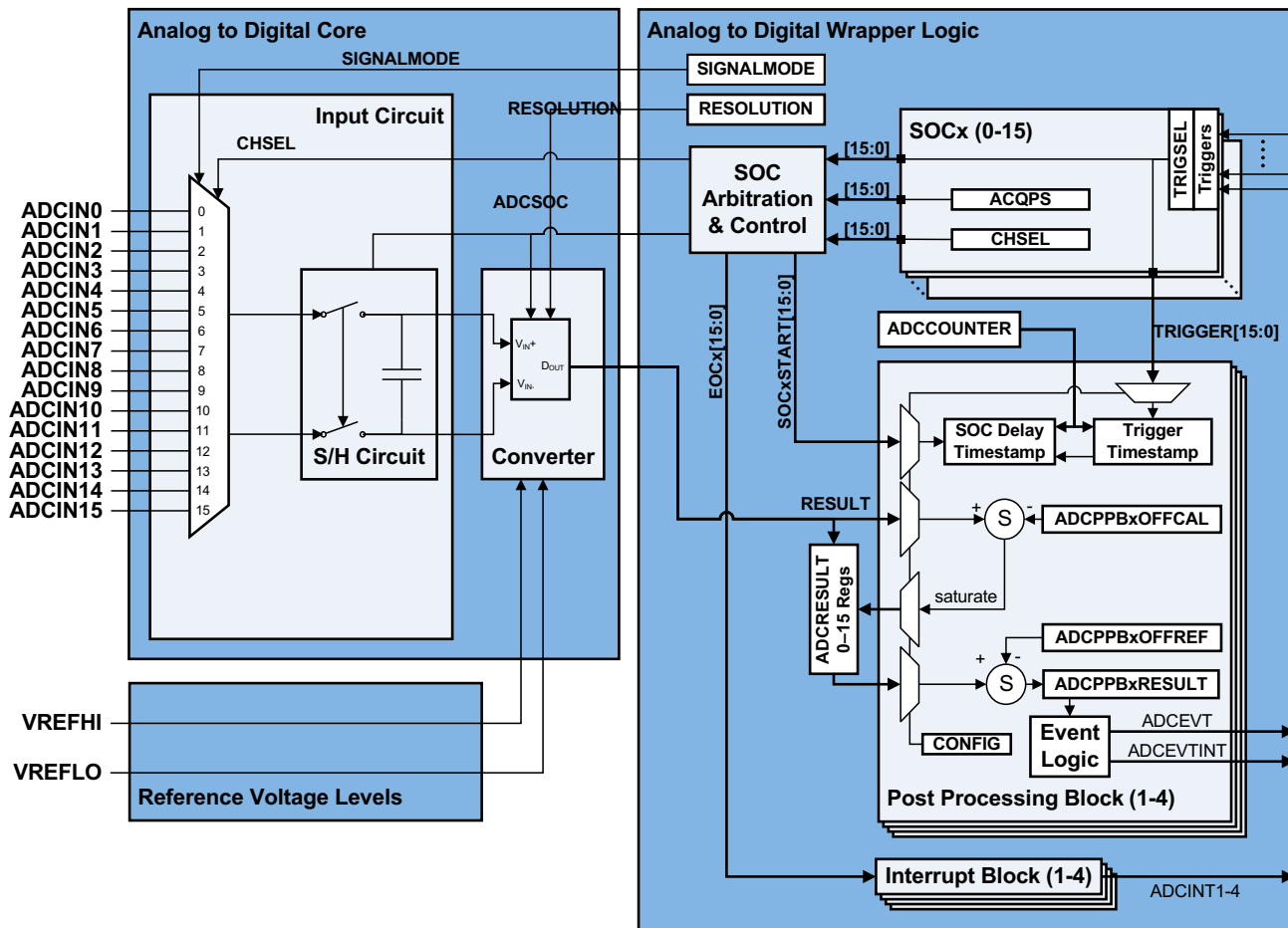


图 5-29. ADC Module Block Diagram

### 5.8.1.1 ADC Electrical Data and Timing

Table 5-41 shows the ADC operating conditions for 16-bit differential mode. Table 5-42 shows the ADC characteristics for 16-bit differential mode. Table 5-43 shows the ADC operating conditions for 12-bit single-ended mode. Table 5-44 shows the ADC characteristics for 12-bit single-ended mode. Table 5-45 shows the ADCEXTSOC timing requirements.

**Table 5-41. ADC Operating Conditions (16-Bit Differential Mode)**

over recommended operating conditions (unless otherwise noted)

	MIN	TYP	MAX	UNIT
ADCCLK (derived from PERx.SYSCLK)	5		50	MHz
Sample window duration (set by ACQPS and PERx.SYSCLK)	320			ns
	1			ADCCLK
V <sub>REFHI</sub>	2.4	2.5 or 3.0	V <sub>DDA</sub>	V
V <sub>REFLO</sub>	V <sub>SSA</sub>	0	V <sub>SSA</sub>	V
V <sub>REFHI</sub> – V <sub>REFLO</sub>	2.4		V <sub>DDA</sub>	V
ADC input conversion range	V <sub>REFLO</sub>		V <sub>REFHI</sub>	V
ADC input signal common mode voltage <sup>(1)</sup>	V <sub>REFCM</sub> – 50	V <sub>REFCM</sub>	V <sub>REFCM</sub> + 50	mV

(1)  $V_{REFCM} = (V_{REFHI} + V_{REFLO})/2$

**NOTE**

The ADC inputs should be kept below V<sub>DDA</sub> + 0.3 V during operation. If an ADC input exceeds this level, the V<sub>REF</sub> internal to the device may be disturbed, which can impact results for other ADC or DAC inputs using the same V<sub>REF</sub>.

**Table 5-42. ADC Characteristics (16-Bit Differential Mode)**

over recommended operating conditions (unless otherwise noted)<sup>(1)</sup>

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
ADC conversion cycles <sup>(2)</sup>		29.6		31	ADCCLKs
Power-up time (after setting ADCPWDNZ to first conversion)				500	μs
Gain error		-64	±9	64	LSBs
Offset error <sup>(3)</sup>		-16	±9	16	LSBs
Channel-to-channel gain error			±6		LSBs
Channel-to-channel offset error			±3		LSBs
ADC-to-ADC gain error	Identical V <sub>REFHI</sub> and V <sub>REFLO</sub> for all ADCs		±6		LSBs
ADC-to-ADC offset error	Identical V <sub>REFHI</sub> and V <sub>REFLO</sub> for all ADCs		±3		LSBs
DNL <sup>(4)</sup>		> -1	±0.5	1	LSBs
INL		-3	±1.5	3	LSBs
SNR <sup>(5)(6)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 10 kHz		87.6		dB
THD <sup>(5)(6)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 10 kHz		-93.5		dB
SFDR <sup>(5)(6)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 10 kHz		95.4		dB
SINAD <sup>(5)(6)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 10 kHz		86.6		dB
ENOB <sup>(5)(6)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 10 kHz, single ADC <sup>(7)</sup>		14.1		bits
	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 10 kHz, synchronous ADCs <sup>(8)</sup>		14.1		
	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 10 kHz, asynchronous ADCs <sup>(9)</sup>		not supported		
PSRR	V <sub>DDA</sub> = 3.3-V DC + 200 mV DC up to Sine at 1 kHz		77		dB
PSRR	V <sub>DDA</sub> = 3.3-V DC + 200 mV Sine at 800 kHz		74		dB
CMRR	DC to 1 MHz		60		dB
V <sub>REFHI</sub> input current			190		μA
ADC-to-ADC isolation <sup>(6)(10)(11)</sup>	V <sub>REFHI</sub> = 2.5 V, synchronous ADCs <sup>(8)</sup>	-2		2	LSBs
	V <sub>REFHI</sub> = 2.5 V, asynchronous ADCs <sup>(9)</sup>		not supported		

(1) Typical values are measured with V<sub>REFHI</sub> = 2.5 V and V<sub>REFLO</sub> = 0 V. Minimum and Maximum values are tested or characterized with V<sub>REFHI</sub> = 2.5 V and V<sub>REFLO</sub> = 0 V.

(2) See § 5.8.1.1.2.

(3) Difference from conversion result 32768 when ADCINp = ADCINn = V<sub>REFCM</sub>.

(4) No missing codes.

(5) AC parameters will be impacted by clock source accuracy and jitter, this should be taken into account when selecting the clock source for the system. The clock source used for these parameters was a high-accuracy external clock fed through the PLL. The on-chip Internal Oscillator has higher jitter than an external crystal and these parameters will degrade if it is used as a clock source.

(6) IO activity is minimized on pins adjacent to ADC input and V<sub>REFHI</sub> pins as part of best practices to reduce capacitive coupling and crosstalk.

(7) One ADC operating while all other ADCs are idle.

(8) All ADCs operating with identical ADCCLK, S+H durations, triggers, and resolution.

(9) Any ADCs operating with heterogeneous ADCCLK, S+H durations, triggers, or resolution.

(10) Maximum DC code deviation due to operation of multiple ADCs simultaneously.

(11) Value based on characterization.

**Table 5-43. ADC Operating Conditions (12-Bit Single-Ended Mode)**

over recommended operating conditions (unless otherwise noted)

	MIN	TYP	MAX	UNIT
ADCCLK (derived from PERx.SYSCLK)	5		50	MHz
Sample window duration (set by ACQPS and PERx.SYSCLK)	75			ns
	1			ADCCLK
V <sub>REFHI</sub>	2.4	2.5 or 3.0	V <sub>DDA</sub>	V
V <sub>REFLO</sub>	V <sub>SSA</sub>	0	V <sub>SSA</sub>	V
V <sub>REFHI</sub> – V <sub>REFLO</sub>	2.4		V <sub>DDA</sub>	V
ADC input conversion range	V <sub>REFLO</sub>		V <sub>REFHI</sub>	V

**NOTE**

The ADC inputs should be kept below V<sub>DDA</sub> + 0.3 V during operation. If an ADC input exceeds this level, the V<sub>REF</sub> internal to the device may be disturbed, which can impact results for other ADC or DAC inputs using the same V<sub>REF</sub>.

**Table 5-44. ADC Characteristics (12-Bit Single-Ended Mode)**

 over recommended operating conditions (unless otherwise noted)<sup>(1)</sup>

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
ADC conversion cycles <sup>(2)</sup>		10.1		11	ADCCLKs
Power-up time				500	μs
Gain error		-5	±3	5	LSBs
Offset error		-4	±2	4	LSBs
Channel-to-channel gain error			±4		LSBs
Channel-to-channel offset error			±2		LSBs
ADC-to-ADC gain error	Identical V <sub>REFHI</sub> and V <sub>REFLO</sub> for all ADCs		±4		LSBs
ADC-to-ADC offset error	Identical V <sub>REFHI</sub> and V <sub>REFLO</sub> for all ADCs		±2		LSBs
DNL <sup>(3)</sup>		> -1	±0.5	1	LSBs
INL		-2	±1.0	2	LSBs
SNR <sup>(4)(5)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 100 kHz		68.8		dB
THD <sup>(4)(5)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 100 kHz		-78.4		dB
SFDR <sup>(4)(5)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 100 kHz		79.2		dB
SINAD <sup>(4)(5)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 100 kHz		68.4		dB
ENOB <sup>(4)(5)</sup>	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 100 kHz, single ADC <sup>(6)</sup> , all packages		11.1		bits
	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 100 kHz, synchronous ADCs <sup>(7)</sup> , all packages		11.1		
	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 100 kHz, asynchronous ADCs <sup>(8)</sup> , 100-pin PZP package		not supported		
	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 100 kHz, asynchronous ADCs <sup>(8)</sup> , 176-pin PTP package		9.7		
	V <sub>REFHI</sub> = 2.5 V, f <sub>in</sub> = 100 kHz, asynchronous ADCs <sup>(8)</sup> , 337-ball ZWT package		10.9		
PSRR	V <sub>DDA</sub> = 3.3-V DC + 200 mV DC up to Sine at 1 kHz		60		dB
PSRR	V <sub>DDA</sub> = 3.3-V DC + 200 mV Sine at 800 kHz		57		dB
ADC-to-ADC isolation <sup>(5)(9)(10)</sup>	V <sub>REFHI</sub> = 2.5 V, synchronous ADCs <sup>(7)</sup> , all packages	-1		1	LSBs
	V <sub>REFHI</sub> = 2.5 V, asynchronous ADCs <sup>(8)</sup> , 100-pin PZP package		not supported		
	V <sub>REFHI</sub> = 2.5 V, asynchronous ADCs <sup>(8)</sup> , 176-pin PTP package	-9		9	
	V <sub>REFHI</sub> = 2.5 V, asynchronous ADCs <sup>(8)</sup> , 337-ball ZWT package	-2		2	
V <sub>REFHI</sub> input current			130		μA

(1) Typical values are measured with V<sub>REFHI</sub> = 2.5 V and V<sub>REFLO</sub> = 0 V. Minimum and Maximum values are tested or characterized with V<sub>REFHI</sub> = 2.5 V and V<sub>REFLO</sub> = 0 V.

(2) See [§ 5.8.1.1.2](#).

(3) No missing codes.

(4) AC parameters will be impacted by clock source accuracy and jitter, this should be taken into account when selecting the clock source for the system. The clock source used for these parameters was a high-accuracy external clock fed through the PLL. The on-chip Internal Oscillator has higher jitter than an external crystal and these parameters will degrade if it is used as a clock source.

(5) IO activity is minimized on pins adjacent to ADC input and V<sub>REFHI</sub> pins as part of best practices to reduce capacitive coupling and crosstalk.

(6) One ADC operating while all other ADCs are idle.

(7) All ADCs operating with identical ADCCLK, S+H durations, triggers, and resolution.

(8) Any ADCs operating with heterogeneous ADCCLK, S+H durations, triggers, or resolution.

(9) Maximum DC code deviation due to operation of multiple ADCs simultaneously.

(10) Value based on characterization.

**Table 5-45. ADCEXTSOC Timing Requirements<sup>(1)</sup>**

		MIN	MAX	UNIT
$t_{w(INT)}$	Pulse duration, INT input low/high	Synchronous	$2t_{c(SYSCLK)}$	cycles
		With qualifier	$t_{w(IQSW)} + t_{w(SP)} + 1t_{c(SYSCLK)}$	cycles

(1) For an explanation of the input qualifier parameters, see [Table 5-24](#).

### 5.8.1.1.1 ADC Input Models

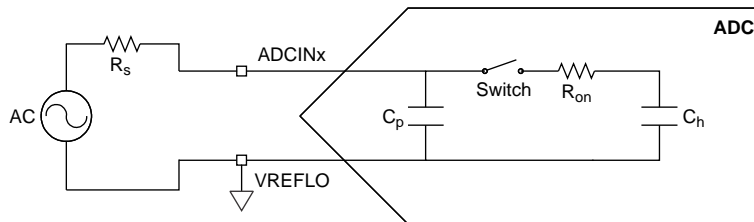
注

ADC channels ADCINA0, ADCINA1, and ADCINB1 have a 50-k $\Omega$  pulldown resistor to  $V_{SSA}$ .

For single-ended operation, the ADC input characteristics are given by [表 5-46](#) and [图 5-30](#).

**表 5-46. Single-Ended Input Model Parameters**

	DESCRIPTION	VALUE (12-BIT MODE)
$C_p$	Parasitic input capacitance	See <a href="#">表 5-48</a>
$R_{on}$	Sampling switch resistance	425 $\Omega$
$C_h$	Sampling capacitor	14.5 pF
$R_s$	Nominal source impedance	50 $\Omega$

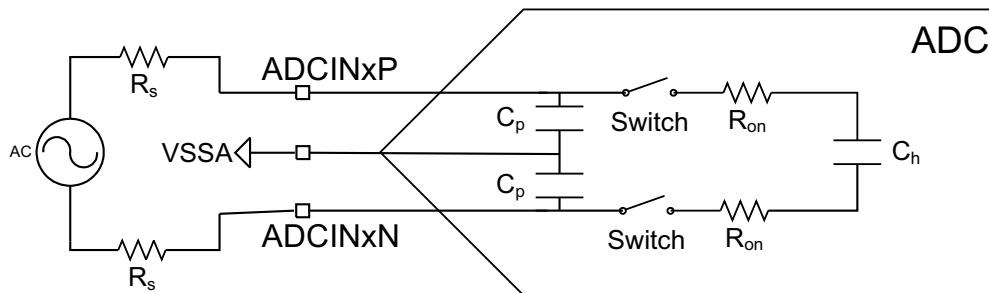


**图 5-30. Single-Ended Input Model**

For differential operation, the ADC input characteristics are given by [表 5-47](#) and [图 5-31](#).

**表 5-47. Differential Input Model Parameters**

	DESCRIPTION	VALUE (16-BIT MODE)
$C_p$	Parasitic input capacitance	See <a href="#">表 5-48</a>
$R_{on}$	Sampling switch resistance	700 $\Omega$
$C_h$	Sampling capacitor	16.5 pF
$R_s$	Nominal source impedance	50 $\Omega$



**图 5-31. Differential Input Model**

表 5-48 shows the parasitic capacitance on each channel. Also note that enabling a comparator will add approximately 1.4 pF of capacitance on positive comparator inputs and 2.5 pF of capacitance on negative comparator inputs.

**表 5-48. Per-Channel Parasitic Capacitance**

ADC CHANNEL	C <sub>p</sub> (pF)	
	COMPARATOR DISABLED	COMPARATOR ENABLED
ADCINA0	12.9	N/A
ADCINA1	10.3	N/A
ADCINA2	5.9	7.3
ADCINA3	6.3	8.8
ADCINA4	5.9	7.3
ADCINA5	6.3	8.8
ADCINB0	117.0	N/A
ADCINB1	10.6	N/A
ADCINB2	5.9	7.3
ADCINB3	6.2	8.7
ADCINB4	5.2	N/A
ADCINB5	5.1	N/A
ADCINC2	5.5	6.9
ADCINC3	5.8	8.3
ADCINC4	5.0	6.4
ADCINC5	5.3	7.8
ADCIND0	5.3	6.7
ADCIND1	5.7	8.2
ADCIND2	5.3	6.7
ADCIND3	5.6	8.1
ADCIND4	4.3	N/A
ADCIND5	4.3	N/A
ADCIN14	8.6	10.0
ADCIN15	9.0	11.5

These input models should be used along with actual signal source impedance to determine the acquisition window duration. See the "Choosing an Acquisition Window Duration" section of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)* for more information.

The user should analyze the ADC input setting assuming worst-case initial conditions on C<sub>h</sub>. This will require assuming that C<sub>h</sub> could start the S+H window completely charged to V<sub>REFHI</sub> or completely discharged to V<sub>REFLO</sub>. When the ADC transitions from an odd-numbered channel to an even-numbered channel, or vice-versa, the actual initial voltage on C<sub>h</sub> will be close to being completely discharged to V<sub>REFLO</sub>. For even-to-even or odd-to-odd channel transitions, the initial voltage on C<sub>h</sub> will be close to the voltage of the previously converted channel.



### 5.8.1.1.2 ADC Timing Diagrams

表 5-49 shows the ADC timings in 12-bit mode (SYSCLK cycles). 表 5-50 shows the ADC timings in 16-bit mode. 图 5-32 and 图 5-33 show the ADC conversion timings for two SOCs given the following assumptions:

- SOC0 and SOC1 are configured to use the same trigger.
- No other SOCs are converting or pending when the trigger occurs.
- The round robin pointer is in a state that causes SOC0 to convert first.
- ADCINTSEL is configured to set an ADCINT flag upon end of conversion for SOC0 (whether this flag propagates through to the CPU to cause an interrupt is determined by the configurations in the PIE module).

The following parameters are identified in the timing diagrams:

- The parameter  $t_{SH}$  is the duration of the S+H window. At the end of this window, the value on the S+H capacitor becomes the voltage to be converted into a digital value. The duration is given by  $(ACQPS + 1)$  SYSCLK cycles. ACQPS can be configured individually for each SOC, so  $t_{SH}$  will not necessarily be the same for different SOCs.
- The parameter  $t_{LAT}$  is the time from the end of the S+H window until the ADC conversion results latch in the ADCRESULTx register. If the ADCRESULTx register is read before this time, the previous conversion results will be returned.
- The parameter  $t_{EOC}$  is the time from the end of the S+H window until the next ADC conversion S+H window can begin. In 16-bit mode, this will coincide with the latching of the conversion results, while in 12-bit mode, the subsequent sample can start before the conversion results are latched.
- The parameter  $t_{INT}$  is the time from the end of the S+H window until an ADCINT flag is set (if configured). If the INTPULSEPOS bit in the ADCCTL1 register is set, this will coincide with the conversion results being latched into the result register. If the bit is cleared, this will coincide with the end of the S+H window.

表 5-49. ADC Timings in 12-Bit Mode (SYSCLK Cycles)

ADCCLK PRESCALE		SYSCLK CYCLES				ADCCLK CYCLES	
ADCCTL2 [PRESCALE]	RATIO ADCCLK:SYSCLK	t <sub>EOC</sub>	t <sub>LAT</sub>	t <sub>INT(EARLY)</sub>	t <sub>INT(LATE)</sub>	t <sub>EOC</sub>	
0	1	11	13	1	11	11.0	
1	1.5	Invalid					
2	2	21	23	1	21	10.5	
3	2.5	26	28	1	26	10.4	
4	3	31	34	1	31	10.3	
5	3.5	36	39	1	36	10.3	
6	4	41	44	1	41	10.3	
7	4.5	46	49	1	46	10.2	
8	5	51	55	1	51	10.2	
9	5.5	56	60	1	56	10.2	
10	6	61	65	1	61	10.2	
11	6.5	66	70	1	66	10.2	
12	7	71	76	1	71	10.1	
13	7.5	76	81	1	76	10.1	
14	8	81	86	1	81	10.1	
15	8.5	86	91	1	86	10.1	

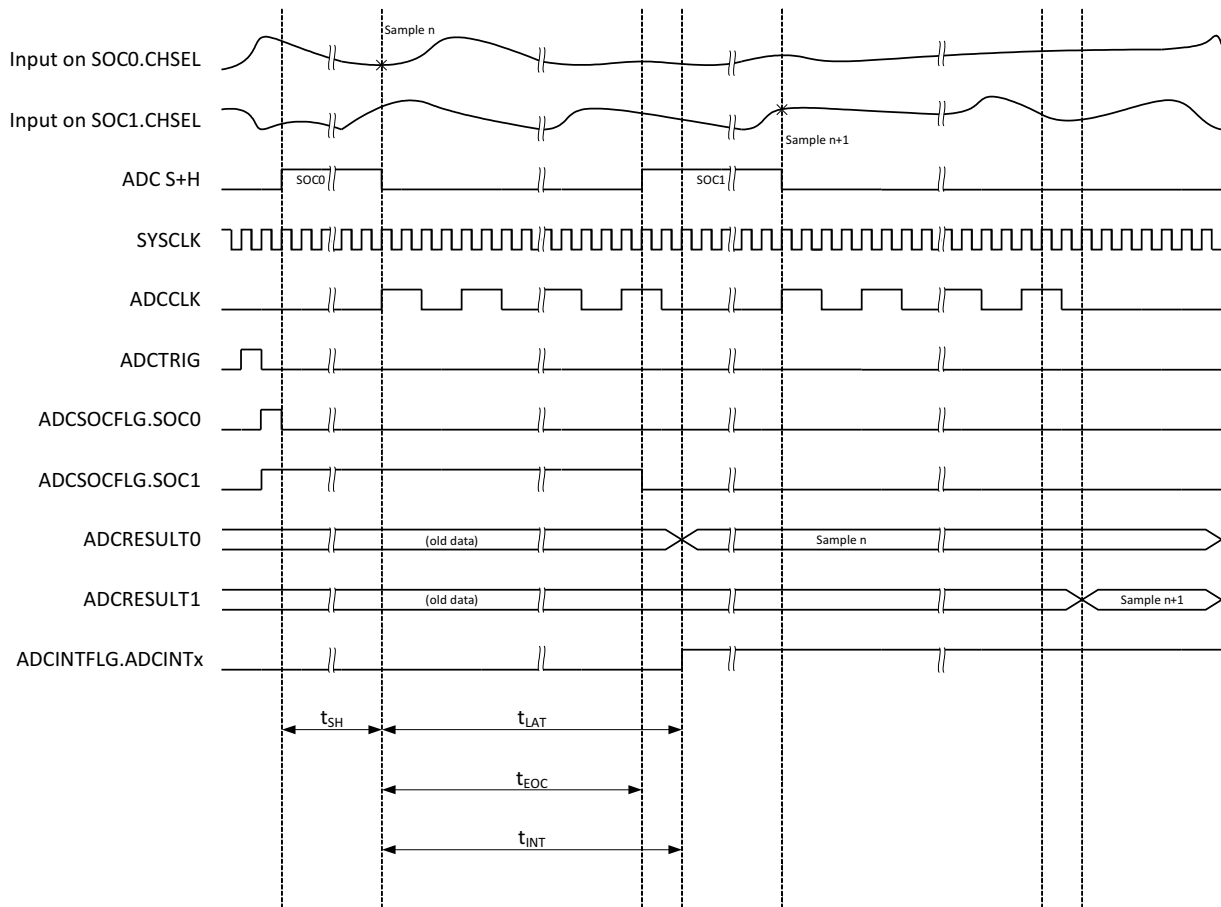


图 5-32. ADC Timings for 12-Bit Mode

表 5-50. ADC Timings in 16-Bit Mode

ADCCLK PRESCALE		SYSCLK CYCLES				ADCCLK CYCLES
ADCCTL2 [PRESCALE]	RATIO ADCCLK:SYSCLK	$t_{EOC}$	$t_{LAT}$	$t_{INT(EARLY)}$	$t_{INT(LATE)}$	$t_{EOC}$
0	1	31	32	1	31	31.0
1	1.5	Invalid				
2	2	60	61	1	60	30.0
3	2.5	75	75	1	75	30.0
4	3	90	91	1	90	30.0
5	3.5	104	106	1	104	29.7
6	4	119	120	1	119	29.8
7	4.5	134	134	1	134	29.8
8	5	149	150	1	149	29.8
9	5.5	163	165	1	163	29.6
10	6	178	179	1	178	29.7
11	6.5	193	193	1	193	29.7
12	7	208	209	1	208	29.7
13	7.5	222	224	1	222	29.6
14	8	237	238	1	237	29.6
15	8.5	252	252	1	252	29.6

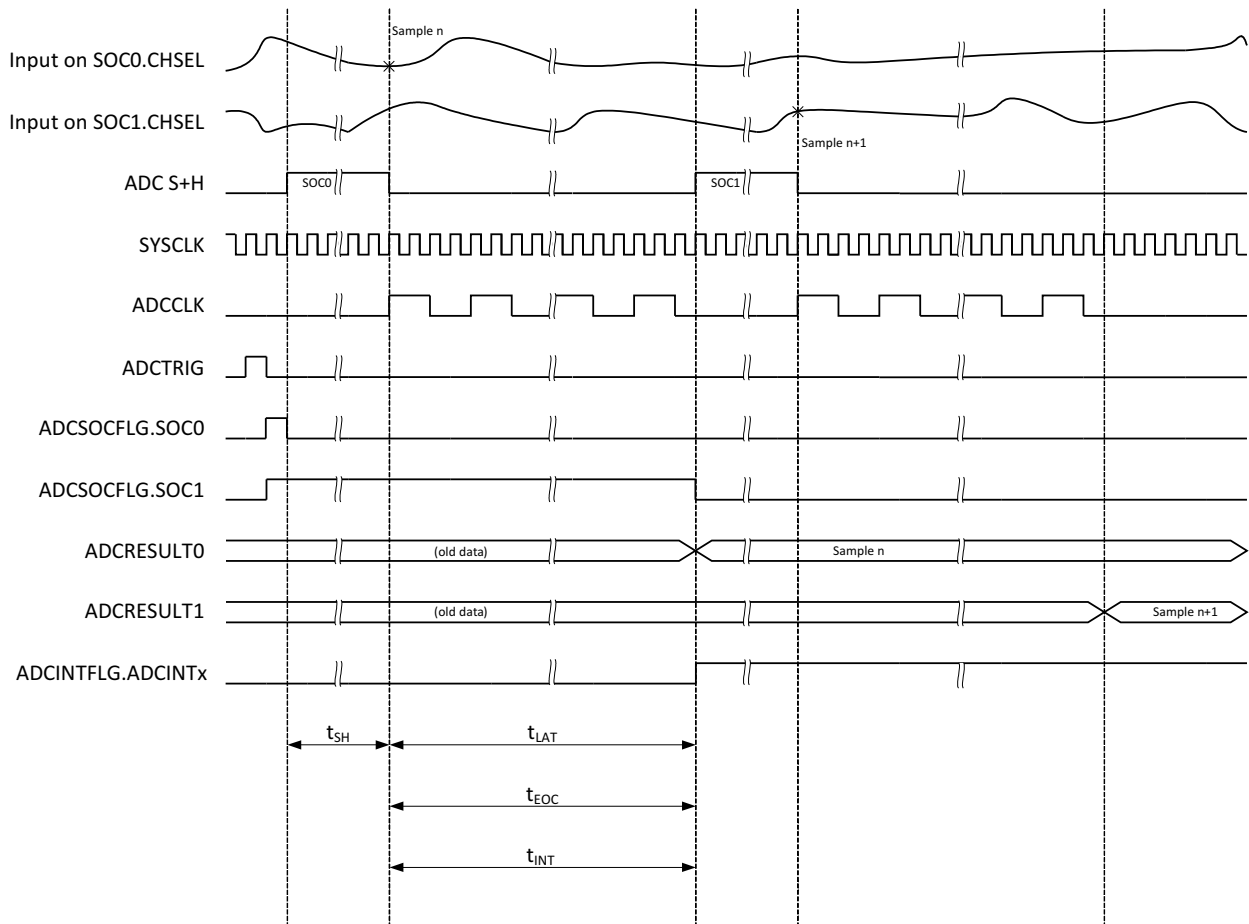


图 5-33. ADC Timings for 16-Bit Mode

### 5.8.1.2 Temperature Sensor Electrical Data and Timing

The temperature sensor can be used to measure the device junction temperature. The temperature sensor is sampled through an internal connection to the ADC and translated into a temperature through TI-provided software. When sampling the temperature sensor, the ADC must meet the acquisition time in [Table 5-51](#).

**Table 5-51. Temperature Sensor Electrical Characteristics**

over recommended operating conditions (unless otherwise noted)

PARAMETER	MIN	TYP	MAX	UNIT
Temperature accuracy		±15		°C
Start-up time (TSNSCTL[ENABLE] to sampling temperature sensor)		500		µs
ADC acquisition time	700			ns

### 5.8.2 Comparator Subsystem (CMPSS)

Each CMPSS module includes two comparators, two internal voltage reference DACs (CMPSS DACs), two digital glitch filters, and one ramp generator. There are two inputs, CMPINxP and CMPINxN. Each of these will be internally connected to an ADCIN pin. The CMPINxP pin is always connected to the positive input of the CMPSS comparators. CMPINxN can be used instead of the DAC output to drive the negative comparator inputs. There are two comparators, and therefore two outputs from the CMPSS module, which are connected to the input of a digital filter module before being passed on to the Comparator TRIP crossbar and either PWM modules or directly to a GPIO pin. 图 5-34 shows the CMPSS connectivity on the 337-ball ZWT and 176-pin PTP packages. 图 5-35 shows CMPSS connectivity on the 100-pin PZP package.

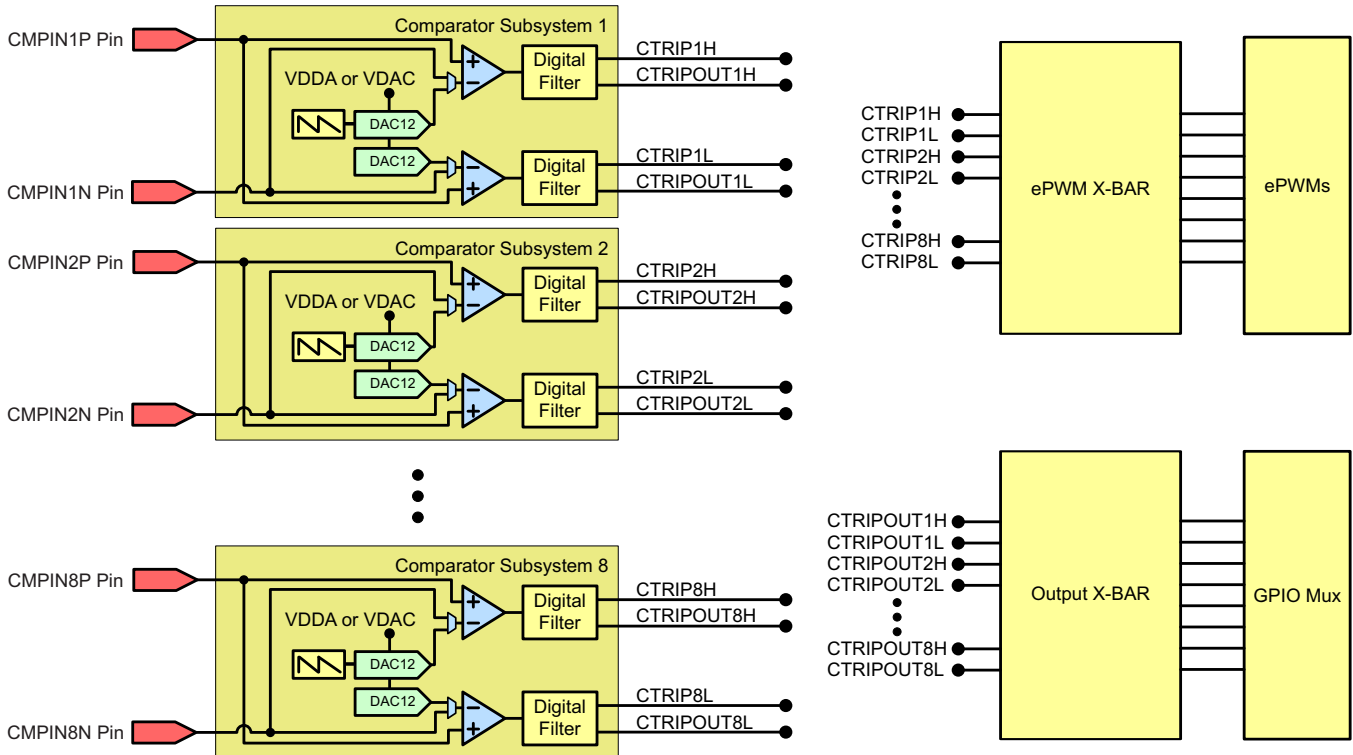


图 5-34. CMPSS Connectivity (337-Ball ZWT and 176-Pin PTP)

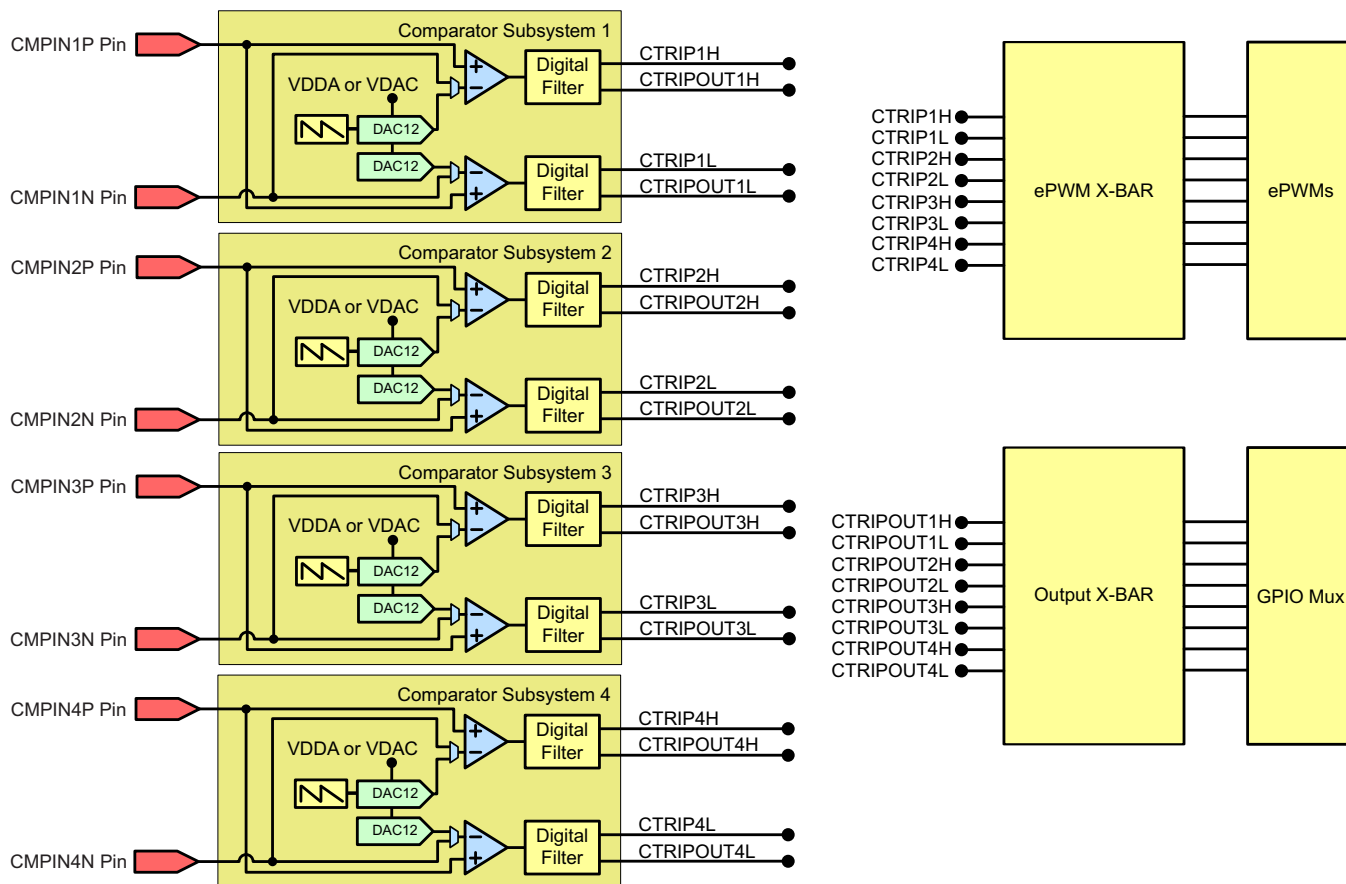


图 5-35. CMPSS Connectivity (100-Pin PZP)

### 5.8.2.1 CMPSS Electrical Data and Timing

Table 5-52 shows the comparator electrical characteristics. Figure 5-36 shows the CMPSS comparator input referred offset. Figure 5-37 shows the CMPSS comparator hysteresis.

**Table 5-52. Comparator Electrical Characteristics**

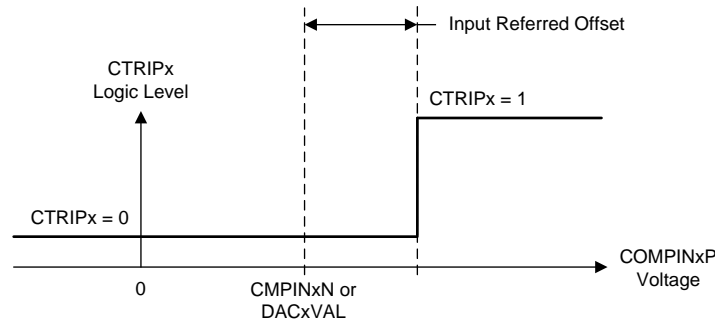
over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Power-up time (from COMPCTL[COMPDACE] to comparator ready)				10	μs
Comparator input (CMPINxx) range		0		V <sub>DDA</sub>	V
Input referred offset error		-20		20	mV
Hysteresis <sup>(1)</sup>	1x		12		CMPSS DAC LSB
	2x		24		
	3x		36		
	4x		48		
Response time (delay from CMPINx input change to output on ePWM X-BAR or Output X-BAR)	Step response		21	60	ns
	Ramp response (1.65 V/μs)		26		
	Ramp response (8.25 mV/μs)		30		

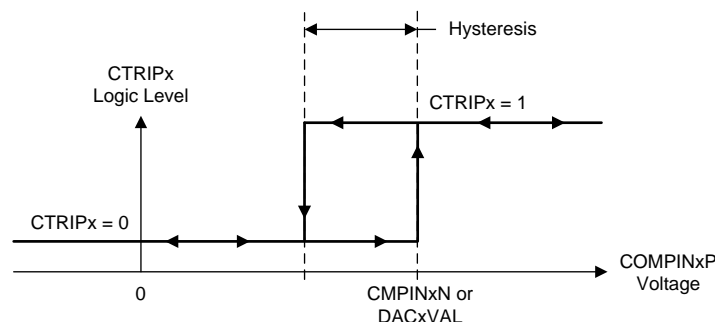
(1) Hysteresis will scale with the CMPSS reference voltage.

