
TMS570LS0x32 16- and 32-Bit RISC Flash Microcontroller

1 Device Overview

1.1 Features

- High-Performance Automotive-Grade Microcontroller for Safety-Critical Applications
 - Dual CPUs Running in Lockstep
 - ECC on Flash and RAM Interfaces
 - Built-In Self-Test for CPU and On-Chip RAMs
 - Error Signaling Module With Error Pin
 - Voltage and Clock Monitoring
- ARM® Cortex®-R4 32-Bit RISC CPU
 - Efficient 1.66 DMIPS/MHz With 8-Stage Pipeline
 - 8-Region Memory Protection Unit (MPU)
 - Open Architecture With Third-Party Support
- Operating Conditions
 - 80-MHz System Clock
 - Core Supply Voltage (V_{CC}): 1.2-V Nominal
 - I/O Supply Voltage (V_{CCIO}): 3.3-V Nominal
 - ADC Supply Voltage (V_{CCAD}): 3.3-V Nominal
- Integrated Memory
 - Up to 384KB of Program Flash With ECC
 - 32KB of RAM With ECC
 - 16KB of Flash for Emulated EEPROM With ECC
- Hercules™ Common Platform Architecture
 - Consistent Memory Map Across Family
 - Real-Time Interrupt (RTI) Timer (OS Timer)
 - 96-Channel Vectored Interrupt Module (VIM)
 - 2-Channel Cyclic Redundancy Checker (CRC)
- Frequency-Modulated Phase-Locked Loop (FMPLL) With Built-In Slip Detector
- IEEE 1149.1 JTAG Boundary Scan and ARM CoreSight™ Components
- Advanced JTAG Security Module (AJSM)
- Multiple Communication Interfaces
 - Two CAN Controllers (DCANs)
 - DCAN1 - 32 Mailboxes With Parity Protection
 - DCAN2 - 16 Mailboxes With Parity Protection
 - Compliant to CAN Protocol Version 2.0B
 - Multibuffered Serial Peripheral Interface (MibSPI) Module
 - 128 Words With Parity Protection
 - Two Standard Serial Peripheral Interface (SPI) Modules
 - UART (SCI) Interface With Local Interconnect Network (LIN 2.1) Interface Support
- Next Generation High-End Timer (N2HET) Module
 - Up to 19 Programmable Pins
 - 128-Word Instruction RAM With Parity Protection
 - Includes Hardware Angle Generator
 - Dedicated High-End Timer Transfer Unit (HTU) With MPU
- Enhanced Quadrature Encoder Pulse (eQEP) Module
 - Motor Position Encoder Interface
- 12-Bit Multibuffered Analog-to-Digital Converter (ADC) Module
 - 16 Channels
 - 64 Result Buffers With Parity Protection
- Up to 45 General-Purpose Input/Output (GPIO) Pins
 - 8 Dedicated Interrupt-Capable GPIO Pins
- Package
 - 100-Pin Quad Flatpack (PZ) [Green]



1.2 Applications

- Braking Systems (ABS and ESC)
- Electric Power Steering (EPS)
- Electric Pump Control
- Battery-Management Systems
- Active Driver Assistance Systems
- Aerospace and Avionics
- Railway Communications
- Off-road Vehicles

1.3 Description

The TMS570LS0432/0332 device is a high-performance automotive-grade microcontroller for safety systems. The safety architecture includes dual CPUs in lockstep, CPU and Memory BIST logic, ECC on both the flash and the data SRAM, parity on peripheral memories, and loopback capability on peripheral I/Os.

The TMS570LS0432/0332 device integrates the ARM Cortex-R4 CPU. The CPU offers an efficient 1.66DMIPS/MHz, and has configurations that can run up to 80 MHz, providing up to 132 DMIPS. The device supports the big-endian (BE32) format.

The TMS570LS0432/0332 device has 384KB and 256KB of integrated flash (respectively) and 32KB of data RAM. Both the flash and RAM have single-bit error correction and double-bit error detection. The flash memory on this device is a nonvolatile, electrically erasable, and programmable memory implemented with a 64-bit-wide data bus interface. The flash operates on a 3.3-V supply input (the same level as I/O supply) for all read, program, and erase operations. When in pipeline mode, the flash operates with a system clock frequency of 80 MHz. The SRAM supports single-cycle read and write accesses in byte, halfword, word, and double-word modes throughout the supported frequency range.

The TMS570LS0432/0332 device features peripherals for real-time control-based applications, including a Next Generation High-End Timer (N2HET) timing coprocessor with up to 19 I/O terminals and a 12-bit Analog-to-Digital Converter (ADC) supporting 16 inputs in the 100-pin package.

The N2HET is an advanced intelligent timer that provides sophisticated timing functions for real-time applications. The timer is software-controlled, using a small instruction set, with a specialized timer micromachine and an attached I/O port. The N2HET can be used for pulse-width-modulated outputs, capture or compare inputs, or GPIO. The N2HET is especially well suited for applications requiring multiple sensor information and drive actuators with complex and accurate time pulses. A High-End Timer Transfer Unit (HTU) can perform DMA-type transactions to transfer N2HET data to or from main memory. A Memory Protection Unit (MPU) is built into the HTU.

The Enhanced Quadrature Encoder Pulse (eQEP) module is used for direct interface with a linear or rotary incremental encoder to get position, direction, and speed information from a rotating machine as used in high-performance motion and position-control systems.

The device has a 12-bit-resolution MibADC with 16 channels and 64 words of parity-protected buffer RAM. The MibADC channels can be converted individually or can be grouped by software for sequential conversion sequences. There are three separate groupings. Each sequence can be converted once when triggered or configured for continuous conversion mode. The MibADC has a 10-bit mode for use when compatibility with older devices or faster conversion time is desired.

The device has multiple communication interfaces: one MibSPI, two SPIs, one UART/LIN, and two DCANs. The SPI provides a convenient method of serial high-speed communications between similar shift-register type devices. The UART/LIN supports the Local Interconnect standard 2.1 and can be used as a UART in full-duplex mode using the standard Non-Return-to-Zero (NRZ) format. The DCAN supports the CAN 2.0 (A and B) protocol standard and uses a serial, multimaster communication protocol that efficiently supports distributed real-time control with robust communication rates of up to 1Mbps. The DCAN is ideal for applications operating in noisy and harsh environments (for example, automotive and industrial applications) that require reliable serial communication or multiplexed wiring.

The Frequency-Modulated Phase-Locked Loop (FMPLL) clock module is used to multiply the external frequency reference to a higher frequency for internal use. The FMPLL provides one of the five possible clock source inputs to the Global Clock Module (GCM). The GCM manages the mapping between the available clock sources and the device clock domains.

The device also has an External Clock Prescaler (ECP) module that when enabled, outputs a continuous external clock on the ECLK pin. The ECLK frequency is a user-programmable ratio of the peripheral interface clock (VCLK) frequency. This low-frequency output can be monitored externally as an indicator of the device operating frequency.

The Error Signaling Module (ESM) monitors all device errors and determines whether an interrupt is generated or the external nERROR pin is toggled when a fault is detected. The nERROR pin can be monitored externally as an indicator of a fault condition in the microcontroller.

The I/O Multiplexing and Control Module (IOMM) allows the configuration of the input/output pins to support alternate functions. See [Table 4-17](#) for a list of the pins that support multiple functions on this device.

With integrated safety features and a wide choice of communication and control peripherals, the TMS570LS0432/0332 device is an ideal solution for real-time control applications with safety-critical requirements.

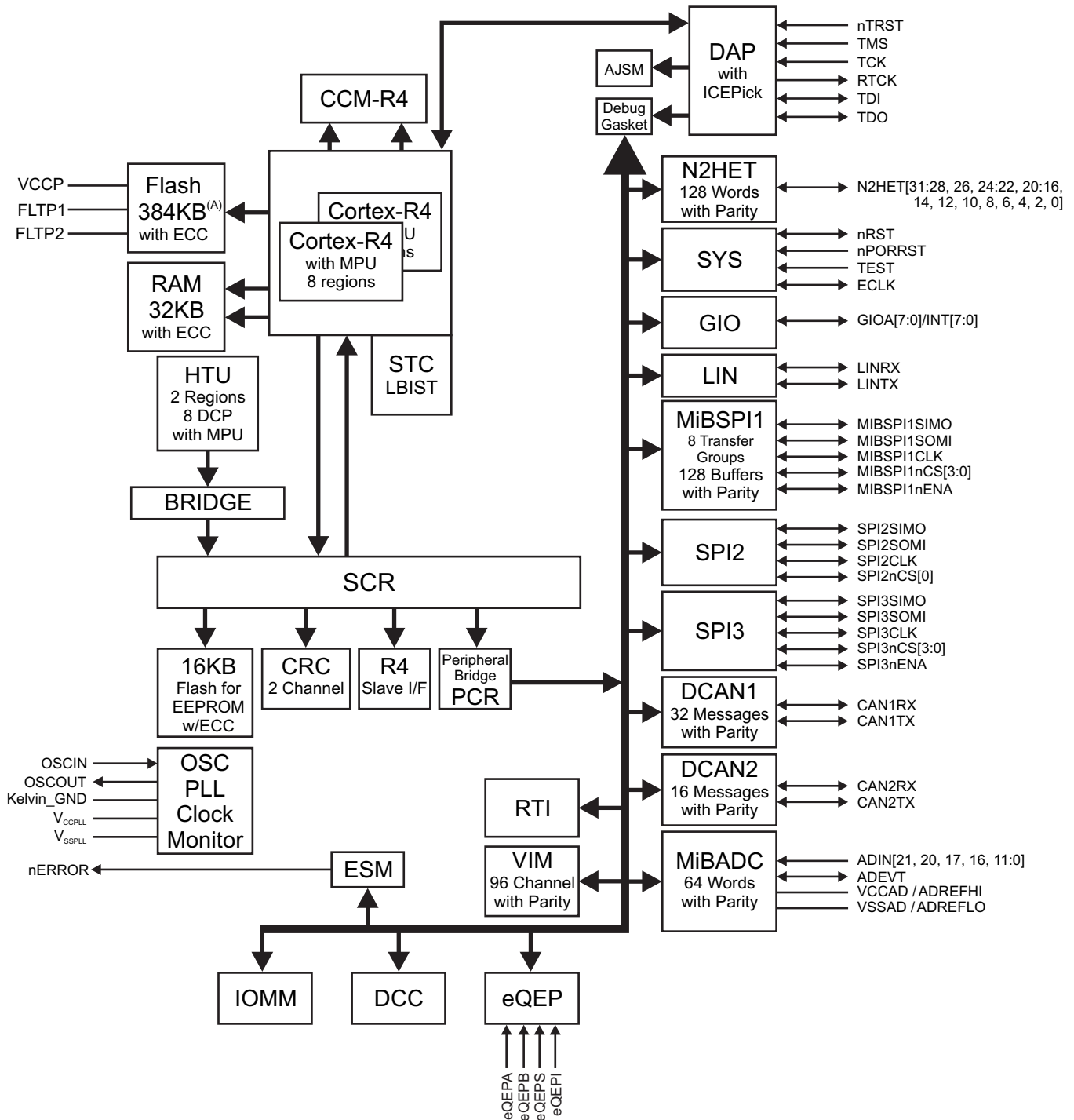
Device Information⁽¹⁾

| PART NUMBER | PACKAGE | BODY SIZE |
|----------------|------------|---------------------|
| TMS570LS0432PZ | LQFP (100) | 14.00 mm x 14.00 mm |
| TMS570LS0332PZ | LQFP (100) | 14.00 mm x 14.00 mm |

(1) For more information, see [Section 9](#), *Mechanical Packaging and Orderable Information*.

1.4 Functional Block Diagram

Figure 1-1 shows a functional block diagram of the device.



A. The TMS570LS0332 device only supports 256KB Flash with ECC.

Figure 1-1. Functional Block Diagram

Table of Contents

| | | | | | |
|----------|-----------------------------------------------------------------------------------|---------------------------|----------|-------------------------------------------------------------|----------------------------|
| 1 | Device Overview | 1 | 6.9 | Flash Memory | 50 |
| 1.1 | Features | 1 | 6.10 | Flash Program and Erase Timings for Program Flash | 52 |
| 1.2 | Applications | 2 | 6.11 | Flash Program and Erase Timings for Data Flash.. | 52 |
| 1.3 | Description | 3 | 6.12 | Tightly Coupled RAM Interface Module | 53 |
| 1.4 | Functional Block Diagram | 5 | 6.13 | Parity Protection for Accesses to peripheral RAMs. | 53 |
| 2 | Revision History | 7 | 6.14 | On-Chip SRAM Initialization and Testing | 54 |
| 3 | Device Comparison | 8 | 6.15 | Vectored Interrupt Manager | 56 |
| 4 | Terminal Configuration and Functions | 9 | 6.16 | Real-Time Interrupt Module | 58 |
| 4.1 | PZ QFP Package Pinout (100-Pin) | 9 | 6.17 | Error Signaling Module | 59 |
| 4.2 | Terminal Functions | 10 | 6.18 | Reset / Abort / Error Sources | 63 |
| 4.3 | Output Multiplexing and Control | 16 | 6.19 | Digital Windowed Watchdog | 64 |
| 4.4 | Special Multiplexed Options | 17 | 6.20 | Debug Subsystem | 65 |
| 5 | Specifications | 18 | 7 | Peripheral Information and Electrical Specifications | 70 |
| 5.1 | Absolute Maximum Ratings | 18 | 7.1 | Peripheral Legend | 70 |
| 5.2 | ESD Ratings | 18 | 7.2 | Multibuffered 12-Bit Analog-to-Digital Converter | 70 |
| 5.3 | Power-On Hours (POH) | 18 | 7.3 | General-Purpose Input/Output | 78 |
| 5.4 | Recommended Operating Conditions | 19 | 7.4 | Enhanced High-End Timer (N2HET) | 79 |
| 5.5 | Switching Characteristics Over Recommended Operating Conditions for Clock Domains | 19 | 7.5 | Controller Area Network (DCAN) | 82 |
| 5.6 | Wait States Required | 20 | 7.6 | Local Interconnect Network Interface (LIN) | 83 |
| 5.7 | Power Consumption | 21 | 7.7 | Multibuffered / Standard Serial Peripheral Interface | 84 |
| 5.8 | Thermal Resistance Characteristics for PZ | 22 | 7.8 | Enhanced Quadrature Encoder (eQEP) | 94 |
| 5.9 | Input/Output Electrical Characteristics | 22 | 8 | Device and Documentation Support | 96 |
| 5.10 | Output Buffer Drive Strengths | 23 | 8.1 | Device Support | 96 |
| 5.11 | Input Timings | 24 | 8.2 | Documentation Support | 99 |
| 5.12 | Output Timings | 25 | 8.3 | Related Links | 99 |
| 6 | System Information and Electrical Specifications | 27 | 8.4 | Community Resources | 99 |
| 6.1 | Voltage Monitor Characteristics | 27 | 8.5 | Trademarks | 99 |
| 6.2 | Power Sequencing and Power-On Reset | 28 | 8.6 | Electrostatic Discharge Caution | 99 |
| 6.3 | Warm Reset (nRST) | 30 | 8.7 | Glossary | 99 |
| 6.4 | ARM Cortex-R4 CPU Information | 31 | 8.8 | Device Identification Code Register | 100 |
| 6.5 | Clocks | 35 | 8.9 | Die Identification Registers | 100 |
| 6.6 | Clock Monitoring | 41 | 8.10 | Module Certifications | 101 |
| 6.7 | Glitch Filters | 43 | 9 | Mechanical Packaging and Orderable Addendum | 106 |
| 6.8 | Device Memory Map | 44 | 9.1 | Packaging Information | 106 |

2 Revision History

Scope: Applicable updates to the Hercules™ TMS570 MCU device family, specifically relating to the TMS570LS0432 devices, which are now in the production data (PD) stage of development have been incorporated.

| Changes from June 30, 2015 to May 31, 2018 (from B Revision (June 2015) to C Revision) | Page |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| <ul style="list-style-type: none"> • Section 5.1 (Absolute Maximum Ratings): Updated/Changed Supply voltage, V_{CCAD} MAX value from "3.6" to "4.6" V 18 • Section 5.7 (Power Consumption): Clarified the conditions for the 3.3V current requirements when programming or erasing flash 21 • Section 6.20.6 (Advanced JTAG Security Module): Updated AJSM description..... 68 • Section 8.8 (Device Identification Code Register): Added the address of the Device ID register..... 100 | |

3 Device Comparison

Table 3-1 lists the features of the TMS570LS0432/0332 devices.

Table 3-1. TMS570LS0432/0332 Device Comparison⁽¹⁾⁽²⁾

| FEATURES | DEVICES | | | | | | |
|---------------------------|---------------------------------|---------------------------------|--------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Generic Part Number | TMS570LS1227ZWT ⁽³⁾ | TMS570LS0714ZWT | TMS570LS0714PGE | TMS570LS0714PZ | TMS570LS0432PZ ⁽³⁾ | TMS570LS0332PZ | TMS570LS0232PZ |
| Package | 337 BGA | 337 BGA | 144 QFP | 100 QFP | 100 QFP | 100 QFP | 100 QFP |
| CPU | ARM Cortex-R4F | ARM Cortex-R4F | ARM Cortex-R4F | ARM Cortex-R4F | ARM Cortex-R4 | ARM Cortex-R4 | ARM Cortex-R4 |
| Frequency (MHz) | 180 | 180 | 160 | 100 | 80 | 80 | 80 |
| Flash (KB) | 1280 | 768 | 768 | 768 | 384 | 256 | 128 |
| RAM (KB) | 192 | 128 | 128 | 128 | 32 | 32 | 32 |
| Data Flash [EEPROM] (KB) | 64 | 64 | 64 | 64 | 16 | 16 | 16 |
| EMAC | 10/100 | – | – | – | – | – | – |
| FlexRay | 2-ch | – | – | – | – | – | – |
| CAN | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| MibADC 12-bit (Ch) | 2 (24ch) | 2 (24ch) | 2 (24ch) | 2 (16ch) | 1 (16ch) | 1 (16ch) | 1 (16ch) |
| N2HET (Ch) | 2 (44) | 2 (44) | 2 (40) | 2 (21) | 1 (19) | 1 (19) | 1 (19) |
| ePWM Channels | 14 | 14 | 14 | 8 | – | – | – |
| eCAP Channels | 6 | 6 | 6 | 4 | 0 | 0 | 0 |
| eQEP Channels | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| MibSPI (CS) | 3 (6 + 6 + 4) | 3 (6 + 6 + 4) | 3 (5 + 6 + 4) | 2 (5 + 1) | 1 (4) | 1 (4) | 1 (4) |
| SPI (CS) | 2 (2 + 1) | 2 (2 + 1) | 1 (1) | 1 (1) | 2 | 2 | 2 |
| SCI (LIN) | 2 (1 with LIN) | 2 (1 with LIN) | 2 (1 with LIN) | 1 (with LIN) | 1 (with LIN) | 1 (with LIN) | 1 (with LIN) |
| I2C | 1 | 1 | 1 | – | – | – | – |
| GPIO (INT) ⁽⁴⁾ | 101 (with 16 interrupt capable) | 101 (with 16 interrupt capable) | 64 (with 10 interrupt capable) | 45 (with 9 interrupt capable) | 45 (with 8 interrupt capable) | 45 (with 9 interrupt capable) | 45 (with 8 interrupt capable) |
| EMIF | 16-bit data | – | – | – | – | – | – |
| ETM (Trace) | – | – | – | – | – | – | – |
| RTP/DMM | – | – | – | – | – | – | – |
| Operating Temperature | –40°C to 125°C | –40°C to 125°C | –40°C to 125°C | –40°C to 125°C | –40°C to 125°C | –40°C to 125°C | –40°C to 125°C |
| Core Supply (V) | 1.14 V – 1.32 V | 1.14 V – 1.32 V | 1.14 V – 1.32 V | 1.14 V – 1.32 V | 1.14 V – 1.32 V | 1.14 V – 1.32 V | 1.14 V – 1.32 V |
| I/O Supply (V) | 3.0 V – 3.6 V | 3.0 V – 3.6 V | 3.0 V – 3.6 V | 3.0 V – 3.6 V | 3.0 V – 3.6 V | 3.0 V – 3.6 V | 3.0 V – 3.6 V |

(1) For additional device variants, see www.ti.com/tms570

(2) This table reflects the maximum configuration for each peripheral. Some functions are multiplexed and not all pins are available at the same time.

(3) Superset device

(4) Total number of pins that can be used as general-purpose input or output when not used as part of a peripheral.

4 Terminal Configuration and Functions

4.1 PZ QFP Package Pinout (100-Pin)

Figure 4-1 shows the 100-pin PZ QFP package pinout.

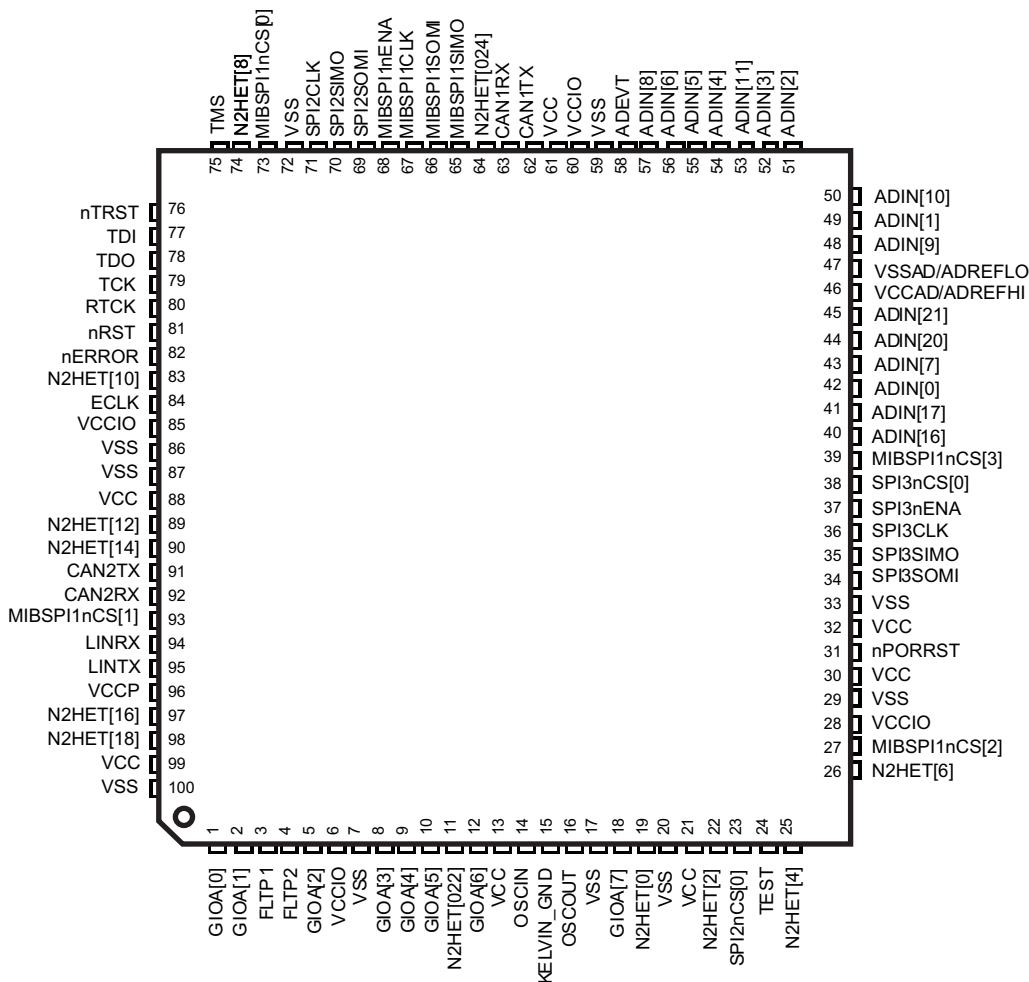


Figure 4-1. PZ QFP Package Pinout (100-Pin)

Note: Pins can have multiplexed functions. Only the default function is depicted in Figure 4-1.

4.2 Terminal Functions

Table 4-1 through Table 4-16 identify the external signal names, the associated pin numbers along with the mechanical package designator, the pin type (Input, Output, I/O, Power, or Ground), whether the pin has any internal pullup/pulldown, whether the pin can be configured as a GPIO, and a functional pin description.

NOTE

In the Terminal Functions table below, the "Reset Pull State" is the state of the pull applied to the terminal while nPORRST is low and immediately after nPORRST goes High. The default pull direction may change when software configures the pin for an alternate function. The "Pull Type" is the type of pull asserted when the signal name in bold is enabled for the given terminal by the IOMM control registers.

All I/O signals except nRST are configured as inputs while nPORRST is low and immediately after nPORRST goes High. While nPORRST is low, the input buffers are disabled, and the output buffers are disabled with the default pulls enabled.

All output-only signals have the output buffer disabled and the default pull enabled while nPORRST is low, and are configured as outputs with the pulls disabled immediately after nPORRST goes High.

4.2.1 High-End Timer (N2HET)

Table 4-1. High-End Timer (N2HET)

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|------------------------------------------------|-----------|----------------|------------------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| N2HET[0] | 19 | I/O | Pulldown | Programmable, 20 μ A | Timer input capture or output compare. The N2HET applicable terminals can be programmed as general-purpose input/output (GPIO). Each terminal has a suppression filter with a programmable duration. |
| N2HET[2] | 22 | | | | |
| N2HET[4] | 25 | | | | |
| N2HET[6] | 26 | | | | |
| N2HET[8] | 74 | | | | |
| N2HET[10] | 83 | | | | |
| N2HET[12] | 89 | | | | |
| N2HET[14] | 90 | | | | |
| N2HET[16] | 97 | | | | |
| MIBSPI1nCS[1]/EQEPS/ N2HET[17] | 93 | | | | |
| N2HET[18] | 98 | | | | |
| MIBSPI1nCS[2]/ N2HET[20]/ N2HET[19] | 27 | | | | |
| MIBSPI1nCS[2]/ N2HET[20]/ N2HET[19] | 27 | | | | |
| N2HET[22] | 11 | | | | |
| N2HET[24] | 64 | | | | |
| MIBSPI1nCS[3]/ N2HET[26] | 39 | | | | |
| ADEVT/N2HET[28] | 58 | | | | |
| GIOA[7]/N2HET[29] | 18 | | | | |
| MIBSPI1nENA/ N2HET[23]/ N2HET[30] | 68 | | | | |
| GIOA[6]/SPI2nCS[1]/N2HET[31] | 12 | | | | |

4.2.2 Enhanced Quadrature Encoder Pulse Modules (eQEP)

Table 4-2. Enhanced Quadrature Encoder Pulse Modules (eQEP)

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|--------------------------------|--------|-------------|------------------|------------------|----------------------|
| SIGNAL NAME | 100 PZ | | | | |
| SPI3CLK/EQEPA | 36 | Input | Pullup | Fixed 20 μ A | Enhanced QEP Input A |
| SPI3nENA/EQEPA | 37 | Input | | | Enhanced QEP Input B |
| SPI3nCS[0]/EQEPI | 38 | I/O | | | Enhanced QEP Index |
| MIBSPI1nCS[1]/EQEPS/N2HET [17] | 93 | I/O | | | Enhanced QEP Strobe |

4.2.3 General-Purpose Input/Output (GPIO)

Table 4-3. General-Purpose Input/Output (GPIO)

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|------------------------------|--------|-------------|------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| GIOA[0]/SPI3nCS[3] | 1 | I/O | Pulldown | Programmable, 20 μ A | General-purpose input/output All GPIO terminals can generate interrupts to the CPU on rising/falling/both edges. |
| GIOA[1]/SPI3nCS[2] | 2 | | | | |
| GIOA[2]/SPI3nCS[1] | 5 | | | | |
| GIOA[3]/SPI2nCS[3] | 8 | | | | |
| GIOA[4]/SPI2nCS[2] | 9 | | | | |
| GIOA[5]/EXTCLKIN | 10 | | | | |
| GIOA[6]/SPI2nCS[1]/N2HET[31] | 12 | | | | |
| GIOA[7]/N2HET[29] | 18 | | | | |

4.2.4 Controller Area Network Interface Modules (DCAN1, DCAN2)

Table 4-4. Controller Area Network Interface Modules (DCAN1, DCAN2)

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------|--------|-------------|------------------|--------------------------|---------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| CAN1RX | 63 | I/O | Pullup | Programmable, 20 μ A | CAN1 Receive, or general-purpose I/O (GPIO) |
| CAN1TX | 62 | | | | CAN1 Transmit, or GPIO |
| CAN2RX | 92 | | | | CAN2 Receive, or GPIO |
| CAN2TX | 91 | | | | CAN2 Transmit, or GPIO |

4.2.5 Multibuffered Serial Peripheral Interface (MibSPI1)

Table 4-5. Multibuffered Serial Peripheral Interface (MibSPI1)

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-----------------------------------|--------|-------------|------------------|--------------------------|--------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| MIBSPI1CLK | 67 | I/O | Pullup | Programmable, 20 μ A | MibSPI1 Serial Clock, or GPIO |
| MIBSPI1nCS[0] | 73 | | | | MibSPI1 Chip Select, or GPIO |
| MIBSPI1nCS[1]/EQEPS/N2HET[17] | 93 | | | | |
| MIBSPI1nCS[2]/N2HET[20]/N2HET[19] | 27 | | | | |
| MIBSPI1nCS[3]/N2HET[26] | 39 | | | | |
| MIBSPI1nENA/N2HET[23]/N2HET[30] | 68 | | | | MibSPI1 Enable, or GPIO |
| MIBSPI1SIMO | 65 | | | | MibSPI1 Slave-In-Master-Out, or GPIO |
| MIBSPI1SOMI | 66 | | | | MibSPI1 Slave-Out-Master-In, or GPIO |

4.2.6 Standard Serial Peripheral Interface (SPI2)

Table 4-6. Standard Serial Peripheral Interface (SPI2)

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------|------------------|--------------------------|-----------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| SPI2CLK | 71 | I/O | Pullup | Programmable, 20 μ A | SPI2 Serial Clock, or GPIO |
| SPI2nCS[0] | 23 | | | | SPI2 Chip Select, or GPIO |
| GIOA[6]/SPI2nCS[1]/N2HET[31] | 12 | | | | |
| GIOA[4]/SPI2nCS[2] | 9 | | | | |
| GIOA[3]/SPI2nCS[3] | 8 | | | | |
| SPI2SIMO | 70 | | | | SPI2 Slave-In-Master-Out, or GPIO |
| SPI2SOMI | 69 | | | | SPI2 Slave-Out-Master-In, or GPIO |
| <p>The drive strengths for the SPI2CLK, SPI2SIMO, and SPI2SOMI signals are selected individually by configuring the respective SRS bits of the SPIPC9 register for SPI2. SRS = 0 for 8-mA drive (fast). This is the default mode as the SRS bits in the SPIPC9 register default to 0. SRS = 1 for 2-mA drive (slow)</p> | | | | | |
| SPI3CLK/EQEPA | 36 | I/O | Pullup | Programmable, 20 μ A | SPI3 Serial Clock, or GPIO |
| SPI3nCS[0]/EQEPI | 38 | | | | SPI3 Chip Select, or GPIO |
| GIOA[2]/SPI3nCS[1] | 5 | | | | |
| GIOA[1]/SPI3nCS[2] | 2 | | | | |
| GIOA[0]/SPI3nCS[3] | 1 | | | | |
| SPI3nENA/EQEPB | 37 | | | | SPI3 Enable, or GPIO |
| SPI3SIMO | 35 | | | | SPI3 Slave-In-Master-Out, or GPIO |
| SPI3SOMI | 34 | | | | SPI3 Slave-Out-Master-In, or GPIO |

4.2.7 Local Interconnect Network Controller (LIN)

Table 4-7. Local Interconnect Network Controller (LIN)

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------|--------|-------------|------------------|--------------------------|-----------------------|
| SIGNAL NAME | 100 PZ | | | | |
| LINRX | 94 | I/O | Pullup | Programmable, 20 μ A | LIN Receive, or GPIO |
| LINTX | 95 | | | | LIN Transmit, or GPIO |

4.2.8 Multibuffered Analog-to-Digital Converter (MibADC)

Table 4-8. Multibuffered Analog-to-Digital Converter (MibADC)

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-----------------|--------|--------------|------------------|--------------------------|-----------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| ADEVT/N2HET[28] | 58 | I/O | Pullup | Programmable, 20 μ A | ADC event trigger or GPIO |
| ADIN[0] | 42 | Input | N/A | None | Analog inputs |
| ADIN[1] | 49 | | | | |
| ADIN[2] | 51 | | | | |
| ADIN[3] | 52 | | | | |
| ADIN[4] | 54 | | | | |
| ADIN[5] | 55 | | | | |
| ADIN[6] | 56 | | | | |
| ADIN[7] | 43 | | | | |
| ADIN[8] | 57 | | | | |
| ADIN[9] | 48 | | | | |
| ADIN[10] | 50 | | | | |
| ADIN[11] | 53 | | | | |
| ADIN[16] | 40 | | | | |
| ADIN[17] | 41 | | | | |
| ADIN[20] | 44 | | | | |
| ADIN[21] | 45 | | | | |
| VCCAD/ADREFHI | 46 | Input/Power | N/A | None | ADC high reference level/ADC operating supply |
| VSSAD/ADREFLO | 47 | Input/Ground | N/A | None | ADC low reference level/ADC supply ground |

4.2.9 System Module

Table 4-9. System Module

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|------------------|--------|-------------|------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| ECLK | 84 | I/O | Pulldown | Programmable, 20 μ A | External prescaled clock output, or GPIO. |
| GIOA[5]/EXTCLKIN | 10 | Input | Pulldown | 20 μ A | External Clock In |
| nPORRST | 31 | Input | Pulldown | 100 μ A | Power-on reset, cold reset External power supply monitor circuitry must drive nPORRST low when any of the supplies to the microcontroller fall out of the specified range. This terminal has a glitch filter. |
| nRST | 81 | I/O | Pullup | 100 μ A | The external circuitry can assert a system reset by driving nRST low. To ensure that an external reset is not arbitrarily generated, TI recommends that an external pullup resistor is connected to this terminal. This terminal has a glitch filter. |

4.2.10 Error Signaling Module (ESM)

Table 4-10. Error Signaling Module (ESM)

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------|--------|-------------|------------------|------------|-----------------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| nERROR | 82 | I/O | Pulldown | 20 μ A | ESM error signal. Indicates error of high severity. |

4.2.11 Main Oscillator

Table 4-11. Main Oscillator

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------|--------|-------------|------------------|-----------|----------------------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| OSCIN | 14 | Input | N/A | None | From external crystal/resonator, or external clock input |
| OSCOUT | 16 | Output | N/A | None | To external crystal/resonator |
| KELVIN_GND | 15 | Input | N/A | None | Dedicated ground for oscillator |

4.2.12 Test/Debug Interface

Table 4-12. Test/Debug Interface

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------|--------|-------------|------------------------------|--------------------|-------------------------------------------------------------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| nTRST | 76 | Input | Pulldown | Fixed, 100 μ A | JTAG test hardware reset |
| RTCK | 80 | Output | N/A | None | JTAG return test clock |
| TCK | 79 | Input | Pulldown | Fixed, 100 μ A | JTAG test clock |
| TDI | 77 | I/O | Pullup | Fixed, 100 μ A | JTAG test data in |
| TDO | 78 | Output | Fixed, 100- μ A Pulldown | None | JTAG test data out |
| TMS | 75 | I/O | Pullup | Fixed, 100 μ A | JTAG test select |
| TEST | 24 | I/O | Pulldown | Fixed, 100 μ A | Test enable. This terminal must be connected to ground directly or through a pulldown resistor. |

4.2.13 Flash

Table 4-13. Flash

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------|--------|-------------|------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| FLTP1 | 3 | Input | N/A | None | Flash test pins. For proper operation this terminal must connect only to a test pad or not be connected at all [no connect (NC)]. The test pad must not be exposed in the final product where it might be subjected to an ESD event. |
| FLTP2 | 4 | Input | N/A | None | |
| VCCP | 96 | 3.3-V Power | N/A | None | Flash external pump voltage (3.3 V). This terminal is required for both flash read and flash program and erase operations. |

4.2.14 Core Supply

Table 4-14. Core Supply

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------|--------|-------------|------------------|-----------|------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| VCC | 13 | 1.2-V Power | N/A | None | Digital logic and RAM supply |
| VCC | 21 | | | | |
| VCC | 30 | | | | |
| VCC | 32 | | | | |
| VCC | 61 | | | | |
| VCC | 88 | | | | |
| VCC | 99 | | | | |

4.2.15 I/O Supply

Table 4-15. I/O Supply

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------|--------|-------------|------------------|-----------|-------------|
| SIGNAL NAME | 100 PZ | | | | |
| VCCIO | 6 | 3.3-V Power | N/A | None | I/O supply |
| VCCIO | 28 | | | | |
| VCCIO | 60 | | | | |
| VCCIO | 85 | | | | |

4.2.16 Core and I/O Supply Ground Reference

Table 4-16. Core and I/O Supply Ground Reference

| TERMINAL | | SIGNAL TYPE | RESET PULL STATE | PULL TYPE | DESCRIPTION |
|-------------|--------|-------------|------------------|-----------|--------------------------------------------------------------------------------------------------------|
| SIGNAL NAME | 100 PZ | | | | |
| VSS | 7 | Ground | N/A | None | Device Ground Reference. This is a single ground reference for all supplies except for the ADC supply. |
| VSS | 17 | | | | |
| VSS | 20 | | | | |
| VSS | 29 | | | | |
| VSS | 33 | | | | |
| VSS | 59 | | | | |
| VSS | 72 | | | | |
| VSS | 86 | | | | |
| VSS | 87 | | | | |
| VSS | 100 | | | | |

4.3 Output Multiplexing and Control

Output multiplexing will be used in the device. The multiplexing is used to allow development of additional package and feature combinations as well as to maintain pinout compatibility with the marketing device family.

