

TMS320VC5510/5510A Fixed-Point Digital Signal Processors

Data Manual

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PRODUCTION DATA information is current as of publication date.
Products conform to specifications per the terms of Texas Instruments
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testing of all parameters.



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REVISION HISTORY

This data sheet revision history highlights the technical changes made to the SPRS076N device-specific data sheet to make it an SPRS076O revision.

| PAGE(s) NO. | ADDITIONS/CHANGES/DELETIONS |
|----------------|--|
| 27 | Section 3.2.1 System Register (SYSR), Table 3–5, System Register (SYSR) Bit Functions: Added <u>HDS1</u> and <u>HDS2</u> to “Enables the internal pullups on the . . .” sentence in the HPE function description. |

Contents

| <i>Section</i> | <i>Page</i> |
|--|-------------|
| 1 Features | 11 |
| 2 Introduction | 12 |
| 2.1 Description | 12 |
| 2.2 Pin Assignments | 13 |
| 2.3 Signal Descriptions | 16 |
| 3 Functional Overview | 22 |
| 3.1 Memory | 23 |
| 3.1.1 On-Chip Dual-Access RAM (DARAM) | 23 |
| 3.1.2 On-Chip Single-Access RAM (SARAM) | 23 |
| 3.1.3 On-Chip ROM | 24 |
| 3.1.4 Instruction Cache | 24 |
| 3.1.5 Memory Map | 25 |
| 3.1.6 Bootloader | 25 |
| 3.2 Peripherals | 26 |
| 3.2.1 System Register (SYSR) | 27 |
| 3.2.2 Direct Memory Access (DMA) | 28 |
| 3.2.3 Enhanced Host Port Interface (EHPI) | 29 |
| 3.2.4 General-Purpose Input/Output Port (GPIO) | 31 |
| 3.3 CPU Register Description | 32 |
| 3.4 Peripheral Register Description | 34 |
| 3.5 Interrupts | 44 |
| 3.5.1 IFR and IER Registers | 45 |
| 3.5.2 Interrupt Timing | 45 |
| 3.6 Notices Concerning CLKOUT Operation | 46 |
| 3.6.1 CLKOUT Voltage Level | 46 |
| 3.6.2 CLKOUT Value During Reset | 46 |
| 4 Support | 47 |
| 4.1 Notices Concerning JTAG (IEEE 1149.1) Boundary Scan Test Capability | 47 |
| 4.1.1 Initialization Requirements for Boundary Scan Test | 47 |
| 4.1.2 Boundary Scan Description Language (BSDL) Model | 47 |
| 4.2 Documentation Support | 47 |
| 4.3 Device and Development-Support Tool Nomenclature | 48 |
| 4.4 TMS320VC5510/5510A Device Nomenclature | 49 |
| 5 Electrical Specifications | 50 |
| 5.1 Absolute Maximum Ratings | 50 |
| 5.2 Electrical Specifications | 50 |
| 5.3 Recommended Operating Conditions | 50 |
| 5.4 Electrical Characteristics Over Recommended Operating Case Temperature Range | 51 |
| 5.5 Timing Parameter Symbolology | 52 |

| Section | Page |
|--|-----------|
| 5.6 Clock Options | 53 |
| 5.6.1 Clock Generation in Bypass Mode (DPLL Disabled) | 53 |
| 5.6.2 Clock Generation in Lock Mode (DPLL Synthesis Enabled) | 54 |
| 5.7 Memory Timing | 55 |
| 5.7.1 Asynchronous Memory Timing | 55 |
| 5.7.2 Synchronous-Burst SRAM (SBSRAM) Timing | 58 |
| 5.7.3 Synchronous DRAM (SDRAM) Timing | 60 |
| 5.8 $\overline{\text{HOLD}}$ and $\overline{\text{HOLDA}}$ Timings | 64 |
| 5.9 Reset Timings | 65 |
| 5.10 External Interrupt Timings | 66 |
| 5.11 XF Timings | 67 |
| 5.12 General-Purpose Input/Output (IOx) Timings | 68 |
| 5.13 TIN/TOUT Timings | 69 |
| 5.14 Multichannel Buffered Serial Port (McBSP) Timings | 70 |
| 5.14.1 McBSP Transmit and Receive Timings | 70 |
| 5.14.2 McBSP General-Purpose I/O Timing | 73 |
| 5.14.3 McBSP as SPI Master or Slave Timing | 74 |
| 5.15 Enhanced Host-Port Interface (EHPI) Timing | 79 |
| 6 Mechanical Data | 85 |
| 6.1 Package Thermal Resistance Characteristics | 85 |
| 6.2 Packaging Information | 85 |

List of Figures

| <i>Figure</i> | | <i>Page</i> |
|---------------|---|-------------|
| 2-1 | TMS320VC5510/5510A GGW and ZGW MicroStar BGA Packages (Bottom View) | 13 |
| 3-1 | TMS320VC5510/5510A Functional Block Diagram | 22 |
| 3-2 | TMS320VC5510/5510A Memory Map | 25 |
| 3-3 | System Register (SYSR) Bit Layout | 27 |
| 3-4 | EHPI Memory Map | 29 |
| 3-5 | I/O Direction Register (IODIR) Bit Layout | 31 |
| 3-6 | I/O Data Register (IODATA) Bit Layout | 31 |
| 3-7 | IFR0, IER0, DBIFR0, and DBIER0 Bit Locations | 45 |
| 3-8 | IFR1, IER1, DBIFR1, and DBIER1 Bit Locations | 45 |
| 4-1 | Device Nomenclature for the TMS320VC5510/5510A | 49 |
| 5-1 | 3.3-V Test Load Circuit | 52 |
| 5-2 | Bypass Mode Clock Timing | 53 |
| 5-3 | External Multiply-by-N Clock Timing | 54 |
| 5-4 | Asynchronous Memory Read Timing | 56 |
| 5-5 | Asynchronous Memory Write Timing | 57 |
| 5-6 | SBSRAM Read Timing | 59 |
| 5-7 | SBSRAM Write Timing | 59 |
| 5-8 | Two SDRAM Read Commands (Active Row) | 61 |
| 5-9 | Two SDRAM WRT Commands (Active Row) | 61 |
| 5-10 | SDRAM ACTV Command | 62 |
| 5-11 | SDRAM DCAB Command | 62 |
| 5-12 | SDRAM REFR Command | 63 |
| 5-13 | SDRAM MRS Command | 63 |
| 5-14 | HOLD/HOLDA Timing | 64 |
| 5-15 | Reset Timing | 65 |
| 5-16 | External Interrupt Timing | 66 |
| 5-17 | XF Timing | 67 |
| 5-18 | General-Purpose Input/Output (IOx) Signal Timings | 68 |
| 5-19 | TIN/TOUT Timing When Configured as Inputs | 69 |
| 5-20 | TIN/TOUT Timing When Configured as Outputs | 69 |
| 5-21 | McBSP Receive Timings | 72 |
| 5-22 | McBSP Transmit Timings | 72 |
| 5-23 | McBSP General-Purpose I/O Timings | 73 |
| 5-24 | McBSP Timing as SPI Master or Slave: CLKSTP = 10b, CLKXP = 0 | 75 |
| 5-25 | McBSP Timing as SPI Master or Slave: CLKSTP = 11b, CLKXP = 0 | 76 |

| <i>Figure</i> | <i>Page</i> |
|---|-------------|
| 5–26 McBSP Timing as SPI Master or Slave: CLKSTP = 10b, CLKXP = 1 | 77 |
| 5–27 McBSP Timing as SPI Master or Slave: CLKSTP = 11b, CLKXP = 1 | 78 |
| 5–28 EHPI Nonmultiplexed Read/Write Timings | 80 |
| 5–29 EHPI Multiplexed Memory (HPID) Access Read/Write Timings Without Autoincrement | 81 |
| 5–30 EHPI Multiplexed Memory (HPID) Access Read Timings With Autoincrement | 82 |
| 5–31 EHPI Multiplexed Memory (HPID) Access Write Timings With Autoincrement | 83 |
| 5–32 EHPI Multiplexed Register Access Read/Write Timings | 84 |

List of Tables

| <i>Table</i> | | <i>Page</i> |
|--------------|---|-------------|
| 2-1 | Pin Assignments | 14 |
| 2-2 | Signal Descriptions | 16 |
| 3-1 | DARAM Blocks | 23 |
| 3-2 | SARAM Blocks | 23 |
| 3-3 | Standard On-Chip ROM Contents | 24 |
| 3-4 | TMS320VC5510/5510A Boot Configurations | 26 |
| 3-5 | System Register (SYSR) Bit Functions | 27 |
| 3-6 | DMA Sync Events | 28 |
| 3-7 | I/O Direction Register (IODIR) Bit Functions | 31 |
| 3-8 | I/O Data Register (IODATA) Bit Functions | 31 |
| 3-9 | CPU Registers | 32 |
| 3-10 | Peripheral Bus Controller Configuration Registers | 34 |
| 3-11 | Instruction Cache Registers | 34 |
| 3-12 | External Memory Interface Registers | 35 |
| 3-13 | DMA Configuration Registers | 36 |
| 3-14 | Clock Generator Registers | 39 |
| 3-15 | Timer Registers | 39 |
| 3-16 | Multichannel Serial Port #0 Registers | 40 |
| 3-17 | Multichannel Serial Port #1 Registers | 41 |
| 3-18 | Multichannel Serial Port #2 Registers | 42 |
| 3-19 | GPIO Registers | 43 |
| 3-20 | Device Revision ID Registers | 43 |
| 3-21 | Interrupt Table | 44 |
| 5-1 | CLKIN in Bypass Mode Timing Requirements | 53 |
| 5-2 | CLKOUT in Bypass Mode Switching Characteristics | 53 |
| 5-3 | CLKIN in Lock Mode Timing Requirements | 54 |
| 5-4 | CLKOUT in Lock Mode Switching Characteristics | 54 |
| 5-5 | Asynchronous Memory Cycles Timing Requirements | 55 |
| 5-6 | Asynchronous Memory Cycles Switching Characteristics | 55 |
| 5-7 | Synchronous-Burst SRAM Cycle Timing Requirements | 58 |
| 5-8 | Synchronous-Burst SRAM Cycle Switching Characteristics | 58 |
| 5-9 | Synchronous DRAM Cycle Timing Requirements | 60 |
| 5-10 | Synchronous DRAM Cycle Switching Characteristics | 60 |
| 5-11 | <u>HOLD</u> and <u>HOLDA</u> Timing Requirements | 64 |
| 5-12 | <u>HOLD</u> and <u>HOLDA</u> Switching Characteristics | 64 |
| 5-13 | Reset Timing Requirements | 65 |
| 5-14 | Reset Switching Characteristics | 65 |
| 5-15 | External Interrupt Timing Requirements | 66 |
| 5-16 | XF Switching Characteristics | 67 |
| 5-17 | General-Purpose Input/Output (GPIO) Pins Configured as Inputs Timing Requirements | 68 |
| 5-18 | General-Purpose Input/Output (GPIO) Pins Configured as Inputs Switching Characteristics | 68 |
| 5-19 | TIN/TOUT Pins Configured as Inputs Timing Requirements | 69 |
| 5-20 | TIN/TOUT Pins Configured as Outputs Switching Characteristics | 69 |

| <i>Table</i> | <i>Page</i> |
|---|-------------|
| 5–21 McBSP Timing Requirements | 70 |
| 5–22 McBSP Switching Characteristics | 71 |
| 5–23 McBSP General-Purpose I/O Timing Requirements | 73 |
| 5–24 McBSP General-Purpose I/O Switching Characteristics | 73 |
| 5–25 McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 10b, CLKXP = 0) | 74 |
| 5–26 McBSP as SPI Master or Slave Switching Characteristics (CLKSTP = 10b, CLKXP = 0) | 74 |
| 5–27 McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 11b, CLKXP = 0) | 76 |
| 5–28 McBSP as SPI Master or Slave Switching Characteristics (CLKSTP = 11b, CLKXP = 0) | 76 |
| 5–29 McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 10b, CLKXP = 1) | 77 |
| 5–30 McBSP as SPI Master or Slave Switching Characteristics (CLKSTP = 10b, CLKXP = 1) | 77 |
| 5–31 McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 11b, CLKXP = 1) | 78 |
| 5–32 McBSP as SPI Master or Slave Switching Characteristics (CLKSTP = 11b, CLKXP = 1) | 78 |
| 5–33 EHPI Timing Requirements | 79 |
| 5–34 EHPI Switching Characteristics | 79 |
| 6–1 Thermal Resistance Characteristics (Ambient) | 85 |
| 6–2 Thermal Resistance Characteristics (Case) | 85 |

1 Features

- **High-Performance, Low-Power, Fixed-Point TMS320C55x™ Digital Signal Processor (DSP)**
 - 6.25-/5-ns Instruction Cycle Time
 - 160-/200-MHz Clock Rate
 - One/Two Instructions Executed per Cycle
 - Dual Multipliers (Up to 400 Million Multiply-Accumulates Per Second (MMACS))
 - Two Arithmetic/Logic Units
 - One Internal Program Bus
 - Three Internal Data/Operand Read Buses
 - Two Internal Data/Operand Write Buses
- **Instruction Cache (24K Bytes)**
- **160K x 16-Bit On-Chip RAM Composed of:**
 - Eight Blocks of 4K x 16-Bit Dual-Access RAM (DARAM) (64K Bytes)
 - 32 Blocks of 4K x 16-Bit Single-Access RAM (SARAM) (256K Bytes)
- **16K x 16-Bit On-Chip ROM (32K Bytes)**
- **8M x 16-Bit Maximum Addressable External Memory Space**
- **32-Bit External Memory Interface (EMIF) With Glueless Interface to:**
 - Asynchronous Static RAM (SRAM)
 - Asynchronous EPROM
 - Synchronous DRAM (SDRAM)
 - Synchronous Burst SRAM (SBSRAM)
- **Programmable Low-Power Control of Six Device Functional Domains**
- **On-Chip Peripherals**
 - Two 20-Bit Timers
 - Six-Channel Direct Memory Access (DMA) Controller
 - Three Multichannel Buffered Serial Ports (McBSPs)
 - 16-Bit Parallel Enhanced Host-Port Interface (EHPI)
 - Programmable Digital Phase-Locked Loop (DPLL) Clock Generator
 - Eight General-Purpose I/O (GPIO) Pins and Dedicated General-Purpose Output (XF)
- **On-Chip Scan-Based Emulation Logic**
- **IEEE Std 1149.1† (JTAG) Boundary Scan Logic**
- **240-Terminal MicroStar BGA™ (Ball Grid Array) (GGW Suffix)**
- **240-Terminal MicroStar BGA™ (Ball Grid Array) (ZGW Suffix) [Lead-Free]**
- **3.3-V I/O Supply Voltage**
- **1.6-V Core Supply Voltage**

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† IEEE Standard 1149.1-1990 Standard-Test-Access Port and Boundary Scan Architecture.

2 Introduction

This section describes the main features of the TMS320VC5510/5510A digital signal processors (DSPs), lists the pin assignments, and describes the function of each pin. This data manual also provides a detailed description section, electrical specifications, parameter measurement information, and mechanical data about the available packaging.

NOTE: This data manual is designed to be used in conjunction with the *TMS320C55x™ DSP Functional Overview* (literature number SPRU312).

2.1 Description

The TMS320VC5510/5510A (5510/5510A) fixed-point digital signal processors (DSPs) are based on the TMS320C55x DSP generation CPU processor core. The C55x™ DSP architecture achieves high performance and low power through increased parallelism and total focus on reduction in power dissipation. The CPU supports an internal bus structure composed of one program bus, three data read buses, two data write buses, and additional buses dedicated to peripheral and DMA activity. These buses provide the ability to perform up to three data reads and two data writes in a single cycle. In parallel, the DMA controller can perform up to two data transfers per cycle independent of the CPU activity.

The C55x CPU provides two multiply-accumulate (MAC) units, each capable of 17-bit x 17-bit multiplication in a single cycle. A central 40-bit arithmetic/logic unit (ALU) is supported by an additional 16-bit ALU. Use of the ALUs is under instruction set control, providing the ability to optimize parallel activity and power consumption. These resources are managed in the address unit (AU) and data unit (DU) of the C55x CPU.

The C55x™ DSP generation supports a variable byte width instruction set for improved code density. The instruction unit (IU) performs 32-bit program fetches from internal or external memory and queues instructions for the program unit (PU). The program unit decodes the instructions, directs tasks to AU and DU resources, and manages the fully protected pipeline. Predictive branching capability avoids pipeline flushes on execution of conditional instructions. The 5510/5510A also includes a 24K-byte instruction cache to minimize external memory accesses, improving data throughput and conserving system power.

The 5510/5510A peripheral set includes an external memory interface (EMIF) that provides glueless access to asynchronous memories like EPROM and SRAM, as well as to high-speed, high-density memories such as synchronous DRAM and synchronous burst SRAM. Three full-duplex multichannel buffered serial ports (McBSPs) provide glueless interface to a variety of industry-standard serial devices, and multichannel communication with up to 128 separately enabled channels. The enhanced host-port interface (EHPI) is a 16-bit parallel interface used to provide host processor access to internal memory on the 5510/5510A. The EHPI can be configured in either multiplexed or non-multiplexed mode to provide glueless interface to a wider variety of host processors. The DMA controller provides data movement for six independent channel contexts without CPU intervention, providing DMA throughput of up to two 16-bit words per cycle. Two general-purpose timers, eight general-purpose I/O (GPIO) pins, and digital phase-locked loop (DPLL) clock generation are also included.

The 5510/5510A is supported by the industry's leading eXpressDSP™ software environment including the Code Composer Studio™ integrated development environment, DSP/BIOS™ software kernel foundation, the TMS320™ DSP Algorithm Standard, and the industry's largest third-party network. Code Composer Studio features code generation tools including a C-Compiler, Visual Linker, simulator, Real-Time Data Exchange (RTDX™), XDS510™ emulation device drivers, and Chip Support Libraries (CSL). DSP/BIOS is a scalable real-time software foundation available for no cost to users of Texas Instruments' DSP products providing a pre-emptive task scheduler and real-time analysis capabilities with very low memory and megahertz overhead. The TMS320 DSP Algorithm Standard is a specification of coding conventions allowing fast integration of algorithms from different teams, sites, or third parties into the application framework. Texas Instruments' extensive DSP third-party network of over 400 providers brings focused competencies and complete solutions to customers.

Texas Instruments (TI) has also developed foundation software available for the 5510/5510A. The C55x DSP Library (DSPLIB) features over 50 C-callable software kernels (FIR/IIR filters, Fast Fourier Transforms (FFTs), and various computational functions). The DSP Image/Video Processing Library (IMGLIB) contains over 20 software kernels highly optimized for C55x DSPs and is compiled with the latest revision of the C55x DSP code generation tools. These imaging functions support a wide range of applications that include compression, video processing, machine vision, and medical imaging.

The TMS320C55x DSP core was created with an open architecture that allows the addition of application-specific hardware to boost performance on specific algorithms. The hardware extensions on the 5510/5510A strike the perfect balance of fixed function performance with programmable flexibility, while achieving low-power consumption, and cost that traditionally has been difficult to find in the video-processor market. The extensions allow the 5510/5510A to deliver exceptional video codec performance with more than half its bandwidth available for performing additional functions such as color space conversion, user-interface operations, security, TCP/IP, voice recognition, and text-to-speech conversion. As a result, a single 5510/5510A DSP can power most portable digital video applications with processing headroom to spare. For more information, see the *TMS320C55x Hardware Extensions for Image/Video Applications Programmer's Reference* (literature number SPRU098). For more information on using the the DSP Image Processing Library, see the *TMS320C55x Image/Video Processing Library Programmer's Reference* (literature number SPRU037).

2.2 Pin Assignments

Figure 2–1 illustrates the ball locations for the 240-pin GGW and ZGW ball grid array (BGA) packages and is used in conjunction with Table 2–1 to locate signal names and ball grid numbers.

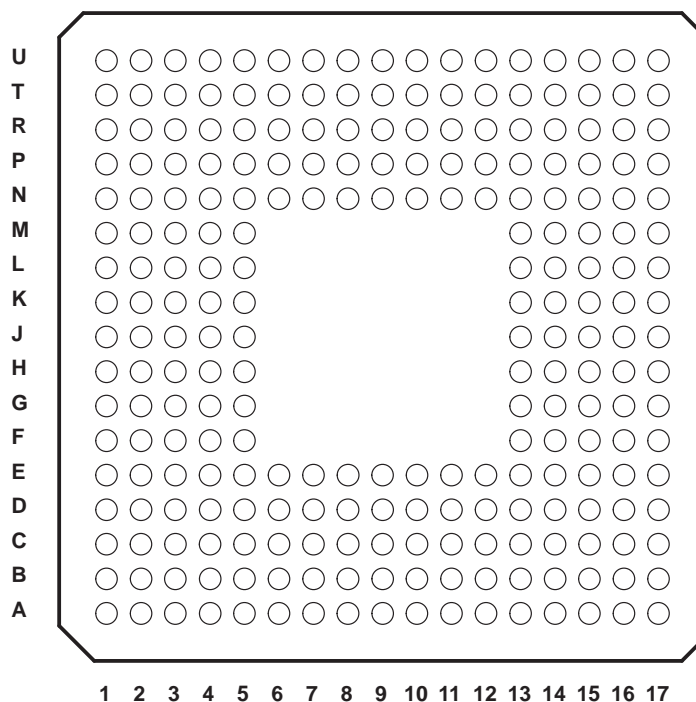


Figure 2–1. TMS320VC5510/5510A GGW and ZGW MicroStar BGA™ Packages (Bottom View)

Table 2–1. Pin Assignments

| BGA BALL # | SIGNAL | BGA BALL # | SIGNAL | BGA BALL # | SIGNAL | BGA BALL # | SIGNAL |
|------------|------------------|------------|------------------|------------|------------------|------------|------------------|
| A1 | V _{SS} | A2 | A9 | A3 | DV _{DD} | A4 | A8 |
| A5 | CV _{DD} | A6 | A4 | A7 | DV _{DD} | A8 | D2 |
| A9 | V _{SS} | A10 | V _{SS} | A11 | SDRAS | A12 | DV _{DD} |
| A13 | SDCAS | A14 | CV _{DD} | A15 | HD10 | A16 | V _{SS} |
| A17 | V _{SS} | B1 | V _{SS} | B2 | XF | B3 | D9 |
| B4 | D7 | B5 | D5 | B6 | D3 | B7 | A2 |
| B8 | A0 | B9 | CLKMEM | B10 | SDA10 | B11 | HD2 |
| B12 | SDWE | B13 | HD1 | B14 | HDRY | B15 | HD3 |
| B16 | HD0 | B17 | HDS1 | C1 | A10 | C2 | D13 |
| C3 | D10 | C4 | A6 | C5 | A7 | C6 | A5 |
| C7 | A3 | C8 | D0 | C9 | HD4 | C10 | HD5 |
| C11 | HD6 | C12 | HD7 | C13 | HD8 | C14 | HD9 |
| C15 | HR/W | C16 | HCS | C17 | TRST | D1 | DV _{DD} |
| D2 | D14 | D3 | D11 | D4 | D8 | D5 | D6 |
| D6 | D4 | D7 | D1 | D8 | A1 | D9 | HD15 |
| D10 | HD14 | D11 | HD13 | D12 | HD12 | D13 | HD11 |
| D14 | HDS2 | D15 | HA11 | D16 | HA0 | D17 | DV _{DD} |
| E1 | A11 | E2 | D15 | E3 | D12 | E4 | CE3 |
| E5 | BOOTM3 | E6 | CV _{DD} | E7 | CV _{DD} | E8 | NC |
| E9 | NC | E10 | CV _{DD} | E11 | NC | E12 | NC |
| E13 | RSVD9 | E14 | HA12 | E15 | HA10 | E16 | HA1/HCNTL1 |
| E17 | RST_MODE | F1 | DV _{DD} | F2 | A13 | F3 | A12 |
| F4 | A16 | F5 | CV _{DD} | F13 | RSVD8 | F14 | HA9 |
| F15 | HA2/HAS | F16 | CLKIN | F17 | CV _{DD} | G1 | CE2 |
| G2 | A17 | G3 | A15 | G4 | A14 | G5 | NC |
| G13 | RSVD7 | G14 | HA8 | G15 | HA3 | G16 | RESET |
| G17 | HA13 | H1 | V _{SS} | H2 | CE1 | H3 | A19 |
| H4 | A18 | H5 | NC | H13 | RSVD6 | H14 | HA4 |
| H15 | CLKOUT | H16 | HA14 | H17 | V _{SS} | J1 | V _{SS} |
| J2 | CE0 | J3 | A21 | J4 | A20 | J5 | NC |
| J13 | RSVD5 | J14 | HA5 | J15 | HA15 | J16 | HA7 |
| J17 | V _{SS} | K1 | IO7 | K2 | BE0 | K3 | BE1 |
| K4 | IO0 | K5 | CV _{DD} | K13 | RSVD4 | K14 | TMS |
| K15 | HBE0 | K16 | HA16 | K17 | HA6 | L1 | CV _{DD} |
| L2 | IO6 | L3 | BE2 | L4 | BE3 | L5 | NC |
| L13 | RSVD3 | L14 | EMU1/OFF | L15 | TDO | L16 | TDI |
| L17 | TCK | M1 | IO5 | M2 | SSWE | M3 | SSOE |
| M4 | IO1/BOOTM0 | M5 | NC | M13 | RSVD2 | M14 | HA18 |
| M15 | HA17 | M16 | HBE1 | M17 | DV _{DD} | N1 | DV _{DD} |
| N2 | IO4 | N3 | D16 | N4 | SSADS | N5 | NC |
| N6 | CV _{DD} | N7 | NC | N8 | NC | N9 | NC |
| N10 | CV _{DD} | N11 | NC | N12 | NC | N13 | RSVD1 |
| N14 | HINT | N15 | HCNTL0 | N16 | HMODE | N17 | HA19 |
| P1 | IO3/BOOTM2 | P2 | CLKS1 | P3 | DR1 | P4 | D19 |
| P5 | D22 | P6 | D23 | P7 | D24 | P8 | CLKS2 |
| P9 | FSX0 | P10 | D31 | P11 | D28 | P12 | INT4 |
| P13 | ARDY | P14 | HOLDA | P15 | TIN/TOUT0 | P16 | CLKMD |

Table 2–1. Pin Assignments (Continued)

| BGA BALL # | SIGNAL | BGA BALL # | SIGNAL | BGA BALL # | SIGNAL | BGA BALL # | SIGNAL |
|------------|------------------|------------|------------------|------------|------------------|------------|-----------------|
| P17 | CV _{DD} | R1 | CV _{DD} | R2 | FSR1 | R3 | D18 |
| R4 | D20 | R5 | CLKR2 | R6 | FSR2 | R7 | DR2 |
| R8 | D26 | R9 | FSX2 | R10 | DX0 | R11 | INT5 |
| R12 | INT0 | R13 | INT2 | R14 | ARE | R15 | CLKX1 |
| R16 | EMU0 | R17 | TIN/TOUT1 | T1 | D17 | T2 | IO2/BOOTM1 |
| T3 | CLKR1 | T4 | D21 | T5 | FSR0 | T6 | DR0 |
| T7 | D25 | T8 | D27 | T9 | D29 | T10 | D30 |
| T11 | NC | T12 | NMI | T13 | AWE | T14 | INT3 |
| T15 | FSX1 | T16 | DX1 | T17 | V _{SS} | U1 | V _{SS} |
| U2 | V _{SS} | U3 | CLKR0 | U4 | CV _{DD} | U5 | CLKS0 |
| U6 | DV _{DD} | U7 | CLKX0 | U8 | CLKX2 | U9 | V _{SS} |
| U10 | V _{SS} | U11 | DX2 | U12 | CV _{DD} | U13 | INT1 |
| U14 | DV _{DD} | U15 | AOE | U16 | HOLD | U17 | V _{SS} |

2.3 Signal Descriptions

Table 2–2 lists each signal, function, and operating mode(s) grouped by function. See Section 2.2 for exact pin locations based on package type.