#### NOTE

The CMPSS inputs must be kept below V<sub>DDA</sub> + 0.3 V to ensure proper functional operation. If a CMPSS input exceeds this level, an internal blocking circuit will isolate the internal comparator from the external pin until the external pin voltage returns below V<sub>DDA</sub> + 0.3 V. During this time, the internal comparator input will be floating and can decay below V<sub>DDA</sub> within approximately 0.5 μs. After this time, the comparator could begin to output an incorrect result depending on the value of the other comparator input.



**Figure 5-36. CMPSS Comparator Input Referred Offset**



**Figure 5-37. CMPSS Comparator Hysteresis**

Table 5-53 shows the CMPSS DAC static electrical characteristics. Figure 5-38 shows the CMPSS DAC static offset. Figure 5-39 shows the CMPSS DAC static gain. Figure 5-40 shows the CMPSS DAC static linearity.

**Table 5-53. CMPSS DAC Static Electrical Characteristics**

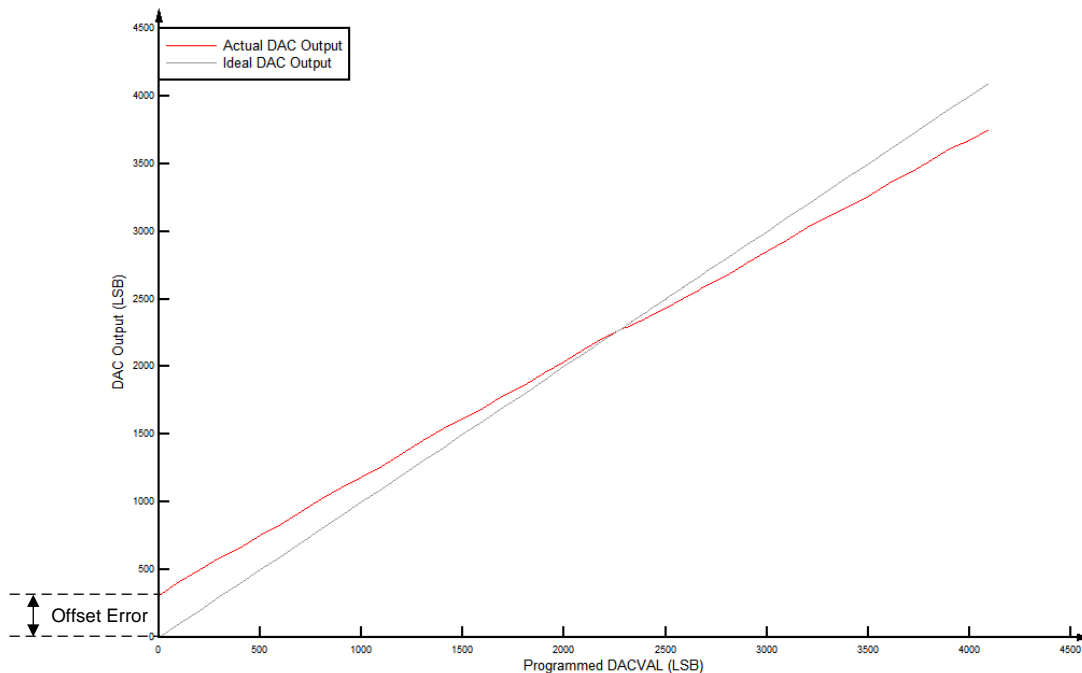
over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
CMPSS DAC output range	Internal reference	0		$V_{DDA}$	V
	External reference	0		VDAC	
Static offset error <sup>(1)</sup>		-25		25	mV
Static gain error <sup>(1)</sup>		-2		2	% of FSR
Static DNL	Endpoint corrected	$>-1$		4	LSB
Static INL	Endpoint corrected	-16		16	LSB
Settling time	Settling to 1 LSB after full-scale output change			1	$\mu$ s
Resolution			12		bits
CMPSS DAC output disturbance <sup>(2)</sup>	Error induced by comparator trip or CMPSS DAC code change within the same CMPSS module	-100		100	LSB
CMPSS DAC disturbance time <sup>(2)</sup>			200		ns
VDAC reference voltage	When VDAC is reference	2.4	2.5 or 3.0	$V_{DDA}$	V
VDAC load <sup>(3)</sup>	When VDAC is reference		6		k $\Omega$

(1) Includes comparator input referred errors.

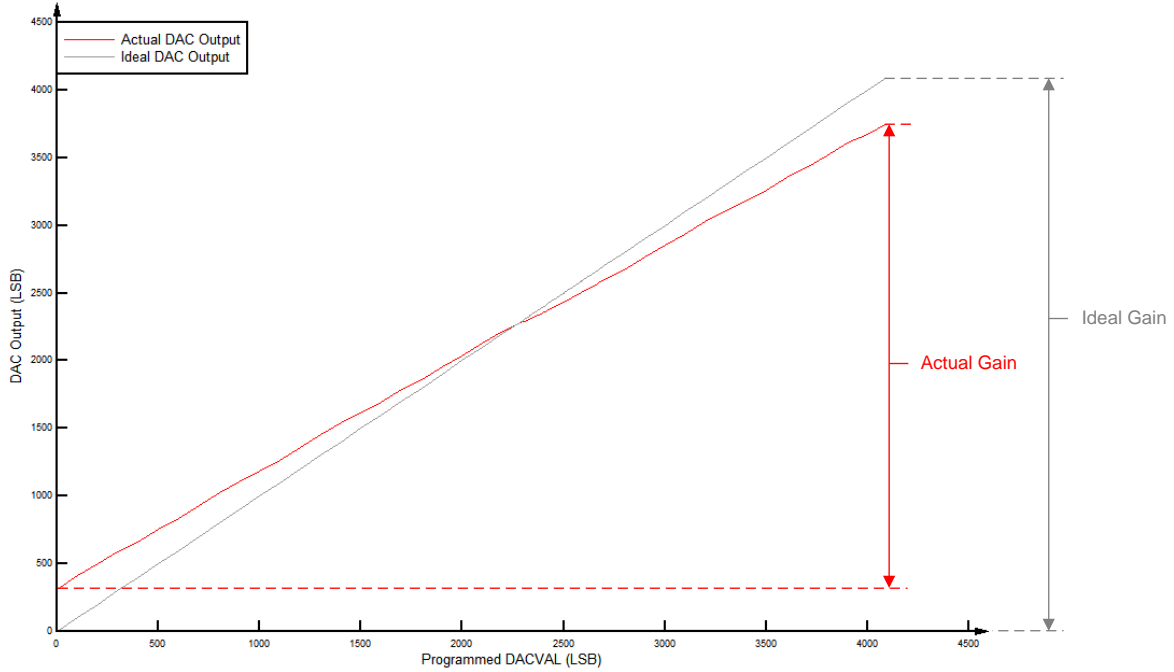
(2) Disturbance error may be present on the CMPSS DAC output for a certain amount of time after a comparator trip.

(3) Per active CMPSS module.

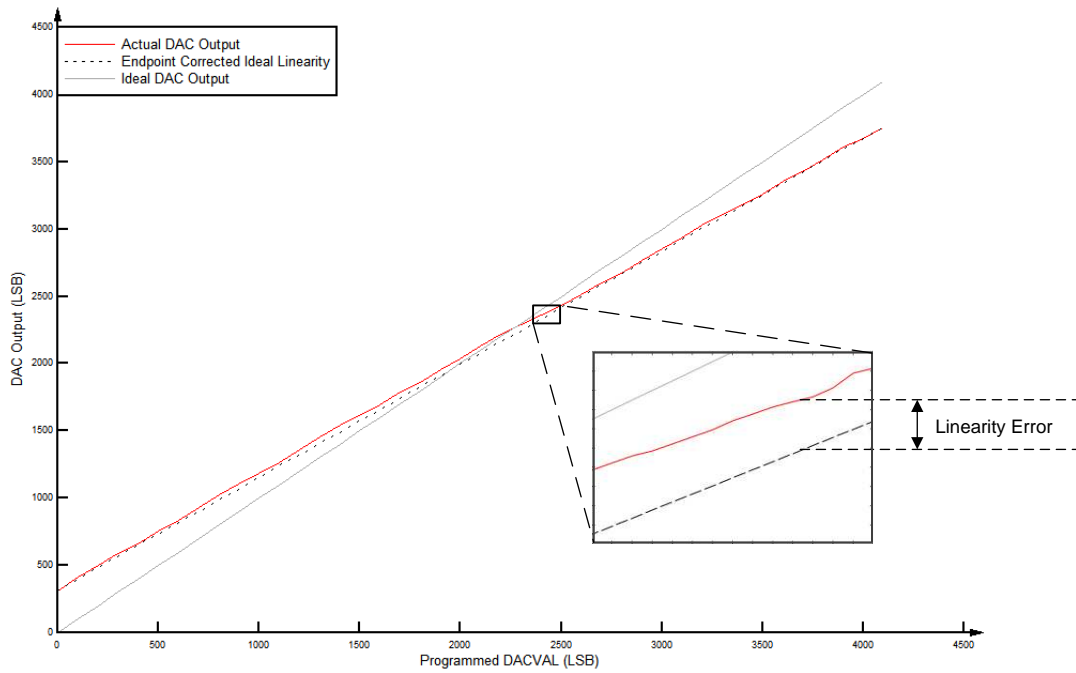


**Figure 5-38. CMPSS DAC Static Offset**





**Figure 5-39. CMPSS DAC Static Gain**



**Figure 5-40. CMPSS DAC Static Linearity**

### 5.8.3 Buffered Digital-to-Analog Converter (DAC)

The buffered DAC module consists of an internal reference DAC and an analog output buffer that is capable of driving an external load. An integrated pulldown resistor on the DAC output helps to provide a known pin voltage when the output buffer is disabled. This pulldown resistor cannot be disabled and remains as a passive component on the pin, even for other shared pin mux functions. Software writes to the DAC value register can take effect immediately or can be synchronized with PWMSYNC events.

Each buffered DAC has the following features:

- 12-bit programmable internal DAC
- Selectable reference voltage
- Pulldown resistor on output
- Ability to synchronize with PWMSYNC

The block diagram for the buffered DAC is shown in 图 5-41.

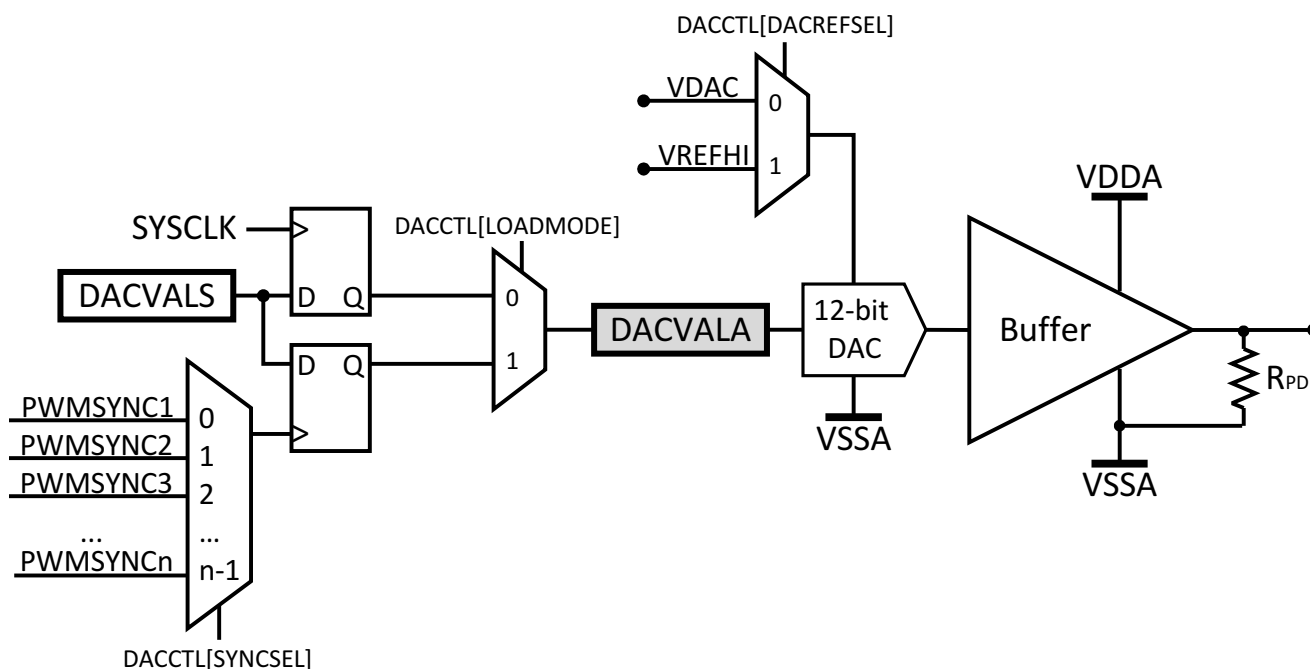


图 5-41. DAC Module Block Diagram

### 5.8.3.1 Buffered DAC Electrical Data and Timing

Table 5-54 shows the buffered DAC electrical characteristics. Figure 5-42 shows the buffered DAC offset. Figure 5-43 shows the buffered DAC gain. Figure 5-44 shows the buffered DAC linearity.

**Table 5-54. Buffered DAC Electrical Characteristics**

over recommended operating conditions (unless otherwise noted)<sup>(1)</sup>

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Power-up time (DACOUTEN to DAC output valid)				10	μs
Trimmed offset error	Midpoint	-10		10	mV
Gain error <sup>(2)</sup>		-2.5		2.5	% of FSR
DNL <sup>(3)</sup>	Endpoint corrected	> -1		1	LSB
INL	Endpoint corrected	-5		5	LSB
DACOUTx settling time	Settling to 2 LSBs after 0.3V-to-3V transition		2		μs
Resolution			12		bits
Voltage output range <sup>(4)</sup>		0.3		V <sub>DDA</sub> - 0.3	V
Capacitive load	Output drive capability			100	pF
Resistive load	Output drive capability	5			kΩ
R <sub>PD</sub>			50		kΩ
Reference voltage <sup>(5)</sup>	VDAC or V <sub>REFHI</sub>	2.4	2.5 or 3.0	V <sub>DDA</sub>	V
Reference load <sup>(6)</sup>	VDAC or V <sub>REFHI</sub>		170		kΩ
Output noise	Integrated noise from 100 Hz to 100 kHz		500		μVrms
	Noise density at 10 kHz		711		nVrms/√Hz
Glitch energy			1.5		V-ns
PSRR <sup>(7)</sup>	DC up to 1 kHz		70		dB
	100 kHz		30		
SNR	1020 Hz		67		dB
THD	1020 Hz		-63		dB
SFDR	1020 Hz, including harmonics and spurs		66		dBc
	1020 Hz, including only spurs		104		

- (1) Typical values are measured with V<sub>REFHI</sub> = 3.3 V and V<sub>REFLO</sub> = 0 V unless otherwise noted. Minimum and Maximum values are tested or characterized with V<sub>REFHI</sub> = 2.5 V and V<sub>REFLO</sub> = 0 V.
- (2) Gain error is calculated for linear output range.
- (3) The DAC output is monotonic.
- (4) This is the linear output range of the DAC. The DAC can generate voltages outside this range, but the output voltage will not be linear due to the buffer.
- (5) For best PSRR performance, VDAC or V<sub>REFHI</sub> should be less than V<sub>DDA</sub>.
- (6) Per active Buffered DAC module.
- (7) V<sub>REFHI</sub> = 3.2 V, V<sub>DDA</sub> = 3.3 V DC + 100 mV Sine.

#### NOTE

The VDAC pin must be kept below V<sub>DDA</sub> + 0.3 V to ensure proper functional operation. If the VDAC pin exceeds this level, a blocking circuit may activate, and the internal value of VDAC may float to 0 V internally, giving improper DAC output.

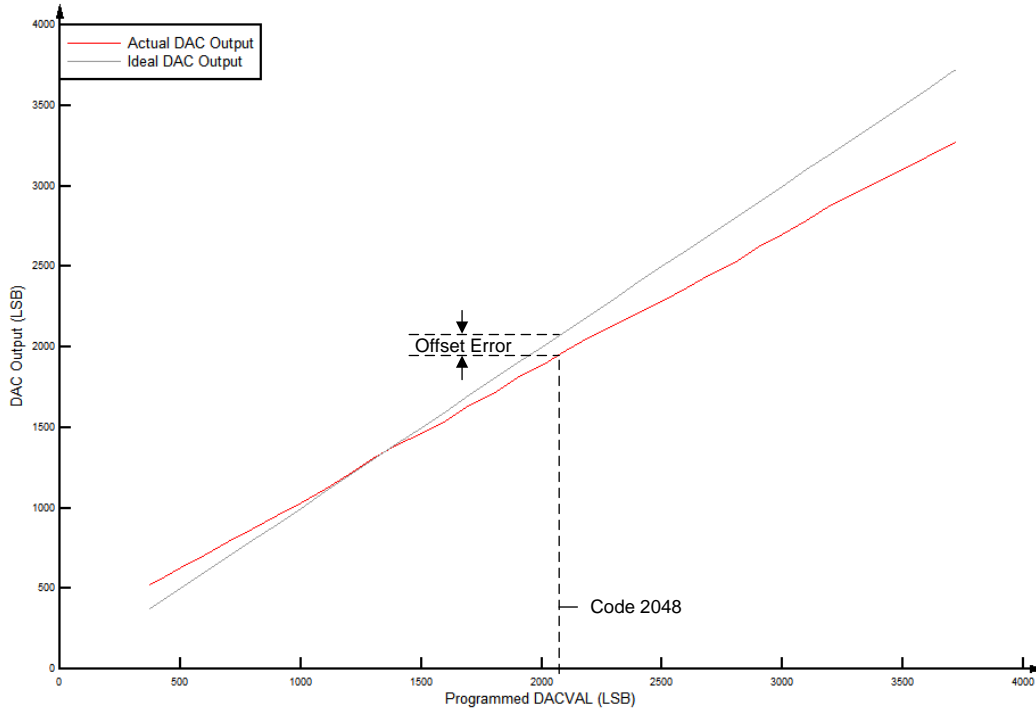


Figure 5-42. Buffered DAC Offset

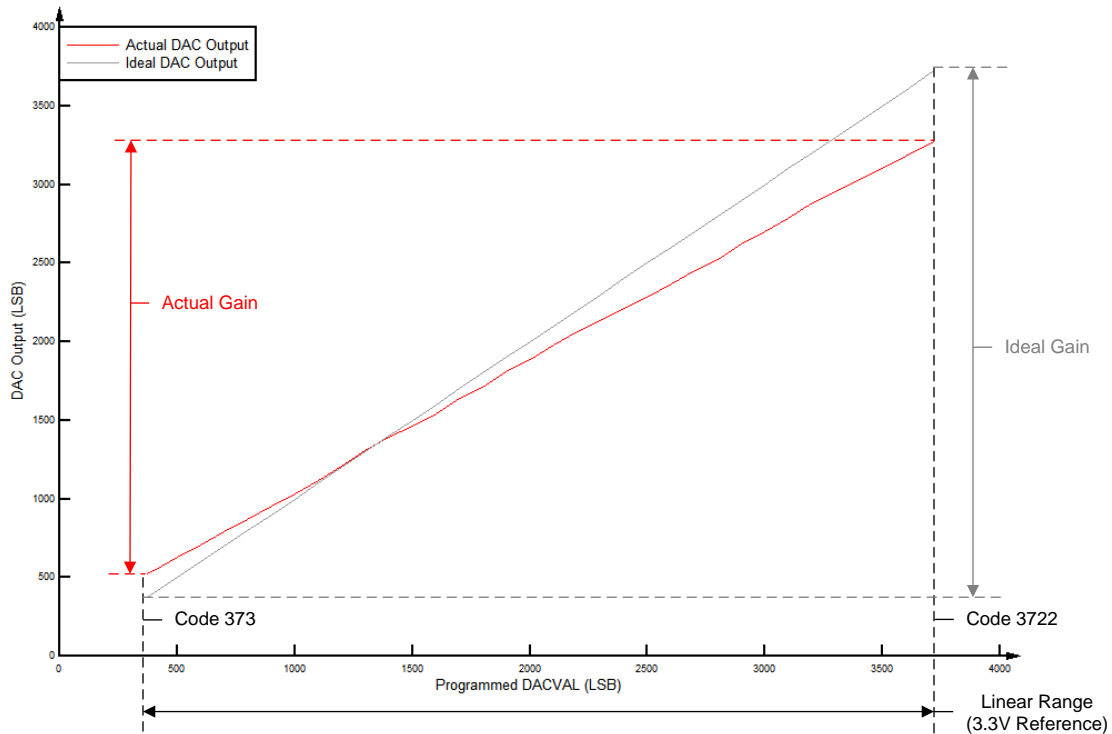


Figure 5-43. Buffered DAC Gain

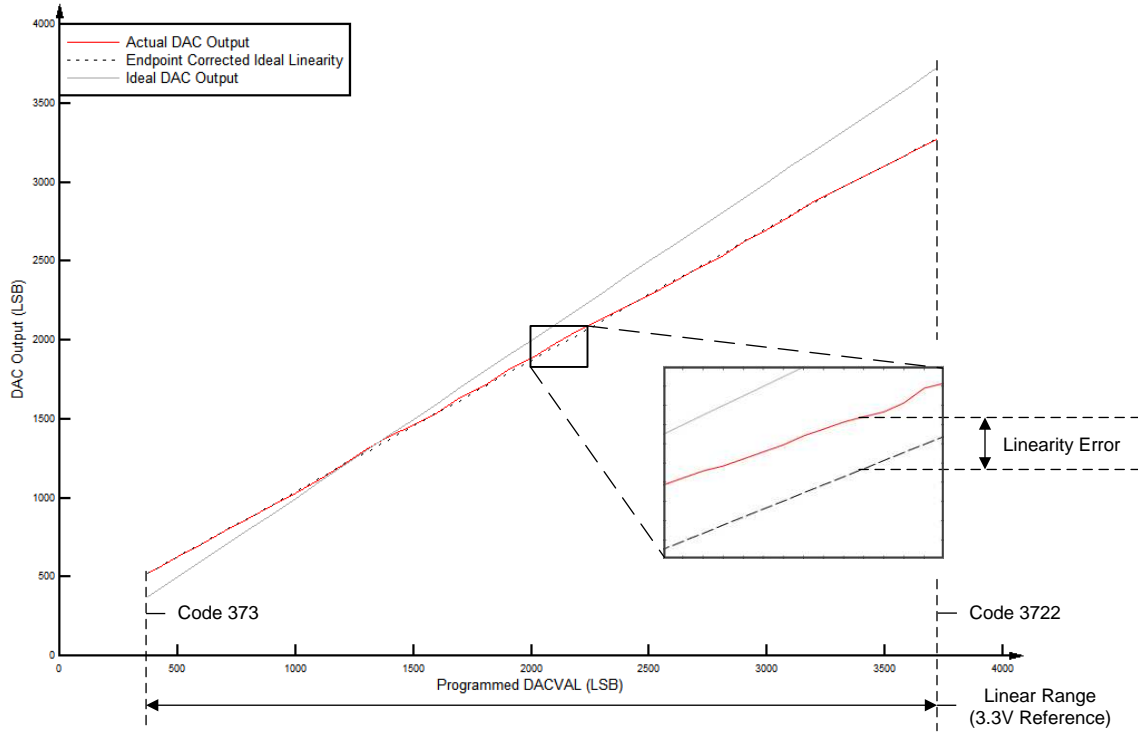


Figure 5-44. Buffered DAC Linearity

## 5.9 Control Peripherals

### 注

For the actual number of each peripheral on a specific device, see [Table 3-1](#).

### 5.9.1 Enhanced Capture (eCAP)

The eCAP module can be used in systems where accurate timing of external events is important.

Applications for eCAP include:

- Speed measurements of rotating machinery (for example, toothed sprockets sensed through Hall sensors)
- Elapsed time measurements between position sensor pulses
- Period and duty cycle measurements of pulse train signals
- Decoding current or voltage amplitude derived from duty cycle encoded current/voltage sensors

The eCAP module includes the following features:

- 4-event time-stamp registers (each 32 bits)
- Edge-polarity selection for up to four sequenced time-stamp capture events
- Interrupt on either of the four events
- Single shot capture of up to four event timestamps
- Continuous mode capture of timestamps in a four-deep circular buffer
- Absolute time-stamp capture
- Difference (Delta) mode time-stamp capture
- All of the above resources dedicated to a single input pin
- When not used in capture mode, the eCAP module can be configured as a single-channel PWM output (APWM).

The eCAP inputs connect to any GPIO input through the Input X-BAR. The APWM outputs connect to GPIO pins through the Output X-BAR to OUTPUTx positions in the GPIO mux. See [Section 4.5.2](#) and [Section 4.5.3](#).

[图 5-45](#) shows the block diagram of an eCAP module.

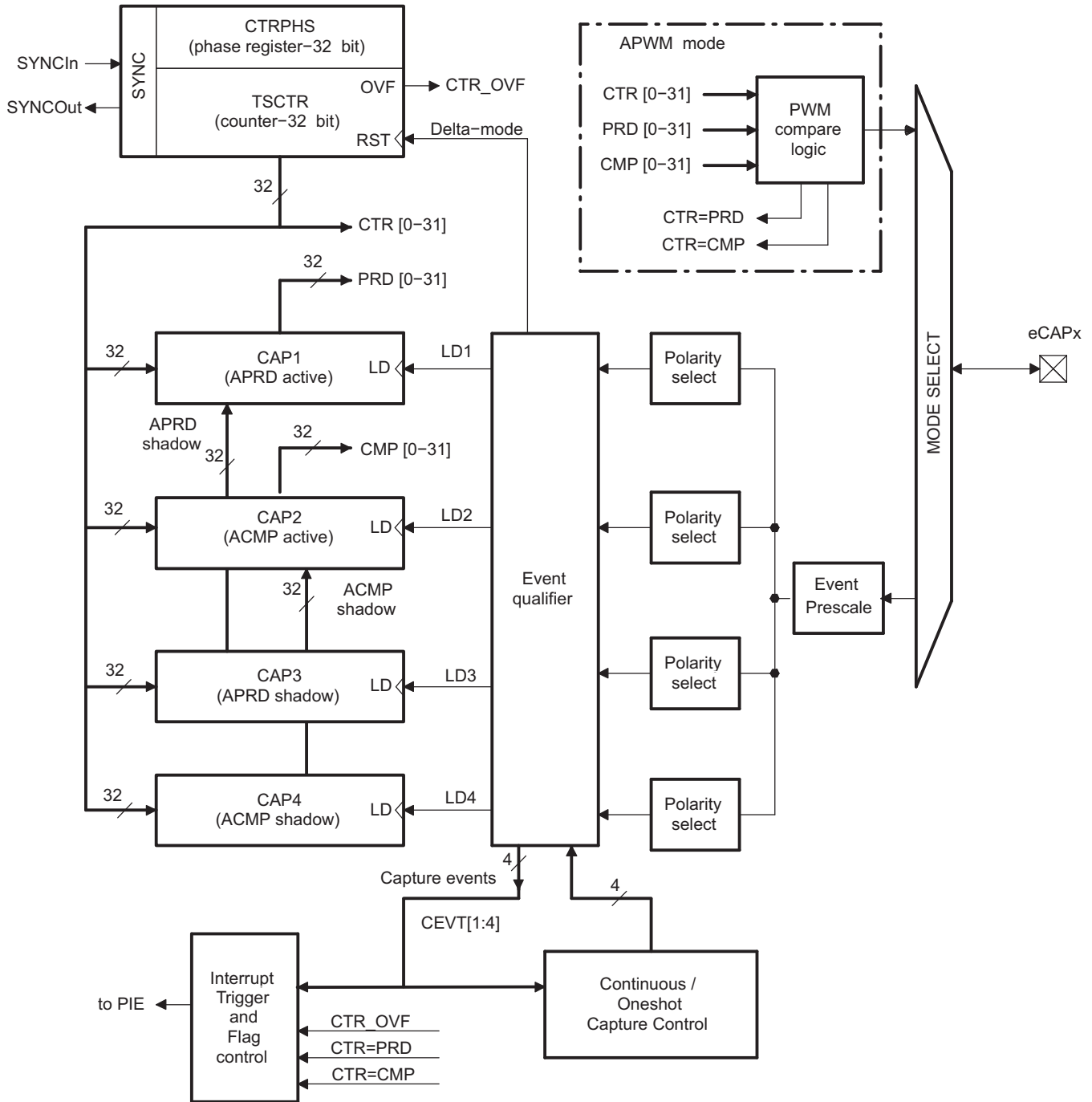


图 5-45. eCAP Block Diagram

The eCAP module is clocked by PERx.SYSCLK.

The clock enable bits (ECAP1–ECAP6) in the PCLKCR3 register turn off the eCAP module individually (for low-power operation). Upon reset, ECAP1ENCLK is set to low, indicating that the peripheral clock is off.

### 5.9.1.1 eCAP Electrical Data and Timing

[Table 5-55](#) shows the eCAP timing requirement and [Table 5-56](#) shows the eCAP switching characteristics.

**Table 5-55. eCAP Timing Requirement<sup>(1)</sup>**

		MIN	MAX	UNIT
$t_{w(CAP)}$	Capture input pulse width			
	Asynchronous	$2t_{c(SYSCLK)}$		cycles
	Synchronous	$2t_{c(SYSCLK)}$		cycles
	With input qualifier	$1t_{c(SYSCLK)} + t_{w(IQSW)}$		cycles

(1) For an explanation of the input qualifier parameters, see [Table 5-24](#).

**Table 5-56. eCAP Switching Characteristics**

over recommended operating conditions (unless otherwise noted)

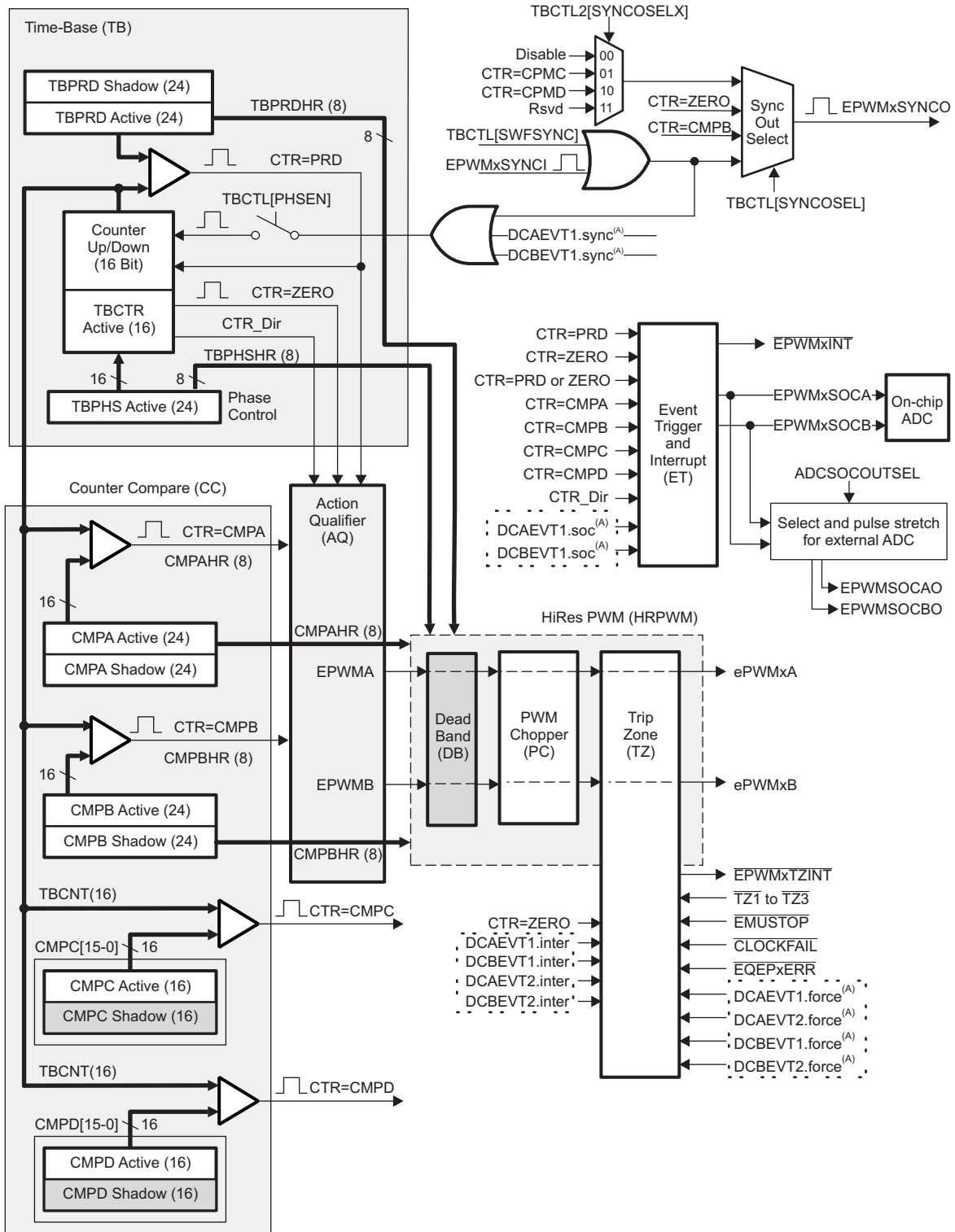
PARAMETER		MIN	MAX	UNIT
$t_{w(APWM)}$	Pulse duration, APWMx output high/low	20		ns



## 5.9.2 Enhanced Pulse Width Modulator (ePWM)

The ePWM peripheral is a key element in controlling many of the power electronic systems found in both commercial and industrial equipment. The ePWM type-4 module is able to generate complex pulse width waveforms with minimal CPU overhead by building the peripheral up from smaller modules with separate resources that can operate together to form a system. Some of the highlights of the ePWM type-4 module include complex waveform generation, dead-band generation, a flexible synchronization scheme, advanced trip-zone functionality, and global register reload capabilities.

图 5-46 shows the signal interconnections with the ePWM. 图 5-47 shows the ePWM trip input connectivity.



A. These events are generated by the ePWM digital compare (DC) submodule based on the levels of the TRIPIN inputs.

图 5-46. ePWM Submodules and Critical Internal Signal Interconnects

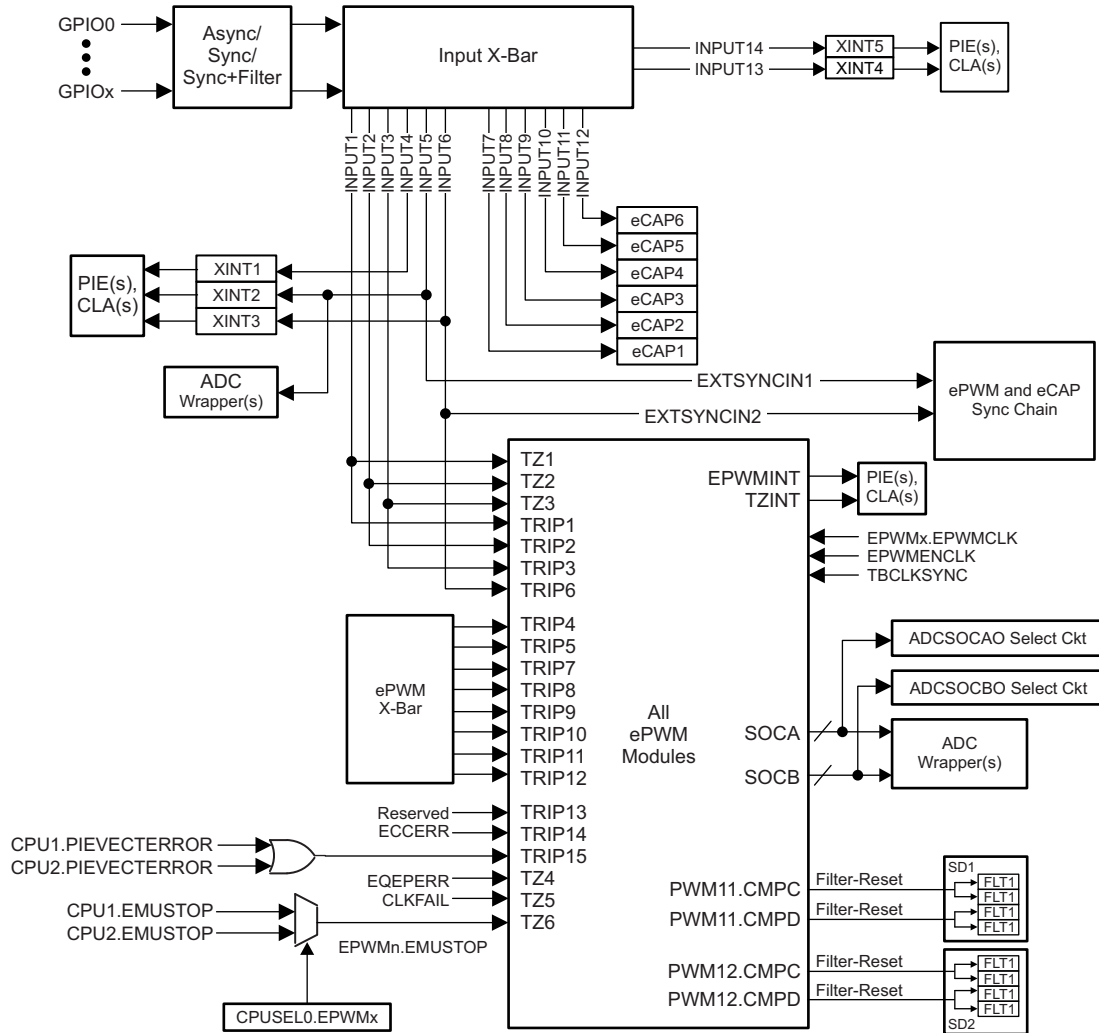


图 5-47. ePWM Trip Input Connectivity

### 5.9.2.1 Control Peripherals Synchronization

The ePWM and eCAP synchronization chain on the device provides flexibility in partitioning the ePWM and eCAP modules between CPU1 and CPU2 and allows localized synchronization within the modules belonging to the same CPU. Like the other peripherals, the partitioning of the ePWM and eCAP modules needs to be done using the CPUSELx registers. 图 5-48 shows the synchronization chain architecture.