In all cases indicated as multiplexed, the output buffers are multiplexed.

4.3.1 Notes on Output Multiplexing

Table 4-17 shows the output signal multiplexing and control signals for selecting the desired functionality for each pin.

- The pins default to the signal defined by the DEFAULT FUNCTION column in Table 4-17
- The CONTROL 1, CONTROL 2, and CONTROL 3 columns indicate the multiplexing control register and the bit that must be set in order to select the corresponding functionality to be output on any particular pin.

For example, consider the multiplexing on pin 18, shown in Table 4-18.

Table 4-17. Output Mux Options

| 100 PZ PIN | DEFAULT FUNCTION | CONTROL 1 | OPTION2 | CONTROL 2 | OPTION 3 | CONTROL 3 |
|------------|------------------|-------------|------------|-------------|-----------|-------------|
| 1 | GIOA[0] | PINMMR0[8] | SPI3nCS[3] | PINMMR0[9] | – | – |
| 2 | GIOA[1] | PINMMR1[0] | SPI3nCS[2] | PINMMR1[1] | – | – |
| 5 | GIOA[2] | PINMMR1[8] | SPI3nCS[1] | PINMMR1[9] | – | – |
| 8 | GIOA[3] | PINMMR1[16] | SPI2nCS[3] | PINMMR1[17] | – | – |
| 9 | GIOA[4] | PINMMR1[24] | SPI2nCS[2] | PINMMR1[25] | – | – |
| 10 | GIOA[5] | PINMMR2[0] | EXTCLKIN | PINMMR2[1] | – | – |
| 12 | GIOA[6] | PINMMR2[8] | SPI2nCS[1] | PINMMR2[9] | N2HET[31] | PINMMR2[10] |
| 18 | GIOA[7] | PINMMR2[16] | N2HET[29] | PINMMR2[17] | – | – |
| 93 | MIBSPI1nCS[1] | PINMMR6[8] | EQEPS | PINMMR6[9] | N2HET[17] | PINMMR6[10] |
| 27 | MIBSPI1nCS[2] | PINMMR3[0] | N2HET[20] | PINMMR3[1] | N2HET[19] | PINMMR3[2] |
| 39 | MIBSPI1nCS[3] | PINMMR4[8] | N2HET[26] | PINMMR4[9] | – | – |
| 68 | MIBSPI1nENA | PINMMR5[8] | N2HET[23] | PINMMR5[9] | N2HET[30] | PINMMR5[10] |
| 36 | SPI3CLK | PINMMR3[16] | EQEPA | PINMMR3[17] | – | – |
| 38 | SPI3nCS[0] | PINMMR4[0] | EQEPI | PINMMR4[1] | – | – |
| 37 | SPI3nENA | PINMMR3[24] | EQEPB | PINMMR3[25] | – | – |
| 58 | ADEVT | PINMMR4[16] | N2HET[28] | PINMMR4[17] | – | – |

Table 4-18. Muxing Example

| 100 PZ PIN | DEFAULT FUNCTION | CONTROL 1 | OPTION2 | CONTROL 2 | OPTION 3 | CONTROL 3 |
|------------|------------------|-------------|-----------|-------------|----------|-----------|
| 18 | GIOA[7] | PINMMR2[16] | N2HET[29] | PINMMR2[17] | – | – |

- When GIOA[7] is configured as an output pin in the GPIO module control register, then the programmed output level appears on pin 18 by default. The PINMMR2[16] bit is set by default to indicate that the GIOA[7] signal is selected to be output.
- If the application must output the N2HET[29] signal on pin 18, it must clear PINMMR2[16] and set PINMMR2[17].
- The pin is connected as input to both the GPIO and N2HET modules. That is, there is no input multiplexing on this pin.

4.3.2 General Rules for Multiplexing Control Registers

- The PINMMR control registers can only be written in privileged mode. A write in a nonprivileged mode will generate an error response.
- If the application writes all 0s to any PINMMR control register, then the default functions are selected for the affected pins.
- Each byte in a PINMMR control register is used to select the functionality for a given pin. If the application sets more than 1 bit within a byte for any pin, then the default function is selected for this pin.
- Some bits within the PINMMR registers could be associated with internal pads that are not brought out in the 100-pin package. As a result, bits marked reserved should not be written as 1.

4.4 Special Multiplexed Options

Special controls are implemented to affect particular functions on this microcontroller. These controls are described in this section.

4.4.1 Filtering for eQEP Inputs

4.4.1.1 eQEPA Input

- When PINMMR8[0] = 1, the eQEPA input is double-synchronized using VCLK.
- When PINMMR8[0] = 0 and PINMMR8[1] = 1, the eQEPA input is double-synchronized and then qualified through a fixed 6-bit counter using VCLK.
- PINMMR8[0] = 0 and PINMMR8[1] = 0 is an illegal combination and behavior defaults to PINMMR8[0] = 1.

4.4.1.2 eQEPB Input

- When PINMMR8[8] = 1, the eQEPB input is double-synchronized using VCLK.
- When PINMMR8[8] = 0 and PINMMR8[9] = 1, the eQEPB input is double-synchronized and then qualified through a fixed 6-bit counter using VCLK.
- PINMMR8[8] = 0 and PINMMR8[9] = 0 is an illegal combination and behavior defaults to PINMMR8[8] = 1.

4.4.1.3 eQEPI Input

- When PINMMR8[16] = 1, the eQEPI input is double-synchronized using VCLK.
- When PINMMR8[16] = 0 and PINMMR8[17] = 1, the eQEPI input is double-synchronized and then qualified through a fixed 6-bit counter using VCLK.
- PINMMR8[16] = 0 and PINMMR8[17] = 0 is an illegal combination and behavior defaults to PINMMR8[16] = 1.

4.4.1.4 eQEPS Input

- When PINMMR8[24] = 1, the eQEPS input is double-synchronized using VCLK.
- When PINMMR8[24] = 0 and PINMMR8[25] = 1, the eQEPS input is double-synchronized and then qualified through a fixed 6-bit counter using VCLK.
- PINMMR8[24] = 0 and PINMMR8[25] = 0 is an illegal combination and behavior defaults to PINMMR8[24] = 1.

4.4.2 N2HET PIN_nDISABLE Input Port

- When PINMMR9[0] = 1, GIOA[5] is connected directly to N2HET PIN_nDISABLE input of the N2HET module.
- When PINMMR9[0] = 0 and PINMMR9[1] = 1, EQEPERR is inverted and double-synchronized using VCLK before connecting directly to the N2HET PIN_nDISABLE input of the N2HET module.
- PINMMR9[0] = 0 and PINMMR9[1] = 0 is an illegal combination and behavior defaults to PINMMR9[0] = 1.

5 Specifications

5.1 Absolute Maximum Ratings⁽¹⁾

Over Operating Free-Air Temperature Range

| | | MIN | MAX | UNIT |
|---------------------------------------|---------------------------------------------------------------------------------------|------|------|------|
| Supply voltage | $V_{CC}^{(2)}$ | -0.3 | 1.43 | V |
| | $V_{CCIO}, V_{CCP}^{(2)}$ | -0.3 | 4.6 | |
| | V_{CCAD} | -0.3 | 4.6 | |
| Input voltage | All input pins | -0.3 | 4.6 | V |
| | ADC input pins | -0.3 | 4.6 | |
| Input clamp current | I_{IK} ($V_I < 0$ or $V_I > V_{CCIO}$) All pins, except ADIN[21:20,17:16,11:0] | -20 | 20 | mA |
| | I_{IK} ($V_I < 0$ or $V_I > V_{CCAD}$) ADIN[21:20,17:16,11:0] | -10 | 10 | |
| | Total | -40 | 40 | |
| Operating free-air temperature, T_A | | -40 | 125 | °C |
| Operating junction temperature, T_J | | -40 | 150 | °C |
| Latch-up performance | I-test, All I/O pins | -100 | 100 | mA |
| Storage temperature, 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 *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Maximum-rated conditions for extended periods may affect device reliability. All voltage values are with respect to their associated grounds.

5.2 ESD Ratings

| | | | VALUE | UNIT | |
|-------------|--------------------------------------------|---------------------------------------------------------|----------------------------------------------|------|---|
| $V_{(ESD)}$ | Electrostatic discharge (ESD) performance: | Human Body Model (HBM), per AEC Q100-002 ⁽¹⁾ | ±2 | kV | |
| | | Charged Device Model (CDM), per AEC Q100-011 | All pins except corner pins | ±500 | V |
| | | | Corner pins (1, 25, 26, 50, 51, 75, 76, 100) | ±750 | V |

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

5.3 Power-On Hours (POH)⁽¹⁾⁽²⁾

| NOMINAL CORE VOLTAGE (V_{CC}) | JUNCTION TEMPERATURE (T_J) | LIFETIME POH |
|-----------------------------------|--------------------------------|--------------|
| 1.2 | 105°C | 100K |

- (1) This information is provided solely for your convenience and does not extend or modify the warranty provided under TI's standard terms and conditions for TI semiconductor products.
- (2) To avoid significant degradation, the device power-on hours (POH) must be limited to those specified in this table. To convert to equivalent POH for a specific temperature profile, see the *Calculating Equivalent Power-on-Hours for Hercules Safety MCUs* Application Report (SPNA207).

5.4 Recommended Operating Conditions⁽¹⁾

| | | MIN | NOM | MAX | UNIT |
|------------------------------------------|----------------------------------------------------------------------------------------------------|------|-----|------|------|
| V _{CC} | Digital logic supply voltage (Core) | 1.14 | 1.2 | 1.32 | V |
| V _{CCIO} | Digital logic supply voltage (I/O) | 3 | 3.3 | 3.6 | V |
| V _{CCAD} / V _{ADREFHI} | MibADC supply voltage / A-to-D high-voltage reference source | 3 | 3.3 | 3.6 | V |
| V _{CCP} | Flash pump supply voltage | 3 | 3.3 | 3.6 | V |
| V _{SS} | Digital logic supply ground | | 0 | | V |
| V _{SSAD} / V _{ADREFLO} | MibADC supply ground / A-to-D low-voltage reference source | -0.1 | | 0.1 | V |
| V _{SLEW} | Maximum positive slew rate for V _{CCIO} , V _{CCAD} and V _{CCP} supplies | | | 1 | V/μs |
| T _A | Operating free-air temperature | -40 | | 125 | °C |
| T _J | Operating junction temperature ⁽²⁾ | -40 | | 150 | °C |

(1) All voltages are with respect to V_{SS}, except V_{CCAD}, which is with respect to V_{SSAD}

(2) Reliability data is based upon a temperature profile that is equivalent to 100,000 power-on hours at 105°C junction temperature.

5.5 Switching Characteristics Over Recommended Operating Conditions for Clock Domains

Table 5-1. Clock Domains Timing Specifications

| PARAMETER | | CONDITIONS | MIN | MAX | UNIT |
|---------------------|--------------------------------------------------------------------------------|------------|-----|-------------------|------|
| f _{HCLK} | HCLK - System clock frequency | | | 80 | MHz |
| f _{GCLK} | GCLK - CPU clock frequency (ratio f _{GCLK} : f _{HCLK} = 1:1) | | | f _{HCLK} | MHz |
| f _{VCLK} | VCLK - Primary peripheral clock frequency | | | 80 | MHz |
| f _{VCLK2} | VCLK2 - Secondary peripheral clock frequency | | | 80 | MHz |
| f _{VCLKA1} | VCLKA1 - Primary asynchronous peripheral clock frequency | | | 80 | MHz |
| f _{RTICK} | RTICK - clock frequency | | | f _{VCLK} | MHz |

5.6 Wait States Required

The TCM RAM can support program and data fetches at full CPU speed without any address or data wait states required. There are no registers which need to be programmed for RAM wait states.

The TCM flash can support zero address and data wait states up to a CPU speed of 45 MHz in nonpipelined mode. The flash supports a maximum CPU clock speed of 80 MHz in pipelined mode with no address wait states and one data wait state.

The proper wait states should be set in the register fields *Address Setup Wait State Enable* (ASWSTEN 0xFFF87000[4]), *Random Wait states* (RWAIT 0xFFF87000[11:8]), and *Emulation Wait states* (EWAIT 0xFFF872B8[19:16]) as shown in [Figure 5-1](#).

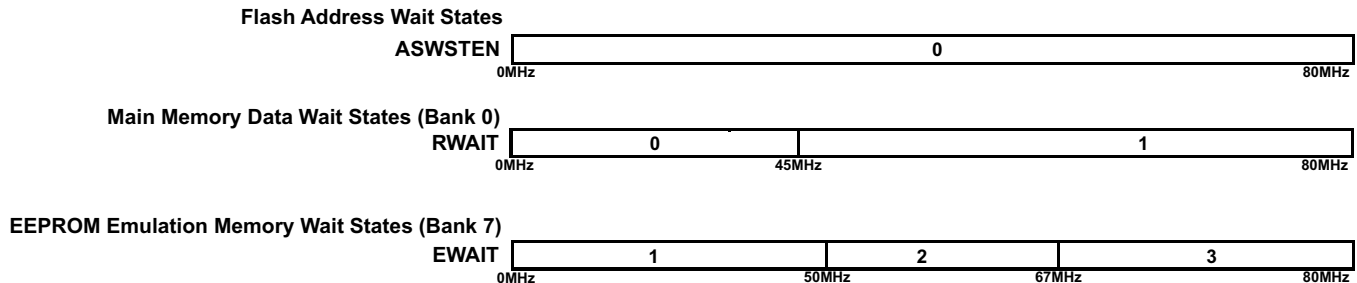


Figure 5-1. Wait States Scheme

The flash wrapper defaults to nonpipelined mode with address wait states disabled, ASWSTEN=0; the main memory random-read data wait state, RWAIT=1; and the emulation memory random-read wait states, EWAIT=1.

5.7 Power Consumption

Over Recommended Operating Conditions

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------------------------------------------------------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----------------------|------|
| I _{CC} | V _{CC} digital supply current (operating mode) | f _{HCLK} = 80 MHz f _{VCLK} = 80 MHz, Flash in pipelined mode, V _{CCmax} | | | 135 ⁽¹⁾ | mA |
| | V _{CC} digital supply current (LBIST mode) | LBIST clock rate = 45 MHz | | | 145 ⁽²⁾⁽³⁾ | |
| | V _{CC} digital supply current (PBIST mode) | PBIST ROM clock frequency = 80 MHz | | | 135 ⁽²⁾⁽³⁾ | |
| I _{CCREFHI} + I _{CCAD} + I _{CCIO} + I _{CCP} | Sum of Flash, IO and ADC 3.3V supply currents | V _{ADREFHI} = V _{ADREFHI} max V _{CCAD} = V _{CCAD} max V _{CCIO} = V _{CCIO} max, No Load on output pins V _{CCP} = V _{CCP} max, Reading from flash | | | 48 | mA |
| | | V _{ADREFHI} = V _{ADREFHI} max V _{CCAD} = V _{CCAD} max V _{CCIO} = V _{CCIO} max, No Load on output pins V _{CCP} = V _{CCP} max, Reading from one bank of flash while programming or erasing another bank | | | 68 | |

- The maximum I_{CC} value can be derated
 - linearly with voltage
 - by 0.76 mA/MHz for lower operating frequency when f_{HCLK} = f_{VCLK}
 - for lower junction temperature by the equation below where T_{JK} is the junction temperature in Kelvin and the result is in milliamperes.

$$60 - 0.001 e^{0.026 T_{JK}}$$
- The maximum I_{CC} value can be derated
 - linearly with voltage
 - for lower junction temperature by the equation below where T_{JK} is the junction temperature in Kelvin and the result is in milliamperes.

$$60 - 0.001 e^{0.026 T_{JK}}$$
- LBIST and PBIST currents are for a short duration, typically less than 10 ms. They are usually ignored for thermal calculations for the device and the voltage regulator

5.8 Thermal Resistance Characteristics for PZ

Table 5-2 shows the thermal resistance characteristics for the PQFP - PZ mechanical packages.

**Table 5-2. Thermal Resistance Characteristics
(S-PQFP Package) [PZ]**

| PARAMETER | °C/W |
|-----------------|------|
| $R_{\theta JA}$ | 48 |
| $R_{\theta JC}$ | 5 |

5.9 Input/Output Electrical Characteristics⁽¹⁾

Over Recommended Operating Conditions

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT | |
|-----------|--------------------------------|--------------------------------------------------|--------------------------|------|------------------|------|---------|
| V_{hys} | Input hysteresis | All inputs | 180 | | | mV | |
| V_{IL} | Low-level input voltage | All inputs ⁽²⁾ | -0.3 | | 0.8 | V | |
| V_{IH} | High-level input voltage | All inputs ⁽²⁾ | 2 | | $V_{CCIO} + 0.3$ | V | |
| V_{OL} | Low-level output voltage | $I_{OL} = I_{OLmax}$ | | | $0.2 V_{CCIO}$ | V | |
| | | $I_{OL} = 50 \mu A$, standard output mode | | | 0.2 | | |
| V_{OH} | High-level output voltage | $I_{OH} = I_{OHmax}$ | $0.8 V_{CCIO}$ | | | V | |
| | | $I_{OH} = 50 \mu A$, standard output mode | $V_{CCIO} - 0.3$ | | | | |
| I_{IC} | Input clamp current (I/O pins) | $V_I < V_{SSIO} - 0.3$ or $V_I > V_{CCIO} + 0.3$ | -3.5 | | 3.5 | mA | |
| I_I | Input current (I/O pins) | I_{IH} 20- μA pulldown | $V_I = V_{CCIO}$ | 5 | | 40 | μA |
| | | I_{IH} 100- μA pulldown | $V_I = V_{CCIO}$ | 40 | | 195 | |
| | | I_{IL} 20- μA pullup | $V_I = V_{SS}$ | -40 | | -5 | |
| | | I_{IL} 100- μA pullup | $V_I = V_{SS}$ | -195 | | -40 | |
| | | All other pins | No pullup or pulldown | -1 | | 1 | |
| C_I | Input capacitance | | | | 2 | pF | |
| C_O | Output capacitance | | | | 3 | pF | |

(1) Source currents (out of the device) are negative while sink currents (into the device) are positive.

(2) This does not apply to the nPORRST pin.

5.10 Output Buffer Drive Strengths

Table 5-3. Output Buffer Drive Strengths

| LOW-LEVEL OUTPUT CURRENT, I_{OL} for $V_I=V_{OLmax}$ or HIGH-LEVEL OUTPUT CURRENT, I_{OH} for $V_I=V_{OHmin}$ | SIGNALS |
|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8 mA | EQEPI, EQEPS, TMS, TDI, TDO, RTCK, nERROR |
| 4 mA | TEST, MIBSPI1SIMO, MIBSPI1SOMI, MIBSPI1CLK, SPI3CLK, SPI3SIMO, SPI3SOMI, nRST |
| 2 mA zero-dominant | AD1EVT, CAN1RX, CAN1TX, CAN2RX, CAN2TX, GIOA[0-7], LINRX, LINTX, MIBSPI1nCS[0-3], MIBSPI1nENA N2HET[0], N2HET[2], N2HET[4], N2HET[6], N2HET[8], N2HET[10], N2HET[12], N2HET[14], N2HET[16], N2HET[18], N2HET[22], N2HET[24], SPI2nCS[0-3], SPI3nENA, SPI3nCS[0] |
| selectable 8 mA/ 2 mA | ECLK, SPI2CLK, SPI2SIMO, SPI2SOMI The default output buffer drive strength is 8 mA for these signals. |

Table 5-4. Selectable 8 mA/ 2 mA Control

| SIGNAL | CONTROL BIT | ADDRESS | 8 mA | 2 mA |
|----------|----------------------------|-------------|------|------|
| ECLK | SYSPC10[0] | 0xFFFF FF78 | 0 | 1 |
| SPI2CLK | SPI2PC9[9] | 0xFFF7 F668 | 0 | 1 |
| SPI2SIMO | SPI2PC9[10] | 0xFFF7 F668 | 0 | 1 |
| SPI2SOMI | SPI2PC9[11] ⁽¹⁾ | 0xFFF7 F668 | 0 | 1 |

(1) Either SPI2PC9[11] or SPI2PC9[24] can change the output strength of the SPI2SOMI pin. In case of a 32-bit write where these 2 bits differ, SPI2PC9[11] determines the drive strength.

5.11 Input Timings

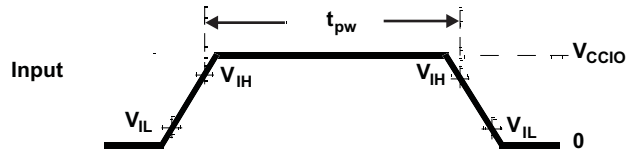


Figure 5-2. TTL-Level Inputs

Table 5-5. Timing Requirements for Inputs⁽¹⁾

| | MIN | MAX | UNIT |
|------------------------------------|--------------------------|-----|------|
| t_{pw} Input minimum pulse width | $t_{c(VCLK)} + 10^{(2)}$ | | ns |

(1) $t_{c(VCLK)}$ = peripheral VBUS clock cycle time = $1 / f_{(VCLK)}$

(2) The timing shown in [Figure 5-2](#) is only valid for pin used in GIO mode.

5.12 Output Timings

Table 5-6. Switching Characteristics for Output Timings versus Load Capacitance (CL)

| PARAMETER | | MIN | MAX | UNIT | |
|------------------|------------------------------|-------------|-------------|------|----|
| Rise time, t_r | 8-mA pins | CL = 15 pF | 2.5 | ns | |
| | | CL = 50 pF | 4 | | |
| | | CL = 100 pF | 7.2 | | |
| | | CL = 150 pF | 12.5 | | |
| Fall time, t_f | | CL = 15 pF | 2.5 | | |
| | | CL = 50 pF | 4 | | |
| | | CL = 100 pF | 7.2 | | |
| | | CL = 150 pF | 12.5 | | |
| Rise time, t_r | 4-mA pins | CL = 15 pF | 5.6 | ns | |
| | | CL = 50 pF | 10.4 | | |
| | | CL = 100 pF | 16.8 | | |
| | | CL = 150 pF | 23.2 | | |
| Fall time, t_f | | CL = 15 pF | 5.6 | | |
| | | CL = 50 pF | 10.4 | | |
| | | CL = 100 pF | 16.8 | | |
| | | CL = 150 pF | 23.2 | | |
| Rise time, t_r | 2-mA-z pins | CL = 15 pF | 8 | ns | |
| | | CL = 50 pF | 15 | | |
| | | CL = 100 pF | 23 | | |
| | | CL = 150 pF | 33 | | |
| Fall time, t_f | | CL = 15 pF | 8 | | |
| | | CL = 50 pF | 15 | | |
| | | CL = 100 pF | 23 | | |
| | | CL = 150 pF | 33 | | |
| Rise time, t_r | Selectable 8-mA/ 2-mA-z pins | 8-mA mode | CL = 15 pF | 2.5 | ns |
| | | | CL = 50 pF | 4 | |
| | | | CL = 100 pF | 7.2 | |
| | | | CL = 150 pF | 12.5 | |
| Fall time, t_f | | CL = 15 pF | 2.5 | | |
| | | CL = 50 pF | 4 | | |
| | | CL = 100 pF | 7.2 | | |
| | | CL = 150 pF | 12.5 | | |
| Rise time, t_r | | 2-mA-z mode | CL = 15 pF | 8 | |
| | | | CL = 50 pF | 15 | |
| | | | CL = 100 pF | 23 | |
| | | | CL = 150 pF | 33 | |
| Fall time, t_f | | | CL = 15 pF | 8 | |
| | | | CL = 50 pF | 15 | |
| | | | CL = 100 pF | 23 | |
| | | | CL = 150 pF | 33 | |

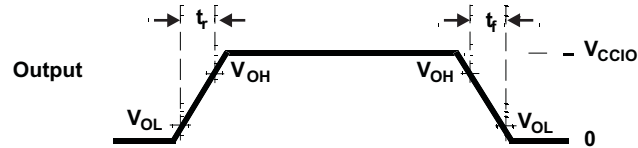


Figure 5-3. CMOS-Level Outputs

Table 5-7. Timing Requirements for Outputs⁽¹⁾

| PARAMETER | | MIN | MAX | UNIT |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|------|
| $t_{d(\text{parallel_out})}$ | Delay between low-to-high, or high-to-low transition of general-purpose output signals that can be configured by an application in parallel, for example, all signals in a GIOA port, or all N2HET signals. | | 5 | ns |

- (1) This specification does not account for any output buffer drive strength differences or any external capacitive loading differences. Check [Table 5-3](#) for output buffer drive strength information on each signal.

6 System Information and Electrical Specifications

6.1 Voltage Monitor Characteristics

A voltage monitor is implemented on this device. The purpose of this voltage monitor is to eliminate the requirement for a specific sequence when powering up the core and I/O voltage supplies.

6.1.1 Important Considerations

- The voltage monitor does not eliminate the need of a voltage supervisor circuit to ensure that the device is held in reset when the voltage supplies are out of range.
- The voltage monitor only monitors the core supply (VCC) and the I/O supply (VCCIO). The other supplies are not monitored by the VMON. For example, if the VCCAD or VCCP are supplied from a source different from that for VCCIO, then there is no internal voltage monitor for the VCCAD and VCCP supplies.

6.1.2 Voltage Monitor Operation

The voltage monitor generates the Power Good MCU signal (PGMCU) as well as the I/Os Power Good I/O signal (PGIO) on the device. During power up or power down, the PGMCU and PGIO are driven low when the core or I/O supplies are lower than the specified minimum monitoring thresholds. The PGIO and PGMCU being low isolates the core logic as well as the I/O controls during the power up or power down of the supplies. This allows the core and I/O supplies to be powered up or down in any order.

When the voltage monitor detects a low voltage on the I/O supply, it will assert a power-on reset. When the voltage monitor detects an out-of-range voltage on the core supply, it asynchronously makes all output pins high impedance, and asserts a power-on reset. The voltage monitor is disabled when the device enters a low power mode.

The VMON also incorporates a glitch filter for the nPORRST input. Refer to [Section 6.2.3.1](#) for the timing information on this glitch filter.

Table 6-1. Voltage Monitoring Specifications

| PARAMETER | | MIN | TYP | MAX | UNIT |
|------------------|----------------------------------------------------------------------|------|-----|------|------|
| V _{MON} | VCC low - VCC level below this threshold is detected as too low. | 0.75 | 0.9 | 1.13 | V |
| | VCC high - VCC level above this threshold is detected as too high. | 1.40 | 1.7 | 2.1 | |
| | VCCIO low - VCCIO level below this threshold is detected as too low. | 1.85 | 2.4 | 2.9 | |

6.1.3 Supply Filtering

The VMON has the capability to filter glitches on the VCC and VCCIO supplies.

[Table 6-2](#) shows the characteristics of the supply filtering. Glitches in the supply larger than the maximum specification cannot be filtered.

Table 6-2. VMON Supply Glitch Filtering Capability

| PARAMETER | MIN | MAX | UNIT |
|-----------------------------------------------|-----|------|------|
| Width of glitch on VCC that can be filtered | 250 | 1000 | ns |
| Width of glitch on VCCIO that can be filtered | 250 | 1000 | ns |

6.2 Power Sequencing and Power-On Reset

6.2.1 Power-Up Sequence

There is no timing dependency between the ramp of the VCCIO and the VCC supply voltage. The power-up sequence starts with the I/O voltage rising above the minimum I/O supply threshold, (for more details, see [Table 6-4](#)), core voltage rising above the minimum core supply threshold, and the release of power-on reset. The high-frequency oscillator will start up first and its amplitude will grow to an acceptable level. The oscillator start-up time is dependent on the type of oscillator and is provided by the oscillator vendor. The different supplies to the device can be powered up in any order.

During power up, the device goes through the sequential phases listed in [Table 6-3](#).

Table 6-3. Power-Up Phases

| | |
|----------------------------------------|-------------------------------|
| Oscillator start-up and validity check | 1032 oscillator cycles |
| eFuse autoload | 1160 oscillator cycles |
| Flash pump power up | 688 oscillator cycles |
| Flash bank power up | 617 oscillator cycles |
| Total | 3497 oscillator cycles |

The CPU reset is released at the end of this sequence and fetches the first instruction from address 0x00000000.

6.2.2 Power-Down Sequence

The different supplies to the device can be powered down in any order.

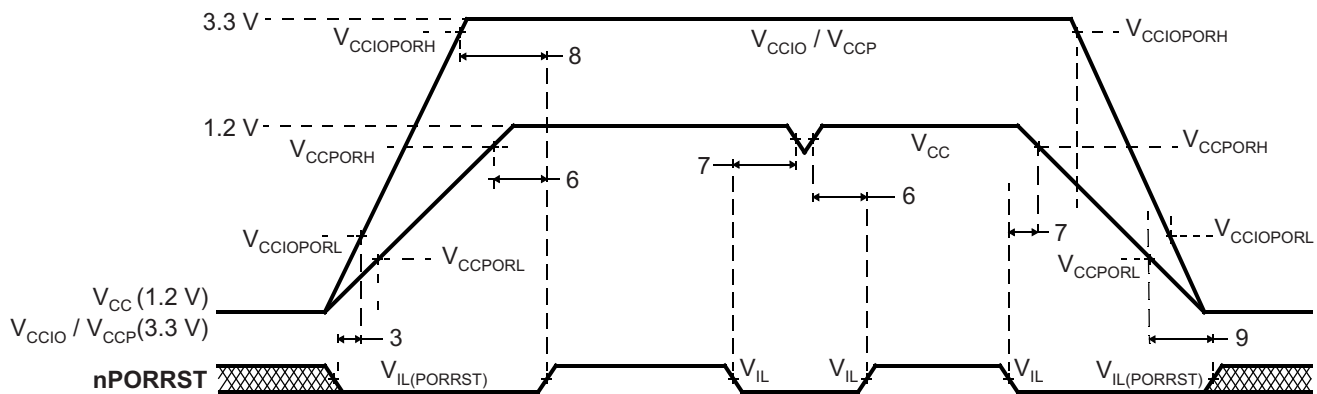
6.2.3 Power-On Reset: nPORRST

This reset must be asserted by an external circuitry whenever the I/O or core supplies are outside the recommended range. This signal has a glitch filter on it. It also has an internal pulldown.

6.2.3.1 nPORRST Electrical and Timing Requirements

Table 6-4. Electrical Requirements for nPORRST

| NO. | PARAMETER | MIN | MAX | UNIT |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------|------|------------------|---------|
| | V_{CCPORL} V_{CC} low supply level when nPORRST must be active during power up | | 0.5 | V |
| | V_{CCPORH} V_{CC} high supply level when nPORRST must remain active during power up and become active during power down | 1.14 | | V |
| | $V_{CCIOPORL}$ V_{CCIO} / V_{CCP} low supply level when nPORRST must be active during power up | | 1.1 | V |
| | $V_{CCIOPORH}$ V_{CCIO} / V_{CCP} high supply level when nPORRST must remain active during power up and become active during power down | 3.0 | | V |
| | $V_{IL(PORRST)}$ Low-level input voltage of nPORRST $V_{CCIO} > 2.5$ V | | $0.2 * V_{CCIO}$ | V |
| | Low-level input voltage of nPORRST $V_{CCIO} < 2.5$ V | | 0.5 | V |
| 3 | $t_{su(PORRST)}$ Setup time, nPORRST active before V_{CCIO} and $V_{CCP} > V_{CCIOPORL}$ during power up | 0 | | ms |
| 6 | $t_h(PORRST)$ Hold time, nPORRST active after $V_{CC} > V_{CCPORH}$ | 1 | | ms |
| 7 | $t_{su(PORRST)}$ Setup time, nPORRST active before $V_{CC} < V_{CCPORH}$ during power down | 2 | | μ s |
| 8 | $t_h(PORRST)$ Hold time, nPORRST active after V_{CCIO} and $V_{CCP} > V_{CCIOPORH}$ | 1 | | ms |
| 9 | $t_h(PORRST)$ Hold time, nPORRST active after $V_{CC} < V_{CCPORL}$ | 0 | | ms |
| | $t_f(nPORRST)$ Filter time nPORRST pin; Pulses less than MIN will be filtered out, pulses greater than MAX will generate a reset. | 475 | 2000 | ns |



Note: There is no timing dependency between the ramp of the V_{CCIO} and the V_{CC} supply voltage; this is just an example.

Figure 6-1. nPORRST Timing Diagram

6.3 Warm Reset (nRST)

This is a bidirectional reset signal. The internal circuitry drives the signal low on detecting any device reset condition. An external circuit can assert a device reset by forcing the signal low. On this terminal, the output buffer is implemented as an open drain (drives low only). To ensure an external reset is not arbitrarily generated, TI recommends that an external pullup resistor is connected to this terminal.

This terminal has a glitch filter. It also has an internal pullup

6.3.1 Causes of Warm Reset

Table 6-5. Causes of Warm Reset

| DEVICE EVENT | SYSTEM STATUS FLAG |
|-------------------------------------|--------------------------------------|
| Power-up reset | Exception Status Register, bit 15 |
| Oscillator fail | Global Status Register, bit 0 |
| PLL slip | Global Status Register, bits 8 and 9 |
| Watchdog exception / Debugger reset | Exception Status Register, bit 13 |
| CPU Reset (driven by the CPU STC) | Exception Status Register, bit 5 |
| Software reset | Exception Status Register, bit 4 |
| External reset | Exception Status Register, bit 3 |

6.3.2 nRST Timing Requirements

Table 6-6. nRST Timing Requirements

| | | MIN | MAX | UNIT |
|---------------|-------------------------------------------------------------------------------------------------------------------|----------------------------------|------|------|
| $t_{v(RST)}$ | Valid time, nRST active after nPORRST inactive | 2256 $t_{c(OSC)}$ ⁽¹⁾ | | ns |
| | Valid time, nRST active (all other system reset conditions) | 32 $t_{c(VCLK)}$ | | |
| $t_{f(nRST)}$ | Filter time nRST pin; Pulses less than MIN will be filtered out, pulses greater than MAX will generate a reset | 475 | 2000 | ns |

(1) Assumes the oscillator has started up and stabilized before nPORRST is released.