Table 2–2. Signal Descriptions

| SIGNAL NAME | TYPE† | OTHER‡ | DESCRIPTION |
|--|-------|--------|---|
| EMIF - ADDRESS BUS | | | |
| A[21:0] | O/Z | E,F | External memory address bus (byte address). Address all external memory (program and data). Since A[23:22] are redundant to the CE[3:0] memory space selects in terms of memory addressing capability, A[23:22] are not externally provided. |
| EMIF - CONTROL SIGNALS COMMON TO ALL MEMORY TYPES | | | |
| $\overline{\text{CE0}}$ $\overline{\text{CE1}}$ $\overline{\text{CE2}}$ $\overline{\text{CE3}}$ | O/Z | E,F | External memory space enables. Select one of four external memory ranges based on the address. |
| $\overline{\text{BE0}}$ $\overline{\text{BE1}}$ $\overline{\text{BE2}}$ $\overline{\text{BE3}}$ | O/Z | E,F | Byte-enable control. Can be used as chip selects for external memory. These signals respond according to the data width of the memory access. 8-bit accesses cause a single byte enable to respond. 16-bit accesses cause two byte enables to respond. 32-bit accesses cause all four byte enables to respond. |
| CLKMEM | O/Z | E,F | Memory interface clock (for SDRAM / SBSRAM). Clock for synchronizing the external synchronous memories to the C55x external memory interface. |
| EMIF - DATA BUS | | | |
| D[31:0] | I/O/Z | D,E,F | External data bus. Provides data exchange between external memories and the C55x external memory interface. The bus holders on D[31:0] are controlled by the BH bit in the system register (SYSR). |
| EMIF - BUS ARBITRATION | | | |
| $\overline{\text{HOLD}}$ | I | – | Hold request. $\overline{\text{HOLD}}$ is asserted by an external host to request control of the address, data and control signals. |
| $\overline{\text{HOLDA}}$ | O/Z | F | Hold acknowledge. $\overline{\text{HOLDA}}$ is asserted by the DSP to indicate that the DSP is in the HOLD state and that the EMIF address, data and control signals are in a high-impedance state, allowing the external memory interface to be accessed by other devices. |
| EMIF - ASYNCHRONOUS MEMORY CONTROL SIGNALS | | | |
| $\overline{\text{ARE}}$ | O/Z | E,F | Asynchronous memory read enable. $\overline{\text{ARE}}$ acts as a strobe during asynchronous memory reads only. |
| $\overline{\text{AOE}}$ | | | Asynchronous memory output enable. $\overline{\text{AOE}}$ indicates whether a memory access is a read (low) or a write (high). |
| $\overline{\text{AWE}}$ | | | Asynchronous memory write enable. $\overline{\text{AWE}}$ acts as a strobe during asynchronous memory writes only. |
| ARDY | I | | Asynchronous memory ready input. ARDY indicates that an external device is ready for a bus transaction to be completed. If the device is not ready (ARDY is low), the processor extends the memory access by one cycle and checks ARDY again. The ARDY signal is sampled at the end of the STROBE period in the memory access. |

† I = Input, O = Output, S = Supply, Z = High impedance

‡ Other Pin Characteristics:

A – Internal pullup (always enabled)

B – Internal pulldown (always enabled)

C – Hysteresis input

D – Pin has bus holder

J – Internal pullup enabled by the HPE bit in the system register (SYSR)

K – Internal pulldown enabled by the HPE bit in the system register (SYSR)

E – Pin is high impedance in HOLD mode (due to $\overline{\text{HOLD}}$ pin).

F – Pin is high impedance in OFF mode (due to EMU1/OFF pin).

G – Pin can be configured as a general-purpose input.

H – Pin can be configured as a general-purpose output.

Table 2–2. Signal Descriptions (Continued)

| SIGNAL NAME | TYPE† | OTHER‡ | DESCRIPTION |
|---|-------|---------|--|
| EMIF - SYNCHRONOUS BURST SRAM CONTROL SIGNALS | | | |
| $\overline{\text{SSADS}}$ | O/Z | E,F | SBSRAM address strobe. $\overline{\text{SSADS}}$ is active (low) during the period of the SBSRAM access when the address is made available to the external memory by the DSP. |
| $\overline{\text{SSOE}}$ | | | SBSRAM output enable. $\overline{\text{SSOE}}$ is active (low) during read accesses to SBSRAM. |
| $\overline{\text{SSWE}}$ | | | SBSRAM write enable. $\overline{\text{SSWE}}$ is active (low) during write accesses to SBSRAM. |
| EMIF - SYNCHRONOUS DRAM CONTROL SIGNALS | | | |
| $\overline{\text{SDRAS}}$ | O/Z | E,F | SDRAM row address strobe. $\overline{\text{SDRAS}}$ is active (low) during the ACTV, DCAB, REFR, and MRS commands. |
| $\overline{\text{SDCAS}}$ | | | SDRAM address column strobe. $\overline{\text{SDCAS}}$ is active (low) during reads, writes, and the REFR and MRS commands. |
| $\overline{\text{SDWE}}$ | | | SDRAM write enable. $\overline{\text{SDWE}}$ is active (low) during writes, and the DCAB and MRS commands. |
| SDA10 | | | SDRAM A10 address (address/autoprecharge disable). SDA10 is used during reads, writes, and all commands. |
| MULTICHANNEL BUFFERED SERIAL PORT SIGNALS | | | |
| CLKR0 CLKR1 CLKR2 | I/O/Z | C,F,G,H | Serial shift clock reference for the receiver |
| DR0 DR1 DR2 | I | G | Serial receive data input |
| FSR0 FSR1 FSR2 | I/O/Z | F,G,H | Frame synchronization signal for the receiver |
| CLKX0 CLKX1 CLKX2 | I/O/Z | C,F,G,H | Serial shift clock reference for the transmitter |
| DX0 DX1 DX2 | O/Z | F,H | Serial transmit data output |
| FSX0 FSX1 FSX2 | I/O/Z | F,G,H | Frame synchronization signal for the transmitter |
| CLKS0 CLKS1 CLKS2 | I | G | External clock source to the sample rate generator |

† I = Input, O = Output, S = Supply, Z = High impedance

‡ Other Pin Characteristics:

A – Internal pullup (always enabled)

B – Internal pulldown (always enabled)

C – Hysteresis input

D – Pin has bus holder

J – Internal pullup enabled by the HPE bit in the system register (SYSR)

K – Internal pulldown enabled by the HPE bit in the system register (SYSR)

E – Pin is high impedance in HOLD mode (due to $\overline{\text{HOLD}}$ pin).

F – Pin is high impedance in OFF mode (due to EMU1/OFF pin).

G – Pin can be configured as a general-purpose input.

H – Pin can be configured as a general-purpose output.

Table 2–2. Signal Descriptions (Continued)

| SIGNAL NAME | TYPE† | OTHER‡ | DESCRIPTION |
|--|-------|--------|---|
| ENHANCED HOST-PORT INTERFACE (EHPI) | | | |
| HA[19:3] HA2/HAS HA1/HCNTL1 HA0 | I | J | Host address bus: In non-multiplexed mode (HMODE pin high): HA[19:0] functions as the host address bus only. In multiplexed mode (HMODE pin low): HA[19:3] are disabled. HA2/HAS functions as $\overline{\text{HAS}}$ (Host Address Strobe). Hosts with multiplexed address and data pins may require HAS to latch the address in the HPIA register. HA1/HCNTL1 functions as HCNTL1 (Host Control Input) and with HCNTL0 determines the type of transaction being performed. |
| HD[15:0] | I/O/Z | D,F | Host data bus. Provides data exchange between the host and C55x EHPI. The bus holders on HD[15:0] are controlled by the HBH bit in the system register (SYSR). |
| $\overline{\text{HCS}}$ | I | J | Host chip select. $\overline{\text{HCS}}$ is the select input for the EHPI and must be driven low during accesses. If the EHPI is not used, HCS must be driven high. |
| HA2/ $\overline{\text{HAS}}$ | I | J | Host address strobe. Operates as $\overline{\text{HAS}}$ when HMODE is low (multiplexed mode). Hosts with multiplexed address and data pins may require HAS to latch the address in the HPIA register. |
| HR/ $\overline{\text{W}}$ | I | J | Host read or write select. Controls the direction of the EHPI transfer. |
| $\overline{\text{HDS1}}$ $\overline{\text{HDS2}}$ | I | J | Host data strobes. $\overline{\text{HDS1}}$ and $\overline{\text{HDS2}}$ are driven by the host read and write strobes to control data transfers. |
| HRDY | O/Z | F,J | Host ready (from DSP to host). HRDY informs the host when the EHPI is ready for the next transfer. |
| $\overline{\text{HBE0}}$ $\overline{\text{HBE1}}$ | I | K | EHPI byte enables. $\overline{\text{HBE0}}$ and $\overline{\text{HBE1}}$ are driven low selectively by the host to indicate whether the transaction involves the lower byte only, the upper byte only, or both. As of revision 2.1, the byte-enable function on the EHPI will no longer be supported. These pins must be driven low by an external device, by external pulldown resistors or by the internal pulldown circuit controlled by the HPE bit in the SYSR register. |
| HMODE | I | J | Host multiplexed/non-multiplexed mode select. When HMODE is high, the EHPI operates in nonmultiplexed mode. When HMODE is low, the EHPI operates in multiplexed mode. |
| HCNTL0 HA1/HCNTL1 | I | J | Host control selects. HCNTL0 and HCNTL1 select host accesses to EHPI address, data or control registers. HA1/HCNTL1 operates as HCNTL1 when HMODE is low (multiplexed mode). |
| $\overline{\text{HINT}}$ | O/Z | F | Host interrupt (from DSP to host). This output is used to interrupt the host. $\overline{\text{HINT}}$ is high following reset. |

† I = Input, O = Output, S = Supply, Z = High impedance

‡ Other Pin Characteristics:

- A – Internal pullup (always enabled)
- B – Internal pulldown (always enabled)
- C – Hysteresis input
- D – Pin has bus holder
- J – Internal pullup enabled by the HPE bit in the system register (SYSR)
- K – Internal pulldown enabled by the HPE bit in the system register (SYSR)
- E – Pin is high impedance in HOLD mode (due to $\overline{\text{HOLD}}$ pin).
- F – Pin is high impedance in OFF mode (due to EMU1/ $\overline{\text{OFF}}$ pin).
- G – Pin can be configured as a general-purpose input.
- H – Pin can be configured as a general-purpose output.

Table 2–2. Signal Descriptions (Continued)

| SIGNAL NAME | TYPE† | OTHER‡ | DESCRIPTION |
|--|-------|--------|--|
| INTERRUPT AND RESET SIGNALS | | | |
| $\overline{\text{RESET}}$ | I | C | Device reset. $\overline{\text{RESET}}$ causes the DSP to terminate execution and causes reinitialization of the CPU and peripherals. The response of the DSP after reset is determined by the RST_MODE pin. |
| RST_MODE | I | | Device reset mode control. RST_MODE controls how a device reset is handled. As of revision 2.1, the RST_MODE function will no longer be supported. RST_MODE will be driven low internally. After reset, the CPU will branch to the reset vector and begin execution. The external state of the RST_MODE pin will have no effect on device operation. |
| $\overline{\text{INT0}}$ $\overline{\text{INT1}}$ $\overline{\text{INT2}}$ $\overline{\text{INT3}}$ $\overline{\text{INT4}}$ $\overline{\text{INT5}}$ | I | C | Maskable external interrupts. $\overline{\text{INT0}}$ – $\overline{\text{INT5}}$ are prioritized and are maskable via the interrupt enable registers (IER0 and IER1) and the Interrupt Mode bit (INTM in ST1_55). $\overline{\text{INT0}}$ – $\overline{\text{INT5}}$ can be polled and reset via the Interrupt Flag Registers (IFR0 and IFR1). |
| $\overline{\text{NMI}}$ | I | C | Nonmaskable external interrupt. $\overline{\text{NMI}}$ is an external interrupt that cannot be masked by the interrupt enable registers (IER0 and IER1). When $\overline{\text{NMI}}$ is activated, the interrupt is always performed. |
| JTAG EMULATION | | | |
| TCK | I | A,C | IEEE Standard 1149.1 test clock. TCK is normally a free-running clock signal with a 50% duty cycle. The changes on the test access port (TAP) of input signals TDI and TMS are clocked into the TAP controller, instruction register, or selected test data register on the rising edge of TCK. Changes at the TAP output signal TDO occur on the falling edge of TCK. |
| TDI | I | A | IEEE Standard 1149.1 test data input. TDI is clocked into the selected register (instruction or data) on the rising edge of TCK. |
| TDO | O | – | IEEE Standard 1149.1 test data output. The contents of the selected register (instruction or data) are shifted out of TDO on the falling edge of TCK. TDO is in the high-impedance state except when the scanning of data is in progress. |
| TMS | I | A | IEEE Standard 1149.1 test mode select. This serial control input is clocked into the TAP controller on the rising edge of TCK. |
| $\overline{\text{TRST}}$ | I | B | IEEE Standard 1149.1 test reset. $\overline{\text{TRST}}$, when high, gives the IEEE standard 1149.1 scan system control of the operations of the device. If $\overline{\text{TRST}}$ is not connected, or driven low, the device operates in its functional mode, and the IEEE standard 1149.1 signals are ignored. This pin has an on-chip pulldown circuit to provide control of the pin when it is not externally connected. An external pullup resistor should not be connected to this pin. |

† I = Input, O = Output, S = Supply, Z = High impedance

‡ Other Pin Characteristics:

A – Internal pullup (always enabled)

B – Internal pulldown (always enabled)

C – Hysteresis input

D – Pin has bus holder

J – Internal pullup enabled by the HPE bit in the system register (SYSR)

K – Internal pulldown enabled by the HPE bit in the system register (SYSR)

E – Pin is high impedance in HOLD mode (due to $\overline{\text{HOLD}}$ pin).

F – Pin is high impedance in OFF mode (due to EMU1/OFF pin).

G – Pin can be configured as a general-purpose input.

H – Pin can be configured as a general-purpose output.

Table 2–2. Signal Descriptions (Continued)

| SIGNAL NAME | TYPE† | OTHER‡ | DESCRIPTION |
|---|-------|--------|--|
| JTAG EMULATION (CONTINUED) | | | |
| EMU0 | I/O/Z | A | Emulation pin 0. When $\overline{\text{TRST}}$ is driven low, EMU0 must be high for activation of the $\overline{\text{OFF}}$ condition. When $\overline{\text{TRST}}$ is driven high, EMU0 is used as an interrupt to or from the emulator system and is defined as input/output by way of the IEEE standard 1449.1 scan system. |
| EMU1/ $\overline{\text{OFF}}$ | I/O/Z | A | Emulation pin 1 / disable all outputs. When $\overline{\text{TRST}}$ is driven high, EMU1/ $\overline{\text{OFF}}$ is used as an interrupt to or from the emulator system and is defined as input/output by way of the IEEE standard 1149.1 scan system. When $\overline{\text{TRST}}$ is driven low, EMU1/ $\overline{\text{OFF}}$ is configured as OFF. The EMU1/ $\overline{\text{OFF}}$ signal, when active low, puts all output drivers into the high-impedance state. Note that OFF is used exclusively for testing and emulation purposes (not for multiprocessing applications). Therefore, for the $\overline{\text{OFF}}$ feature, the following apply: TRST = low EMU0 = high EMU1/ $\overline{\text{OFF}}$ = low |
| RSVD[1:9] | I/O | | Reserved. Reserved for future emulation purposes. These pins should be left unconnected. |
| CLOCK SIGNALS | | | |
| CLKIN | I | C | Clock input |
| CLKOUT | O/Z | F | Clock output. CLKOUT can represent the internal CPU clock or can be divided down to generate a slower clock by programming the CLKDIV field in the system register (SYSR). |
| CLKMD | I | C | Clock mode select. CLKMD selects the mode of the clock generator after reset. When CLKMD is low after reset, the clock generator will run at the same frequency as CLKIN. If CLKMD is high after reset, the clock generator will run at one-half of the frequency of CLKIN. The clock generator can later be reprogrammed in software. |
| TIMERS | | | |
| TIN/TOUT0 | I/O/Z | F,H | Timer 0 input/output. When configured as an output, TIN/TOUT0 generates a pulse or toggles when on-chip Timer 0 counts down to zero. When configured as an input, TIN/TOUT0 is used as a clock reference for Timer 0. The operation of this pin is configured in the timer control register (TCR0). |
| TIN/TOUT1 | | F,H | Timer 1 input/output. When configured as an output, TIN/TOUT1 generates a pulse or toggles when on-chip Timer 1 counts down to zero. When configured as an input, TIN/TOUT1 is used as a clock reference for Timer 1. The operation of this pin is configured in the timer control register (TCR1). |
| GENERAL-PURPOSE I/O SIGNALS | | | |
| IO7 IO6 IO5 IO4 IO3/BOOTM2 IO2/BOOTM1 IO1/BOOTM0 IO0 | I/O/Z | F,G,H | General-purpose configurable inputs/outputs. IO[7:0] can be individually configured as inputs or outputs via the GPIO direction register (IODIR). Data can be read from inputs or data written to outputs via the GPIO Data Register (IODATA). In addition, the bootloader uses IO4 as an output during the boot process. For detailed information on the operation of the bootloader, see the <i>Using the TMS320VC5510 Bootloader</i> application report (literature number SPRA763). Boot Mode Selection signals. BOOTM[2:0] are sampled following reset to configure the boot mode for the DSP. These signals are shared with IO[3:1]. After boot is complete, these signals can be used as general-purpose inputs/outputs. |
| BOOTM3 | I | A | Boot Mode Selection signal. BOOTM3 is sampled during the operation of the on-chip bootloader in conjunction with BOOTM[2:0] to configure the boot mode. |
| XF | O/Z | F,H | External flag output |

† I = Input, O = Output, S = Supply, Z = High impedance

‡ Other Pin Characteristics:

A – Internal pullup (always enabled)

B – Internal pulldown (always enabled)

C – Hysteresis input

D – Pin has bus holder

J – Internal pullup enabled by the HPE bit in the system register (SYSR)

K – Internal pulldown enabled by the HPE bit in the system register (SYSR)

E – Pin is high impedance in HOLD mode (due to $\overline{\text{HOLD}}$ pin).F – Pin is high impedance in OFF mode (due to EMU1/ $\overline{\text{OFF}}$ pin).

G – Pin can be configured as a general-purpose input.

H – Pin can be configured as a general-purpose output.

Table 2–2. Signal Descriptions (Continued)

| SIGNAL NAME | TYPE† | OTHER‡ | DESCRIPTION |
|----------------------------|-------|--------|---|
| SUPPLY VOLTAGE PINS | | | |
| CV _{DD} | S | | Dedicated power supply for the internal logic (CPU and peripherals) |
| DV _{DD} | S | | Dedicated power supply for the I/O pins |
| V _{SS} | S | | Ground |
| MISCELLANEOUS PINS | | | |
| NC | | | No connection – do not connect |

† I = Input, O = Output, S = Supply, Z = High impedance

‡ Other Pin Characteristics:

- | | |
|--|---|
| A – Internal pullup (always enabled) | E – Pin is high impedance in HOLD mode (due to $\overline{\text{HOLD}}$ pin). |
| B – Internal pulldown (always enabled) | F – Pin is high impedance in OFF mode (due to EMU1/ $\overline{\text{OFF}}$ pin). |
| C – Hysteresis input | G – Pin can be configured as a general-purpose input. |
| D – Pin has bus holder | H – Pin can be configured as a general-purpose output. |
| J – Internal pullup enabled by the HPE bit in the system register (SYSR) | |
| K – Internal pulldown enabled by the HPE bit in the system register (SYSR) | |

3 Functional Overview

The following functional overview is based on the block diagram in Figure 3–1.