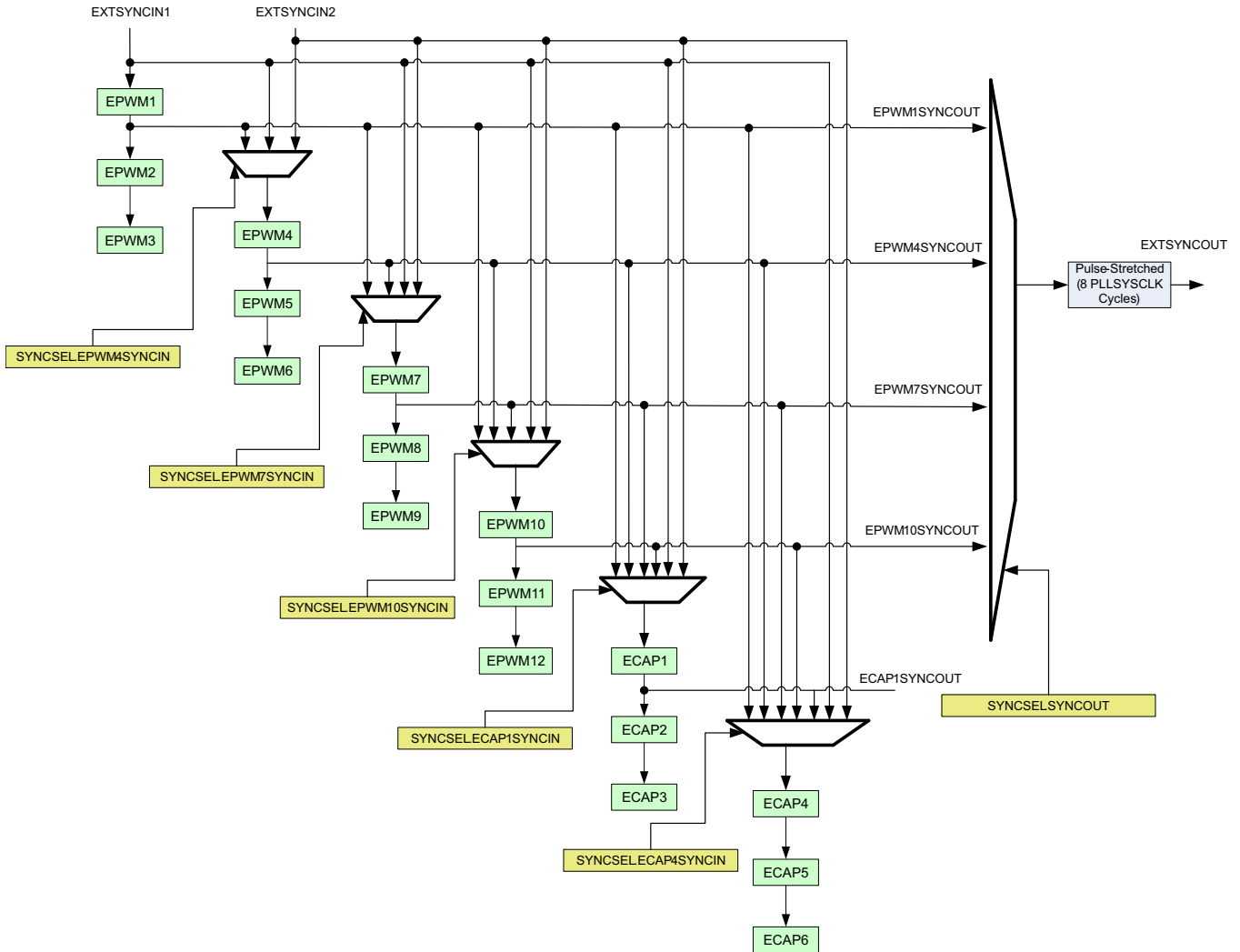


图 5-48. Synchronization Chain Architecture

### 5.9.2.2 ePWM Electrical Data and Timing

Table 5-57 shows the PWM timing requirements and Table 5-58 shows the PWM switching characteristics.

**Table 5-57. ePWM Timing Requirements<sup>(1)</sup>**

		MIN	MAX	UNIT
$t_{w(\text{SYNCIN})}$	Sync input pulse width			
	Asynchronous	$2t_{c(\text{EPWMCLK})}$		cycles
	Synchronous	$2t_{c(\text{EPWMCLK})}$		cycles
	With input qualifier	$1t_{c(\text{EPWMCLK})} + t_{w(\text{IQSW})}$		cycles

(1) For an explanation of the input qualifier parameters, see Table 5-24.

**Table 5-58. ePWM Switching Characteristics**

over recommended operating conditions (unless otherwise noted)

PARAMETER		MIN	MAX	UNIT
$t_{w(\text{PWM})}$	Pulse duration, PWMx output high/low	20		ns
$t_{w(\text{SYNCOUT})}$	Sync output pulse width	$8t_{c(\text{SYSCLK})}$		cycles
$t_{d(\text{TZ-PWM})}$	Delay time, trip input active to PWM forced high Delay time, trip input active to PWM forced low Delay time, trip input active to PWM Hi-Z		25	ns

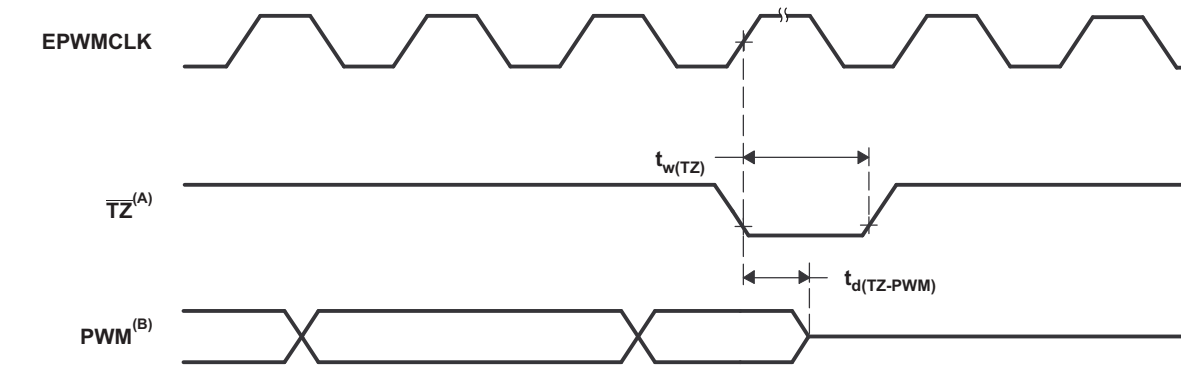
#### 5.9.2.2.1 Trip-Zone Input Timing

Table 5-59 shows the trip-zone input timing requirements. Figure 5-49 shows the PWM Hi-Z characteristics.

**Table 5-59. Trip-Zone Input Timing Requirements<sup>(1)</sup>**

		MIN	MAX	UNIT
$t_{w(\text{TZ})}$	Pulse duration, $\overline{\text{TZx}}$ input low			
	Asynchronous	$1t_{c(\text{EPWMCLK})}$		cycles
	Synchronous	$2t_{c(\text{EPWMCLK})}$		cycles
	With input qualifier	$1t_{c(\text{EPWMCLK})} + t_{w(\text{IQSW})}$		cycles

(1) For an explanation of the input qualifier parameters, see Table 5-24.



- A.  $\overline{\text{TZ}}$ :  $\overline{\text{TZ1}}$ ,  $\overline{\text{TZ2}}$ ,  $\overline{\text{TZ3}}$ , TRIP1–TRIP12
- B. PWM refers to all the PWM pins in the device. The state of the PWM pins after  $\overline{\text{TZ}}$  is taken high depends on the PWM recovery software.

**Figure 5-49. PWM Hi-Z Characteristics**

### 5.9.2.3 External ADC Start-of-Conversion Electrical Data and Timing

表 5-60 shows the external ADC start-of-conversion switching characteristics. 图 5-50 shows the ADCSOCAO or ADCSOCBO timing.

表 5-60. External ADC Start-of-Conversion Switching Characteristics

over recommended operating conditions (unless otherwise noted)

PARAMETER	MIN	MAX	UNIT
$t_{w(ADCSOCL)}$ Pulse duration, ADCSOCxO low	$32t_{c(SYSCLK)}$		cycles

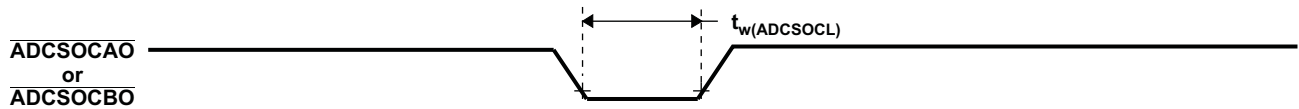


图 5-50. ADCSOCAO or ADCSOCBO Timing

### 5.9.3 Enhanced Quadrature Encoder Pulse (eQEP)

The eQEP module interfaces directly with linear or rotary incremental encoders to obtain position, direction, and speed information from rotating machines used in high-performance motion and position-control systems.

Each eQEP peripheral comprises five major functional blocks:

- Quadrature Capture Unit (QCAP)
- Position Counter/Control Unit (PCCU)
- Quadrature Decoder Unit (QDU)
- Unit Time Base for speed and frequency measurement (UTIME)
- Watchdog timer for detecting stalls (QWDOG)

The eQEP peripherals are clocked by PERx.SYSCLK. [图 5-51](#) shows the eQEP block diagram.

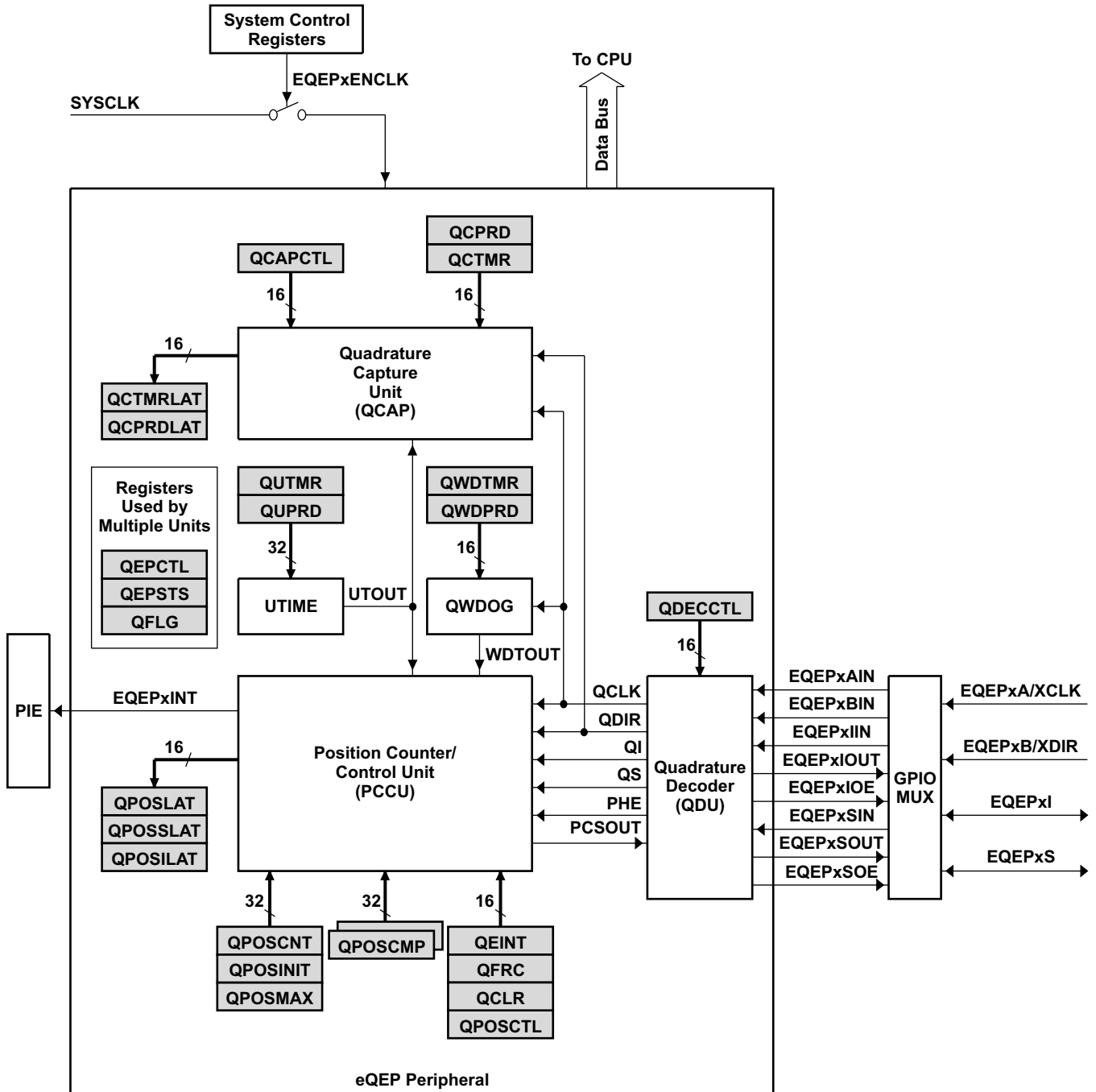


图 5-51. eQEP Block Diagram



### 5.9.3.1 eQEP Electrical Data and Timing

Table 5-61 shows the eQEP timing requirement and Table 5-62 shows the eQEP switching characteristics.

**Table 5-61. eQEP Timing Requirements<sup>(1)</sup>**

			MIN	MAX	UNIT
$t_{w(QEPP)}$	QEP input period	Synchronous	$2t_{c(SYSCLK)}$		cycles
		With input qualifier	$2[1t_{c(SYSCLK)} + t_{w(IQSW)}]$		cycles
$t_{w(INDEXH)}$	QEP Index Input High time	Synchronous	$2t_{c(SYSCLK)}$		cycles
		With input qualifier	$2t_{c(SYSCLK)} + t_{w(IQSW)}$		cycles
$t_{w(INDEXL)}$	QEP Index Input Low time	Synchronous	$2t_{c(SYSCLK)}$		cycles
		With input qualifier	$2t_{c(SYSCLK)} + t_{w(IQSW)}$		cycles
$t_{w(STROBH)}$	QEP Strobe High time	Synchronous	$2t_{c(SYSCLK)}$		cycles
		With input qualifier	$2t_{c(SYSCLK)} + t_{w(IQSW)}$		cycles
$t_{w(STROBL)}$	QEP Strobe Input Low time	Synchronous	$2t_{c(SYSCLK)}$		cycles
		With input qualifier	$2t_{c(SYSCLK)} + t_{w(IQSW)}$		cycles

(1) For an explanation of the input qualifier parameters, see Table 5-24.

**Table 5-62. eQEP Switching Characteristics**

over recommended operating conditions (unless otherwise noted)

PARAMETER		MIN	MAX	UNIT
$t_{d(CNTR)xin}$	Delay time, external clock to counter increment		$4t_{c(SYSCLK)}$	cycles
$t_{d(PCS-OUT)QEP}$	Delay time, QEP input edge to position compare sync output		$6t_{c(SYSCLK)}$	cycles

### 5.9.4 High-Resolution Pulse Width Modulator (HRPWM)

The HRPWM combines multiple delay lines in a single module and a simplified calibration system by using a dedicated calibration delay line. For each ePWM module, there are two HR outputs:

- HR Duty and Deadband control on Channel A
- HR Duty and Deadband control on Channel B

The HRPWM module offers PWM resolution (time granularity) that is significantly better than what can be achieved using conventionally derived digital PWM methods. The key points for the HRPWM module are:

- Significantly extends the time resolution capabilities of conventionally derived digital PWM
- This capability can be used in both single edge (duty cycle and phase-shift control) as well as dual edge control for frequency/period modulation.
- Finer time granularity control or edge positioning is controlled through extensions to the Compare A, B, phase, period and deadband registers of the ePWM module.

注

The minimum HRPWMCLK frequency allowed for HRPWM is 60 MHz.

注

When dual-edge high-resolution is enabled (high-resolution period mode), the PWMxB output is not available for use.

#### 5.9.4.1 HRPWM Electrical Data and Timing

Table 5-63 shows the high-resolution PWM switching characteristics.

**Table 5-63. High-Resolution PWM Characteristics**

PARAMETER	MIN	TYP	MAX	UNIT
Micro Edge Positioning (MEP) step size <sup>(1)</sup>		150	310	ps

(1) Maximum MEP step size is based on worst-case process, maximum temperature and minimum voltage. MEP step size will increase with low voltage and high temperature and decrease with voltage and cold temperature. Applications that use the HRPWM feature should use MEP Scale Factor Optimizer (SFO) estimation software functions. See the TI software libraries for details of using SFO function in end applications. SFO functions help to estimate the number of MEP steps per SYSCLK period dynamically while the HRPWM is in operation.

### 5.9.5 Sigma-Delta Filter Module (SDFM)

The SDFM is a four-channel digital filter designed specifically for current measurement and resolver position decoding in motor control applications. Each channel can receive an independent sigma-delta ( $\Sigma\Delta$ ) modulated bit stream. The bit streams are processed by four individually programmable digital decimation filters. The filter set includes a fast comparator for immediate digital threshold comparisons for overcurrent and undercurrent monitoring. [图 5-52](#) shows a block diagram of the SDFMs.

SDFM features include:

- Eight external pins per SDFM module:
  - Four sigma-delta data input pins per SDFM module (SDx\_Dy, where x = 1 to 2 and y = 1 to 4)
  - Four sigma-delta clock input pins per SDFM module (SDx\_Cy, where x = 1 to 2 and y = 1 to 4)
- Four different configurable modulator clock modes:
  - Modulator clock rate equals modulator data rate
  - Modulator clock rate running at half the modulator data rate
  - Modulator data is Manchester encoded. Modulator clock not required.
  - Modulator clock rate is double that of modulator data rate
- Four independent configurable comparator units:
  - Four different filter type selection (Sinc1/Sinc2/Sincfast/Sinc3) options available
  - Ability to detect over-value and under-value conditions
  - Comparator Over-Sampling Ratio (COSR) value for comparator programmable from 1 to 32
- Four independent configurable data filter units:
  - Four different filter type selection (Sinc1/Sinc2/Sincfast/Sinc3) options available
  - Data filter Over-Sampling Ratio (DOSR) value for data filter unit programmable from 1 to 256
  - Ability to enable or disable individual filter module
  - Ability to synchronize all four independent filters of a SDFM module using the Master Filter Enable (MFE) bit or the PWM signals.
- Filter data can be 16-bit or 32-bit representation
- PWMs can be used to generate modulator clock for sigma-delta modulators

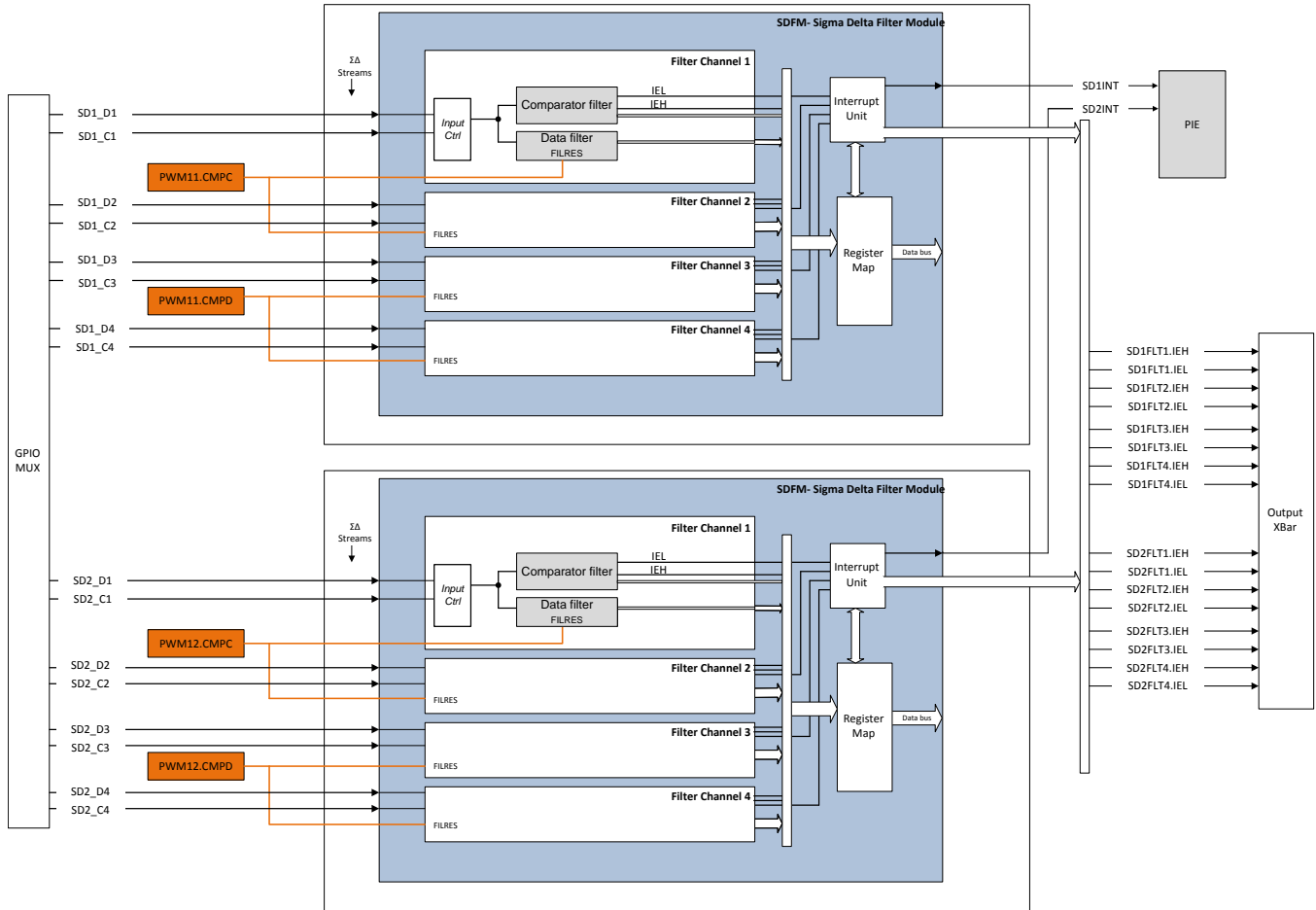


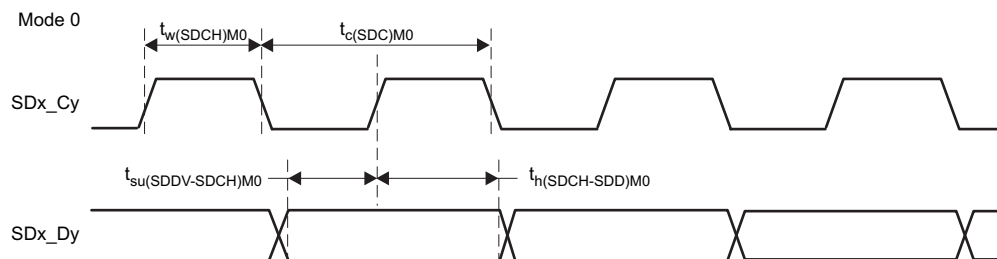
图 5-52. SDFM Block Diagram

### 5.9.5.1 SDFM Electrical Data and Timing

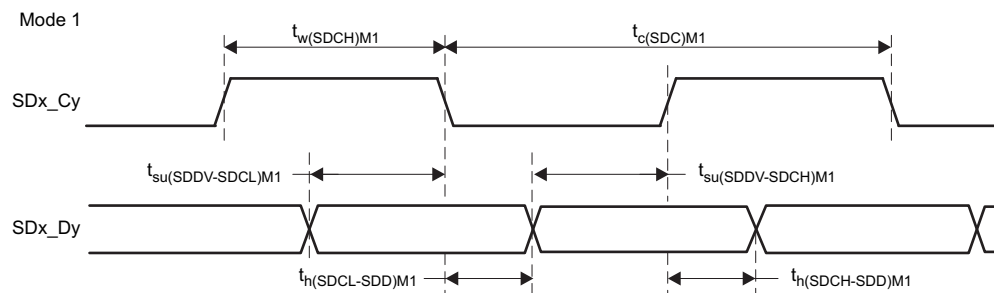
Table 5-64 shows the SDFM timing requirements. Figure 5-53 through Figure 5-56 show the SDFM timing diagrams.

**Table 5-64. SDFM Timing Requirements**

		MIN	MAX	UNIT
<b>Mode 0</b>				
$t_{c(SDC)M0}$	Cycle time, SDx_Cy	40	256 * SYSCLK period	ns
$t_{w(SDCH)M0}$	Pulse duration, SDx_Cy high	10	$t_{c(SDC)M0} - 10$	ns
$t_{su(SDDV-SDCH)M0}$	Setup time, SDx_Dy valid before SDx_Cy goes high	5		ns
$t_{h(SDCH-SDD)M0}$	Hold time, SDx_Dy wait after SDx_Cy goes high	5		ns
<b>Mode 1</b>				
$t_{c(SDC)M1}$	Cycle time, SDx_Cy	80	256 * SYSCLK period	ns
$t_{w(SDCH)M1}$	Pulse duration, SDx_Cy high	10	$t_{c(SDC)M1} - 10$	ns
$t_{su(SDDV-SDCL)M1}$	Setup time, SDx_Dy valid before SDx_Cy goes low	5		ns
$t_{su(SDDV-SDCH)M1}$	Setup time, SDx_Dy valid before SDx_Cy goes high	5		ns
$t_{h(SDCL-SDD)M1}$	Hold time, SDx_Dy wait after SDx_Cy goes low	5		ns
$t_{h(SDCH-SDD)M1}$	Hold time, SDx_Dy wait after SDx_Cy goes high	5		ns
<b>Mode 2</b>				
$t_{c(SDD)M2}$	Cycle time, SDx_Dy	$8 * t_c(\text{SYSCLK})$	$20 * t_c(\text{SYSCLK})$	ns
$t_{w(SDDH)M2}$	Pulse duration, SDx_Dy high	10		ns
<b>Mode 3</b>				
$t_{c(SDC)M3}$	Cycle time, SDx_Cy	40	256 * SYSCLK period	ns
$t_{w(SDCH)M3}$	Pulse duration, SDx_Cy high	10	$t_{c(SDC)M3} - 5$	ns
$t_{su(SDDV-SDCH)M3}$	Setup time, SDx_Dy valid before SDx_Cy goes high	5		ns
$t_{h(SDCH-SDD)M3}$	Hold time, SDx_Dy wait after SDx_Cy goes high	5		ns



**Figure 5-53. SDFM Timing Diagram – Mode 0**



**Figure 5-54. SDFM Timing Diagram – Mode 1**

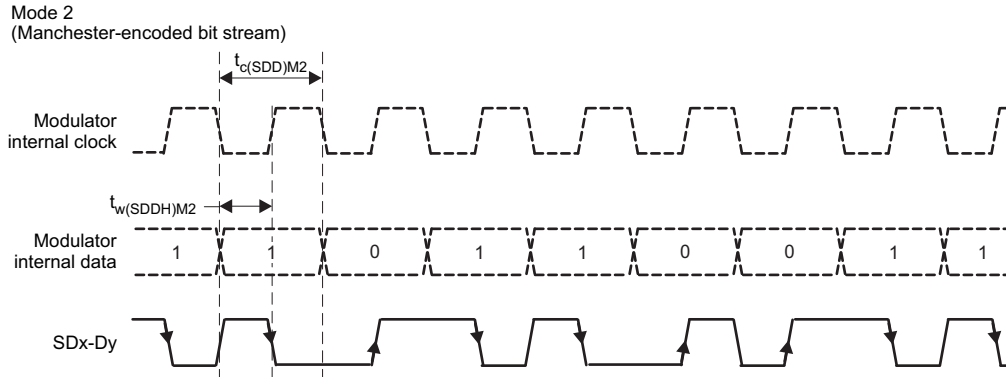


Figure 5-55. SDFM Timing Diagram – Mode 2

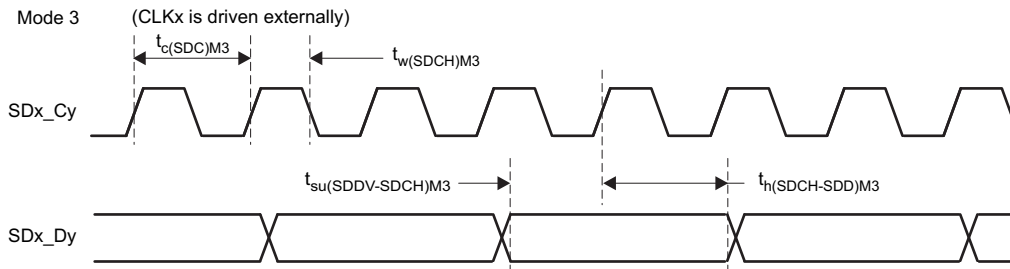


Figure 5-56. SDFM Timing Diagram – Mode 3

## 5.10 Communications Peripherals

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### 注

For the actual number of each peripheral on a specific device, see [Table 3-1](#).

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### 5.10.1 Controller Area Network (CAN)

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### 注

The CAN module uses the IP known as D\_CAN. This document uses the names “CAN” and “D\_CAN” interchangeably to reference this peripheral.

---

The CAN module implements the following features:

- Complies with ISO11898-1 ( Bosch® CAN protocol specification 2.0 A and B)
  - Bit rates up to 1 Mbps
  - Multiple clock sources
  - 32 message objects, each with the following properties:
    - Configurable as receive or transmit
    - Configurable with standard or extended identifier
    - Programmable receive and identifier masks for each object
    - Supports data and remote frames
    - Holds 0 to 8 bytes of data
    - Parity-checked configuration and data RAM
  - Individual identifier mask for each message object
  - Programmable FIFO mode for receive message objects
  - Programmable loop-back modes for self-test operation
  - Suspend mode for debug support
  - Software module reset
  - Automatic bus on after Bus-Off state by a programmable 32-bit timer
  - Message RAM parity check mechanism
  - Two interrupt lines
  - Global power down and wakeup support
- 

### 注

For a CANx Bit-CLK of 200 MHz, the smallest bit rate possible is 7.8125 kbps.

---

### 注

The accuracy of the on-chip zero-pin oscillator is in [Table 5-18](#), Internal Oscillator Electrical Characteristics. Depending on parameters such as the CAN bit timing settings, bit rate, bus length, and propagation delay, the accuracy of this oscillator may not meet the requirements of the CAN protocol. In this situation, an external clock source must be used.

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### 5.10.2 Inter-Integrated Circuit (I<sup>2</sup>C)

The I<sup>2</sup>C module has the following features:

- Compliance with the Philips Semiconductors I<sup>2</sup>C-bus specification (version 2.1):
  - Support for 1-bit to 8-bit format transfers
  - 7-bit and 10-bit addressing modes
  - General call
  - START byte mode
  - Support for multiple master-transmitters and slave-receivers
  - Support for multiple slave-transmitters and master-receivers
  - Combined master transmit/receive and receive/transmit mode
  - Data transfer rate of from 10 kbps up to 400 kbps (I<sup>2</sup>C Fast-mode rate)
- One 16-byte receive FIFO and one 16-byte transmit FIFO
- One interrupt that can be used by the CPU. This interrupt can be generated as a result of one of the following conditions:
  - Transmit-data ready
  - Receive-data ready
  - Register-access ready
  - No-acknowledgment received
  - Arbitration lost
  - Stop condition detected
  - Addressed as slave
- An additional interrupt that can be used by the CPU when in FIFO mode
- Module enable/disable capability
- Free data format mode



图 5-57 shows how the I<sup>2</sup>C peripheral module interfaces within the device.

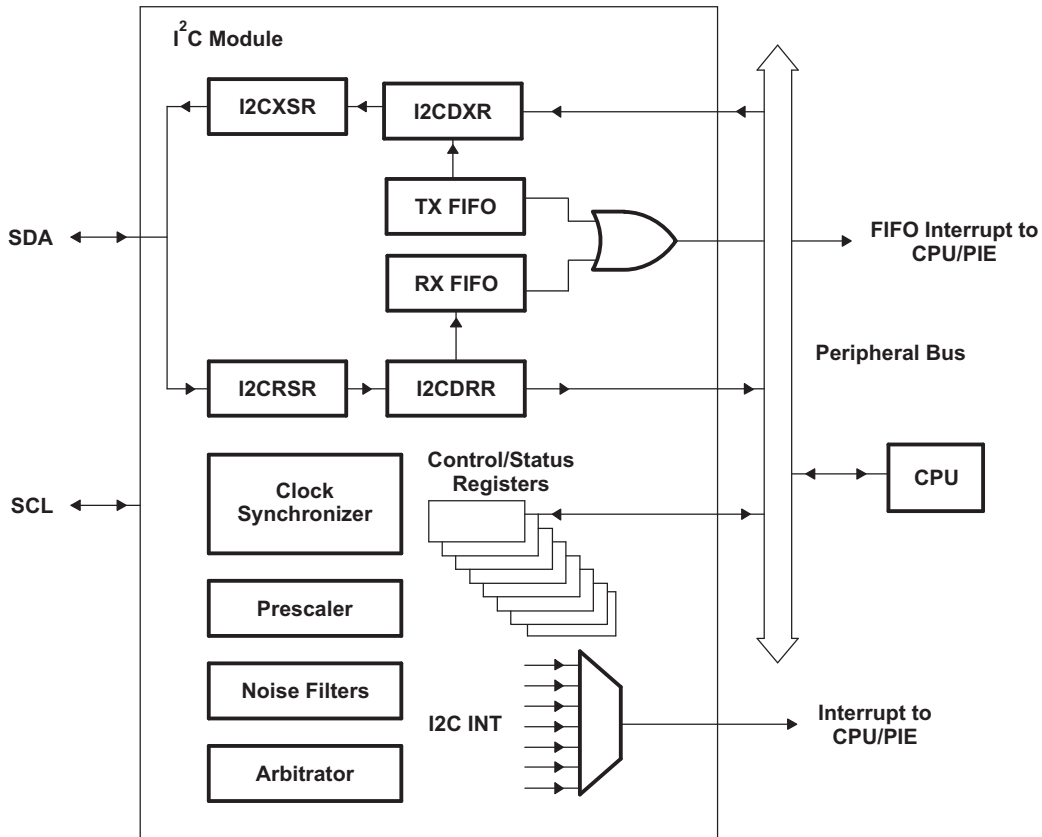


图 5-57. I<sup>2</sup>C Peripheral Module Interfaces

### 5.10.2.1 I<sup>2</sup>C Electrical Data and Timing

Table 5-65 shows the I<sup>2</sup>C timing requirements. Table 5-66 shows the I<sup>2</sup>C switching characteristics.

**Table 5-65. I<sup>2</sup>C Timing Requirements**

			MIN	MAX	UNIT
$t_{h(SDA-SCL)START}$	Hold time, START condition, SCL fall delay after SDA fall		0.6		$\mu$ s
$t_{su(SCL-SDA)START}$	Setup time, Repeated START, SCL rise before SDA fall delay		0.6		$\mu$ s
$t_h(SCL-DAT)$	Hold time, data after SCL fall		0		$\mu$ s
$t_{su}(DAT-SCL)$	Setup time, data before SCL rise		100		ns
$t_r(SDA)$	Rise time, SDA	Input tolerance	20	300	ns
$t_r(SCL)$	Rise time, SCL	Input tolerance	20	300	ns
$t_f(SDA)$	Fall time, SDA	Input tolerance	11.4	300	ns
$t_f(SCL)$	Fall time, SCL	Input tolerance	11.4	300	ns
$t_{su}(SCL-SDA)STOP$	Setup time, STOP condition, SCL rise before SDA rise delay		0.6		$\mu$ s

**Table 5-66. I<sup>2</sup>C Switching Characteristics**

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
$f_{SCL}$	SCL clock frequency	0	400	kHz
$t_w(SCLL)$	Pulse duration, SCL clock low	1.3		$\mu$ s
$t_w(SCLH)$	Pulse duration, SCL clock high	0.6		$\mu$ s
$t_w(SP)$	Pulse duration of spikes that will be suppressed by the input filter	0	50	ns
$t_{BUF}$	Bus free time between STOP and START conditions	1.3		$\mu$ s
$t_v(SCL-DAT)$	Valid time, data after SCL fall		0.9	$\mu$ s
$t_v(SCL-ACK)$	Valid time, Acknowledge after SCL fall		0.9	$\mu$ s
$V_{IL}$	Valid low-level input voltage	-0.3	$0.3 * V_{DDIO}$	V
$V_{IH}$	Valid high-level input voltage	$0.7 * V_{DDIO}$	$V_{DDIO} + 0.3$	V
$V_{OL}$	Low-level output voltage	Sinking 3 mA	0.4	V
$I_i$	Input current on pins	$0.1 V_{bus} < V_i < 0.9 V_{bus}$	10	$\mu$ A

### 5.10.3 Multichannel Buffered Serial Port (McBSP)

The McBSP module has the following features:

- Compatible with McBSP in TMS320C28x and TMS320F28x DSP devices
- Full-duplex communication
- Double-buffered data registers that allow a continuous data stream
- Independent framing and clocking for receive and transmit
- External shift clock generation or an internal programmable frequency shift clock
- 8-bit data transfer mode can be configured to transmit with LSB or MSB first
- Programmable polarity for both frame synchronization and data clocks
- Highly programmable internal clock and frame generation
- Direct interface to industry-standard CODECs, Analog Interface Chips (AICs), and other serially connected A/D and D/A devices
- Supports AC97, I2S, and SPI protocols
- McBSP clock rate,

$$\text{CLKG} = \frac{\text{CLKSRG}}{(1 + \text{CLKGDV})}$$

where CLKSRG source could be LSPCLK, CLKX, or CLKR.

图 5-58 shows the block diagram of the McBSP module.

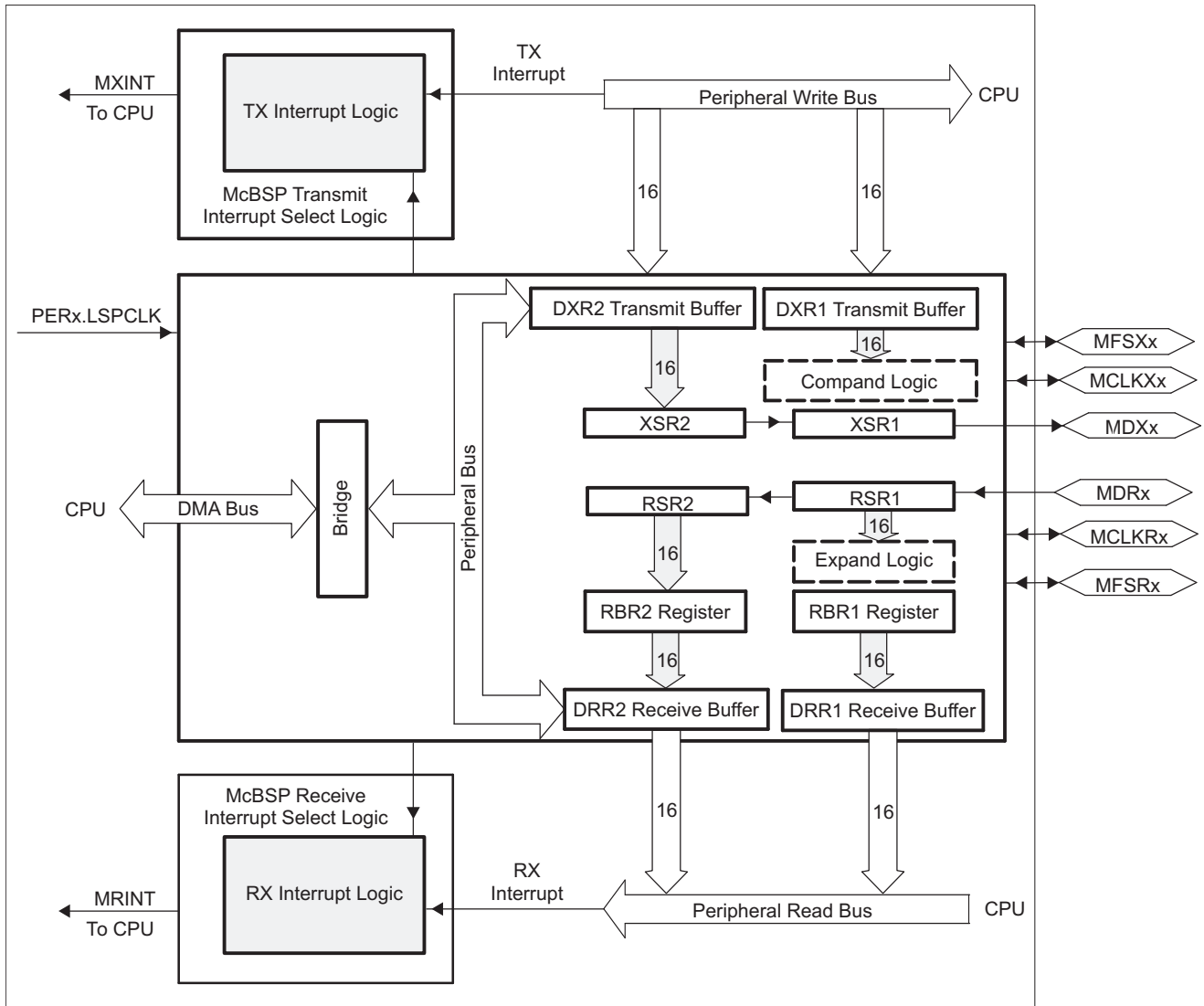


图 5-58. McBSP Block Diagram

### 5.10.3.1 McBSP Electrical Data and Timing

#### 5.10.3.1.1 McBSP Transmit and Receive Timing

Table 5-67 shows the McBSP timing requirements. Table 5-68 shows the McBSP switching characteristics. Figure 5-59 and Figure 5-60 show the McBSP timing diagrams.