6.4 ARM Cortex-R4 CPU Information

6.4.1 Summary of ARM Cortex-R4 CPU Features

The features of the ARM Cortex-R4 CPU include:

- An integer unit with integral Embedded ICE-RT logic.
- High-speed Advanced Microprocessor Bus Architecture (AMBA) Advanced eXtensible Interfaces (AXI) for Level two (L2) master and slave interfaces.
- Dynamic branch prediction with a global history buffer, and a 4-entry return stack
- Low interrupt latency.
- Nonmaskable interrupt.
- A Harvard Level one (L1) memory system with:
 - Tightly Coupled Memory (TCM) interfaces with support for error correction or parity checking memories
 - ARMv7-R architecture Memory Protection Unit (MPU) with 8 regions
- Dual core logic for fault detection in safety-critical applications.
- An L2 memory interface:
 - Single 64-bit master AXI interface
 - 64-bit slave AXI interface to TCM RAM blocks
- A debug interface to a CoreSight Debug Access Port (DAP).
- Six Hardware Breakpoints
- Two Watchpoints
- A Performance Monitoring Unit (PMU)
- A Vectored Interrupt Controller (VIC) port.

For more information on the ARM Cortex-R4 CPU, see www.arm.com.

6.4.2 ARM Cortex-R4 CPU Features Enabled by Software

The following CPU features are disabled on reset and must be enabled by the application if required.

- ECC On Tightly Coupled Memory (TCM) Accesses
- Hardware Vectored Interrupt (VIC) Port
- Memory Protection Unit (MPU)

6.4.3 Dual Core Implementation

The device has two Cortex-R4 cores, where the output signals of both CPUs are compared in the CCM-R4 unit. To avoid common mode impacts the signals of the CPUs to be compared are delayed by 2 clock cycles as shown in [Figure 6-3](#).

The CPUs have a diverse CPU placement given by following requirements:

- Different orientation; for example, CPU1 = "north" orientation, CPU2 = "flip west" orientation
- Dedicated guard ring for each CPU



Figure 6-2. Dual - CPU Orientation

6.4.4 Duplicate clock tree after GCLK

The CPU clock domain is split into two clock trees, one for each CPU, with the clock of the 2nd CPU running at the same frequency and in phase to the clock of CPU1. See [Figure 6-3](#).

6.4.5 ARM Cortex-R4 CPU Compare Module (CCM) for Safety

This device has two ARM Cortex-R4 CPU cores, where the output signals of both CPUs are compared in the CCM-R4 unit. To avoid common mode impacts the signals of the CPUs to be compared are delayed in a different way as shown in [Figure 6-3](#).

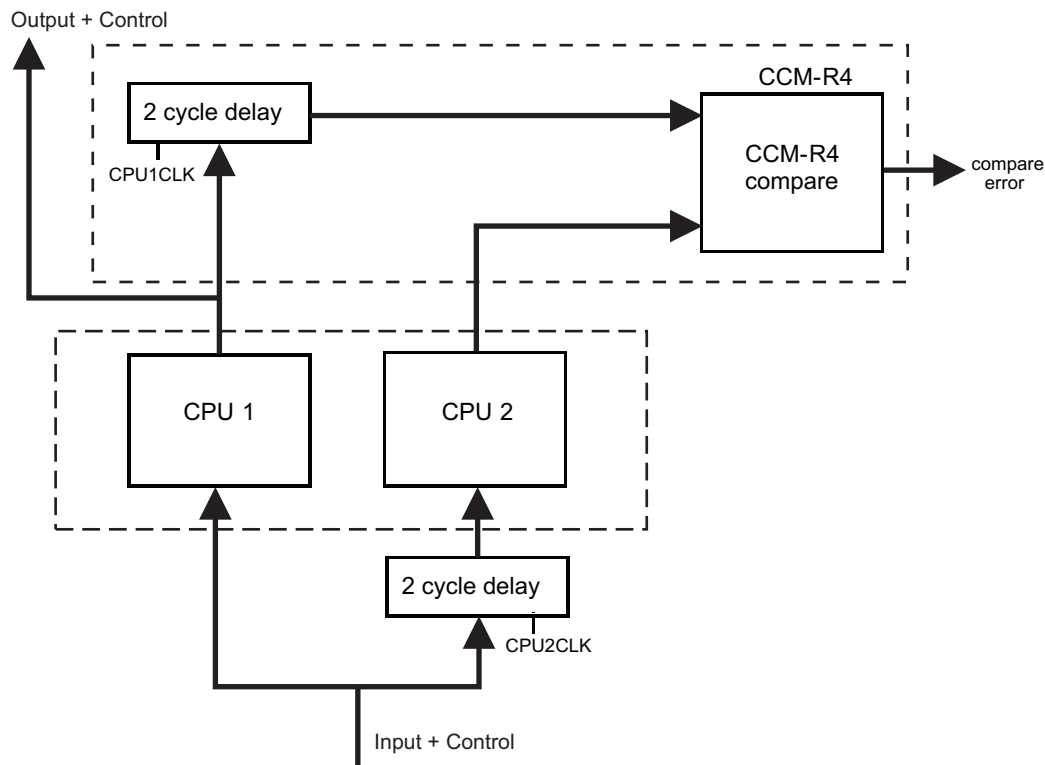


Figure 6-3. Dual Core Implementation

To avoid an erroneous CCM-R4 compare error, the application software must initialize the registers of both CPUs before the registers are used, including function calls where the register values are pushed onto the stack.

6.4.6 CPU Self-Test

The CPU STC (Self-Test Controller) is used to test the two Cortex-R4 CPU Cores using the Deterministic Logic BIST Controller as the test engine.

The main features of the self-test controller are:

- Ability to divide the complete test run into independent test intervals
- Capable of running the complete test or running a few intervals at a time
- Ability to continue from the last executed interval (test set) or to restart from the beginning (first test set)
- Complete isolation of the self-tested CPU core from the rest of the system during the self-test run
- Ability to capture the failure interval number
- Timeout counter for the CPU self-test run as a fail-safe feature

6.4.6.1 Application Sequence for CPU Self-Test

1. Configure clock domain frequencies.
2. Select the number of test intervals to be run.
3. Configure the timeout period for the self-test run.
4. Save the CPU state if required
5. Enable self-test.
6. Wait for CPU reset.
7. In the reset handler, read CPU self-test status to identify any failures.
8. Retrieve CPU state if required.

For more information, see the *TMS570LS04x/03x 16/32-Bit RISC Flash Microcontroller Technical Reference Manual (SPNU517)*.

6.4.6.2 CPU Self-Test Clock Configuration

The maximum clock rate for the self-test is 45 MHz. The STCCLK is divided down from the CPU clock, when necessary. This divider is configured by the STCCLKDIV register at address 0xFFFFE108.

6.4.6.3 CPU Self-Test Coverage

Table 6-7 shows CPU test coverage achieved for each self-test interval. It also lists the cumulative test cycles. The test time can be calculated by multiplying the number of test cycles with the STC clock period.

Table 6-7. CPU Self-Test Coverage

| INTERVALS | TEST COVERAGE, % | TEST CYCLES |
|-----------|------------------|-------------|
| 0 | 0 | 0 |
| 1 | 60.06 | 1365 |
| 2 | 68.71 | 2730 |
| 3 | 73.35 | 4095 |
| 4 | 76.57 | 5460 |
| 5 | 78.7 | 6825 |
| 6 | 80.4 | 8190 |
| 7 | 81.76 | 9555 |
| 8 | 82.94 | 10920 |
| 9 | 83.84 | 12285 |
| 10 | 84.58 | 13650 |
| 11 | 85.31 | 15015 |
| 12 | 85.9 | 16380 |
| 13 | 86.59 | 17745 |
| 14 | 87.17 | 19110 |
| 15 | 87.67 | 20475 |
| 16 | 88.11 | 21840 |
| 17 | 88.53 | 23205 |
| 18 | 88.93 | 24570 |
| 19 | 89.26 | 25935 |
| 20 | 89.56 | 27300 |
| 21 | 89.86 | 28665 |
| 22 | 90.1 | 30030 |
| 23 | 90.36 | 31395 |
| 24 | 90.62 | 32760 |

Table 6-7. CPU Self-Test Coverage (continued)

| INTERVALS | TEST COVERAGE, % | TEST CYCLES |
|-----------|------------------|-------------|
| 25 | 90.86 | 34125 |
| 26 | 91.06 | 35490 |

6.5 Clocks

6.5.1 Clock Sources

The table below lists the available clock sources on the device. Each of the clock sources can be enabled or disabled using the CSDISx registers in the system module. The clock source number in the table corresponds to the control bit in the CSDISx register for that clock source.

The table also shows the default state of each clock source.

Table 6-8. Available Clock Sources

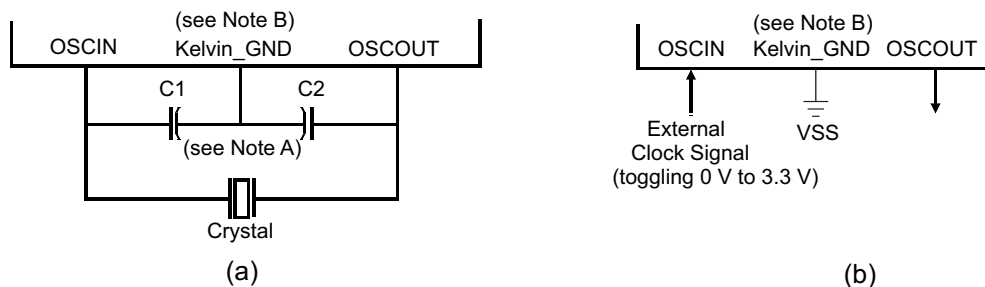
| CLOCK SOURCE NO. | NAME | DESCRIPTION | DEFAULT STATE |
|------------------|-----------|--------------------------------------------------------|---------------|
| 0 | OSCIN | Main Oscillator | Enabled |
| 1 | PLL1 | Output From PLL1 | Disabled |
| 2 | Reserved | Reserved | Disabled |
| 3 | EXTCLKIN1 | External Clock Input #1 | Disabled |
| 4 | CLK80K | Low-Frequency Output of Internal Reference Oscillator | Enabled |
| 5 | CLK10M | High-Frequency Output of Internal Reference Oscillator | Enabled |
| 6 | Reserved | Reserved | Disabled |
| 7 | Reserved | Reserved | Disabled |

6.5.1.1 Main Oscillator

The oscillator is enabled by connecting the appropriate fundamental resonator/crystal and load capacitors across the external OSCIN and OSCOUT pins as shown in [Figure 6-4](#). The oscillator is a single stage inverter held in bias by an integrated bias resistor. This resistor is disabled during leakage test measurement and low power modes.

TI strongly encourages each customer to submit samples of the device to the resonator/crystal vendors for validation. The vendors are equipped to determine what load capacitors will best tune their resonator/crystal to the microcontroller device for optimum start-up and operation over temperature/voltage extremes.

An external oscillator source can be used by connecting a 3.3 V clock signal to the OSCIN pin and leaving the OSCOUT pin unconnected (open) as shown in [Figure 6-4](#).



Note A: The values of C1 and C2 should be provided by the resonator/crystal vendor.

Note B: Kelvin_GND should not be connected to any other GND when used with a crystal; however, when used with an external clock source, Kelvin_GND may be tied to VSS.

Figure 6-4. Recommended Crystal/Clock Connection

6.5.1.1.1 Timing Requirements for Main Oscillator

Table 6-9. Timing Requirements for Main Oscillator

| PARAMETER | | MIN | TYP | MAX | UNIT |
|-------------|-----------------------------------------------------------------------|-----|-----|-----|------|
| tc(OSC) | Cycle time, OSCIN (when using a sine-wave input) | 50 | | 200 | ns |
| tc(OSC_SQR) | Cycle time, OSCIN, (when input to the OSCIN is a square wave) | 50 | | 200 | ns |
| tw(OSCIL) | Pulse duration, OSCIN low (when input to the OSCIN is a square wave) | 15 | | | ns |
| tw(OSCIH) | Pulse duration, OSCIN high (when input to the OSCIN is a square wave) | 15 | | | ns |

6.5.1.2 Low-Power Oscillator

The Low-Power Oscillator (LPO) is comprised of two oscillators — HF LPO and LF LPO.

6.5.1.2.1 Features

The main features of the LPO are:

- Supplies a clock at extremely low power for power-saving modes. This is connected as clock source # 4 of the Global Clock Module.
- Supplies a high-frequency clock for nontiming-critical systems. This is connected as clock source # 5 of the Global Clock Module.
- Provides a comparison clock for the crystal oscillator failure detection circuit.

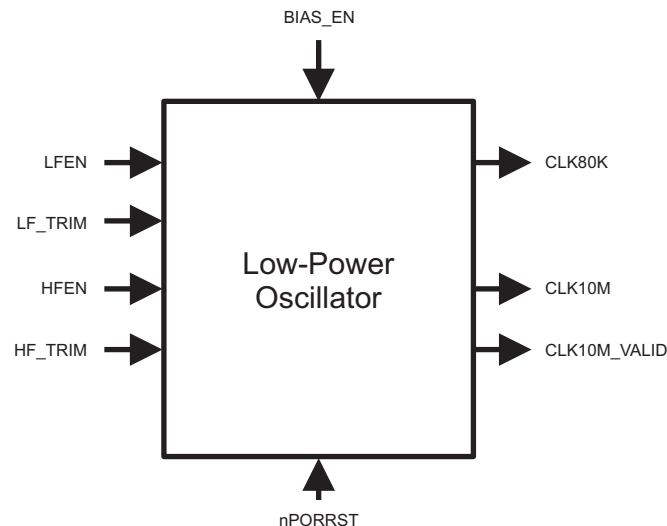


Figure 6-5. LPO Block Diagram

Figure 6-5 shows a block diagram of the internal reference oscillator. This is an LPO and provides two clock sources: one nominally 80 kHz and one nominally 10 MHz.

6.5.1.2.2 LPO Electrical and Timing Specifications

Table 6-10. LPO Specifications

| PARAMETER | | MIN | TYP | MAX | UNIT |
|-------------------------------------------|--------------------------------------------------------------------------|-------|------|-------|------|
| Clock Detection | Oscillator fail frequency - lower threshold, using untrimmed LPO output | 1.375 | 2.4 | 4.875 | MHz |
| | Oscillator fail frequency - higher threshold, using untrimmed LPO output | 22 | 38.4 | 78 | |
| LPO - HF oscillator (f _{HFLPO}) | Untrimmed frequency | 5.5 | 9 | 19.5 | MHz |
| | Trimmed frequency | 8 | 9.6 | 11 | MHz |
| | Start-up time from STANDBY (LPO BIAS_EN High for at least 900 μs) | | | 10 | μs |
| | Cold start-up time | | | 900 | μs |
| LPO - LF oscillator (f _{LFLPO}) | Untrimmed frequency | 36 | 85 | 180 | kHz |
| | Start-up time from STANDBY (LPO BIAS_EN High for at least 900 μs) | | | 100 | μs |
| | Cold start-up time | | | 2000 | μs |

6.5.1.3 Phase Locked Loop (PLL) Clock Modules

The PLL is used to multiply the input frequency to some higher frequency.

The main features of the PLL are:

- Frequency modulation can be optionally superimposed on the synthesized frequency of PLL.
- Configurable frequency multipliers and dividers.
- Built-in PLL Slip monitoring circuit.
- Option to reset the device on a PLL slip detection.

6.5.1.3.1 Block Diagram

Figure 6-6 shows a high-level block diagram of the PLL macro on this microcontroller.

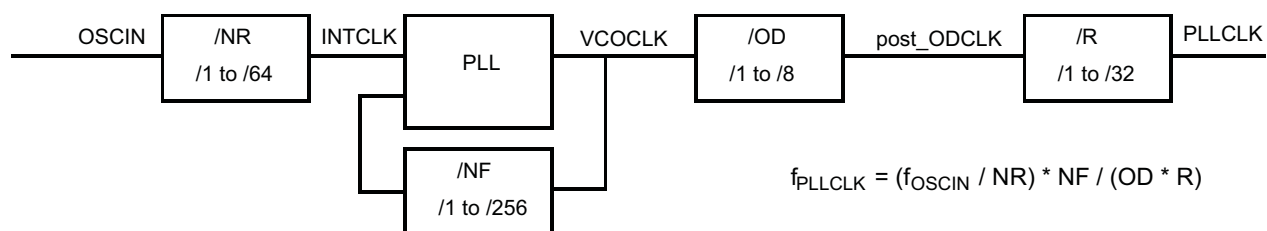


Figure 6-6. PLL Block Diagram

6.5.1.3.2 PLL Timing Specifications

Table 6-11. PLL Timing Specifications

| PARAMETER | | MIN | MAX | UNIT |
|-------------------------|---------------------------------------------------------|-----|-----|------|
| f _{INTCLK} | PLL1 Reference Clock frequency | 1 | 20 | MHz |
| f _{post_ODCLK} | Post-ODCLK – PLL1 Post-divider input clock frequency | | 400 | MHz |
| f _{VCOCLK} | VCOCLK – PLL1 Output Divider (OD) input clock frequency | 150 | 550 | MHz |

6.5.2 Clock Domains

6.5.2.1 Clock Domain Descriptions

Table 6-12 lists the device clock domains and their default clock sources. The table also shows the system module control register that is used to select an available clock source for each clock domain.

Table 6-12. Clock Domain Descriptions

| CLOCK DOMAIN NAME | DEFAULT CLOCK SOURCE | CLOCK SOURCE SELECTION REGISTER | DESCRIPTION |
|-------------------|----------------------|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| HCLK | OSCIN | GHVSR | <ul style="list-style-type: none"> Is disabled through the CDDISx registers bit 1 |
| GCLK | OSCIN | GHVSR | <ul style="list-style-type: none"> Always the same frequency as HCLK In phase with HCLK Is disabled separately from HCLK through the CDDISx registers bit 0 Can be divided by 1 up to 8 when running CPU self-test (LBIST) using the CLKDIV field of the STCCLKDIV register at address 0xFFFFE108 |
| GCLK2 | OSCIN | GHVSR | <ul style="list-style-type: none"> Always the same frequency as GCLK 2 cycles delayed from GCLK Is disabled along with GCLK Gets divided by the same divider setting as that for GCLK when running CPU self-test (LBIST) |
| VCLK | OSCIN | GHVSR | <ul style="list-style-type: none"> Divided down from HCLK Can be HCLK/1, HCLK/2, ... or HCLK/16 Is disabled separately from HCLK through the CDDISx registers bit 2 Can be disabled separately for eQEP using CDDISx registers bit 9 |
| VCLK2 | OSCIN | GHVSR | <ul style="list-style-type: none"> Divided down from HCLK Can be HCLK/1, HCLK/2, ... or HCLK/16 Frequency must be an integer multiple of VCLK frequency Is disabled separately from HCLK through the CDDISx registers bit 3 |
| VCLKA1 | VCLK | VCLKASRC | <ul style="list-style-type: none"> Defaults to VCLK as the source Frequency can be as fast as HCLK frequency Is disabled through the CDDISx registers bit 4 |
| RTICK | VCLK | RCLKSRC | <ul style="list-style-type: none"> Defaults to VCLK as the source If a clock source other than VCLK is selected for RTICK, then the RTICK frequency must be less than or equal to VCLK/3 <ul style="list-style-type: none"> Application can ensure this by programming the RT11DIV field of the RCLKSRC register, if necessary Is disabled through the CDDISx registers bit 6 |

6.5.2.2 Mapping of Clock Domains to Device Modules

Each clock domain has a dedicated functionality as shown in the figure below.

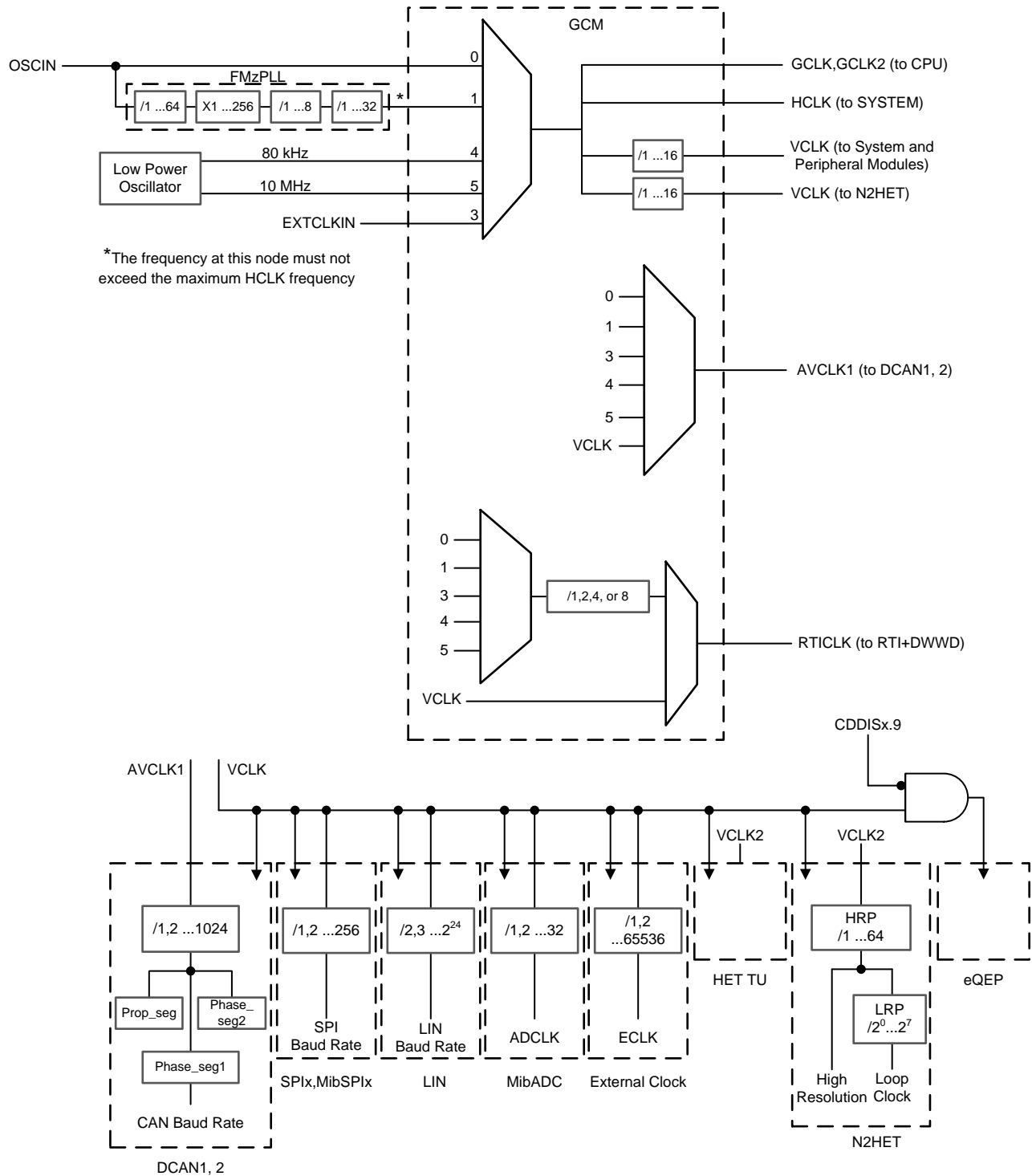


Figure 6-7. Device Clock Domains

6.5.3 Clock Test Mode

The TMS570 platform architecture defines a special mode that allows various clock signals to be brought out on to the ECLK pin and N2HET[2] device outputs. This mode is called the Clock Test mode. It is very useful for debugging purposes and can be configured through the CLKTEST register in the system module.

Table 6-13. Clock Test Mode Options

| CLKTEST[3-0] | SIGNAL ON ECLK | CLKTEST[11-8] | SIGNAL ON N2HET[2] |
|--------------|---------------------------------------------|---------------|-------------------------|
| 0000 | Oscillator | 0000 | Oscillator Valid Status |
| 0001 | Main PLL free-running clock output (PLLCLK) | 0001 | Main PLL Valid status |
| 0010 | Reserved | 0010 | Reserved |
| 0011 | Reserved | 0011 | Reserved |
| 0100 | CLK80K | 0100 | Reserved |
| 0101 | CLK10M | 0101 | CLK10M Valid status |
| 0110 | Reserved | 0110 | Reserved |
| 0111 | Reserved | 0111 | Reserved |
| 1000 | GCLK | 1000 | CLK80K |
| 1001 | RTI Base | 1001 | Oscillator Valid status |
| 1010 | Reserved | 1010 | Oscillator Valid status |
| 1011 | VCLKA1 | 1011 | Oscillator Valid status |
| 1100 | Reserved | 1100 | Oscillator Valid status |
| 1101 | Reserved | 1101 | Oscillator Valid status |
| 1110 | Reserved | 1110 | Oscillator Valid status |
| 1111 | Flash HD Pump Oscillator | 1111 | Oscillator Valid status |

6.6 Clock Monitoring

The LPO Clock Detect (LPOCLKDET) module consists of a clock monitor (CLKDET) and an internal low-power oscillator (LPO).

The LPO provides two different clock sources – a low frequency (LFLPO) and a high frequency (HFLPO).

The CLKDET is a supervisor circuit for an externally supplied clock signal (OSCIN). In case the OSCIN frequency falls out of a frequency window, the CLKDET flags this condition in the global status register (GLBSTAT bit 0: OSC FAIL) and switches all clock domains sourced by OSCIN to the HFLPO clock (limp mode clock).

The valid OSCIN frequency range is defined as: $f_{HFLPO} / 4 < f_{OSCIN} < f_{HFLPO} * 4$.

6.6.1 Clock Monitor Timings

For more information on LPO and Clock detection, refer to [Table 6-10](#).

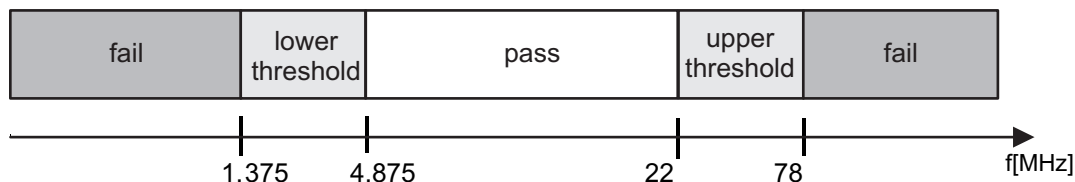


Figure 6-8. LPO and Clock Detection, Untrimmed HFLPO

6.6.2 External Clock (ECLK) Output Functionality

The ECLK pin can be configured to output a prescaled clock signal indicative of an internal device clock. This output can be externally monitored as a safety diagnostic.

6.6.3 Dual Clock Comparator

The Dual Clock Comparator (DCC) module determines the accuracy of selectable clock sources by counting the pulses of two independent clock sources (counter 0 and counter 1). If one clock is out of spec, an error signal is generated. For example, the DCC can be configured to use CLK10M as the reference clock (for counter 0) and VCLK as the "clock under test" (for counter 1). This configuration allows the DCC to monitor the PLL output clock when VCLK is using the PLL output as its source.

6.6.3.1 Features

- Takes two different clock sources as input to two independent counter blocks.
- One of the clock sources is the known-good, or reference clock; the second clock source is the "clock under test."
- Each counter block is programmable with initial, or seed values.
- The counter blocks start counting down from their seed values at the same time; a mismatch from the expected frequency for the clock under test generates an error signal which is used to interrupt the CPU.

6.6.3.2 Mapping of DCC Clock Source Inputs

Table 6-14. DCC Counter 0 Clock Sources

| TEST MODE | CLOCK SOURCE [3:0] | CLOCK NAME |
|-----------|--------------------|--------------------|
| 0 | Others | Oscillator (OSCIN) |
| | 0x5 | High-frequency LPO |
| | 0xA | Test clock (TCK) |
| 1 | X | VCLK |

Table 6-15. DCC Counter 1 Clock Sources

| TEST MODE | KEY [3:0] | CLOCK SOURCE [3:0] | CLOCK NAME |
|-----------|-----------|--------------------|------------------------------------|
| 0 | Others | – | N2HET[31] |
| | 0xA | 0x0 | Main PLL free-running clock output |
| | | 0x1 | n/a |
| | | 0x2 | Low-frequency LPO |
| | | 0x3 | High-frequency LPO |
| | | 0x4 | Flash HD pump oscillator |
| | | 0x5 | EXTCLKIN |
| | | 0x6 | n/a |
| | | 0x7 | Ring oscillator |
| | | 0x8 - 0xF | VCLK |
| 1 | X | X | HCLK |

6.7 Glitch Filters

A glitch filter is present on the following signals.

Table 6-16. Glitch Filter Timing Specifications

| PIN | PARAMETER | | MIN | MAX | UNIT |
|---------|------------------|-------------------------------------------------------------------------------------------------------------------------------------|-----|------|------|
| nPORRST | $t_{f(nPORRST)}$ | Filter time nPORRST pin; pulses less than MIN will be filtered out, pulses greater than MAX will generate a reset ⁽¹⁾ | 475 | 2000 | ns |
| nRST | $t_{f(nRST)}$ | Filter time nRST pin; pulses less than MIN will be filtered out, pulses greater than MAX will generate a reset | 475 | 2000 | ns |
| TEST | $t_{f(TEST)}$ | Filter time TEST pin; pulses less than MIN will be filtered out, pulses greater than MAX will pass through | 475 | 2000 | ns |

- (1) The glitch filter design on the nPORRST signal is designed such that no size pulse will reset any part of the microcontroller (flash pump, I/O pins, and so forth) without also generating a valid reset signal to the CPU.

6.8 Device Memory Map

6.8.1 Memory Map Diagram

Figure 6-9 shows the device memory map.

| | |
|-------------|--------------------------------------------------------------------|
| 0xFFFFFFFF | SYSTEM Modules |
| 0xFFFF80000 | ----- |
| 0xFFFF7FFFF | Peripherals - Frame 1 |
| 0xFF000000 | CRC |
| 0xFE000000 | RESERVED |
| 0xFCFFFFFF | Peripherals - Frame 2 |
| 0xFC000000 | RESERVED |
| 0xF07FFFFF | Flash Module Bus2 Interface (Flash ECC, OTP andEEPROM accesses) |
| 0xF0000000 | RESERVED |
| 0x2005FFFF | Flash (384KB) (Mirrored Image) |
| 0x20000000 | RESERVED |
| 0x08407FFF | RAM - ECC |
| 0x08400000 | RESERVED |
| 0x08007FFF | RAM (32KB) |
| 0x08000000 | RESERVED |
| 0x0005FFFF | Flash (384KB) |
| 0x00000000 | |

Figure 6-9. TMS570LS0432 Memory Map

| | |
|-------------|----------------------------------------------------------------------------|
| 0xFFFFFFFF | SYSTEM Modules |
| 0xFFF80000 | ----- |
| 0xFFF7FFFF | Peripherals - Frame 1 |
| 0xFF000000 | CRC |
| 0xFE000000 | RESERVED |
| 0xFCFFFFFF | Peripherals - Frame 2 |
| 0xFC000000 | RESERVED |
| 0xF07FFFFFF | Flash Module Bus2 Interface (Flash ECC, OTP andEEPROM accesses) |
| 0xF0000000 | RESERVED |
| 0x2003FFFF | Flash (256KB) (Mirrored Image) |
| 0x20000000 | RESERVED |
| 0x08407FFF | RAM - ECC |
| 0x08400000 | RESERVED |
| 0x08007FFF | RAM (32KB) |
| 0x08000000 | RESERVED |
| 0x0003FFFF | Flash (256KB) |
| 0x00000000 | |

Figure 6-10. TMS570LS0332 Memory Map

The Flash memory in all configurations is mirrored to support ECC logic testing. The base address of the mirrored Flash image is 0x2000 0000.

6.8.2 Memory Map Table

See [Figure 1-1](#) for a block diagram showing the device interconnects.

Table 6-17. Device Memory Map

| MODULE NAME | FRAME CHIP SELECT | ADDRESS RANGE | | FRAME SIZE | ACTUAL SIZE | RESPONSE FOR ACCESS TO UNIMPLEMENTED LOCATIONS IN FRAME |
|----------------------------------------------------------|--------------------|---------------|-------------|------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | START | END | | | |
| Memories tightly coupled to the ARM Cortex-R4 CPU | | | | | | |
| TCM Flash | CS0 | 0x0000_0000 | 0x00FF_FFFF | 16MB | 384KB ⁽¹⁾ | Abort |
| TCM RAM + RAM ECC | CSRAM0 | 0x0800_0000 | 0x0BFF_3FFF | 64MB | 32KB | |
| Mirrored Flash | Flash mirror frame | 0x2000_0000 | 0x20FF_FFFF | 16MB | 384KB ⁽¹⁾ | |
| Flash Module Bus2 Interface | | | | | | |
| Customer OTP, TCM Flash Banks | | 0xF000_0000 | 0xF000_07FF | 64KB | 2KB | Abort |
| Customer OTP, EEPROM Bank | | 0xF000_E000 | 0xF000_E3FF | | 1KB | |
| Customer OTP–ECC, TCM Flash Banks | | 0xF004_0000 | 0xF004_00FF | 8KB | 256B | |
| Customer OTP–ECC, EEPROM Bank | | 0xF004_1C00 | 0xF004_1C7F | | 128B | |
| TI OTP, TCM Flash Banks | | 0xF008_0000 | 0xF008_07FF | 64KB | 2KB | |
| TI OTP, EEPROM Bank | | 0xF008_E000 | 0xF008_E3FF | | 1KB | |
| TI OTP–ECC, TCM Flash Banks | | 0xF00C_0000 | 0xF00C_00FF | 8KB | 256B | |
| TI OTP–ECC, EEPROM Bank | | 0xF00C_1C00 | 0xF00C_1C7F | | 128B | |
| EEPROM Bank–ECC | | 0xF010_0000 | 0xF010_07FF | 256KB | 2KB | |
| EEPROM Bank | | 0xF020_0000 | 0xF020_3FFF | 2MB | 16KB | |
| Flash Data Space ECC | | 0xF040_0000 | 0xF040_DFFF | 1MB | 48KB | |
| Cyclic Redundancy Checker (CRC) Module Registers | | | | | | |
| CRC | CRC frame | 0xFE00_0000 | 0xFEFF_FFFF | 16MB | 512B | Accesses above 0x200 generate abort. |
| Peripheral Memories | | | | | | |
| MIBSPI1 RAM | PCS[7] | 0xFF0E_0000 | 0xFF0F_FFFF | 128KB | 2KB | Abort for accesses above 2KB |
| DCAN2 RAM | PCS[14] | 0xFF1C_0000 | 0xFF1D_FFFF | 128KB | 2KB | Wrap around for accesses to unimplemented address offsets lower than 0x7FF. Abort generated for accesses beyond offset 0x800. |
| DCAN1 RAM | PCS[15] | 0xFF1E_0000 | 0xFF1F_FFFF | 128KB | 2KB | Wrap around for accesses to unimplemented address offsets lower than 0x7FF. Abort generated for accesses beyond offset 0x800. |
| MIBADC RAM | | | | | 8KB | Wrap around for accesses to unimplemented address offsets lower than 0x1FFF. |
| MIBADC Look-Up Table | PCS[31] | 0xFF3E_0000 | 0xFF3F_FFFF | 128KB | 384 bytes | Look-up table for ADC wrapper. Starts at offset 0x2000 and ends at 0x217F. Wrap around for accesses between offsets 0x180 and 0x3FFF. Aborts generated for accesses beyond 0x4000 |

(1) The TMS570LS0332 device has only 256KB of flash.