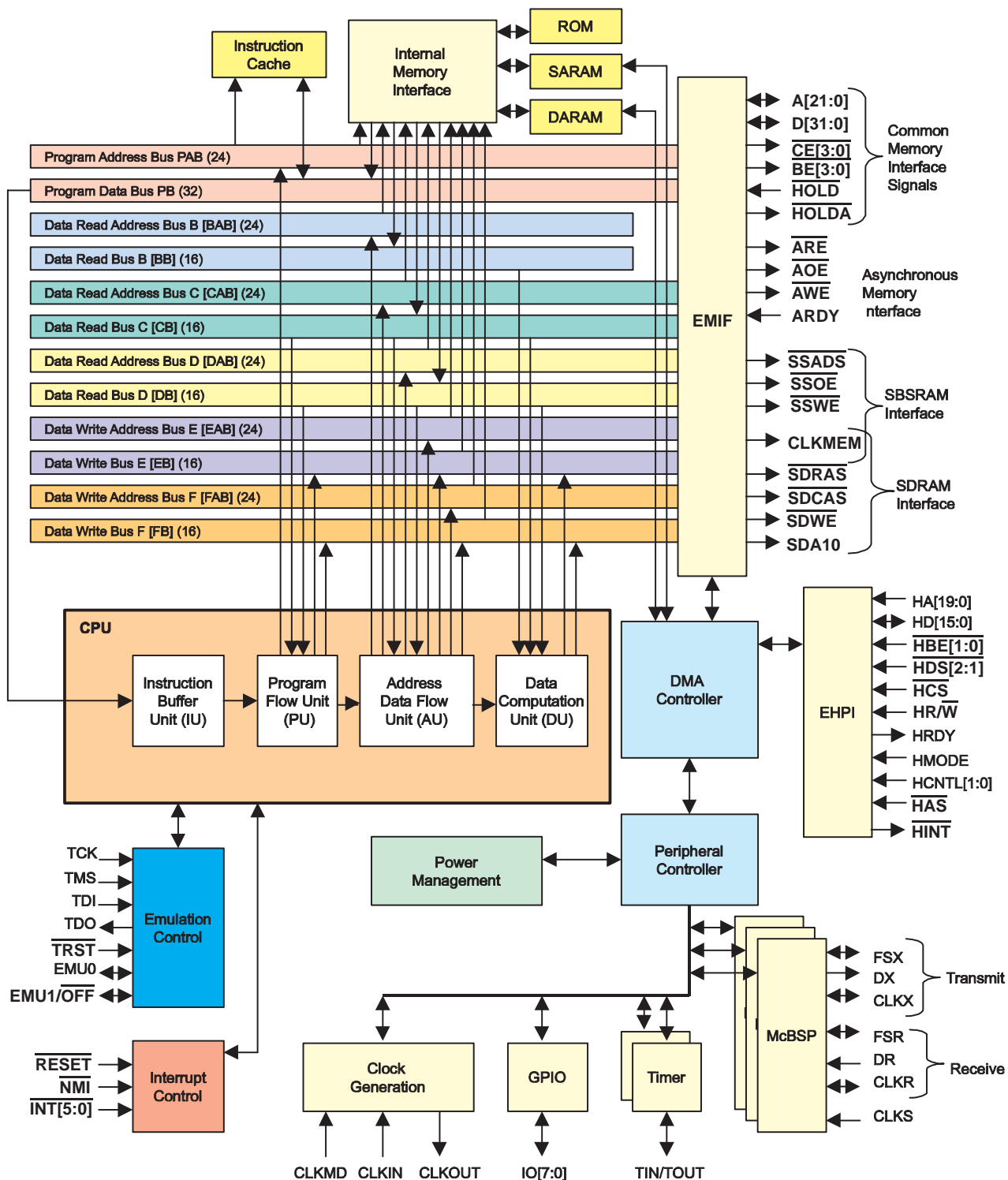


Figure 3–1. TMS320VC5510/5510A Functional Block Diagram

3.1 Memory

The 5510/5510A supports a unified memory map (program and data accesses are made to the same physical space). The total on-chip memory is 352K bytes (176K 16-bit words).

3.1.1 On-Chip Dual-Access RAM (DARAM)

The DARAM is located in the byte address range 000000h–00FFFFh and is composed of eight blocks of 8K-bytes each (see Table 3–1). Each DARAM block can perform two accesses per cycle (two reads, two writes, or a read and a write). DARAM can be accessed by the internal program, data, or DMA buses.

Table 3–1. DARAM Blocks

| BYTE ADDRESS RANGE | MEMORY BLOCK |
|--------------------|--------------|
| 000000h – 001FFFh | DARAM 0† |
| 002000h – 003FFFh | DARAM 1 |
| 004000h – 005FFFh | DARAM 2 |
| 006000h – 007FFFh | DARAM 3 |
| 008000h – 009FFFh | DARAM 4 |
| 00A000h – 00BFFFh | DARAM 5 |
| 00C000h – 00DFFFh | DARAM 6 |
| 00E000h – 00FFFFh | DARAM 7 |

† First 192 bytes are reserved for Memory-Mapped Registers (MMRs).

3.1.2 On-Chip Single-Access RAM (SARAM)

The SARAM is located at the byte address range 010000h–04FFFFh and is composed of 32 blocks of 8K-bytes each (see Table 3–2). Each SARAM block can perform one access per cycle (one read or one write). SARAM can be accessed by the internal program, data, or DMA buses.

Table 3–2. SARAM Blocks

| BYTE ADDRESS RANGE | MEMORY BLOCK | BYTE ADDRESS RANGE | MEMORY BLOCK |
|--------------------|--------------|--------------------|--------------|
| 010000h – 011FFFh | SARAM 0 | 030000h – 031FFFh | SARAM 16 |
| 012000h – 013FFFh | SARAM 1 | 032000h – 033FFFh | SARAM 17 |
| 014000h – 015FFFh | SARAM 2 | 034000h – 035FFFh | SARAM 18 |
| 016000h – 017FFFh | SARAM 3 | 036000h – 037FFFh | SARAM 19 |
| 018000h – 019FFFh | SARAM 4 | 038000h – 039FFFh | SARAM 20 |
| 01A000h – 01BFFFh | SARAM 5 | 03A000h – 03BFFFh | SARAM 21 |
| 01C000h – 01DFFFh | SARAM 6 | 03C000h – 03DFFFh | SARAM 22 |
| 01E000h – 01FFFFh | SARAM 7 | 03E000h – 03FFFFh | SARAM 23 |
| 020000h – 021FFFh | SARAM 8 | 040000h – 041FFFh | SARAM 24 |
| 022000h – 023FFFh | SARAM 9 | 042000h – 043FFFh | SARAM 25 |
| 024000h – 025FFFh | SARAM 10 | 044000h – 045FFFh | SARAM 26 |
| 026000h – 027FFFh | SARAM 11 | 046000h – 047FFFh | SARAM 27 |
| 028000h – 029FFFh | SARAM 12 | 048000h – 049FFFh | SARAM 28 |
| 02A000h – 02BFFFh | SARAM 13 | 04A000h – 04BFFFh | SARAM 29 |
| 02C000h – 02DFFFh | SARAM 14 | 04C000h – 04DFFFh | SARAM 30 |
| 02E000h – 02FFFFh | SARAM 15 | 04E000h – 04FFFFh | SARAM 31 |

3.1.3 On-Chip ROM

The ROM is located at the byte address range FF8000h–FFFFFFh when MPNMC = 0 at reset. The ROM is composed of a single block of 32K bytes. When MPNMC = 1 at reset, the on-chip ROM is disabled and not present in the memory map, and byte address range FF8000h–FFFFFFh is directed to external memory space. MPNMC is a bit located in the ST3 status register, and its status is determined by the logic level on the BOOTM[2:0] pins when sampled at reset. If BOOTM[2:0] are all logic 0 at reset, the MPNMC bit is set to 1 and the on-chip ROM is disabled; otherwise, the MPNMC bit is cleared to 0 and the on-chip ROM is enabled. These pins are not sampled again until the next hardware reset. The software reset instruction does not affect the MPNMC bit. Software can also be used to set or clear the MPNMC bit. ROM can be accessed by the program, data, or DMA buses. The first 16-bit word access to ROM requires three cycles. Subsequent accesses require two cycles per 16-bit word.

The standard on-chip ROM contains a bootloader which provides a variety of methods to load application code automatically after power up or a hardware reset. For more information, see Section 3.1.5 of this document. The vector table associated with the bootloader is also contained in the ROM.

A sine look-up table is provided containing 256 values (crossing 360 degrees) expressed in Q15 format.

The remaining components are used during factory testing purposes.

Table 3–3. Standard On-Chip ROM Contents

| BYTE ADDRESS RANGE | DESCRIPTION |
|--------------------|--------------------|
| FF8000h – FF8FFFh | Bootloader |
| FF9000h – FFF9FFFh | Reserved |
| FFFA00h – FFFBFFFh | Sine look-up table |
| FFFC00h – FFFEFFFh | Factory Test Code |
| FFFF00h – FFFFFBh | Vector Table |
| FFFFFCh – FFFFFFFh | ID Code |

3.1.4 Instruction Cache

The 24K-byte instruction cache provides three configurations:

- One 2-way cache block only
- One 2-way cache block plus one RAMSET block
- One 2-way cache block plus two RAMSET blocks

The 2-way cache uses 2-way set associative mapping and holds up to 16K bytes. It is organized as 512 sets of two cache lines per set. Each cache line contains 16 bytes. Each tag has two corresponding cache lines, providing two opportunities for a hit on a given tag. The 2-way cache is updated based on a least-recently-used algorithm.

Each RAMSET block provides a 4K-byte bank of memory to hold a continuous image of code. Each RAMSET is composed of 256 lines with 16 bytes per line. Each RAMSET uses a single tag to define a continuous memory image in the RAMSET. The tag defines the start address of the RAMSET. Once the TAG is loaded, the RAMSET is filled. The RAMSET contents remain constant until the tag is changed. The RAMSETs provide an efficient method to cache frequently used functions.

Control bits in CPU status register ST3_55 provide the ability to enable, freeze, and flush the cache.

For more information on the instruction cache, see the *TMS320VC5510 DSP Instruction Cache Reference Guide* (literature number SPRU576).

3.1.5 Memory Map

| Byte Address [†] (Hex) | Memory Blocks | Block Length |
|---------------------------------|---|-----------------|
| 000000 | DARAM [‡] (8 Blocks) | 65,536 Bytes |
| 010000 | SARAM [§] (32 Blocks) | 262,144 Bytes |
| 050000 | External [¶] – $\overline{\text{CE0}}$ | 3,866,624 Bytes |
| 400000 | External [¶] – $\overline{\text{CE1}}$ | 4,194,304 Bytes |
| 800000 | External [¶] – $\overline{\text{CE2}}$ | 4,194,304 Bytes |
| C00000 | External [¶] – $\overline{\text{CE3}}$ | 4,161,536 Bytes |
| FF8000 | ROM [#] if MPNMC=0 (1 Block) | 32,768 Bytes |
| FFFFFF | External [¶] – $\overline{\text{CE3}}$ if MPNMC=1 | |

[†] Address shown represents the first byte address in each block.

[‡] Dual-access RAM (DARAM): two accesses per cycle per block, 8 blocks of 8K bytes.

[§] Single-access RAM (SARAM): one access per cycle per block, 32 blocks of 8K bytes.

[¶] External memory spaces are selected by the chip-enable signal shown ($\overline{\text{CE}}[0:3]$).

Supported memory types include: asynchronous, synchronous DRAM (SDRAM), and synchronous burst SRAM (SBSRAM).

[#] Read-only memory (ROM): one access every two cycles, one block of 32K bytes.

Figure 3–2. TMS320VC5510/5510A Memory Map

3.1.6 Bootloader

The on-chip bootloader provides a method to transfer application code and tables from an external source to the on-chip RAM at power up. The 5510/5510A provides several options to download the code to accommodate varying system requirements. These options include:

- Enhanced Host-Port Interface (EHPI) boot
- External memory boot from 8-/16-/32-bit-wide asynchronous memory
- Serial slave boot from McBSP0 with 8- or 16-bit element length
- Serial EEPROM boot from McBSP0 in 8-bit SPI format

External pins BOOTM3, BOOTM2, BOOTM1, and BOOTM0 select the boot configuration. The values of BOOTM[2:0] are latched with the rising edge of the $\overline{\text{RESET}}$ input. BOOTM[0] is shared with general-purpose IO1. BOOTM[1] is shared with general-purpose IO2. BOOTM[2] is shared with general-purpose IO3.

The boot configurations available are summarized in Table 3–4. For detailed information on the bootloader functions, refer to the *Using the TMS320VC5510 Bootloader* Application Report (literature number SPRA763).

Table 3–4. TMS320VC5510/5510A Boot Configurations

| BOOTM[3:0] | BOOT PROCESS | EXECUTION START BYTE ADDRESS AFTER BOOT IS COMPLETE |
|------------|--|---|
| 0000 | No boot | FFFF00h (reset vector) |
| 0001 | Serial SPI EEPROM boot from McBSP0 supporting 24-bit address | Destination specified in the boot table |
| 0010 | Reserved | – |
| 0011 | Reserved | – |
| 0100 | Reserved | – |
| 0101 | Reserved | – |
| 0110 | Reserved | – |
| 0111 | Reserved | – |
| 1000 | No boot | FFFF00h (reset vector) |
| 1001 | Serial SPI EEPROM boot from McBSP0 supporting 16-bit address | Destination specified in the boot table |
| 1010 | Parallel EMIF boot from 8-bit asynchronous memory | Destination specified in the boot table |
| 1011 | Parallel EMIF boot from 16-bit asynchronous memory | Destination specified in the boot table |
| 1100 | Parallel EMIF boot from 32-bit asynchronous memory | Destination specified in the boot table |
| 1101 | EHPI boot | 010000h (on-chip SARAM) |
| 1110 | Standard serial boot from McBSP0, 16-bit element length | Destination specified in the boot table |
| 1111 | Standard serial boot from McBSP0, 8-bit element length | Destination specified in the boot table |

3.2 Peripherals

The 5510/5510A supports the following peripherals:

- An external memory interface (EMIF)
- A six-channel direct memory access (DMA) controller
- 16-bit parallel Enhanced Host-Port Interface (EHPI)
- A digital phase-locked loop (DPLL) clock generator
- Two timers
- Three multichannel buffered serial ports (McBSPs)
- Eight configurable general-purpose I/O pins

Peripheral information specific to the 5510/5510A peripherals is included in the following sections. For detailed information on the C55x™ DSP peripherals, see the following documents:

- *TMS320C55x™ DSP Functional Overview* (literature number SPRU312)
- *TMS320C55x DSP Peripherals Overview Reference Guide* (literature number SPRU317)
- *TMS320VC5510 DSP Instruction Cache Reference Guide* (literature number SPRU576)
- *TMS320VC5501/5502/5503/5507/5509/5510 DSP Multichannel Buffered Serial Port (McBSP) Reference Guide* (literature number SPRU592)
- *TMS320VC5503/5507/5509/5510 DSP Direct Memory Access (DMA) Controller Reference Guide* (literature number SPRU587)
- *TMS320VC5510 DSP Host Port Interface (HPI) Reference Guide* (literature number SPRU588)
- *TMS320VC5503/5507/5509/5510 DSP Timers Reference Guide* (literature number SPRU595)

3.2.1 System Register (SYSR)

The 5510/5510A system register (SYSR) provides control over certain device-specific functions. SYSR is located at port address 07FDh.

| | | | | | | | | | | |
|----------|-------|-------|-------|--------|----------|----------|----------|----------|---------|---|
| 15 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 0 |
| Reserved | HPE | BH | HBH | BOOTM3 | Reserved | Reserved | Reserved | Reserved | CLKDIV | |
| R-000000 | R/W-1 | R/W-0 | R/W-0 | R-0 | R-0 | R/W-0 | R/W-0 | R/W-0 | R/W-000 | |

LEGEND: R = Read, W = Write, *n* = value after reset

Figure 3–3. System Register (SYSR) Bit Layout

Table 3–5. System Register (SYSR) Bit Functions

| BIT NO. | BIT NAME | RESET VALUE | FUNCTION |
|---------|----------|-------------|---|
| 15–10 | Reserved | 000000 | These bits are reserved and are unaffected by writes. |
| 9 | HPE | 1 | EHPI pullup/pulldown enable. Enables the internal pullups on the EHPI control pins <u>HDS1</u> , <u>HDS2</u> , <u>HCS</u> , <u>HAS</u> , <u>HR/W</u> , <u>HMODE</u> , <u>HCNTL0</u> , and <u>HA1/HCNTL1</u> . Enables the internal pulldowns on EHPI control pins <u>HBE0</u> and <u>HBE1</u> . HPE = 0 Pullups and pulldowns disabled HPE = 1 Pullups and pulldowns enabled. |
| 8 | BH | 0 | EMIF data bus holder enable. Enables internal bus holders on D[31:0]. BH = 0 EMIF data bus holders disabled. BH = 1 EMIF data bus holders enabled. |
| 7 | HBH | 0 | EHPI data bus holder enable. Enables internal bus holders on HD[15:0]. HBH = 0 EHPI data bus holders disabled. HBH = 1 EHPI data bus holders enabled. |
| 6 | BOOTM3 | 0 | BOOTM3 status. This read-only bit represents the state of the BOOTM3 pin. |
| 5 | Reserved | 0 | This bit is reserved and is unaffected by writes. |
| 4 | Reserved | 0 | This bit is reserved and must be written as 0. |
| 3 | Reserved | 0 | This bit is reserved and is unaffected by writes. |
| 2–0 | CLKDIV | 000 | CLKOUT divide factor. Allows the clock present on the CLKOUT pin to be a divided-down version of the internal CPU clock. This field does not affect the programming of the PLL. CLKDIV = 000 CLKOUT represents the CPU clock divided by 1 CLKDIV = 001 CLKOUT represents the CPU clock divided by 2 CLKDIV = 010 CLKOUT represents the CPU clock divided by 4 CLKDIV = 011 CLKOUT represents the CPU clock divided by 6 CLKDIV = 100 CLKOUT represents the CPU clock divided by 8 CLKDIV = 101 CLKOUT represents the CPU clock divided by 10 CLKDIV = 110 CLKOUT represents the CPU clock divided by 12 CLKDIV = 111 CLKOUT represents the CPU clock divided by 14 |

3.2.2 Direct Memory Access (DMA)

The 5510/5510A DMA provides the following features:

- Four standard ports, one for each of the following data resources: DARAM, SARAM, Peripherals, and External Memory
- Six channels, which allow the DMA controller to track the context of six independent DMA channels
- Programmable low/high priority for each DMA channel
- One interrupt for each DMA channel
- Event synchronization. DMA transfers in each channel can be dependent on the occurrence of selected events.
- Programmable address modification for source and destination addresses
- Dedicated Idle Domain allows the DMA controller to be placed in a low-power (idle) state under software control.
- DMA controller supports EHPI accesses to internal/external memory

The 5510/5510A DMA controller allows transfers to be synchronized to selected events. The 5510/5510A supports 14 separate sync events and each channel can be tied to separate sync events independent of the other channels. Sync events are selected by programming the SYNC field in the channel-specific DMA Channel Control Register (DMA_CCR). The sync events available on the 5510/5510A are shown in Table 3–6.

For more information on the 5510/5510A DMA, see the *TMS320VC5503/5507/5509/5510 DSP Direct Memory Access (DMA) Controller Reference Guide* (literature number SPRU587).

Table 3–6. DMA Sync Events

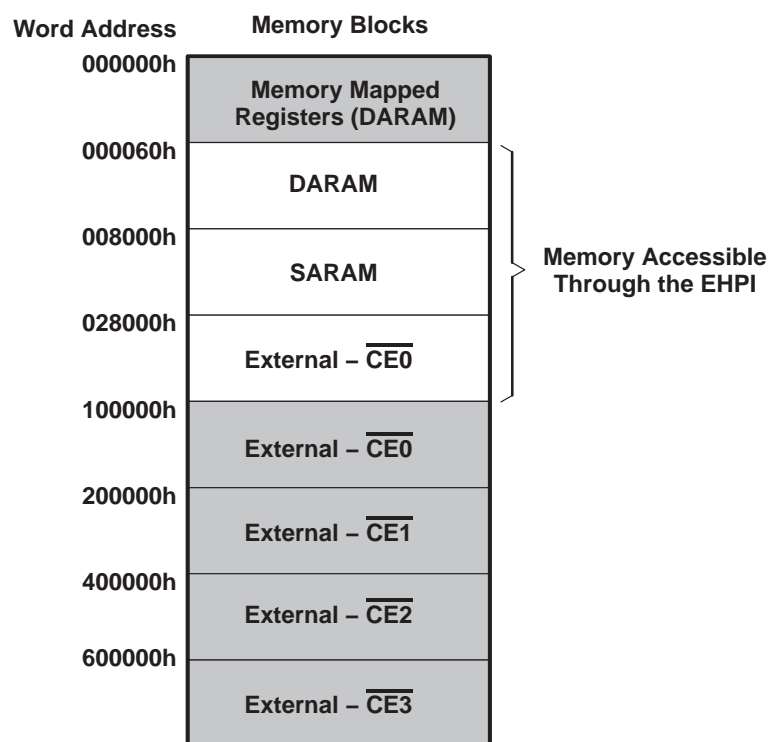
| SYNC FIELD IN DMA_CCR | SYNC EVENT |
|-----------------------|------------------------------------|
| 00000b | No sync event |
| 00001b | McBSP0 receive event (REVT0) |
| 00010b | McBSP0 transmit event (XEVT0) |
| 00101b | McBSP1 receive event (REVT1) |
| 00110b | McBSP1 transmit event (XEVT1) |
| 01001b | McBSP2 receive event (REVT2) |
| 01010b | McBSP2 transmit event (XEVT2) |
| 01101b | Timer 0 event |
| 01110b | Timer 1 event |
| 01111b | External Interrupt 0 |
| 10000b | External Interrupt 1 |
| 10001b | External Interrupt 2 |
| 10010b | External Interrupt 3 |
| 10011b | External Interrupt 4 |
| 10100b | External Interrupt 5 |
| Other values | Reserved (do not use these values) |

3.2.3 Enhanced Host Port Interface (EHPI)

The 5510/5510A EHPI provides a 16-bit parallel interface to a host with the following features:

- 20-bit host address bus
- 16-bit host data bus
- Multiplexed and non-multiplexed bus modes
- Host access to on-chip SARAM, on-chip DARAM, and external memory
- 20-bit address register (in multiplexed mode) with autoincrement capability for faster transfers
- Multiple address/data strobes provide a glueless interface to a variety of hosts
- HRDY signal for handshaking with host

The 5510/5510A EHPI can access internal DARAM, internal SARAM and a portion of the external memory space. The EHPI cannot directly access the on-chip peripherals and cannot access the memory-mapped registers below word address 000060h in DARAM. Note that all memory accesses made through the EHPI are word-addressed. A map of the memory space accessible by the EHPI is shown in Figure 3–4. The EHPI can access from word address 000060h to 0FFFFFFh. The shaded areas of the memory map are not accessible by the EHPI.



NOTE A: The shaded areas of the memory map are not accessible by the EHPI.

Figure 3–4. EHPI Memory Map

When the EHPI inputs are uncontrolled, noise on the inputs can cause spurious accesses that may corrupt internal memory. If the EHPI is not driven by a host, the $\overline{\text{HCS}}$ pin should be driven high by one of the following methods:

- An external device
- External pullup resistor, or
- The on-chip pullup circuit controlled by the HPE bit in the System Register (SYSR). See Section 3.2.1 for more information on how to configure this control.

As of revision 2.1, the byte-enable function of the EHPI is no longer supported. Pins $\overline{\text{HBE0}}$ and $\overline{\text{HBE1}}$ must be driven low at all times.

For more information on the 5510/5510A EHPI, see the *TMS320VC5510 DSP Host Port Interface (HPI) Reference Guide* (literature number SPRU588).

3.2.4 General-Purpose Input/Output Port (GPIO)

The 5510/5510A provides eight dedicated general-purpose input/output pins, IO0–IO7. Each pin can be independently configured as an input or an output using the I/O Direction Register (IODIR). The I/O Data Register (IODATA) is used to monitor the logic state of pins configured as inputs and control the logic state of pins configured as outputs. IODIR and IODATA are accessible to the CPU and to the DMA controller at addresses in I/O space. See Table 3–19 for address information. The description of the IODIR is shown in Figure 3–5 and Table 3–7. The description of IODATA is shown in Figure 3–6 and Table 3–8.

To configure a GPIO pin as an input, clear the direction bit that corresponds to the pin in IODIR to 0. To read the logic state of the input pin, read the corresponding bit in IODATA.

To configure a GPIO pin as an output, set the direction bit that corresponds to the pin in IODIR to 1. To control the logic state of the output pin, write to the corresponding bit in IODATA.

| 15 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| Reserved | IO7DIR | IO6DIR | IO5DIR | IO4DIR | IO3DIR | IO2DIR | IO1DIR | IO0DIR | |
| R-00000000 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

LEGEND: R = Read, W = Write, *n* = value after reset

Figure 3–5. I/O Direction Register (IODIR) Bit Layout

Table 3–7. I/O Direction Register (IODIR) Bit Functions

| BIT NO. | BIT NAME | RESET VALUE | FUNCTION |
|---------|----------|-------------|--|
| 15–8 | Reserved | 0 | These bits are reserved and are unaffected by writes. |
| 7–0 | IOxDIR | 0 | IOx Direction Control Bit. Controls whether IOx operates as an input or an output. IOxDIR = 0 IOx is configured as an input. IOxDIR = 1 IOx is configured as an output. |

| 15 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Reserved | IO7D | IO6D | IO5D | IO4D | IO3D | IO2D | IO1D | IO0D | |
| R-00000000 | R/W-pin | R/W-pin | R/W-pin | R/W-pin | R/W-pin | R/W-pin | R/W-pin | R/W-pin | R/W-pin |

LEGEND: R = Read, W = Write, *pin* = value present on the pin (IO7–IO0 default to inputs after reset)

Figure 3–6. I/O Data Register (IODATA) Bit Layout

Table 3–8. I/O Data Register (IODATA) Bit Functions

| BIT NO. | BIT NAME | RESET VALUE | FUNCTION |
|---------|----------|-------------------------|---|
| 15–8 | Reserved | 0 | These bits are reserved and are unaffected by writes. |
| 7–0 | IOxD | <i>pin</i> [†] | IOx Data Bit. If IOx is configured as an input (IOxDIR = 0 in IODIR): IOxD = 0 The signal on the IOx pin is low. IOxD = 1 The signal on the IOx pin is high. If IOx is configured as an output (IOxDIR = 1 in IODIR): IOxD = 0 Drive the signal on the IOx pin low. IOxD = 1 Drive the signal on the IOx pin high. |

[†] *pin* = value present on the pin (IO7–IO0 default to inputs after reset)

3.3 CPU Register Description

The 5510/5510A CPU registers are shown in Table 3–9. For code compatibility, many TMS320C55x (C55x) CPU registers map to comparable TMS320C54x™ (C54x™) CPU register addresses. The corresponding TMS320C54x (C54x) CPU registers are indicated in these instances.