**Table 5-67. McBSP Timing Requirements<sup>(1) (2)</sup>**

NO.			MIN	MAX	UNIT
	McBSP module clock (CLKG, CLKX, CLKR) range		1		kHz
				25	MHz
	McBSP module cycle time (CLKG, CLKX, CLKR) range		40		ns
				1	ms
M11	$t_{c(CLKRX)}$	Cycle time, CLKR/X	CLKR/X ext	2P	ns
M12	$t_{w(CLKRX)}$	Pulse duration, CLKR/X high or CLKR/X low	CLKR/X ext	P – 7	ns
M13	$t_{r(CLKRX)}$	Rise time, CLKR/X	CLKR/X ext	7	ns
M14	$t_{f(CLKRX)}$	Fall time, CLKR/X	CLKR/X ext	7	ns
M15	$t_{su(FRH-CKRL)}$	Setup time, external FSR high before CLKR low	CLKR int	18	ns
			CLKR ext	2	
M16	$t_{h(CKRL-FRH)}$	Hold time, external FSR high after CLKR low	CLKR int	0	ns
			CLKR ext	6	
M17	$t_{su(DRV-CKRL)}$	Setup time, DR valid before CLKR low	CLKR int	18	ns
			CLKR ext	5	
M18	$t_{h(CKRL-DRV)}$	Hold time, DR valid after CLKR low	CLKR int	0	ns
			CLKR ext	3	
M19	$t_{su(FXH-CKXL)}$	Setup time, external FSX high before CLKX low	CLKX int	18	ns
			CLKX ext	2	
M20	$t_{h(CKXL-FXH)}$	Hold time, external FSX high after CLKX low	CLKX int	0	ns
			CLKX ext	6	

- (1) Polarity bits CLKRP = CLKXP = FSRP = FSXP = 0. If the polarity of any of the signals is inverted, then the timing references of that signal are also inverted.
- (2)  $2P = 1/CLKG$  in ns. CLKG is the output of sample rate generator mux.  $CLKG = CLKSRG / (1 + CLKGDV)$ . CLKSRG can be LSPCLK, CLKX, CLKR as source.  $CLKSRG \leq (SYSCLK/2)$ .

**Table 5-68. McBSP Switching Characteristics<sup>(1) (2)</sup>**

over recommended operating conditions (unless otherwise noted)

NO.	PARAMETER		MIN	MAX	UNIT		
M1	$t_{c(CKRX)}$	Cycle time, CLKR/X	CLKR/X int	2P	ns		
M2	$t_{w(CKRXH)}$	Pulse duration, CLKR/X high	CLKR/X int	D - 5 <sup>(3)</sup>	D + 5 <sup>(3)</sup>	ns	
M3	$t_{w(CKRXL)}$	Pulse duration, CLKR/X low	CLKR/X int	C - 5 <sup>(3)</sup>	C + 5 <sup>(3)</sup>	ns	
M4	$t_{d(CKRH-FRV)}$	Delay time, CLKR high to internal FSR valid	CLKR int	0	4	ns	
			CLKR ext	3	27		
M5	$t_{d(CKXH-FXV)}$	Delay time, CLKX high to internal FSX valid	CLKX int	0	4	ns	
			CLKX ext	3	27		
M6	$t_{dis(CKXH-DXHZ)}$	Disable time, CLKX high to DX high impedance following last data bit	CLKX int		8	ns	
			CLKX ext		14		
M7	$t_{d(CKXH-DXV)}$	Delay time, CLKX high to DX valid. This applies to all bits except the first bit transmitted.	CLKX int		9	ns	
			CLKX ext		28		
		Delay time, CLKX high to DX valid Only applies to first bit transmitted when in Data Delay 1 or 2 (XDATDLY=01b or 10b) modes	DXENA = 0	CLKX int			8
				CLKX ext			14
DXENA = 1	CLKX int		P + 8				
	CLKX ext		P + 14				
M8	$t_{en(CKXH-DX)}$	Enable time, CLKX high to DX driven Only applies to first bit transmitted when in Data Delay 1 or 2 (XDATDLY=01b or 10b) modes	DXENA = 0	CLKX int	0	ns	
				CLKX ext	6		
		DXENA = 1	CLKX int	P			
			CLKX ext	P + 6			
M9	$t_{d(FXH-DXV)}$	Delay time, FSX high to DX valid Only applies to first bit transmitted when in Data Delay 0 (XDATDLY=00b) mode.	DXENA = 0	FSX int	8	ns	
				FSX ext	14		
		DXENA = 1	FSX int	P + 8			
			FSX ext	P + 14			
M10	$t_{en(FXH-DX)}$	Enable time, FSX high to DX driven Only applies to first bit transmitted when in Data Delay 0 (XDATDLY=00b) mode	DXENA = 0	FSX int	0	ns	
				FSX ext	6		
		DXENA = 1	FSX int	P			
			FSX ext	P + 6			

(1) Polarity bits CLKRP = CLKXP = FSRP = FSXP = 0. If the polarity of any of the signals is inverted, then the timing references of that signal are also inverted.

(2) 2P = 1/CLKG in ns.

(3) C = CLKRX low pulse width = P  
D = CLKRX high pulse width = P

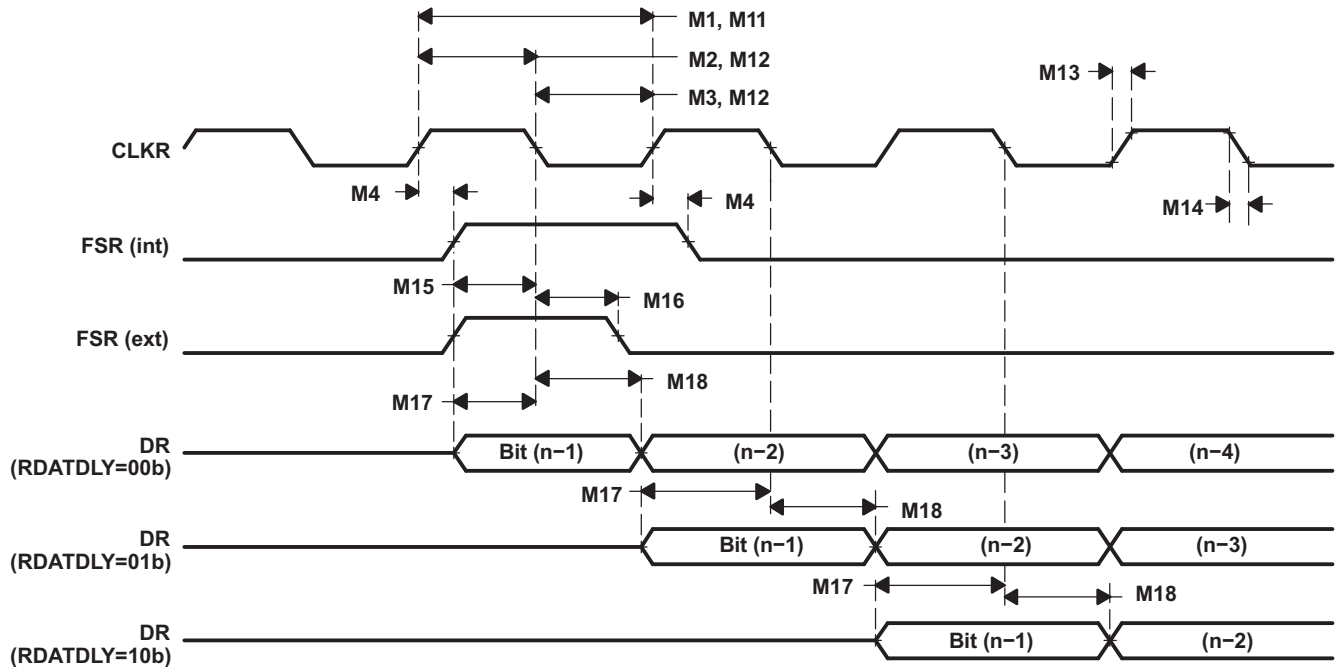


Figure 5-59. McBSP Receive Timing

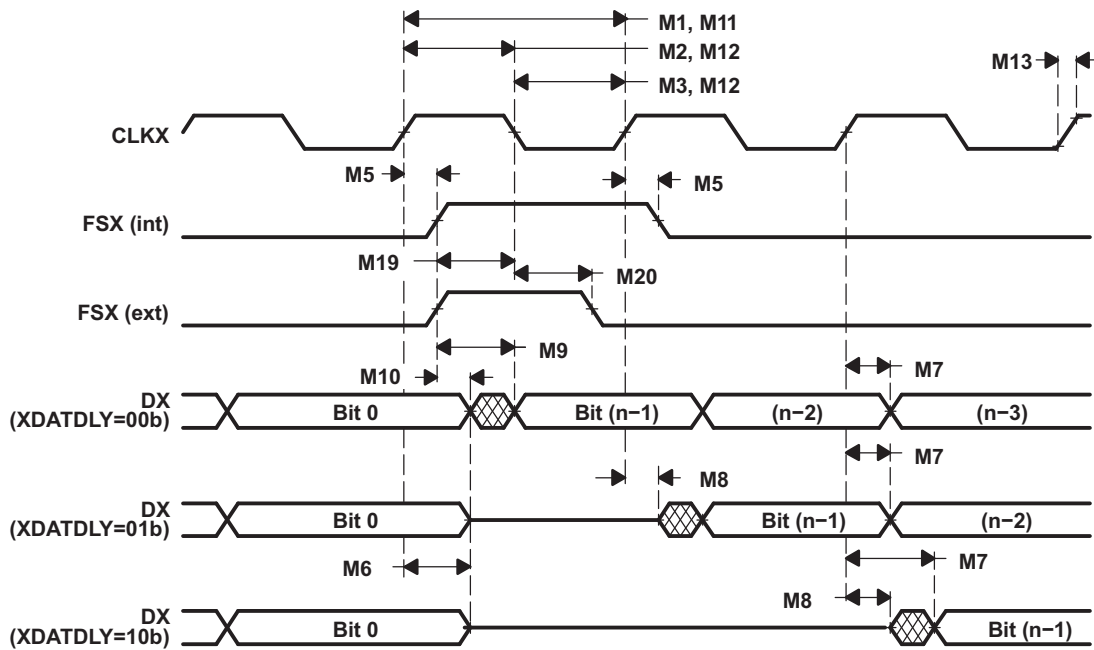


Figure 5-60. McBSP Transmit Timing

5.10.3.1.2 McBSP as SPI Master or Slave Timing

For CLKSTP = 10b and CLKXP = 0, Table 5-69 shows the timing requirements, Table 5-70 shows the switching characteristics, and Figure 5-61 shows the timing diagram.

Table 5-69. McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 10b, CLKXP = 0)<sup>(1)</sup>

NO.			MASTER		SLAVE		UNIT
			MIN	MAX	MIN	MAX	
M30	$t_{su}(DRV-CKXL)$	Setup time, DR valid before CLKX low	30		8P – 10		ns
M31	$t_h(CKXL-DRV)$	Hold time, DR valid after CLKX low	1		8P – 10		ns
M32	$t_{su}(BFXL-CKXH)$	Setup time, FSX low before CLKX high			8P + 10		ns
M33	$t_c(CKX)$	Cycle time, CLKX		$2P^{(2)}$		16P	ns

(1) For all SPI slave modes, CLKX has to be a minimum of 8 CLKG cycles. Furthermore, CLKG should be LSPCLK/2 by setting CLKSM = CLKGDV = 1.

(2)  $2P = 1/CLKG$

Table 5-70. McBSP as SPI Master or Slave Switching Characteristics Over Recommended Operating Conditions (Unless Otherwise Noted) (CLKSTP = 10b, CLKXP = 0)

NO.	PARAMETER	MASTER		SLAVE		UNIT
		MIN	MAX	MIN	MAX	
M24	$t_h(CKXL-FXL)$		$2P^{(1)}$			ns
M25	$t_d(FXL-CKXH)$		P			ns
M28	$t_{dis}(FXH-DXHZ)$		6		6P + 6	ns
M29	$t_d(FXL-DXV)$		6		4P + 6	ns

(1)  $2P = 1/CLKG$

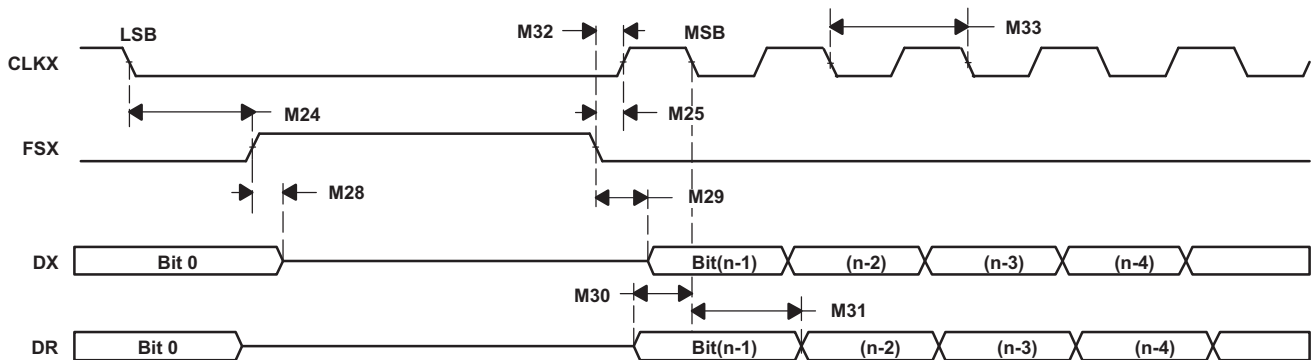


Figure 5-61. McBSP Timing as SPI Master or Slave: CLKSTP = 10b, CLKXP = 0



For CLKSTP = 11b and CLKXP = 0, Table 5-71 shows the timing requirements, Table 5-72 shows the switching characteristics, and Figure 5-62 shows the timing diagram.

**Table 5-71. McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 11b, CLKXP = 0)<sup>(1)</sup>**

NO.			MASTER		SLAVE		UNIT
			MIN	MAX	MIN	MAX	
M39	$t_{su}(DRV-CKXH)$	Setup time, DR valid before CLKX high	30		8P – 10		ns
M40	$t_h(CKXH-DRV)$	Hold time, DR valid after CLKX high	1		8P – 10		ns
M41	$t_{su}(FXL-CKXH)$	Setup time, FSX low before CLKX high			16P + 10		ns
M42	$t_c(CKX)$	Cycle time, CLKX	2P <sup>(2)</sup>		16P		ns

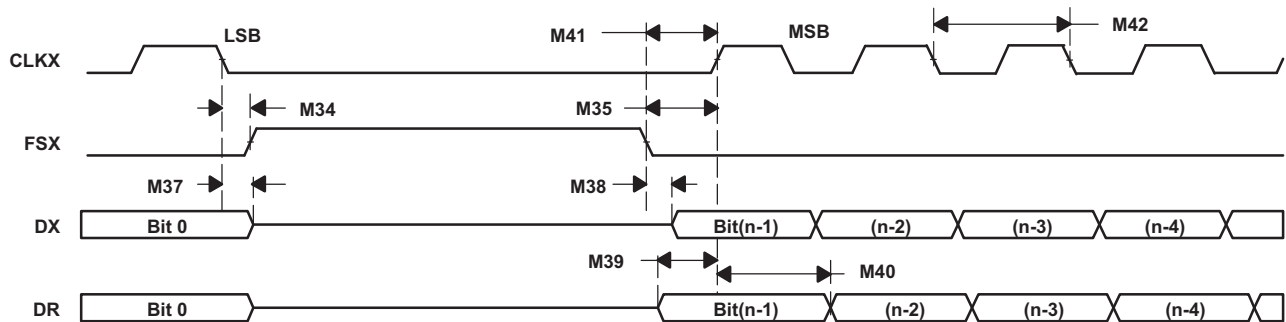
(1) For all SPI slave modes, CLKX has to be a minimum of 8 CLKG cycles. Furthermore, CLKG should be LSPCLK/2 by setting CLKSM = CLKGDV = 1.

(2) 2P = 1/CLKG

**Table 5-72. McBSP as SPI Master or Slave Switching Characteristics Over Recommended Operating Conditions (Unless Otherwise Noted) (CLKSTP = 11b, CLKXP = 0)**

NO.	PARAMETER	MASTER		SLAVE		UNIT
		MIN	MAX	MIN	MAX	
M34	$t_h(CKXL-FXL)$		P			ns
M35	$t_d(FXL-CKXH)$		2P <sup>(1)</sup>			ns
M37	$t_{dis}(CKXL-DXHZ)$		P + 6		7P + 6	ns
M38	$t_d(FXL-DXV)$		6		4P + 6	ns

(1) 2P = 1/CLKG



**Figure 5-62. McBSP Timing as SPI Master or Slave: CLKSTP = 11b, CLKXP = 0**

For CLKSTP = 10b and CLKXP = 1, Table 5-73 shows the timing requirements, Table 5-74 shows the switching characteristics, and Figure 5-63 shows the timing diagram.

**Table 5-73. McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 10b, CLKXP = 1)<sup>(1)</sup>**

NO.			MASTER		SLAVE		UNIT
			MIN	MAX	MIN	MAX	
M49	$t_{su}(DRV-CKXH)$	Setup time, DR valid before CLKX high	30		8P – 10		ns
M50	$t_h(CKXH-DRV)$	Hold time, DR valid after CLKX high	1		8P – 10		ns
M51	$t_{su}(FXL-CKXL)$	Setup time, FSX low before CLKX low			8P + 10		ns
M52	$t_c(CKX)$	Cycle time, CLKX	2P <sup>(2)</sup>		16P		ns

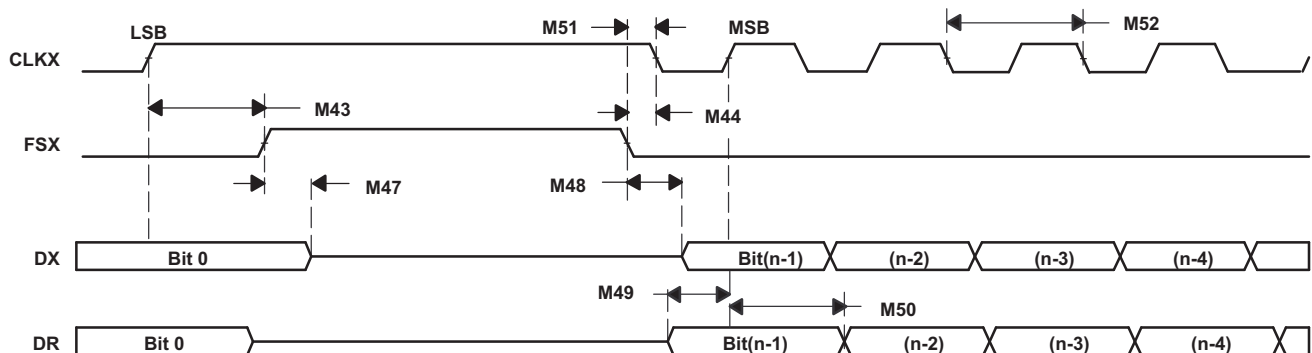
(1) For all SPI slave modes, CLKX has to be a minimum of 8 CLKG cycles. Furthermore, CLKG should be LSPCLK/2 by setting CLKSM = CLKGDV = 1.

(2) 2P = 1/CLKG

**Table 5-74. McBSP as SPI Master or Slave Switching Characteristics Over Recommended Operating Conditions (Unless Otherwise Noted) (CLKSTP = 10b, CLKXP = 1)**

NO.	PARAMETER	MASTER		SLAVE		UNIT
		MIN	MAX	MIN	MAX	
M43	$t_h(CKXH-FXL)$	2P <sup>(1)</sup>				ns
M44	$t_d(FXL-CKXL)$	P				ns
M47	$t_{dis}(FXH-DXHZ)$	6		6P + 6		ns
M48	$t_d(FXL-DXV)$	6		4P + 6		ns

(1) 2P = 1/CLKG



**Figure 5-63. McBSP Timing as SPI Master or Slave: CLKSTP = 10b, CLKXP = 1**

For CLKSTP = 11b and CLKXP = 1, Table 5-75 shows the timing requirements, Table 5-76 shows the switching characteristics, and Figure 5-64 shows the timing diagram.

**Table 5-75. McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 11b, CLKXP = 1)<sup>(1)</sup>**

NO.			MASTER		SLAVE		UNIT
			MIN	MAX	MIN	MAX	
M58	$t_{su(DRV-CKXL)}$	Setup time, DR valid before CLKX low	30		8P – 10		ns
M59	$t_h(CKXL-DRV)$	Hold time, DR valid after CLKX low	1		8P – 10		ns
M60	$t_{su(FXL-CKXL)}$	Setup time, FSX low before CLKX low			16P + 10		ns
M61	$t_c(CKX)$	Cycle time, CLKX	2P <sup>(2)</sup>		16P		ns

(1) For all SPI slave modes, CLKX has to be a minimum of 8 CLKG cycles. Furthermore, CLKG should be LSPCLK/2 by setting CLKSM = CLKGDV = 1.

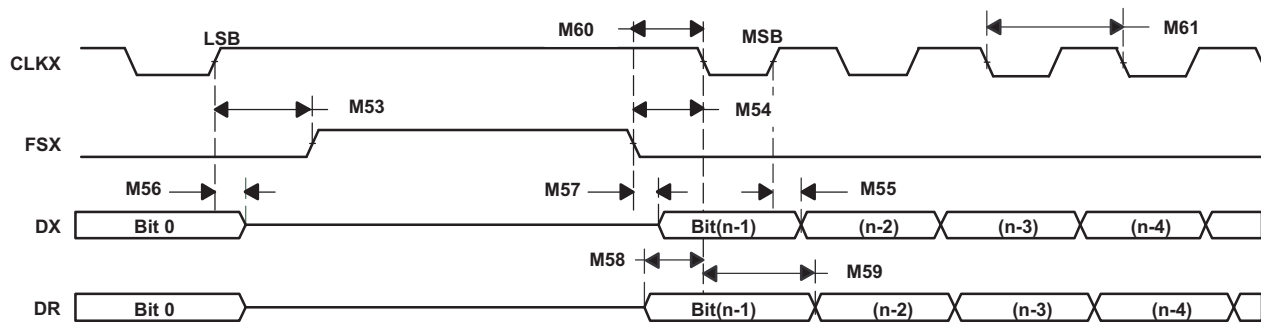
(2) 2P = 1/CLKG

**Table 5-76. McBSP as SPI Master or Slave Switching Characteristics Over Recommended Operating Conditions (Unless Otherwise Noted) (CLKSTP = 11b, CLKXP = 1)<sup>(1)</sup>**

NO.	PARAMETER	MASTER <sup>(2)</sup>		SLAVE		UNIT	
		MIN	MAX	MIN	MAX		
M53	$t_h(CKXH-FXL)$	Hold time, FSX low after CLKX high	P			ns	
M54	$t_d(FXL-CKXL)$	Delay time, FSX low to CLKX low	2P <sup>(1)</sup>			ns	
M55	$t_d(CLKXH-DXV)$	Delay time, CLKX high to DX valid	-2	0	3P + 6	5P + 20	ns
M56	$t_{dis}(CKXH-DXHZ)$	Disable time, DX high impedance following last data bit from CLKX high	P + 6		7P + 6		ns
M57	$t_d(FXL-DXV)$	Delay time, FSX low to DX valid	6		4P + 6		ns

(1) 2P = 1/CLKG

(2) C = CLKX low pulse width = P  
 D = CLKX high pulse width = P



**Figure 5-64. McBSP Timing as SPI Master or Slave: CLKSTP = 11b, CLKXP = 1**

#### 5.10.4 Serial Communications Interface (SCI)

The SCI is a 2-wire asynchronous serial port, commonly known as a UART. The SCI module supports digital communications between the CPU and other asynchronous peripherals that use the standard non-return-to-zero (NRZ) format

The SCI receiver and transmitter each have a 16-level-deep FIFO for reducing servicing overhead, and each has its own separate enable and interrupt bits. Both can be operated independently for half-duplex communication, or simultaneously for full-duplex communication. To specify data integrity, the SCI checks received data for break detection, parity, overrun, and framing errors. The bit rate is programmable to different speeds through a 16-bit baud-select register. [图 5-65](#) shows the SCI block diagram.

Features of the SCI module include:

- Two external pins:
  - SCITXD: SCI transmit-output pin
  - SCIRXD: SCI receive-input pin
  - NOTE:** Both pins can be used as GPIO if not used for SCI.
  - Baud rate programmable to 64K different rates
- Data-word format
  - One start bit
  - Data-word length programmable from 1 to 8 bits
  - Optional even/odd/no parity bit
  - 1 or 2 stop bits
- Four error-detection flags: parity, overrun, framing, and break detection
- Two wakeup multiprocessor modes: idle-line and address bit
- Half- or full-duplex operation
- Double-buffered receive and transmit functions
- Transmitter and receiver operations can be accomplished through interrupt-driven or polled algorithms with status flags.
  - Transmitter: TXRDY flag (transmitter-buffer register is ready to receive another character) and TX EMPTY flag (transmitter-shift register is empty)
  - Receiver: RXRDY flag (receiver-buffer register is ready to receive another character), BRKDT flag (break condition occurred), and RX ERROR flag (monitoring four interrupt conditions)
- Separate enable bits for transmitter and receiver interrupts (except BRKDT)
- NRZ format
- Auto baud-detect hardware logic
- 16-level transmit and receive FIFO

---

#### 注

All registers in this module are 8-bit registers. When a register is accessed, the register data is in the lower byte (bits 7–0), and the upper byte (bits 15–8) is read as zeros. Writing to the upper byte has no effect.

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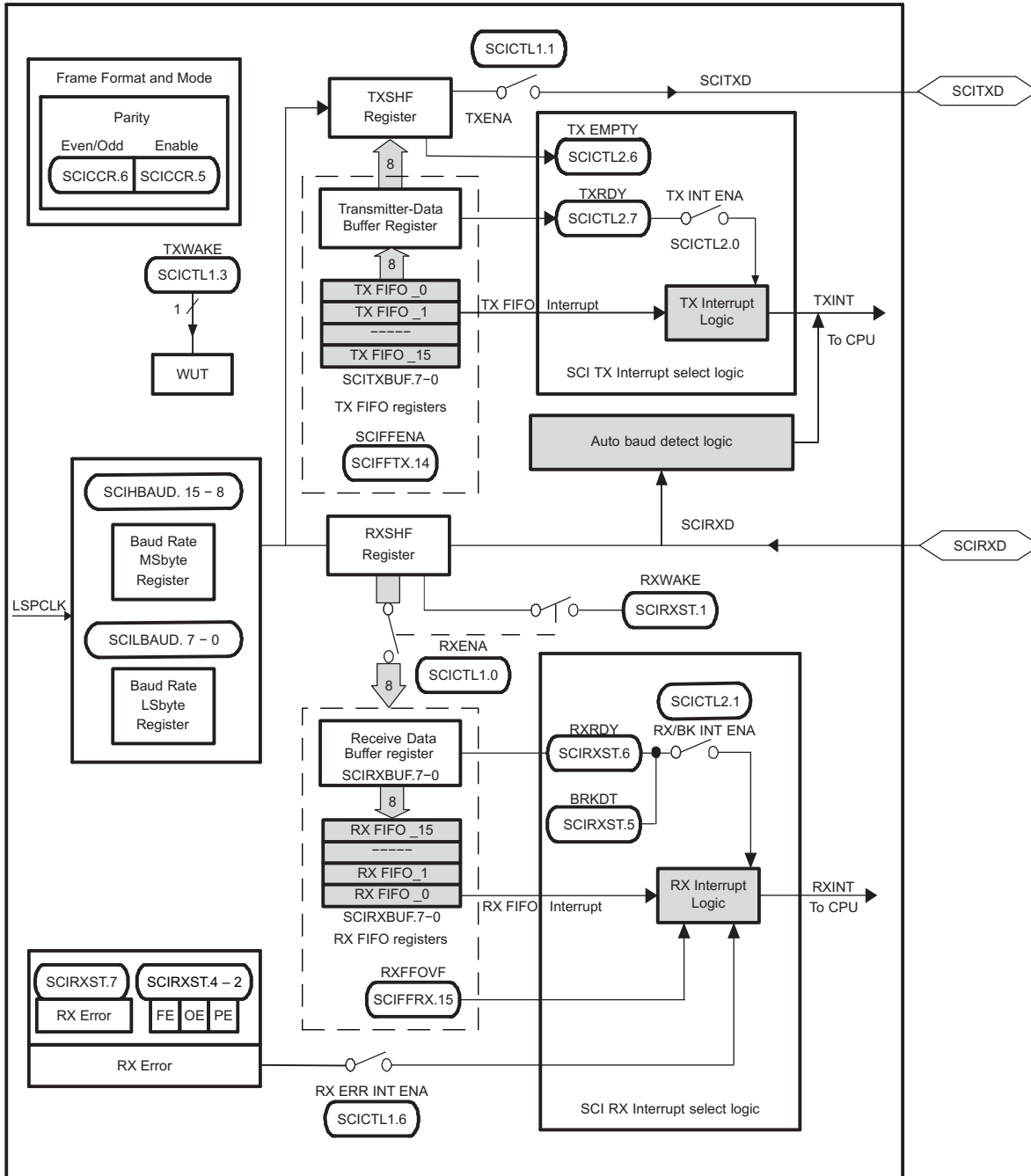


图 5-65. SCI Block Diagram

The major elements used in full-duplex operation include:

- A transmitter (TX) and its major registers:
  - SCITXBUF register – Transmitter Data Buffer register. Contains data (loaded by the CPU) to be transmitted
  - TXSHF register – Transmitter Shift register. Accepts data from the SCITXBUF register and shifts data onto the SCITXD pin, 1 bit at a time
- A receiver (RX) and its major registers:
  - RXSHF register – Receiver Shift register. Shifts data in from the SCIRXD pin, 1 bit at a time
  - SCIRXBUF register – Receiver Data Buffer register. Contains data to be read by the CPU. Data from a remote processor is loaded into the RXSHF register and then into the SCIRXBUF and SCIRXEMU registers
- A programmable baud generator
- Data-memory-mapped control and status registers enable the CPU to access the I<sup>2</sup>C module registers and FIFOs.

The SCI receiver and transmitter operate independently.

### 5.10.5 Serial Peripheral Interface (SPI)

The SPI is a high-speed synchronous serial input/output (I/O) port that allows a serial bit stream of programmed length (1 to 16 bits) to be shifted into and out of the device at a programmed bit-transfer rate. The SPI is normally used for communications between the microcontroller and external peripherals or another controller. Typical applications include external I/O or peripheral expansion through devices such as shift registers, display drivers, and ADCs. Multidevice communications are supported by the master/slave operation of the SPI. The port supports 16-level receive and transmit FIFOs for reducing CPU servicing overhead.

The SPI module features include:

- SPISOMI: SPI slave-output/master-input pin
- SPISIMO: SPI slave-input/master-output pin
- $\overline{\text{SPISTE}}$ : SPI slave transmit-enable pin
- SPICLK: SPI serial-clock pin
- Two operational modes: master and slave
- Baud rate: 125 different programmable rates
- Data word length: 1 to 16 data bits
- Four clocking schemes (controlled by clock polarity and clock phase bits) include:
  - Falling edge without phase delay: SPICLK active-high. SPI transmits data on the falling edge of the SPICLK signal and receives data on the rising edge of the SPICLK signal.
  - Falling edge with phase delay: SPICLK active-high. SPI transmits data one half-cycle ahead of the falling edge of the SPICLK signal and receives data on the falling edge of the SPICLK signal.
  - Rising edge without phase delay: SPICLK inactive-low. SPI transmits data on the rising edge of the SPICLK signal and receives data on the falling edge of the SPICLK signal.
  - Rising edge with phase delay: SPICLK inactive-low. SPI transmits data one half-cycle ahead of the falling edge of the SPICLK signal and receives data on the rising edge of the SPICLK signal.
- Simultaneous receive-and-transmit operation (transmit function can be disabled in software)
- Transmitter and receiver operations are accomplished through either interrupt-driven or polled algorithms.
- 16-level transmit and receive FIFO
- Delayed transmit control
- 3-wire SPI mode
- $\overline{\text{SPISTE}}$  inversion for digital audio interface receive mode on devices with two SPI modules
- DMA support
- High-speed mode for up to 50-MHz full-duplex communication

The SPI operates in master or slave mode. The master initiates data transfer by sending the SPICLK signal. For both the slave and the master, data is shifted out of the shift registers on one edge of the SPICLK and latched into the shift register on the opposite SPICLK clock edge. If the CLOCK PHASE bit (SPICTL.3) is high, data is transmitted and received a half-cycle before the SPICLK transition. As a result, both controllers send and receive data simultaneously. The application software determines whether the data is meaningful or dummy data. There are three possible methods for data transmission:

- Master sends data; slave sends dummy data
- Master sends data; slave sends data
- Master sends dummy data; slave sends data

The master can initiate a data transfer at any time because it controls the SPICLK signal. The software, however, determines how the master detects when the slave is ready to broadcast data.

图 5-66 shows the SPI CPU Interface.

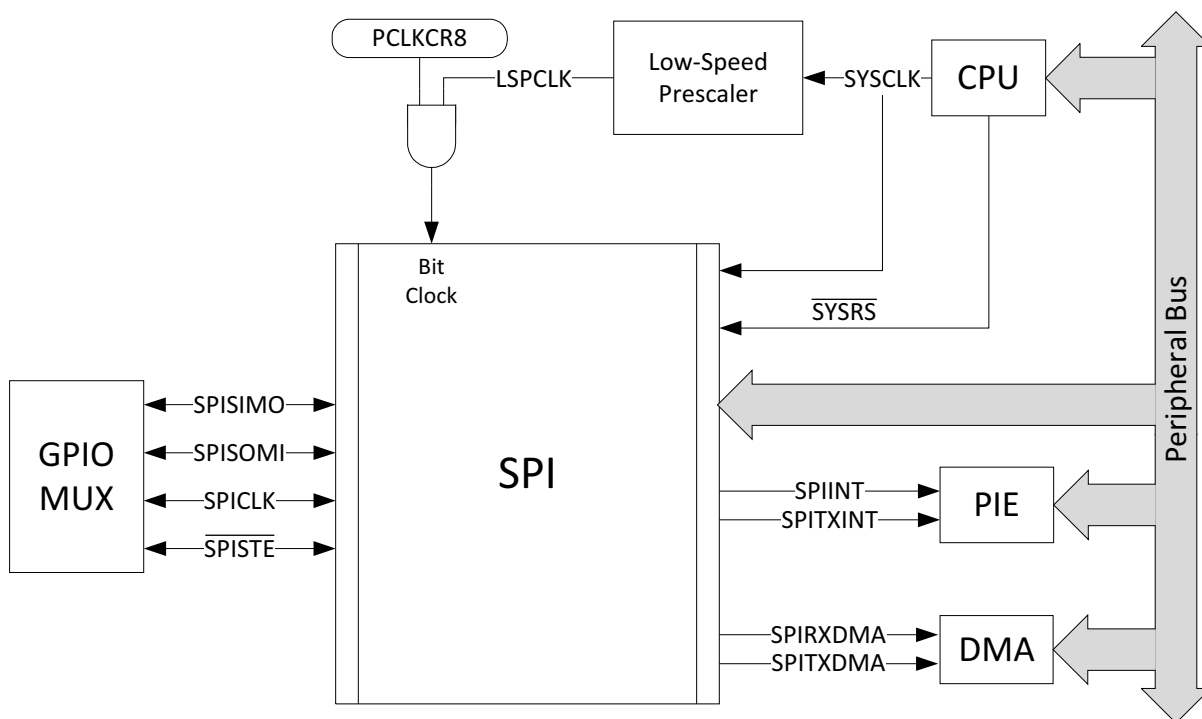


图 5-66. SPI CPU Interface



### 5.10.5.1 SPI Electrical Data and Timing

The following sections contain the SPI External Timings in Non-High-Speed Mode:

- [Section 5.10.5.1.1](#) Master Mode External Timings Where Clock Phase = 0
- [Section 5.10.5.1.2](#) Master Mode External Timings Where Clock Phase = 1
- [Section 5.10.5.1.3](#) Slave Mode External Timings Where Clock Phase = 0
- [Section 5.10.5.1.4](#) Slave Mode External Timings Where Clock Phase = 1

The following sections contain the SPI External Timings in High-Speed Mode:

- [Section 5.10.5.1.5](#) High-Speed Master Mode External Timings Where Clock Phase = 0
- [Section 5.10.5.1.6](#) High-Speed Master Mode External Timings Where Clock Phase = 1
- [Section 5.10.5.1.7](#) High-Speed Slave Mode External Timings Where Clock Phase = 0
- [Section 5.10.5.1.8](#) High-Speed Slave Mode External Timings Where Clock Phase = 1

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注

All timing parameters for SPI High-Speed Mode assume a load capacitance of 5 pF on SPICLK, SPISIMO, and SPISOMI.

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For more information about the SPI in High-Speed mode, see the "Serial Peripheral Interface (SPI)" chapter of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)*.

To use the SPI in High-Speed mode, the application must use the high-speed enabled GPIOs (see [Section 4.5.5](#)).

### 5.10.5.1.1 Master Mode External Timings Where Clock Phase = 0

Table 5-77 shows the SPI master mode external timings where (SPIBRR + 1) is even or SPIBRR = 0 or 2.

Table 5-78 shows the SPI master mode external timings where (SPIBRR + 1) is odd and SPIBRR > 3.

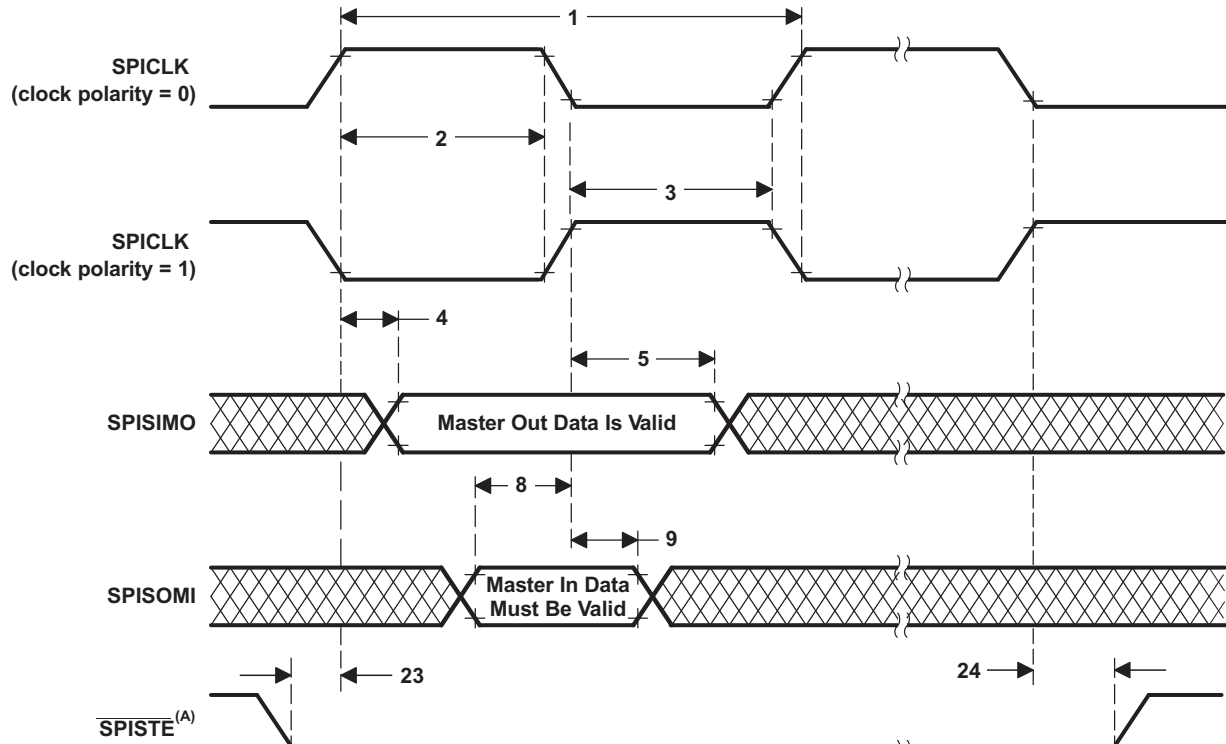
Figure 5-67 shows the SPI master mode external timing where the clock phase = 0.