Table 6-17. Device Memory Map (continued)

| MODULE NAME | FRAME CHIP SELECT | ADDRESS RANGE | | FRAME SIZE | ACTUAL SIZE | RESPONSE FOR ACCESS TO UNIMPLEMENTED LOCATIONS IN FRAME |
|------------------------------------------------------|-------------------|---------------|-------------|------------|-------------|--------------------------------------------------------------------------------------------------------------------------|
| | | START | END | | | |
| N2HET RAM | PCS[35] | 0xFF46_0000 | 0xFF47_FFFF | 128KB | 16KB | Wrap around for accesses to unimplemented address offsets lower than 0x3FFF. Abort generated for accesses beyond 0x3FFF. |
| HTU RAM | PCS[39] | 0xFF4E_0000 | 0xFF4F_FFFF | 128KB | 1KB | Abort |
| Debug Components | | | | | | |
| CoreSight Debug ROM | CSCS0 | 0xFFA0_0000 | 0xFFA0_0FFF | 4KB | 4KB | Reads return zeros, writes have no effect |
| Cortex-R4 Debug | CSCS1 | 0xFFA0_1000 | 0xFFA0_1FFF | 4KB | 4KB | Reads return zeros, writes have no effect |
| Peripheral Control Registers | | | | | | |
| HTU | PS[22] | 0xFFF7_A400 | 0xFFF7_A4FF | 256B | 256B | Reads return zeros, writes have no effect |
| N2HET | PS[17] | 0xFFF7_B800 | 0xFFF7_B8FF | 256B | 256B | Reads return zeros, writes have no effect |
| GIO | PS[16] | 0xFFF7_BC00 | 0xFFF7_BCFF | 256B | 256B | Reads return zeros, writes have no effect |
| MIBADC | PS[15] | 0xFFF7_C000 | 0xFFF7_C1FF | 512B | 512B | Reads return zeros, writes have no effect |
| DCAN1 | PS[8] | 0xFFF7_DC00 | 0xFFF7_DFFF | 512B | 512B | Reads return zeros, writes have no effect |
| DCAN2 | PS[8] | 0xFFF7_DE00 | 0xFFF7_DFFF | 512B | 512B | Reads return zeros, writes have no effect |
| LIN | PS[6] | 0xFFF7_E400 | 0xFFF7_E4FF | 256B | 256B | Reads return zeros, writes have no effect |
| MibSPI1 | PS[2] | 0xFFF7_F400 | 0xFFF7_F5FF | 512B | 512B | Reads return zeros, writes have no effect |
| SPI2 | PS[2] | 0xFFF7_F600 | 0xFFF7_F7FF | 512B | 512B | Reads return zeros, writes have no effect |
| SPI3 | PS[1] | 0xFFF7_F800 | 0xFFF7_F9FF | 512B | 512B | Reads return zeros, writes have no effect |
| EQEP | PS[25] | 0xFFF7_9900 | 0xFFF7_99FF | 256B | 256B | Reads return zeros, writes have no effect |
| EQEP (Mirrored) | PS2[25] | 0xFCF7_9900 | 0xFCF7_99FF | 256B | 256B | Reads return zeros, writes have no effect |
| System Modules Control Registers and Memories | | | | | | |
| VIM RAM | PPCS2 | 0xFFF8_2000 | 0xFFF8_2FFF | 4KB | 1KB | Wrap around for accesses to unimplemented address offsets lower than 0x3FFF. Accesses beyond 0x3FFF will be ignored. |
| Flash Wrapper | PPCS7 | 0xFFF8_7000 | 0xFFF8_7FFF | 4KB | 4KB | Abort |
| eFuse Farm Controller | PPCS12 | 0xFFF8_C000 | 0xFFF8_CFFF | 4KB | 4KB | Abort |
| PCR registers | PPS0 | 0xFFFF_E000 | 0xFFFF_E0FF | 256B | 256B | Reads return zeros, writes have no effect |
| System Module - Frame 2 (see device TRM) | PPS0 | 0xFFFF_E100 | 0xFFFF_E1FF | 256B | 256B | Reads return zeros, writes have no effect |
| PBIST | PPS1 | 0xFFFF_E400 | 0xFFFF_E5FF | 512B | 512B | Reads return zeros, writes have no effect |
| STC | PPS1 | 0xFFFF_E600 | 0xFFFF_E6FF | 256B | 256B | Reads return zeros, writes have no effect |
| IOMM Multiplexing control module | PPS2 | 0xFFFF_EA00 | 0xFFFF_EBFF | 512B | 512B | Generates address error interrupt if enabled. |

Table 6-17. Device Memory Map (continued)

| MODULE NAME | FRAME CHIP SELECT | ADDRESS RANGE | | FRAME SIZE | ACTUAL SIZE | RESPONSE FOR ACCESS TO UNIMPLEMENTED LOCATIONS IN FRAME |
|------------------------------------------|-------------------|---------------|-------------|------------|-------------|---------------------------------------------------------|
| | | START | END | | | |
| DCC | PPS3 | 0xFFFF_EC00 | 0xFFFF_ECFE | 256B | 256B | Reads return zeros, writes have no effect |
| ESM | PPS5 | 0xFFFF_F500 | 0xFFFF_F5FF | 256B | 256B | Reads return zeros, writes have no effect |
| CCMR4 | PPS5 | 0xFFFF_F600 | 0xFFFF_F6FF | 256B | 256B | Reads return zeros, writes have no effect |
| RAM ECC even | PPS6 | 0xFFFF_F800 | 0xFFFF_F8FF | 256B | 256B | Reads return zeros, writes have no effect |
| RAM ECC odd | PPS6 | 0xFFFF_F900 | 0xFFFF_F9FF | 256B | 256B | Reads return zeros, writes have no effect |
| RTI + DWWD | PPS7 | 0xFFFF_FC00 | 0xFFFF_FCFE | 256B | 256B | Reads return zeros, writes have no effect |
| VIM Parity | PPS7 | 0xFFFF_FD00 | 0xFFFF_FDFF | 256B | 256B | Reads return zeros, writes have no effect |
| VIM | PPS7 | 0xFFFF_FE00 | 0xFFFF_FEFF | 256B | 256B | Reads return zeros, writes have no effect |
| System Module - Frame 1 (see device TRM) | PPS7 | 0xFFFF_FF00 | 0xFFFF_FFFF | 256B | 256B | Reads return zeros, writes have no effect |

6.8.3 Master/Slave Access Privileges

The table below lists the access permissions for each bus master on the device. A bus master is a module that can initiate a read or a write transaction on the device.

Each slave module on the main interconnect is listed in the table. A "Yes" indicates that the module listed in the "MASTERS" column can access that slave module.

Table 6-18. Master / Slave Access Matrix

| MASTERS | ACCESS MODE | SLAVES ON MAIN SCR | | | |
|-----------|----------------|----------------------------------------------------|----------------------------------------------------|-----|-------------------------------------------------------------------------------------------------------------|
| | | Flash Module Bus2 Interface: OTP, ECC, EEPROM Bank | Non-CPU Accesses to Program Flash and CPU Data RAM | CRC | Peripheral Control Registers, All Peripheral Memories, And All System Module Control Registers And Memories |
| CPU READ | User/Privilege | Yes | Yes | Yes | Yes |
| CPU WRITE | User/Privilege | No | Yes | Yes | Yes |
| HTU | Privilege | No | Yes | Yes | Yes |

6.9 Flash Memory

6.9.1 Flash Memory Configuration

Flash Bank: A separate block of logic consisting of 1 to 16 sectors. Each flash bank normally has a customer-OTP and a TI-OTP area. These flash sectors share input/output buffers, data paths, sense amplifiers, and control logic.

Flash Sector: A contiguous region of flash memory which must be erased simultaneously due to physical construction constraints.

Flash Pump: A charge pump which generates all the voltages required for reading, programming, or erasing the flash banks.

Flash Module: Interface circuitry required between the host CPU and the flash banks and pump module.

Table 6-19. Flash Memory Banks and Sectors

| MEMORY ARRAYS (or BANKS) | SECTOR NO. | SEGMENT | LOW ADDRESS | HIGH ADDRESS |
|-----------------------------------------------------|------------|-------------|-------------|--------------|
| BANK0 (384KB) ⁽¹⁾ | 0 | 8KB | 0x0000_0000 | 0x0000_1FFF |
| | 1 | 8KB | 0x0000_2000 | 0x0000_3FFF |
| | 2 | 8KB | 0x0000_4000 | 0x0000_5FFF |
| | 3 | 8KB | 0x0000_6000 | 0x0000_7FFF |
| | 4 | 8KB | 0x0000_8000 | 0x0000_9FFF |
| | 5 | 8KB | 0x0000_A000 | 0x0000_BFFF |
| | 6 | 8KB | 0x0000_C000 | 0x0000_DFFF |
| | 7 | 8KB | 0x0000_E000 | 0x0000_FFFF |
| | 8 | 8KB | 0x0001_0000 | 0x0001_1FFF |
| | 9 | 8KB | 0x0001_2000 | 0x0001_3FFF |
| | 10 | 8KB | 0x0001_4000 | 0x0001_5FFF |
| | 11 | 8KB | 0x0001_6000 | 0x0001_7FFF |
| | 12 | 32KB | 0x0001_8000 | 0x0001_FFFF |
| | 13 | 128KB | 0x0002_0000 | 0x0003_FFFF |
| 14 ⁽²⁾ | 128KB | 0x0004_0000 | 0x0005_FFFF | |
| BANK7 (16KB) for EEPROM emulation ⁽³⁾⁽⁴⁾ | 0 | 4KB | 0xF020_0000 | 0xF020_0FFF |
| | 1 | 4KB | 0xF020_1000 | 0xF020_1FFF |
| | 2 | 4KB | 0xF020_2000 | 0xF020_2FFF |
| | 3 | 4KB | 0xF020_3000 | 0xF020_3FFF |

(1) This Flash bank is 144-bit wide with ECC support.

(2) Sector 14 is not accessible or included in the TMS570LS0332 configuration.

(3) Flash bank7 is an FLEE bank and can be programmed while executing code from flash bank0. It is 72-bit wide with ECC support.

(4) Code execution is not allowed from flash bank7.

6.9.2 Main Features of Flash Module

- Support for multiple flash banks for program and/or data storage
- Simultaneous read access on a bank while performing program or erase operation on any other bank
- Integrated state machines to automate flash erase and program operations
- Software interface for flash program and erase operations
- Pipelined mode operation to improve instruction access interface bandwidth
- Support for Single Error Correction Double Error Detection (SECEDED) block inside Cortex-R4 CPU
 - Error address is captured for host system debugging
- Support for a rich set of diagnostic features

6.9.3 ECC Protection for Flash Accesses

All accesses to the program flash memory are protected by Single Error Correction Double Error Detection (SECEDED) logic embedded inside the CPU. The flash module provides 8 bits of ECC code for 64 bits of instructions or data fetched from the flash memory. The CPU calculates the expected ECC code based on the 64 bits received and compares it with the ECC code returned by the flash module. A single-bit error is corrected and flagged by the CPU, while a multibit error is only flagged. The CPU signals an ECC error through its Event bus. This signaling mechanism is not enabled by default and must be enabled by setting the "X" bit of the Performance Monitor Control Register, c9.

```
MRC p15,#0,r1,c9,c12,#0      ;Enabling Event monitor states
ORR r1, r1, #0x00000010
MCR p15,#0,r1,c9,c12,#0      ;Set 4th bit ('X') of PMNC register
MRC p15,#0,r1,c9,c12,#0
```

The application must also explicitly enable the CPU's ECC checking for accesses on the CPU's ATCM and BTCM interfaces. These are connected to the program flash and data RAM respectively. ECC checking for these interfaces can be done by setting the B1TCMPCEN, B0TCMPCEN and ATCMPCEN bits of the System Control coprocessor's Auxiliary Control Register, c1.

```
MRC p15, #0, r1, c1, c0, #1
ORR r1, r1, #0x0e000000      ;Enable ECC checking for ATCM and BTCMs
DMB
MCR p15, #0, r1, c1, c0, #1
```

6.9.4 Flash Access Speeds

For information on flash memory access speeds and the relevant wait states required, see [Section 5.6](#).

6.10 Flash Program and Erase Timings for Program Flash

Table 6-20. Timing Specifications for Program Flash

| PARAMETER | | MIN | NOM | MAX | UNIT |
|----------------------------|------------------------------------------------------------|----------------------------------|------|------|---------------|
| t_{prog} (144bit) | Wide Word (144 bit) programming time | | 40 | 300 | μs |
| t_{prog} (Total) | 384KByte programming time ⁽¹⁾ | -40°C to 125°C | | 4 | s |
| | | 0°C to 60°C, for first 25 cycles | 1 | 2 | |
| t_{erase} | Sector/Bank erase time ⁽²⁾ | -40°C to 125°C | 0.30 | 4 | s |
| | | 0°C to 60°C, for first 25 cycles | 16 | 100 | ms |
| t_{wec} | Write/erase cycles with 15 year Data Retention requirement | -40°C to 125°C | | 1000 | cycles |

- (1) This programming time includes overhead of state machine, but does not include data transfer time. The programming time assumes programming 144 bits at a time at the maximum specified operating frequency.
- (2) During bank erase, the selected sectors are erased simultaneously. The time to erase the bank is specified as equal to the time to erase a sector.

6.11 Flash Program and Erase Timings for Data Flash

Table 6-21. Timing Specifications for Data Flash

| PARAMETER | | MIN | NOM | MAX | UNIT |
|----------------------------|------------------------------------------------------------|----------------------------------|-------|--------|---------------|
| t_{prog} (72 bit) | Wide Word (72 bit) programming time | | 47 | 300 | μs |
| t_{prog} (Total) | 16KB programming time ⁽¹⁾ | -40°C to 125°C | | 330 | ms |
| | | 0°C to 60°C, for first 25 cycles | 100 | 165 | |
| t_{erase} | Sector/Bank erase time ⁽²⁾ | -40°C to 125°C | 0.200 | 8 | s |
| | | 0°C to 60°C, for first 25 cycles | 14 | 100 | ms |
| t_{wec} | Write/erase cycles with 15 year Data Retention requirement | -40°C to 125°C | | 100000 | cycles |

- (1) This programming time includes overhead of state machine, but does not include data transfer time. The programming time assumes programming 72 bits at a time at the maximum specified operating frequency.
- (2) During bank erase, the selected sectors are erased simultaneously. The time to erase the bank is specified as equal to the time to erase a sector.

6.12 Tightly Coupled RAM Interface Module

Figure 6-11 illustrates the connection of the Tightly Coupled RAM (TCRAM) to the Cortex-R4 CPU.

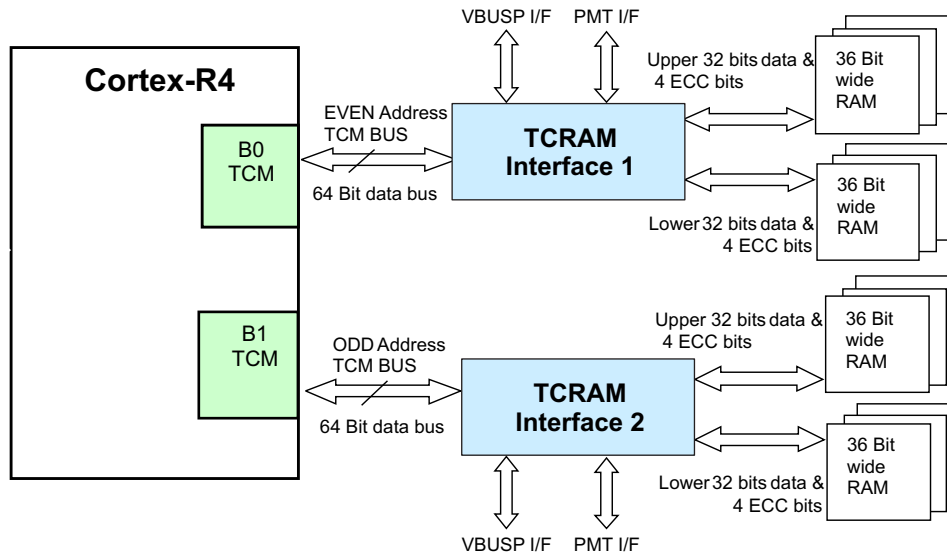


Figure 6-11. TCRAM Block Diagram

6.12.1 Features

The features of the Tightly Coupled RAM (TCRAM) module are:

- Acts as slave to the BTCM interface of the Cortex-R4 CPU
- Supports CPU's internal ECC scheme by providing 64-bit data and 8-bit ECC code
- Monitors CPU Event Bus and generates single-bit or multibit error interrupts
- Stores addresses for single-bit and multibit errors
- Provides CPU address bus integrity checking by supporting parity checking on the address bus
- Performs redundant address decoding for the RAM bank chip select and ECC select generation logic
- Provides enhanced safety for the RAM addressing by implementing two 36-bit wide byte-interleaved RAM banks and generating independent RAM access control signals to the two banks
- Supports auto-initialization of the RAM banks along with the ECC bits
- No support for bit-wise RAM accesses

6.12.2 TCRAMW ECC Support

The TCRAMW passes on the ECC code for each data read by the Cortex-R4 CPU from the RAM. It also stores the CPU's ECC port contents in the ECC RAM when the CPU does a write to the RAM. The TCRAMW monitors the CPU's event bus and provides registers for indicating single-bit and multibit errors and also for identifying the address that caused the single-bit or multibit error. The event signaling and the ECC checking for the RAM accesses must be enabled inside the CPU.

For more information see the device Technical Reference Manual.

6.13 Parity Protection for Accesses to peripheral RAMs

Accesses to some peripheral RAMs are protected by odd/even parity checking. During a read access the parity is calculated based on the data read from the peripheral RAM and compared with the good parity value stored in the parity RAM for that peripheral. If any word fails the parity check, the module generates a parity error signal that is mapped to the Error Signaling Module. The module also captures the peripheral RAM address that caused the parity error.

The parity protection for peripheral RAMs is not enabled by default and must be enabled by the application. Each individual peripheral contains control registers to enable the parity protection for accesses to its RAM.

NOTE

The CPU read access gets the actual data from the peripheral. The application can choose to generate an interrupt whenever a peripheral RAM parity error is detected.

6.14 On-Chip SRAM Initialization and Testing

6.14.1 On-Chip SRAM Self-Test Using PBIST

6.14.1.1 Features

- Extensive instruction set to support various memory test algorithms
- ROM-based algorithms allow the application to run TI production-level memory tests
- Independent testing of all on-chip SRAM

6.14.1.2 PBIST RAM Groups

Table 6-22. PBIST RAM Grouping

| MEMORY | RAM GROUP | TEST CLOCK | MEM TYPE | TEST PATTERN (ALGORITHM) | | | |
|-----------|-----------|------------|-------------|--------------------------|--------------------------|--------------------------------------------------|-----------------------------------------------------|
| | | | | TRIPLE READ SLOW READ | TRIPLE READ FAST READ | MARCH 13N ⁽¹⁾ TWO PORT (CYCLES) | MARCH 13N ⁽¹⁾ SINGLE PORT (CYCLES) |
| | | | | ALGO MASK 0x1 | ALGO MASK 0x2 | ALGO MASK 0x4 | ALGO MASK 0x8 |
| PBIST_ROM | 1 | ROM CLK | ROM | X | X | | |
| STC_ROM | 2 | ROM CLK | ROM | X | X | | |
| DCAN1 | 3 | VCLK | Dual Port | | | 12720 | |
| DCAN2 | 4 | VCLK | Dual Port | | | 6480 | |
| RAM | 6 | HCLK | Single Port | | | | 133160 |
| MIBSPI1 | 7 | VCLK | Dual Port | | | 33440 | |
| VIM | 10 | VCLK | Dual Port | | | 12560 | |
| MIBADC | 11 | VCLK | Dual Port | | | 4200 | |
| N2HET1 | 13 | VCLK | Dual Port | | | 25440 | |
| HTU1 | 14 | VCLK | Dual Port | | | 6480 | |

(1) There are several memory testing algorithms stored in the PBIST ROM. However, TI recommends the March13N algorithm for application testing.

The PBIST ROM clock can be divided down from HCLK. The divider is selected by programming the ROM_DIV field of the Memory Self-Test Global Control Register (MSTGCR) at address 0xFFFFF58.

6.14.2 On-Chip SRAM Auto Initialization

This microcontroller allows some of the on-chip memories to be initialized through the Memory Hardware Initialization mechanism in the System module. This hardware mechanism allows an application to program the memory arrays with error detection capability to a known state based on their error detection scheme (odd/even parity or ECC).

The MINITGCR register enables the memory initialization sequence, and the MSINENA register selects the memories that are to be initialized.

For more information on these registers refer to the device Technical Reference Manual.

The mapping of the different on-chip memories to the specific bits of the MSINENA registers is shown in [Table 6-23](#).

Table 6-23. Memory Initialization

| CONNECTING MODULE | ADDRESS RANGE | | MSINENA REGISTER BIT NO. ⁽¹⁾ |
|-------------------|---------------|----------------|-----------------------------------------|
| | BASE ADDRESS | ENDING ADDRESS | |
| RAM | 0x08000000 | 0x08007FFF | 0 |
| MIBSPI1 RAM | 0xFF0E0000 | 0xFF0FFFFF | 7 ⁽²⁾ |
| DCAN2 RAM | 0xFF1C0000 | 0xFF1DFFFF | 6 |
| DCAN1 RAM | 0xFF1E0000 | 0xFF1FFFFF | 5 |
| MIBADC RAM | 0xFF3E0000 | 0xFF3FFFFF | 8 |
| N2HET RAM | 0xFF460000 | 0xFF47FFFF | 3 |
| HTU RAM | 0xFF4E0000 | 0xFF4FFFFF | 4 |
| VIM RAM | 0xFF820000 | 0xFF82FFF | 2 |

(1) Unassigned register bits are reserved.

(2) The MibSPI1 module performs an initialization of the transmit and receive RAMs as soon as the module is brought out of reset using the SPI Global Control Register 0 (SPIGCR0). This is independent of whether the application chooses to initialize the MibSPI1 RAMs using the system module auto-initialization method.

6.15 Vectored Interrupt Manager

The vectored interrupt manager (VIM) provides hardware assistance for prioritizing and controlling the many interrupt sources present on this device. Interrupts are caused by events outside of the normal flow of program execution. Normally, these events require a timely response from the central processing unit (CPU); therefore, when an interrupt occurs, the CPU switches execution from the normal program flow to an interrupt service routine (ISR).

6.15.1 VIM Features

The VIM module has the following features:

- Supports 96 interrupt channels.
 - Provides programmable priority and enable for interrupt request lines.
- Provides a direct hardware dispatch mechanism for fastest IRQ dispatch.
- Provides two software dispatch mechanisms when the CPU VIC port is not used.
 - Index interrupt
 - Register vectored interrupt
- Parity protected vector interrupt table against soft errors.

6.15.2 Interrupt Request Assignments

Table 6-24. Interrupt Request Assignments

| MODULES | INTERRUPT SOURCES | DEFAULT VIM INTERRUPT CHANNEL |
|----------|--------------------------------|-------------------------------|
| ESM | ESM High level interrupt (NMI) | 0 |
| Reserved | Reserved | 1 |
| RTI | RTI compare interrupt 0 | 2 |
| RTI | RTI compare interrupt 1 | 3 |
| RTI | RTI compare interrupt 2 | 4 |
| RTI | RTI compare interrupt 3 | 5 |
| RTI | RTI overflow interrupt 0 | 6 |
| RTI | RTI overflow interrupt 1 | 7 |
| Reserved | Reserved | 8 |
| GIO | GIO interrupt A | 9 |
| N2HET | N2HET level 0 interrupt | 10 |
| HTU | HTU level 0 interrupt | 11 |
| MIBSPI1 | MIBSPI1 level 0 interrupt | 12 |
| LIN | LIN level 0 interrupt | 13 |
| MIBADC | MIBADC event group interrupt | 14 |
| MIBADC | MIBADC sw group 1 interrupt | 15 |
| DCAN1 | DCAN1 level 0 interrupt | 16 |
| SPI2 | SPI2 level 0 interrupt | 17 |
| Reserved | Reserved | 18 |
| Reserved | Reserved | 19 |
| ESM | ESM Low level interrupt | 20 |
| SYSTEM | Software interrupt (SSI) | 21 |
| CPU | PMU interrupt | 22 |
| GIO | GIO interrupt B | 23 |
| N2HET | N2HET level 1 interrupt | 24 |
| HTU | HTU level 1 interrupt | 25 |

Table 6-24. Interrupt Request Assignments (continued)

| MODULES | INTERRUPT SOURCES | DEFAULT VIM INTERRUPT CHANNEL |
|----------|------------------------------------|-------------------------------|
| MIBSPI1 | MIBSPI1 level 1 interrupt | 26 |
| LIN | LIN level 1 interrupt | 27 |
| MIBADC | MIBADC sw group 2 interrupt | 28 |
| DCAN1 | DCAN1 level 1 interrupt | 29 |
| SPI2 | SPI2 level 1 interrupt | 30 |
| MIBADC | MIBADC magnitude compare interrupt | 31 |
| Reserved | Reserved | 32-34 |
| DCAN2 | DCAN2 level 0 interrupt | 35 |
| Reserved | Reserved | 36 |
| SPI3 | SPI3 level 0 interrupt | 37 |
| SPI3 | SPI3 level 1 interrupt | 38 |
| Reserved | Reserved | 39-41 |
| DCAN2 | DCAN2 level 1 interrupt | 42 |
| Reserved | Reserved | 43-60 |
| FMC | FSM_DONE interrupt | 61 |
| Reserved | Reserved | 62-79 |
| HWAG | HWA_INT_REQ_H | 80 |
| Reserved | Reserved | 81 |
| DCC | DCC done interrupt | 82 |
| Reserved | Reserved | 83 |
| eQEPINTn | eQEP Interrupt | 84 |
| PBIST | PBIST Done Interrupt | 85 |
| Reserved | Reserved | 86-87 |
| HWAG | HWA_INT_REQ_L | 88 |
| Reserved | Reserved | 89-95 |

NOTE

Address location 0x00000000 in the VIM RAM is reserved for the phantom interrupt ISR entry; therefore only request channels 0..94 can be used and are offset by 1 address in the VIM RAM.

6.16 Real-Time Interrupt Module

The real-time interrupt (RTI) module provides timer functionality for operating systems and for benchmarking code. The RTI module can incorporate several counters that define the timebases needed for scheduling an operating system.

The timers also allow you to benchmark certain areas of code by reading the values of the counters at the beginning and the end of the desired code range and calculating the difference between the values.

6.16.1 Features

The RTI module has the following features:

- Two independent 64 bit counter blocks
- Four configurable compares for generating operating system ticks. Each event can be driven by either counter block 0 or counter block 1.
- Fast enabling/disabling of events
- Two time-stamp (capture) functions for system or peripheral interrupts, one for each counter block

6.16.2 Block Diagrams

Figure 6-12 shows a high-level block diagram for one of the two 64-bit counter blocks inside the RTI module. Both the counter blocks are identical.

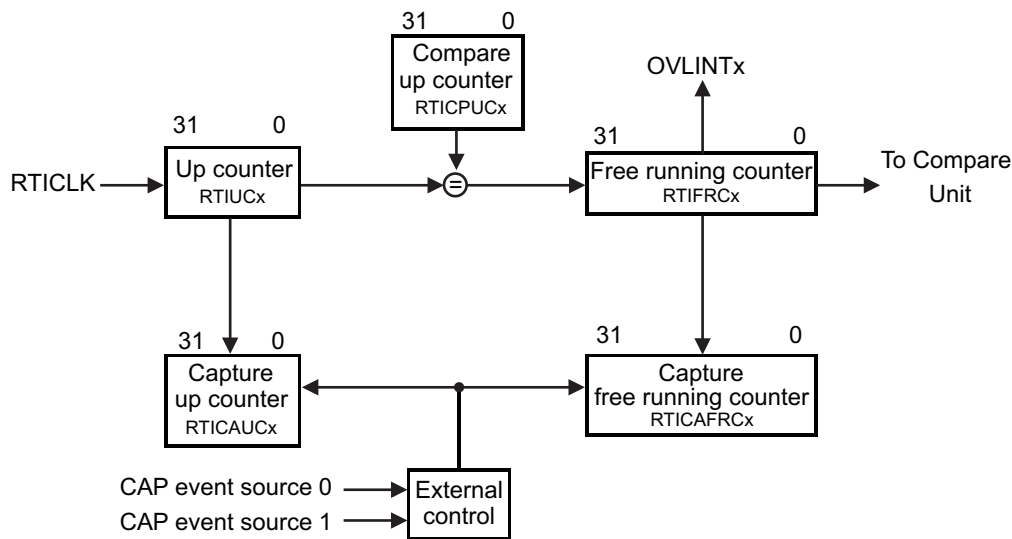


Figure 6-12. Counter Block Diagram

Figure 6-13 shows a typical high-level block diagram for one of the four compares inside the RTI module. Each of the four compares are identical.

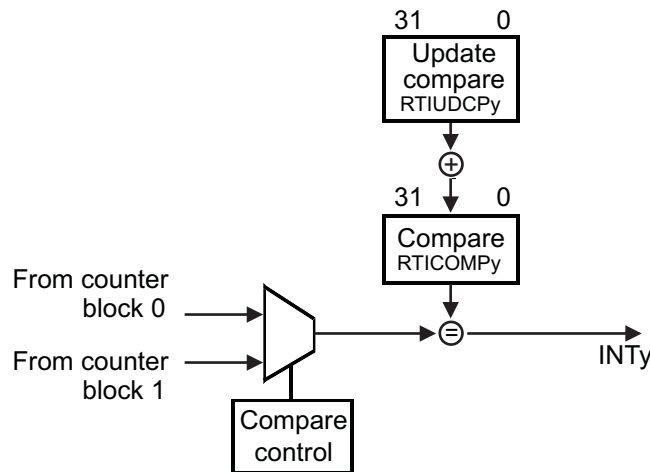


Figure 6-13. Compare Block Diagram

6.16.3 Clock Source Options

The RTI module uses the RTICLK clock domain for generating the RTI time bases.

The application can select the clock source for the RTICLK by configuring the RCLKSRC register in the System module at address 0xFFFFF50. The default source for RTICLK is VCLK.

For more information, on the clock sources see [Table 6-8](#) and [Table 6-12](#).

6.17 Error Signaling Module

The Error Signaling Module (ESM) manages the various error conditions on the TMS570 microcontroller. The error condition is handled based on a fixed severity level assigned to it. Any severe error condition can be configured to drive a low level on a dedicated device terminal called nERROR. This can be used as an indicator to an external monitor circuit to put the system into a safe state.

6.17.1 Features

The features of the Error Signaling Module are:

- 128 interrupt/error channels are supported, divided into 3 different groups
 - 64 channels with maskable interrupt and configurable error pin behavior
 - 32 error channels with nonmaskable interrupt and predefined error pin behavior
 - 32 channels with predefined error pin behavior only
- Error pin to signal severe device failure
- Configurable timebase for error signal
- Error forcing capability

6.17.2 ESM Channel Assignments

The Error Signaling Module (ESM) integrates all the device error conditions and groups them in the order of severity. Group1 is used for errors of the lowest severity while Group3 is used for errors of the highest severity. The device response to each error is determined by the severity group it is connected to. [Table 6-26](#) shows the channel assignment for each group.