Table 3–9. CPU Registers

| C54x REGISTER | VC5510/5510A REGISTER | WORD ADDRESS (HEX) | DESCRIPTION |
|---------------|-----------------------|--------------------|---|
| IMR | IER0 | 00 | Interrupt Mask Register 0 |
| IFR | IFR0 | 01 | Interrupt Flag Register 0 |
| – | ST0_55 | 02 | Status Register 0 for C55x |
| – | ST1_55 | 03 | Status Register 1 for C55x |
| – | ST3_55 | 04 | Status Register 3 for C55x |
| – | – | 05 | Reserved |
| ST0 | ST0 | 06 | Status Register ST0 (for 54x compatibility) |
| ST1 | ST1 | 07 | Status Register ST1 (for 54x compatibility) |
| AL | AC0L | 08 | Accumulator 0 (equivalent to Accumulator A on C54x) |
| AH | AC0H | 09 | |
| AG | AC0G | 0A | |
| BL | AC1L | 0B | Accumulator 1 (equivalent to Accumulator A on C54x) |
| BH | AC1H | 0C | |
| BG | AC1G | 0D | |
| TREG | T3 | 0E | Temporary Register |
| TRN | TRN0 | 0F | Transition Register |
| AR0 | AR0 | 10 | Auxiliary Register 0 |
| AR1 | AR1 | 11 | Auxiliary Register 1 |
| AR2 | AR2 | 12 | Auxiliary Register 2 |
| AR3 | AR3 | 13 | Auxiliary Register 3 |
| AR4 | AR4 | 14 | Auxiliary Register 4 |
| AR5 | AR5 | 15 | Auxiliary Register 5 |
| AR6 | AR6 | 16 | Auxiliary Register 6 |
| AR7 | AR7 | 17 | Auxiliary Register 7 |
| SP | SP | 18 | Stack Pointer Register |
| BK | BK03 | 19 | Circular Buffer Size Register |
| BRC | BRC0 | 1A | Block Repeat Counter |
| RSA | RSA0L | 1B | Block Repeat Start Address |
| REA | REA0L | 1C | Block Repeat End Address |
| PMST | PMST | 1D | Processor Mode Status Register |
| XPC | XPC | 1E | Program Counter Extension Register |
| – | – | 1F | Reserved |
| – | T0 | 20 | Temporary Data Register 0 |
| – | T1 | 21 | Temporary Data Register 1 |
| – | T2 | 22 | Temporary Data Register 2 |
| – | T3 | 23 | Temporary Data Register 3 |

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Table 3–9. CPU Registers (Continued)

| C54x REGISTER | VC5510/5510A REGISTER | WORD ADDRESS (HEX) | DESCRIPTION |
|---------------|-----------------------|--------------------|--|
| – | AC2L | 24 | Accumulator 2 |
| – | AC2H | 25 | |
| – | AC2G | 26 | |
| – | CDP | 27 | Coefficient Data Pointer |
| – | AC3L | 28 | Accumulator 3 |
| – | AC3H | 29 | |
| – | AC3G | 2A | |
| – | DPH | 2B | Extended Data Page Pointer |
| – | MDP05 | 2C | Reserved |
| – | MDP67 | 2D | Reserved |
| – | DP | 2E | Memory Data Page Start Address |
| – | PDP | 2F | Peripheral Data Page Start Address |
| – | BK47 | 30 | Circular Buffer Size Register for AR[4–7] |
| – | BKC | 31 | Circular Buffer Size Register for CDP |
| – | BSA01 | 32 | Circular Buffer Start Address Register for AR[0–1] |
| – | BSA23 | 33 | Circular Buffer Start Address Register for AR[2–3] |
| – | BSA45 | 34 | Circular Buffer Start Address Register for AR[4–5] |
| – | BSA67 | 35 | Circular Buffer Start Address Register for AR[6–7] |
| – | BSAC | 36 | Circular Buffer Coefficient Start Address Register |
| – | BIOS | 37 | Data Page Pointer Storage Location for 128-word Data Table |
| – | TRN1 | 38 | Transition Register 1 |
| – | BRC1 | 39 | Block Repeat Counter 1 |
| – | BRS1 | 3A | Block Repeat Save 1 |
| – | CSR | 3B | Computed Single Repeat |
| – | RSA0H | 3C | Repeat Start Address 0 |
| – | RSA0L | 3D | |
| – | REA0H | 3E | Repeat End Address 0 |
| – | REA0L | 3F | |
| – | RSA1H | 40 | Repeat Start Address 1 |
| – | RSA1L | 41 | |
| – | REA1H | 42 | Repeat End Address 1 |
| – | REA1L | 43 | |
| – | RPTC | 44 | Repeat Counter |
| – | IER1 | 45 | Interrupt Mask Register 1 |
| – | IFR1 | 46 | Interrupt Flag Register 1 |
| – | DBIER0 | 47 | Debug IER0 |
| – | DBIER1 | 48 | Debug IER1 |
| – | IVPD | 49 | Interrupt Vector Pointer DSP |
| – | IVPH | 4A | Interrupt Vector Pointer HOST |
| – | ST2_55 | 4B | Status Register 2 for C55x |
| – | SSP | 4C | System Stack Pointer |
| – | SP | 4D | User Stack Pointer |
| – | SPH | 4E | Extended Data Page Pointer for the SP and the SSP |
| – | CDPH | 4F | Main Data Page Pointer for the CDP |

3.4 Peripheral Register Description

Peripheral registers on the 5510/5510A are accessed using the port qualifier. For more information on the use of the port qualifier, see the *TMS320C55x Assembly Language Tools User's Guide* (literature number SPRU280). For detailed information on the operation of the peripherals and the functions of each of the peripheral registers, refer to the *TMS320C55x DSP Peripherals Overview Reference Guide* (literature number SPRU317).

NOTE: The CPU access latency to the peripheral memory-mapped registers is 6 CPU cycles. Following peripheral register update(s), the CPU must wait at least 6 CPU cycles before attempting to use that peripheral. When more than one peripheral register is updated in a sequence, the CPU only needs to wait following the final register write. For example, if the EMIF is being reconfigured, the CPU must wait until the very last EMIF register update takes effect before trying to access the external memory. The users should consult the respective peripheral user's guide to determine if a peripheral requires additional time to initialize itself to the new configuration after the register updates take effect.

Table 3–10. Peripheral Bus Controller Configuration Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|--------------|---------------|--------------------------------|
| 0x0001 | ICR | Idle Control Register |
| 0x0002 | ISTR | Idle Status Register |
| 0x000F | BOOT_MOD | Boot Mode Register (read only) |

Table 3–11. Instruction Cache Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|--------------|---------------|---------------------------------------|
| 0x1400 | ICGC | I-Cache Global Control Register |
| 0x1401 | ICFL0 | I-Cache Flush Line Address Register 0 |
| 0x1402 | ICFL1 | I-Cache Flush Line Address Register 1 |
| 0x1403 | ICWC | I-Cache N-Way Control Register |
| 0x1404 | ICSTAT | I-Cache Status Register |
| 0x1405 | ICRC1 | I-Cache Ramset 1 Control Register |
| 0x1406 | ICRTAG1 | I-Cache Ramset 1 Tag Register |
| 0x1407 | ICRC2 | I-Cache Ramset 2 Control Register |
| 0x1408 | ICRTAG2 | I-Cache Ramset 2 Tag Register |

Table 3–12. External Memory Interface Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|--------------|---------------|-----------------------------------|
| 0x0800 | EGCR | EMIF Global Control Register |
| 0x0801 | EMIRST | EMIF Global Reset Register |
| 0x0802 | EMIBE | EMIF Bus Error Status Register |
| 0x0803 | CE01 | EMIF CE0 Space Control Register 1 |
| 0x0804 | CE02 | EMIF CE0 Space Control Register 2 |
| 0x0805 | CE03 | EMIF CE0 Space Control Register 3 |
| 0x0806 | CE11 | EMIF CE1 Space Control Register 1 |
| 0x0807 | CE12 | EMIF CE1 Space Control Register 2 |
| 0x0808 | CE13 | EMIF CE1 Space Control Register 3 |
| 0x0809 | CE21 | EMIF CE2 Space Control Register 1 |
| 0x080A | CE22 | EMIF CE2 Space Control Register 2 |
| 0x080B | CE23 | EMIF CE2 Space Control Register 3 |
| 0x080C | CE31 | EMIF CE3 Space Control Register 1 |
| 0x080D | CE32 | EMIF CE3 Space Control Register 2 |
| 0x080E | CE33 | EMIF CE3 Space Control Register 3 |
| 0x080F | SDC1 | EMIF SDRAM Control Register 1 |
| 0x0810 | SDPER | EMIF SDRAM Period Register |
| 0x0811 | SDCNT | EMIF SDRAM Counter Register |
| 0x0812 | INIT | EMIF SDRAM Init Register |
| 0x0813 | SDC2 | EMIF SDRAM Control Register 2 |

Table 3–13. DMA Configuration Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|-----------------------------|-----------------------|---|
| GLOBAL REGISTER | | |
| 0x0E00 | DMAGCR | DMA Global Control Register |
| 0x0E02 | DMAGSCR | DMA Software Compatibility Register |
| 0x0E03 | DMAGTCR | DMA Timeout Control Register |
| CHANNEL #0 REGISTERS | | |
| 0x0C00 | DMACSDP0 | DMA Channel 0 Source / Destination Parameters Register |
| 0x0C01 | DMACCR0 | DMA Channel 0 Control Register |
| 0x0C02 | DMACICR0 | DMA Channel 0 Interrupt Control Register |
| 0x0C03 | DMACSR0 | DMA Channel 0 Status Register |
| 0x0C04 | DMACSSAL0 | DMA Channel 0 Source Start Address Register (lower bits) |
| 0x0C05 | DMACSSAU0 | DMA Channel 0 Source Start Address Register (upper bits) |
| 0x0C06 | DMACDSAL0 | DMA Channel 0 Source Destination Address Register (lower bits) |
| 0x0C07 | DMACDSAU0 | DMA Channel 0 Source Destination Address Register (upper bits) |
| 0x0C08 | DMACEN0 | DMA Channel 0 Element Number Register |
| 0x0C09 | DMACFN0 | DMA Channel 0 Frame Number Register |
| 0x0C0A | DMACFI0/ DMACSFIO† | DMA Channel 0 Frame Index Register/ DMA Channel 0 Source Frame Index Register† |
| 0x0C0B | DMACEIO/ DMACSEIO‡ | DMA Channel 0 Element Index Register/ DMA Channel 0 Source Element Index Register‡ |
| 0x0C0C | DMACSAC0 | DMA Channel 0 Source Address Counter |
| 0x0C0D | DMACDAC0 | DMA Channel 0 Destination Address Counter |
| 0x0C0E | DMACDEI0 | DMA Channel 0 Destination Element Index Register |
| 0x0C0F | DMACDFI0 | DMA Channel 0 Destination Frame Index Register |
| CHANNEL #1 REGISTERS | | |
| 0x0C20 | DMACSDP1 | DMA Channel 1 Source / Destination Parameters Register |
| 0x0C21 | DMACCR1 | DMA Channel 1 Control Register |
| 0x0C22 | DMACICR1 | DMA Channel 1 Interrupt Control Register |
| 0x0C23 | DMACSR1 | DMA Channel 1 Status Register |
| 0x0C24 | DMACSSAL1 | DMA Channel 1 Source Start Address Register (lower bits) |
| 0x0C25 | DMACSSAU1 | DMA Channel 1 Source Start Address Register (upper bits) |
| 0x0C26 | DMACDSAL1 | DMA Channel 1 Source Destination Address Register (lower bits) |
| 0x0C27 | DMACDSAU1 | DMA Channel 1 Source Destination Address Register (upper bits) |
| 0x0C28 | DMACEN1 | DMA Channel 1 Element Number Register |
| 0x0C29 | DMACFN1 | DMA Channel 1 Frame Number Register |
| 0x0C2A | DMACFI1/ DMACSF11† | DMA Channel 1 Frame Index Register/ DMA Channel 1 Source Frame Index Register† |
| 0x0C2B | DMACEI1/ DMACSEI1‡ | DMA Channel 1 Element Index Register/ DMA Channel 1 Source Element Index Register‡ |
| 0x0C2C | DMACSAC1 | DMA Channel 1 Source Address Counter |
| 0x0C2D | DMACDAC1 | DMA Channel 1 Destination Address Counter |
| 0x0C2E | DMACDEI1 | DMA Channel 1 Destination Element Index Register |
| 0x0C2F | DMACDFI1 | DMA Channel 1 Destination Frame Index Register |

† On revision 1.x, the channel frame index applies to both source and destination and this register behaves as DMACFI. On revision 2.0 and later, DMACSF1 and DMACDF1 provide separate source and destination frame indexing. Revision 2.0 and later can be programmed for software compatibility with revision 1.x through the Software Compatibility Register (DMAGSCR).

‡ On revision 1.x, the channel element index applies to both source and destination and this register behaves as DMACEI. On revision 2.0 and later, DMACSEI and DMACDEI provide separate source and destination frame indexing. Revision 2.0 and later can be programmed for software compatibility with revision 1.x through the Software Compatibility Register (DMAGSCR).

Table 3–13. DMA Configuration Registers (Continued)

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|-----------------------------|-----------------------|---|
| CHANNEL #2 REGISTERS | | |
| 0x0C40 | DMACSDP2 | DMA Channel 2 Source / Destination Parameters Register |
| 0x0C41 | DMACCR2 | DMA Channel 2 Control Register |
| 0x0C42 | DMACICR2 | DMA Channel 2 Interrupt Control Register |
| 0x0C43 | DMACSR2 | DMA Channel 2 Status Register |
| 0x0C44 | DMACSSAL2 | DMA Channel 2 Source Start Address Register (lower bits) |
| 0x0C45 | DMACSSAU2 | DMA Channel 2 Source Start Address Register (upper bits) |
| 0x0C46 | DMACDSAL2 | DMA Channel 2 Source Destination Address Register (lower bits) |
| 0x0C47 | DMACDSAU2 | DMA Channel 2 Source Destination Address Register (upper bits) |
| 0x0C48 | DMACEN2 | DMA Channel 2 Element Number Register |
| 0x0C49 | DMACFN2 | DMA Channel 2 Frame Number Register |
| 0x0C4A | DMACFI2/ DMACSF12† | DMA Channel 2 Frame Index Register/ DMA Channel 2 Source Frame Index Register† |
| 0x0C4B | DMACEI2/ DMACSEI2‡ | DMA Channel 2 Element Index Register/ DMA Channel 2 Source Element Index Register‡ |
| 0x0C4C | DMACSAC2 | DMA Channel 2 Source Address Counter |
| 0x0C4D | DMACDAC2 | DMA Channel 2 Destination Address Counter |
| 0x0C4E | DMACDEI2 | DMA Channel 2 Destination Element Index Register |
| 0x0C4F | DMACDFI2 | DMA Channel 2 Destination Frame Index Register |
| CHANNEL #3 REGISTERS | | |
| 0x0C60 | DMACSDP3 | DMA Channel 3 Source / Destination Parameters Register |
| 0x0C61 | DMACCR3 | DMA Channel 3 Control Register |
| 0x0C62 | DMACICR3 | DMA Channel 3 Interrupt Control Register |
| 0x0C63 | DMACSR3 | DMA Channel 3 Status Register |
| 0x0C64 | DMACSSAL3 | DMA Channel 3 Source Start Address Register (lower bits) |
| 0x0C65 | DMACSSAU3 | DMA Channel 3 Source Start Address Register (upper bits) |
| 0x0C66 | DMACDSAL3 | DMA Channel 3 Source Destination Address Register (lower bits) |
| 0x0C67 | DMACDSAU3 | DMA Channel 3 Source Destination Address Register (upper bits) |
| 0x0C68 | DMACEN3 | DMA Channel 3 Element Number Register |
| 0x0C69 | DMACFN3 | DMA Channel 3 Frame Number Register |
| 0x0C6A | DMACFI3/ DMACSF13† | DMA Channel 3 Frame Index Register/ DMA Channel 3 Source Frame Index Register† |
| 0x0C6B | DMACEI3/ DMACSEI3‡ | DMA Channel 3 Element Index Register/ DMA Channel 3 Source Element Index Register‡ |
| 0x0C6C | DMACSAC3 | DMA Channel 3 Source Address Counter |
| 0x0C6D | DMACDAC3 | DMA Channel 3 Destination Address Counter |
| 0x0C6E | DMACDEI3 | DMA Channel 3 Destination Element Index Register |
| 0x0C6F | DMACDFI3 | DMA Channel 3 Destination Frame Index Register |

† On revision 1.x, the channel frame index applies to both source and destination and this register behaves as DMACFIn. On revision 2.0 and later, DMACSFIn and DMACDFIn provide separate source and destination frame indexing. Revision 2.0 and later can be programmed for software compatibility with revision 1.x through the Software Compatibility Register (DMAGSCR).

‡ On revision 1.x, the channel element index applies to both source and destination and this register behaves as DMACEIn. On revision 2.0 and later, DMACSEIn and DMACDEIn provide separate source and destination frame indexing. Revision 2.0 and later can be programmed for software compatibility with revision 1.x through the Software Compatibility Register (DMAGSCR).

Table 3–13. DMA Configuration Registers (Continued)

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|-----------------------------|-----------------------|---|
| CHANNEL #4 REGISTERS | | |
| 0x0C80 | DMACSDP4 | DMA Channel 4 Source / Destination Parameters Register |
| 0x0C81 | DMACCR4 | DMA Channel 4 Control Register |
| 0x0C82 | DMACICR4 | DMA Channel 4 Interrupt Control Register |
| 0x0C83 | DMACSR4 | DMA Channel 4 Status Register |
| 0x0C84 | DMACSSAL4 | DMA Channel 4 Source Start Address Register (lower bits) |
| 0x0C85 | DMACSSAU4 | DMA Channel 4 Source Start Address Register (upper bits) |
| 0x0C86 | DMACDSAL4 | DMA Channel 4 Source Destination Address Register (lower bits) |
| 0x0C87 | DMACDSAU4 | DMA Channel 4 Source Destination Address Register (upper bits) |
| 0x0C88 | DMACEN4 | DMA Channel 4 Element Number Register |
| 0x0C89 | DMACFN4 | DMA Channel 4 Frame Number Register |
| 0x0C8A | DMACFI4/ DMACSF14† | DMA Channel 4 Frame Index Register/ DMA Channel 4 Source Frame Index Register† |
| 0x0C8B | DMACEI4/ DMACSEI4‡ | DMA Channel 4 Element Index Register/ DMA Channel 4 Source Element Index Register‡ |
| 0x0C8C | DMACSA4 | DMA Channel 4 Source Address Counter |
| 0x0C8D | DMACDA4 | DMA Channel 4 Destination Address Counter |
| 0x0C8E | DMACDEI4 | DMA Channel 4 Destination Element Index Register |
| 0x0C8F | DMACDFI4 | DMA Channel 4 Destination Frame Index Register |
| CHANNEL #5 REGISTERS | | |
| 0x0CA0 | DMACSDP5 | DMA Channel 5 Source / Destination Parameters Register |
| 0x0CA1 | DMACCR5 | DMA Channel 5 Control Register |
| 0x0CA2 | DMACICR5 | DMA Channel 5 Interrupt Control Register |
| 0x0CA3 | DMACSR5 | DMA Channel 5 Status Register |
| 0x0CA4 | DMACSSAL5 | DMA Channel 5 Source Start Address Register (lower bits) |
| 0x0CA5 | DMACSSAU5 | DMA Channel 5 Source Start Address Register (upper bits) |
| 0x0CA6 | DMACDSAL5 | DMA Channel 5 Source Destination Address Register (lower bits) |
| 0x0CA7 | DMACDSAU5 | DMA Channel 5 Source Destination Address Register (upper bits) |
| 0x0CA8 | DMACEN5 | DMA Channel 5 Element Number Register |
| 0x0CA9 | DMACFN5 | DMA Channel 5 Frame Number Register |
| 0x0CAA | DMACFI5/ DMACSF15† | DMA Channel 5 Frame Index Register/ DMA Channel 5 Source Frame Index Register† |
| 0x0CAB | DMACEI5/ DMACSEI5‡ | DMA Channel 5 Element Index Register/ DMA Channel 5 Source Element Index Register‡ |
| 0x0CAC | DMACSA5 | DMA Channel 5 Source Address Counter |
| 0x0CAD | DMACDA5 | DMA Channel 5 Destination Address Counter |
| 0x0CAE | DMACDEI5 | DMA Channel 5 Destination Element Index Register |
| 0x0CAF | DMACDFI5 | DMA Channel 5 Destination Frame Index Register |

† On revision 1.x, the channel frame index applies to both source and destination and this register behaves as DMACFIn. On revision 2.0 and later, DMACSFIn and DMACDFIn provide separate source and destination frame indexing. Revision 2.0 and later can be programmed for software compatibility with revision 1.x through the Software Compatibility Register (DMAGSCR).

‡ On revision 1.x, the channel element index applies to both source and destination and this register behaves as DMACEIn. On revision 2.0 and later, DMACSEIn and DMACDEIn provide separate source and destination frame indexing. Revision 2.0 and later can be programmed for software compatibility with revision 1.x through the Software Compatibility Register (DMAGSCR).