**Table 5-77. SPI Master Mode External Timings Where (SPIBRR + 1) is Even or SPIBRR = 0 or 2**

NO.			MIN	MAX	UNIT
1	$t_{c(SPC)M}$	Cycle time, SPICLK	$4t_{c(LSPCLK)}$	$128t_{c(LSPCLK)}$	ns
2	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	ns
	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	
3	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	ns
	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	
4	$t_{d(SPCH-SIMO)M}$	Delay time, SPICLK high to SPISIMO valid (clock polarity = 0)		3	ns
	$t_{d(SPCL-SIMO)M}$	Delay time, SPICLK low to SPISIMO valid (clock polarity = 1)		3	
5	$t_{v(SPCL-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} - 3$		ns
	$t_{v(SPCH-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} - 3$		
8	$t_{su(SOMI-SPCL)M}$	Setup time, SPISOMI before SPICLK low (clock polarity = 0)	20		ns
	$t_{su(SOMI-SPCH)M}$	Setup time, SPISOMI before SPICLK high (clock polarity = 1)	20		
9	$t_{h(SPCL-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK low (clock polarity = 0)	0		ns
	$t_{h(SPCH-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK high (clock polarity = 1)	0		
23	$t_{d(STE-SPCH)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)} - 3$		ns
	$t_{d(STE-SPCL)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)} - 3$		
24	$t_{d(SPCL-STE)M}$	Delay time, SPICLK low to $\overline{SPISTE}$ invalid (clock polarity = 0)	$0.5t_{c(SPC)} - 3$		ns
	$t_{d(SPCH-STE)M}$	Delay time, SPICLK high to $\overline{SPISTE}$ invalid (clock polarity = 1)	$0.5t_{c(SPC)} - 3$		

**Table 5-78. SPI Master Mode External Timings Where (SPIBRR + 1) is Odd and SPIBRR > 3**

NO.			MIN	MAX	UNIT
1	$t_{c(SPC)M}$	Cycle time, SPICLK	$5t_{c(LSPCLK)}$	$127t_{c(LSPCLK)}$	ns
2	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} + 1$	ns
	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} + 1$	
3	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} + 1$	ns
	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} + 1$	
4	$t_{d(SPCH-SIMO)M}$	Delay time, SPICLK high to SPISIMO valid (clock polarity = 0)		3	ns
	$t_{d(SPCL-SIMO)M}$	Delay time, SPICLK low to SPISIMO valid (clock polarity = 1)		3	
5	$t_{v(SPCL-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 3$		ns
	$t_{v(SPCH-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 3$		
8	$t_{su(SOMI-SPCL)M}$	Setup time, SPISOMI before SPICLK low (clock polarity = 0)	20		ns
	$t_{su(SOMI-SPCH)M}$	Setup time, SPISOMI before SPICLK high (clock polarity = 1)	20		
9	$t_{h(SPCL-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK low (clock polarity = 0)	0		ns
	$t_{h(SPCH-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK high (clock polarity = 1)	0		
23	$t_{d(STE-SPCH)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)} - 3$		ns
	$t_{d(STE-SPCL)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)} - 3$		
24	$t_{d(SPCL-STE)M}$	Delay time, SPICLK low to $\overline{SPISTE}$ invalid (clock polarity = 0)	$0.5t_{c(SPC)} - 3$		ns
	$t_{d(SPCH-STE)M}$	Delay time, SPICLK high to $\overline{SPISTE}$ invalid (clock polarity = 1)	$0.5t_{c(SPC)} - 3$		



- A. On the trailing end of the word,  $\overline{\text{SPISTE}}$  will go inactive except between back-to-back transmit words in both FIFO and non-FIFO modes.

**Figure 5-67. SPI Master Mode External Timing (Clock Phase = 0)**

### 5.10.5.1.2 Master Mode External Timings Where Clock Phase = 1

Table 5-79 shows the SPI master mode external timings where (SPIBRR + 1) is even or SPIBRR = 0 or 2.

Table 5-80 shows the SPI master mode external timings where (SPIBRR + 1) is odd or SPIBRR > 3.

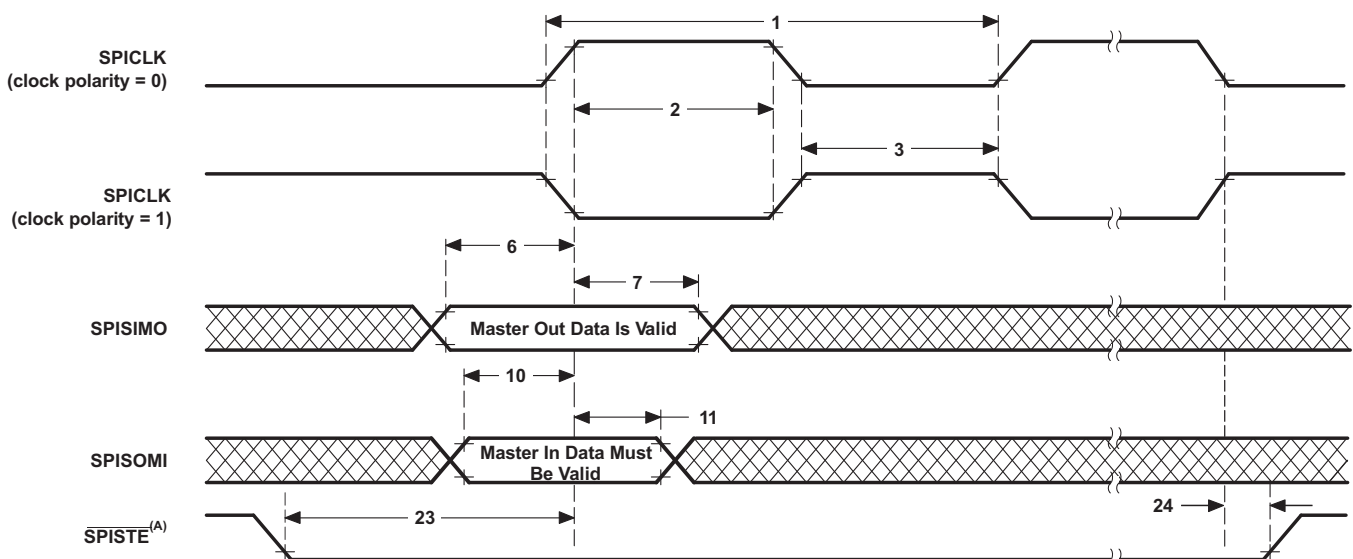
Figure 5-68 shows the SPI master mode external timing where the clock phase = 1.

**Table 5-79. SPI Master Mode External Timings Where (SPIBRR + 1) is Even or SPIBRR = 0 or 2**

NO.			MIN	MAX	UNIT
1	$t_{c(SPC)M}$	Cycle time, SPICLK	$4t_{c(LSPCLK)}$	$128t_{c(LSPCLK)}$	ns
2	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	ns
	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	
3	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	ns
	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	
6	$t_{d(SIMO-SPCH)M}$	Delay time, SPISIMO data valid to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 3$		ns
	$t_{d(SIMO-SPCL)M}$	Delay time, SPISIMO data valid to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 3$		
7	$t_{v(SPCH-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 3$		ns
	$t_{v(SPCL-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 3$		
10	$t_{su(SOMI-SPCH)M}$	Setup time, SPISOMI before SPICLK high (clock polarity = 0)	20		ns
	$t_{su(SOMI-SPCL)M}$	Setup time, SPISOMI before SPICLK low (clock polarity = 1)	20		
11	$t_{h(SPCH-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK high (clock polarity = 0)	0		ns
	$t_{h(SPCL-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK low (clock polarity = 1)	0		
23	$t_{d(STE-SPCH)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)} - 3$		ns
	$t_{d(STE-SPCL)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)} - 3$		
24	$t_{d(SPCL-STE)M}$	Delay time, SPICLK low to $\overline{SPISTE}$ invalid (clock polarity = 0)	$0.5t_{c(SPC)} - 3$		ns
	$t_{d(SPCH-STE)M}$	Delay time, SPICLK high to $\overline{SPISTE}$ invalid (clock polarity = 1)	$0.5t_{c(SPC)} - 3$		

**Table 5-80. SPI Master Mode External Timings Where (SPIBRR + 1) is Odd or SPIBRR > 3**

NO.			MIN	MAX	UNIT
1	$t_{c(SPC)M}$	Cycle time, SPICLK	$5t_{c(LSPCLK)}$	$127t_{c(LSPCLK)}$	ns
2	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} + 1$	ns
	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} + 1$	
3	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} + 1$	ns
	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} + 1$	
6	$t_{d(SIMO-SPCH)M}$	Delay time, SPISIMO data valid to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 3$		ns
	$t_{d(SIMO-SPCL)M}$	Delay time, SPISIMO data valid to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 3$		
7	$t_{v(SPCH-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 3$		ns
	$t_{v(SPCL-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 3$		
10	$t_{su(SOMI-SPCH)M}$	Setup time, SPISOMI before SPICLK high (clock polarity = 0)	20		ns
	$t_{su(SOMI-SPCL)M}$	Setup time, SPISOMI before SPICLK low (clock polarity = 1)	20		
11	$t_{h(SPCH-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK high (clock polarity = 0)	0		ns
	$t_{h(SPCL-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK low (clock polarity = 1)	0		
23	$t_{d(STE-SPCH)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)} - 3$		ns
	$t_{d(STE-SPCL)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)} - 3$		
24	$t_{d(SPCL-STE)M}$	Delay time, SPICLK low to $\overline{SPISTE}$ invalid (clock polarity = 0)	$0.5t_{c(SPC)} - 3$		ns
	$t_{d(SPCH-STE)M}$	Delay time, SPICLK high to $\overline{SPISTE}$ invalid (clock polarity = 1)	$0.5t_{c(SPC)} - 3$		



A. On the trailing end of the word,  $\overline{SPISTE}$  will go inactive except between back-to-back transmit words in both FIFO and non-FIFO modes.

**Figure 5-68. SPI Master Mode External Timing (Clock Phase = 1)**

### 5.10.5.1.3 Slave Mode External Timings Where Clock Phase = 0

Table 5-81 and Figure 5-69 show the SPI slave mode external timings where the clock phase = 0.

**Table 5-81. SPI Slave Mode External Timings Where Clock Phase = 0**

NO.			MIN	MAX	UNIT
12	$t_{c(SPC)S}$	Cycle time, SPICLK	$4t_{c(SYSCLK)}$		ns
13	$t_{w(SPCH)S}$	Pulse duration, SPICLK high (clock polarity = 0)	$2t_{c(SYSCLK)} - 1$		ns
	$t_{w(SPCL)S}$	Pulse duration, SPICLK low (clock polarity = 1)	$2t_{c(SYSCLK)} - 1$		
14	$t_{w(SPCL)S}$	Pulse duration, SPICLK low (clock polarity = 0)	$2t_{c(SYSCLK)} - 1$		ns
	$t_{w(SPCH)S}$	Pulse duration, SPICLK high (clock polarity = 1)	$2t_{c(SYSCLK)} - 1$		
15	$t_{d(SPCH-SOM)S}$	Delay time, SPICLK high to SPISOMI valid (clock polarity = 0)		20	ns
	$t_{d(SPCL-SOM)S}$	Delay time, SPICLK low to SPISOMI valid (clock polarity = 1)		20	
16	$t_{v(SPCH-SOM)S}$	Valid time, SPISOMI data valid after SPICLK high (clock polarity = 0)	0		ns
	$t_{v(SPCL-SOM)S}$	Valid time, SPISOMI data valid after SPICLK low (clock polarity = 1)	0		
19	$t_{su(SIMO-SPCL)S}$	Setup time, SPISIMO before SPICLK low (clock polarity = 0)	5		ns
	$t_{su(SIMO-SPCH)S}$	Setup time, SPISIMO before SPICLK high (clock polarity = 1)	5		
20	$t_{h(SPCL-SIMO)S}$	Hold time, SPISIMO data valid after SPICLK low (clock polarity = 0)	5		ns
	$t_{h(SPCH-SIMO)S}$	Hold time, SPISIMO data valid after SPICLK high (clock polarity = 1)	5		
25	$t_{su(STE-SPCH)S}$	Setup time, $\overline{SPISTE}$ valid before SPICLK high (clock polarity = 0)	$2t_{c(SYSCLK)}$		ns
	$t_{su(STE-SPCL)S}$	Setup time, $\overline{SPISTE}$ valid before SPICLK low (clock polarity = 1)	$2t_{c(SYSCLK)}$		
26	$t_{h(SPCL-STE)S}$	Hold time, $\overline{SPISTE}$ invalid after SPICLK low (clock polarity = 0)	$2t_{c(SYSCLK)}$		ns
	$t_{h(SPCH-STE)S}$	Hold time, $\overline{SPISTE}$ invalid after SPICLK high (clock polarity = 1)	$2t_{c(SYSCLK)}$		

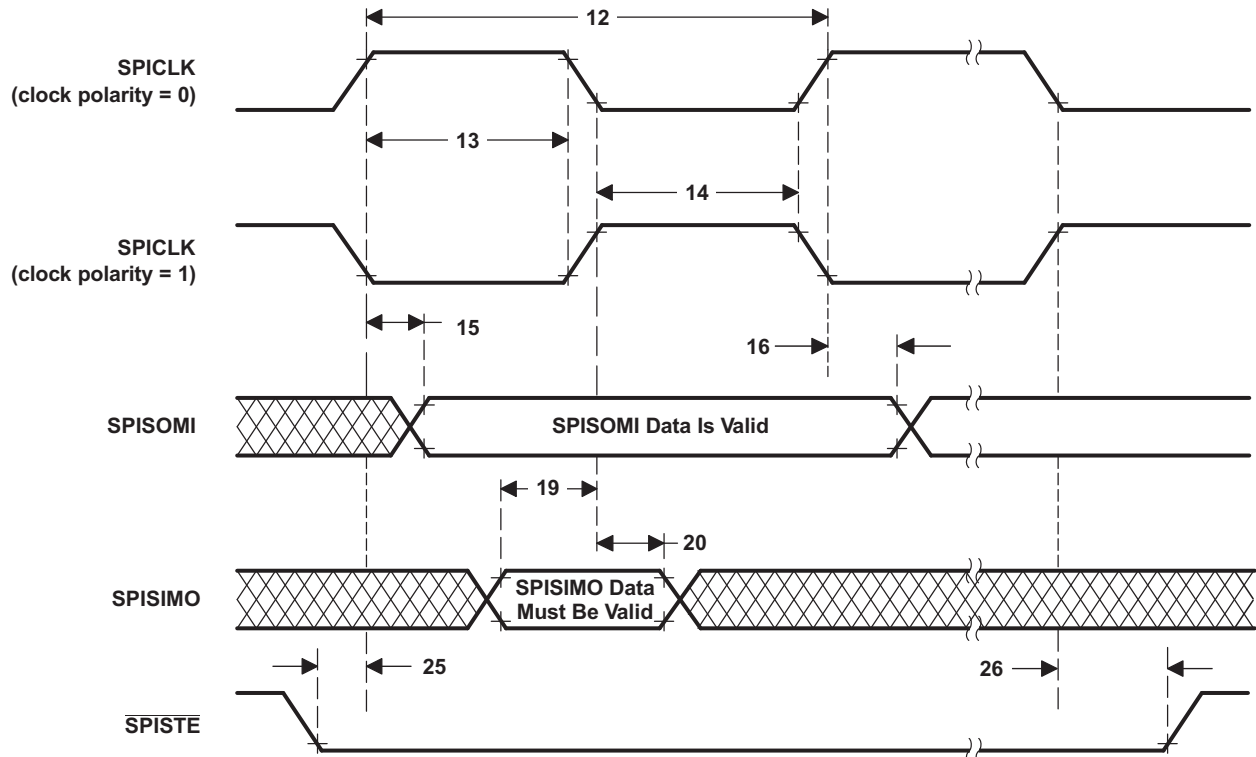


Figure 5-69. SPI Slave Mode External Timing (Clock Phase = 0)

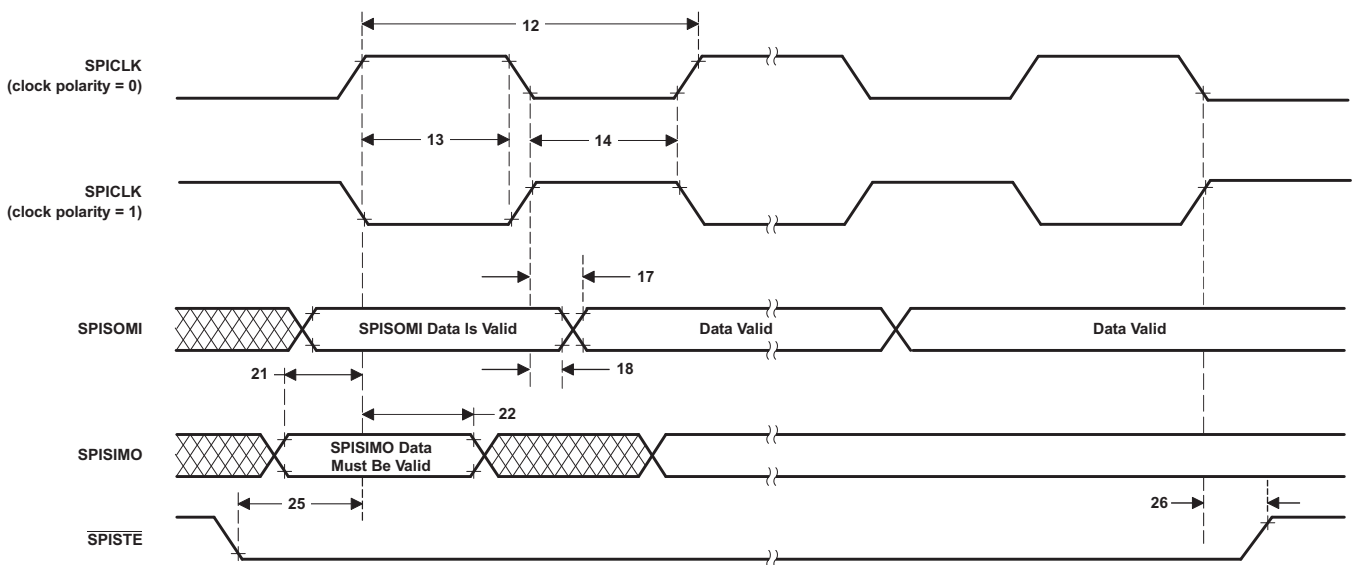


### 5.10.5.1.4 Slave Mode External Timings Where Clock Phase = 1

Table 5-82 and Figure 5-70 show the SPI slave mode external timings where the clock phase = 1.

**Table 5-82. SPI Slave Mode External Timings Where Clock Phase = 1**

NO.			MIN	MAX	UNIT
12	$t_{c(SPC)S}$	Cycle time, SPICLK	$8t_{c(SYSCLK)}$		ns
13	$t_{w(SPCH)S}$	Pulse duration, SPICLK high (clock polarity = 0)	$4t_{c(SYSCLK)} - 1$		ns
	$t_{w(SPCL)S}$	Pulse duration, SPICLK low (clock polarity = 1)	$4t_{c(SYSCLK)} - 1$		
14	$t_{w(SPCL)S}$	Pulse duration, SPICLK low (clock polarity = 0)	$4t_{c(SYSCLK)} - 1$		ns
	$t_{w(SPCH)S}$	Pulse duration, SPICLK high (clock polarity = 1)	$4t_{c(SYSCLK)} - 1$		
17	$t_{d(SPCL-SOMI)S}$	Delay time, SPICLK low to SPISOMI (clock polarity = 0)		20	ns
	$t_{d(SPCH-SOMI)S}$	Delay time, SPICLK high to SPISOMI (clock polarity = 1)		20	
18	$t_{v(SPCL-SOMI)S}$	Valid time, SPISOMI data valid after SPICLK low (clock polarity = 0)	0		ns
	$t_{v(SPCH-SOMI)S}$	Valid time, SPISOMI data valid after SPICLK high (clock polarity = 1)	0		
21	$t_{su(SIMO-SPCH)S}$	Setup time, SPISIMO before SPICLK high (clock polarity = 0)	5		ns
	$t_{su(SIMO-SPCL)S}$	Setup time, SPISIMO before SPICLK low (clock polarity = 1)	5		
22	$t_{h(SPCH-SIMO)S}$	Hold time, SPISIMO data valid after SPICLK high (clock polarity = 0)	5		ns
	$t_{h(SPCL-SIMO)S}$	Hold time, SPISIMO data valid after SPICLK low (clock polarity = 1)	5		
25	$t_{su(STE-SPCH)S}$	Setup time, $\overline{SPISTE}$ valid before SPICLK high (clock polarity = 0)	$2t_{c(SYSCLK)}$		ns
	$t_{su(STE-SPCL)S}$	Setup time, $\overline{SPISTE}$ valid before SPICLK low (clock polarity = 1)	$2t_{c(SYSCLK)}$		
26	$t_{h(STE-SPCL)S}$	Hold time, $\overline{SPISTE}$ invalid after SPICLK low (clock polarity = 0)	$2t_{c(SYSCLK)}$		ns
	$t_{h(STE-SPCH)S}$	Hold time, $\overline{SPISTE}$ invalid after SPICLK high (clock polarity = 1)	$2t_{c(SYSCLK)}$		



**Figure 5-70. SPI Slave Mode External Timing (Clock Phase = 1)**

### 5.10.5.1.5 High-Speed Master Mode External Timings Where Clock Phase = 0

Table 5-83 shows the high-speed SPI master mode external timings where (SPIBRR + 1) is even or SPIBRR = 0 or 2.

Table 5-84 shows the high-speed SPI master mode external timings where (SPIBRR + 1) is odd and SPIBRR > 3.

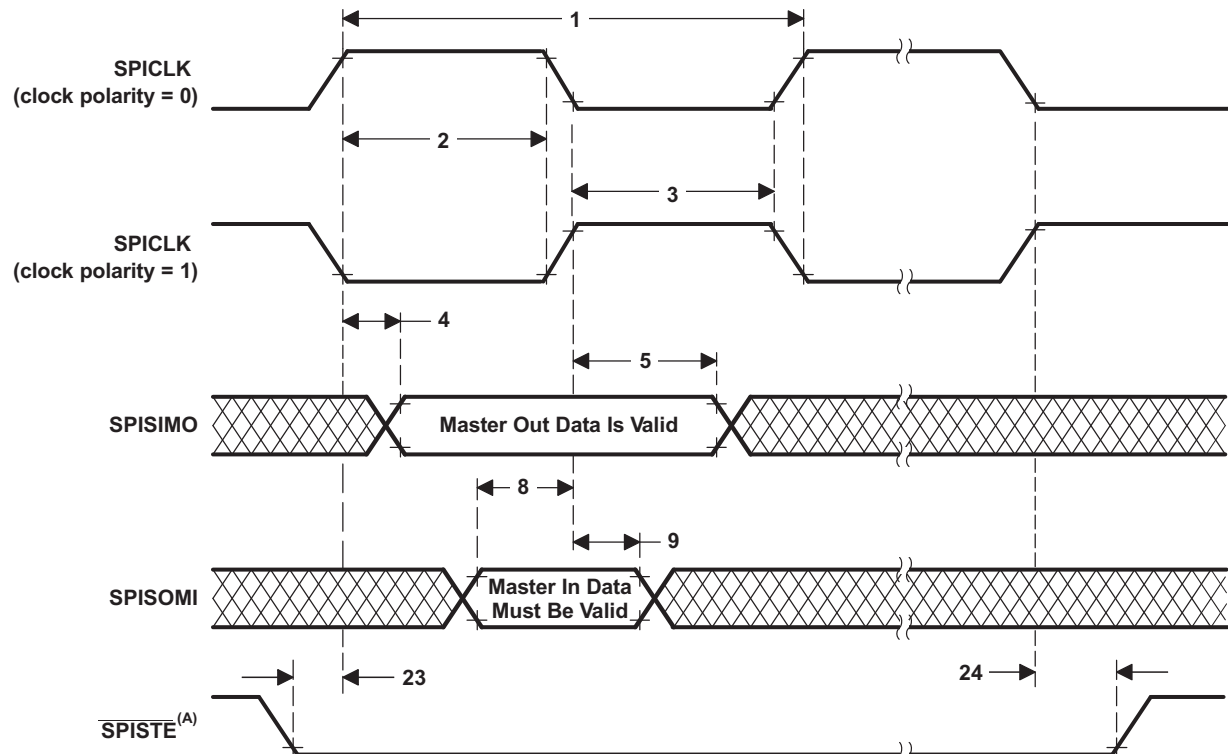
Figure 5-71 shows the high-speed SPI master mode external timing where the clock phase = 0.

**Table 5-83. High-Speed SPI Master Mode External Timings Where (SPIBRR + 1) is Even or SPIBRR = 0 or 2**

NO.			MIN	MAX	UNIT
1	$t_{c(SPC)M}$	Cycle time, SPICLK	$4t_{c(LSPCLK)}$	$128t_{c(LSPCLK)}$	ns
2	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	ns
	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	
3	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	ns
	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	
4	$t_{d(SPCH-SIMO)M}$	Delay time, SPICLK high to SPISIMO valid (clock polarity = 0)		1	ns
	$t_{d(SPCL-SIMO)M}$	Delay time, SPICLK low to SPISIMO valid (clock polarity = 1)		1	
5	$t_{v(SPCL-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$		ns
	$t_{v(SPCH-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$		
8	$t_{su(SOMI-SPCL)M}$	Setup time, SPISOMI before SPICLK low (clock polarity = 0)	1		ns
	$t_{su(SOMI-SPCH)M}$	Setup time, SPISOMI before SPICLK high (clock polarity = 1)	1		
9	$t_{h(SPCL-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK low (clock polarity = 0)	5		ns
	$t_{h(SPCH-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK high (clock polarity = 1)	5		
23	$t_{d(STE-SPCH)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)} - 1$		ns
	$t_{d(STE-SPCL)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)} - 1$		
24	$t_{d(SPCL-STE)M}$	Delay time, SPICLK low to $\overline{SPISTE}$ invalid (clock polarity = 0)	$0.5t_{c(SPC)} - 1$		ns
	$t_{d(SPCH-STE)M}$	Delay time, SPICLK high to $\overline{SPISTE}$ invalid (clock polarity = 1)	$0.5t_{c(SPC)} - 1$		

**Table 5-84. High-Speed SPI Master Mode External Timings Where (SPIBRR + 1) is Odd and SPIBRR > 3**

NO.			MIN	MAX	UNIT
1	$t_{c(SPC)M}$	Cycle time, SPICLK	$5t_{c(LSPCLK)}$	$127t_{c(LSPCLK)}$	ns
2	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} + 1$	ns
	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} + 1$	
3	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} + 1$	ns
	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} + 1$	
4	$t_{d(SPCH-SIMO)M}$	Delay time, SPICLK high to SPISIMO valid (clock polarity = 0)		1	ns
	$t_{d(SPCL-SIMO)M}$	Delay time, SPICLK low to SPISIMO valid (clock polarity = 1)		1	
5	$t_{v(SPCL-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$		ns
	$t_{v(SPCH-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$		
8	$t_{su(SOMI-SPCL)M}$	Setup time, SPISOMI before SPICLK low (clock polarity = 0)	1		ns
	$t_{su(SOMI-SPCH)M}$	Setup time, SPISOMI before SPICLK high (clock polarity = 1)	1		
9	$t_{h(SPCL-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK low (clock polarity = 0)	5		ns
	$t_{h(SPCH-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK high (clock polarity = 1)	5		
23	$t_{d(STE-SPCH)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)} - 1$		ns
	$t_{d(STE-SPCL)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)} - 1$		
24	$t_{d(SPCL-STE)M}$	Delay time, SPICLK low to $\overline{SPISTE}$ invalid (clock polarity = 0)	$0.5t_{c(SPC)} - 1$		ns
	$t_{d(SPCH-STE)M}$	Delay time, SPICLK high to $\overline{SPISTE}$ invalid (clock polarity = 1)	$0.5t_{c(SPC)} - 1$		



- A. On the trailing end of the word,  $\overline{\text{SPISTE}}$  will go inactive except between back-to-back transmit words in both FIFO and non-FIFO modes.

**Figure 5-71. High-Speed SPI Master Mode External Timing (Clock Phase = 0)**

**5.10.5.1.6 High-Speed Master Mode External Timings Where Clock Phase = 1**

Table 5-85 shows the high-speed SPI master mode external timings where (SPIBRR + 1) is even or SPIBRR = 0 or 2.

Table 5-86 shows the high-speed SPI master mode external timings where (SPIBRR + 1) is odd or SPIBRR > 3.

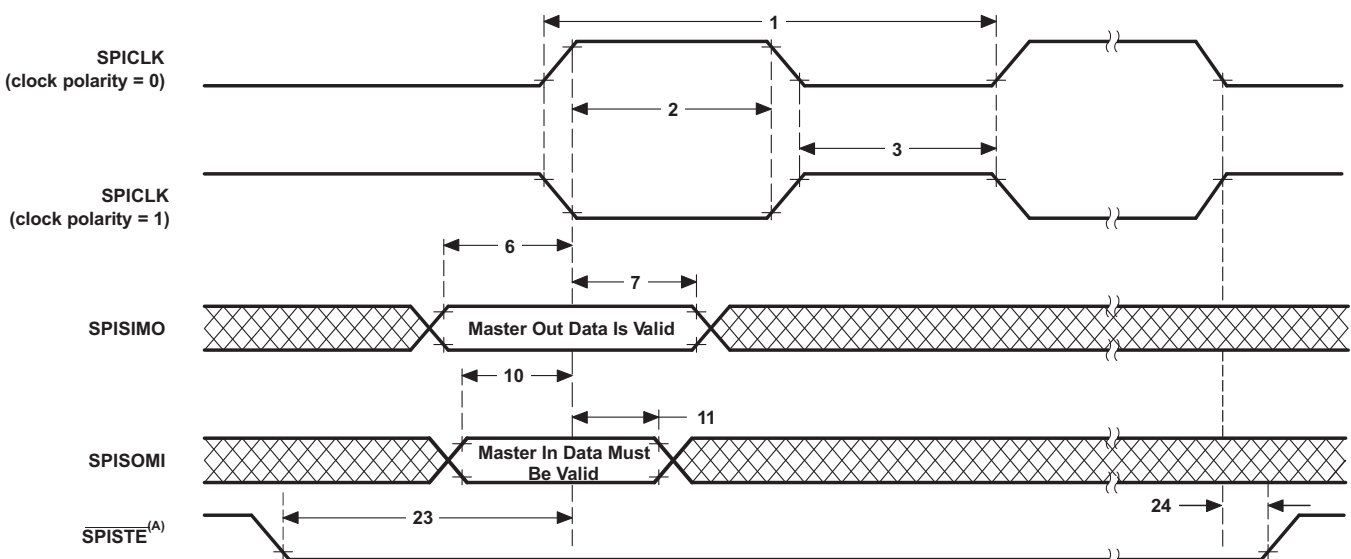
Figure 5-72 shows the high-speed SPI master mode external timing where the clock phase = 1.

**Table 5-85. High-Speed SPI Master Mode External Timings Where (SPIBRR + 1) is Even or SPIBRR = 0 or 2**

NO.			MIN	MAX	UNIT
1	$t_{c(SPC)M}$	Cycle time, SPICLK	$4t_{c(LSPCLK)}$	$128t_{c(LSPCLK)}$	ns
2	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	ns
	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	
3	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	ns
	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$	$0.5t_{c(SPC)M} + 1$	
6	$t_{d(SIMO-SPCH)M}$	Delay time, SPISIMO data valid to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$		ns
	$t_{d(SIMO-SPCL)M}$	Delay time, SPISIMO data valid to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$		
7	$t_{v(SPCH-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 1$		ns
	$t_{v(SPCL-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 1$		
10	$t_{su(SOMI-SPCH)M}$	Setup time, SPISOMI before SPICLK high (clock polarity = 0)	1		ns
	$t_{su(SOMI-SPCL)M}$	Setup time, SPISOMI before SPICLK low (clock polarity = 1)	1		
11	$t_{h(SPCH-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK high (clock polarity = 0)	5		ns
	$t_{h(SPCL-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK low (clock polarity = 1)	5		
23	$t_{d(STE-SPCH)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)} - 1$		ns
	$t_{d(STE-SPCL)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)} - 1$		
24	$t_{d(SPCL-STE)M}$	Delay time, SPICLK low to $\overline{SPISTE}$ invalid (clock polarity = 0)	$0.5t_{c(SPC)} - 1$		ns
	$t_{d(SPCH-STE)M}$	Delay time, SPICLK high to $\overline{SPISTE}$ invalid (clock polarity = 1)	$0.5t_{c(SPC)} - 1$		

Table 5-86. High-Speed SPI Master Mode External Timings Where (SPIBRR + 1) is Odd or SPIBRR > 3

NO.			MIN	MAX	UNIT
1	$t_{c(SPC)M}$	Cycle time, SPICLK	$5t_{c(LSPCLK)}$	$127t_{c(LSPCLK)}$	ns
2	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} + 1$	ns
	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} + 1$	
3	$t_{w(SPCL)M}$	Pulse duration, SPICLK low (clock polarity = 0)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} + 1$	ns
	$t_{w(SPCH)M}$	Pulse duration, SPICLK high (clock polarity = 1)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} + 1$	
6	$t_{d(SIMO-SPCH)M}$	Delay time, SPISIMO data valid to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$		ns
	$t_{d(SIMO-SPCL)M}$	Delay time, SPISIMO data valid to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$		
7	$t_{v(SPCH-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)M} + 0.5t_{c(LSPCLK)} - 1$		ns
	$t_{v(SPCL-SIMO)M}$	Valid time, SPISIMO data valid after SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)M} - 0.5t_{c(LSPCLK)} - 1$		
10	$t_{su(SOMI-SPCH)M}$	Setup time, SPISOMI before SPICLK high (clock polarity = 0)	1		ns
	$t_{su(SOMI-SPCL)M}$	Setup time, SPISOMI before SPICLK low (clock polarity = 1)	1		
11	$t_{h(SPCH-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK high (clock polarity = 0)	5		ns
	$t_{h(SPCL-SOMI)M}$	Hold time, SPISOMI data valid after SPICLK low (clock polarity = 1)	5		
23	$t_{d(STE-SPCH)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK high (clock polarity = 0)	$0.5t_{c(SPC)} - 1$		ns
	$t_{d(STE-SPCL)M}$	Delay time, $\overline{SPISTE}$ low to SPICLK low (clock polarity = 1)	$0.5t_{c(SPC)} - 1$		
24	$t_{d(SPCL-STE)M}$	Delay time, SPICLK low to $\overline{SPISTE}$ invalid (clock polarity = 0)	$0.5t_{c(SPC)} - 1$		ns
	$t_{d(SPCH-STE)M}$	Delay time, SPICLK high to $\overline{SPISTE}$ invalid (clock polarity = 1)	$0.5t_{c(SPC)} - 1$		



A. On the trailing end of the word,  $\overline{SPISTE}$  will go inactive except between back-to-back transmit words in both FIFO and non-FIFO modes.

Figure 5-72. High-Speed SPI Master Mode External Timing (Clock Phase = 1)

### 5.10.5.1.7 High-Speed Slave Mode External Timings Where Clock Phase = 0

Table 5-87 and Figure 5-73 show the high-speed SPI slave mode external timings where the clock phase = 0.

**Table 5-87. High-Speed SPI Slave Mode External Timings Where Clock Phase = 0**

NO.			MIN	MAX	UNIT
12	$t_{c(SPC)S}$	Cycle time, SPICLK	$4t_{c(SYCLK)}$		ns
13	$t_{w(SPCH)S}$	Pulse duration, SPICLK high (clock polarity = 0)	$2t_{c(SYCLK)} - 1$		ns
	$t_{w(SPCL)S}$	Pulse duration, SPICLK low (clock polarity = 1)	$2t_{c(SYCLK)} - 1$		
14	$t_{w(SPCL)S}$	Pulse duration, SPICLK low (clock polarity = 0)	$2t_{c(SYCLK)} - 1$		ns
	$t_{w(SPCH)S}$	Pulse duration, SPICLK high (clock polarity = 1)	$2t_{c(SYCLK)} - 1$		
15	$t_{d(SPCH-SOM)S}$	Delay time, SPICLK high to SPISOMI valid (clock polarity = 0)		9	ns
	$t_{d(SPCL-SOM)S}$	Delay time, SPICLK low to SPISOMI valid (clock polarity = 1)		9	
16	$t_{v(SPCH-SOM)S}$	Valid time, SPISOMI data valid after SPICLK high (clock polarity = 0)	0		ns
	$t_{v(SPCL-SOM)S}$	Valid time, SPISOMI data valid after SPICLK low (clock polarity = 1)	0		
19	$t_{su(SIMO-SPCL)S}$	Setup time, SPISIMO before SPICLK low (clock polarity = 0)	5		ns
	$t_{su(SIMO-SPCH)S}$	Setup time, SPISIMO before SPICLK high (clock polarity = 1)	5		
20	$t_{h(SPCL-SIMO)S}$	Hold time, SPISIMO data valid after SPICLK low (clock polarity = 0)	5		ns
	$t_{h(SPCH-SIMO)S}$	Hold time, SPISIMO data valid after SPICLK high (clock polarity = 1)	5		
25	$t_{su(STE-SPCH)S}$	Setup time, $\overline{SPISTE}$ valid before SPICLK high (clock polarity = 0)	$2t_{c(SYCLK)}$		ns
	$t_{su(STE-SPCL)S}$	Setup time, $\overline{SPISTE}$ valid before SPICLK low (clock polarity = 1)	$2t_{c(SYCLK)}$		
26	$t_{h(SPCL-STE)S}$	Hold time, $\overline{SPISTE}$ invalid after SPICLK low (clock polarity = 0)	$2t_{c(SYCLK)}$		ns
	$t_{h(SPCH-STE)S}$	Hold time, $\overline{SPISTE}$ invalid after SPICLK high (clock polarity = 1)	$2t_{c(SYCLK)}$		

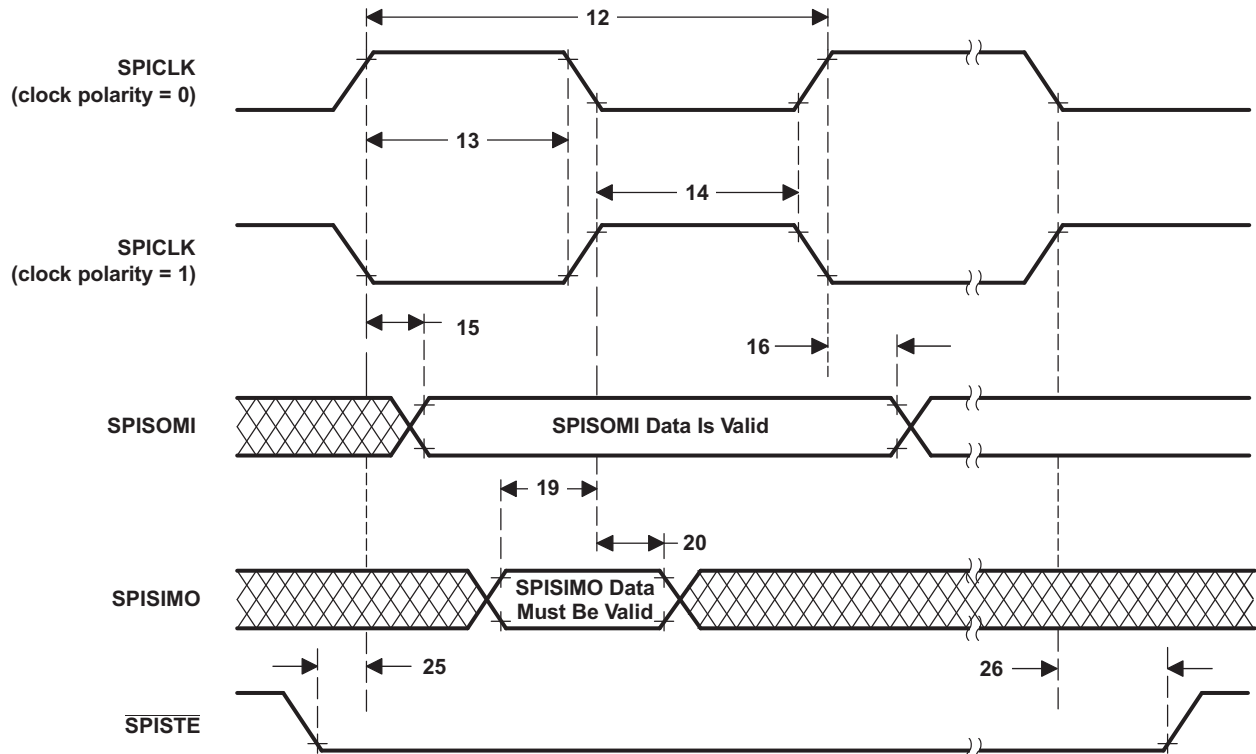


Figure 5-73. High-Speed SPI Slave Mode External Timing (Clock Phase = 0)

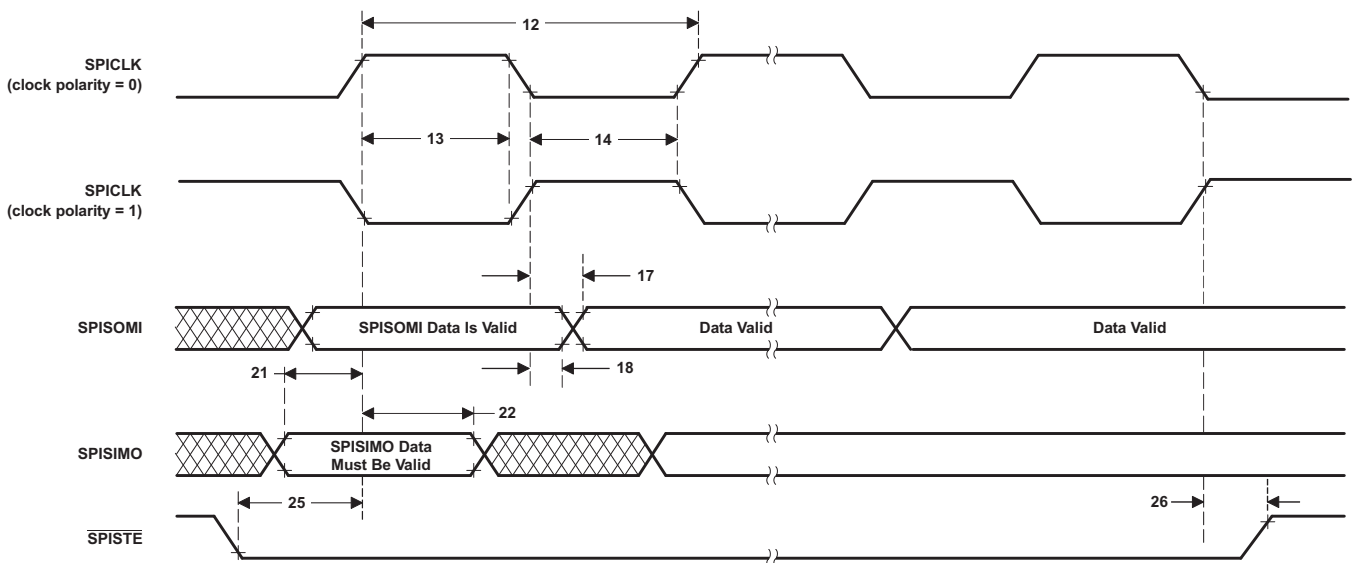


### 5.10.5.1.8 High-Speed Slave Mode External Timings Where Clock Phase = 1

Table 5-88 and Figure 5-74 show the high-speed SPI slave mode external timings where the clock phase = 1.