Table 6-25. ESM Groups

| ERROR GROUP | INTERRUPT CHARACTERISTICS | INFLUENCE ON ERROR PIN |
|-------------|--------------------------------|------------------------|
| Group1 | Maskable, low or high priority | Configurable |
| Group2 | Nonmaskable, high priority | Fixed |
| Group3 | No interrupt generated | Fixed |

Table 6-26. ESM Channel Assignments

| ERROR SOURCES | GROUP | CHANNELS |
|----------------------------------------------------------------------------------------------|--------|----------|
| Reserved | Group1 | 0 |
| Reserved | Group1 | 1 |
| Reserved | Group1 | 2 |
| Reserved | Group1 | 3 |
| Reserved | Group1 | 4 |
| Reserved | Group1 | 5 |
| FMC - correctable error: bus1 and bus2 interfaces (does not include accesses to EEPROM bank) | Group1 | 6 |
| N2HET - parity | Group1 | 7 |
| HTU - parity | Group1 | 8 |
| HTU - MPU | Group1 | 9 |
| PLL - Slip | Group1 | 10 |
| Clock Monitor - interrupt | Group1 | 11 |
| Reserved | Group1 | 12 |
| Reserved | Group1 | 13 |
| Reserved | Group1 | 14 |
| VIM RAM - parity | Group1 | 15 |
| Reserved | Group1 | 16 |
| MibSPI1 - parity | Group1 | 17 |
| Reserved | Group1 | 18 |
| MibADC - parity | Group1 | 19 |
| Reserved | Group1 | 20 |
| DCAN1 - parity | Group1 | 21 |
| Reserved | Group1 | 22 |
| DCAN2 - parity | Group1 | 23 |
| Reserved | Group1 | 24 |
| Reserved | Group1 | 25 |
| RAM even bank (B0TCM) - correctable error | Group1 | 26 |
| CPU - self-test | Group1 | 27 |
| RAM odd bank (B1TCM) - correctable error | Group1 | 28 |
| Reserved | Group1 | 29 |
| DCC - error | Group1 | 30 |
| CCM-R4 - self-test | Group1 | 31 |
| Reserved | Group1 | 32 |
| Reserved | Group1 | 33 |
| Reserved | Group1 | 34 |
| FMC - correctable error (EEPROM bank access) | Group1 | 35 |
| FMC - uncorrectable error (EEPROM bank access) | Group1 | 36 |
| IOMM - Mux configuration error | Group1 | 37 |
| Reserved | Group1 | 38 |

Table 6-26. ESM Channel Assignments (continued)

| ERROR SOURCES | GROUP | CHANNELS |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| Reserved | Group1 | 39 |
| eFuse farm – this error signal is generated whenever any bit in the eFuse farm error status register is set. The application can choose to generate and interrupt whenever this bit is set in order to service any eFuse farm error condition. | Group1 | 40 |
| eFuse farm - self test error. It is not necessary to generate a separate interrupt when this bit gets set. | Group1 | 41 |
| Reserved | Group1 | 42 |
| Reserved | Group1 | 43 |
| Reserved | Group1 | 44 |
| Reserved | Group1 | 45 |
| Reserved | Group1 | 46 |
| Reserved | Group1 | 47 |
| Reserved | Group1 | 48 |
| Reserved | Group1 | 49 |
| Reserved | Group1 | 50 |
| Reserved | Group1 | 51 |
| Reserved | Group1 | 52 |
| Reserved | Group1 | 53 |
| Reserved | Group1 | 54 |
| Reserved | Group1 | 55 |
| Reserved | Group1 | 56 |
| Reserved | Group1 | 57 |
| Reserved | Group1 | 58 |
| Reserved | Group1 | 59 |
| Reserved | Group1 | 60 |
| Reserved | Group1 | 61 |
| Reserved | Group1 | 62 |
| Reserved | Group1 | 63 |
| Reserved | Group2 | 0 |
| Reserved | Group2 | 1 |
| CCMR4 - compare | Group2 | 2 |
| Reserved | Group2 | 3 |
| FMC - uncorrectable error (address parity on bus1 accesses) | Group2 | 4 |
| Reserved | Group2 | 5 |
| RAM even bank (B0TCM) - uncorrectable error | Group2 | 6 |
| Reserved | Group2 | 7 |
| RAM odd bank (B1TCM) - uncorrectable error | Group2 | 8 |
| Reserved | Group2 | 9 |
| RAM even bank (B0TCM) - address bus parity error | Group2 | 10 |
| Reserved | Group2 | 11 |
| RAM odd bank (B1TCM) - address bus parity error | Group2 | 12 |
| Reserved | Group2 | 13 |
| Reserved | Group2 | 14 |
| Reserved | Group2 | 15 |
| TCM - ECC live lock detect | Group2 | 16 |
| Reserved | Group2 | 17 |
| Reserved | Group2 | 18 |
| Reserved | Group2 | 19 |

Table 6-26. ESM Channel Assignments (continued)

| ERROR SOURCES | GROUP | CHANNELS |
|-----------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| Reserved | Group2 | 20 |
| Reserved | Group2 | 21 |
| Reserved | Group2 | 22 |
| Reserved | Group2 | 23 |
| RTI_WWD_NMI | Group2 | 24 |
| Reserved | Group2 | 25 |
| Reserved | Group2 | 26 |
| Reserved | Group2 | 27 |
| Reserved | Group2 | 28 |
| Reserved | Group2 | 29 |
| Reserved | Group2 | 30 |
| Reserved | Group2 | 31 |
| Reserved | Group3 | 0 |
| eFuse Farm - autoload error | Group3 | 1 |
| Reserved | Group3 | 2 |
| RAM even bank (B0TCM) - ECC uncorrectable error | Group3 | 3 |
| Reserved | Group3 | 4 |
| RAM odd bank (B1TCM) - ECC uncorrectable error | Group3 | 5 |
| Reserved | Group3 | 6 |
| FMC - uncorrectable error: bus1 and bus2 interfaces (does not include address parity error and errors on accesses to EEPROM bank) | Group3 | 7 |
| Reserved | Group3 | 8 |
| Reserved | Group3 | 9 |
| Reserved | Group3 | 10 |
| Reserved | Group3 | 11 |
| Reserved | Group3 | 12 |
| Reserved | Group3 | 13 |
| Reserved | Group3 | 14 |
| Reserved | Group3 | 15 |
| Reserved | Group3 | 16 |
| Reserved | Group3 | 17 |
| Reserved | Group3 | 18 |
| Reserved | Group3 | 19 |
| Reserved | Group3 | 20 |
| Reserved | Group3 | 21 |
| Reserved | Group3 | 22 |
| Reserved | Group3 | 23 |
| Reserved | Group3 | 24 |
| Reserved | Group3 | 25 |
| Reserved | Group3 | 26 |
| Reserved | Group3 | 27 |
| Reserved | Group3 | 28 |
| Reserved | Group3 | 29 |
| Reserved | Group3 | 30 |
| Reserved | Group3 | 31 |

6.18 Reset / Abort / Error Sources

Table 6-27. Reset/Abort/Error Sources

| ERROR SOURCE | SYSTEM MODE | ERROR RESPONSE | ESM HOOKUP GROUP.CHANNEL |
|----------------------------------------------------------------------------------------------------------|----------------|-------------------------------------------------|--------------------------|
| CPU TRANSACTIONS | | | |
| Precise write error (NCNB/Strongly Ordered) | User/Privilege | Precise Abort (CPU) | n/a |
| Precise read error (NCB/Device or Normal) | User/Privilege | Precise Abort (CPU) | n/a |
| Imprecise write error (NCB/Device or Normal) | User/Privilege | Imprecise Abort (CPU) | n/a |
| Illegal instruction | User/Privilege | Undefined Instruction Trap (CPU) ⁽¹⁾ | n/a |
| MPU access violation | User/Privilege | Abort (CPU) | n/a |
| SRAM | | | |
| B0 TCM (even) ECC single error (correctable) | User/Privilege | ESM | 1.26 |
| B0 TCM (even) ECC double error (noncorrectable) | User/Privilege | Abort (CPU), ESM → nERROR | 3.3 |
| B0 TCM (even) uncorrectable error (that is, redundant address decode) | User/Privilege | ESM → NMI → nERROR | 2.6 |
| B0 TCM (even) address bus parity error | User/Privilege | ESM → NMI → nERROR | 2.10 |
| B1 TCM (odd) ECC single error (correctable) | User/Privilege | ESM | 1.28 |
| B1 TCM (odd) ECC double error (noncorrectable) | User/Privilege | Abort (CPU), ESM → nERROR | 3.5 |
| B1 TCM (odd) uncorrectable error (that is, redundant address decode) | User/Privilege | ESM → NMI → nERROR | 2.8 |
| B1 TCM (odd) address bus parity error | User/Privilege | ESM → NMI → nERROR | 2.12 |
| FLASH WITH CPU BASED ECC | | | |
| FMC correctable error - Bus1 and Bus2 interfaces (does not include accesses to EEPROM bank) | User/Privilege | ESM | 1.6 |
| FMC uncorrectable error - Bus1 accesses (does not include address parity error) | User/Privilege | Abort (CPU), ESM → nERROR | 3.7 |
| FMC uncorrectable error - Bus2 accesses (does not include address parity error and EEPROM bank accesses) | User/Privilege | ESM → nERROR | 3.7 |
| FMC uncorrectable error - address parity error on Bus1 accesses | User/Privilege | ESM → NMI → nERROR | 2.4 |
| FMC correctable error - Accesses to EEPROM bank | User/Privilege | ESM | 1.35 |
| FMC uncorrectable error - Accesses to EEPROM bank | User/Privilege | ESM | 1.36 |
| HIGH-END TIMER TRANSFER UNIT (HTU) | | | |
| NCNB (Strongly Ordered) transaction with slave error response | User/Privilege | Interrupt → VIM | n/a |
| External imprecise error (Illegal transaction with ok response) | User/Privilege | Interrupt → VIM | n/a |
| Memory access permission violation | User/Privilege | ESM | 1.9 |
| Memory parity error | User/Privilege | ESM | 1.8 |
| N2HET | | | |
| Memory parity error | User/Privilege | ESM | 1.7 |
| MIBSPI | | | |
| MibSPI1 memory parity error | User/Privilege | ESM | 1.17 |
| MIBADC | | | |
| MibADC Memory parity error | User/Privilege | ESM | 1.19 |
| DCAN | | | |
| DCAN1 memory parity error | User/Privilege | ESM | 1.21 |

(1) The Undefined Instruction TRAP is NOT detectable outside the CPU. The trap is taken only if the instruction reaches the execute stage of the CPU.

Table 6-27. Reset/Abort/Error Sources (continued)

| ERROR SOURCE | SYSTEM MODE | ERROR RESPONSE | ESM HOOKUP GROUP.CHANNEL |
|-------------------------------------------------------------|----------------|----------------------|--------------------------|
| DCAN2 memory parity error | User/Privilege | ESM | 1.23 |
| PLL | | | |
| PLL slip error | User/Privilege | ESM | 1.10 |
| CLOCK MONITOR | | | |
| Clock monitor interrupt | User/Privilege | ESM | 1.11 |
| DCC | | | |
| DCC error | User/Privilege | ESM | 1.30 |
| CCM-R4 | | | |
| Self test failure | User/Privilege | ESM | 1.31 |
| Compare failure | User/Privilege | ESM → NMI → nERROR | 2.2 |
| VIM | | | |
| Memory parity error | User/Privilege | ESM | 1.15 |
| VOLTAGE MONITOR | | | |
| VMON out of voltage range | n/a | Reset | n/a |
| CPU SELF-TEST (LBIST) | | | |
| CPU Self-test (LBIST) error | User/Privilege | ESM | 1.27 |
| PIN MULTIPLEXING CONTROL | | | |
| Mux configuration error | User/Privilege | ESM | 1.37 |
| eFuse CONTROLLER | | | |
| eFuse Controller Autoload error | User/Privilege | ESM → nERROR | 3.1 |
| eFuse Controller - Any bit set in the error status register | User/Privilege | ESM | 1.40 |
| eFuse Controller self-test error | User/Privilege | ESM | 1.41 |
| WINDOWED WATCHDOG | | | |
| WWD Nonmaskable Interrupt exception | n/a | ESM => NMI => nERROR | 2.24 |
| ERRORS REFLECTED IN THE SYSESR REGISTER | | | |
| Power-Up Reset | n/a | Reset | n/a |
| Oscillator fail / PLL slip ⁽²⁾ | n/a | Reset | n/a |
| Watchdog exception | n/a | Reset | n/a |
| CPU Reset (driven by the CPU STC) | n/a | Reset | n/a |
| Software Reset | n/a | Reset | n/a |
| External Reset | n/a | Reset | n/a |

(2) Oscillator fail/PLL slip can be configured in the system register (SYS.PLLCTL1) to generate a reset.

6.19 Digital Windowed Watchdog

This device includes a digital windowed watchdog (DWWD) module that protects against runaway code execution.

The DWWD module allows the application to configure the time window within which the DWWD module expects the application to service the watchdog. A watchdog violation occurs if the application services the watchdog outside of this window, or fails to service the watchdog at all. The application can choose to generate a system reset or a nonmaskable interrupt to the CPU in case of a watchdog violation.

The watchdog is disabled by default and must be enabled by the application. Once enabled, the watchdog can only be disabled upon a system reset.

6.20 Debug Subsystem

6.20.1 Block Diagram

The device contains an ICEPICK module to allow JTAG access to the scan chains (see [Figure 6-14](#)).

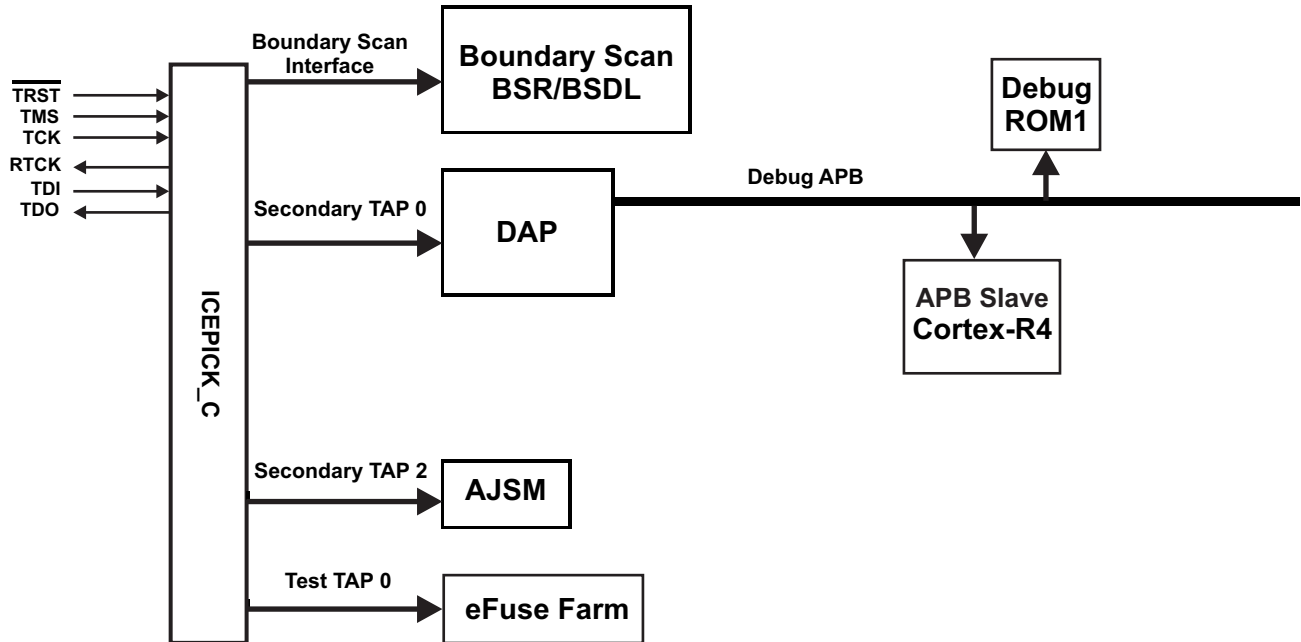


Figure 6-14. Debug Subsystem Block Diagram

6.20.2 Debug Components Memory Map

Table 6-28. Debug Components Memory Map

| MODULE NAME | FRAME CHIP SELECT | FRAME ADDRESS RANGE | | FRAME SIZE | ACTUAL SIZE | RESPONSE FOR ACCESS TO UNIMPLEMENTED LOCATIONS IN FRAME |
|---------------------|-------------------|---------------------|--------------|------------|-------------|---------------------------------------------------------|
| | | START | END | | | |
| CoreSight Debug ROM | CSCS0 | 0xFFFA0_0000 | 0xFFFA0_0FFF | 4KB | 4KB | Reads return zeros, writes have no effect |
| Cortex-R4 Debug | CSCS1 | 0xFFFA0_1000 | 0xFFFA0_1FFF | 4KB | 4KB | Reads return zeros, writes have no effect |

6.20.3 JTAG Identification Code

The JTAG ID code for this device is the same as the device ICEPick Identification Code.

Table 6-29. JTAG Identification Code

| SILICON REVISION | IDENTIFICATION CODE |
|------------------|---------------------|
| Initial Silicon | 0x0B97102F |
| Revision A | 0x1B97102F |
| Revision B | 0x2B97102F |

6.20.4 Debug ROM

The Debug ROM stores the location of the components on the Debug APB bus:

Table 6-30. Debug ROM table

| ADDRESS | DESCRIPTION | VALUE |
|---------|----------------------|-------------|
| 0x000 | Pointer to Cortex-R4 | 0x0000 1003 |
| 0x001 | Reserved | 0x0000 2002 |
| 0x002 | Reserved | 0x0000 3002 |
| 0x003 | Reserved | 0x0000 4002 |
| 0x004 | End of table | 0x0000 0000 |

6.20.5 JTAG Scan Interface Timings

Table 6-31. JTAG Scan Interface Timing⁽¹⁾

| NO. | PARAMETER | MIN | MAX | UNIT | |
|-----|-------------------------|-----------------------------------------------|-----|------|-----|
| | f_{TCK} | TCK frequency (at HCLKmax) | | 12 | MHz |
| | f_{RTCK} | RTCK frequency (at TCKmax and HCLKmax) | | 10 | MHz |
| 1 | $t_d(TCK-RTCK)$ | Delay time, TCK to RTCK | | 24 | ns |
| 2 | $t_{su}(TDI/TMS-RTCKr)$ | Setup time, TDI, TMS before RTCK rise (RTCKr) | | 26 | ns |
| 3 | $t_h(RTCKr-TDI/TMS)$ | Hold time, TDI, TMS after RTCKr | | 0 | ns |
| 4 | $t_h(RTCKr-TDO)$ | Hold time, TDO after RTCKf | | 0 | ns |
| 5 | $t_d(TCKf-TDO)$ | Delay time, TDO valid after RTCK fall (RTCKf) | | 12 | ns |

(1) Timings for TDO are specified for a maximum of 50 pF load on TDO

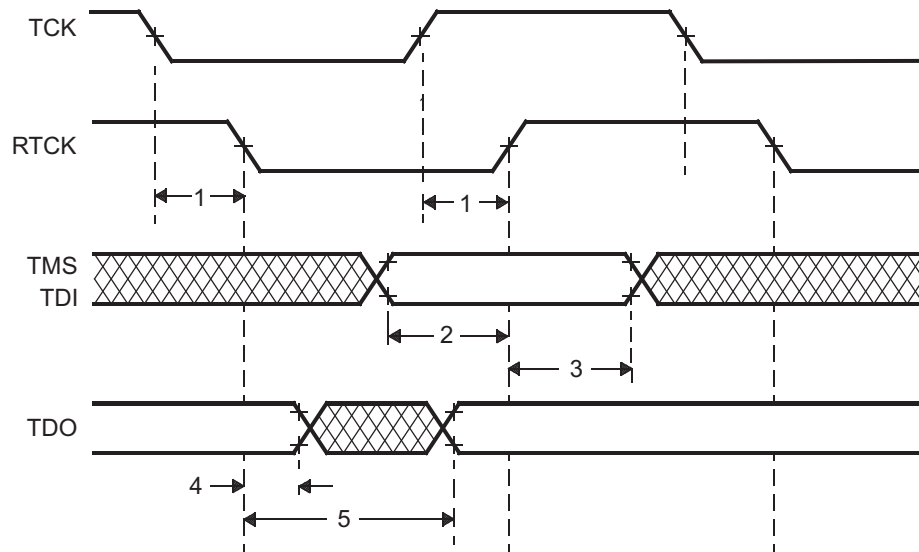


Figure 6-15. JTAG Timing

6.20.6 Advanced JTAG Security Module

This device includes an Advanced JTAG Security Module (AJSM), which lets the user limit JTAG access to the device after programming.

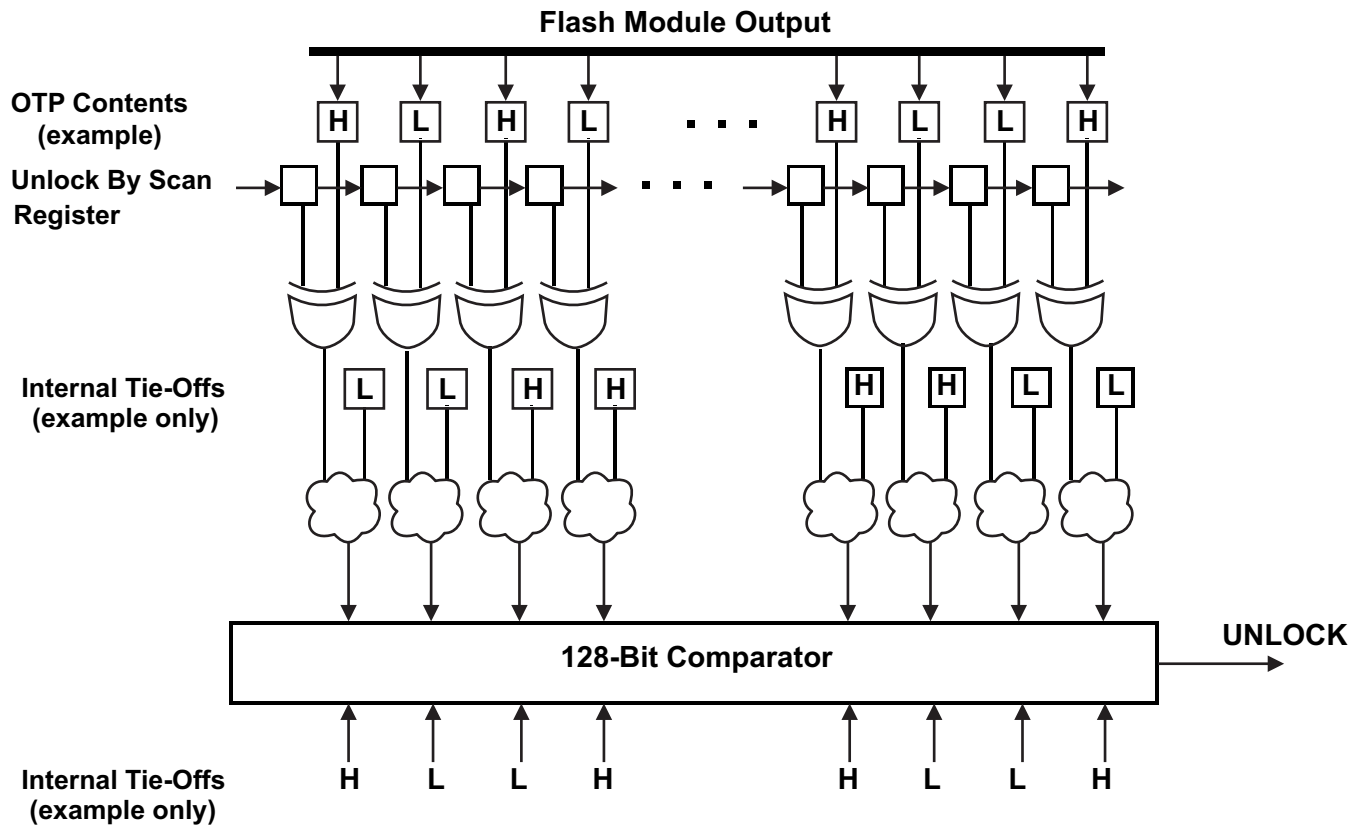


Figure 6-16. AJSM Unlock

The device is unlocked by default by virtue of a 128-bit visible unlock code programmed in the One-Time Programmable (OTP) address 0xF000 0000. The OTP contents are XOR-ed with the contents of the Unlock-By-Scan register. The outputs of these XOR gates are again combined with a set of secret internal tie-offs. The output of this combinational logic is compared against a secret, hard-wired, 128-bit value. A match asserts the UNLOCK signal, so that the device is now unlocked.

A user can lock the device by changing bits in the visible unlock code from 1 to 0. Changing a 0 to 1 is not possible because the visible unlock code is stored in the OTP flash region. Also, changing all the 128 bits to zeros is not a valid condition and will permanently lock the device.

Once locked, a user can unlock the device by scanning an appropriate value into the Unlock-By-Scan register of the AJSM module. This register is accessible by configuring an IR value of 0b1011 on the AJSM TAP. The value to be scanned is such that the XOR of the OTP contents and the contents of the Unlock-By-Scan register results in the original visible unlock code.

The Unlock-By-Scan register is reset only by asserting power-on reset (nPORRST).

A locked device only permits JTAG accesses to the AJSM scan chain through the Secondary TAP 2 of the ICEPick module. All other secondary TAPs, test TAPs, and the boundary scan interface are not accessible in this state.

6.20.7 Boundary Scan Chain

The device supports BSDL-compliant boundary scan for testing pin-to-pin compatibility. The boundary scan chain is connected to the Boundary Scan Interface of the ICEPICK module.

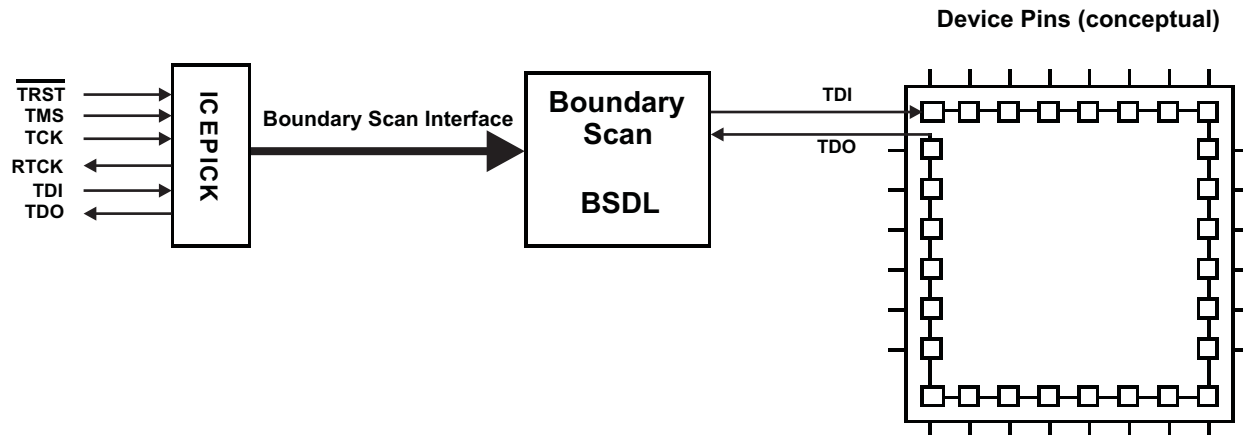


Figure 6-17. Boundary Scan Implementation (Conceptual Diagram)

Data is serially shifted into all boundary-scan buffers through TDI, and out through TDO.

7 Peripheral Information and Electrical Specifications

7.1 Peripheral Legend

Table 7-1. Peripheral Legend

| ABBREVIATION | FULL NAME |
|--------------|-------------------------------------------|
| MibADC | Multibuffered Analog-to-Digital Converter |
| CCM-R4 | CPU Compare Module – Cortex-R4 |
| CRC | Cyclic Redundancy Check |
| DCAN | Controller Area Network |
| DCC | Dual Clock Comparator |
| ESM | Error Signaling Module |
| GIO | General-Purpose Input/Output |
| HTU | High-End Timer Transfer Unit |
| LIN | Local Interconnect Network |
| MibSPI | Multibuffered Serial Peripheral Interface |
| N2HET | Platform High-End Timer |
| RTI | Real-Time Interrupt Module |
| SCI | Serial Communications Interface |
| SPI | Serial Peripheral Interface |
| VIM | Vectored Interrupt Manager |
| eQEP | Enhanced Quadrature Encoder Pulse |

7.2 Multibuffered 12-Bit Analog-to-Digital Converter

The multibuffered A-to-D converter (MibADC) has a separate power bus for its analog circuitry that enhances the A-to-D performance by preventing digital switching noise on the logic circuitry which could be present on V_{SS} and V_{CC} from coupling into the A-to-D analog stage. All A-to-D specifications are given with respect to AD_{REFLO} unless otherwise noted.

Table 7-2. MibADC Overview

| DESCRIPTION | VALUE |
|------------------------|-----------------------------------------------------------------------------------|
| Resolution | 12 bits |
| Monotonic | Assured |
| Output conversion code | 00h to FFFh [00 for $V_{AI} \leq AD_{REFLO}$; FFF for $V_{AI} \geq AD_{REFHI}$] |

7.2.1 Features

- 12-bit resolution
- AD_{REFHI} and AD_{REFLO} pins (high and low reference voltages)
- Total Sample/Hold/Convert time: 600 ns Typical Minimum at 30 MHz ADCLK
- One memory region per conversion group is available (event, group 1, group 2)
- Allocation of channels to conversion groups is completely programmable
- Memory regions are serviced by interrupt
- Programmable interrupt threshold counter is available for each group
- Programmable magnitude threshold interrupt for each group for any one channel
- Option to read either 8-, 10-, or 12-bit values from memory regions
- Single or continuous conversion modes
- Embedded self-test
- Embedded calibration logic
- Enhanced power-down mode
 - Optional feature to automatically power down ADC core when no conversion is in progress

- External event pin (ADEVT) programmable as general-purpose I/O

7.2.2 Event Trigger Options

The ADC module supports three conversion groups: Event Group, Group1, and Group2. Each of these three groups can be configured to be hardware event-triggered. In that case, the application can select from among eight event sources to be the trigger for the conversions of a group.

7.2.2.1 MIBADC Event Trigger Hookup

Table 7-3. MIBADC Event Trigger Hookup

| EVENT NUMBER | SOURCE SELECT BITS For G1, G2, or EVENT (G1SRC[2:0], G2SRC[2:0], or EVSRC[2:0]) | TRIGGER |
|--------------|---------------------------------------------------------------------------------------|-------------------------|
| 1 | 000 | ADEVT |
| 2 | 001 | N2HET[8] |
| 3 | 010 | N2HET[10] |
| 4 | 011 | RTI compare 0 interrupt |
| 5 | 100 | N2HET[12] |
| 6 | 101 | N2HET[14] |
| 7 | 110 | N2HET[17] |
| 8 | 111 | N2HET[19] |

NOTE

For ADEVT, N2HET trigger sources, the connection to the MibADC module trigger input is made from the output side of the input buffer. This way, a trigger condition can be generated either by configuring the function as output onto the pad, or by driving the function from an external trigger source as input. If the mux controller module is used to select different functionality instead of ADEVT or N2HET[x], care must be taken to disable these signals from triggering conversions; there is no multiplexing on input connections.

NOTE

For the RTI compare 0 interrupt source, the connection is made directly from the output of the RTI module. That is, the interrupt condition can be used as a trigger source even if the actual interrupt is not signaled to the CPU.

7.2.3 ADC Electrical and Timing Specifications

Table 7-4. MibADC Recommended Operating Conditions

| PARAMETER | | MIN | MAX | UNIT |
|---------------------|------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------|------|
| AD _{REFHI} | A-to-D high-voltage reference source | AD _{REFLO} | V _{CCAD} | V |
| AD _{REFLO} | A-to-D low-voltage reference source | V _{SSAD} | AD _{REFHI} | V |
| V _{AI} | Analog input voltage | AD _{REFLO} | AD _{REFHI} | V |
| I _{AI} | Analog input clamp current (V _{AI} < V _{SSAD} - 0.3 or V _{AI} > V _{CCAD} + 0.3) | -2 | 2 | mA |

Table 7-5. MibADC Electrical Characteristics Over Full Ranges of Recommended Operating Conditions⁽¹⁾

| PARAMETER | DESCRIPTION/CONDITIONS | MIN | TYP | MAX | UNIT | | |
|----------------------|----------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------|------|------|-----|----|
| R _{mux} | Analog input mux on-resistance | | 95 | 250 | Ω | | |
| R _{samp} | ADC sample switch on-resistance | | 60 | 250 | Ω | | |
| C _{mux} | Input mux capacitance | | 7 | 16 | pF | | |
| C _{samp} | ADC sample capacitance | | 8 | 13 | pF | | |
| I _{AIL} | Analog off-state input leakage current | V _{CCAD} = 3.6 V MAX | V _{SSAD} < V _{IN} < V _{SSAD} + 100 mV | -300 | -1 | 200 | nA |
| | | | V _{SSAD} + 100 mV < V _{IN} < V _{CCAD} - 200 mV | -200 | -0.3 | 200 | |
| | | | V _{CCAD} - 200 mV < V _{IN} < V _{CCAD} | -200 | 1 | 500 | |
| I _{AOSB} | Analog on-state input bias | V _{CCAD} = 3.6 V MAX | V _{SSAD} < V _{IN} < V _{SSAD} + 100 mV | -8 | | 2 | μA |
| | | | V _{SSAD} + 100 mV < V _{IN} < V _{CCAD} - 200 mV | -4 | | 2 | |
| | | | V _{CCAD} - 200 mV < V _{IN} < V _{CCAD} | -4 | | 12 | |
| I _{ADREFHI} | AD _{REFHI} input current | AD _{REFHI} = V _{CCAD} , AD _{REFLO} = V _{SSAD} | | | 3 | mA | |
| I _{CCAD} | Static supply current | Normal operating mode | | | (2) | mA | |
| | | ADC core in power-down mode | | | 5 | μA | |

(1) 1 LSB = (AD_{REFHI} - AD_{REFLO}) / 2ⁿ where n = 10 in 10-bit mode and 12 in 12-bit mode
 (2) See Section 5.7.

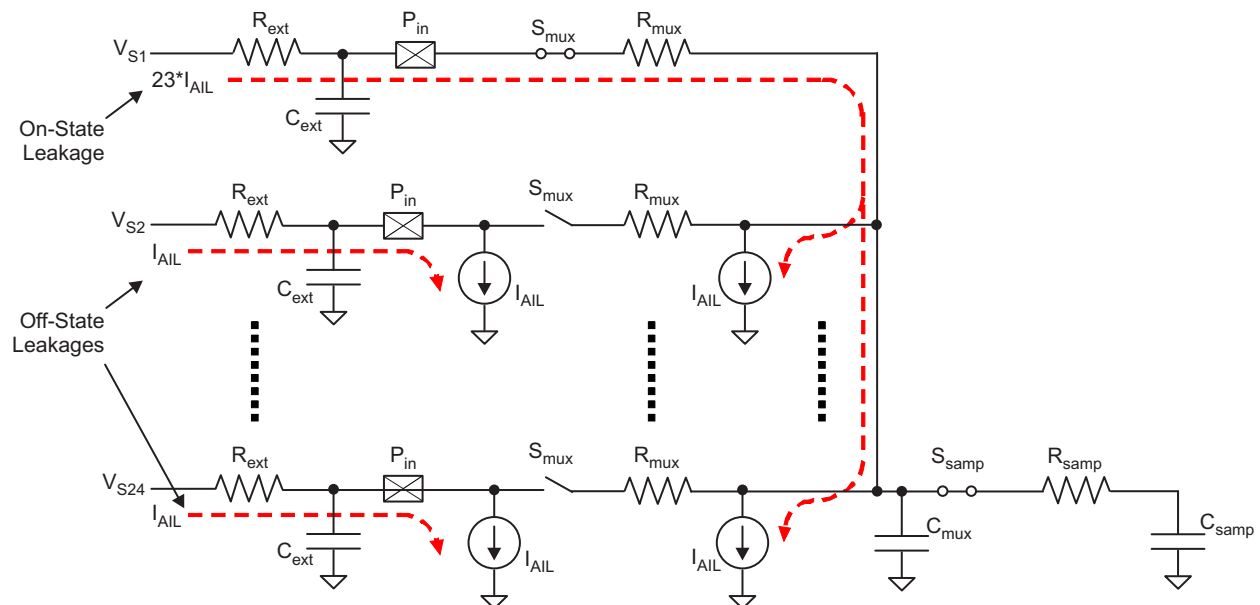


Figure 7-1. MibADC Input Equivalent Circuit

Table 7-6. MibADC Timing Specifications

| PARAMETER | | MIN | NOM | MAX | UNIT |
|----------------------|---------------------------------------------------------------|-----|-----|-----|---------|
| $t_{c(ADCLK)}^{(1)}$ | Cycle time, MibADC clock | 33 | | | ns |
| $t_{d(SH)}^{(2)}$ | Delay time, sample and hold time | 200 | | | ns |
| $t_{d(PU-ADV)}$ | Delay time from ADC power on until first input can be sampled | 1 | | | μ s |
| 12-BIT MODE | | | | | |
| $t_{d(C)}$ | Delay time, conversion time | 400 | | | ns |
| $t_{d(SHC)}^{(3)}$ | Delay time, total sample/hold and conversion time | 600 | | | ns |
| 10-BIT MODE | | | | | |
| $t_{d(C)}$ | Delay time, conversion time | 330 | | | ns |
| $t_{d(SHC)}^{(3)}$ | Delay time, total sample/hold and conversion time | 530 | | | ns |

- (1) The MibADC clock is the ADCLK, generated by dividing down the VCLK by a prescale factor defined by the ADCLOCKCR register bits 4:0.
- (2) The sample and hold time for the ADC conversions is defined by the ADCLK frequency and the AD<GP>SAMP register for each conversion group. The sample time must be determined by accounting for the external impedance connected to the input channel as well as the internal impedance of the ADC.
- (3) This is the minimum sample/hold and conversion time that can be achieved. These parameters are dependent on many factors for example, the prescale settings.