Table 3–14. Clock Generator Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|--------------|---------------|---------------------|
| 0x1C00 | CLKMD | Clock Mode Register |

Table 3–15. Timer Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|--------------|---------------|----------------------------------|
| 0x1000 | TIM0 | Timer 0 Count Register |
| 0x1001 | PRD0 | Timer 0 Period Register |
| 0x1002 | TCR0 | Timer 0 Timer Control Register |
| 0x1003 | PRSC0 | Timer 0 Timer Prescaler Register |
| 0x2400 | TIM1 | Timer 1 Timer Count Register |
| 0x2401 | PRD1 | Timer 1 Period Register |
| 0x2402 | TCR1 | Timer 1 Timer Control Register |
| 0x2403 | PRSC1 | Timer 1 Timer Prescaler Register |

Table 3–16. Multichannel Serial Port #0 Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|--------------|---------------|--|
| 0x2800 | DRR20 | McBSP 0 Data Receive Register 2 |
| 0x2801 | DRR10 | McBSP 0 Data Receive Register 1 |
| 0x2802 | DXR20 | McBSP 0 Data Transmit Register 2 |
| 0x2803 | DXR10 | McBSP 0 Data Transmit Register 1 |
| 0x2804 | SPCR20 | McBSP 0 Serial Port Control Register 2 |
| 0x2805 | SPCR10 | McBSP 0 Serial Port Control Register 1 |
| 0x2806 | RCR20 | McBSP 0 Receive Control Register 2 |
| 0x2807 | RCR10 | McBSP 0 Receive Control Register 1 |
| 0x2808 | XCR20 | McBSP 0 Transmit Control Register 2 |
| 0x2809 | XCR10 | McBSP 0 Transmit Control Register 1 |
| 0x280A | SRGR20 | McBSP 0 Sample Rate Generator Register 2 |
| 0x280B | SRGR10 | McBSP 0 Sample Rate Generator Register 1 |
| 0x280C | MCR20 | McBSP 0 Multichannel Control Register 2 |
| 0x280D | MCR10 | McBSP 0 Multichannel Control Register 1 |
| 0x280E | RCERA0 | McBSP 0 Receive Channel Enable Register Partition A |
| 0x280F | RCERB0 | McBSP 0 Receive Channel Enable Register Partition B |
| 0x2810 | XCERA0 | McBSP 0 Transmit Channel Enable Register Partition A |
| 0x2811 | XCERB0 | McBSP 0 Transmit Channel Enable Register Partition B |
| 0x2812 | PCR0 | McBSP 0 Pin Control Register |
| 0x2813 | RCERC0 | McBSP 0 Receive Channel Enable Register Partition C |
| 0x2814 | RCERD0 | McBSP 0 Receive Channel Enable Register Partition D |
| 0x2815 | XCERC0 | McBSP 0 Transmit Channel Enable Register Partition C |
| 0x2816 | XCERD0 | McBSP 0 Transmit Channel Enable Register Partition D |
| 0x2817 | RCERE0 | McBSP 0 Receive Channel Enable Register Partition E |
| 0x2818 | RCERF0 | McBSP 0 Receive Channel Enable Register Partition F |
| 0x2819 | XCERE0 | McBSP 0 Transmit Channel Enable Register Partition E |
| 0x281A | XCERF0 | McBSP 0 Transmit Channel Enable Register Partition F |
| 0x281B | RCERG0 | McBSP 0 Receive Channel Enable Register Partition G |
| 0x281C | RCERH0 | McBSP 0 Receive Channel Enable Register Partition H |
| 0x281D | XCERG0 | McBSP 0 Transmit Channel Enable Register Partition G |
| 0x281E | XCERH0 | McBSP 0 Transmit Channel Enable Register Partition H |

Table 3–17. Multichannel Serial Port #1 Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|--------------|---------------|--|
| 0x2C00 | DRR21 | McBSP 1 Data Receive Register 2 |
| 0x2C01 | DRR11 | McBSP 1 Data Receive Register 1 |
| 0x2C02 | DXR21 | McBSP 1 Data Transmit Register 2 |
| 0x2C03 | DXR11 | McBSP 1 Data Transmit Register 1 |
| 0x2C04 | SPCR21 | McBSP 1 Serial Port Control Register 2 |
| 0x2C05 | SPCR11 | McBSP 1 Serial Port Control Register 1 |
| 0x2C06 | RCR21 | McBSP 1 Receive Control Register 2 |
| 0x2C07 | RCR11 | McBSP 1 Receive Control Register 1 |
| 0x2C08 | XCR21 | McBSP 1 Transmit Control Register 2 |
| 0x2C09 | XCR11 | McBSP 1 Transmit Control Register 1 |
| 0x2C0A | SRGR21 | McBSP 1 Sample Rate Generator Register 2 |
| 0x2C0B | SRGR11 | McBSP 1 Sample Rate Generator Register 1 |
| 0x2C0C | MCR21 | McBSP 1 Multichannel Control Register 2 |
| 0x2C0D | MCR11 | McBSP 1 Multichannel Control Register 1 |
| 0x2C0E | RCERA1 | McBSP 1 Receive Channel Enable Register Partition A |
| 0x2C0F | RCERB1 | McBSP 1 Receive Channel Enable Register Partition B |
| 0x2C10 | XCERA1 | McBSP 1 Transmit Channel Enable Register Partition A |
| 0x2C11 | XCERB1 | McBSP 1 Transmit Channel Enable Register Partition B |
| 0x2C12 | PCR1 | McBSP 1 Pin Control Register |
| 0x2C13 | RCERC1 | McBSP 1 Receive Channel Enable Register Partition C |
| 0x2C14 | RCERD1 | McBSP 1 Receive Channel Enable Register Partition D |
| 0x2C15 | XCERC1 | McBSP 1 Transmit Channel Enable Register Partition C |
| 0x2C16 | XCERD1 | McBSP 1 Transmit Channel Enable Register Partition D |
| 0x2C17 | RCERE1 | McBSP 1 Receive Channel Enable Register Partition E |
| 0x2C18 | RCERF1 | McBSP 1 Receive Channel Enable Register Partition F |
| 0x2C19 | XCERE1 | McBSP 1 Transmit Channel Enable Register Partition E |
| 0x2C1A | XCERF1 | McBSP 1 Transmit Channel Enable Register Partition F |
| 0x2C1B | RCERG1 | McBSP 1 Receive Channel Enable Register Partition G |
| 0x2C1C | RCERH1 | McBSP 1 Receive Channel Enable Register Partition H |
| 0x2C1D | XCERG1 | McBSP 1 Transmit Channel Enable Register Partition G |
| 0x2C1E | XCERH1 | McBSP 1 Transmit Channel Enable Register Partition H |

Table 3–18. Multichannel Serial Port #2 Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|--------------|---------------|--|
| 0x3000 | DRR22 | McBSP 2 Data Receive Register 2 |
| 0x3001 | DRR12 | McBSP 2 Data Receive Register 1 |
| 0x3002 | DXR22 | McBSP 2 Data Transmit Register 2 |
| 0x3003 | DXR12 | McBSP 2 Data Transmit Register 1 |
| 0x3004 | SPCR22 | McBSP 2 Serial Port Control Register 2 |
| 0x3005 | SPCR12 | McBSP 2 Serial Port Control Register 1 |
| 0x3006 | RCR22 | McBSP 2 Receive Control Register 2 |
| 0x3007 | RCR12 | McBSP 2 Receive Control Register 1 |
| 0x3008 | XCR22 | McBSP 2 Transmit Control Register 2 |
| 0x3009 | XCR12 | McBSP 2 Transmit Control Register 1 |
| 0x300A | SRGR22 | McBSP 2 Sample Rate Generator Register 2 |
| 0x300B | SRGR12 | McBSP 2 Sample Rate Generator Register 1 |
| 0x300C | MCR22 | McBSP 2 Multichannel Control Register 2 |
| 0x300D | MCR12 | McBSP 2 Multichannel Control Register 1 |
| 0x300E | RCERA2 | McBSP 2 Receive Channel Enable Register Partition A |
| 0x300F | RCERB2 | McBSP 2 Receive Channel Enable Register Partition B |
| 0x3010 | XCERA2 | McBSP 2 Transmit Channel Enable Register Partition A |
| 0x3011 | XCERB2 | McBSP 2 Transmit Channel Enable Register Partition B |
| 0x3012 | PCR2 | McBSP 2 Pin Control Register |
| 0x3013 | RCERC2 | McBSP 2 Receive Channel Enable Register Partition C |
| 0x3014 | RCERD2 | McBSP 2 Receive Channel Enable Register Partition D |
| 0x3015 | XCERC2 | McBSP 2 Transmit Channel Enable Register Partition C |
| 0x3016 | XCERD2 | McBSP 2 Transmit Channel Enable Register Partition D |
| 0x3017 | RCERE2 | McBSP 2 Receive Channel Enable Register Partition E |
| 0x3018 | RCERF2 | McBSP 2 Receive Channel Enable Register Partition F |
| 0x3019 | XCERE2 | McBSP 2 Transmit Channel Enable Register Partition E |
| 0x301A | XCERF2 | McBSP 2 Transmit Channel Enable Register Partition F |
| 0x301B | RCERG2 | McBSP 2 Receive Channel Enable Register Partition G |
| 0x301C | RCERH2 | McBSP 2 Receive Channel Enable Register Partition H |
| 0x301D | XCERG2 | McBSP 2 Transmit Channel Enable Register Partition G |
| 0x301E | XCERH2 | McBSP 2 Transmit Channel Enable Register Partition H |

Table 3–19. GPIO Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|--------------|---------------|--|
| 0x3400 | IODIR | General-purpose I/O Direction Register |
| 0x3401 | IODATA | General-purpose I/O Data Register |

Table 3–20. Device Revision ID Registers

| PORT ADDRESS | REGISTER NAME | DESCRIPTION |
|-----------------|---------------|---|
| 0x3800 – 0x3803 | DieID[63:0] | Factory Die Identification [†] |
| 0x3804 | RevID[15:0] | Identifies silicon revision Revision 2.1: 0x6511 Revision 2.2: 0x6512 |

[†] The Die_ID register contains factory identification information and does not require any intervention from the user. When the DIE_ID register is used, at least 3 TCK clocks after reset are required to properly initialize the register contents.

3.5 Interrupts

Vector-relative locations and priorities for all internal and external interrupts are shown in Table 3–21. The locations of the interrupt vectors are defined as an offset from the location defined in the interrupt vector pointers (IVPD and IVPH). For more detailed information about the interrupt vector pointers and interrupts, see the *TMS320C55x DSP CPU Reference Guide* (literature number SPRU371).

Table 3–21. Interrupt Table

| NAME | SOFTWARE (TRAP) EQUIVALENT | OFFSET LOCATION (HEX BYTES) | PRIORITY | FUNCTION |
|---------------------------|----------------------------|-----------------------------|----------|--------------------------------------|
| $\overline{\text{RESET}}$ | SINT0 | 0 | 0 | Reset (hardware and software) |
| $\overline{\text{NMI}}$ | SINT1 | 8 | 1 | Nonmaskable interrupt |
| $\overline{\text{INT0}}$ | SINT2 | 10 | 3 | External interrupt #0 |
| $\overline{\text{INT2}}$ | SINT3 | 18 | 5 | External interrupt #2 |
| TINT0 | SINT4 | 20 | 6 | Timer #0 interrupt |
| RINT0 | SINT5 | 28 | 7 | McBSP #0 receive interrupt |
| RINT1 | SINT6 | 30 | 9 | McBSP #1 receive interrupt |
| XINT1 | SINT7 | 38 | 10 | McBSP #1 transmit interrupt |
| – | SINT8 | 40 | 11 | Software interrupt #8 |
| DMAC1 | SINT9 | 48 | 13 | DMA Channel #1 interrupt |
| DSPINT | SINT10 | 50 | 14 | Interrupt from host (EHPI) |
| $\overline{\text{INT3}}$ | SINT11 | 58 | 15 | External interrupt #3 |
| RINT2 | SINT12 | 60 | 17 | McBSP #2 receive interrupt |
| XINT2 | SINT13 | 68 | 18 | McBSP #2 transmit interrupt |
| DMAC4 | SINT14 | 70 | 21 | DMA Channel #4 interrupt |
| DMAC5 | SINT15 | 78 | 22 | DMA Channel #5 interrupt |
| $\overline{\text{INT1}}$ | SINT16 | 80 | 4 | External interrupt #1 |
| XINT0 | SINT17 | 88 | 8 | McBSP #0 transmit interrupt |
| DMAC0 | SINT18 | 90 | 12 | DMA Channel #0 interrupt |
| INT4 | SINT19 | 98 | 16 | External interrupt #4 |
| DMAC2 | SINT20 | A0 | 19 | DMA Channel #2 interrupt |
| DMAC3 | SINT21 | A8 | 20 | DMA Channel #3 interrupt |
| TINT1 | SINT22 | B0 | 23 | Timer #1 interrupt |
| $\overline{\text{INT5}}$ | SINT23 | B8 | 24 | External interrupt #5 |
| BERR | SINT24 | C0 | 2 | Bus Error interrupt |
| DLOG | SINT25 | C8 | 25 | Data Log interrupt |
| RTOS | SINT26 | D0 | 26 | Real-time Operating System interrupt |
| – | SINT27 | D8 | 27 | Software interrupt #27 |
| – | SINT28 | E0 | 28 | Software interrupt #28 |
| – | SINT29 | E8 | 29 | Software interrupt #29 |
| – | SINT30 | F0 | 30 | Software interrupt #30 |
| | SINT31 | F8 | 31 | Software interrupt #31 |

The bit layouts of these registers for each interrupt are shown in Figure 3–7.

| | | | | | | | |
|-------|-------|-------|-------|------|--------|----------|----------|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
| DMAC5 | DMAC4 | XINT2 | RINT2 | INT3 | DSPINT | DMAC1 | Reserved |
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| XINT1 | RINT1 | RINT0 | TINT0 | INT2 | INT0 | Reserved | |

Figure 3–7. IFR0, IER0, DBIFR0, and DBIER0 Bit Locations

| | | | | | | | | | | | |
|----------|--|-------|--|-------|--|-------|--|------|--|-------|--|
| 15 | | | | 11 | | 10 | | 9 | | 8 | |
| Reserved | | | | | | RTOS | | DLOG | | BERR | |
| 7 | | 6 | | 5 | | 4 | | 3 | | 2 | |
| 1 | | 0 | | 1 | | 0 | | 1 | | 0 | |
| INT5 | | TINT1 | | DMAC3 | | DMAC2 | | INT4 | | DMAC0 | |
| XINT0 | | INT1 | | | | | | | | | |

Figure 3–8. IFR1, IER1, DBIFR1, and DBIER1 Bit Locations

3.5.2 Interrupt Timing

The external interrupts ($\overline{\text{NMI}}$ and $\overline{\text{INTx}}$) are automatically synchronized to the CPU. The interrupt inputs are sampled on the falling edges of the CPU clock. A sequence on the interrupt pin of 1-0-0-0 on consecutive cycles is required for an interrupt to be detected. Therefore, the minimum low pulse duration on the external interrupts on the 5510/5510A is three CPU clock periods.

3.6 Notices Concerning CLKOUT Operation

3.6.1 CLKOUT Voltage Level

On the TMS320VC5510/5510A, CLKOUT is driven at CV_{DD} supply voltage. This voltage level may be too low to interface to some devices. In that event, buffers may need to be employed to support interfacing CLKOUT.

3.6.2 CLKOUT Value During Reset

During reset, the CLKOUT pin is driven to a logic 1.

4 Support

4.1 Notices Concerning JTAG (IEEE 1149.1) Boundary Scan Test Capability

4.1.1 Initialization Requirements for Boundary Scan Test

The TMS320VC5510/5510A uses the JTAG port for boundary scan tests, emulation capability and factory test purposes. To use boundary scan test, the EMU0 and EMU1/ $\overline{\text{OFF}}$ pins must be held LOW through a rising edge of the $\overline{\text{TRST}}$ signal prior to the first scan. This operation selects the appropriate TAP control for boundary scan. If at any time during a boundary scan test a rising edge of $\overline{\text{TRST}}$ occurs when EMU0 or EMU1/ $\overline{\text{OFF}}$ are not low, a factory test mode may be selected preventing boundary scan test from being completed. For this reason, it is recommended that EMU0 and EMU1/ $\overline{\text{OFF}}$ be pulled or driven low at all times during boundary scan test.

4.1.2 Boundary Scan Description Language (BSDL) Model

BSDL models are available on the web in the TMS320VC5510/5510A product folder under the "simulation models" section.

4.2 Documentation Support

Extensive documentation supports all TMS320™ DSP family of devices from product announcement through applications development. The following types of documentation are available to support the design and use of the TMS320C5000™ platform of DSPs:

- *TMS320C55x™ DSP Functional Overview* (literature number SPRU312)
- *TMS320C55x DSP Peripherals Overview Reference Guide* (literature number SPRU317)
- *TMS320C55x DSP CPU Reference Guide* (literature number SPRU371)
- *TMS320C55x DSP CPU Programmer's Reference Supplement* (literature number SPRU652)
- *TMS320C55x Assembly Language Tools User's Guide* (literature number SPRU280)
- *TMS320C55x Hardware Extensions for Image/Video Applications Programmer's Reference* (literature number SPRU098)
- *TMS320C55x Image/Video Processing Library Programmer's Reference* (literature number SPRU037)
- *TMS320VC5510 DSP Instruction Cache Reference Guide* (literature number SPRU576)
- *TMS320VC5501/5502/5503/5507/5509/5510 DSP Multichannel Buffered Serial Port (McBSP) Reference Guide* (literature number SPRU592)
- *TMS320VC5503/5507/5509/5510 DSP Direct Memory Access (DMA) Controller Reference Guide* (literature number SPRU587)
- *TMS320VC5510 DSP Host Port Interface (HPI) Reference Guide* (literature number SPRU588)
- *TMS320VC5503/5507/5509/5510 DSP Timers Reference Guide* (literature number SPRU595)
- *Using the TMS320VC5510 Bootloader* application report (literature number SPRA763)
- *TMS320VC5510/5510A Hardware Designer's Resource Guide* (literature number SPRAA43)
- *TMS320VC5510/5510A Digital Signal Processors Silicon Errata* (literature number SPRZ008)
- Device-specific data sheets
- Complete user's guides
- Development support tools
- Hardware and software application reports

The reference set describes in detail the TMS320C55x DSP products currently available and the hardware and software applications, including algorithms, for fixed-point TMS320™ DSP family of devices.

A series of DSP textbooks is published by Prentice-Hall and John Wiley & Sons to support digital signal processing research and education. The TMS320 DSP newsletter, *Details on Signal Processing*, is published quarterly and distributed to update TMS320 DSP customers on product information.

Information regarding Texas Instruments (TI) DSP products is also available on the Worldwide Web at <http://www.ti.com> uniform resource locator (URL).

TMS320 and TMS320C5000 are trademarks of Texas Instruments.

4.3 Device and Development-Support Tool Nomenclature

To designate the stages in the product development cycle, TI assigns prefixes to the part numbers of all DSP devices and support tools. Each DSP commercial family member has one of three prefixes: TMX, TMP, or TMS (e.g., **TMS**320VC5510A). Texas Instruments recommends two of three possible prefix designators for its support tools: TMDX and TMDS. These prefixes represent evolutionary stages of product development from engineering prototypes (TMX/TMDX) through fully qualified production devices/tools (TMS/TMDS).

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

Support tool development evolutionary flow:

- TMDX** Development-support product that has not yet completed Texas Instruments internal qualification testing.
- TMDS** Fully qualified development-support product

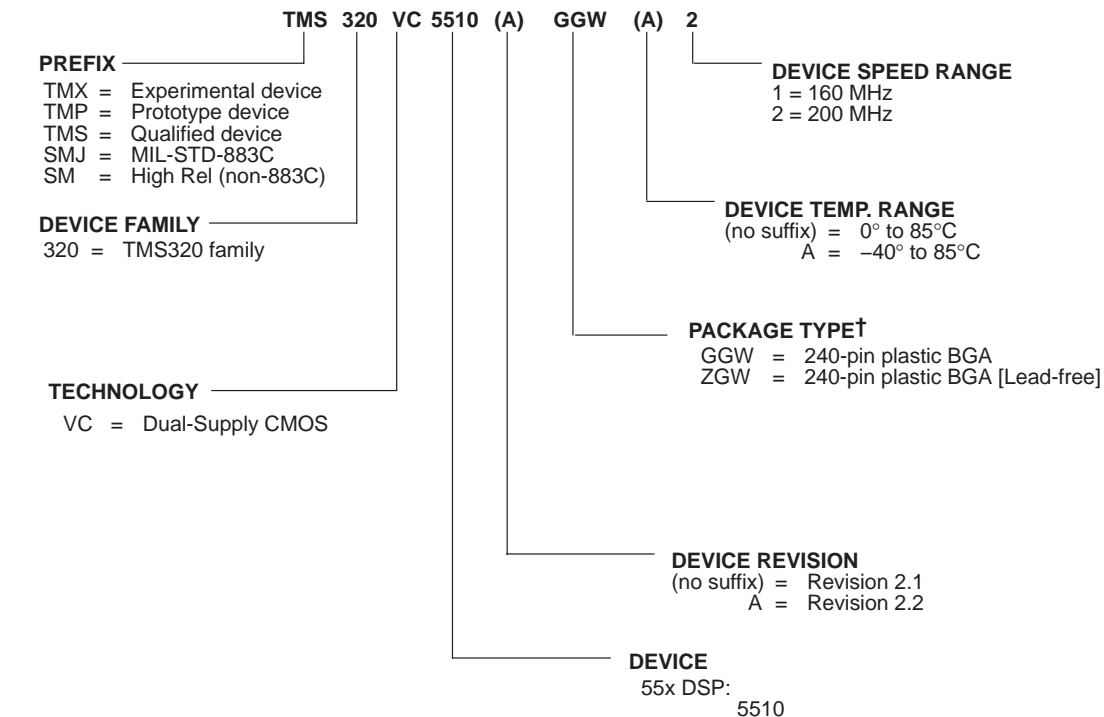
TMX and TMP devices and TMDX development-support tools are shipped against the following disclaimer:

"Developmental product is intended for internal evaluation purposes."

TMS devices and TMDS development-support tools 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.

4.4 TMS320VC5510/5510A Device Nomenclature



† BGA = Ball Grid Array

Figure 4–1. Device Nomenclature for the TMS320VC5510/5510A

5 Electrical Specifications

This section provides the absolute maximum ratings and the recommended operating conditions for the TMS320VC5510/5510A DSPs.

All electrical and switching characteristics in this data manual are valid over the recommended operating conditions unless otherwise specified.

5.1 Absolute Maximum Ratings

The list of absolute maximum ratings are specified over operating case temperature. Stresses beyond those listed under “absolute maximum ratings” (Section 5.2) 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” (Section 5.3) is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability. All supply voltage values (core and I/O) are with respect to V_{SS} . Figure 5–1 provides the test load circuit values for a 3.3-V device. Measured timing information contained in this data manual is based on the test load setup and conditions shown in Figure 5–1.

5.2 Electrical Specifications

This section provides the absolute maximum ratings for the TMS320VC5510/5510A DSPs.

| | |
|--|------------------|
| Supply voltage I/O range, DV_{DD} | – 0.3 V to 4.0 V |
| Supply voltage core range, CV_{DD} | – 0.3 V to 2.0 V |
| Input voltage range, V_I | – 0.3 V to 4.5 V |
| Output voltage range, V_O | – 0.3 V to 4.5 V |
| Operating case temperature range, T_C : (Commercial) | 0°C to 85°C |
| (Extended) | – 40°C to 85°C |
| Storage temperature range T_{stg} | – 55°C to 150°C |

5.3 Recommended Operating Conditions

| | | MIN | NOM | MAX | UNIT |
|-----------|-------------------------------|---|-----|-----------------|------|
| DV_{DD} | Device supply voltage, I/O | 3.0 | 3.3 | 3.6 | V |
| CV_{DD} | Device supply voltage, core | 1.55 | 1.6 | 1.65 | V |
| V_{SS} | Supply voltage, GND | 0 | | | V |
| V_{IH} | High-level input voltage, I/O | Hysteresis inputs $DV_{DD} = 3.3 \pm 0.3$ V | | 2.4 | V |
| | | All other inputs | | $DV_{DD} + 0.3$ | |
| V_{IL} | Low-level input voltage, I/O | Hysteresis inputs $DV_{DD} = 3.3 \pm 0.3$ V | | –0.3 | V |
| | | All other inputs | | 0.8 | |
| I_{OH} | High-level output current | All outputs | | –8 | mA |
| I_{OL} | Low-level output current | All outputs | | 8 | mA |
| T_C | Operating case temperature | Prototype (TMX) and Commercial Temperature Range Production Devices | | 0 | °C |
| | | Extended Temperature Range Production (TMS) devices | | –40 | |

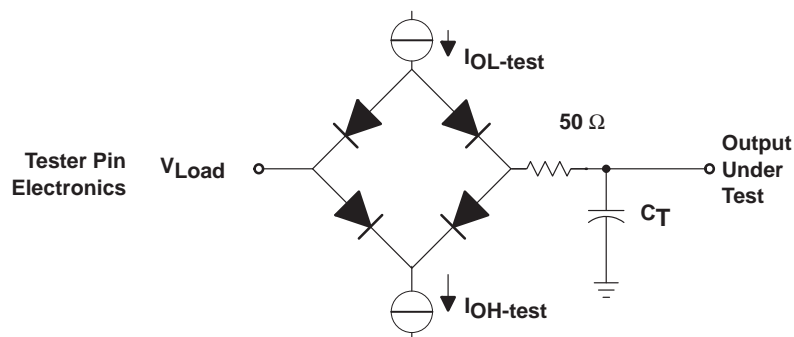
† See the TMS320VC5510/5510A Digital Signal Processors Silicon Errata (literature number SPRZ008) for further clarification and distinguishing markings.

5.4 Electrical Characteristics Over Recommended Operating Case Temperature Range (Unless Otherwise Noted)

| PARAMETER | | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|------------------|--|--|--|--|-------|-----|-----|------|
| V _{OH} | High-level output voltage | All output except CLKOUT | DV _{DD} = 3.3 ± 0.3 V, I _{OH} = MAX | | 2.4 | | | V |
| | | CLKOUT | CV _{DD} = 1.6 ± 0.05 V, I _{OH} = MAX | | 1.24 | | | |
| V _{OL} | Low-level output voltage | | I _{OL} = MAX | | | | 0.4 | V |
| I _{IZ} | Input current for outputs in high impedance | Output-only or input/output pins with bus holders | Bus holders enabled CV _{DD} = MAX, V _O = V _{SS} to V _{DD} | | – 275 | | 275 | μA |
| | | All other output-only or input/output pins | Bus holders disabled CV _{DD} = MAX, V _O = V _{SS} to V _{DD} | | – 5 | | 5 | |
| I _I | Input current | Input pins with internal pulldown | CV _{DD} = MAX, V _I = V _{SS} to V _{DD} | | – 5 | | 300 | μA |
| | | Input pins with internal pullup | Pullup enabled CV _{DD} = MAX, V _I = V _{SS} to V _{DD} | | – 300 | | 5 | |
| | | All other input-only pins or input-only pins with pullup/pulldown disabled | CV _{DD} = MAX, V _I = V _{SS} to V _{DD} | | – 5 | | 5 | |
| I _{DDC} | CV _{DD} supply current, CPU + internal memory access † | | CV _{DD} = 1.6 V, CPU clock = 200 MHz T _C = 25°C | | 112 | | | mA |
| I _{DDP} | DV _{DD} supply current, pins active ‡ | | DV _{DD} = 3.3 V CPU clock = 100 MHz T _C = 25°C | | 8 | | | mA |
| I _{DDC} | CV _{DD} supply current, standby Only CLKGEN domain enabled, PLL enabled. | | CV _{DD} = 1.6 V 10-MHz clock input, DPLL mode = x 20 T _C = 25°C | | 32 | | | mA |
| I _{DDC} | CV _{DD} supply current, standby All domains idled. | | CV _{DD} = 1.6 V input clock stopped, T _C = 25°C | | 69 | | | μA |
| | | | CV _{DD} = 1.6 V input clock stopped, T _C = 55°C | | 374 | | | μA |
| | | | CV _{DD} = 1.6 V input clock stopped, T _C = 85°C | | 976 | | | μA |
| I _{DDP} | DV _{DD} supply current, standby All domains idled. | | DV _{DD} = 3.3 V no pin activity, T _C = 25°C | | 10 | | | μA |
| | | | DV _{DD} = 3.3 V no pin activity, T _C = 55°C | | 10 | | | μA |
| | | | DV _{DD} = 3.3 V no pin activity, T _C = 85°C | | 10 | | | μA |
| C _I | Input capacitance | | | | 3 | | | pF |
| C _O | Output capacitance | | | | 3 | | | pF |

† Test Condition: CPU executing 75% Dual-MAC / 25% ADD with moderate data bus activity (table of sine values). CPU and CLKGEN domains are active. All other domains are idled. The DPLL is enabled.