**Table 5-88. High-Speed SPI Slave Mode External Timings Where Clock Phase = 1**

NO.			MIN	MAX	UNIT
12	$t_{c(SPC)S}$	Cycle time, SPICLK	$8t_{c(SYSCLK)}$		ns
13	$t_{w(SPCH)S}$	Pulse duration, SPICLK high (clock polarity = 0)	$4t_{c(SYSCLK)} - 1$		ns
	$t_{w(SPCL)S}$	Pulse duration, SPICLK low (clock polarity = 1)	$4t_{c(SYSCLK)} - 1$		
14	$t_{w(SPCL)S}$	Pulse duration, SPICLK low (clock polarity = 0)	$4t_{c(SYSCLK)} - 1$		ns
	$t_{w(SPCH)S}$	Pulse duration, SPICLK high (clock polarity = 1)	$4t_{c(SYSCLK)} - 1$		
17	$t_{d(SPCL-SOMI)S}$	Delay time, SPICLK low to SPISOMI (clock polarity = 0)		9	ns
	$t_{d(SPCH-SOMI)S}$	Delay time, SPICLK high to SPISOMI (clock polarity = 1)		9	
18	$t_{v(SPCL-SOMI)S}$	Valid time, SPISOMI data valid after SPICLK low (clock polarity = 0)	0		ns
	$t_{v(SPCH-SOMI)S}$	Valid time, SPISOMI data valid after SPICLK high (clock polarity = 1)	0		
21	$t_{su(SIMO-SPCH)S}$	Setup time, SPISIMO before SPICLK high (clock polarity = 0)	5		ns
	$t_{su(SIMO-SPCL)S}$	Setup time, SPISIMO before SPICLK low (clock polarity = 1)	5		
22	$t_{h(SPCH-SIMO)S}$	Hold time, SPISIMO data valid after SPICLK high (clock polarity = 0)	5		ns
	$t_{h(SPCL-SIMO)S}$	Hold time, SPISIMO data valid after SPICLK low (clock polarity = 1)	5		
25	$t_{su(STE-SPCH)S}$	Setup time, $\overline{SPISTE}$ valid before SPICLK high (clock polarity = 0)	$2t_{c(SYSCLK)}$		ns
	$t_{su(STE-SPCL)S}$	Setup time, $\overline{SPISTE}$ valid before SPICLK low (clock polarity = 1)	$2t_{c(SYSCLK)}$		
26	$t_{h(STE-SPCL)S}$	Hold time, $\overline{SPISTE}$ invalid after SPICLK low (clock polarity = 0)	$2t_{c(SYSCLK)}$		ns
	$t_{h(STE-SPCH)S}$	Hold time, $\overline{SPISTE}$ invalid after SPICLK high (clock polarity = 1)	$2t_{c(SYSCLK)}$		



**Figure 5-74. High-Speed SPI Slave Mode External Timing (Clock Phase = 1)**

### 5.10.6 Universal Serial Bus (USB) Controller

The USB controller operates as a full-speed or low-speed function controller during point-to-point communications with USB host or device functions.

The USB module has the following features:

- USB 2.0 full-speed (12 Mbps) and low-speed (1.5 Mbps) operation
- Integrated PHY
- Three transfer types: control, interrupt, and bulk
- 32 endpoints
  - One dedicated control IN endpoint and one dedicated control OUT endpoint
  - 15 configurable IN endpoints and 15 configurable OUT endpoints
- 4KB of dedicated endpoint memory

图 5-75 shows the USB block diagram.

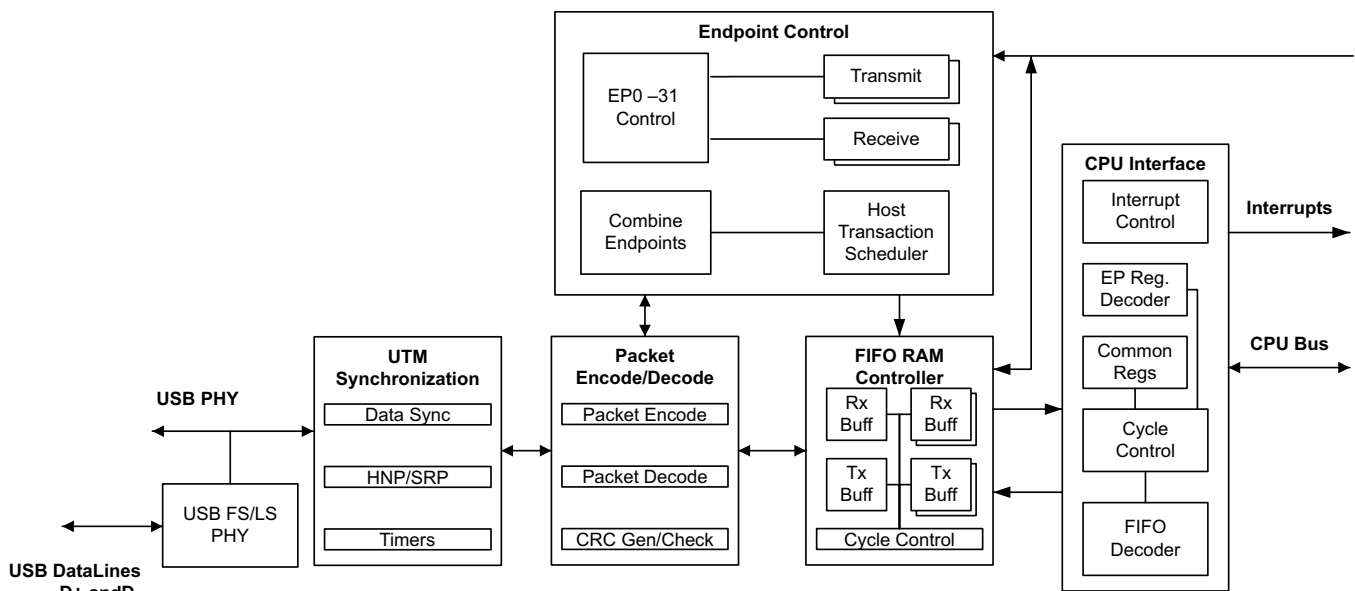


图 5-75. USB Block Diagram

注

The accuracy of the on-chip zero-pin oscillator (Table 5-18, Internal Oscillator Electrical Characteristics) will not meet the accuracy requirements of the USB protocol. An external clock source must be used for applications using USB. For applications using the USB boot mode, see 节 6.10 (Boot ROM and Peripheral Booting) for clock frequency requirements.

### 5.10.6.1 USB Electrical Data and Timing

Table 5-89 shows the USB input ports DP and DM timing requirements. Table 5-90 shows the USB output ports DP and DM switching characteristics.

**Table 5-89. USB Input Ports DP and DM Timing Requirements**

		MIN	MAX	UNIT
V(CM)	Differential input common mode range	0.8	2.5	V
Z(IN)	Input impedance	300		kΩ
VCRS	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
VDI	Differential input voltage		0.2	V

**Table 5-90. USB Output Ports DP and DM Switching Characteristics**

over recommended operating conditions (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	28	44	Ω
t <sub>r</sub>	Rise time Full speed, differential, C <sub>L</sub> = 50 pF, 10%/90%, R <sub>pu</sub> on D+	4	20	ns
t <sub>f</sub>	Fall time Full speed, differential, C <sub>L</sub> = 50 pF, 10%/90%, R <sub>pu</sub> on D+	4	20	ns

### 5.10.7 Universal Parallel Port (uPP) Interface

The uPP interface is a high-speed parallel interface with dedicated data lines and minimal control signals. The uPP interface is designed to interface cleanly with high-speed ADCs or DACs with 8-bit data width. It can also be interconnected with field-programmable gate arrays (FPGAs) or other uPP devices to achieve high-speed digital data transfer. It can operate in receive mode or transmit mode (simplex mode).

The uPP interface includes an internal DMA controller to maximize throughput and minimize CPU overhead during high-speed data transmission. All uPP transactions use internal DMA to feed data to or retrieve data from the I/O channels. Even though there is only one I/O channel, the DMA controller includes two DMA channels to support data interleave mode, in which all DMA resources service a single I/O channel.

On this device, the uPP interface is the dedicated resource for the CPU1 subsystem. CPU1, CPU1.CLA1, and CPU1.DMA have access to this module. Two dedicated 512-byte data RAMs (also known as MSG RAMs) are tightly coupled with the uPP module (one for each, TX and RX). These data RAMs are used to store the bulk of data to avoid frequent interruptions to the CPU. Only CPU1 and CPU1.CLA1 have access to these data RAMs. 图 5-76 shows the integration of the uPP on this device.

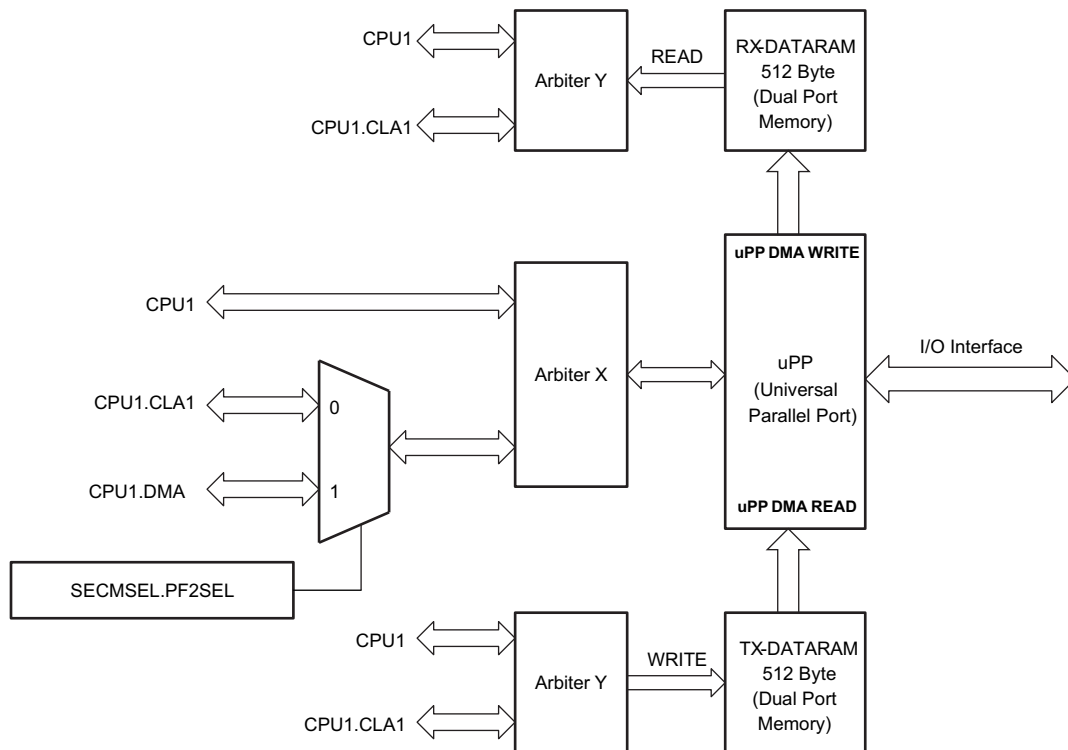


图 5-76. uPP Integration

注

On some TI devices, the uPP module is also called the Radio Peripheral Interface (RPI) module.

The uPP interface supports the following:

- Mainstream high-speed data converters with parallel conversion interface.
- Mainstream high-speed streaming interface with frame START indication.
- Mainstream high-speed streaming interface with data ENABLE indication.
- Mainstream high-speed streaming interface with synchronization WAIT signal.
- SDR (single-data-rate) or DDR (double-data-rate, interleaved) interface.
- Multiplexing of interleaved data in SDR transmit case.
- Demultiplexing and multiplexing of interleaved data in DDR case.
- I/O interface clock frequency up to 50 MHz for SDR, and 25 MHz for DDR.
- Single-channel 8-bit input receive or output transmit mode.
- Max throughput is 50MB/s for pure read or pure write.
- Available as a DSP to FPGA general-purpose streaming interface.

图 5-77 shows the uPP functional block diagram.

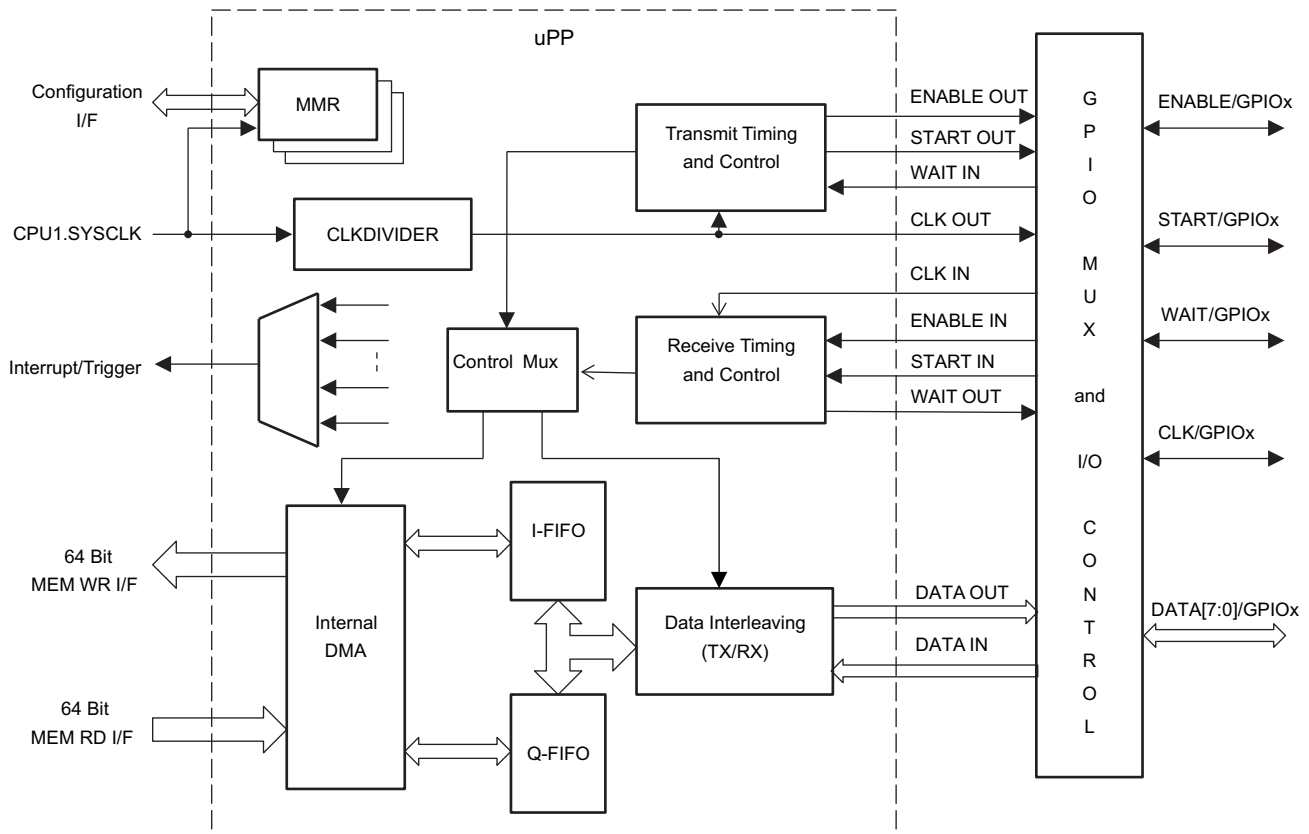


图 5-77. uPP Functional Block Diagram

### 5.10.7.1 uPP Electrical Data and Timing

Table 5-91 shows the uPP timing requirements. Table 5-92 shows the uPP switching characteristics. Figure 5-78 through Figure 5-81 show the uPP timing diagrams.

**Table 5-91. uPP Timing Requirements**

NO.			MIN	MAX	UNIT
1	$t_{c(CLK)}$	Cycle time, CLK	SDR mode	20	ns
			DDR mode	40	
2	$t_{w(CLKH)}$	Pulse width, CLK high	SDR mode	8	ns
			DDR mode	18	
3	$t_{w(CLKL)}$	Pulse width, CLK low	SDR mode	8	ns
			DDR mode	18	
4	$t_{su(STV-CLKH)}$	Setup time, START valid before CLK high	4		ns
5	$t_{h(CLKH-STV)}$	Hold time, START valid after CLK high	0.8		ns
6	$t_{su(ENV-CLKH)}$	Setup time, ENABLE valid before CLK high	4		ns
7	$t_{h(CLKH-ENV)}$	Hold time, ENABLE valid after CLK high	0.8		ns
8	$t_{su(DV-CLKH)}$	Setup time, DATA valid before CLK high	4		ns
9	$t_{h(CLKH-DV)}$	Hold time, DATA valid after CLK high	0.8		ns
10	$t_{su(DV-CLKL)}$	Setup time, DATA valid before CLK low	4		ns
11	$t_{h(CLKL-DV)}$	Hold time, DATA valid after CLK low	0.8		ns
19	$t_{su(WTV-CLKH)}$	Setup time, WAIT valid before CLK high	SDR mode	20	ns
20	$t_{h(CLKH-WTV)}$	Hold time, WAIT valid after CLK high	SDR mode	0	ns
21	$t_{su(WTV-CLKL)}$	Setup time, WAIT valid before CLK low	DDR mode	20	ns
22	$t_{h(CLKL-WTV)}$	Hold time, WAIT valid after CLK low	DDR mode	0	ns

**Table 5-92. uPP Switching Characteristics**

over recommended operating conditions (unless otherwise noted)

NO.	PARAMETER		MIN	MAX	UNIT
12	$t_{c(CLK)}$	Cycle time, CLK	SDR mode	20	ns
			DDR mode	40	
13	$t_{w(CLKH)}$	Pulse width, CLK high	SDR mode	8	ns
			DDR mode	18	
14	$t_{w(CLKL)}$	Pulse width, CLK low	SDR mode	8	ns
			DDR mode	18	
15	$t_{d(CLKH-STV)}$	Delay time, START valid after CLK high	3	12	ns
16	$t_{d(CLKH-ENV)}$	Delay time, ENABLE valid after CLK high	3	12	ns
17	$t_{d(CLKH-DV)}$	Delay time, DATA valid after CLK high	3	12	ns
18	$t_{d(CLKL-DV)}$	Delay time, DATA valid after CLK low	3	12	ns

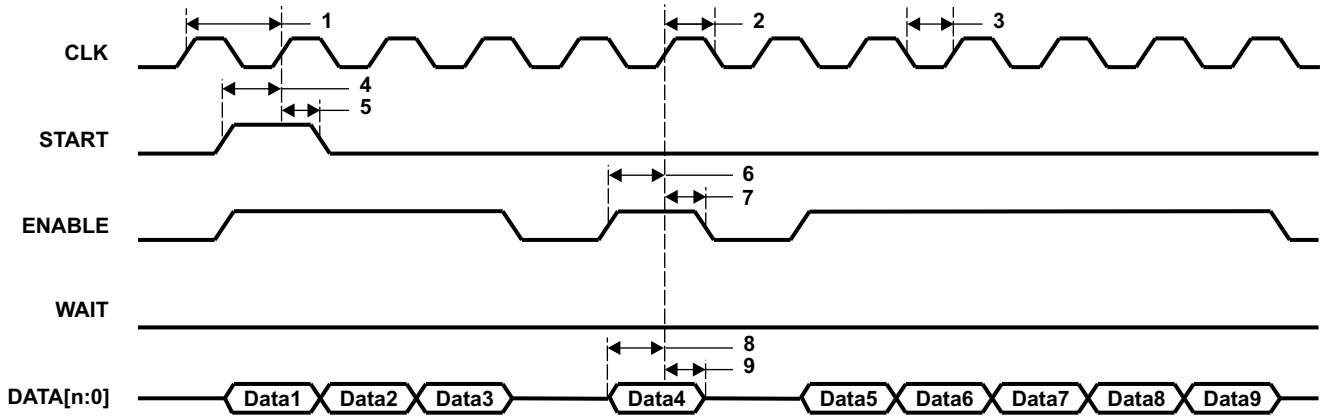


Figure 5-78. uPP Single Data Rate (SDR) Receive Timing

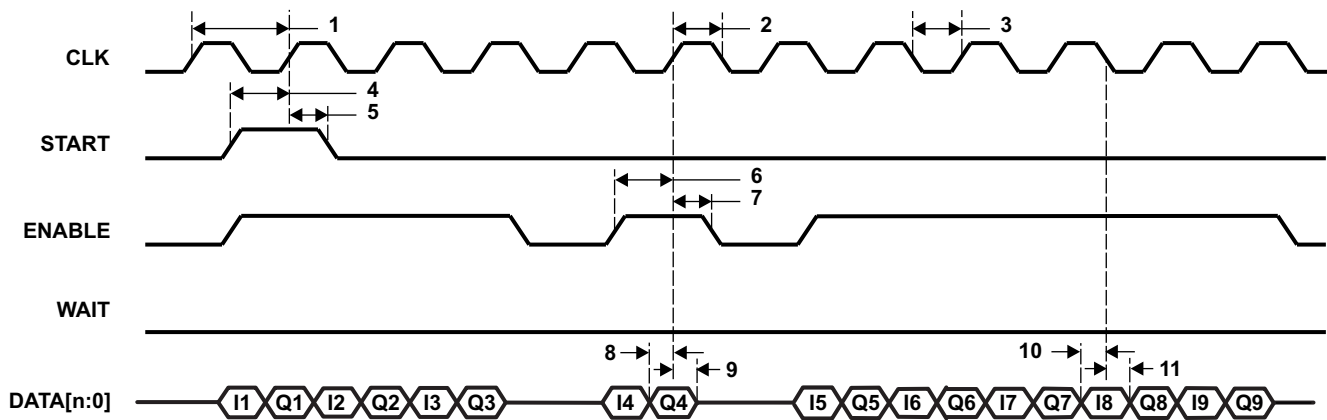


Figure 5-79. uPP Double Data Rate (DDR) Receive Timing

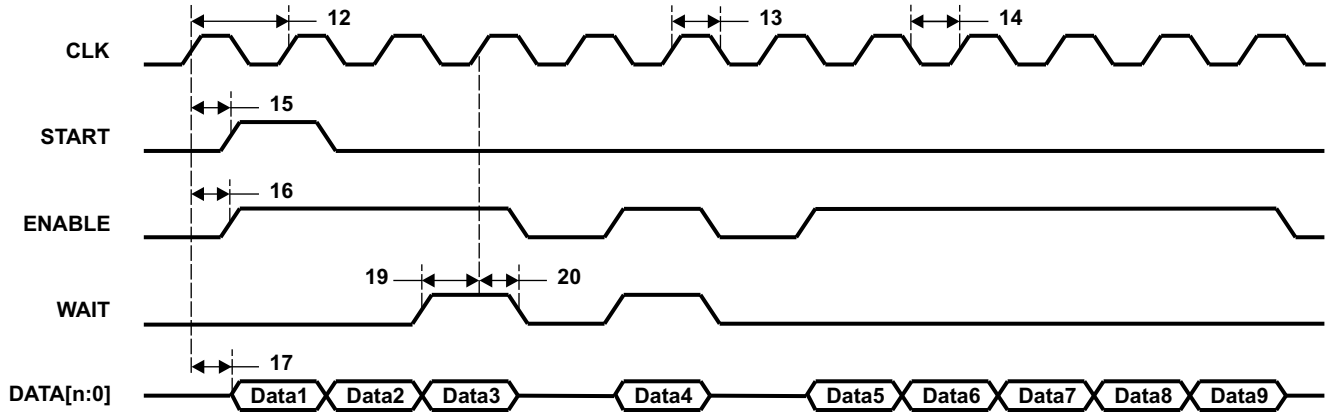


Figure 5-80. uPP Single Data Rate (SDR) Transmit Timing

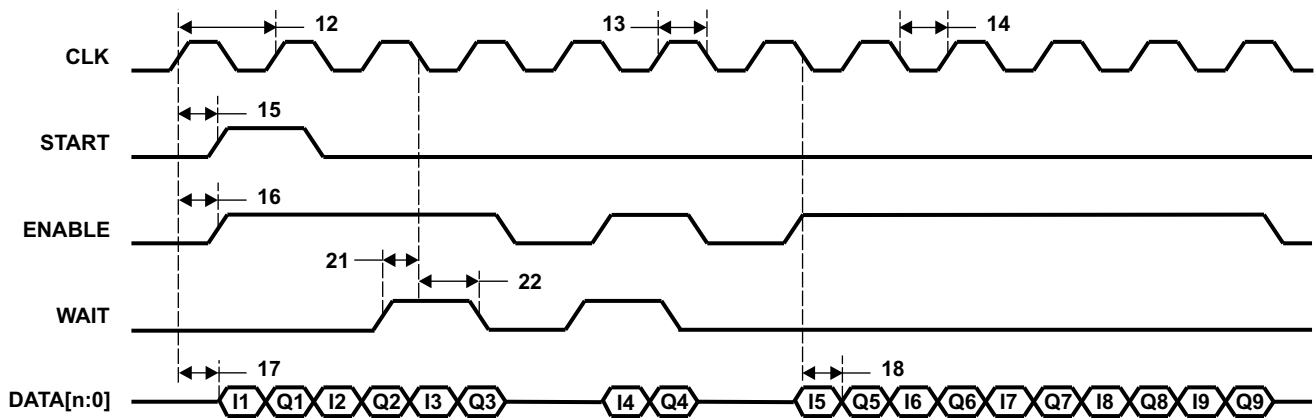


Figure 5-81. uPP Double Data Rate (DDR) Transmit Timing



## 6 Detailed Description

### 6.1 Overview

The Delfino TMS320F2837xD is a powerful 32-bit floating-point microcontroller unit (MCU) designed for advanced closed-loop control applications such as [industrial drives and servo motor control](#); [solar inverters and converters](#); [digital power](#); [transportation](#); and [power line communications](#). Complete development packages for digital power and industrial drives are available as part of the [powerSUITE](#) and [DesignDRIVE](#) initiatives. While the Delfino product line is not new to the TMS320C2000 portfolio, the F2837xD supports a new dual-core C28x architecture that significantly boosts system performance. The integrated analog and control peripherals also let designers consolidate control architectures and eliminate multiprocessor use in high-end systems.

The dual real-time control subsystems are based on TI's 32-bit C28x floating-point CPUs, which provide 200 MHz of signal processing performance in each core. The C28x CPUs are further boosted by the new TMU accelerator, which enables fast execution of algorithms with trigonometric operations common in transforms and torque loop calculations; and the VCU accelerator, which reduces the time for complex math operations common in encoded applications.

The F2837xD microcontroller family features two CLA real-time control co-processors. The CLA is an independent 32-bit floating-point processor that runs at the same speed as the main CPU. The CLA responds to peripheral triggers and executes code concurrently with the main C28x CPU. This parallel processing capability can effectively double the computational performance of a real-time control system. By using the CLA to service time-critical functions, the main C28x CPU is free to perform other tasks, such as communications and diagnostics. The dual C28x+CLA architecture enables intelligent partitioning between various system tasks. For example, one C28x+CLA core can be used to track speed and position, while the other C28x+CLA core can be used to control torque and current loops.

The TMS320F2837xD supports up to 1MB (512KW) of onboard flash memory with error correction code (ECC) and up to 204KB (102KW) of SRAM. Two 128-bit secure zones are also available on each CPU for code protection.

Performance analog and control peripherals are also integrated on the F2837xD MCU to further enable system consolidation. Four independent 16-bit ADCs provide precise and efficient management of multiple analog signals, which ultimately boosts system throughput. The new sigma-delta filter module (SDFM) works in conjunction with the sigma-delta modulator to enable isolated current shunt measurements. The Comparator Subsystem (CMPSS) with windowed comparators allows for protection of power stages when current limit conditions are exceeded or not met. Other analog and control peripherals include DACs, PWMs, eCAPs, eQEPs, and other peripherals.

The Configurable Logic Block (CLB) lets TI offer additional interfacing and control features for select C2000 devices. See [Table 3-1](#) for the devices that support the CLB feature.

Peripherals such as EMIFs, CAN modules (ISO11898-1/CAN 2.0B-compliant), and a new uPP interface extend the connectivity of the F2837xD. The uPP interface is a new feature of the C2000 MCUs and supports high-speed parallel connection to FPGAs or other processors with similar uPP interfaces. Lastly, a USB 2.0 port with MAC and PHY lets users easily add universal serial bus (USB) connectivity to their application.

### 6.2 Functional Block Diagram

 **图 6-1** shows the CPU system and associated peripherals.

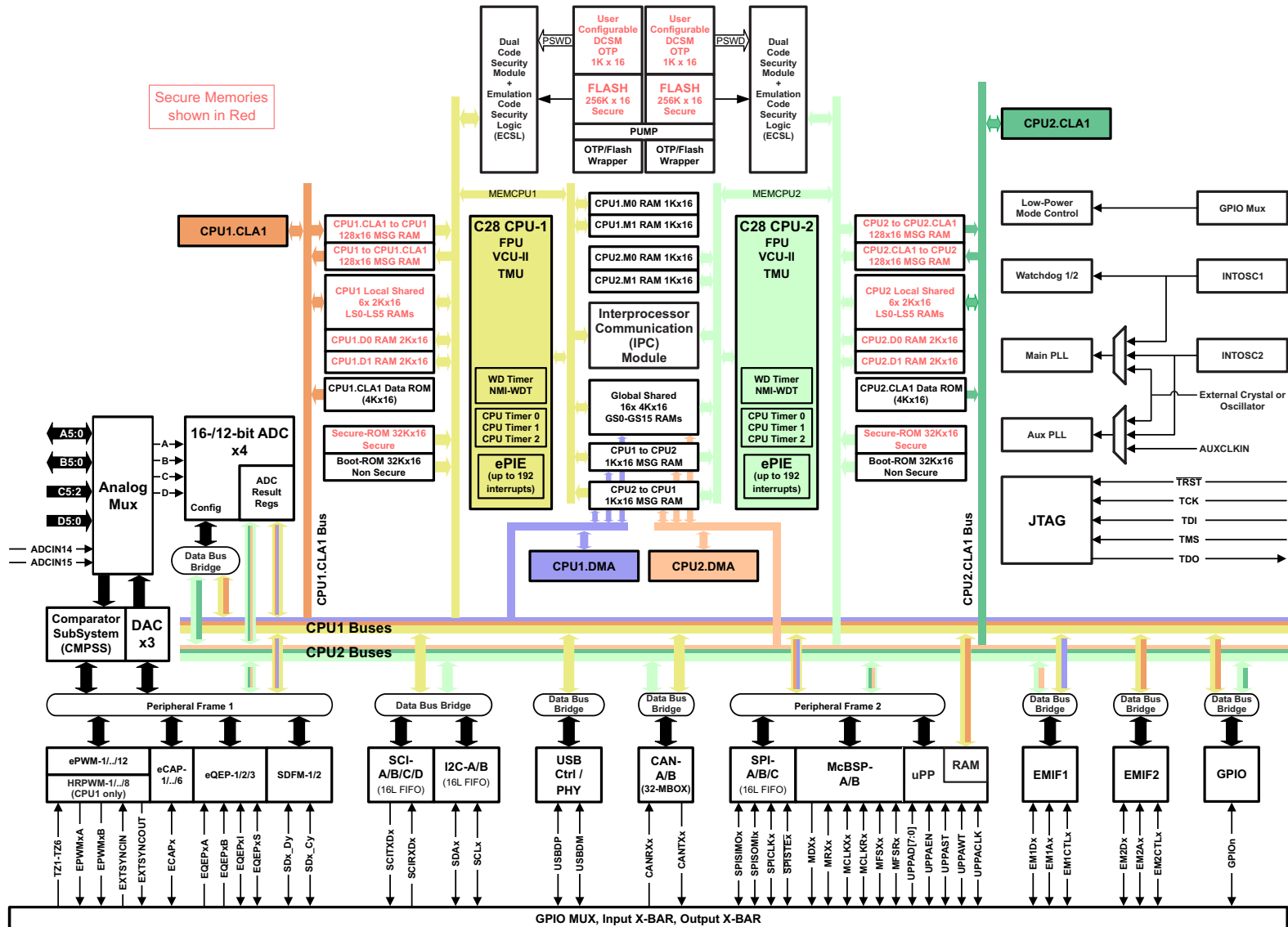


图 6-1. Functional Block Diagram

## 6.3 Memory

### 6.3.1 C28x Memory Map

Both C28x CPUs on the device have the same memory map except where noted in 表 6-1. The GSx\_RAM (Global Shared RAM) should be assigned to either CPU by the GSxMSEL register. Memories accessible by the CLA or DMA (direct memory access) are noted as well.

表 6-1. C28x Memory Map

MEMORY	SIZE	START ADDRESS	END ADDRESS	CLA ACCESS	DMA ACCESS
M0 RAM	1K x 16	0x0000 0000	0x0000 03FF		
M1 RAM	1K x 16	0x0000 0400	0x0000 07FF		
PieVectTable	512 x 16	0x0000 0D00	0x0000 0EFF		
CPUx.CLA1 to CPUx MSGRAM	128 x 16	0x0000 1480	0x0000 14FF	Yes	
CPUx to CPUx.CLA1 MSGRAM	128 x 16	0x0000 1500	0x0000 157F	Yes	
UPP TX MSG RAM	512 x 16	0x0000 6C00	0x0000 6DFF	Yes	
UPP RX MSG RAM	512 x 16	0x0000 6E00	0x0000 6FFF	Yes	
LS0 RAM	2K x 16	0x0000 8000	0x0000 87FF	Yes	
LS1 RAM	2K x 16	0x0000 8800	0x0000 8FFF	Yes	
LS2 RAM	2K x 16	0x0000 9000	0x0000 97FF	Yes	
LS3 RAM	2K x 16	0x0000 9800	0x0000 9FFF	Yes	
LS4 RAM	2K x 16	0x0000 A000	0x0000 A7FF	Yes	
LS5 RAM	2K x 16	0x0000 A800	0x0000 AFFF	Yes	
D0 RAM	2K x 16	0x0000 B000	0x0000 B7FF		
D1 RAM	2K x 16	0x0000 B800	0x0000 BFFF		
GS0 RAM <sup>(1)</sup>	4K x 16	0x0000 C000	0x0000 CFFF		Yes
GS1 RAM <sup>(1)</sup>	4K x 16	0x0000 D000	0x0000 DFFF		Yes
GS2 RAM <sup>(1)</sup>	4K x 16	0x0000 E000	0x0000 EFFF		Yes
GS3 RAM <sup>(1)</sup>	4K x 16	0x0000 F000	0x0000 FFFF		Yes
GS4 RAM <sup>(1)</sup>	4K x 16	0x0001 0000	0x0001 0FFF		Yes
GS5 RAM <sup>(1)</sup>	4K x 16	0x0001 1000	0x0001 1FFF		Yes
GS6 RAM <sup>(1)</sup>	4K x 16	0x0001 2000	0x0001 2FFF		Yes
GS7 RAM <sup>(1)</sup>	4K x 16	0x0001 3000	0x0001 3FFF		Yes
GS8 RAM <sup>(1)</sup>	4K x 16	0x0001 4000	0x0001 4FFF		Yes
GS9 RAM <sup>(1)</sup>	4K x 16	0x0001 5000	0x0001 5FFF		Yes
GS10 RAM <sup>(1)</sup>	4K x 16	0x0001 6000	0x0001 6FFF		Yes
GS11 RAM <sup>(1)</sup>	4K x 16	0x0001 7000	0x0001 7FFF		Yes
GS12 RAM <sup>(1)(2)</sup>	4K x 16	0x0001 8000	0x0001 8FFF		Yes
GS13 RAM <sup>(1)(2)</sup>	4K x 16	0x0001 9000	0x0001 9FFF		Yes
GS14 RAM <sup>(1)(2)</sup>	4K x 16	0x0001 A000	0x0001 AFFF		Yes
GS15 RAM <sup>(1)(2)</sup>	4K x 16	0x0001 B000	0x0001 BFFF		Yes
CPU2 to CPU1 MSGRAM <sup>(1)</sup>	1K x 16	0x0003 F800	0x0003 FBFF		Yes
CPU1 to CPU2 MSGRAM <sup>(1)</sup>	1K x 16	0x0003 FC00	0x0003 FFFF		Yes
CAN A Message RAM <sup>(1)</sup>	2K x 16	0x0004 9000	0x0004 97FF		
CAN B Message RAM <sup>(1)</sup>	2K x 16	0x0004 B000	0x0004 B7FF		
Flash	256K x 16	0x0008 0000	0x000B FFFF		
Secure ROM	32K x 16	0x003F 0000	0x003F 7FFF		
Boot ROM	32K x 16	0x003F 8000	0x003F FFBF		
Vectors	64 x 16	0x003F FFC0	0x003F FFFF		

(1) Shared between CPU subsystems.