Table 7-7. MibADC Operating Characteristics Over Full Ranges of Recommended Operating Conditions

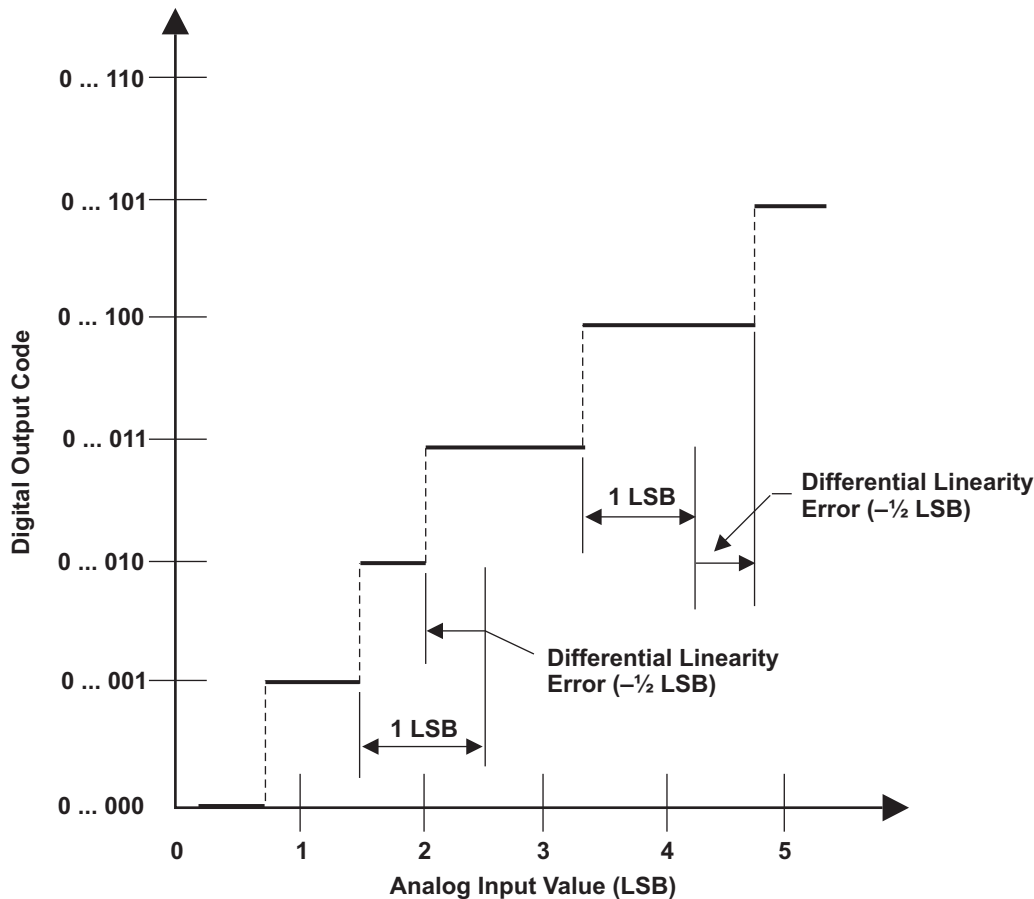
| PARAMETER | | DESCRIPTION/CONDITIONS | | MIN | TYP | MAX | UNIT |
|------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------------|-----|-------|--------------------|
| CR | Conversion range over which specified accuracy is maintained | AD _{REFHI} - AD _{REFLO} | | 3 | | 3.6 | V |
| Z _{SET} | Offset Error | Difference between the first ideal transition (from code 000h to 001h) and the actual transition | 10-bit mode | With ADC Calibration | | 1 | LSB ⁽¹⁾ |
| | | | | Without ADC Calibration | | 2 | |
| | | | 12-bit mode | With ADC Calibration | | 2 | |
| | | | | Without ADC Calibration | | 4 | |
| F _{SET} | Gain Error | Difference between the last ideal transition (from code FFEh to FFFh) and the actual transition minus offset. | 10-bit mode | | | 2 | LSB |
| | | | 12-bit mode | | | 3 | |
| E _{DNL} | Differential nonlinearity error | Difference between the actual step width and the ideal value. (See Figure 7-2) | 10-bit mode | | | ± 1.5 | LSB |
| | | | 12-bit mode | | | ± 2 | |
| E _{INL} | Integral nonlinearity error | Maximum deviation from the best straight line through the MibADC. MibADC transfer characteristics, excluding the quantization error. (See Figure 7-3) | 10-bit mode | | | ± 2 | LSB |
| | | | 12-bit mode | | | ± 2 | |
| E _{TOT} | Total unadjusted error | Maximum value of the difference between an analog value and the ideal midstep value. (See Figure 7-4) | 10-bit mode | With ADC Calibration | | ± 2 | LSB |
| | | | | Without ADC Calibration | | ± 4 | |
| | | | 12-bit mode | With ADC Calibration | | ± 4 | |
| | | | | Without ADC Calibration | | ± 7 | |

(1) 1 LSB = (AD_{REFHI} - AD_{REFLO}) / 2ⁿ where n = 10 in 10-bit mode and 12 in 12-bit mode

7.2.4 Performance (Accuracy) Specifications

7.2.4.1 MibADC Nonlinearity Errors

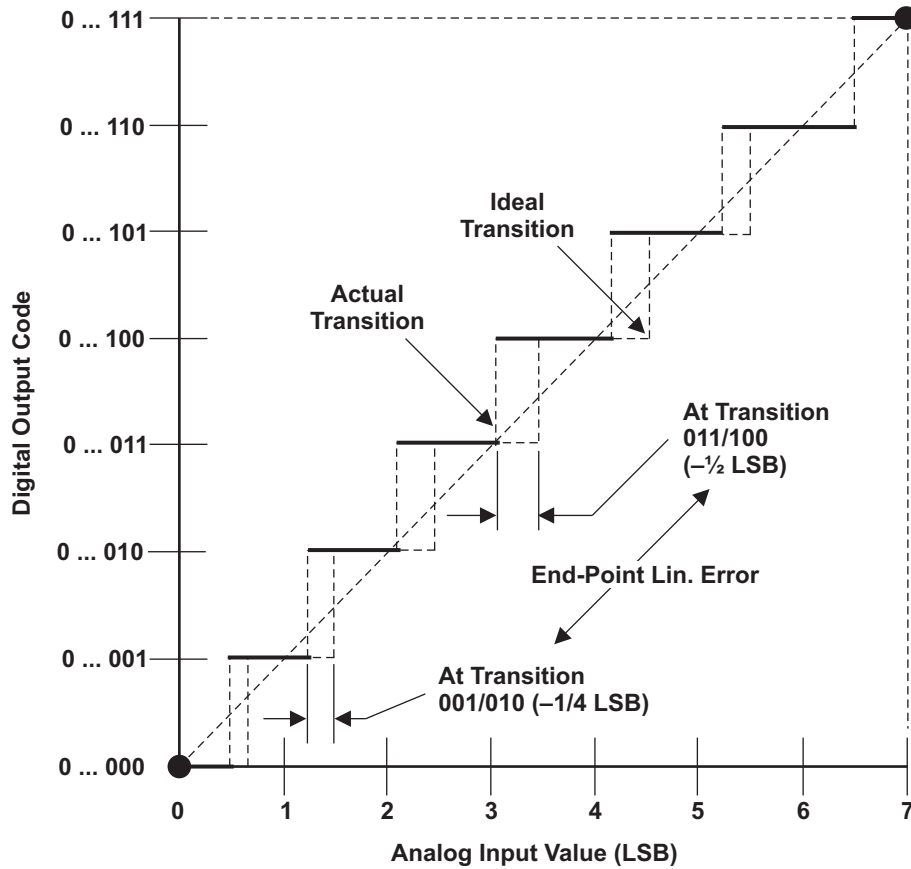
The differential nonlinearity error shown in Figure 7-2 (sometimes referred to as differential linearity) is the difference between an actual step width and the ideal value of 1 LSB.



NOTE A: $1 \text{ LSB} = (AD_{\text{REFHI}} - AD_{\text{REFLO}}) / 2^n$ where $n=10$ in 10-bit mode and 12 in 12-bit mode

Figure 7-2. Differential Nonlinearity (DNL) Error

The integral nonlinearity error shown in [Figure 7-3](#) (sometimes referred to as linearity error) is the deviation of the values on the actual transfer function from a straight line.

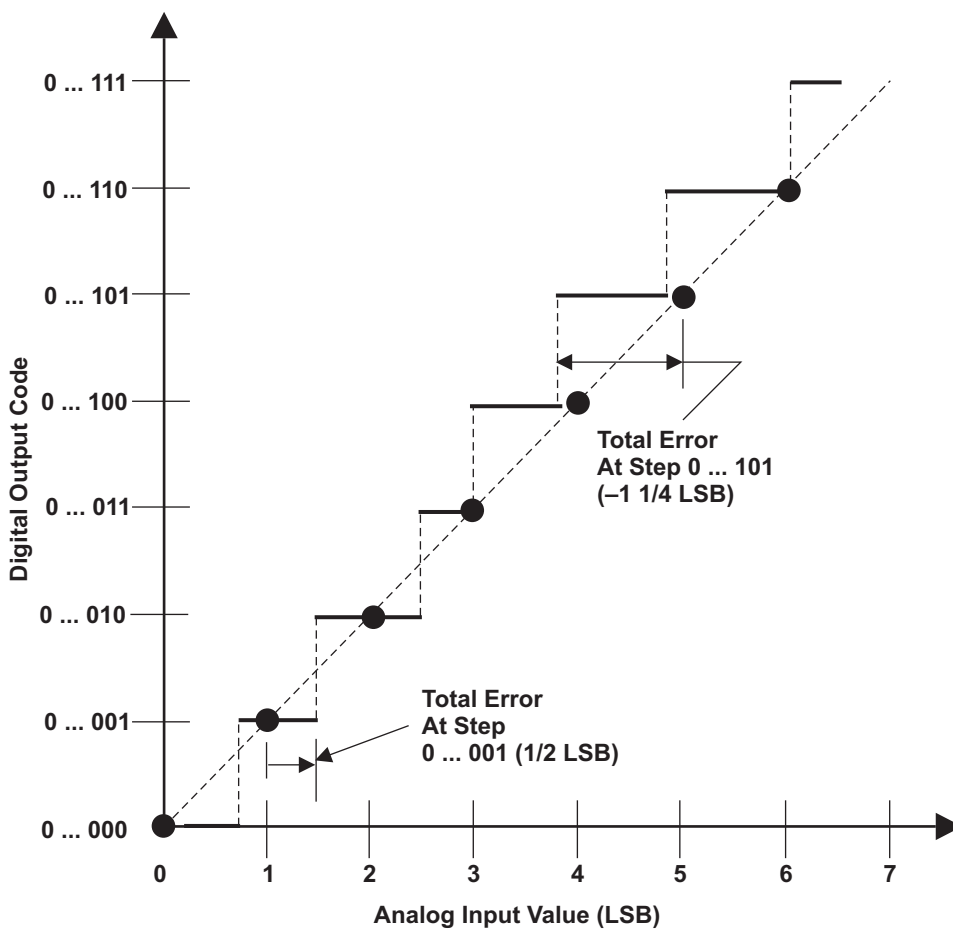


NOTE A: $1 \text{ LSB} = (AD_{\text{REFHI}} - AD_{\text{REFLO}}) / 2^n$ where $n=10$ in 10-bit mode and 12 in 12-bit mode

Figure 7-3. Integral Nonlinearity (INL) Error

7.2.4.2 MibADC Total Error

The absolute accuracy or total error of an MibADC as shown in Figure 7-4 is the maximum value of the difference between an analog value and the ideal midstep value.



NOTE A: $1 \text{ LSB} = (AD_{\text{REFHI}} - AD_{\text{REFLO}}) / 2^n$ where $n=10$ in 10-bit mode and 12 in 12-bit mode

Figure 7-4. Absolute Accuracy (Total) Error

7.3 General-Purpose Input/Output

The GPIO module on this device supports one port GIOA. The I/O pins are bidirectional and bit-programmable. GIOA supports external interrupt capability.

7.3.1 Features

The GPIO module has the following features:

- Each I/O pin can be configured as:
 - Input
 - Output
 - Open Drain
- The interrupts have the following characteristics:
 - Programmable interrupt detection either on both edges or on a single edge (set in GIOINTDET)
 - Programmable edge-detection polarity, either rising or falling edge (set in GIOPOL register)
 - Individual interrupt flags (set in GIOFLG register)
 - Individual interrupt enables, set and cleared through GIOENASET and GIOENACLR registers respectively
 - Programmable interrupt priority, set through GIOLVLSET and GIOLVLCLR registers
- Internal pullup/pulldown allows unused I/O pins to be left unconnected

For information on input and output timings see [Section 5.11](#) and [Section 5.12](#)

7.4 Enhanced High-End Timer (N2HET)

The N2HET is an advanced intelligent timer that provides sophisticated timing functions for real-time applications. The timer is software-controlled, using a reduced instruction set, with a specialized timer micromachine and an attached I/O port. The N2HET can be used for pulse width modulated outputs, capture or compare inputs, or general-purpose I/O. It is especially well suited for applications requiring multiple sensor information and drive actuators with complex and accurate time pulses.

7.4.1 Features

The N2HET module has the following features:

- Programmable timer for input and output timing functions
- Reduced instruction set (30 instructions) for dedicated time and angle functions
- 128 words of instruction RAM protected by parity
- User defined number of 25-bit virtual counters for timer, event counters and angle counters
- 7-bit hardware counters for each pin allow up to 32-bit resolution in conjunction with the 25-bit virtual counters
- Up to 19 pins usable for input signal measurements or output signal generation
- Programmable suppression filter for each input pin with adjustable limiting frequency
- Low CPU overhead and interrupt load
- Efficient data transfer to or from the CPU memory with dedicated High-End-Timer Transfer Unit (HTU)
- Diagnostic capabilities with different loopback mechanisms and pin status readback functionality

7.4.2 N2HET RAM Organization

The timer RAM uses 4 RAM banks, where each bank has two port access capability. This means that one RAM address may be written while another address is read. The RAM words are 96-bits wide, which are split into three 32-bit fields (program, control, and data).

7.4.3 Input Timing Specifications

The N2HET instructions PCNT and WCAP impose some timing constraints on the input signals.

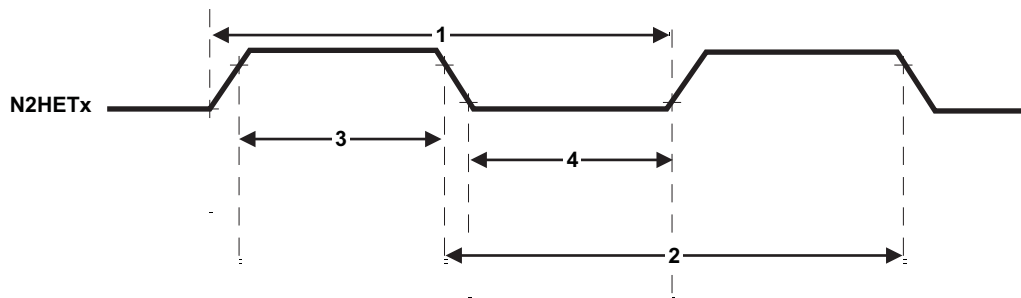


Figure 7-5. N2HET Input Capture Timings

Table 7-8. Dynamic Characteristics for the N2HET Input Capture Functionality

| PARAMETER | | MIN ⁽¹⁾ (2) | MAX ⁽¹⁾ (2) | UNIT |
|-----------|-----------------------------------------------------------------------|---------------------------------|--------------------------------------------------|------|
| 1 | Input signal period, PCNT or WCAP for rising edge to rising edge | (hr)(lr) $t_{c(VCLK2)} + 2$ | $2^{25}(\text{hr})(\text{lr})t_{c(VCLK2)} - 2$ | ns |
| 2 | Input signal period, PCNT or WCAP for falling edge to falling edge | (hr) (lr) $t_{c(VCLK2)} + 2$ | $2^{25} (\text{hr})(\text{lr}) t_{c(VCLK2)} - 2$ | ns |
| 3 | Input signal high phase, PCNT or WCAP for rising edge to falling edge | $2(\text{hr}) t_{c(VCLK2)} + 2$ | $2^{25} (\text{hr})(\text{lr}) t_{c(VCLK2)} - 2$ | ns |
| 4 | Input signal low phase, PCNT or WCAP for falling edge to rising edge | $2(\text{hr}) t_{c(VCLK2)} + 2$ | $2^{25} (\text{hr})(\text{lr}) t_{c(VCLK2)} - 2$ | ns |

(1) hr = High-resolution prescaler, configured using the HRPFC field of the Prescale Factor Register (HETPFR).

(2) lr = Loop-resolution prescaler, configured using the LFPRC field of the Prescale Factor Register (HETPFR).

7.4.4 N2HET Checking

7.4.4.1 Output Monitoring using Dual Clock Comparator (DCC)

N2HET[31] is connected as a clock source for counter 1 in DCC1. This allows the application to measure the frequency of the pulse-width modulated (PWM) signal on N2HET[31].

N2HET[31] can be configured to be an internal-only channel. That is, the connection to the DCC module is made directly from the output of the N2HET module (from the input of the output buffer).

For more information on DCC, see [Section 6.6.3](#).

7.4.5 Disabling N2HET Outputs

Some applications require the N2HET outputs to be disabled under some fault condition. The N2HET module provides this capability through the "Pin Disable" input signal. This signal, when driven low, causes the N2HET outputs identified by a programmable register (HETPINDIS) to be tri-stated.

For more details on the "N2HET Pin Disable" feature, see the device-specific Technical Reference Manual listed in [Section 8.2.1](#).

GIOA[5] and EQEPERR are connected to the "Pin Disable" input for N2HET. In the case of GIOA[5] connection, this connection is made from the output of the input buffer. In the case of EQEPERR, the EQEPERR output signal is asserted in the event of a phase error. This signal is inverted and double-synchronized to VCLK2 for input into the N2HET PIN_nDISABLE port.

The PIN_nDISABLE port input source is selectable between the GIOA[5] and EQEPERR sources. This is achieved through the PINMMR9[1:0] bits.

7.4.6 High-End Timer Transfer Unit (N2HET)

A High-End Timer Transfer Unit (N2HET) can perform DMA type transactions to transfer N2HET data to or from main memory. A Memory Protection Unit (MPU) is built into the N2HET.

7.4.6.1 Features

- CPU independent
- Master Port to access system memory
- 8 control packets supporting dual buffer configuration
- Control packet information is stored in RAM protected by parity
- Event synchronization (N2HET transfer requests)
- Supports 32- or 64-bit transactions
- Addressing modes for N2HET address (8 byte or 16 byte) and system memory address (fixed, 32-bit or 64-bit)
- One shot, circular, and auto switch buffer transfer modes
- Request lost detection

7.4.6.2 Trigger Connections

Table 7-9. N2HET Request Line Connection

| MODULES | REQUEST SOURCE | HTU REQUEST |
|---------|----------------|-------------|
| N2HET | HTUREQ[0] | HTU DCP[0] |
| N2HET | HTUREQ[1] | HTU DCP[1] |
| N2HET | HTUREQ[2] | HTU DCP[2] |
| N2HET | HTUREQ[3] | HTU DCP[3] |
| N2HET | HTUREQ[4] | HTU DCP[4] |
| N2HET | HTUREQ[5] | HTU DCP[5] |
| N2HET | HTUREQ[6] | HTU DCP[6] |
| N2HET | HTUREQ[7] | HTU DCP[7] |

7.5 Controller Area Network (DCAN)

The DCAN supports the CAN 2.0B protocol standard and uses a serial, multimaster communication protocol that efficiently supports distributed real-time control with robust communication rates of up to 1 Mbps. The DCAN is ideal for applications operating in noisy and harsh environments (for example, automotive and industrial fields) that require reliable serial communication or multiplexed wiring.

7.5.1 Features

Features of the DCAN module include:

- Supports CAN protocol version 2.0 part A, B
- Bit rates up to 1 Mbps
- The CAN kernel can be clocked by the oscillator for baud-rate generation.
- 32 and 16 mailboxes on DCAN1 and DCAN2, respectively
- Individual identifier mask for each message object
- Programmable FIFO mode for message objects
- Programmable loop-back modes for self-test operation
- Automatic bus on after Bus-Off state by a programmable 32-bit timer
- Message RAM protected by parity
- Direct access to Message RAM during test mode
- CAN RX / TX pins configurable as general-purpose I/O pins
- Message RAM Auto Initialization

For more information on the DCAN, see the device-specific Technical Reference Manual listed in [Section 8.2.1](#).

7.5.2 Electrical and Timing Specifications

Table 7-10. Dynamic Characteristics for the DCANx TX and RX pins

| PARAMETER | | MIN | MAX | UNIT |
|-----------------|------------------------------------------------------------------|-----|-----|------|
| $t_{d(CANnTX)}$ | Delay time, transmit shift register to CANnTX pin ⁽¹⁾ | | 15 | ns |
| $t_{d(CANnRX)}$ | Delay time, CANnRX pin to receive shift register | | 5 | ns |

(1) These values do not include rise/fall times of the output buffer.

7.6 Local Interconnect Network Interface (LIN)

The SCI/LIN module can be programmed to work either as an SCI or as a LIN. The core of the module is an SCI. The SCI's hardware features are augmented to achieve LIN compatibility.

The SCI module is a universal asynchronous receiver-transmitter that implements the standard nonreturn to zero format. The SCI can be used to communicate, for example, through an RS-232 port or over a K-line.

The LIN standard is based on the SCI (UART) serial data link format. The communication concept is single-master/multiple-slave with a message identification for multicast transmission between any network nodes.

7.6.1 LIN Features

The following are features of the LIN module:

- Compatible to LIN 1.3, 2.0 and 2.1 protocols
- Multibuffered receive and transmit units
- Identification masks for message filtering
- Automatic Master Header Generation
 - Programmable Synch Break Field
 - Synch Field
 - Identifier Field
- Slave Automatic Synchronization
 - Synch break detection
 - Optional baudrate update
 - Synchronization Validation
- 2^{31} programmable transmission rates with 7 fractional bits
- Error detection
- 2 Interrupt lines with priority encoding

7.7 Multibuffered / Standard Serial Peripheral Interface

The MibSPI is a high-speed synchronous serial input/output port that allows a serial bit stream of programmed length (2 to 16 bits) to be shifted in and out of the device at a programmed bit-transfer rate. Typical applications for the SPI include interfacing to external peripherals, such as I/Os, memories, display drivers, and ADCs.

7.7.1 Features

Both Standard and MibSPI modules have the following features:

- 16-bit shift register
- Receive buffer register
- 11-bit baud clock generator
- SPICLK can be internally generated (master mode) or received from an external clock source (slave mode)
- Each word transferred can have a unique format
- SPI I/Os not used in the communication can be used as digital input/output signals

Table 7-11. MibSPI/SPI Default Configurations

| MibSPIx/SPIx | I/Os |
|--------------|--------------------------------------------------------------------------|
| MibSPI1 | MIBSPI1SIMO[0], MIBSPI1SOMI[0], MIBSPI1CLK, MIBSPI1nCS[3:0], MIBSPI1nENA |
| SPI2 | SPI2SIMO, SPI2SOMI, SPI2CLK, SPI2nCS[0] |
| SPI3 | SPI3SIMO, SPI3SOMI, SPI3CLK, SPI3nENA, SPI3nCS[0] |

7.7.2 MibSPI Transmit and Receive RAM Organization

The Multibuffer RAM is comprised of 128 buffers. Each entry in the Multibuffer RAM consists of four parts: a 16-bit transmit field, a 16-bit receive field, a 16-bit control field, and a 16-bit status field. The Multibuffer RAM can be partitioned into multiple transfer group with variable number of buffers each.

7.7.3 MibSPI Transmit Trigger Events

Each of the transfer groups can be configured individually. For each of the transfer groups a trigger event and a trigger source can be chosen. A trigger event can be, for example, a rising edge or a permanent low level at a selectable trigger source. Up to 15 trigger sources are available which can be used by each transfer group. These trigger options are listed in [Table 7-12](#).

7.7.3.1 MIBSPI1 Event Trigger Hookup

Table 7-12. MIBSPI1 Event Trigger Hookup

| EVENT NO. | TGxCTRL TRIGSRC[3:0] | TRIGGER |
|-----------|----------------------|-----------------------|
| Disabled | 0000 | No trigger source |
| EVENT0 | 0001 | GIOA[0] |
| EVENT1 | 0010 | GIOA[1] |
| EVENT2 | 0011 | GIOA[2] |
| EVENT3 | 0100 | GIOA[3] |
| EVENT4 | 0101 | GIOA[4] |
| EVENT5 | 0110 | GIOA[5] |
| EVENT6 | 0111 | GIOA[6] |
| EVENT7 | 1000 | GIOA[7] |
| EVENT8 | 1001 | N2HET[8] |
| EVENT9 | 1010 | N2HET[10] |
| EVENT10 | 1011 | N2HET[12] |
| EVENT11 | 1100 | N2HET[14] |
| EVENT12 | 1101 | N2HET[16] |
| EVENT13 | 1110 | N2HET[18] |
| EVENT14 | 1111 | Internal Tick counter |

NOTE

For N2HET trigger sources, the connection to the MibSPI1 module trigger input is made from the input side of the output buffer (at the N2HET module boundary). This way, a trigger condition can be generated even if the N2HET signal is not selected to be output on the pad.

NOTE

For GIOx trigger sources, the connection to the MibSPI1 module trigger input is made from the output side of the input buffer. This way, a trigger condition can be generated either by selecting the GIOx pin as an output pin, or by driving the GIOx pin from an external trigger source.

7.7.4 MibSPI/SPI Master Mode I/O Timing Specifications

Table 7-13. SPI Master Mode External Timing Parameters (CLOCK PHASE = 0, SPICLK = output, SPISIMO = output, and SPISOMI = input)⁽¹⁾⁽²⁾⁽³⁾

| NO. | PARAMETER | | MIN | MAX | UNIT | |
|------------------|----------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------|----|
| 1 | $t_{c(SPC)M}$ | Cycle time, SPICLK ⁽⁴⁾ | 40 | $256t_{c(VCLK)}$ | ns | |
| 2 ⁽⁵⁾ | $t_{w(SPCH)M}$ | Pulse duration, SPICLK high (clock polarity = 0) | $0.5t_{c(SPC)M} - t_{f(SPC)M} - 3$ | $0.5t_{c(SPC)M} + 3$ | ns | |
| | $t_{w(SPCL)M}$ | Pulse duration, SPICLK low (clock polarity = 1) | $0.5t_{c(SPC)M} - t_{f(SPC)M} - 3$ | $0.5t_{c(SPC)M} + 3$ | | |
| 3 ⁽⁵⁾ | $t_{w(SPCL)M}$ | Pulse duration, SPICLK low (clock polarity = 0) | $0.5t_{c(SPC)M} - t_{f(SPC)M} - 3$ | $0.5t_{c(SPC)M} + 3$ | ns | |
| | $t_{w(SPCH)M}$ | Pulse duration, SPICLK high (clock polarity = 1) | $0.5t_{c(SPC)M} - t_{f(SPC)M} - 3$ | $0.5t_{c(SPC)M} + 3$ | | |
| 4 ⁽⁵⁾ | $t_{d(SPCH-SIMO)M}$ | Delay time, SPISIMO valid before SPICLK low (clock polarity = 0) | $0.5t_{c(SPC)M} - 6$ | | ns | |
| | $t_{d(SPCL-SIMO)M}$ | Delay time, SPISIMO valid before SPICLK high (clock polarity = 1) | $0.5t_{c(SPC)M} - 6$ | | | |
| 5 ⁽⁵⁾ | $t_{v(SPCL-SIMO)M}$ | Valid time, SPISIMO data valid after SPICLK low (clock polarity = 0) | $0.5t_{c(SPC)M} - t_{f(SPC)} - 4$ | | ns | |
| | $t_{v(SPCH-SIMO)M}$ | Valid time, SPISIMO data valid after SPICLK high (clock polarity = 1) | $0.5t_{c(SPC)M} - t_{f(SPC)} - 4$ | | | |
| 6 ⁽⁵⁾ | $t_{su(SOMI-SPCL)M}$ | Setup time, SPISOMI before SPICLK low (clock polarity = 0) | $t_{f(SPC)} + 2.2$ | | ns | |
| | $t_{su(SOMI-SPCH)M}$ | Setup time, SPISOMI before SPICLK high (clock polarity = 1) | $t_{f(SPC)} + 2.2$ | | | |
| 7 ⁽⁵⁾ | $t_{h(SPCL-SOMI)M}$ | Hold time, SPISOMI data valid after SPICLK low (clock polarity = 0) | 10 | | ns | |
| | $t_{h(SPCH-SOMI)M}$ | Hold time, SPISOMI data valid after SPICLK high (clock polarity = 1) | 10 | | | |
| 8 ⁽⁶⁾ | $t_{C2DELAY}$ | Setup time CS active until SPICLK high (clock polarity = 0) | CSHOLD = 0 | $C2DELAY * t_{c(VCLK)} + 2 * t_{c(VCLK)} - t_{f(SPIC)} + t_{f(SPC)} - 7$ | $(C2DELAY + 2) * t_{c(VCLK)} - t_{f(SPIC)} + t_{f(SPC)} + 5.5$ | ns |
| | | | CSHOLD = 1 | $C2DELAY * t_{c(VCLK)} + 3 * t_{c(VCLK)} - t_{f(SPIC)} + t_{f(SPC)} - 7$ | $(C2DELAY + 3) * t_{c(VCLK)} - t_{f(SPIC)} + t_{f(SPC)} + 5.5$ | |
| | | Setup time CS active until SPICLK low (clock polarity = 1) | CSHOLD = 0 | $C2DELAY * t_{c(VCLK)} + 2 * t_{c(VCLK)} - t_{f(SPIC)} + t_{f(SPC)} - 7$ | $(C2DELAY + 2) * t_{c(VCLK)} - t_{f(SPIC)} + t_{f(SPC)} + 5.5$ | ns |
| | | | CSHOLD = 1 | $C2DELAY * t_{c(VCLK)} + 3 * t_{c(VCLK)} - t_{f(SPIC)} + t_{f(SPC)} - 7$ | $(C2DELAY + 3) * t_{c(VCLK)} - t_{f(SPIC)} + t_{f(SPC)} + 5.5$ | |
| 9 ⁽⁶⁾ | $t_{T2DELAY}$ | Hold time SPICLK low until CS inactive (clock polarity = 0) | $0.5 * t_{c(SPC)M} + T2DELAY * t_{c(VCLK)} + t_{c(VCLK)} - t_{f(SPC)} + t_{f(SPIC)} - 7$ | $0.5 * t_{c(SPC)M} + T2DELAY * t_{c(VCLK)} + t_{c(VCLK)} - t_{f(SPC)} + t_{f(SPIC)} + 11$ | ns | |
| | | Hold time SPICLK high until CS inactive (clock polarity = 1) | $0.5 * t_{c(SPC)M} + T2DELAY * t_{c(VCLK)} + t_{c(VCLK)} - t_{f(SPC)} + t_{f(SPIC)} - 7$ | $0.5 * t_{c(SPC)M} + T2DELAY * t_{c(VCLK)} + t_{c(VCLK)} - t_{f(SPC)} + t_{f(SPIC)} + 11$ | ns | |
| 10 | t_{SPIENA} | SPIENAn Sample point | $(C2DELAY + 1) * t_{c(VCLK)} - t_{f(SPIC)} - 29$ | $(C2DELAY + 1) * t_{c(VCLK)}$ | ns | |
| 11 | $t_{SPIENAW}$ | SPIENAn Sample point from write to buffer | | $(C2DELAY + 2) * t_{c(VCLK)}$ | ns | |

(1) The MASTER bit (SPIGCR1.0) is set and the CLOCK PHASE bit (SPIFMTx.16) is cleared.

(2) $t_{c(VCLK)}$ = interface clock cycle time = $1 / f_{VCLK}$

(3) For rise and fall timings, see [Table 5-6](#).

(4) When the SPI is in Master mode, the following must be true:

For PS values from 1 to 255: $t_{c(SPC)M} \geq (PS + 1)t_{c(VCLK)} \geq 40$ ns, where PS is the prescale value set in the SPIFMTx.[15:8] register bits.

For PS values of 0: $t_{c(SPC)M} = 2t_{c(VCLK)} \geq 40$ ns.

The external load on the SPICLK pin must be less than 60 pF.

(5) The active edge of the SPICLK signal referenced is controlled by the CLOCK POLARITY bit (SPIFMTx.17).

(6) C2DELAY and T2DELAY is programmed in the SPIDELAY register

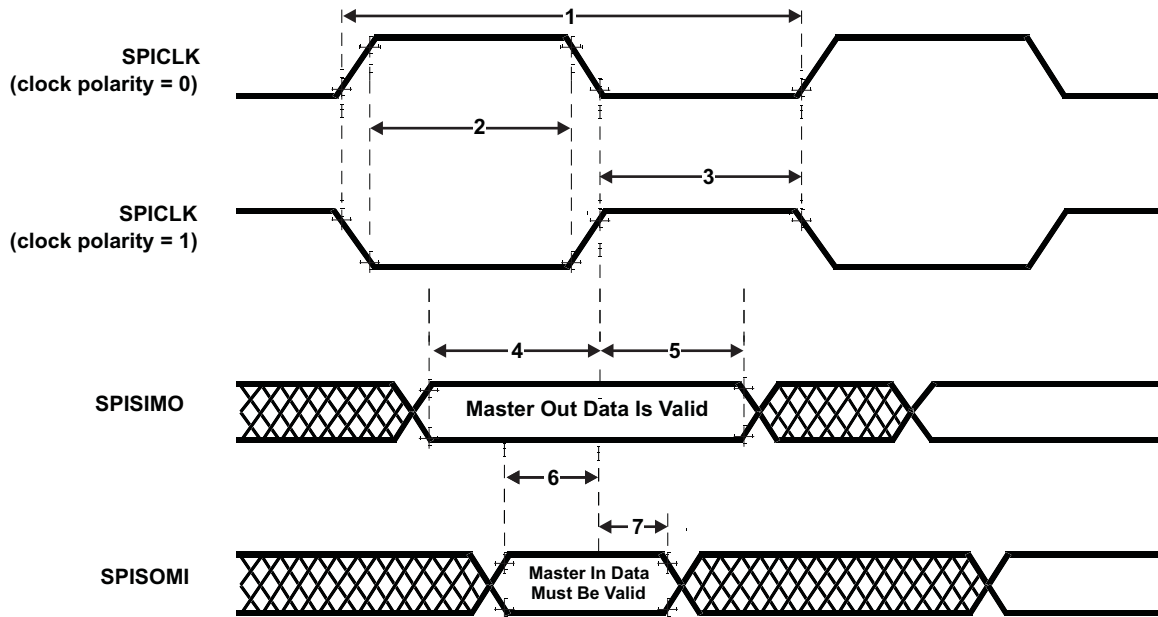


Figure 7-6. SPI Master Mode External Timing (CLOCK PHASE = 0)

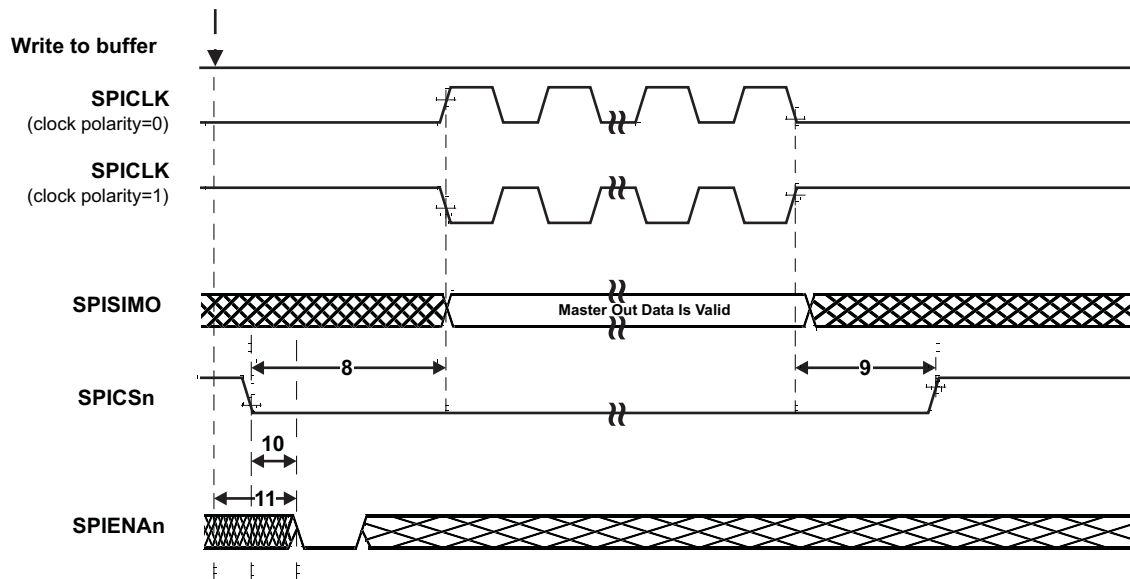


Figure 7-7. SPI Master Mode Chip Select Timing (CLOCK PHASE = 0)

Table 7-14. SPI Master Mode External Timing Parameters (CLOCK PHASE = 1, SPICLK = output, SPISIMO = output, and SPISOMI = input)⁽¹⁾⁽²⁾⁽³⁾

| NO. | PARAMETER | | MIN | MAX | UNIT | |
|------------------|----------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----|
| 1 | $t_{c(SPC)M}$ | Cycle time, SPICLK ⁽⁴⁾ | 40 | $256t_{c(VCLK)}$ | ns | |
| 2 ⁽⁵⁾ | $t_{w(SPCH)M}$ | Pulse duration, SPICLK high (clock polarity = 0) | $0.5t_{c(SPC)M} - t_{f(SPC)M} - 3$ | $0.5t_{c(SPC)M} + 3$ | ns | |
| | $t_{w(SPCL)M}$ | Pulse duration, SPICLK low (clock polarity = 1) | $0.5t_{c(SPC)M} - t_{f(SPC)M} - 3$ | $0.5t_{c(SPC)M} + 3$ | | |
| 3 ⁽⁵⁾ | $t_{w(SPCL)M}$ | Pulse duration, SPICLK low (clock polarity = 0) | $0.5t_{c(SPC)M} - t_{f(SPC)M} - 3$ | $0.5t_{c(SPC)M} + 3$ | ns | |
| | $t_{w(SPCH)M}$ | Pulse duration, SPICLK high (clock polarity = 1) | $0.5t_{c(SPC)M} - t_{f(SPC)M} - 3$ | $0.5t_{c(SPC)M} + 3$ | | |
| 4 ⁽⁵⁾ | $t_{v(SIMO-SPCH)M}$ | Valid time, SPICLK high after SPISIMO data valid (clock polarity = 0) | $0.5t_{c(SPC)M} - 6$ | | ns | |
| | $t_{v(SIMO-SPCL)M}$ | Valid time, SPICLK low after SPISIMO data valid (clock polarity = 1) | $0.5t_{c(SPC)M} - 6$ | | | |
| 5 ⁽⁵⁾ | $t_{v(SPCH-SIMO)M}$ | Valid time, SPISIMO data valid after SPICLK high (clock polarity = 0) | $0.5t_{c(SPC)M} - t_{f(SPC)} - 4$ | | ns | |
| | $t_{v(SPCL-SIMO)M}$ | Valid time, SPISIMO data valid after SPICLK low (clock polarity = 1) | $0.5t_{c(SPC)M} - t_{f(SPC)} - 4$ | | | |
| 6 ⁽⁵⁾ | $t_{su(SOMI-SPCH)M}$ | Setup time, SPISOMI before SPICLK high (clock polarity = 0) | $t_{f(SPC)} + 2.2$ | | ns | |
| | $t_{su(SOMI-SPCL)M}$ | Setup time, SPISOMI before SPICLK low (clock polarity = 1) | $t_{f(SPC)} + 2.2$ | | | |
| 7 ⁽⁵⁾ | $t_{v(SPCH-SOMI)M}$ | Valid time, SPISOMI data valid after SPICLK high (clock polarity = 0) | 10 | | ns | |
| | $t_{v(SPCL-SOMI)M}$ | Valid time, SPISOMI data valid after SPICLK low (clock polarity = 1) | 10 | | | |
| 8 ⁽⁶⁾ | $t_{C2DELAY}$ | Setup time CS active until SPICLK high (clock polarity = 0) | CSHOLD = 0 | $0.5 * t_{c(SPC)M} + (C2DELAY + 2) * t_{c(VCLK)} - t_{f(SPICS)} + t_{f(SPC)} - 7$ | $0.5 * t_{c(SPC)M} + (C2DELAY + 2) * t_{c(VCLK)} - t_{f(SPICS)} + t_{f(SPC)} + 5.5$ | ns |
| | | | CSHOLD = 1 | $0.5 * t_{c(SPC)M} + (C2DELAY + 3) * t_{c(VCLK)} - t_{f(SPICS)} + t_{f(SPC)} - 7$ | $0.5 * t_{c(SPC)M} + (C2DELAY + 3) * t_{c(VCLK)} - t_{f(SPICS)} + t_{f(SPC)} + 5.5$ | |
| | | Setup time CS active until SPICLK low (clock polarity = 1) | CSHOLD = 0 | $0.5 * t_{c(SPC)M} + (C2DELAY + 2) * t_{c(VCLK)} - t_{f(SPICS)} + t_{f(SPC)} - 7$ | $0.5 * t_{c(SPC)M} + (C2DELAY + 2) * t_{c(VCLK)} - t_{f(SPICS)} + t_{f(SPC)} + 5.5$ | ns |
| | | | CSHOLD = 1 | $0.5 * t_{c(SPC)M} + (C2DELAY + 3) * t_{c(VCLK)} - t_{f(SPICS)} + t_{f(SPC)} - 7$ | $0.5 * t_{c(SPC)M} + (C2DELAY + 3) * t_{c(VCLK)} - t_{f(SPICS)} + t_{f(SPC)} + 5.5$ | |
| 9 ⁽⁶⁾ | $t_{T2DELAY}$ | Hold time SPICLK low until CS inactive (clock polarity = 0) | $T2DELAY * t_{c(VCLK)} + t_{c(VCLK)} - t_{f(SPC)} + t_{f(SPICS)} - 7$ | $T2DELAY * t_{c(VCLK)} + t_{c(VCLK)} - t_{f(SPC)} + t_{f(SPICS)} + 11$ | ns | |
| | | Hold time SPICLK high until CS inactive (clock polarity = 1) | $T2DELAY * t_{c(VCLK)} + t_{c(VCLK)} - t_{f(SPC)} + t_{f(SPICS)} - 7$ | $T2DELAY * t_{c(VCLK)} + t_{c(VCLK)} - t_{f(SPC)} + t_{f(SPICS)} + 11$ | ns | |
| 10 | t_{SPIENA} | SPIENAn Sample Point | $(C2DELAY + 1) * t_{c(VCLK)} - t_{f(SPICS)} - 29$ | $(C2DELAY + 1) * t_{c(VCLK)}$ | ns | |
| 11 | $t_{SPIENAW}$ | SPIENAn Sample point from write to buffer | | $(C2DELAY + 2) * t_{c(VCLK)}$ | ns | |

(1) The MASTER bit (SPIGCR1.0) is set and the CLOCK PHASE bit (SPIFMTx.16) is set.