‡ Test Condition: One word of a table of 16-bit sine values is written to the EMIF each microsecond (16 Mbps). Each EMIF output pin is connected to a 10-pF load capacitance.



Where:

- $I_{OL-test}$ = +2 mA (all outputs)
- $I_{OH-test}$ = -2 mA (all outputs)
- V_{Load} = 50% of DV_{dd}
- C_T = 15 pF typical load circuit capacitance.

Figure 5–1. 3.3-V Test Load Circuit

5.5 Timing Parameter Symbolology

Timing parameter symbols used in the timing requirements and switching characteristics tables are created in accordance with JEDEC Standard 100. To shorten the symbols, some of the pin names and other related terminology have been abbreviated as follows:

Lowercase subscripts and their meanings:

| | |
|-----|--|
| a | access time |
| c | cycle time (period) |
| d | delay time |
| dis | disable time |
| en | enable time |
| f | fall time |
| h | hold time |
| r | rise time |
| su | setup time |
| t | transition time |
| v | valid time |
| w | pulse duration (width) |
| X | Unknown, changing, or don't care level |

Letters and symbols and their meanings:

| | |
|---|----------------|
| H | High |
| L | Low |
| V | Valid |
| Z | High impedance |

5.6 Clock Options

This section provides the timing requirements and switching characteristics for the various clock options available on the 5510/5510A.

5.6.1 Clock Generation in Bypass Mode (DPLL Disabled)

The frequency of the reference clock provided at the CLKIN pin can be divided by a factor of one, two, or four to generate the internal CPU clock cycle. The divide factor (D) is set in the BYPASS_DIV field of the clock mode register. The contents of this field only affect clock generation while the device is in bypass mode. In this mode, the digital phase-locked loop (DPLL) clock synthesis is disabled.

Table 5–1 and Table 5–2 assume testing over recommended operating conditions and $H = 0.5t_{c(CO)}$ (see Figure 5–2).

Table 5–1. CLKIN in Bypass Mode Timing Requirements

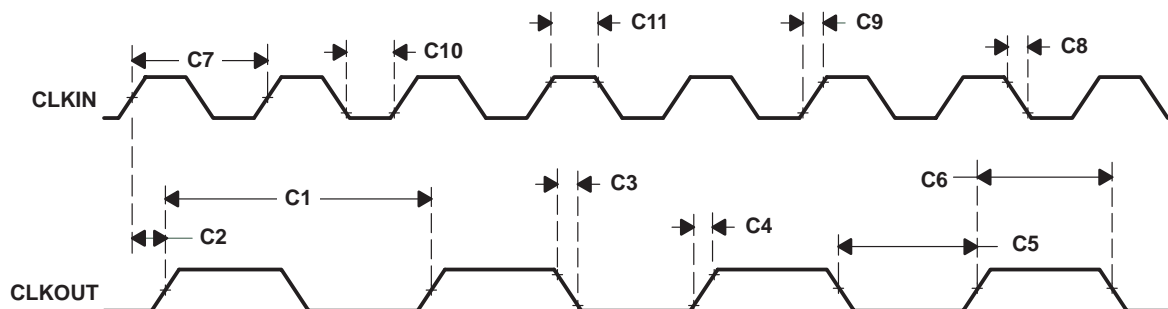
| NO. | | VC5510/5510A-160 | | VC5510/5510A-200 | | UNIT |
|-----|---|------------------|-----|------------------|-----|------|
| | | MIN | MAX | MIN | MAX | |
| C7 | $t_{c(CI)}$ Cycle time, CLKIN | 20 | † | 20 | † | ns |
| C8 | $t_{f(CI)}$ Fall time, CLKIN | | 6 | | 6 | ns |
| C9 | $t_{r(CI)}$ Rise time, CLKIN | | 6 | | 6 | ns |
| C10 | $t_{w(CIL)}$ Pulse duration, CLKIN low | 4 | | 4 | | ns |
| C11 | $t_{w(CIH)}$ Pulse duration, CLKIN high | 4 | | 4 | | ns |

† This device utilizes a fully static design and therefore can operate with $t_{c(CI)}$ approaching ∞ . The device is characterized at frequencies approaching 0 Hz.

Table 5–2. CLKOUT in Bypass Mode Switching Characteristics

| NO. | PARAMETER | VC5510/5510A-160 | | | VC5510/5510A-200 | | | UNIT |
|-----|--|------------------|--------------------------|-----|------------------|--------------------------|-----|------|
| | | MIN | TYP | MAX | MIN | TYP | MAX | |
| C1 | $t_{c(CO)}$ Cycle time, CLKOUT | 20 | $t_{c(CI)}/N^{\ddagger}$ | | 20 | $t_{c(CI)}/N^{\ddagger}$ | | ns |
| C2 | $t_{d(CI-CO)}$ Delay time, CLKIN high/low to CLKOUT high/low | 1 | 7 | 14 | 1 | 7 | 14 | ns |
| C3 | $t_{f(CO)}$ Fall time, CLKOUT | | 1 | | | 1 | | ns |
| C4 | $t_{r(CO)}$ Rise time, CLKOUT | | 1 | | | 1 | | ns |
| C5 | $t_{w(COL)}$ Pulse duration, CLKOUT low | H–1 | | H+1 | H–1 | | H+1 | ns |
| C6 | $t_{w(COH)}$ Pulse duration, CLKOUT high | H–1 | | H+1 | H–1 | | H+1 | ns |

$\ddagger N$ = Clock frequency synthesis factor



NOTE A: The relationship of CLKIN to CLKOUT depends on the divide factor chosen. The waveform relationship shown in Figure 5–2 is intended to illustrate the timing parameters only and may differ based on configuration.

Figure 5–2. Bypass Mode Clock Timing

5.6.2 Clock Generation in Lock Mode (DPLL Synthesis Enabled)

The frequency of the reference clock provided at the CLKIN pin can be multiplied by a synthesis factor of N to generate the internal CPU clock cycle. The synthesis factor is determined by:

$$N = \frac{M}{D_L}$$

where: M = the multiply factor set in the PLL_MULT field of the clock mode register,

D_L = the divide factor set in the PLL_DIV field of the clock mode register

Valid values for M are (multiply by) 2 to 31. Valid values for D_L are (divide by) 1, 2, 3, and 4.

For detailed information on clock generation configuration, see the *TMS320C55x DSP Peripherals Overview Reference Guide* (literature number SPRU317).

Table 5–3 and Table 5–4 assume testing over recommended operating conditions and $H = 0.5t_{c(CO)}$ (see Figure 5–3).

Table 5–3. CLKIN in Lock Mode Timing Requirements

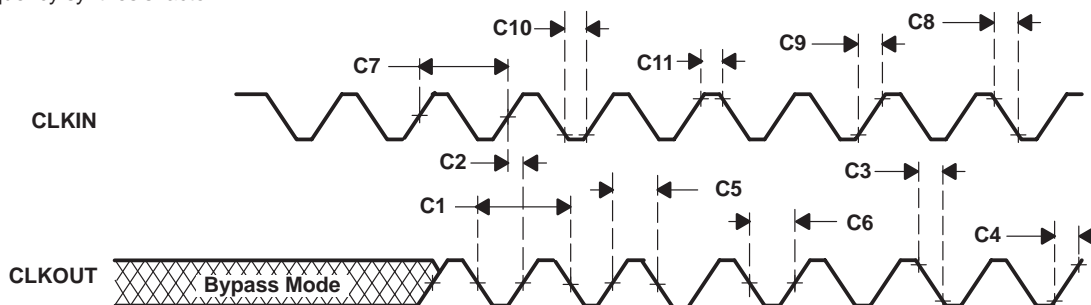
| NO. | | | VC5510/5510A-160 | | VC5510/5510A-200 | | UNIT |
|-----|-------------|----------------------------|------------------------|-----|------------------|-----|------|
| | | | MIN | MAX | MIN | MAX | |
| C7 | $t_{c(CI)}$ | Cycle time, CLKIN | DPLL synthesis enabled | | 20† | 400 | ns |
| C8 | $t_f(CI)$ | Fall time, CLKIN | | 6 | | 6 | ns |
| C9 | $t_r(CI)$ | Rise time, CLKIN | | 6 | | 6 | ns |
| C10 | $t_w(CIL)$ | Pulse duration, CLKIN low | 4 | | 4 | | ns |
| C11 | $t_w(CIH)$ | Pulse duration, CLKIN high | 4 | | 4 | | ns |

† The clock frequency synthesis factor and minimum CLKIN cycle time should be chosen such that the resulting CLKOUT cycle time is within the specified range ($t_{c(CO)}$).

Table 5–4. CLKOUT in Lock Mode Switching Characteristics

| NO. | PARAMETER | | VC5510/5510A-160 | | | VC5510/5510A-200 | | | UNIT |
|-----|--------------|---|------------------|------------------------|-----|------------------|------------------------|-----|------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| C1 | $t_{c(CO)}$ | Cycle time, CLKOUT | 6.25 | $t_{c(CI)}/N^\ddagger$ | | 5 | $t_{c(CI)}/N^\ddagger$ | | ns |
| C2 | $t_d(CI-CO)$ | Delay time, CLKIN high/low to CLKOUT high/low | 1 | 7 | 14 | 1 | 7 | 14 | ns |
| C3 | $t_f(CO)$ | Fall time, CLKOUT | | 1 | | | 1 | | ns |
| C4 | $t_r(CO)$ | Rise time, CLKOUT | | 1 | | | 1 | | ns |
| C5 | $t_w(COL)$ | Pulse duration, CLKOUT low | H–1 | | H+1 | H–1 | | H+1 | ns |
| C6 | $t_w(COH)$ | Pulse duration, CLKOUT high | H–1 | | H+1 | H–1 | | H+1 | ns |

‡ N = Clock frequency synthesis factor



NOTE A: The waveform relationship of CLKIN to CLKOUT depends on the multiply and divide factors chosen. The waveform relationship shown in Figure 5–3 is intended to illustrate the timing parameters only and may differ based on configuration.

Figure 5–3. External Multiply-by-N Clock Timing

5.7 Memory Timing

5.7.1 Asynchronous Memory Timing

Table 5–5 and Table 5–6 assume testing over recommended operating conditions (see Figure 5–4 and Figure 5–5). Note that the asynchronous memory interface is read-only when configured as 8-bit mode. Asynchronous writes in 8-bit mode are not supported.

Table 5–5. Asynchronous Memory Cycles Timing Requirements

| NO. | | | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|-----|--------------------|---|--------------------------------------|------|
| | | | MIN MAX | |
| A6 | $t_{su}(DV-COH)$ | Setup time, read data valid before CLKOUT high [†] | 6 | ns |
| A7 | $t_h(COH-DV)$ | Hold time, read data valid after CLKOUT high | 0 | ns |
| A10 | $t_{su}(ARDY-COH)$ | Setup time, ARDY valid before CLKOUT high | 7 | ns |
| A11 | $t_h(COH-ARDY)$ | Hold time, ARDY valid after CLKOUT high | 0 | ns |

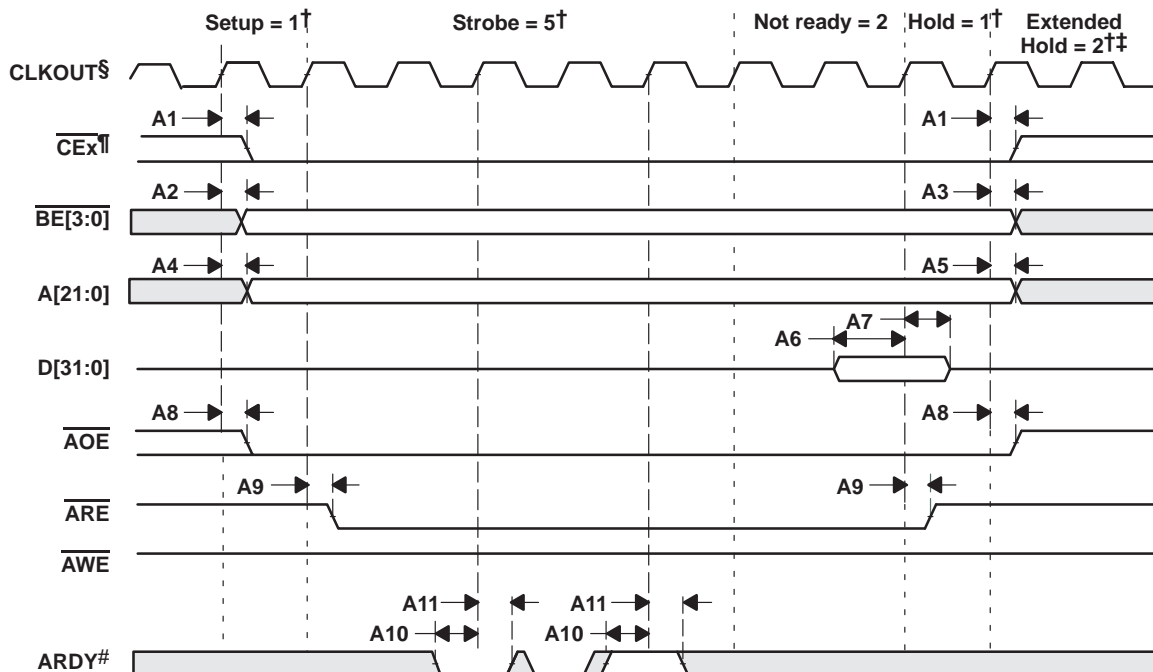
[†] To ensure data setup time, simply program the strobe width wide enough. ARDY is internally synchronized. If ARDY does meet setup or hold time, it may be recognized in the current cycle or the next cycle. Thus, ARDY can be an asynchronous input.

Table 5–6. Asynchronous Memory Cycles Switching Characteristics^{‡§}

| NO. | PARAMETER | | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|-----|-----------------|---|--------------------------------------|------|
| | | | MIN MAX | |
| A1 | $t_d(COH-CEV)$ | Delay time, CLKOUT high to \overline{CE} transition | –2 4 | ns |
| A2 | $t_d(COH-BEV)$ | Delay time, CLKOUT high to \overline{BEx} valid | 4 | ns |
| A3 | $t_d(COH-BEIV)$ | Delay time, CLKOUT high to \overline{BEx} invalid | –2 | ns |
| A4 | $t_d(COH-AV)$ | Delay time, CLKOUT high to address valid | 4 | ns |
| A5 | $t_d(COH-AIV)$ | Delay time, CLKOUT high to address invalid | –2 | ns |
| A8 | $t_d(COH-AOEV)$ | Delay time, CLKOUT high to \overline{AOE} valid | –2 4 | ns |
| A9 | $t_d(COH-AREV)$ | Delay time, CLKOUT high to \overline{ARE} valid | –2 4 | ns |
| A12 | $t_d(COH-DV)$ | Delay time, CLKOUT high to data valid (write) | 4 | ns |
| A13 | $t_d(COH-DIV)$ | Delay time, CLKOUT high to data invalid (write) | –2 | ns |
| A14 | $t_d(COH-AWEV)$ | Delay time, CLKOUT high to \overline{AWE} valid | –2 4 | ns |

[‡] The minimum delay is also the minimum output hold after CLKOUT high.

[§] All timings referenced to CLKOUT assume CLKOUT represents the internal CPU clock (divide-by-1 mode).



† Setup, Strobe, Hold, and Extended Hold are programmable in the EMIF. The programmable Hold period is not associated with the activity of the HOLD and HOLDA signals.

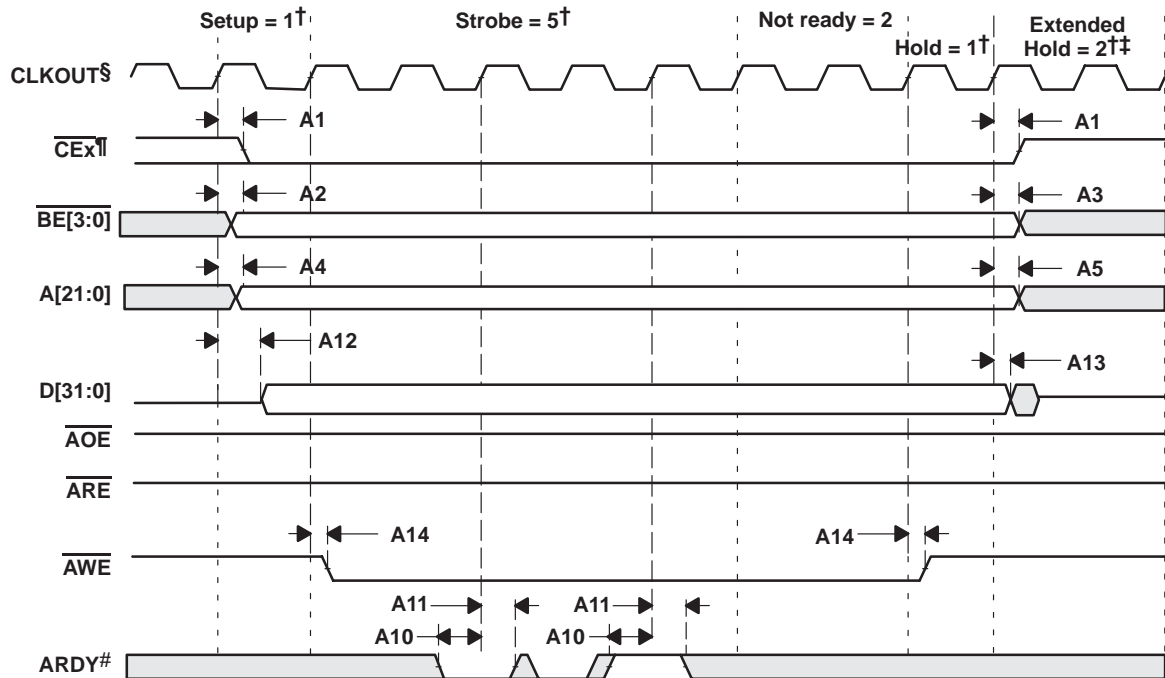
‡ The extended hold time is programmable in the EMIF and is only present when consecutive memory accesses are made to different CEX spaces, or are of different types (read/write).

§ All timings referenced to CLKOUT assume CLKOUT is the same frequency as the internal CPU clock (divide-by-1 mode).

¶ The chip enable that becomes active depends on the address.

ARDY is synchronized internally. If the setup time shown is not met, ARDY will be recognized on the next clock cycle.

Figure 5–4. Asynchronous Memory Read Timing



† Setup, Strobe, Hold, and Extended Hold are programmable in the EMIF. The programmable Hold period is not associated with the activity of the HOLD and HOLDA signals.

‡ The extended hold time is programmable in the EMIF and is only present when consecutive memory accesses are made to different $\overline{\text{CEX}}$ spaces, or are of different types (read/write).

§ All timings referenced to CLKOUT assume CLKOUT is the same frequency as the internal CPU clock (divide-by-1 mode).

¶ The chip enable that becomes active depends on the address.

ARDY is synchronized internally. If the setup time shown is not met, ARDY will be recognized on the next clock cycle.

Figure 5–5. Asynchronous Memory Write Timing

5.7.2 Synchronous-Burst SRAM (SBSRAM) Timing

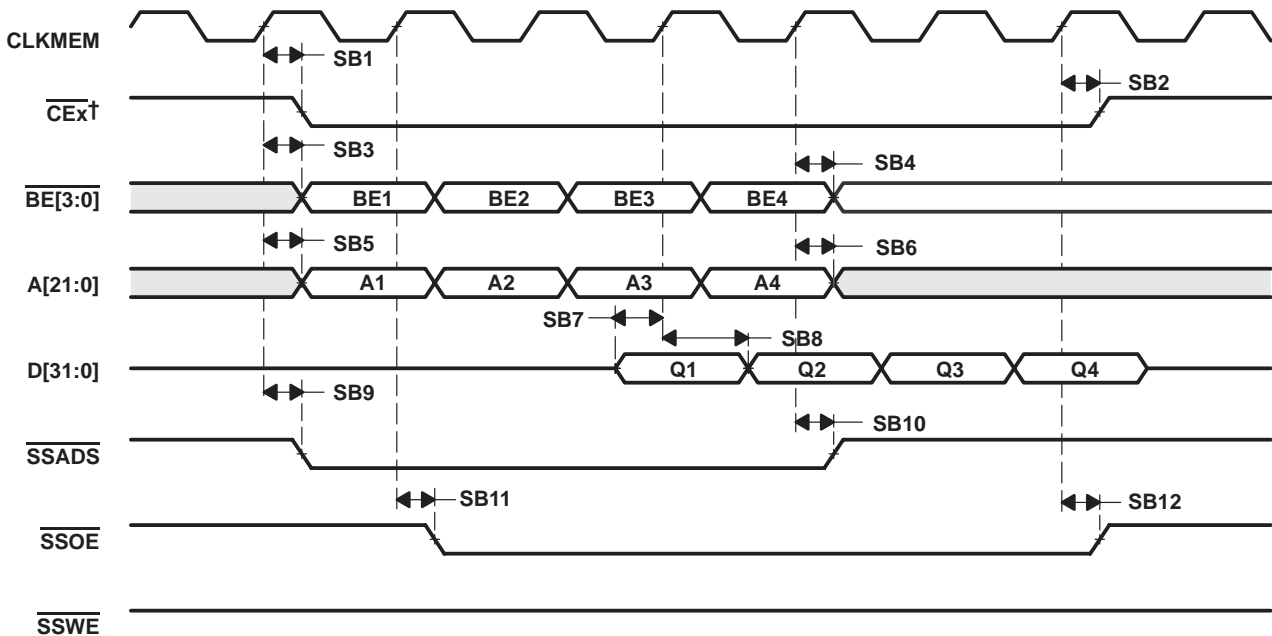
Table 5–7 and Table 5–8 assume testing over recommended operating conditions (see Figure 5–6 and Figure 5–7).