(2) Available only on F28379D, F28377D, and F28375D.

### 6.3.2 Flash Memory Map

On the F28379D, F28377D, and F28375D devices, each CPU has its own flash bank [512KB (256KW)], the total flash for each device is 1MB (512KW). Only one bank can be programmed or erased at a time and the code to program the flash should be executed out of RAM. 表 6-2 shows the addresses of flash sectors on CPU1 and CPU2 for F28379D, F28377D, and F28375D.

**表 6-2. Addresses of Flash Sectors on CPU1 and CPU2 for F28379D, F28377D, and F28375D**

SECTOR	SIZE	START ADDRESS	END ADDRESS
<b>OTP Sectors</b>			
TI OTP	1K x 16	0x0007 0000	0x0007 03FF
User configurable DCSM OTP	1K x 16	0x0007 8000	0x0007 83FF
<b>Sectors</b>			
Sector A	8K x 16	0x0008 0000	0x0008 1FFF
Sector B	8K x 16	0x0008 2000	0x0008 3FFF
Sector C	8K x 16	0x0008 4000	0x0008 5FFF
Sector D	8K x 16	0x0008 6000	0x0008 7FFF
Sector E	32K x 16	0x0008 8000	0x0008 FFFF
Sector F	32K x 16	0x0009 0000	0x0009 7FFF
Sector G	32K x 16	0x0009 8000	0x0009 FFFF
Sector H	32K x 16	0x000A 0000	0x000A 7FFF
Sector I	32K x 16	0x000A 8000	0x000A FFFF
Sector J	32K x 16	0x000B 0000	0x000B 7FFF
Sector K	8K x 16	0x000B 8000	0x000B 9FFF
Sector L	8K x 16	0x000B A000	0x000B BFFF
Sector M	8K x 16	0x000B C000	0x000B DFFF
Sector N	8K x 16	0x000B E000	0x000B FFFF
<b>Flash ECC Locations</b>			
TI OTP ECC	128 x 16	0x0107 0000	0x0107 007F
User-configurable DCSM OTP ECC	128 x 16	0x0107 1000	0x0107 107F
Flash ECC	32K x 16	0x0108 0000	0x0108 7FFF

On the F28376D and F28374D devices, each CPU has its own flash bank [256KB (128KW)], the total flash for each device is 512KB (256KW). Only one bank can be programmed or erased at a time and the code to program the flash should be executed out of RAM. 表 6-3 shows the addresses of flash sectors on CPU1 and CPU2 for F28376D and F28374D.

**表 6-3. Addresses of Flash Sectors on CPU1 and CPU2 for F28376D and F28374D**

SECTOR	SIZE	START ADDRESS	END ADDRESS
<b>OTP Sectors</b>			
TI OTP	1K x 16	0x0007 0000	0x0007 03FF
User configurable DCSM OTP	1K x 16	0x0007 8000	0x0007 83FF
<b>Sectors</b>			
Sector A	8K x 16	0x0008 0000	0x0008 1FFF
Sector B	8K x 16	0x0008 2000	0x0008 3FFF
Sector C	8K x 16	0x0008 4000	0x0008 5FFF
Sector D	8K x 16	0x0008 6000	0x0008 7FFF
Sector E	32K x 16	0x0008 8000	0x0008 FFFF
Sector F	32K x 16	0x0009 0000	0x0009 7FFF
Sector G	32K x 16	0x0009 8000	0x0009 FFFF
<b>Flash ECC Locations</b>			
TI OTP ECC	128 x 16	0x0107 0000	0x0107 007F
User-configurable DCSM OTP ECC	128 x 16	0x0107 1000	0x0107 107F
Flash ECC	16K x16	0x0108 0000	0x0108 3FFF

### 6.3.3 EMIF Chip Select Memory Map

The EMIF1 memory map is the same for both CPU subsystems. EMIF2 is available only on the CPU1 subsystem. The EMIF memory map is shown in [表 6-4](#).

**表 6-4. EMIF Chip Select Memory Map**

EMIF CHIP SELECT	SIZE	START ADDRESS	END ADDRESS	CLA ACCESS	DMA ACCESS
EMIF1_CS0n - Data	256M x 16	0x8000 0000	0x8FFF FFFF		Yes
EMIF1_CS2n - Program + Data	2M x 16	0x0010 0000	0x002F FFFF		Yes
EMIF1_CS3n - Program + Data	512K x 16	0x0030 0000	0x0037 FFFF		Yes
EMIF1_CS4n - Program + Data	393K x 16	0x0038 0000	0x003D FFFF		Yes
EMIF2_CS0n - Data <sup>(1)</sup>	64M x 16	0x9000 0000	0x93FF FFFF		
EMIF2_CS2n - Program + Data <sup>(1)</sup>	4K x 16	0x0000 2000	0x0000 2FFF	Yes (Data only)	

(1) Available only on the CPU1 subsystem.

### 6.3.4 Peripheral Registers Memory Map

The peripheral registers memory map can be found in [表 6-5](#). The peripheral registers can be assigned to either the CPU1 or CPU2 subsystems except where noted in [表 6-5](#). Registers in the peripheral frames share a secondary master (CLA or DMA) selection with all other registers within the same peripheral frame. See the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)* for details on the CPU subsystem and secondary master selection.

**表 6-5. Peripheral Registers Memory Map**

REGISTERS	STRUCTURE NAME	START ADDRESS	END ADDRESS	CLA ACCESS	DMA ACCESS
AdcaResultRegs	ADC_RESULT_REGS	0x0000 0B00	0x0000 0B1F	Yes	Yes
AdcbResultRegs	ADC_RESULT_REGS	0x0000 0B20	0x0000 0B3F	Yes	Yes
AdccResultRegs	ADC_RESULT_REGS	0x0000 0B40	0x0000 0B5F	Yes	Yes
AdcdResultRegs	ADC_RESULT_REGS	0x0000 0B60	0x0000 0B7F	Yes	Yes
CpuTimer0Regs <sup>(1)</sup>	CPUTIMER_REGS	0x0000 0C00	0x0000 0C07		
CpuTimer1Regs <sup>(1)</sup>	CPUTIMER_REGS	0x0000 0C08	0x0000 0C0F		
CpuTimer2Regs <sup>(1)</sup>	CPUTIMER_REGS	0x0000 0C10	0x0000 0C17		
PieCtrlRegs <sup>(1)</sup>	PIE_CTRL_REGS	0x0000 0CE0	0x0000 0CFF		
Cla1SoftIntRegs	CLA_SOFTINT_REGS	0x0000 0CE0	0x0000 0CFF	Yes – CLA only, no CPU access	
DmaRegs <sup>(1)</sup>	DMA_REGS	0x0000 1000	0x0000 11FF		
Cla1Regs <sup>(1)</sup>	CLA_REGS	0x0000 1400	0x0000 147F		
<b>Peripheral Frame 1</b>					
EPwm1Regs	EPWM_REGS	0x0000 4000	0x0000 40FF	Yes	Yes
EPwm2Regs	EPWM_REGS	0x0000 4100	0x0000 41FF	Yes	Yes
EPwm3Regs	EPWM_REGS	0x0000 4200	0x0000 42FF	Yes	Yes
EPwm4Regs	EPWM_REGS	0x0000 4300	0x0000 43FF	Yes	Yes
EPwm5Regs	EPWM_REGS	0x0000 4400	0x0000 44FF	Yes	Yes
EPwm6Regs	EPWM_REGS	0x0000 4500	0x0000 45FF	Yes	Yes
EPwm7Regs	EPWM_REGS	0x0000 4600	0x0000 46FF	Yes	Yes
EPwm8Regs	EPWM_REGS	0x0000 4700	0x0000 47FF	Yes	Yes
EPwm9Regs	EPWM_REGS	0x0000 4800	0x0000 48FF	Yes	Yes
EPwm10Regs	EPWM_REGS	0x0000 4900	0x0000 49FF	Yes	Yes
EPwm11Regs	EPWM_REGS	0x0000 4A00	0x0000 4AFF	Yes	Yes
EPwm12Regs	EPWM_REGS	0x0000 4B00	0x0000 4BFF	Yes	Yes

表 6-5. Peripheral Registers Memory Map (continued)

REGISTERS	STRUCTURE NAME	START ADDRESS	END ADDRESS	CLA ACCESS	DMA ACCESS
ECap1Regs	ECAP_REGS	0x0000 5000	0x0000 501F	Yes	Yes
ECap2Regs	ECAP_REGS	0x0000 5020	0x0000 503F	Yes	Yes
ECap3Regs	ECAP_REGS	0x0000 5040	0x0000 505F	Yes	Yes
ECap4Regs	ECAP_REGS	0x0000 5060	0x0000 507F	Yes	Yes
ECap5Regs	ECAP_REGS	0x0000 5080	0x0000 509F	Yes	Yes
ECap6Regs	ECAP_REGS	0x0000 50A0	0x0000 50BF	Yes	Yes
EQep1Regs	EQEP_REGS	0x0000 5100	0x0000 513F	Yes	Yes
EQep2Regs	EQEP_REGS	0x0000 5140	0x0000 517F	Yes	Yes
EQep3Regs	EQEP_REGS	0x0000 5180	0x0000 51BF	Yes	Yes
DacaRegs	DAC_REGS	0x0000 5C00	0x0000 5C0F	Yes	Yes
DacbRegs	DAC_REGS	0x0000 5C10	0x0000 5C1F	Yes	Yes
DaccRegs	DAC_REGS	0x0000 5C20	0x0000 5C2F	Yes	Yes
Cmpss1Regs	CMPSS_REGS	0x0000 5C80	0x0000 5C9F	Yes	Yes
Cmpss2Regs	CMPSS_REGS	0x0000 5CA0	0x0000 5CBF	Yes	Yes
Cmpss3Regs	CMPSS_REGS	0x0000 5CC0	0x0000 5CDF	Yes	Yes
Cmpss4Regs	CMPSS_REGS	0x0000 5CE0	0x0000 5CFF	Yes	Yes
Cmpss5Regs	CMPSS_REGS	0x0000 5D00	0x0000 5D1F	Yes	Yes
Cmpss6Regs	CMPSS_REGS	0x0000 5D20	0x0000 5D3F	Yes	Yes
Cmpss7Regs	CMPSS_REGS	0x0000 5D40	0x0000 5D5F	Yes	Yes
Cmpss8Regs	CMPSS_REGS	0x0000 5D60	0x0000 5D7F	Yes	Yes
Sdfm1Regs	SDFM_REGS	0x0000 5E00	0x0000 5E7F	Yes	Yes
Sdfm2Regs	SDFM_REGS	0x0000 5E80	0x0000 5EFF	Yes	Yes
<b>Peripheral Frame 2</b>					
McbspaRegs	MCBSP_REGS	0x0000 6000	0x0000 603F	Yes	Yes
McbspbRegs	MCBSP_REGS	0x0000 6040	0x0000 607F	Yes	Yes
SpiaRegs	SPI_REGS	0x0000 6100	0x0000 610F	Yes	Yes
SpibRegs	SPI_REGS	0x0000 6110	0x0000 611F	Yes	Yes
SpicRegs	SPI_REGS	0x0000 6120	0x0000 612F	Yes	Yes
UppRegs <sup>(2)</sup>	UPP_REGS	0x0000 6200	0x0000 62FF	Yes	Yes
<b>Peripheral Frame 3</b>					
WdRegs <sup>(1)</sup>	WD_REGS	0x0000 7000	0x0000 703F		
NmiIntruptRegs <sup>(1)</sup>	NMI_INTRUPT_REGS	0x0000 7060	0x0000 706F		
XintRegs <sup>(1)</sup>	XINT_REGS	0x0000 7070	0x0000 707F		
SciaRegs	SCI_REGS	0x0000 7200	0x0000 720F		
ScibRegs	SCI_REGS	0x0000 7210	0x0000 721F		
ScicRegs	SCI_REGS	0x0000 7220	0x0000 722F		
ScidRegs	SCI_REGS	0x0000 7230	0x0000 723F		
I2caRegs	I2C_REGS	0x0000 7300	0x0000 733F		
I2cbRegs	I2C_REGS	0x0000 7340	0x0000 737F		
AdcaRegs	ADC_REGS	0x0000 7400	0x0000 747F	Yes	
AdcbRegs	ADC_REGS	0x0000 7480	0x0000 74FF	Yes	
AdccRegs	ADC_REGS	0x0000 7500	0x0000 757F	Yes	
AdcdRegs	ADC_REGS	0x0000 7580	0x0000 75FF	Yes	
InputXbarRegs <sup>(2)</sup>	INPUT_XBAR_REGS	0x0000 7900	0x0000 791F		
XbarRegs <sup>(2)</sup>	XBAR_REGS	0x0000 7920	0x0000 793F		
TrigRegs <sup>(2)</sup>	TRIG_REGS	0x0000 7940	0x0000 794F		
DmaClaSrcSelRegs <sup>(1)</sup>	DMA_CLA_SRC_SEL_REGS	0x0000 7980	0x0000 798F		

**表 6-5. Peripheral Registers Memory Map (continued)**

REGISTERS	STRUCTURE NAME	START ADDRESS	END ADDRESS	CLA ACCESS	DMA ACCESS
EPwmXbarRegs <sup>(2)</sup>	EPWM_XBAR_REGS	0x0000 7A00	0x0000 7A3F		
OutputXbarRegs <sup>(2)</sup>	OUTPUT_XBAR_REGS	0x0000 7A80	0x0000 7ABF		
GpioCtrlRegs <sup>(2)</sup>	GPIO_CTRL_REGS	0x0000 7C00	0x0000 7D7F		
GpioDataRegs <sup>(1)</sup>	GPIO_DATA_REGS	0x0000 7F00	0x0000 7F2F	Yes	
UsbaRegs <sup>(2)</sup>	USB_REGS	0x0004 0000	0x0004 0FFF		
Emif1Regs	EMIF_REGS	0x0004 7000	0x0004 77FF		
Emif2Regs <sup>(2)</sup>	EMIF_REGS	0x0004 7800	0x0004 7FFF		
CanaRegs	CAN_REGS	0x0004 8000	0x0004 87FF		
CanbRegs	CAN_REGS	0x0004 A000	0x0004 A7FF		
IpcRegs <sup>(1)</sup>	IPC_REGS_CPU1 IPC_REGS_CPU2	0x0005 0000	0x0005 0023		
FlashPumpSemaphoreRegs <sup>(1)</sup>	FLASH_PUMP_SEMAPHORE_REGS	0x0005 0024	0x0005 0025		
DevCfgRegs <sup>(2)</sup>	DEV_CFG_REGS	0x0005 D000	0x0005 D17F		
AnalogSubsysRegs <sup>(2)</sup>	ANALOG_SUBSYS_REGS	0x0005 D180	0x0005 D1FF		
ClkCfgRegs <sup>(3)</sup>	CLK_CFG_REGS	0x0005 D200	0x0005 D2FF		
CpuSysRegs <sup>(1)</sup>	CPU_SYS_REGS	0x0005 D300	0x0005 D3FF		
RomPrefetchRegs <sup>(2)</sup>	ROM_PREFETCH_REGS	0x0005 E608	0x0005 E60B		
DcsmZ1Regs <sup>(1)</sup>	DCSM_Z1_REGS	0x0005 F000	0x0005 F02F		
DcsmZ2Regs <sup>(1)</sup>	DCSM_Z2_REGS	0x0005 F040	0x0005 F05F		
DcsmCommonRegs <sup>(1)</sup>	DCSM_COMMON_REGS	0x0005 F070	0x0005 F07F		
MemCfgRegs <sup>(1)</sup>	MEM_CFG_REGS	0x0005 F400	0x0005 F47F		
Emif1ConfigRegs <sup>(1)</sup>	EMIF1_CONFIG_REGS	0x0005 F480	0x0005 F49F		
Emif2ConfigRegs <sup>(2)</sup>	EMIF2_CONFIG_REGS	0x0005 F4A0	0x0005 F4BF		
AccessProtectionRegs <sup>(1)</sup>	ACCESS_PROTECTION_REGS	0x0005 F4C0	0x0005 F4FF		
MemoryErrorRegs <sup>(1)</sup>	MEMORY_ERROR_REGS	0x0005 F500	0x0005 F53F		
RomWaitStateRegs <sup>(2)</sup>	ROM_WAIT_STATE_REGS	0x0005 F540	0x0005 F541		
Flash0CtrlRegs <sup>(1)</sup>	FLASH_CTRL_REGS	0x0005 F800	0x0005 FAFF		
Flash0EccRegs <sup>(1)</sup>	FLASH_ECC_REGS	0x0005 FB00	0x0005 FB3F		

(1) A unique copy of these registers exist on each CPU subsystem.

(2) These registers are available only on the CPU1 subsystem.

(3) These registers are mapped to either CPU1 or CPU2 based on a semaphore.



### 6.3.5 Memory Types

表 6-6 provides more information about each memory type.

表 6-6. Memory Types

MEMORY TYPE	ECC-CAPABLE	PARITY	SECURITY	HIBERNATE RETENTION	ACCESS PROTECTION
M0, M1	Yes	–	–	Yes	–
D0, D1	Yes	–	Yes	–	Yes
LSx	–	Yes	Yes	–	Yes
GSx	–	Yes	–	–	Yes
CPU/CLA MSGRAM	–	Yes	Yes	–	Yes
Boot ROM	–	–	–	N/A	–
Secure ROM	–	–	Yes	N/A	–
Flash	Yes	–	Yes	N/A	N/A
User-configurable DCSM OTP	Yes	–	Yes	N/A	N/A

#### 6.3.5.1 Dedicated RAM (Mx and Dx RAM)

The CPU subsystem has four dedicated ECC-capable RAM blocks: M0, M1, D0, and D1. M0/M1 memories are small nonsecure blocks that are tightly coupled with the CPU (that is, only the CPU has access to them). D0/D1 memories are secure blocks and also have the access-protection feature (CPU write/CPU fetch protection).

#### 6.3.5.2 Local Shared RAM (LSx RAM)

RAM blocks which are dedicated to each subsystem and are accessible to its CPU and CLA only, are called local shared RAMs (LSx RAMs).

All LSx RAM blocks have parity. These memories are secure and have the access protection (CPU write/CPU fetch) feature.

By default, these memories are dedicated to the CPU only, and the user could choose to share these memories with the CLA by configuring the MSEL\_LSx bit field in the LSxMSEL registers appropriately.

表 6-7 shows the master access for the LSx RAM.

表 6-7. Master Access for LSx RAM  
(With Assumption That all Other Access Protections are Disabled)

MSEL_LSx	CLAPGM_LSx	CPU ALLOWED ACCESS	CLA ALLOWED ACCESS	COMMENT
00	X	All	–	LSx memory is configured as CPU dedicated RAM.
01	0	All	Data Read Data Write	LSx memory is shared between CPU and CLA1.
01	1	Emulation Read Emulation Write	Fetch Only	LSx memory is CLA1 program memory.

### 6.3.5.3 Global Shared RAM (GSx RAM)

RAM blocks which are accessible from both the CPU and DMA are called global shared RAMs (GSx RAMs). Each shared RAM block can be owned by either CPU subsystem based on the configuration of respective bits in the GSxMSEL register.

All GSx RAM blocks have parity.

When a GSx RAM block is owned by a CPU subsystem, the CPUx and CPUx.DMA will have full access to that RAM block whereas the other CPUy and CPUy.DMA will only have read access (no fetch/write access).

表 6-8 shows the master access for the GSx RAM.

**表 6-8. Master Access for GSx RAM  
(With Assumption That all Other Access Protections are Disabled)**

GSxMSEL	CPU	INSTRUCTION FETCH	READ	WRITE	CPUx.DMA READ	CPUx.DMA WRITE
0	CPU1	Yes	Yes	Yes	Yes	Yes
	CPU2	–	Yes	–	Yes	–
1	CPU1	–	Yes	–	Yes	–
	CPU2	Yes	Yes	Yes	Yes	Yes

The GSx RAMs have access protection (CPU write/CPU fetch/DMA write).

### 6.3.5.4 CPU Message RAM (CPU MSGRAM)

These RAM blocks can be used to share data between CPU1 and CPU2. Since these RAMs are used for interprocessor communication, they are also called IPC RAMs. The CPU MSGRAMs have CPU/DMA read/write access from its own CPU subsystem, and CPU/DMA read only access from the other subsystem.

This RAM has parity.

### 6.3.5.5 CLA Message RAM (CLA MSGRAM)

These RAM blocks can be used to share data between the CPU and CLA. The CLA has read and write access to the "CLA to CPU MSGRAM". The CPU has read and write access to the "CPU to CLA MSGRAM". The CPU and CLA both have read access to both MSGRAMs.

This RAM has parity.

## 6.4 Identification

表 6-9 shows the Device Identification Registers.

表 6-9. Device Identification Registers

NAME	ADDRESS	SIZE (x16)	DESCRIPTION
PARTIDH	0x0005 D00A	2	Device part identification number
			TMS320F28379D            0x00F9 0300
			TMS320F28377D            0x00FF 0300
			TMS320F28376D            0x00FE 0300
			TMS320F28375D            0x00FD 0300
			TMS320F28374D            0x00FC 0300
REVID	0x0005 D00C	2	Silicon revision number
			Revision 0                    0x0000 0000
			Revision A                    0x0000 0000
			Revision B                    0x0000 0002
			Revision C                    0x0000 0003

## 6.5 Bus Architecture – Peripheral Connectivity

表 6-10 shows a broad view of the peripheral and configuration register accessibility from each bus master. Peripherals can be individually assigned to the CPU1 or CPU2 subsystem (for example, ePWM can be assigned to CPU1 and eQEP assigned to CPU2). Peripherals within peripheral frames 1 or 2 will all be mapped to the respective secondary master as a group (if SPI is assigned to CPUx.DMA, then McBSP is also assigned to CPUx.DMA).

**表 6-10. Bus Master Peripheral Access**

PERIPHERALS (BY BUS ACCESS TYPE)	CPU1.DMA	CPU1.CLA1	CPU1	CPU2	CPU2.CLA1	CPU2.DMA
<b>Peripherals that can be assigned to CPU1 or CPU2 and have common selectable Secondary Masters</b>						
Peripheral Frame 1: • ePWM • SDFM • eCAP <sup>(1)</sup> • eQEP <sup>(1)</sup> • CMPSS <sup>(1)</sup> • DAC <sup>(1)</sup>	Y	Y	Y	Y	Y	Y
Peripheral Frame 1: • HRPWM	Y	Y	Y			
Peripheral Frame 2: • SPI • McBSP • uPP Configuration on CPU1 subsystem only (but still within Peripheral Frame 1) <sup>(1)</sup>	Y	Y	Y	Y	Y	Y
<b>Peripherals that can be assigned to CPU1 or CPU2 subsystems</b>						
SCI			Y	Y		
I <sup>2</sup> C			Y	Y		
CAN			Y	Y		
ADC Configuration		Y	Y	Y	Y	
EMIF1	Y		Y	Y		Y
<b>Peripherals and Device Configuration Registers only on CPU1 subsystem</b>						
EMIF2		Y	Y			
USB			Y			
Device Capability, Peripheral Reset, Peripheral CPU Select			Y			
GPIO Pin Mapping and Configuration			Y			
Analog System Control			Y			
uPP Message RAMs		Y	Y			
Reset Configuration			Y			
<b>Accessible by only one CPU at a time with Semaphore</b>						
Clock and PLL Configuration			Y	Y		
<b>Peripherals and Registers with Unique Copies of Registers for each CPU and CLA Master<sup>(2)</sup></b>						
System Configuration (WD, NMIWD, LPM, Peripheral Clock Gating)			Y	Y		
Flash Configuration <sup>(3)</sup>			Y	Y		
CPU Timers			Y	Y		
DMA and CLA Trigger Source Select			Y	Y		
GPIO Data <sup>(4)</sup>		Y	Y	Y	Y	
ADC Results	Y	Y	Y	Y	Y	Y

(1) These modules are on a Peripheral Frame with DMA access; however, they cannot trigger a DMA transfer.

(2) Each CPUx and CPUx.CLA1 can only access its own copy of these registers.

(3) At any given time, only one CPU can perform program or erase operations on the Flash.

(4) The GPIO Data Registers are unique for each CPUx and CPUx.CLAx. When the GPIO Pin Mapping Register is configured to assign a GPIO to a particular master, the respective GPIO Data Register will control the GPIO. See the "General-Purpose Input/Output (GPIO)" chapter of the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual (SPRUHM8)* for more details.

## 6.6 C28x Processor

The CPU is a 32-bit fixed-point processor. This device draws from the best features of digital signal processing; reduced instruction set computing (RISC); and microcontroller architectures, firmware, and tool sets.

The CPU features include a modified Harvard architecture and circular addressing. The RISC features are single-cycle instruction execution, register-to-register operations, and modified Harvard architecture. The microcontroller features include ease of use through an intuitive instruction set, byte packing and unpacking, and bit manipulation. The modified Harvard architecture of the CPU enables instruction and data fetches to be performed in parallel. The CPU can read instructions and data while it writes data simultaneously to maintain the single-cycle instruction operation across the pipeline. The CPU does this over six separate address/data buses.

For more information on CPU architecture and instruction set, see the *TMS320C28x CPU and Instruction Set Reference Guide (SPRU430)*.

### 6.6.1 Floating-Point Unit

The C28x plus floating-point (C28x+FPU) processor extends the capabilities of the C28x fixed-point CPU by adding registers and instructions to support IEEE single-precision floating point operations.

Devices with the C28x+FPU include the standard C28x register set plus an additional set of floating-point unit registers. The additional floating-point unit registers are the following:

- Eight floating-point result registers, RnH (where n = 0–7)
- Floating-point Status Register (STF)
- Repeat Block Register (RB)

All of the floating-point registers, except the repeat block register, are shadowed. This shadowing can be used in high-priority interrupts for fast context save and restore of the floating-point registers.

For more information, see the *TMS320C28x Extended Instruction Sets Reference Guide (SPRUHS1)*.

### 6.6.2 Trigonometric Math Unit

The TMU extends the capabilities of a C28x+FPU by adding instructions and leveraging existing FPU instructions to speed up the execution of common trigonometric and arithmetic operations listed in [表 6-11](#).

**表 6-11. TMU Supported Instructions**

INSTRUCTIONS	C EQUIVALENT OPERATION	PIPELINE CYCLES
MPY2PIF32 RaH,RbH	$a = b * 2\pi$	2/3
DIV2PIF32 RaH,RbH	$a = b / 2\pi$	2/3
DIVF32 RaH,RbH,RcH	$a = b/c$	5
SQRTF32 RaH,RbH	$a = \text{sqrt}(b)$	5
SINPUF32 RaH,RbH	$a = \sin(b*2\pi)$	4
COSPUF32 RaH,RbH	$a = \cos(b*2\pi)$	4
ATANPUF32 RaH,RbH	$a = \text{atan}(b)/2\pi$	4
QUADF32 RaH,RbH,RcH,RdH	Operation to assist in calculating ATANPU2	5

No changes have been made to existing instructions, pipeline or memory bus architecture. All TMU instructions use the existing FPU register set (R0H to R7H) to carry out their operations. A detailed explanation of the workings of the FPU can be found in the *TMS320C28x Extended Instruction Sets Reference Guide (SPRUHS1)*.

### 6.6.3 Viterbi, Complex Math, and CRC Unit II (VCU-II)

The VCU-II is the second-generation Viterbi, Complex Math, and CRC extension to the C28x CPU. The VCU-II extends the capabilities of the C28x CPU by adding registers and instructions to accelerate the performance of FFTs and communications-based algorithms. The C28x+VCU-II supports the following algorithm types:

- **Viterbi Decoding**

Viterbi decoding is commonly used in baseband communications applications. The Viterbi decode algorithm consists of three main parts: branch metric calculations, compare-select (Viterbi butterfly), and a traceback operation. 表 6-12 shows a summary of the VCU performance for each of these operations.

**表 6-12. Viterbi Decode Performance**

VITERBI OPERATION	VCU CYCLES
Branch Metric Calculation (code rate = 1/2)	1
Branch Metric Calculation (code rate = 1/3)	2p
Viterbi Butterfly (add-compare-select)	2 <sup>(1)</sup>
Traceback per Stage	3 <sup>(2)</sup>

(1) C28x CPU takes 15 cycles per butterfly.

(2) C28x CPU takes 22 cycles per stage.

- **Cyclic Redundancy Check**

Cyclic redundancy check (CRC) algorithms provide a straightforward method for verifying data integrity over large data blocks, communication packets, or code sections. The C28x+VCU can perform 8-bit, 16-bit, 24-bit, and 32-bit CRCs. For example, the VCU can compute the CRC for a block length of 10 bytes in 10 cycles. A CRC result register contains the current CRC, which is updated whenever a CRC instruction is executed.

- **Complex Math**

Complex math is used in many applications, a few of which are:

- Fast Fourier Transform (FFT)

The complex FFT is used in spread spectrum communications, as well as in many signal processing algorithms.

- Complex filters

Complex filters improve data reliability, transmission distance, and power efficiency. The C28x+VCU can perform a complex I and Q multiply with coefficients (four multiplies) in a single cycle. In addition, the C28x+VCU can read/write the real and imaginary parts of 16-bit complex data to memory in a single cycle.

表 6-13 shows a summary of the VCU operations enabled by the VCU.

**表 6-13. Complex Math Performance**

COMPLEX MATH OPERATION	VCU CYCLES	NOTES
Add or Subtract	1	32 +/- 32 = 32-bit (Useful for filters)
Add or Subtract	1	16 +/- 32 = 15-bit (Useful for FFT)
Multiply	2p	16 x 16 = 32-bit
Multiply and Accumulate (MAC)	2p	32 + 32 = 32-bit, 16 x 16 = 32-bit
RPT MAC	2p+N	Repeat MAC. Single cycle after the first operation.

For more information, see the *TMS320C28x Extended Instruction Sets Reference Guide* ([SPRUHS1](#)).

## 6.7 Control Law Accelerator

The CLA is an independent single-precision (32-bit) FPU processor with its own bus structure, fetch mechanism, and pipeline. Eight individual CLA tasks can be specified. Each task is started by software or a peripheral such as the ADC, ePWM, eCAP, eQEP, or CPU Timer 0. The CLA executes one task at a time to completion. When a task completes, the main CPU is notified by an interrupt to the PIE and the CLA automatically begins the next highest-priority pending task. The CLA can directly access the ADC Result registers, ePWM, eCAP, eQEP, Comparator and DAC registers. Dedicated message RAMs provide a method to pass additional data between the main CPU and the CLA.

图 6-2 shows the CLA block diagram.

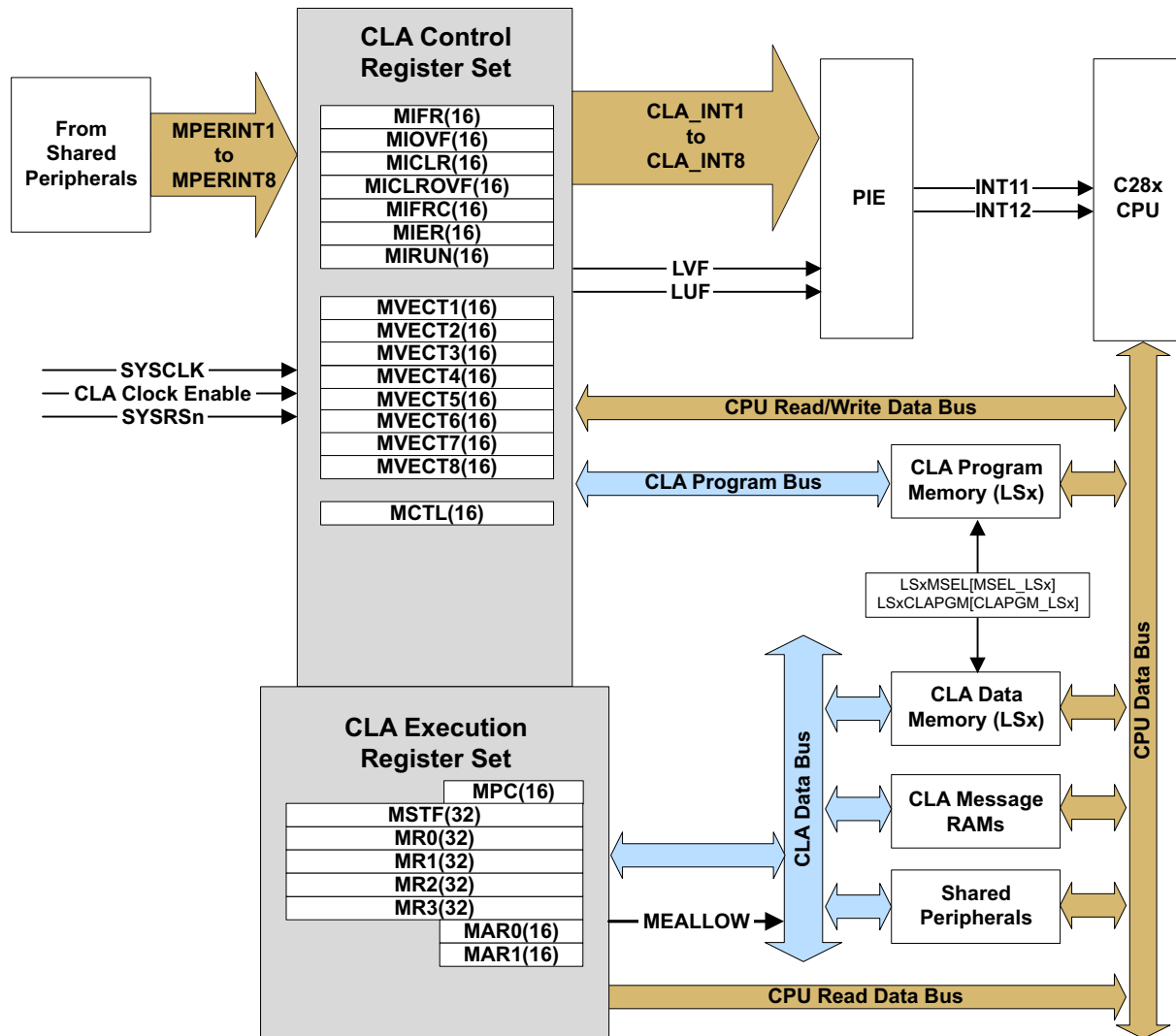


图 6-2. CLA Block Diagram

## 6.8 Direct Memory Access

Each CPU has its own 6-channel DMA module. The DMA module provides a hardware method of transferring data between peripherals and/or memory without intervention from the CPU, thereby freeing up bandwidth for other system functions. Additionally, the DMA has the capability to orthogonally rearrange the data as it is transferred as well as “ping-pong” data between buffers. These features are useful for structuring data into blocks for optimal CPU processing.

The DMA module is an event-based machine, meaning it requires a peripheral or software trigger to start a DMA transfer. Although it can be made into a periodic time-driven machine by configuring a timer as the interrupt trigger source, there is no mechanism within the module itself to start memory transfers periodically. The interrupt trigger source for each of the six DMA channels can be configured separately and each channel contains its own independent PIE interrupt to let the CPU know when a DMA transfer has either started or completed. Five of the six channels are exactly the same, while Channel 1 has the ability to be configured at a higher priority than the others.

DMA features include:

- Six channels with independent PIE interrupts
- Peripheral interrupt trigger sources
  - ADC interrupts and EVT signals
  - Multichannel buffered serial port transmit and receive
  - External interrupts
  - CPU timers
  - EPWMxSOC signals
  - SPIx transmit and receive
  - SDFM
  - Software trigger
- Data sources and destinations:
  - GSx RAM
  - CPU message RAM (IPC RAM)
  - ADC result registers
  - ePWMx
  - SPI
  - McBSP
  - EMIF
- Word Size: 16-bit or 32-bit (SPI and McBSP limited to 16-bit)
- Throughput: four cycles/word (without arbitration)



图 6-3 shows a device-level block diagram of the DMA.

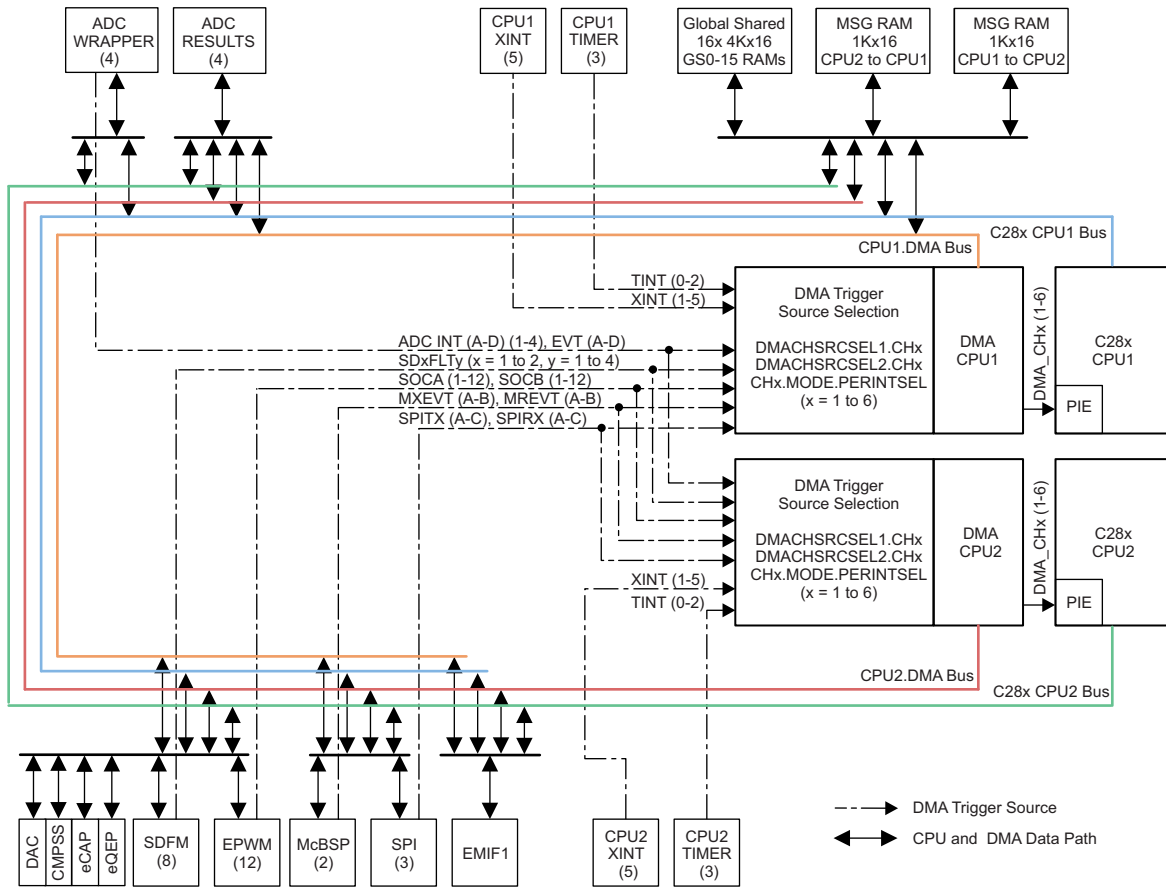


图 6-3. DMA Block Diagram

## 6.9 Interprocessor Communication Module

The IPC module supports several methods of interprocessor communication:

- Thirty-two IPC flags per CPU, which can be used to signal events or indicate status through software polling. Four flags per CPU can generate interrupts.
- Shared data registers, which can be used to send commands or other small pieces of information between CPUs. Although the register names were chosen to support a command/response system, they can be used for any purpose as defined in software.
- Boot mode and status registers, which allow CPU1 to control the CPU2 boot process.
- A general-purpose free-running 64-bit counter.
- Two shared message RAMs, which can be used to transfer bulk data. Each RAM can be read by both CPUs. CPU1 can write to one RAM and CPU2 can write to the other.