(2) $t_{c(VCLK)}$ = interface clock cycle time = $1 / f_{VCLK}$

(3) For rise and fall timings, see the [Table 5-6](#).

(4) When the SPI is in Master mode, the following must be true:

For PS values from 1 to 255: $t_{c(SPC)M} \geq (PS + 1)t_{c(VCLK)} \geq 40$ ns, where PS is the prescale value set in the SPIFMTx.[15:8] register bits.
For PS values of 0: $t_{c(SPC)M} = 2t_{c(VCLK)} \geq 40$ ns.

The external load on the SPICLK pin must be less than 60 pF.

(5) The active edge of the SPICLK signal referenced is controlled by the CLOCK POLARITY bit (SPIFMTx.17).

(6) C2DELAY and T2DELAY is programmed in the SPIDELAY register

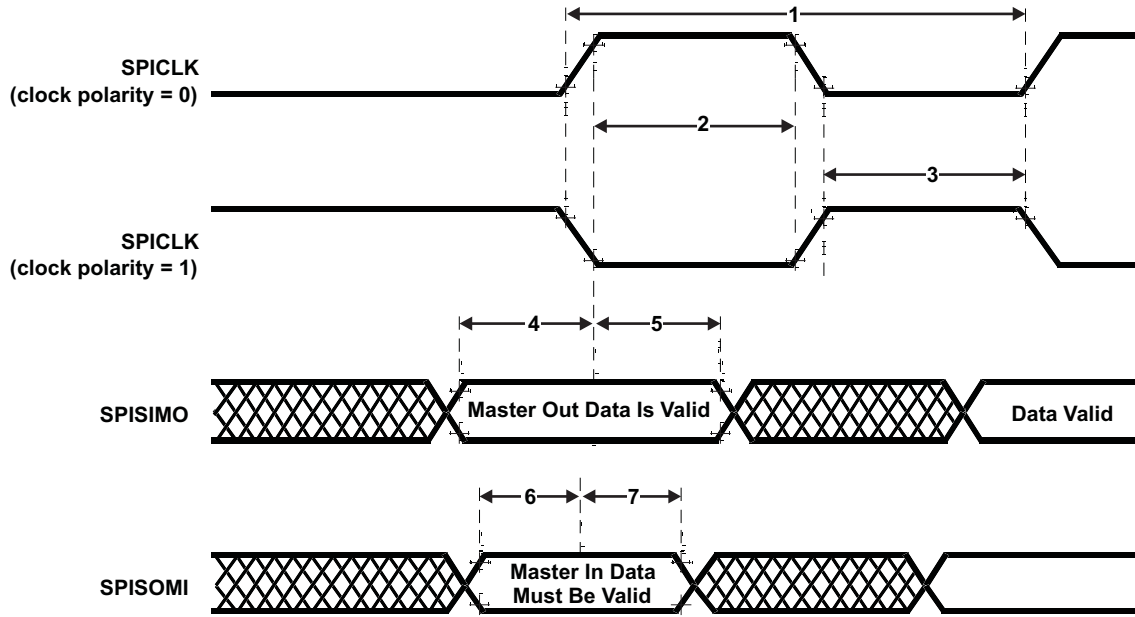


Figure 7-8. SPI Master Mode External Timing (CLOCK PHASE = 1)

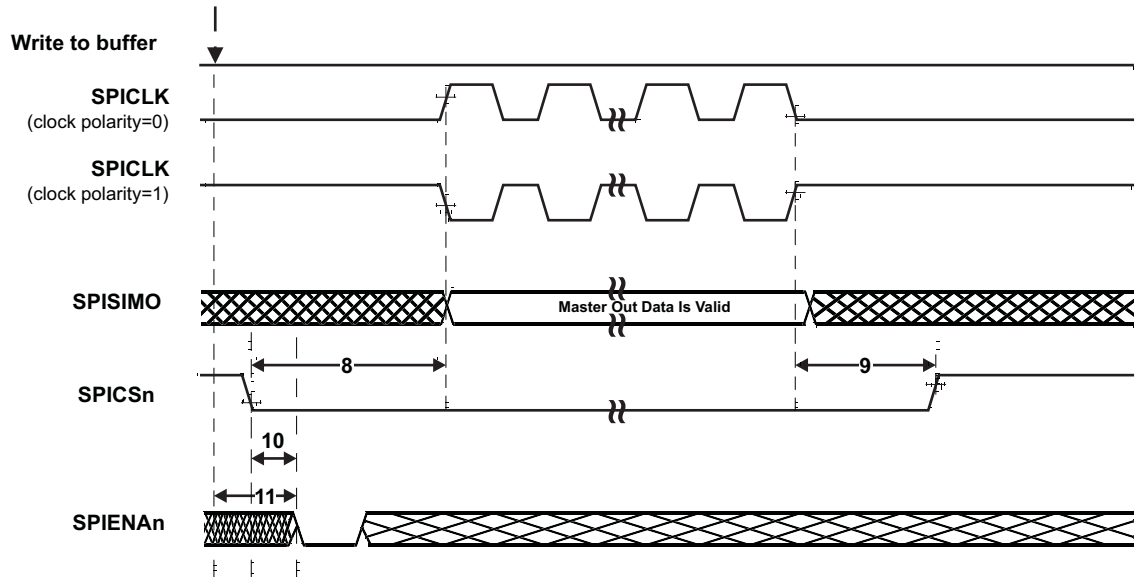


Figure 7-9. SPI Master Mode Chip Select Timing (CLOCK PHASE = 1)

7.7.5 SPI Slave Mode I/O Timings

Table 7-15. SPI Slave Mode External Timing Parameters (CLOCK PHASE = 0, SPICLK = input, SPISIMO = input, and SPISOMI = output)⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾

| NO. | PARAMETER | MIN | MAX | UNIT |
|------------------|----------------------------------------------------------------------------------------------------------------|------------------|-------------------------------------|------|
| 1 | $t_{c(SPC)S}$ Cycle time, SPICLK ⁽⁵⁾ | 40 | | ns |
| 2 ⁽⁶⁾ | $t_{w(SPCH)S}$ Pulse duration, SPICLK high (clock polarity = 0) | 14 | | ns |
| | $t_{w(SPCL)S}$ Pulse duration, SPICLK low (clock polarity = 1) | 14 | | |
| 3 ⁽⁶⁾ | $t_{w(SPCL)S}$ Pulse duration, SPICLK low (clock polarity = 0) | 14 | | ns |
| | $t_{w(SPCH)S}$ Pulse duration, SPICLK high (clock polarity = 1) | 14 | | |
| 4 ⁽⁶⁾ | $t_{d(SPCH-SOMI)S}$ Delay time, SPISOMI valid after SPICLK high (clock polarity = 0) | | $t_{rr(SOMI)} + 20$ | ns |
| | $t_{d(SPCL-SOMI)S}$ Delay time, SPISOMI valid after SPICLK low (clock polarity = 1) | | $t_{rr(SOMI)} + 20$ | |
| 5 ⁽⁶⁾ | $t_{h(SPCH-SOMI)S}$ Hold time, SPISOMI data valid after SPICLK high (clock polarity = 0) | 2 | | ns |
| | $t_{h(SPCL-SOMI)S}$ Hold time, SPISOMI data valid after SPICLK low (clock polarity = 1) | 2 | | |
| 6 ⁽⁶⁾ | $t_{su(SIMO-SPCL)S}$ Setup time, SPISIMO before SPICLK low (clock polarity = 0) | 4 | | ns |
| | $t_{su(SIMO-SPCH)S}$ Setup time, SPISIMO before SPICLK high (clock polarity = 1) | 4 | | |
| 7 ⁽⁶⁾ | $t_{h(SPCL-SIMO)S}$ Hold time, SPISIMO data valid after SPICLK low (clock polarity = 0) | 2 | | ns |
| | $t_{h(SPCH-SIMO)S}$ Hold time, SPISIMO data valid after SPICLK high (clock polarity = 1) | 2 | | |
| 8 | $t_{d(SPCL-SENAH)S}$ Delay time, SPIENAn high after last SPICLK low (clock polarity = 0) | $1.5t_{c(VCLK)}$ | $2.5t_{c(VCLK)} + t_{r(ENAn)} + 22$ | ns |
| | $t_{d(SPCH-SENAH)S}$ Delay time, SPIENAn high after last SPICLK high (clock polarity = 1) | $1.5t_{c(VCLK)}$ | $2.5t_{c(VCLK)} + t_{r(ENAn)} + 22$ | |
| 9 | $t_{d(SCSL-SENAL)S}$ Delay time, SPIENAn low after SPICSn low (if new data has been written to the SPI buffer) | $t_{r(ENAn)}$ | $t_{c(VCLK)} + t_{r(ENAn)} + 27$ | ns |

(1) The MASTER bit (SPIGCR1.0) is cleared and the CLOCK PHASE bit (SPIFMTx.16) is cleared.

(2) If the SPI is in slave mode, the following must be true: $t_{c(SPC)S} \geq (PS + 1) t_{c(VCLK)}$, where PS = prescale value set in SPIFMTx.[15:8].

(3) For rise and fall timings, see [Table 5-6](#).

(4) $t_{c(VCLK)}$ = interface clock cycle time = $1 / f_{(VCLK)}$

(5) When the SPI is in Slave mode, the following must be true:

For PS values from 1 to 255: $t_{c(SPC)S} \geq (PS + 1) t_{c(VCLK)} \geq 40$ ns, where PS is the prescale value set in the SPIFMTx.[15:8] register bits.

For PS values of 0: $t_{c(SPC)S} = 2t_{c(VCLK)} \geq 40$ ns.

(6) The active edge of the SPICLK signal referenced is controlled by the CLOCK POLARITY bit (SPIFMTx.17).

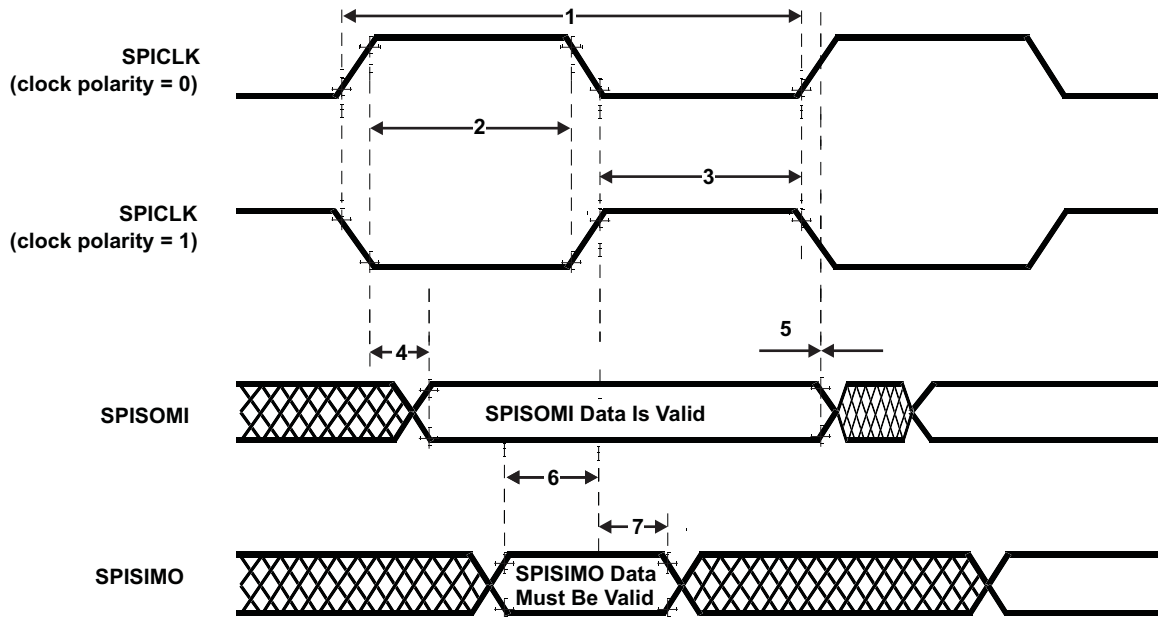


Figure 7-10. SPI Slave Mode External Timing (CLOCK PHASE = 0)

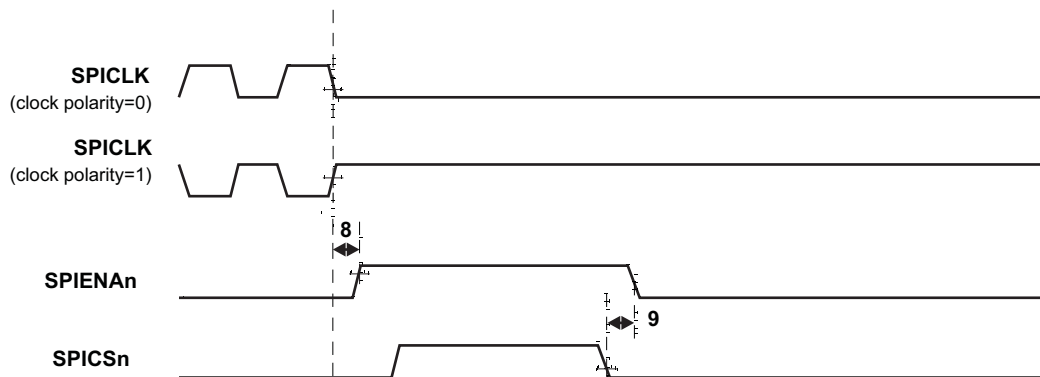


Figure 7-11. SPI Slave Mode Enable Timing (CLOCK PHASE = 0)

Table 7-16. SPI Slave Mode External Timing Parameters (CLOCK PHASE = 1, SPICLK = input, SPISIMO = input, and SPISOMI = output)⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾

| NO. | PARAMETER | MIN | MAX | UNIT |
|------------------|----------------------------------------------------------------------------------------------------------------|------------------|-------------------------------------|------|
| 1 | $t_{c(SPC)S}$ Cycle time, SPICLK ⁽⁵⁾ | 40 | | ns |
| 2 ⁽⁶⁾ | $t_{w(SPCH)S}$ Pulse duration, SPICLK high (clock polarity = 0) | 14 | | ns |
| | $t_{w(SPCL)S}$ Pulse duration, SPICLK low (clock polarity = 1) | 14 | | |
| 3 ⁽⁶⁾ | $t_{w(SPCL)S}$ Pulse duration, SPICLK low (clock polarity = 0) | 14 | | ns |
| | $t_{w(SPCH)S}$ Pulse duration, SPICLK high (clock polarity = 1) | 14 | | |
| 4 ⁽⁶⁾ | $t_{d(SOMI-SPCL)S}$ Delay time, SPISOMI data valid after SPICLK low (clock polarity = 0) | | $t_{r(SOMI)} + 20$ | ns |
| | $t_{d(SOMI-SPCH)S}$ Delay time, SPISOMI data valid after SPICLK high (clock polarity = 1) | | $t_{r(SOMI)} + 20$ | |
| 5 ⁽⁶⁾ | $t_{h(SPCL-SOMI)S}$ Hold time, SPISOMI data valid after SPICLK high (clock polarity = 0) | 2 | | ns |
| | $t_{h(SPCH-SOMI)S}$ Hold time, SPISOMI data valid after SPICLK low (clock polarity = 1) | 2 | | |
| 6 ⁽⁶⁾ | $t_{su(SIMO-SPCH)S}$ Setup time, SPISIMO before SPICLK high (clock polarity = 0) | 4 | | ns |
| | $t_{su(SIMO-SPCL)S}$ Setup time, SPISIMO before SPICLK low (clock polarity = 1) | 4 | | |
| 7 ⁽⁶⁾ | $t_{v(SPCH-SIMO)S}$ High time, SPISIMO data valid after SPICLK high (clock polarity = 0) | 2 | | ns |
| | $t_{v(SPCL-SIMO)S}$ High time, SPISIMO data valid after SPICLK low (clock polarity = 1) | 2 | | |
| 8 | $t_{d(SPCH-SENAn)S}$ Delay time, SPIENAn high after last SPICLK high (clock polarity = 0) | $1.5t_{c(VCLK)}$ | $2.5t_{c(VCLK)} + t_{r(ENAn)} + 22$ | ns |
| | $t_{d(SPCL-SENAn)S}$ Delay time, SPIENAn high after last SPICLK low (clock polarity = 1) | $1.5t_{c(VCLK)}$ | $2.5t_{c(VCLK)} + t_{r(ENAn)} + 22$ | |
| 9 | $t_{d(SCSL-SENAL)S}$ Delay time, SPIENAn low after SPICSn low (if new data has been written to the SPI buffer) | $t_{r(ENAn)}$ | $t_{c(VCLK)} + t_{r(ENAn)} + 27$ | ns |
| 10 | $t_{d(SCSL-SOMI)S}$ Delay time, SOMI valid after SPICSn low (if new data has been written to the SPI buffer) | $t_{c(VCLK)}$ | $2t_{c(VCLK)} + t_{r(SOMI)} + 28$ | ns |

- (1) The MASTER bit (SPIGCR1.0) is cleared and the CLOCK PHASE bit (SPIFMTx.16) is set.
- (2) If the SPI is in slave mode, the following must be true: $t_{c(SPC)S} \leq (PS + 1) t_{c(VCLK)}$, where PS = prescale value set in SPIFMTx.[15:8].
- (3) For rise and fall timings, see [Table 5-6](#).
- (4) $t_{c(VCLK)}$ = interface clock cycle time = $1 / f_{(VCLK)}$
- (5) When the SPI is in Slave mode, the following must be true:
For PS values from 1 to 255: $t_{c(SPC)S} \geq (PS + 1) t_{c(VCLK)} \geq 40$ ns, where PS is the prescale value set in the SPIFMTx.[15:8] register bits.
For PS values of 0: $t_{c(SPC)S} = 2t_{c(VCLK)} \geq 40$ ns.
- (6) The active edge of the SPICLK signal referenced is controlled by the CLOCK POLARITY bit (SPIFMTx.17).

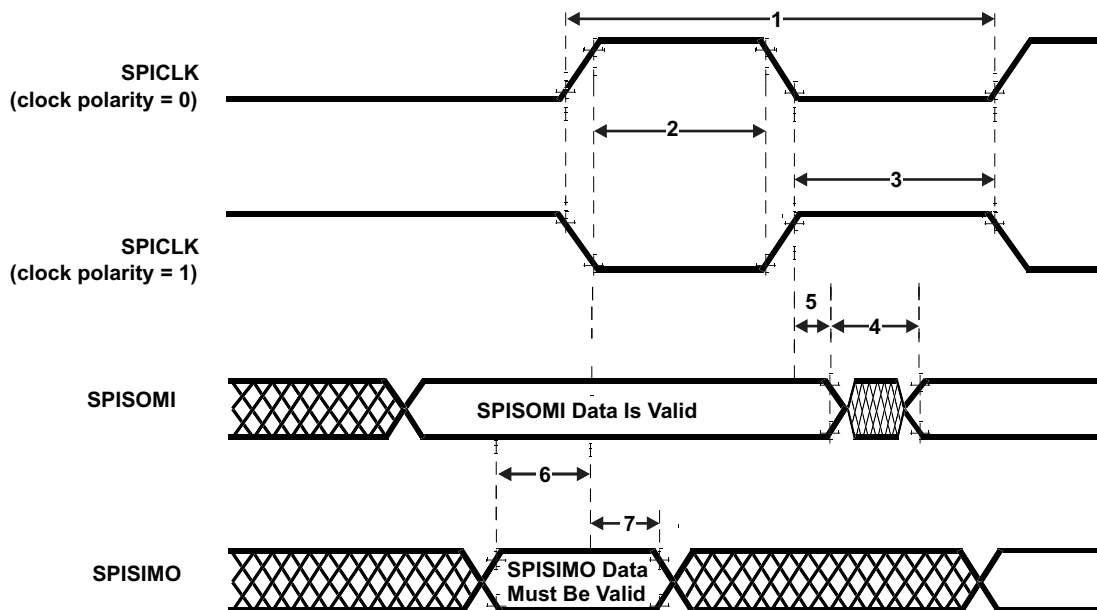


Figure 7-12. SPI Slave Mode External Timing (CLOCK PHASE = 1)

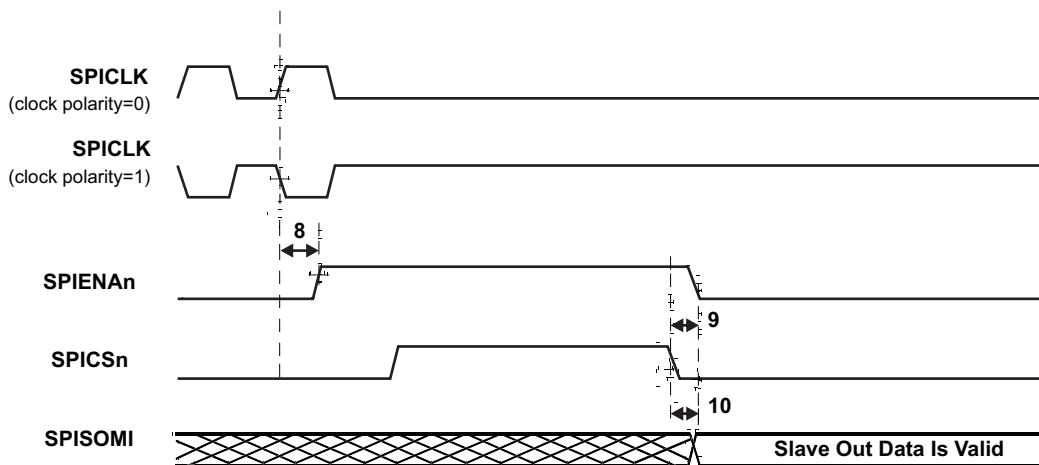


Figure 7-13. SPI Slave Mode Enable Timing (CLOCK PHASE = 1)

7.8 Enhanced Quadrature Encoder (eQEP)

Figure 7-14 shows the eQEP module interconnections on the device.

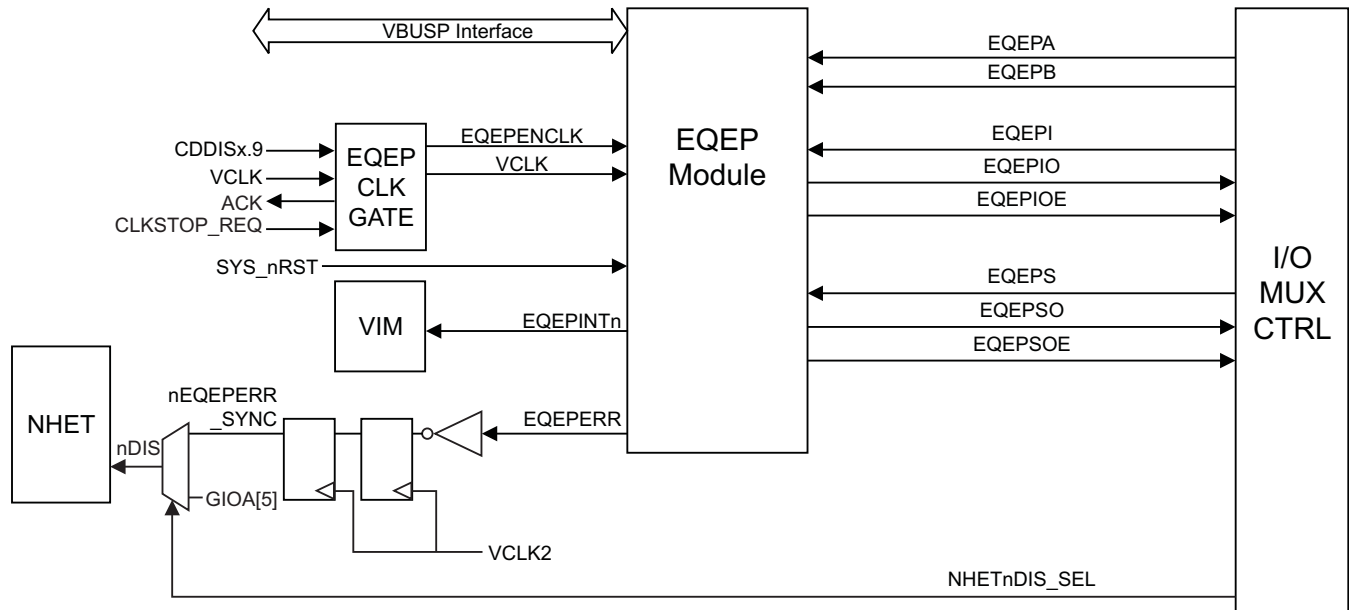


Figure 7-14. eQEP Module Interconnections

7.8.1 Clock Enable Control for eQEPx Modules

The device level control of the eQEP clock is accomplished through the enable/disable of the VCLK clock domain for eQEP only. This is realized using bit 9 of the CLKDDIS register. The eQEP clock source is enabled by default.

7.8.2 Using eQEPx Phase Error

The eQEP module sets the EQEPERR signal output whenever a phase error is detected in its inputs EQEPxA and EQEPxB. This error signal from both the eQEP modules is input to the connection selection multiplexor. As shown in Figure 7-14, the output of this selection multiplexor is inverted and connected to the N2HET module. This connection allows the application to define the response to a phase error indicated by the eQEP modules.

7.8.3 Input Connections to eQEPx Modules

The input connections to each of the eQEP modules can be selected between a double-VCLK-synchronized input or a double-VCLK-synchronized and filtered input, as shown in Table 7-17.

Table 7-17. Device-Level Input Synchronization

| INPUT SIGNAL | CONTROL FOR DOUBLE-SYNCHRONIZED CONNECTION TO eQEPx | CONTROL FOR DOUBLE-SYNCHRONIZED AND FILTERED CONNECTION TO eQEPx |
|--------------|-----------------------------------------------------|------------------------------------------------------------------|
| eQEPA | PINMMR8[0] = 1 | PINMMR8[0] = 0 and PINMMR8[1] = 1 |
| eQEPB | PINMMR8[8] = 1 | PINMMR8[8] = 0 and PINMMR8[9] = 1 |
| eQEPI | PINMMR8[16] = 1 | PINMMR8[16] = 0 and PINMMR8[17] = 1 |
| eQEPS | PINMMR8[24] = 1 | PINMMR8[24] = 0 and PINMMR8[25] = 1 |

7.8.4 Enhanced Quadrature Encoder Pulse (eQEPx) Timing

Table 7-18. eQEPx Timing Requirements

| PARAMETER | | TEST CONDITIONS | MIN | MAX | UNIT |
|-----------------|----------------------------|--------------------------------|---------------------------------------|-----|--------|
| $t_{w(QEPP)}$ | QEP input period | Synchronous | $2 t_{c(VCLK)}$ | | cycles |
| | | Synchronous, with input filter | $2 t_{c(VCLK)} + \text{filter width}$ | | cycles |
| $t_{w(INDEXH)}$ | QEP Index Input High Time | Synchronous | $2 t_{c(VCLK)}$ | | cycles |
| | | Synchronous, with input filter | $2 t_{c(VCLK)} + \text{filter width}$ | | cycles |
| $t_{w(INDEXL)}$ | QEP Index Input Low Time | Synchronous | $2 t_{c(VCLK)}$ | | cycles |
| | | Synchronous, with input filter | $2 t_{c(VCLK)} + \text{filter width}$ | | cycles |
| $t_{w(STROBH)}$ | QEP Strobe Input High Time | Synchronous | $2 t_{c(VCLK)}$ | | cycles |
| | | Synchronous, with input filter | $2 t_{c(VCLK)} + \text{filter width}$ | | cycles |
| $t_{w(STROBL)}$ | QEP Strobe Input Low Time | Synchronous | $2 t_{c(VCLK)}$ | | cycles |
| | | Synchronous, with input filter | $2 t_{c(VCLK)} + \text{filter width}$ | | cycles |

Table 7-19. eQEPx Switching Characteristics

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

8 Device and Documentation Support

8.1 Device Support

8.1.1 Development Support

Texas Instruments (TI) offers an extensive line of development tools for the Hercules™ Safety generation of MCUs, including tools to evaluate the performance of the processors, generate code, develop algorithm implementations, and fully integrate and debug software and hardware modules.

The following products support development of Hercules™-based applications:

Software Development Tools

- Code Composer Studio™ Integrated Development Environment (IDE)
 - C/C++ Compiler
 - Code generation tools
 - Assembler/Linker
 - Cycle Accurate Simulator
- Application algorithms
- Sample applications code

Hardware Development Tools

- Development and evaluation boards
- JTAG-based emulators - XDS100™v2, XDS200, XDS560™ v2 emulator
- Flash programming tools
- Power supply
- Documentation and cables

8.1.1.1 Getting Started

This section gives a brief overview of the steps to take when first developing for a TMS570 MCU device. For more detail on each of these steps, see the following:

- *Initialization of the TMS570LS043x, TMS570LS033x and RM42L432 Hercules ARM Cortex-R4 Microcontrollers* ([SPNA163](#))
- *Compatibility Considerations: Migrating From TMS570LS31x/21x or TMS570LS12x/11x to TMS570LS04x/03x Safety Microcontrollers* ([SPNA175](#))

8.1.2 Device Nomenclature

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

Device development evolutionary flow:

- TMX** Experimental device that is not necessarily representative of the final device's electrical specifications.
- TMP** Final silicon die that conforms to the device's electrical specifications but has not completed quality and reliability verification.
- TMS** Fully-qualified production device.

TMX and TMP devices are shipped against the following disclaimer:

"Developmental product is intended for internal evaluation purposes."

TMS devices have been characterized fully, and the quality and reliability of the device have been demonstrated fully. TI's standard warranty applies.

Predictions show that prototype devices (TMX or TMP) have a greater failure rate than the standard production devices. Texas Instruments recommends that these devices not be used in any production system because their expected end-use failure rate still is undefined. Only qualified production devices are to be used.

Figure 8-1 illustrates the numbering and symbol nomenclature for the TMS570LS0432/0332.