Table 5–7. Synchronous-Burst SRAM Cycle Timing Requirements

| NO. | | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|------------|---|--------------------------------------|------|
| | | MIN MAX | |
| SB7 | $t_{su}(DV-CLKMEMH)$ Setup time, read data valid before CLKMEM high | 5 | ns |
| SB8 | $t_h(CLKMEMH-DV)$ Hold time, read data valid after CLKMEM high | 2 | ns |

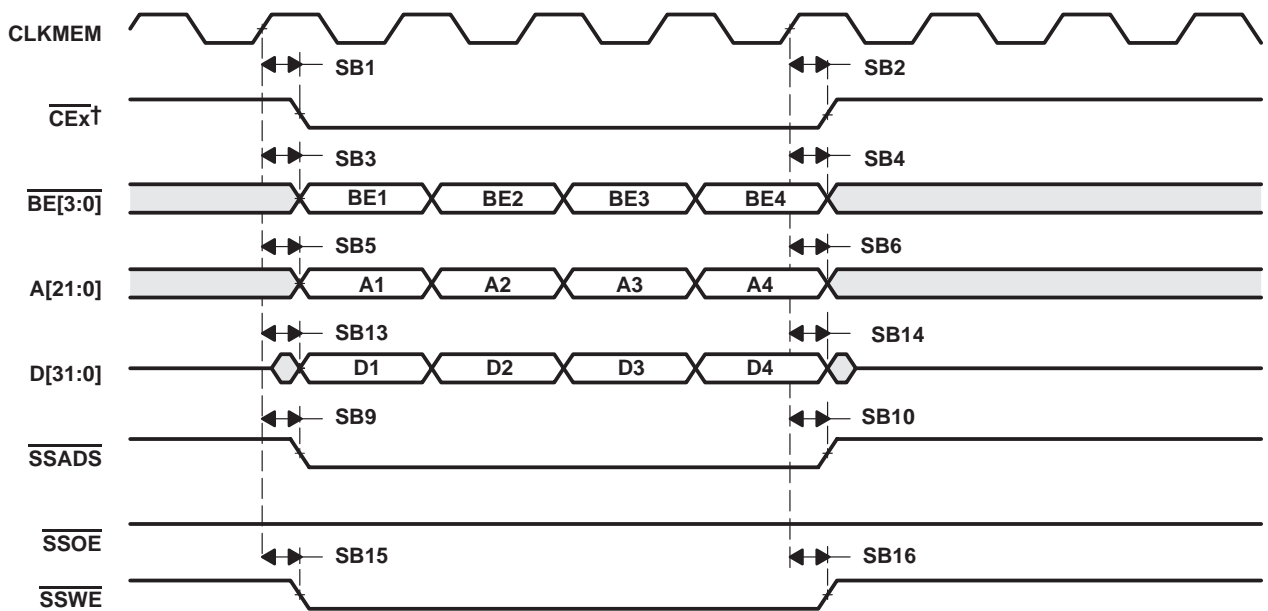
Table 5–8. Synchronous-Burst SRAM Cycle Switching Characteristics

| NO. | PARAMETER | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|-------------|---|--------------------------------------|------|
| | | MIN MAX | |
| SB1 | $t_d(CLKMEMH-CEL)$ Delay time, CLKMEM high to \overline{CEx} low | 3 6 | ns |
| SB2 | $t_d(CLKMEMH-CEH)$ Delay time, CLKMEM high to \overline{CEx} high | 3 6 | ns |
| SB3 | $t_d(CLKMEMH-BEV)$ Delay time, CLKMEM high to \overline{BEx} valid | 3 6 | ns |
| SB4 | $t_d(CLKMEMH-BEIV)$ Delay time, CLKMEM high to \overline{BEx} invalid | 3 6 | ns |
| SB5 | $t_d(CLKMEMH-AV)$ Delay time, CLKMEM high to address valid | 3 6 | ns |
| SB6 | $t_d(CLKMEMH-AIV)$ Delay time, CLKMEM high to address invalid | 3 6 | ns |
| SB9 | $t_d(CLKMEMH-ADSL)$ Delay time, CLKMEM high to \overline{SSADS} low | 3 6 | ns |
| SB10 | $t_d(CLKMEMH-ADSH)$ Delay time, CLKMEM high to \overline{SSADS} high | 3 6 | ns |
| SB11 | $t_d(CLKMEMH-OEL)$ Delay time, CLKMEM high to \overline{SSOE} low | 3 6 | ns |
| SB12 | $t_d(CLKMEMH-OEH)$ Delay time, CLKMEM high to \overline{SSOE} high | 3 6 | ns |
| SB13 | $t_d(CLKMEMH-DV)$ Delay time, CLKMEM high to data valid | 3 6 | ns |
| SB14 | $t_d(CLKMEMH-DIV)$ Delay time, CLKMEM high to data invalid | 3 6 | ns |
| SB15 | $t_d(CLKMEMH-WEL)$ Delay time, CLKMEM high to \overline{SSWE} low | 3 6 | ns |
| SB16 | $t_d(CLKMEMH-WEH)$ Delay time, CLKMEM high to \overline{SSWE} high | 3 6 | ns |



† The chip enable that becomes active depends on the address.

Figure 5-6. SBSRAM Read Timing



† The chip enable that becomes active depends on the address.

Figure 5-7. SBSRAM Write Timing

5.7.3 Synchronous DRAM (SDRAM) Timing

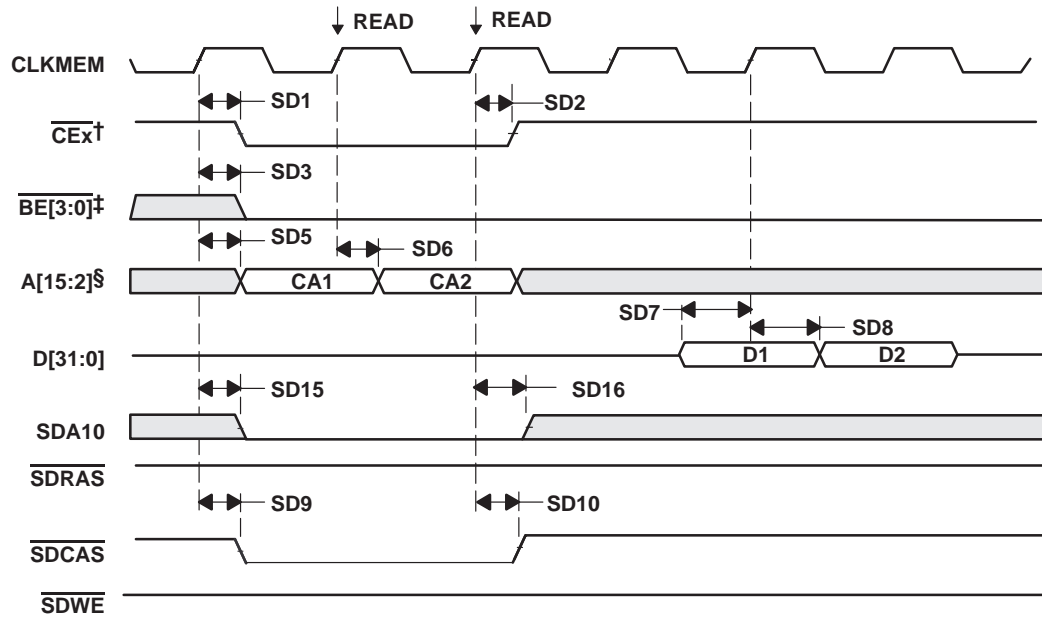
Table 5–9 and Table 5–10 assume testing over recommended operating conditions (see Figure 5–8 through Figure 5–13).

Table 5–9. Synchronous DRAM Cycle Timing Requirements

| NO. | | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|-----|---|--------------------------------------|------|
| | | MIN MAX | |
| SD7 | $t_{su}(DV-CLKMEMH)$ Setup time, read data valid before CLKMEM high | 5 | ns |
| SD8 | $t_h(CLKMEMH-DV)$ Hold time, read data valid after CLKMEM high | 2 | ns |

Table 5–10. Synchronous DRAM Cycle Switching Characteristics

| NO. | PARAMETER | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|------|--|--------------------------------------|------|
| | | MIN MAX | |
| SD1 | $t_d(CLKMEMH-CEL)$ Delay time, CLKMEM high to \overline{CE} low | 3 6 | ns |
| SD2 | $t_d(CLKMEMH-CEH)$ Delay time, CLKMEM high to \overline{CE} high | 3 6 | ns |
| SD3 | $t_d(CLKMEMH-BEV)$ Delay time, CLKMEM high to \overline{BEX} valid | 3 6 | ns |
| SD4 | $t_d(CLKMEMH-BEIV)$ Delay time, CLKMEM high to \overline{BEX} invalid | 3 6 | ns |
| SD5 | $t_d(CLKMEMH-AV)$ Delay time, CLKMEM high to address valid | 3 6 | ns |
| SD6 | $t_d(CLKMEMH-AIV)$ Delay time, CLKMEM high to address invalid | 3 6 | ns |
| SD9 | $t_d(CLKMEMH-SDCASL)$ Delay time, CLKMEM high to \overline{SDCAS} low | 3 5 | ns |
| SD10 | $t_d(CLKMEMH-SDCASH)$ Delay time, CLKMEM high to \overline{SDCAS} high | 3 5 | ns |
| SD11 | $t_d(CLKMEMH-DV)$ Delay time, CLKMEM high to data valid | 3 5 | ns |
| SD12 | $t_d(CLKMEMH-DIV)$ Delay time, CLKMEM high to data invalid | 3 5 | ns |
| SD13 | $t_d(CLKMEMH-SDWEL)$ Delay time, CLKMEM high to \overline{SDWE} low | 3 5 | ns |
| SD14 | $t_d(CLKMEMH-SDWEH)$ Delay time, CLKMEM high to \overline{SDWE} high | 3 5 | ns |
| SD15 | $t_d(CLKMEMH-SDA10V)$ Delay time, CLKMEM high to SDA10 valid | 3 5 | ns |
| SD16 | $t_d(CLKMEMH-SDA10IV)$ Delay time, CLKMEM high to SDA10 invalid | 3 5 | ns |
| SD17 | $t_d(CLKMEMH-SDRASL)$ Delay time, CLKMEM high to \overline{SDRAS} low | 3 5 | ns |
| SD18 | $t_d(CLKMEMH-SDRASH)$ Delay time, CLKMEM high to \overline{SDRAS} high | 3 5 | ns |

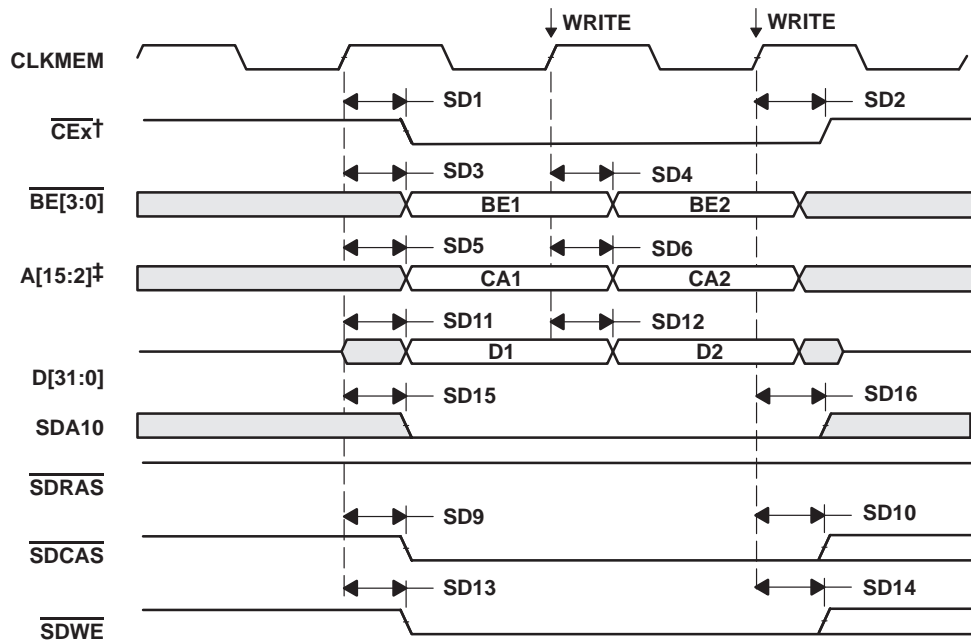


† The chip enable that becomes active depends on the address.

‡ All BE[3:0] signals are driven low (active) during reads. Byte manipulation of the read data is performed inside the EMIF. These signals remain active until the next access that is not an SDRAM read occurs.

§ The number of address signals used depends on the SDRAM size and width.

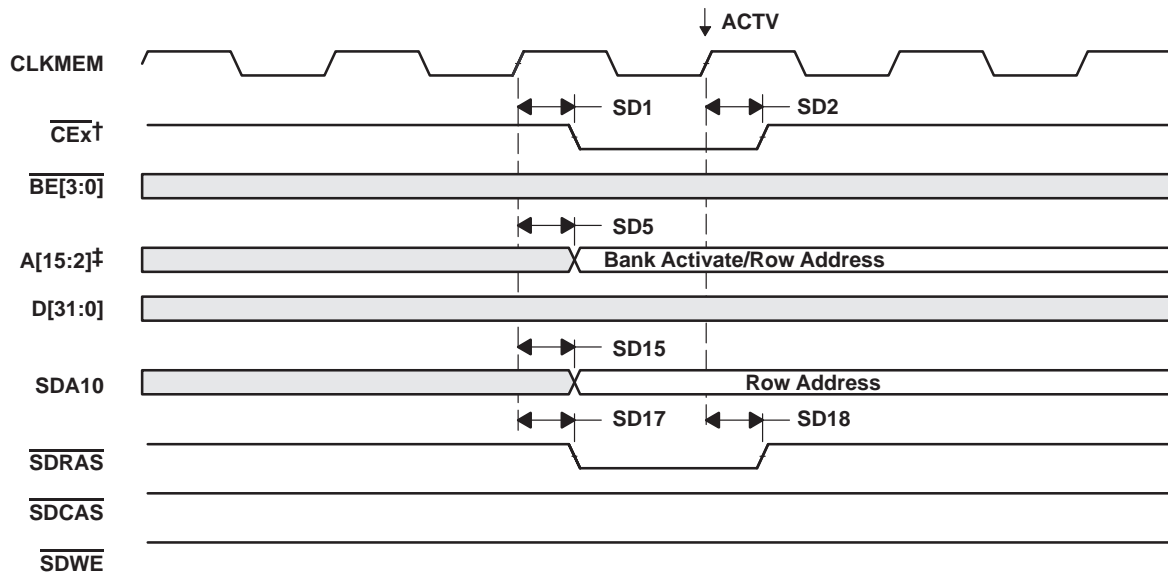
Figure 5–8. Two SDRAM Read Commands (Active Row)



† The chip enable that becomes active depends on the address.

‡ The number of address signals used depends on the SDRAM size and width.

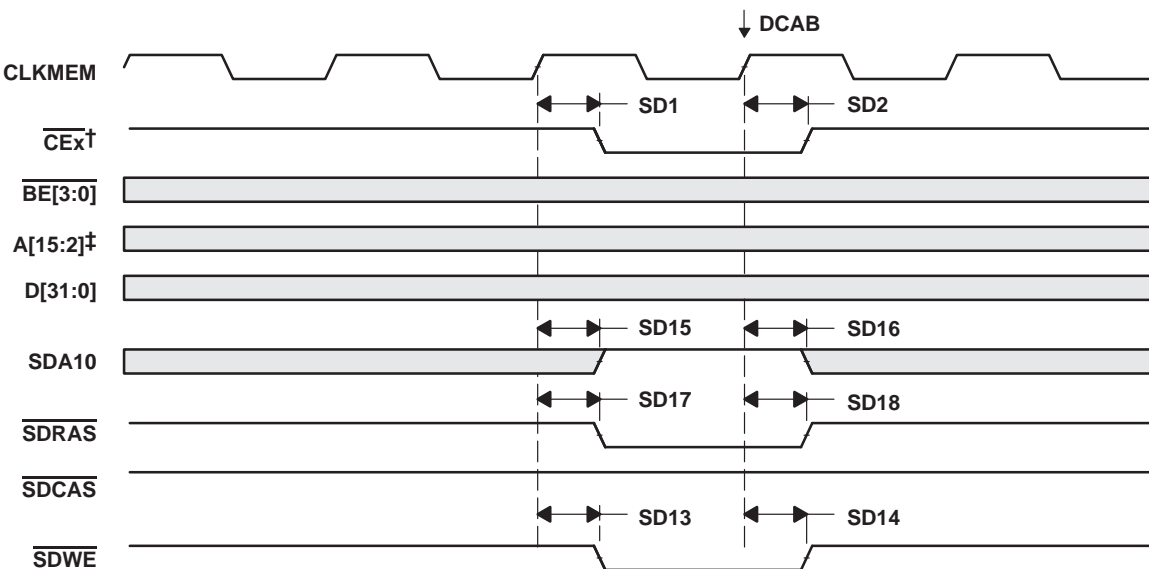
Figure 5–9. Two SDRAM WRT Commands (Active Row)



† The chip enable that becomes active depends on the address.

‡ The number of address signals used depends on the SDRAM size and width.

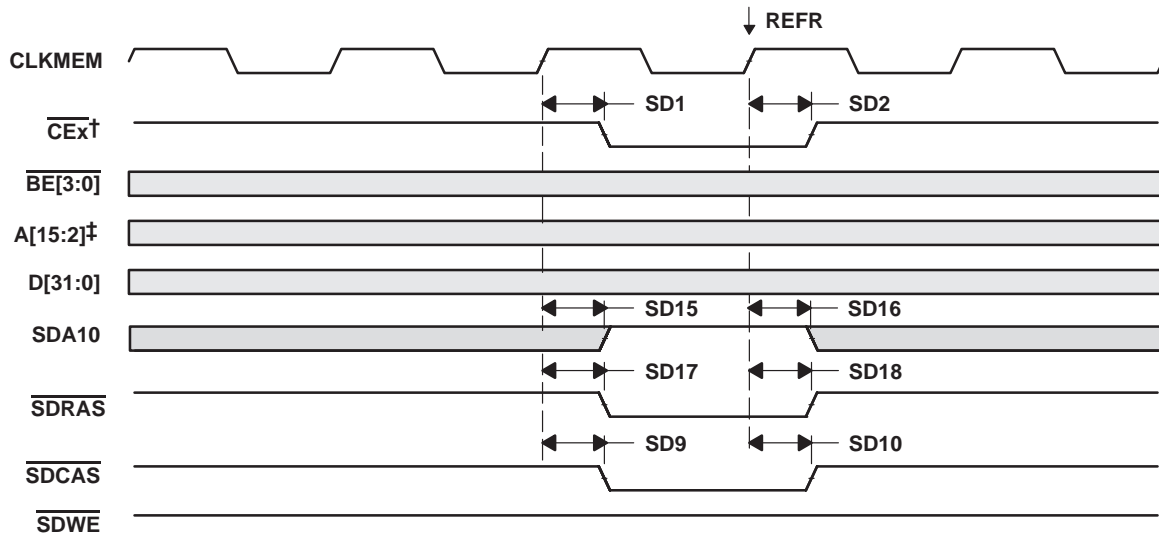
Figure 5–10. SDRAM ACTV Command



† The chip enable that becomes active depends on the address.

‡ The number of address signals used depends on the SDRAM size and width.

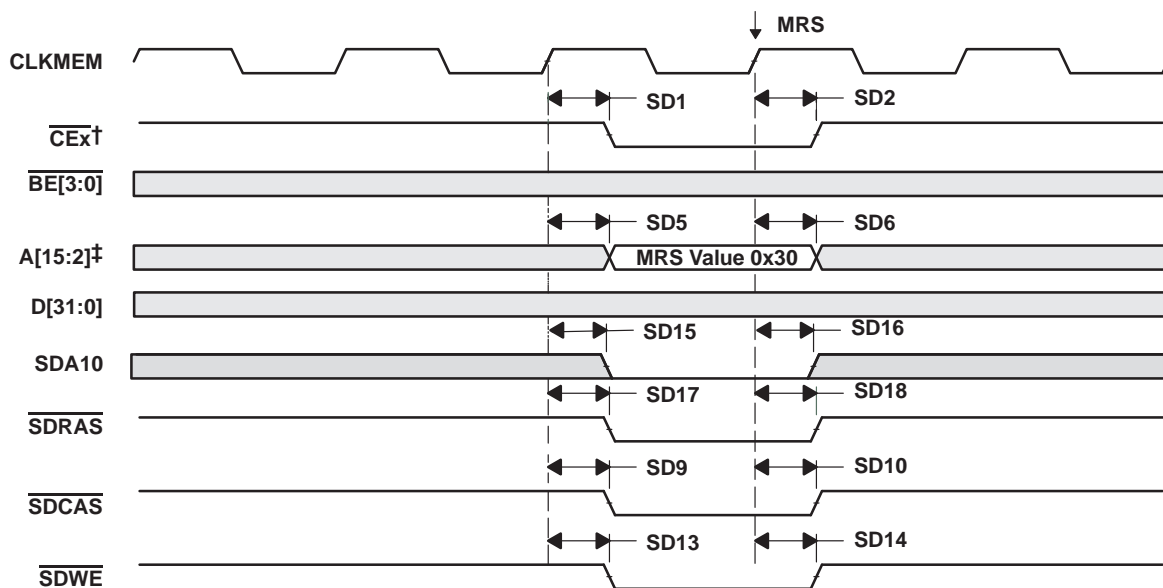
Figure 5–11. SDRAM DCAB Command



† The chip enable that becomes active depends on the address.

‡ The number of address signals used depends on the SDRAM size and width.

Figure 5–12. SDRAM REFR Command



† The chip enable that becomes active depends on the address.

‡ The number of address signals used depends on the SDRAM size and width.

Figure 5–13. SDRAM MRS Command

5.8 $\overline{\text{HOLD}}$ and $\overline{\text{HOLDA}}$ Timings

Table 5–11 and Table 5–12 assume testing over recommended operating conditions (see Figure 5–14).

Table 5–11. $\overline{\text{HOLD}}$ and $\overline{\text{HOLDA}}$ Timing Requirements

| NO. | | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|-----|---|--------------------------------------|------|
| | | MIN MAX | |
| H1 | $t_{\text{su}}(\text{HOLDH-COH})$ Setup time, $\overline{\text{HOLD}}$ high before CLKOUT high† | 7 | ns |

† $\overline{\text{HOLD}}$ is synchronized internally. If the setup time shown is not met, $\overline{\text{HOLD}}$ will be recognized on the next clock cycle.

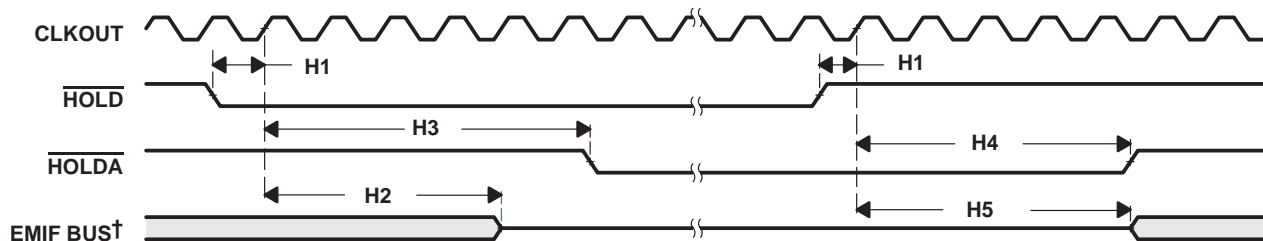
Table 5–12. $\overline{\text{HOLD}}$ and $\overline{\text{HOLDA}}$ Switching Characteristics‡

| NO. | PARAMETER | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|-----|--|--------------------------------------|------|
| | | MIN MAX | |
| H2 | $t_{\text{R}}(\text{COH-BHZ})$ Response time, CLKOUT high to EMIF Bus high impedance (HZ)¶ | 4P | § |
| H3 | $t_{\text{R}}(\text{COH-HOLDAL})$ Response time, CLKOUT high to $\overline{\text{HOLDA}}$ low | 5P–1 | ns |
| H4 | $t_{\text{R}}(\text{COH-HOLDAH})$ Response time, CLKOUT high to $\overline{\text{HOLDA}}$ high | 4P–1 | 4P+5 |
| H5 | $t_{\text{R}}(\text{COH-BLZ})$ Response time, CLKOUT high to EMIF Bus low impedance (LZ) (active)¶ | 4P–1 | 4P+5 |

‡ P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

§ All pending EMIF transactions are allowed to complete before $\overline{\text{HOLDA}}$ is asserted. If no bus transactions are occurring, then the minimum delay time can be achieved. Also, bus hold can be indefinitely delayed by setting $\text{NOHOLD} = 1$.

¶ EMIF Bus consists of $\overline{\text{CE}}[3:0]$, $\overline{\text{BE}}[3:0]$, $\text{D}[31:0]$, $\text{A}[21:0]$, $\overline{\text{ARE}}$, $\overline{\text{AOE}}$, $\overline{\text{AWE}}$, $\overline{\text{SSADS}}$, $\overline{\text{SSOE}}$, $\overline{\text{SSWE}}$, SDA10 , $\overline{\text{SDRAS}}$, $\overline{\text{SDCAS}}$, and $\overline{\text{SDWE}}$.



† EMIF Bus consists of $\overline{\text{CE}}[3:0]$, $\overline{\text{BE}}[3:0]$, $\text{D}[31:0]$, $\text{A}[21:0]$, $\overline{\text{ARE}}$, $\overline{\text{AOE}}$, $\overline{\text{AWE}}$, $\overline{\text{SSADS}}$, $\overline{\text{SSOE}}$, $\overline{\text{SSWE}}$, SDA10 , $\overline{\text{SDRAS}}$, $\overline{\text{SDCAS}}$, $\overline{\text{SDWE}}$, and CLKMEM .

Figure 5–14. $\overline{\text{HOLD}}$ / $\overline{\text{HOLDA}}$ Timing

5.9 Reset Timings

Table 5–13 and Table 5–14 assume testing over recommended operating conditions (see Figure 5–15).