图 6-4 shows the IPC architecture.

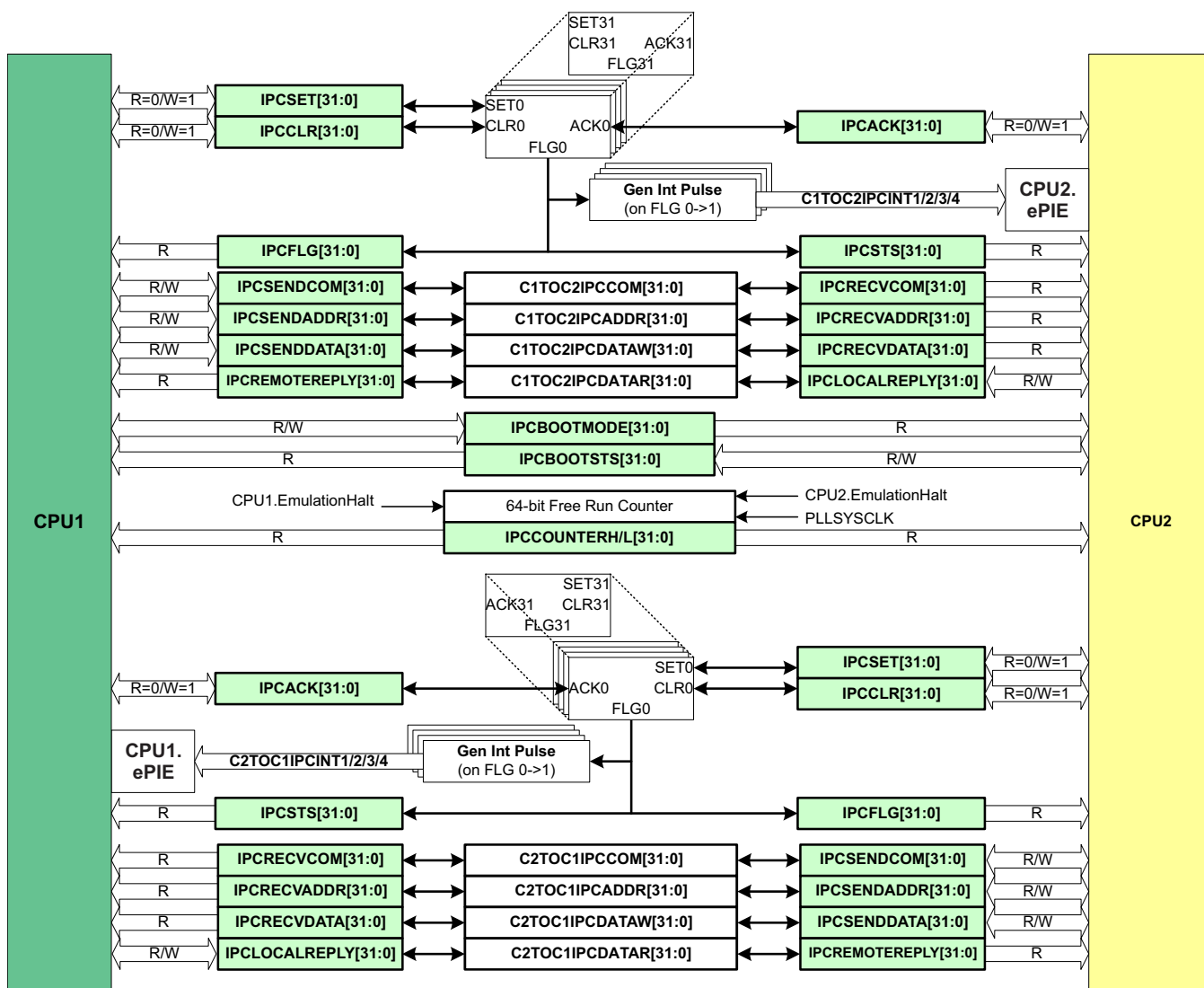


图 6-4. IPC Architecture

## 6.10 Boot ROM and Peripheral Booting

The device boot ROM (on both the CPUs) contains bootloading software. The CPU1 boot ROM does the system initialization before bringing CPU2 out of reset. The device boot ROM is executed each time the device comes out of reset. Users can configure the device to boot to flash (using GET mode) or choose to boot the device through one of the bootable peripherals by configuring the boot mode GPIO pins.

The CPU1 boot ROM, being master, owns the boot mode GPIO and boot configurations. The CPU2 boot ROM either boots to flash (if configured to do so through user configurable DCSM OTP) or enters a WAIT BOOT mode if no OTP is programmed. In WAIT BOOT mode, the CPU1 application instructs the CPU2 boot ROM on how to boot further using boot mode IPC commands supported by CPU2 boot ROM.

表 6-14 shows the possible boot modes supported on the device. The default boot mode pins are GPIO72 (boot mode pin 1) and GPIO 84 (boot mode pin 0). Users may choose to have weak pullups for boot mode pins if they use a peripheral on these pins as well, so the pullups can be overdriven. On this device, customers can change the factory default boot mode pins by programming user configurable DCSM OTP locations. This is recommended only for cases in which the factory default boot mode pins do not fit into the customer design. More details on the locations to be programmed is available in the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual* ([SPRUHM8](#)).

表 6-14. Device Boot Mode

MODE NO.	CPU1 BOOT MODE	CPU2 BOOT MODE	$\overline{\text{TRST}}$	GPIO72 (BOOT MODE PIN 1)	GPIO84 (BOOT MODE PIN 0)
0	Parallel IO	Boot from Master	0	0	0
1	SCI Mode	Boot from Master	0	0	1
2	Wait Boot Mode	Boot from master	0	1	0
3	Get Mode	Boot from Master	0	1	1
4-7	EMU Boot Mode (Emulator Connected)	Boot from Master	1	X	X

### 注

The default behavior of Get mode is boot-to-flash. On unprogrammed devices, using Get mode will result in repeated watchdog resets, which may prevent proper JTAG connection and device initialization. Use Wait mode or another boot mode for unprogrammed devices.

### CAUTION

Some reset sources are internally driven by the device. The user must ensure the pins used for boot mode are not actively driven by other devices in the system for these cases. The boot configuration has a provision for changing the boot pins in OTP. For more details, see the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual* ([SPRUHM8](#)).

### 6.10.1 EMU Boot or Emulation Boot

The CPU enters this boot when it detects that  $\overline{\text{TRST}}$  is HIGH (in other words, when an emulator/debugger is connected). In this mode, the user can program the EMUBOOTCTRL register (at location 0xD00) to instruct the device on how to boot. If the contents of the EMUBOOTCTRL locations are invalid, then the device would default into WAIT Boot mode. The emulation boot allows users to verify the device boot before programming the boot mode into OTP.

### 6.10.2 WAIT Boot Mode

The device in this boot mode loops in the boot ROM. This mode is useful if users want to connect a debugger on a secure device or if users do not want the device to execute an application in flash yet.

### 6.10.3 Get Mode

The default behavior of Get mode is boot-to-flash. This behavior can be changed by programming the Zx-OTPBOOTCTRL locations in user configurable DCSM OTP. The user configurable DCSM OTP on this device is divided in to two secure zones: Z1 and Z2. The Get mode function in boot ROM first checks if a valid OTPBOOTCTRL value is programmed in Z1. If the answer is yes, then the device boots as per the Z1-OTPBOOTCTRL location. The Z2-OTPBOOTCTRL location is read and decodes only if Z1-OTPBOOTCTRL is invalid or not programmed. If either Zx-OTPBOOTCTRL location is not programmed, then the device defaults to factory default operation, which is to use factory default boot mode pins to boot to flash if the boot mode pins are set to GET MODE. Users can choose the device through which to boot—SPI, I2C, CAN, and USB—by programming proper values into the user configurable DCSM OTP. More details on this can be found in the *TMS320F2837xD Dual-Core Delfino Microcontrollers Technical Reference Manual* ([SPRUHM8](#)).

### 6.10.4 Peripheral Pins Used by Bootloaders

表 6-15 shows the GPIO pins used by each peripheral bootloader. This device supports two sets of GPIOs for each mode, as shown in 表 6-15.

表 6-15. GPIO Pins Used by Each Peripheral Bootloader

BOOTLOADER	GPIO PINS	NOTES
SCI-Boot0	SCITXDA: GPIO84 SCIRXDA: GPIO85	SCIA Boot IO option 1 (default SCI option when chosen through Boot Mode GPIOs)
SCI-Boot1	SCITXDA: GPIO28 SCIRXDA: GPIO29	SCIA Boot option 2 – with alternate IOs.
Parallel Boot	D0 – GPIO65 D1 – GPIO64 D2 – GPIO58 D3 – GPIO59 D4 – GPIO60 D5 – GPIO61 D6 – GPIO62 D7 – GPIO63 HOST_CTRL – GPIO70 DSP_CTRL – GPIO69	
CAN-Boot0	CANRXA: GPIO70 CANTXA: GPIO71	CAN-A Boot -IO Option 1
CAN-Boot1	CANRXA: GPIO62 CANTXA: GPIO63	CAN-A Boot -IO option 2
I2C-Boot0	SDAA: GPIO91 SCLA: GPIO92	I2CA Boot- IO option 1
I2C-Boot1	SDAA: GPIO32 SCLA: GPIO33	I2CA Boot- IO option 2
SPI-Boot0	SPISIMOA - GPIO58 SPISOMIA - GPIO59 SPICLKA - GPIO60 SPISTEA - GPIO61	SPIA Boot- IO Option 1
SPI-Boot1	SPISIMOA – GPIO16 SPISOMIA – GPIO17 SPICLKA – GPIO18 SPISTEA – GPIO19	SPIA Boot - IO Option 2
USB Boot	USB0DM - GPIO42 USB0DP - GPIO43	The USB Bootloader will switch the clock source to the external crystal oscillator (X1 and X2 pins). A 20-MHz crystal should be present on the board if this boot mode is selected.

## 6.11 Dual Code Security Module

The dual code security module (DCSM) prevents access to on-chip secure memories. The term “secure” means access to secure memories and resources is blocked. The term “unsecure” means access is allowed; for example, through a debugging tool such as Code Composer Studio.

The code security mechanism offers protection for two zones, Zone 1 (Z1) and Zone 2 (Z2). The security implementation for both the zones is identical. Each zone has its own dedicated secure resource (OTP memory and secure ROM) and allocated secure resource (CLA, LSx RAM, and flash sectors).

The security of each zone is ensured by its own 128-bit password (CSM password). The password for each zone is stored in an OTP memory location based on a zone-specific link pointer. The link pointer value can be changed to program a different set of security settings (including passwords) in OTP.

## 6.12 Timers

CPU-Timers 0, 1, and 2 are identical 32-bit timers with presetable periods and with 16-bit clock prescaling. The timers have a 32-bit count-down register that generates an interrupt when the counter reaches zero. The counter is decremented at the CPU clock speed divided by the prescale value setting. When the counter reaches zero, it is automatically reloaded with a 32-bit period value.

CPU-Timer 0 is for general use and is connected to the PIE block. CPU-Timer 1 is also for general use and is connected to INT13 of the CPU. CPU-Timer 2 is reserved for TI-RTOS. It is connected to INT14 of the CPU. If TI-RTOS is not being used, CPU-Timer 2 is available for general use.

CPU-Timer 2 can be clocked by any one of the following:

- SYSCLK (default)
- Internal zero-pin oscillator 1 (INTOSC1)
- Internal zero-pin oscillator 2 (INTOSC2)
- X1 (XTAL)
- AUXPLLCLK

## 6.13 Nonmaskable Interrupt With Watchdog Timer (NMIWD)

The NMIWD module is used to handle system-level errors. There is an NMIWD module for each CPU. The conditions monitored are:

- Missing system clock due to oscillator failure
- Uncorrectable ECC error on CPU access to flash memory
- Uncorrectable ECC error on CPU, CLA, or DMA access to RAM
- Vector fetch error on the other CPU
- CPU1 only: Watchdog or NMI watchdog reset on CPU2

If the CPU does not respond to the latched error condition, then the NMI watchdog will trigger a reset after a programmable time interval. The default time is 65536 SYSCLK cycles.

## 6.14 Watchdog

The watchdog module is the same as the one on previous TMS320C2000 devices, but with an optional lower limit on the time between software resets of the counter. This windowed countdown is disabled by default, so the watchdog is fully backwards-compatible.

The watchdog generates either a reset or an interrupt. It is clocked from the internal oscillator with a selectable frequency divider.

图 6-5 shows the various functional blocks within the watchdog module.

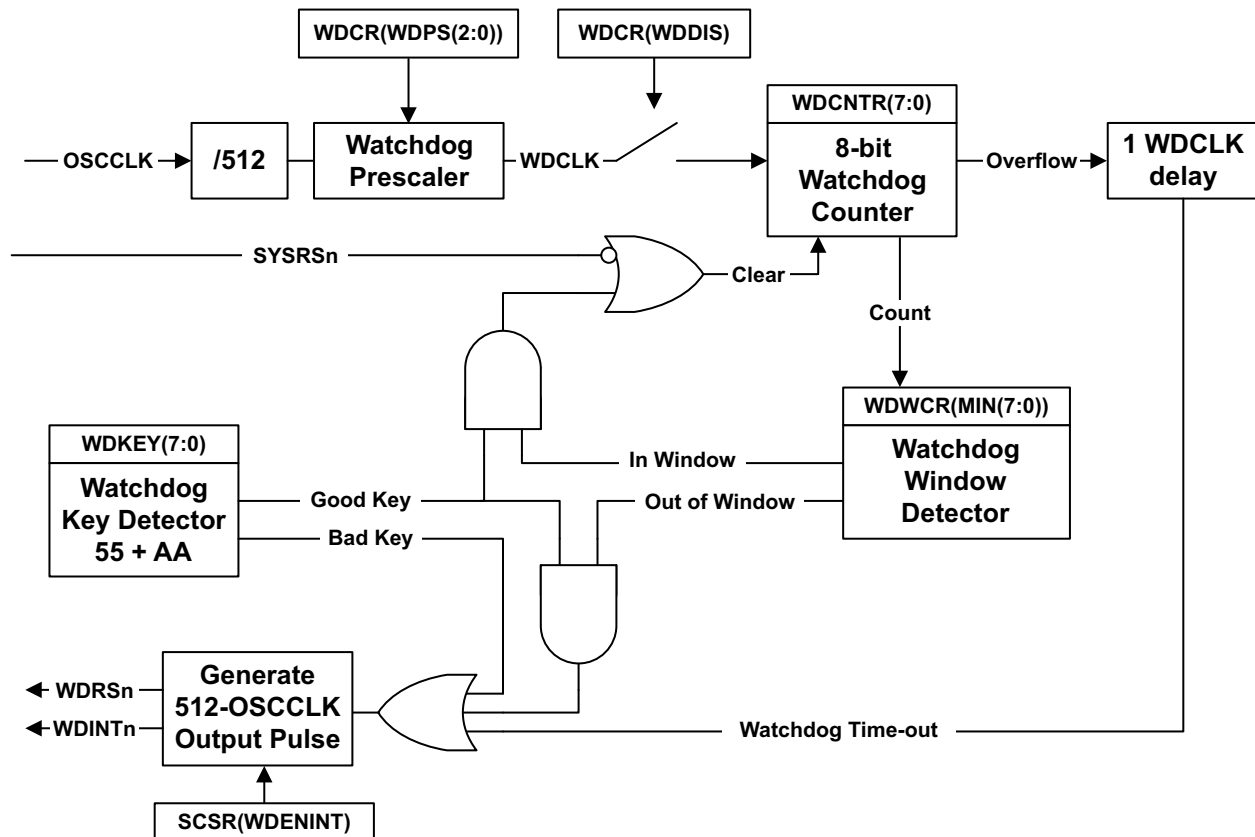


图 6-5. Windowed Watchdog

## 6.15 Configurable Logic Block (CLB)

The configurable logic block enables TI to offer additional interfacing and control features for select C2000 devices. TI uses the CLB to create specific on-chip solutions, such as [Position Manager](#), that would otherwise be accomplished using additional logic devices. Configuration files, application programmer's interface (API), and use examples are provided with the C2000 [controlSUITE](#) software package. In some solutions, the TI-configured CLB is used in conjunction with other on-chip resources, such as the SPI port or the C28x CPU, to perform more complex functionality. See [Table 3-1](#) for the devices that support the CLB feature.

## 7 Applications, Implementation, and Layout

### 注

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

### 7.1 TI Design or Reference Design

#### 7.1.1 Industrial Servo Drive and AC Inverter Drive Reference Design

**TIDM-SERVODRIVE** — The DesignDRIVE Development Kit is a reference design for a complete industrial drive directly connecting to a three-phase ACI or PMSM motor. Many drive topologies can be created from the combined control, power, and communications technologies included on this single platform. This platform includes multiple position sensor interfaces, diverse current sensing techniques, hot-side partitioning options, and expansion for safety and industrial Ethernet.

#### 7.1.2 Isolated Current Shunt and Voltage Measurement Reference Design for Motor Drives

**TIDA-00171** — This evaluation kit and reference design implement the AMC130x reinforced isolated delta-sigma modulators along with integrated Sinc filters in the C2000 TMS320F28377D Delfino microcontroller. The design provides an ability to evaluate the performance of these measurements: three motor currents, three inverter voltages, and the DC Link voltage. Provided in the kit is firmware to configure the Sinc filters, set the PLL frequency, and receive data from Sinc filters. A versatile run-time GUI is also provided to help the user validate the AMC130x performance and supports configuration changes to Sinc filter parameters in the Delfino controller.

#### 7.1.3 Isolated, Shunt-Based Current Sensing Reference Design

**TIPD165** — This Verified TI Design implements an isolated current sensing data acquisition solution based on the AMC1304M25 isolated delta-sigma ( $\Delta\Sigma$ ) modulator and a TMS320F28377D microcontroller. This circuit was designed for shunt-based current measurement applications, which require excellent galvanic isolation and accuracy, such as industrial motor drives, photovoltaic inverters, and energy metering. It is capable of measuring load currents from  $-10\text{ A}$  to  $+10\text{ A}$  with better than 0.3% uncalibrated accuracy, and it also provides dual functionality of a high-resolution channel and an additional overcurrent or short-circuit detection channel. The design's functionality and performance were verified against the circuit design goals by fabricating three PCBs and measuring results for dc and ac input signals.

#### 7.1.4 Differential Signal Conditioning Circuit for Current and Voltage Measurement Using Fluxgate Sensors

**TIDA-00201** — This design provides a 4-channel signal conditioning solution for differential ADCs integrated into a microcontroller measuring motor current using fluxgate sensors. Also provided is an alternative measurement circuit with external differential SAR ADCs as well as circuits for high-speed overcurrent and earth fault detection. Proper differential signal conditioning improves noise immunity on critical current measurements in motor drives. This reference design can help increase the effective resolution of the analog-to-digital conversion, improving motor drive efficiency.



## 7.2 Development Tools

### 7.2.1 *F28377D Delfino Experimenter Kit*

[TMDXDOCK28377D](#) — The F28377D Delfino Experimenter Kit provides a robust hardware prototyping platform for real-time, closed-loop control development.

### 7.2.2 *F28377D Delfino controlCARD*

[TMDXCNC28377D](#) — The F28377D Delfino controlCARD from Texas Instruments is an ideal product for initial software development and short run builds for system prototypes, test stands, and many other projects that require easy access to high-performance controllers.

## 7.3 Software Tools

### 7.3.1 *controlSUITE*

[CONTROLSUITE](#) — controlSUITE™ for C2000 microcontrollers is a cohesive set of software infrastructure and software tools designed to minimize software development time.

### 7.3.2 *Code Composer Studio (CCS) Integrated Development Environment (IDE)*

[CCSTUDIO](#) — Code Composer Studio is an integrated development environment (IDE) that supports TI's Microcontroller and Embedded Processors portfolio. Code Composer Studio comprises a suite of tools used to develop and debug embedded applications. It includes an optimizing C/C++ compiler, source code editor, project build environment, debugger, profiler, and many other features.

### 7.3.3 *Pin Mux Tool*

[PINMUXTOOL](#) — The Pin Mux Utility is a software tool which provides a Graphical User Interface for configuring pin multiplexing settings, resolving conflicts and specifying I/O cell characteristics for TI MPUs.

### 7.3.4 *F021 Flash Application Programming Interface (API)*

[F021FLASHAPI](#) — The F021 Flash Application Programming Interface (API) provides a software library of functions to program, erase, and verify F021 on-chip Flash memory.

## 7.4 Training

### 7.4.1 *F2837xD Workshop*

[F2837xD Workshop](#) — The F2837xD workshop is a hands-on technical course facilitated by qualified Texas Instruments' instructors.

## 8 器件和文档支持

### 8.1 器件支持

#### 8.1.1 开发支持

德州仪器 (TI) 为 C28x 系列 MCU 提供了大量的开发工具，其中包括用于评估处理器性能、生成代码、开发算法执行的工具，以及完全集成和调试软件和硬件模块的工具。

以下产品提供开发支持：

##### 软件开发工具

- Code Composer Studio™(CCS) 集成开发环境 (IDE)
  - C28x C/C++ 编译器
    - 对 TMU 和 FPU 的 C 支持
  - CLA C 编译器 (ANSI C 的子集)
  - 代码生成工具
  - 汇编器/连接器
  - 周期精确模拟器
- ControlSUITE
  - CLA 库
  - FPU 和 VCU 优化库
  - 应用算法
  - 示例 应用 代码

##### 硬件开发工具

- 开发和评估工具
- 基于 JTAG 的仿真器 - XDS510™类别， XDS560™仿真器， XDS100v2， XDS100v3， XDS200
- 闪存编程工具

有关处理器平台开发支持工具的完整列表，请访问德州仪器 (TI) 网站 [www.ti.com](http://www.ti.com)。要咨询技术问题，请访问 <http://e2e.ti.com>。有关定价和购买信息，请联系最近的 TI 销售办事处或授权分销商。

#### 8.1.2 器件和开发支持工具命名规则

为了标明产品开发周期的阶段，TI 为所有 TMS320™MCU 器件和支持工具的部件号指定前缀。每一个 TMS320 MCU 商用系列成员产品具有以下三个前缀中的一个：TMX、TMP 或者 TMS（例如，TMS320F28379D）。德州仪器 (TI) 建议为其支持的工具使用三个可用前缀指示符中的两个：TMDX 和 TMDS。这些前缀代表了产品从工程原型机（其中 TMX 针对器件，而 TMDX 针对工具）直到完全合格的生产器件和工具（其中 TMS 针对器件，而 TMDS 针对工具）的产品开发进化阶段。

器件开发进化流程：

- TMX** 试验器件不一定代表最终器件的电气规范标准。
- TMP** 最终的芯片模型符合器件的电气规范标准，但是未经完整的质量和可靠性验证。
- TMS** 完全合格的产品器件

支持工具开发进化流程:

**TMDX** 还未经完整的德州仪器 (TI) 内部质量测试的开发支持工具

**TMDS** 完全合格的开发支持产品

TMX 和 TMP 器件和 TMDX 开发支持工具出货时带有如下的免责声明:  
“开发产品用于内部评估的目的。”

TMS 器件和 TMDS 开发支持工具已进行完全特性描述, 并且器件的质量和可靠性已经完全论证。TI 的标准保修证书适用。

预测显示原型器件 (TMX 或者 TMP) 的故障率大于标准生产器件。由于它们的预计的最终使用故障率仍未定义, 德州仪器 (TI) 建议不要将这些器件用于任何生产系统。只有合格的生产器件将被使用。

TI 器件的命名规则也包括一个带有器件系列名称的后缀。这个后缀包括封装类型 (例如 PTP) 和温度范围 (如 T)。图 8-1 提供了解读任一系列产品成员完整器件名称的图例。

要获取器件部件号以及更多订购信息, 请访问 TI 网站 ([www.ti.com](http://www.ti.com)) 或者联系您的 TI 销售代表。

有关芯片 的 器件命名标记的更多说明, 请参见《TMS320F28379D、TMS320F28377D、TMS320F28376D、TMS320F28375D、TMS320F28374D 双核 Delfino 微控制器芯片勘误表》(文献编号: SPRZ412)。

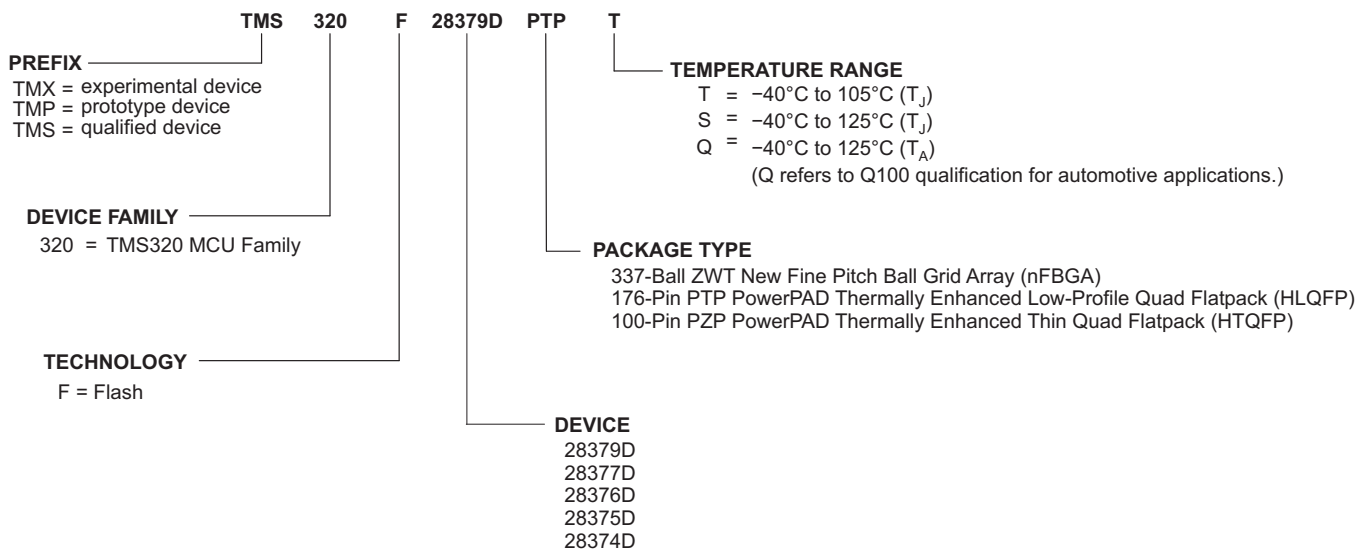


图 8-1. 器件命名规则

## 8.2 文档支持

### 8.2.1 相关文档

从产品声明到应用开发的大量文档提供了对所有 TMS320 MCU 系列器件的支持。提供的文档类型包括：数据表和数据手册（含设计规范）；以及硬件和软件应用。

下列文档可从 TI 网站 ([www.ti.com.cn](http://www.ti.com.cn)) 中下载：

#### 数据手册和勘误表

**SPRS880** 《TMS320F2837xD 双核 Delfino™ 微控制器数据手册》包含引脚分配、信号描述以及电子和时序规范。

**SPRZ412** 《TMS320F28379D、TMS320F28377D、TMS320F28376D、TMS320F28375D、TMS320F28374D 双核 Delfino 芯片勘误表》对与芯片有关的已知报告进行了说明并提供了权变措施。

#### 技术参考手册

**SPRUHM8** 《TMS320F2837xD 双核 Delfino 微控制器技术参考手册》详述了每一个外设和 2837xD 微控制器中的子系统的集成、环境、功能说明以及程序设计模型。

#### CPU 用户指南

**SPRU430** **TMS320C28x CPU 和指令集参考指南**描述了 TMS320C28x 定点数字信号处理器 (DSP) 的中央处理器 (CPU) 和汇编语言指令。此参考指南还介绍了上述 DSP 所提供的仿真特性。

**SPRUHS1** 《TMS320C28x 扩展指令集参考指南》介绍了 TMU、VCU-II 和 FPU 加速器的架构、管道和指令集。

#### 外设指南

**SPRU566** 《TMS320x28xx, 28xxx DSP 外设参考指南》描述了 28x DSP 的外设参考指南。

#### 工具指南

**SPRU513** 《TMS320C28x 汇编语言工具 v6.4 用户指南》描述了用于 TMS320C28x 器件的汇编语言工具（用于开发汇编语言代码的汇编程序和其他工具）、汇编器指令、宏、通用目标文件格式、和符号调试指令。

**SPRU514** 《TMS320C28x 优化 C/C++ 编译器 v6.4 用户指南》介绍了 TMS320C28x C/C++ 编译器。此编译器接受 ANSI 标准 C/C++ 源代码，并为 TMS320C28x 器件生成 TMS320 DSP 汇编语言源代码。

**SPRU608** **TMS320C28x 指令集模拟器技术概览**描述了用于 TMS320C2000 IDE 的 Code Composer Studio 内提供的模拟器，此模拟器能够模拟 C28x 内核。

#### 应用报告

**SZZA021** 《半导体封装方法》介绍了准备向最终用户发货时半导体器件所用的封装方法。

**SPRABX4** 《计算嵌入式处理器的有效使用寿命》介绍了如何计算 TI 嵌入式处理器 (EP) 在电子系统中运行时的有效使用寿命。本文档的目标读者为希望确定 TI EP 的可靠性是否符合终端系统可靠性要求的总工程师。

**SPRAAM0** 《TMS320C28x 数字信号控制器使用入门》介绍了如何开始使用 TMS320C28x DSP 软件和硬件开发来辅助实现初始设计和调试目的。

### 8.2.2 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](http://ti.com) 上您的器件对应的产品文件夹。单击右上角的“提醒我”(Alert me) 按钮。点击后，您将每周定期收到已更改的产品信息（如果有的话）。有关更改的详细信息，请查阅已修订文档的修订历史记录。

### 8.3 相关链接

以下表格列出了快速访问链接。范围包括技术文档、支持与社区资源、工具和软件，并且可以快速访问样片或购买链接。

表 8-1. 相关链接

器件	产品文件夹	样片与购买	技术文章	工具与软件	支持与社区
TMS320F28379D	<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>
TMS320F28377D	<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>
TMS320F28376D	<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>
TMS320F28375D	<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>
TMS320F28374D	<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>

### 8.4 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 and 标准且不一定反映 TI 的观点；请见 TI 的 [使用条款](#)。

**TI E2E™ 在线社区** [TI 工程师对工程师 \(E2E\) 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 中，您可以咨询问题、共享知识、探索思路，在同领域工程师的帮助下解决问题。

**德州仪器 (TI) 嵌入式处理器维基网站** [德州仪器 \(TI\) 嵌入式处理器维基网站](#)。此网站的建立是为了帮助开发人员从德州仪器 (TI) 的嵌入式处理器入门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。

### 8.5 商标

PowerPAD, Delfino, TMS320C2000, 接口和, controlSUITE, Code Composer Studio, XDS510, XDS560, TMS320, E2E are trademarks of Texas Instruments.

ARM is a registered trademark of ARM Limited (or its subsidiaries) in the EU and/or elsewhere. All rights reserved.

Bosch is a registered trademark of Robert Bosch GmbH Corporation.

All other trademarks are the property of their respective owners.

### 8.6 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。

### 8.7 Glossary

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

## 9 机械、封装和可订购信息

### 9.1 封装信息

以下页中包括机械、封装和可订购信息。这些信息是针对指定器件可提供的最新数据。这些数据会在无通知且不对本文档进行修订的情况下发生改变。欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

## 重要声明

德州仪器(TI)及其下属子公司有权根据 JESD46 最新标准,对所提供的产品和服务进行更正、修改、增强、改进或其它更改,并有权根据 JESD48 最新标准中止提供任何产品和服务。客户在下订单前应获取最新的相关信息,并验证这些信息是否完整且是最新的。所有产品的销售都遵循在订单确认时所提供的TI 销售条款与条件。

TI 保证其所销售的组件的性能符合产品销售时 TI 半导体产品销售条件与条款的适用规范。仅在 TI 保证的范围内,且 TI 认为有必要时才会使用测试或其它质量控制技术。除非适用法律做出了硬性规定,否则没有必要对每种组件的所有参数进行测试。

TI 对应用帮助或客户产品设计不承担任何义务。客户应对其使用 TI 组件的产品和应用自行负责。为尽量减小与客户产品和应用相关的风险,客户应提供充分的设计与操作安全措施。

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对于 TI 的产品手册或数据表中 TI 信息的重要部分,仅在没有对内容进行任何篡改且带有相关授权、条件、限制和声明的情况下才允许进行复制。TI 对此类篡改过的文件不承担任何责任或义务。复制第三方的信息可能需要服从额外的限制条件。

在转售 TI 组件或服务时,如果对该组件或服务参数的陈述与 TI 标明的参数相比存在差异或虚假成分,则会失去相关 TI 组件或服务的所有明示或暗示授权,且这是不正当的、欺诈性商业行为。TI 对任何此类虚假陈述均不承担任何责任或义务。

客户认可并同意,尽管任何应用相关信息或支持仍可能由 TI 提供,但他们将独力负责满足与其产品及其应用中使用的 TI 产品相关的所有法律、法规和安全相关要求。客户声明并同意,他们具备制定与实施安全措施所需的全部专业技术和知识,可预见故障的危险后果、监测故障及其后果、降低有可能造成人身伤害的故障的发生机率并采取适当的补救措施。客户将全额赔偿因在此类安全关键应用中使用任何 TI 组件而对 TI 及其代理造成的任何损失。

在某些场合中,为了推进安全相关应用有可能对 TI 组件进行特别的促销。TI 的目标是利用此类组件帮助客户设计和创立其特有的可满足适用的功能安全性标准和要求的终端产品解决方案。尽管如此,此类组件仍然服从这些条款。

TI 组件未获得用于 FDA Class III (或类似的生命攸关医疗设备)的授权许可,除非各方授权官员已经达成了专门管控此类使用的特别协议。

只有那些 TI 特别注明属于军用等级或“增强型塑料”的 TI 组件才是设计或专门用于军事/航空应用或环境的。购买者认可并同意,对并非指定面向军事或航空航天用途的 TI 组件进行军事或航空航天方面的应用,其风险由客户单独承担,并且由客户独力负责满足与此类使用相关的所有法律和法规要求。

TI 已明确指定符合 ISO/TS16949 要求的产品,这些产品主要用于汽车。在任何情况下,因使用非指定产品而无法达到 ISO/TS16949 要求, TI 不承担任何责任。

	产品		应用
数字音频	<a href="http://www.ti.com.cn/audio">www.ti.com.cn/audio</a>	通信与电信	<a href="http://www.ti.com.cn/telecom">www.ti.com.cn/telecom</a>
放大器和线性器件	<a href="http://www.ti.com.cn/amplifiers">www.ti.com.cn/amplifiers</a>	计算机及周边	<a href="http://www.ti.com.cn/computer">www.ti.com.cn/computer</a>
数据转换器	<a href="http://www.ti.com.cn/dataconverters">www.ti.com.cn/dataconverters</a>	消费电子	<a href="http://www.ti.com.cn/consumer-apps">www.ti.com.cn/consumer-apps</a>
DLP® 产品	<a href="http://www.dlp.com">www.dlp.com</a>	能源	<a href="http://www.ti.com.cn/energy">www.ti.com.cn/energy</a>
DSP - 数字信号处理器	<a href="http://www.ti.com.cn/dsp">www.ti.com.cn/dsp</a>	工业应用	<a href="http://www.ti.com.cn/industrial">www.ti.com.cn/industrial</a>
时钟和计时器	<a href="http://www.ti.com.cn/clockandtimers">www.ti.com.cn/clockandtimers</a>	医疗电子	<a href="http://www.ti.com.cn/medical">www.ti.com.cn/medical</a>
接口	<a href="http://www.ti.com.cn/interface">www.ti.com.cn/interface</a>	安防应用	<a href="http://www.ti.com.cn/security">www.ti.com.cn/security</a>
逻辑	<a href="http://www.ti.com.cn/logic">www.ti.com.cn/logic</a>	汽车电子	<a href="http://www.ti.com.cn/automotive">www.ti.com.cn/automotive</a>
电源管理	<a href="http://www.ti.com.cn/power">www.ti.com.cn/power</a>	视频和影像	<a href="http://www.ti.com.cn/video">www.ti.com.cn/video</a>
微控制器 (MCU)	<a href="http://www.ti.com.cn/microcontrollers">www.ti.com.cn/microcontrollers</a>		
RFID 系统	<a href="http://www.ti.com.cn/rfidsys">www.ti.com.cn/rfidsys</a>		
OMAP应用处理器	<a href="http://www.ti.com/omap">www.ti.com/omap</a>		
无线连通性	<a href="http://www.ti.com.cn/wirelessconnectivity">www.ti.com.cn/wirelessconnectivity</a>	德州仪器在线技术支持社区	<a href="http://www.deyisupport.com">www.deyisupport.com</a>

邮寄地址: 上海市浦东新区世纪大道1568号, 中建大厦32楼邮政编码: 200122  
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**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TMS320F28374DPTPS	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 125	TMS320 F28374DPTPS	<a href="#">Samples</a>
TMS320F28374DPTPT	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 105	TMS320 F28374DPTPT	<a href="#">Samples</a>
TMS320F28374DZWTS	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 125	TMS320 F28374DZWTS	<a href="#">Samples</a>
TMS320F28374DZWTT	ACTIVE	NFBGA	ZWT	337	90	TBD	Call TI	Call TI	-40 to 105		<a href="#">Samples</a>
TMS320F28375DPTPS	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 125	TMS320 F28375DPTPS	<a href="#">Samples</a>
TMS320F28375DPTPT	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 105	TMS320 F28375DPTPT	<a href="#">Samples</a>
TMS320F28375DPZPS	ACTIVE	HTQFP	PZP	100	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 125	TMS320 F28375DPZPS	<a href="#">Samples</a>
TMS320F28375DZWTS	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 125	TMS320 F28375DZWTS	<a href="#">Samples</a>
TMS320F28375DZWTT	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 105	TMS320 F28375DZWTT	<a href="#">Samples</a>
TMS320F28376DPTPS	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 125	TMS320 F28376DPTPS	<a href="#">Samples</a>
TMS320F28376DPTPT	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 105	TMS320 F28376DPTPT	<a href="#">Samples</a>
TMS320F28376DZWTS	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 125	TMS320 F28376DZWTS	<a href="#">Samples</a>
TMS320F28376DZWTT	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 105	TMS320 F28376DZWTT	<a href="#">Samples</a>
TMS320F28377DPTPQ	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 125	TMS320 F28377DPTPQ	<a href="#">Samples</a>
TMS320F28377DPTPS	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 125	TMS320 F28377DPTPS	<a href="#">Samples</a>
TMS320F28377DPTPT	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 105	TMS320 F28377DPTPT	<a href="#">Samples</a>
TMS320F28377DZWTQ	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 125	TMS320 F28377DZWTQ	<a href="#">Samples</a>



Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TMS320F28377DZWTQR	ACTIVE	NFBGA	ZWT	337	1000	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 125	TMS320 F28377DZWTQ	<a href="#">Samples</a>
TMS320F28377DZWTS	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 125	TMS320 F28377DZWTS	<a href="#">Samples</a>
TMS320F28377DZWTT	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 105	TMS320 F28377DZWTT	<a href="#">Samples</a>
TMS320F28379DPTPS	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 125	TMS320 F28379DPTPS	<a href="#">Samples</a>
TMS320F28379DPTPT	ACTIVE	HLQFP	PTP	176	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 105	TMS320 F28379DPTPT	<a href="#">Samples</a>
TMS320F28379DZWTS	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 125	TMS320 F28379DZWTS	<a href="#">Samples</a>
TMS320F28379DZWTT	ACTIVE	NFBGA	ZWT	337	90	Green (RoHS & no Sb/Br)	SNAGCU	Level-3-260C-168 HR	-40 to 105	TMS320 F28379DZWTT	<a href="#">Samples</a>
TMX320F28379DZWTT	PREVIEW	NFBGA	ZWT	337		TBD	Call TI	Call TI	-40 to 105		

(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.

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

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(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.

<sup>(5)</sup> 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.

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

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