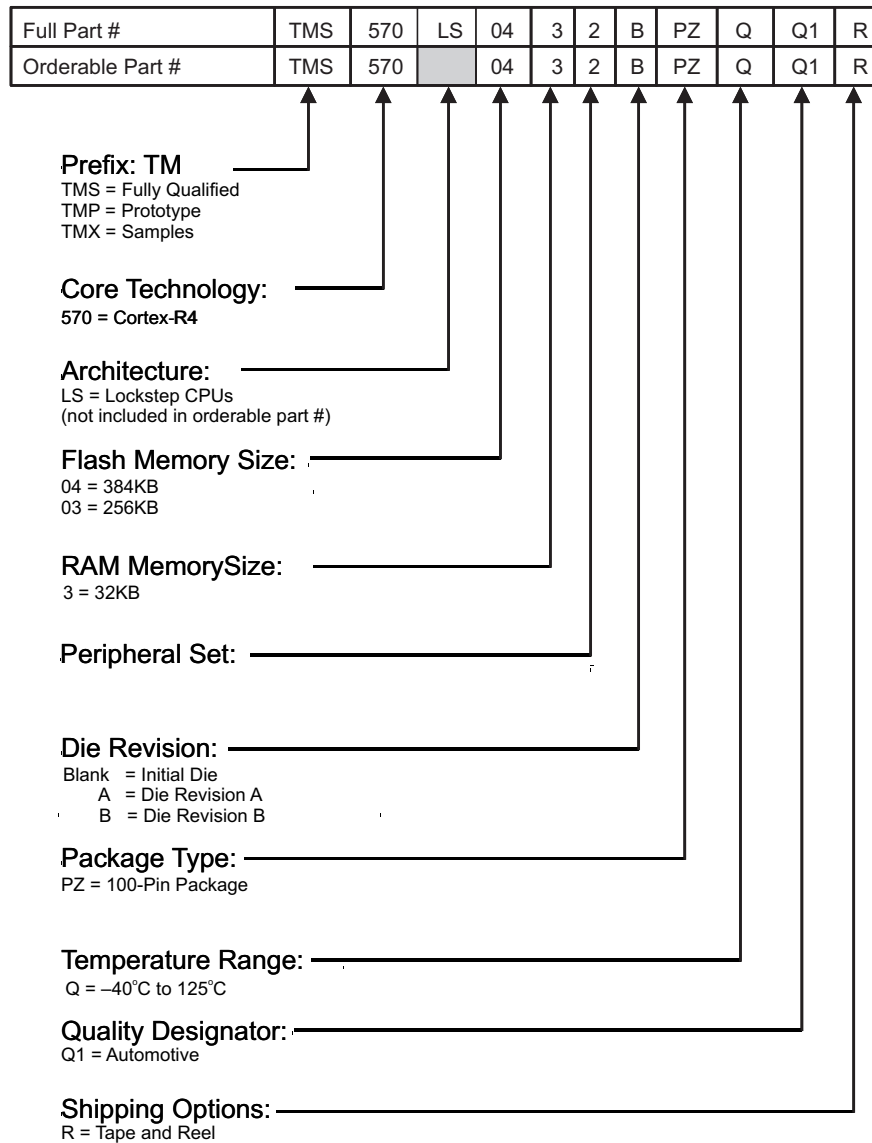


Figure 8-1. Device Numbering Conventions

8.2 Documentation Support

8.2.1 Related Documentation from Texas Instruments

The following documents describe the *TMS570LS0432/0332* microcontroller.

- SPNU517** *TMS570LS04x/03x 16/32-Bit RISC Flash Microcontroller Technical Reference Manual* details the integration, the environment, the functional description, and the programming models for each peripheral and subsystem in the device.
- SPNZ197** *TMS570LS0x32 Microcontroller Silicon Revision A, Silicon Errata* describes the usage notes and known exceptions to the functional specifications for the device silicon revision(s).
- SPNZ226** *TMS570LS0x32 Microcontroller Silicon Revision B, Silicon Errata* describes the usage notes and known exceptions to the functional specifications for the device silicon revision(s).
- SPNA207** *Calculating Equivalent Power-on-Hours for Hercules™ Safety MCUs* details how to use the spreadsheet to calculate the aging effect of temperature on Texas Instruments Hercules Safety MCUs.

8.3 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 8-1. Related Links

| PARTS | PRODUCT FOLDER | SAMPLE & BUY | TECHNICAL DOCUMENTS | TOOLS & SOFTWARE | SUPPORT & COMMUNITY |
|--------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| TMS570LS0432 | Click here | Click here | Click here | Click here | Click here |
| TMS570LS0332 | Click here | Click here | Click here | Click here | Click here |

8.4 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

TI E2E™ Online Community The TI engineer-to-engineer (E2E) community was created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

TI Embedded Processors Wiki Established to help developers get started with Embedded Processors from Texas Instruments and to foster innovation and growth of general knowledge about the hardware and software surrounding these devices.

8.5 Trademarks

Hercules, Code Composer Studio, XDS100, XDS560, E2E are trademarks of Texas Instruments.

CoreSight is a trademark of ARM Limited.

ARM, Cortex are registered trademarks of ARM Limited (or its subsidiaries) in the EU and/or elsewhere.

All rights reserved.

All other trademarks are the property of their respective owners.

8.6 Electrostatic Discharge Caution



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

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

8.7 Glossary

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

8.8 Device Identification Code Register

The device identification code register at address 0xFFFFFFF0 identifies several aspects of the device including the silicon version. The details of the device identification code register are shown in [Table 8-2](#). The device identification code register value for this device is:

- Rev 0 = 0x8048AD05
- Rev A = 0x8048AD0D
- Rev B = 0x8048AD15

Figure 8-2. Device ID Bit Allocation Register

| | | | | | | | | | | | | | | | |
|-------|------------------|-------------|---------------|-----------|---------|---------|----|----|----|----|----|-----|-----|-----|------|
| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| CP-15 | UNIQUE ID | | | | | | | | | | | | | | TECH |
| R-1 | R-00000000100100 | | | | | | | | | | | | | | R-0 |
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| TECH | | I/O VOLTAGE | PERIPH PARITY | FLASH ECC | RAM ECC | VERSION | | | | | | 1 | 0 | 1 | |
| R-101 | | R-0 | R-1 | R-10 | R-1 | R-00001 | | | | | | R-1 | R-0 | R-1 | |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

Table 8-2. Device ID Bit Allocation Register Field Descriptions

| BIT | FIELD | VALUE | DESCRIPTION |
|-------|-------------------|--------|----------------------------------------------------------------------------------------------------------------------|
| 31 | CP15 | 1 | Indicates the presence of coprocessor 15 CP15 present |
| 30-17 | UNIQUE ID | 100100 | Silicon version (revision) bits. This bit field holds a unique number for a dedicated device configuration (die). |
| 16-13 | TECH | 0101 | Process technology on which the device is manufactured. F021 |
| 12 | I/O VOLTAGE | 0 | I/O voltage of the device. I/O are 3.3v |
| 11 | PERIPHERAL PARITY | 1 | Peripheral Parity Parity on peripheral memories |
| 10-9 | FLASH ECC | 10 | Flash ECC Program memory with ECC |
| 8 | RAM ECC | 1 | Indicates if RAM memory ECC is present. ECC implemented |
| 7-3 | REVISION | 0 | Revision of the Device. |
| 2-0 | FAMILY ID | 101 | The platform family ID is always 0b101 |

8.9 Die Identification Registers

The two die ID registers at addresses 0xFFFFFFF7C and 0xFFFFFFF80 form a 64-bit die id with the information as shown in [Table 8-3](#).



Table 8-3. Die-ID Registers

| ITEM | NO. OF BITS | BIT LOCATION |
|-------------------|-------------|--------------------|
| X Coord. on Wafer | 12 | 0xFFFFFFF7C[11:0] |
| Y Coord. on Wafer | 12 | 0xFFFFFFF7C[23:12] |
| Wafer # | 8 | 0xFFFFFFF7C[31:24] |
| Lot # | 24 | 0xFFFFFFF80[23:0] |
| Reserved | 8 | 0xFFFFFFF80[31:24] |

8.10 Module Certifications

The following communications modules have received certification of adherence to a standard.

8.10.1 DCAN Certification

| | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Testhouse C&S group GmbH Am Exer 19b D-38302 Wolfenbuettel Phone: +49 5331/90 555-0 Fax: +49 5331/90 555-110</p> |   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Authentication

on CAN Conformance

Texas Instruments

P10_0294_021_CAN_DL_Test_Authentication_r01.doc


Date of Approval: 2011-Feb-08


C&S is worldwide recognized as a neutral expert in testing of communication systems such as CAN Transceiver, CAN, CAN Software Drivers, (CAN) Network Management, FlexRay and LIN.

Herewith C&S group is proud to confirm that the followings tests on the subsequently specified device implementations have been performed by C&S resulting in the findings given below:

C&S Conformance Test Results

| | |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Manufacturer | Texas Instruments |
| Component/Part Number | TMSx70 x021 Microcontroller Family, DCAN Core Release 0xA3170504, 980 A2C0007940000 X470MUF C63C1 P80576 24 YFB-08A9X6W |
| Date of Tests | February 2011 |
| Version of Test Specification | CAN Conformance Test 1 ISO CAN Conformance Tests according to "ISO 16845:2004 Road vehicles - Controller area network (CAN) - Conformance test plan" and C&S enhancement/ corrections according to "CAN CONFORMANCE TESTING Test Specification C&S Version 2.0 RC" 2 C&S Register Functionality Tests according to "C&S Register Functionality Test Specification V2.0" 3 C&S Robustness Tests according to "C&S Robustness Test Specification V1.4" |
| Corresponding Test Report | P10_0294_020_CAN_DL_Test_report_r01 |
| 1 ISO CAN conformance tests | Pass |
| 2 C&S Register Functionality tests | Pass |
| 3 C&S Robustness tests | Pass |
| • Further Observations | None |


 Frank Fischer, CTO


 Lothar Kukla, Project Manager

Quote No. P10_0294 R01

Figure 8-3. DCAN Certification

8.10.2 LIN Certifications

8.10.2.1 LIN Master Mode

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lin
LOCAL INTERCONNECT NETWORK

DAKKS
Deutsche
Akkreditierungsstelle
D-PL-17201-01-01

Accredited test lab by DAKKS GmbH according DIN ISO/IEC 17025.
The accreditation is valid for all test methods stated in the certificate.

Test Summary

for
LIN 2.1 Conformance Test - Master

Client / Manufacturer: **Texas Instruments**
Automotive Applications
12500 TI Boulevard
75243 DALLAS, TEXAS
UNITED STATES OF AMERICA

Implementation Under Test: **Microcontroller TMS570LS3137**

Part Number: **LIN Master Mode**

Revision: SW: : 2013-05-31_IHR_LIN

Test Sample Marking: TMX570LS 3137 CZWTQQ1 YFC-2AAQ32W

Test Board: Gladiator 337 SN# 58 rev. B

Performed Tests: **LIN OSI Layer 2 – Data Link Layer**
Node Configuration / Network Management

Specification References: **LIN Conformance Test Specification, 10-Oct-2008**
for the LIN Specification Package Revision 2.1 , 24-Nov-2006

Result / Status: **The device has *passed* the test.**

Version / Date: 1.0 / 13-May-2013

Document Number: Test Summary_DLL21_Master_20121130_130513_TMS570LS_V1.0.doc

ihr Reference: 20121130

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It contains 7 pages and shall not be reproduced except in full without written approval of the ihr Test Center. All performed test results concerns the above mentioned IUT revision only.

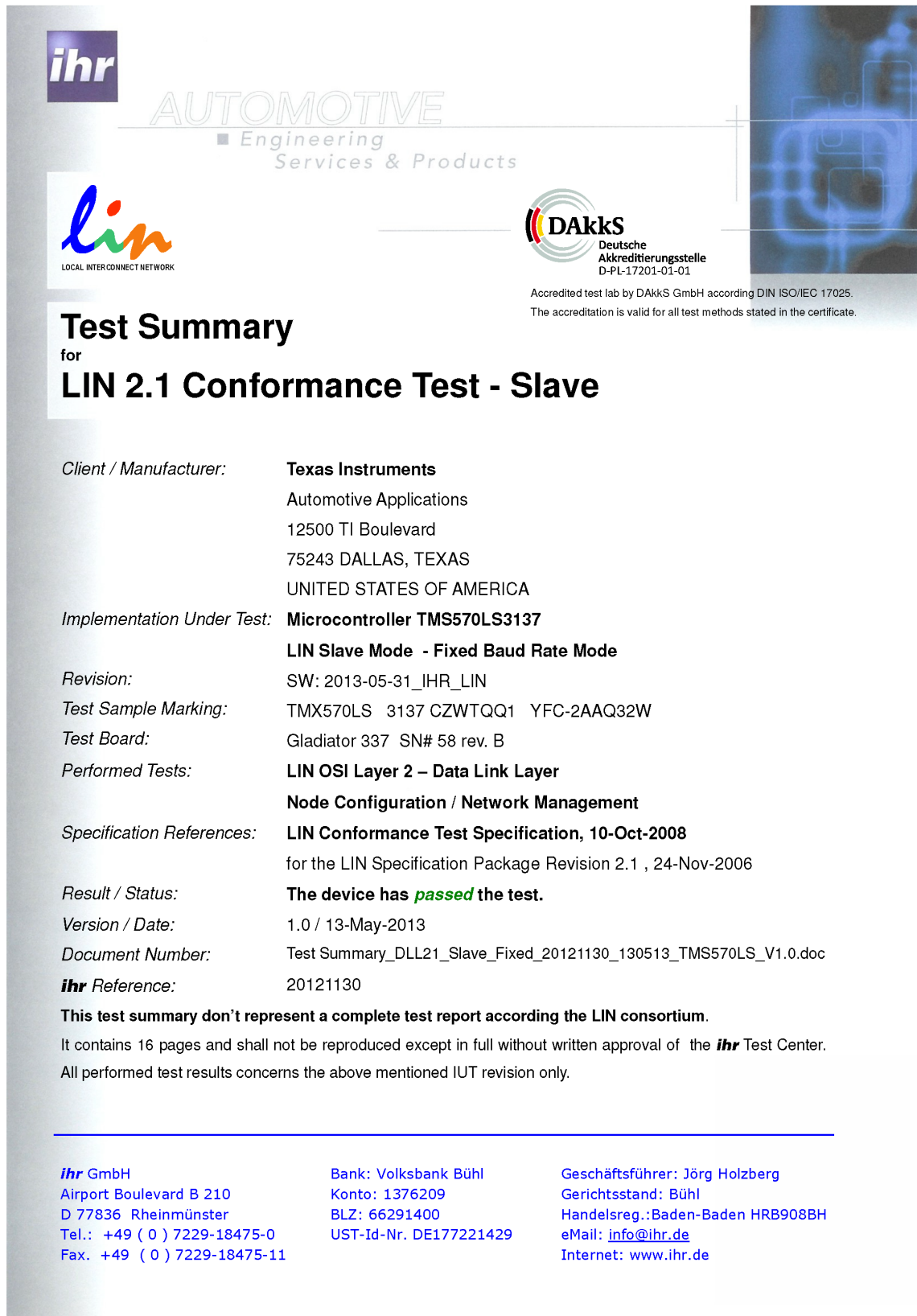
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Figure 8-4. LIN Certification - Master Mode

8.10.2.2 LIN Slave Mode - Fixed Baud Rate



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Deutsche
Akkreditierungsstelle
D-PL-17201-01-01

Accredited test lab by DAkks GmbH according DIN ISO/IEC 17025.
The accreditation is valid for all test methods stated in the certificate.

Test Summary

for
LIN 2.1 Conformance Test - Slave

Client / Manufacturer: **Texas Instruments**
Automotive Applications
12500 TI Boulevard
75243 DALLAS, TEXAS
UNITED STATES OF AMERICA

Implementation Under Test: **Microcontroller TMS570LS3137**
LIN Slave Mode - Fixed Baud Rate Mode

Revision: SW: 2013-05-31_IHR_LIN

Test Sample Marking: TMX570LS 3137 CZWTQQ1 YFC-2AAQ32W

Test Board: Gladiator 337 SN# 58 rev. B

Performed Tests: **LIN OSI Layer 2 – Data Link Layer**
Node Configuration / Network Management

Specification References: **LIN Conformance Test Specification, 10-Oct-2008**
for the LIN Specification Package Revision 2.1 , 24-Nov-2006

Result / Status: **The device has *passed* the test.**

Version / Date: 1.0 / 13-May-2013

Document Number: Test Summary_DLL21_Slave_Fixed_20121130_130513_TMS570LS_V1.0.doc

ihr Reference: 20121130

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Figure 8-5. LIN Certification - Slave Mode - Fixed Baud Rate

8.10.2.3 LIN Slave Mode - Adaptive Baud Rate

Test Summary
for
LIN 2.1 Conformance Test - Slave

Client / Manufacturer: **Texas Instruments**
Automotive Applications
12500 TI Boulevard
75243 DALLAS, TEXAS
UNITED STATES OF AMERICA

Implementation Under Test: **Microcontroller TMS570LS3137**
LIN Slave Mode - Adaptive Baud Rate Mode

Revision: SW: 2013-05-31_IHR_LIN

Test Sample Marking: TMX570LS 3137 CZWTQQ1 YFC-2AAQ32W

Test Board: Gladiator 337 SN# 58 rev. B

Performed Tests: **LIN OSI Layer 2 – Data Link Layer**
Node Configuration / Network Management

Specification References: **LIN Conformance Test Specification, 10-Oct-2008**
for the LIN Specification Package Revision 2.1 , 24-Nov-2006

Result / Status: **The device has *passed* the test.**

Version / Date: 1.0 / 13-May-2013

Document Number: Test Summary_DLL21_Slave_Adapt_TI_TMS570LS_130513_V1.0.doc

ihr Reference: 20121130

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Figure 8-6. LIN Certification - Slave Mode - Adaptive Baud Rate

9 Mechanical Packaging and Orderable Addendum

9.1 Packaging Information

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

PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|-----------------------------------|---------------|----------------------|-----------------|------------------------|-------------|--------------------------------------|-----------------------------------|--------------|------------------------|
| TMS5700332BPZQQ1 | Active | Production | LQFP (PZ) 100 | 90 JEDEC TRAY (5+1) | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | TMS570LS 0332BPZQQ1 |
| TMS5700332BPZQQ1.B | Active | Production | LQFP (PZ) 100 | 90 JEDEC TRAY (5+1) | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | TMS570LS 0332BPZQQ1 |
| TMS5700432BPZQQ1 | Active | Production | LQFP (PZ) 100 | 90 JEDEC TRAY (10+1) | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | TMS570LS 0432BPZQQ1 |
| TMS5700432BPZQQ1.B | Active | Production | LQFP (PZ) 100 | 90 JEDEC TRAY (10+1) | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | TMS570LS 0432BPZQQ1 |
| TMS5700432BPZQQ1R | Active | Production | LQFP (PZ) 100 | 1000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | TMS570LS 0432BPZQQ1 |
| TMS5700432BPZQQ1R.B | Active | Production | LQFP (PZ) 100 | 1000 LARGE T&R | Yes | NIPDAU | Level-3-260C-168 HR | -40 to 125 | TMS570LS 0432BPZQQ1 |

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

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

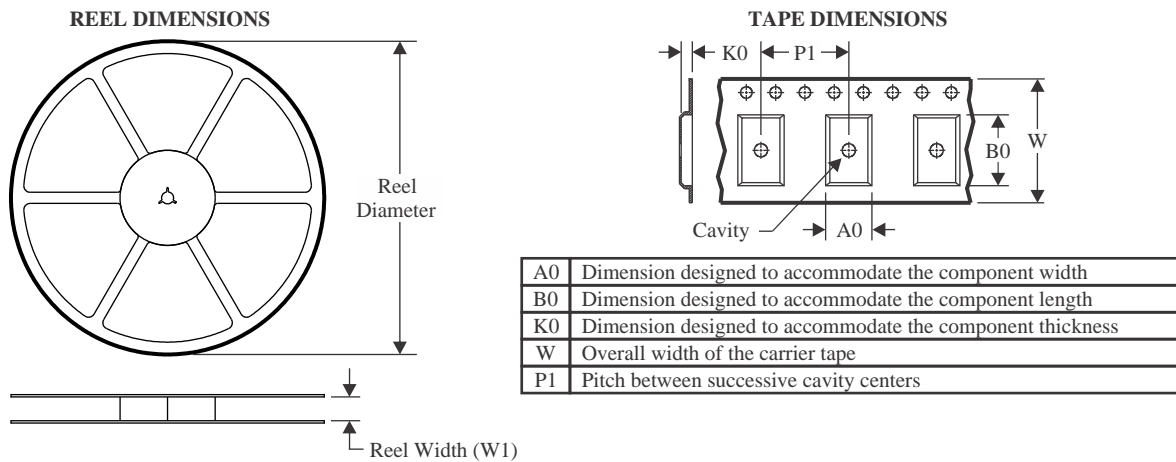
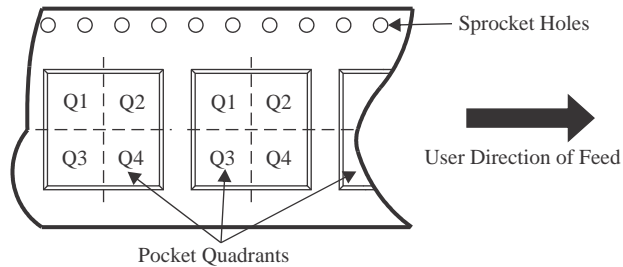
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


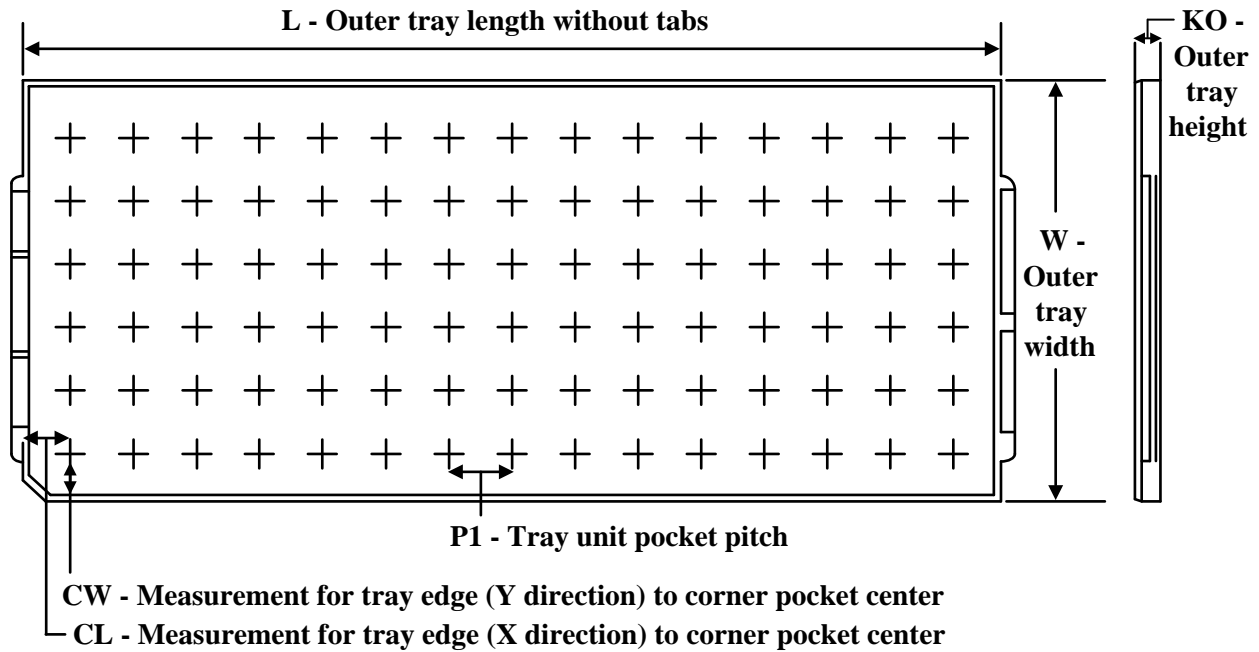
*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TMS5700432BPZQQ1R | LQFP | PZ | 100 | 1000 | 330.0 | 32.4 | 16.9 | 16.9 | 2.0 | 24.0 | 32.0 | Q2 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

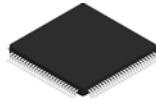
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TMS5700432BPZQQ1R | LQFP | PZ | 100 | 1000 | 367.0 | 367.0 | 55.0 |

TRAY


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

*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | Unit array matrix | Max temperature (°C) | L (mm) | W (mm) | K0 (µm) | P1 (mm) | CL (mm) | CW (mm) |
|--------------------|--------------|--------------|------|-----|-------------------|----------------------|--------|--------|---------|---------|---------|---------|
| TMS5700332BPZQQ1 | PZ | LQFP | 100 | 90 | 6 x 15 | 150 | 315 | 135.9 | 7620 | 20.3 | 15.4 | 15.4 |
| TMS5700332BPZQQ1.B | PZ | LQFP | 100 | 90 | 6 x 15 | 150 | 315 | 135.9 | 7620 | 20.3 | 15.4 | 15.4 |
| TMS5700432BPZQQ1 | PZ | LQFP | 100 | 90 | 6 x 15 | 150 | 315 | 135.9 | 7620 | 20.3 | 15.4 | 15.4 |
| TMS5700432BPZQQ1.B | PZ | LQFP | 100 | 90 | 6 x 15 | 150 | 315 | 135.9 | 7620 | 20.3 | 15.4 | 15.4 |

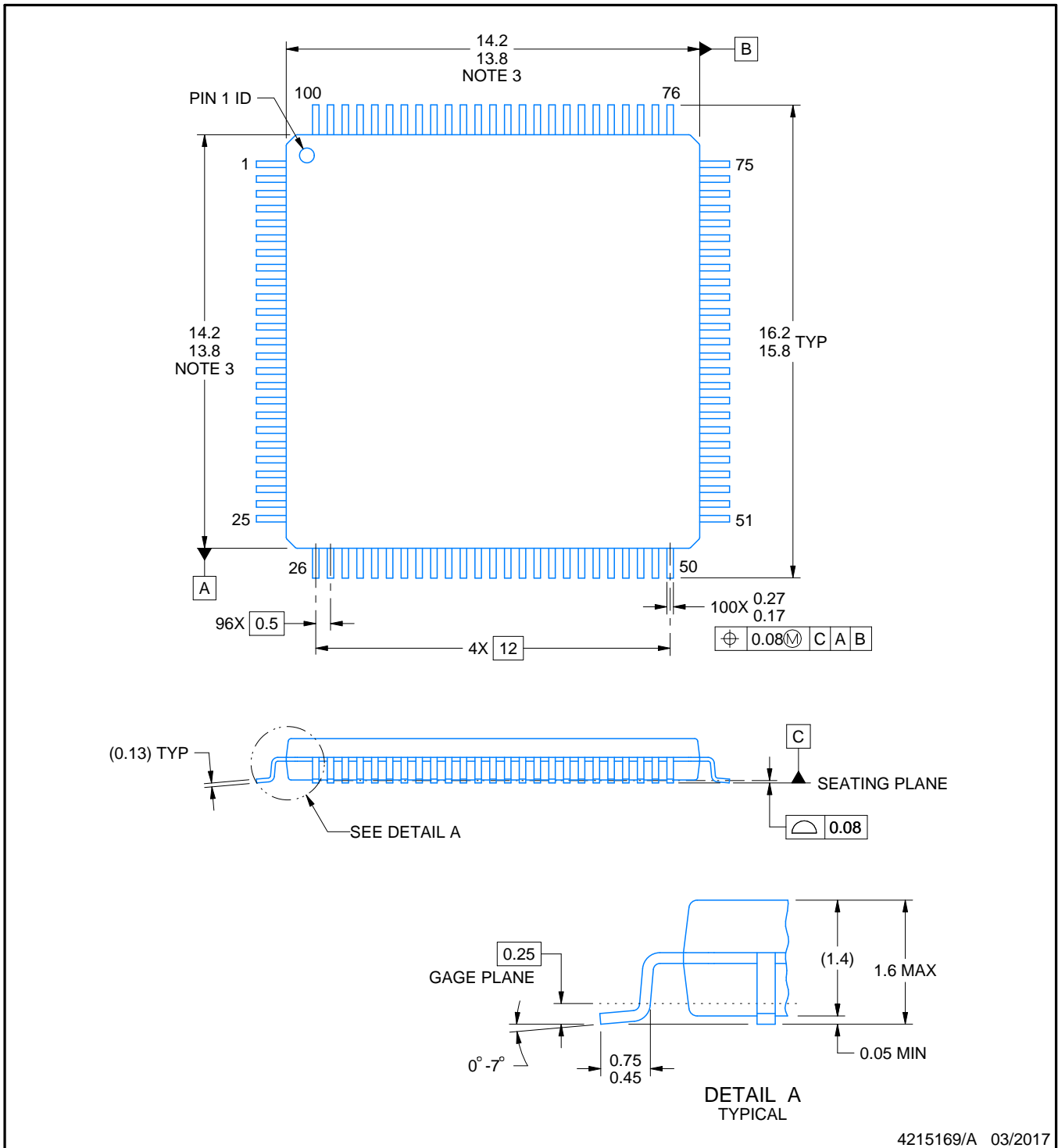


PZ0100A

PACKAGE OUTLINE

LQFP - 1.6 mm max height

PLASTIC QUAD FLATPACK



4215169/A 03/2017

NOTES:

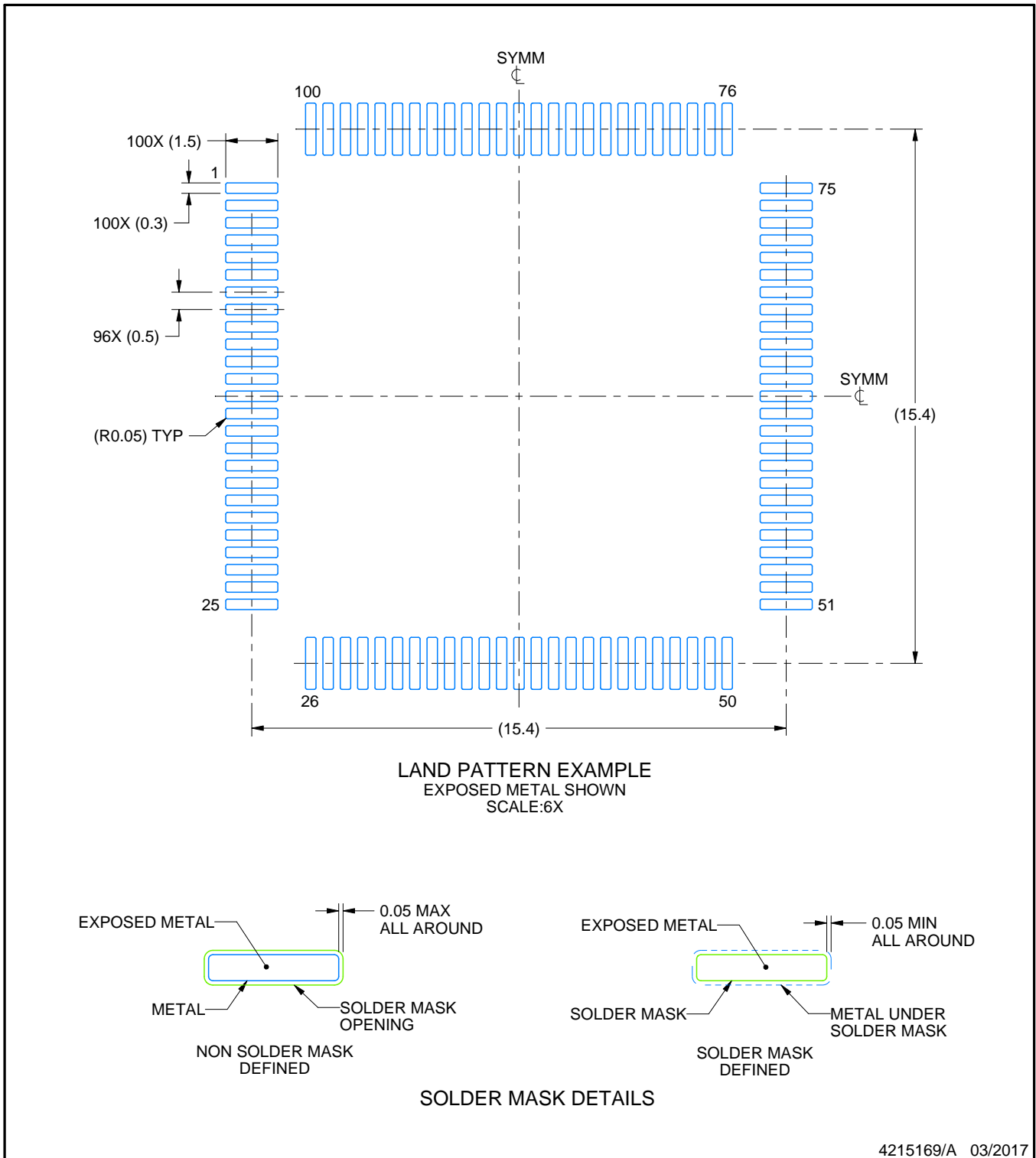
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MS-026.

EXAMPLE BOARD LAYOUT

PZ0100A

LQFP - 1.6 mm max height

PLASTIC QUAD FLATPACK



NOTES: (continued)

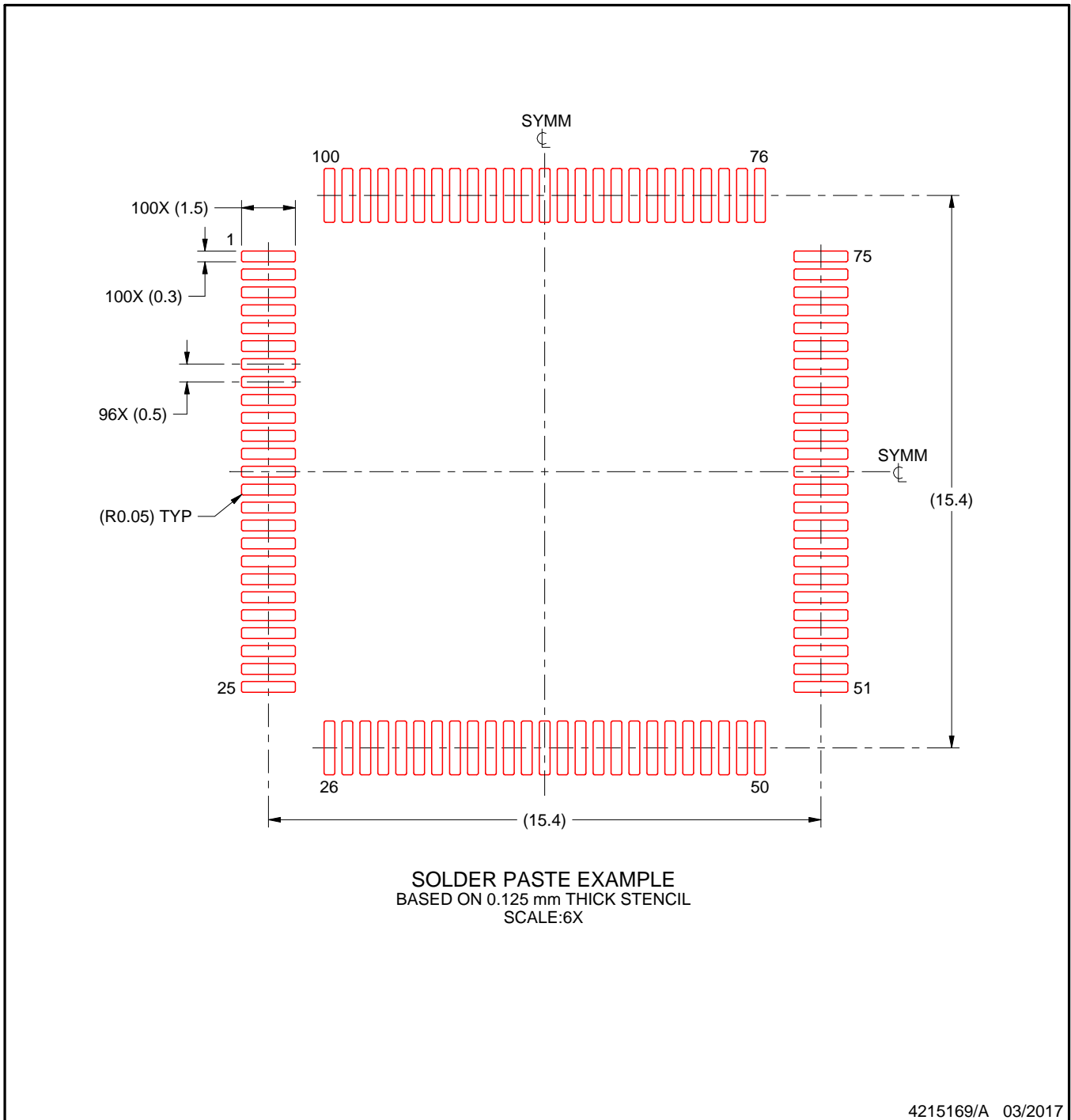
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
7. For more information, see Texas Instruments literature number SLMA004 (www.ti.com/lit/slma004).

EXAMPLE STENCIL DESIGN

PZ0100A

LQFP - 1.6 mm max height

PLASTIC QUAD FLATPACK



NOTES: (continued)

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

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