Table 5–13. Reset Timing Requirements†

| NO. | | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|-----|-------------------------------------|--------------------------------------|------|
| | | MIN MAX | |
| R1 | $t_{w(RSL)}$ Pulse width, reset low | 2P + 5 | ns |

† P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

Table 5–14. Reset Switching Characteristics†

| NO. | PARAMETER | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|-----|---|--------------------------------------|------|
| | | MIN MAX | |
| R3 | $t_d(RSL-EMIFHZ)$ Delay time, reset low to EMIF group high impedance‡ | 19 | ns |
| R4 | $t_d(RSL-EMIFV)$ Delay time, reset low to EMIF group valid‡ | 38P + 19 | ns |
| R5 | $t_d(RSL-LOWIV)$ Delay time, reset low to low group invalid§ | 17 | ns |
| R6 | $t_d(RSL-LOWV)$ Delay time, reset low to low group valid§ | 38P + 17 | ns |
| R7 | $t_d(RSL-HIGHIV)$ Delay time, reset low to high group invalid§ | 9 | ns |
| R8 | $t_d(RSL-HIGHV)$ Delay time, reset low to high group valid§ | 38P + 9 | ns |
| R9 | $t_d(RSL-ZHZ)$ Delay time, reset low to Z group high impedance¶ | 18 | ns |
| R10 | $t_d(RSL-ZV)$ Delay time, reset low to Z group valid¶ | 39P + 18 | ns |

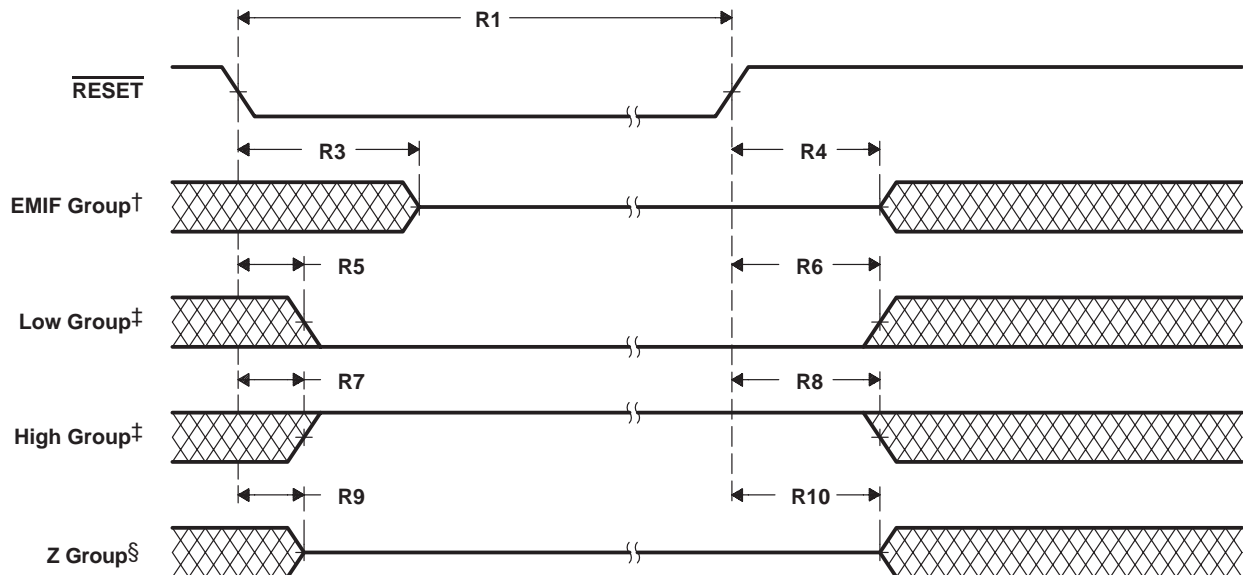
† P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

‡ EMIF group: $\overline{CE}[0:3]$, $\overline{BE}[0:3]$, \overline{CLKMEM} , \overline{ARE} , \overline{AOE} , \overline{AWE} , \overline{SSADS} , \overline{SSOE} , \overline{SSWE} , \overline{SDRAS} , \overline{SDCAS} , \overline{SDWE} , and SDA10

§ High group: \overline{HINT}

Low group: \overline{HOLDA}

¶ Z group: A[21:0], D[31:0], $\overline{CLKR}[2:0]$, $\overline{CLKX}[2:0]$, $\overline{FSR}[2:0]$, $\overline{FSX}[2:0]$, $\overline{DX}[2:0]$, IO[7:0], XF, and TIN/TOUT[1:0]



† EMIF group: $\overline{CE}[0:3]$, $\overline{BE}[0:3]$, \overline{CLKMEM} , \overline{ARE} , \overline{AOE} , \overline{AWE} , \overline{SSADS} , \overline{SSOE} , \overline{SSWE} , \overline{SDRAS} , \overline{SDCAS} , \overline{SDWE} , and SDA10

‡ High group: \overline{HINT}

Low group: \overline{HOLDA}

§ Z group: A[21:0], D[31:0], $\overline{CLKR}[2:0]$, $\overline{CLKX}[2:0]$, $\overline{FSR}[2:0]$, $\overline{FSX}[2:0]$, $\overline{DX}[2:0]$, IO[7:0], XF, and TIN/TOUT[1:0]

Figure 5–15. Reset Timing

5.10 External Interrupt Timings

Table 5–15 assumes testing over recommended operating conditions (see Figure 5–16).

Table 5–15. External Interrupt Timing Requirements†

| NO. | | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|-----|--|--------------------------------------|------|
| | | MIN MAX | |
| I1 | $t_{w(INTH)}A$ Pulse width, interrupt high, CPU active | 2P | ns |
| I2 | $t_{w(INTL)}A$ Pulse width, interrupt low, CPU active | 3P | ns |

† P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

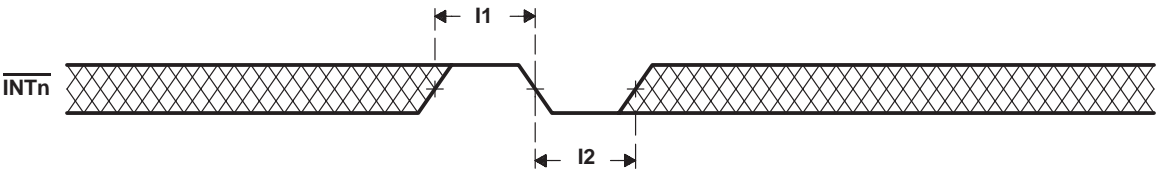


Figure 5–16. External Interrupt Timings

5.11 XF Timings

Table 5–16 assumes testing over recommended operating conditions (see Figure 5–17).

Table 5–16. XF Switching Characteristics

| NO. | PARAMETER | | VC5510/5510A-160 VC5510/5510A-200 | | UNIT |
|-----|-----------|------------------------------------|--------------------------------------|-----|------|
| | | | MIN | MAX | |
| X1 | $t_d(XF)$ | Delay time, CLKOUT high to XF high | 0 | 4 | ns |
| | | Delay time, CLKOUT high to XF low | 0 | 4 | |

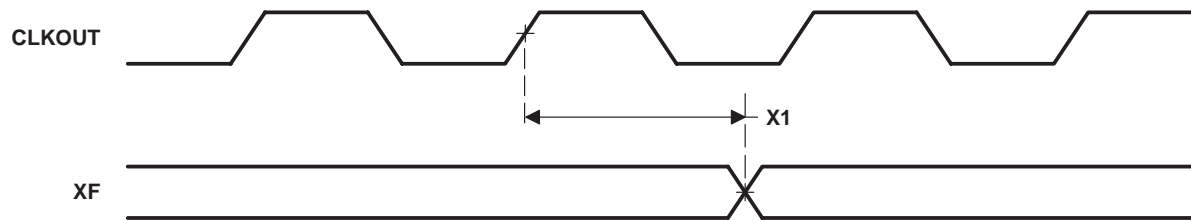


Figure 5–17. XF Timing

5.12 General-Purpose Input/Output (IOx) Timings

Table 5–17 and Table 5–18 assume testing over recommended operating conditions (see Figure 5–18).

Table 5–17. General-Purpose Input/Output (GPIO) Pins Configured as Inputs Timing Requirements

| NO. | | VC5510/5510A-160 VC5510/5510A-200 | | UNIT |
|-----|---|--------------------------------------|-----|------|
| | | MIN | MAX | |
| G2 | $t_{su}(GPIO-COH)$ Setup time, IOx input valid before CLKOUT high | 8 | | ns |
| G3 | $t_h(COH-GPIO)$ Hold time, IOx input valid after CLKOUT high | 0 | | ns |

Table 5–18. General-Purpose Input/Output (GPIO) Pins Configured as Inputs Switching Characteristics

| NO. | PARAMETER | VC5510/5510A-160 VC5510/5510A-200 | | UNIT |
|-----|--|--------------------------------------|-----|------|
| | | MIN | MAX | |
| G1 | $t_d(COH-GPIO)$ Delay time, CLKOUT high to IOx output change | 0 | 6 | ns |

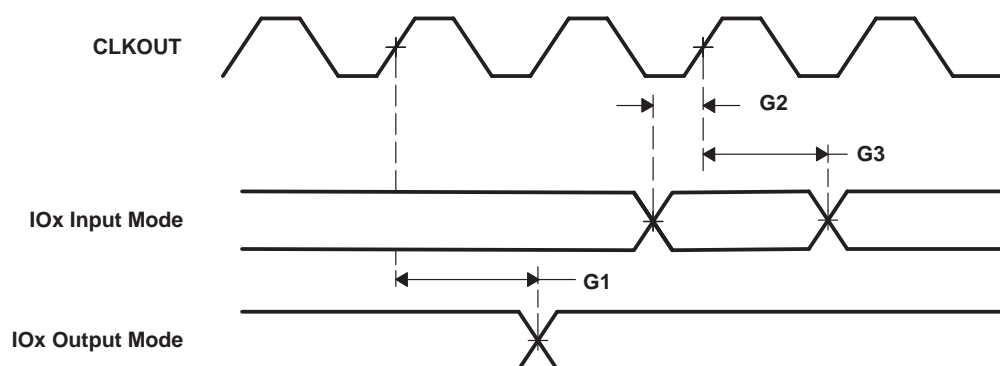


Figure 5–18. General-Purpose Input/Output (IOx) Signal Timings

5.13 TIN/TOUT Timings

Table 5–19 and Table 5–20 assume testing over recommended operating conditions (see Figure 5–19 and Figure 5–20).

Table 5–19. TIN/TOUT Pins Configured as Inputs Timing Requirements†

| NO. | | VC5510/5510A-160 VC5510/5510A-200 | | UNIT |
|-----------|--|--------------------------------------|-----|------|
| | | MIN | MAX | |
| T4 | $t_w(\text{TIN/TOUTL})$ Pulse width, TIN/TOUT low | $2P + 1$ | | ns |
| T5 | $t_w(\text{TIN/TOUTH})$ Pulse width, TIN/TOUT high | $2P + 1$ | | ns |

† $P = 1/\text{CPU clock frequency}$ in ns. For example, when running parts at 200 MHz, use $P = 5$ ns.

Table 5–20. TIN/TOUT Pins Configured as Outputs Switching Characteristics†‡

| NO. | PARAMETER | VC5510/5510A-160 VC5510/5510A-200 | | UNIT |
|-----------|--|--------------------------------------|-----|------|
| | | MIN | MAX | |
| T1 | $t_d(\text{COH-TIN/TOUTH})$ Delay time, CLKOUT high to TIN/TOUT high | 0 | 2 | ns |
| T2 | $t_d(\text{COH-TIN/TOUTL})$ Delay time, CLKOUT high to TIN/TOUT low | 0 | 2 | ns |
| T3 | $t_w(\text{TIN/TOUT})$ Pulse duration, TIN/TOUT (output) | P | | ns |

† $P = 1/\text{CPU clock frequency}$ in ns. For example, when running parts at 200 MHz, use $P = 5$ ns.

‡ For proper operation of the TIN/TOUT pin configured as an output, the timer period must be configured for at least 4 cycles.

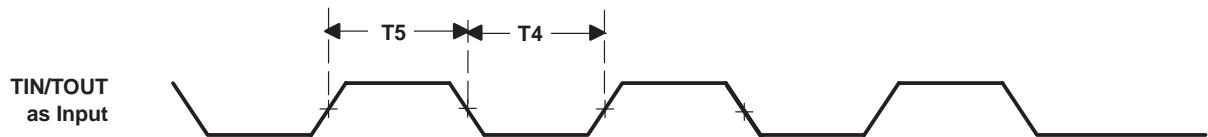


Figure 5–19. TIN/TOUT Timing When Configured as Inputs

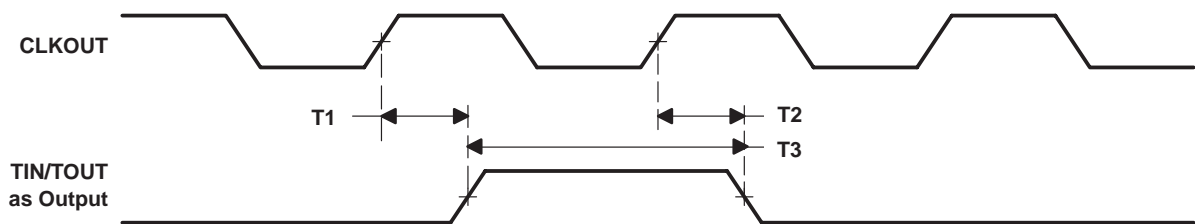


Figure 5–20. TIN/TOUT Timing When Configured as Outputs

5.14 Multichannel Buffered Serial Port (McBSP) Timings

5.14.1 McBSP Transmit and Receive Timings

Table 5–21 and Table 5–22 assume testing over recommended operating conditions (see Figure 5–21 and Figure 5–22).

Table 5–21. McBSP Timing Requirements†‡

| NO. | | | | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|------------|---------------------------|---|------------|--------------------------------------|------|
| | | | | MIN MAX | |
| M11 | $t_c(\text{CKRX})$ | Cycle time, CLKR/X | CLKR/X ext | 2P | ns |
| M12 | $t_w(\text{CKRX})$ | Pulse duration, CLKR/X high or CLKR/X low | CLKR/X ext | P–1 | ns |
| M13 | $t_r(\text{CKRX})$ | Rise time, CLKR/X | CLKR/X ext | 5 | ns |
| M14 | $t_f(\text{CKRX})$ | Fall time, CLKR/X | CLKR/X ext | 5 | ns |
| M15 | $t_{su}(\text{FRH-CKRL})$ | Setup time, external FSR high before CLKR low | CLKR int | 5 | ns |
| | | | CLKR ext | 1 | |
| M16 | $t_h(\text{CKRL-FRH})$ | Hold time, external FSR high after CLKR low | CLKR int | 0 | ns |
| | | | CLKR ext | 2 | |
| M17 | $t_{su}(\text{DRV-CKRL})$ | Setup time, DR valid before CLKR low | CLKR int | 4 | ns |
| | | | CLKR ext | 1 | |
| M18 | $t_h(\text{CKRL-DRV})$ | Hold time, DR valid after CLKR low | CLKR int | 0 | ns |
| | | | CLKR ext | 2 | |
| M19 | $t_{su}(\text{FXH-CKXL})$ | Setup time, external FSX high before CLKX low | CLKX int | 5 | ns |
| | | | CLKX ext | 1 | |
| M20 | $t_h(\text{CKXL-FXH})$ | Hold time, external FSX high after CLKX low | CLKX int | 0 | ns |
| | | | CLKX ext | 2 | |

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

‡ P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

Table 5–22. McBSP Switching Characteristics†‡

| NO. | PARAMETER | | | VC5510/5510A-160 VC5510/5510A-200 | | UNIT |
|-----|------------------------------------|--|------------|--------------------------------------|------|------|
| | | | | MIN | MAX | |
| M1 | $t_c(\text{CKRX})$ | Cycle time, CLKR/X | CLKR/X int | 2P | | ns |
| M2 | $t_w(\text{CKRXH})$ | Pulse duration, CLKR/X high | CLKR/X int | D–1§ | D+1§ | ns |
| M3 | $t_w(\text{CKRXL})$ | Pulse duration, CLKR/X low | CLKR/X int | C–1§ | C+1§ | ns |
| M4 | $t_d(\text{CKRH-FRV})$ | Delay time, CLKR high to internal FSR valid | CLKR int | –2 | 2 | ns |
| | | | CLKR ext | 3 | 7 | ns |
| M5 | $t_d(\text{CKXH-FXV})$ | Delay time, CLKX high to internal FSX valid | CLKX int | –2 | 2 | ns |
| | | | CLKX ext | 3 | 7 | |
| M6 | $t_{\text{dis}}(\text{CKXH-DXHZ})$ | Disable time, CLKX high to DX high impedance following last data bit | CLKX int | 0 | 2 | ns |
| | | | CLKX ext | 1 | 11 | |
| M7 | $t_d(\text{CKXH-DXV})$ | Delay time, CLKX high to DX valid. This applies to all bits except the first bit transmitted. | CLKX int | | 6 | ns |
| | | | CLKX ext | | 9 | |
| | | Delay time, CLKX high to DX valid¶ Only applies to first bit transmitted when in Data Delay 1 or 2 (XDATDLY=01b or 10b) modes | DXENA = 0 | CLKX int | 6 | |
| | | | | CLKX ext | 9 | |
| | | | DXENA = 1 | CLKX int | 2P+6 | |
| | | | | CLKX ext | 2P+9 | |
| M8 | $t_{\text{en}}(\text{CKXH-DX})$ | Enable time, CLKX high to DX driven¶ Only applies to first bit transmitted when in Data Delay 1 or 2 (XDATDLY=01b or 10b) modes | DXENA = 0 | CLKX int | 0 | ns |
| | | | | CLKX ext | 6 | |
| | | | DXENA = 1 | CLKX int | P | |
| | | | | CLKX ext | P+6 | |
| M9 | $t_d(\text{FXH-DXV})$ | Delay time, FSX high to DX valid¶ Only applies to first bit transmitted when in Data Delay 0 (XDATDLY=00b) mode. | DXENA = 0 | FSX int | 5 | ns |
| | | | | FSX ext | 9 | |
| | | | DXENA = 1 | FSX int | 2P+5 | |
| | | | | FSX ext | 2P+9 | |
| M10 | $t_{\text{en}}(\text{FXH-DX})$ | Enable time, FSX high to DX driven¶ Only applies to first bit transmitted when in Data Delay 0 (XDATDLY=00b) mode | DXENA = 0 | FSX int | 0 | ns |
| | | | | FSX ext | 6 | |
| | | | DXENA = 1 | FSX int | P | |
| | | | | FSX ext | P+6 | |

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

‡ P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

§ T = CLKRX period = (1 + CLKGDV) * P

C = CLKRX low pulse width = T/2 when CLKGDV is odd or zero and = (CLKGDV/2) * P when CLKGDV is even

D = CLKRX high pulse width = T/2 when CLKGDV is odd or zero and = (CLKGDV/2 + 1) * P when CLKGDV is even

¶ See the TMS320VC5501/5502/5503/5507/5509/5510 DSP Multichannel Buffered Serial Port (McBSP) Reference Guide (literature number SPRU592) for a description of the DX enable (DXENA) and data delay features of the McBSP.

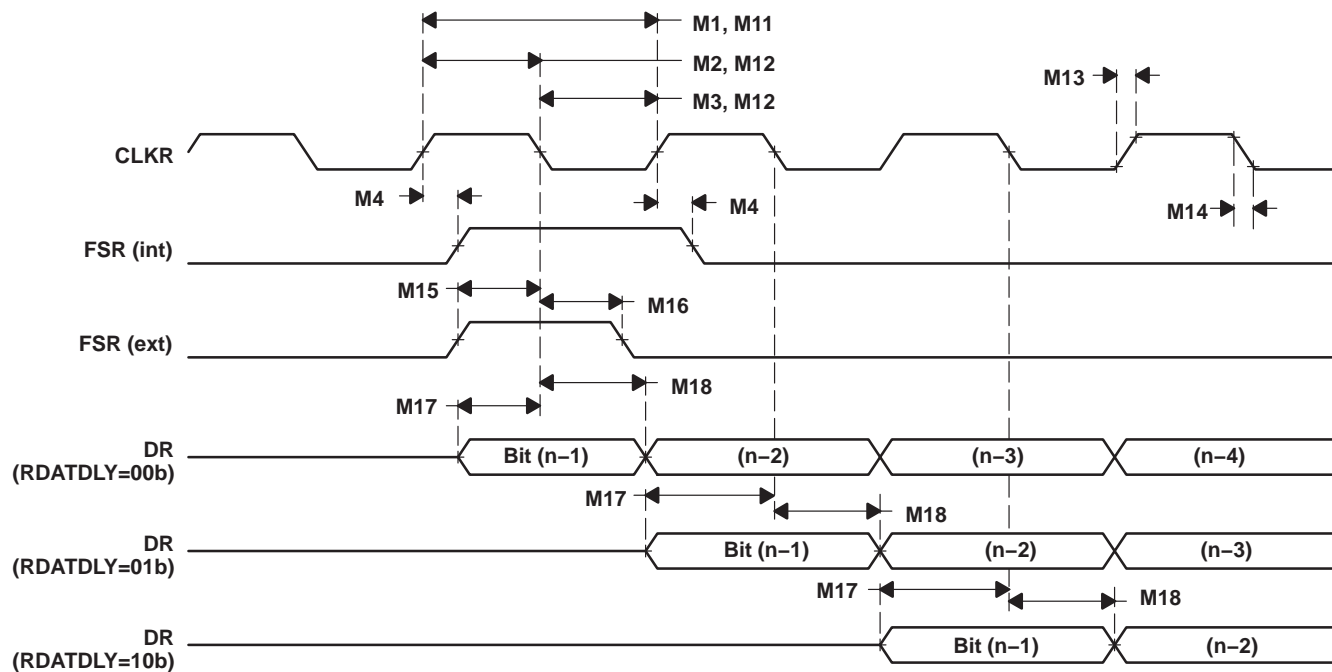


Figure 5-21. McBSP Receive Timings

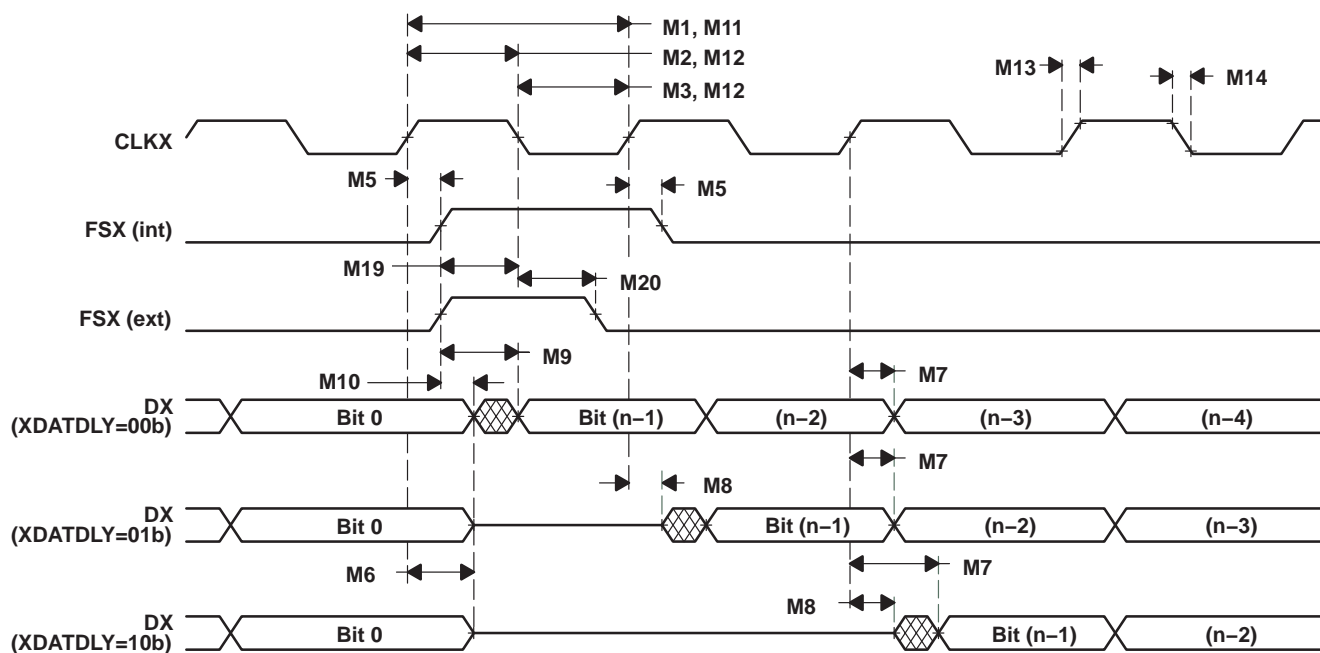


Figure 5-22. McBSP Transmit Timings

5.14.2 McBSP General-Purpose I/O Timing

Table 5–23 and Table 5–24 assume testing over recommended operating conditions (see Figure 5–23).

Table 5–23. McBSP General-Purpose I/O Timing Requirements

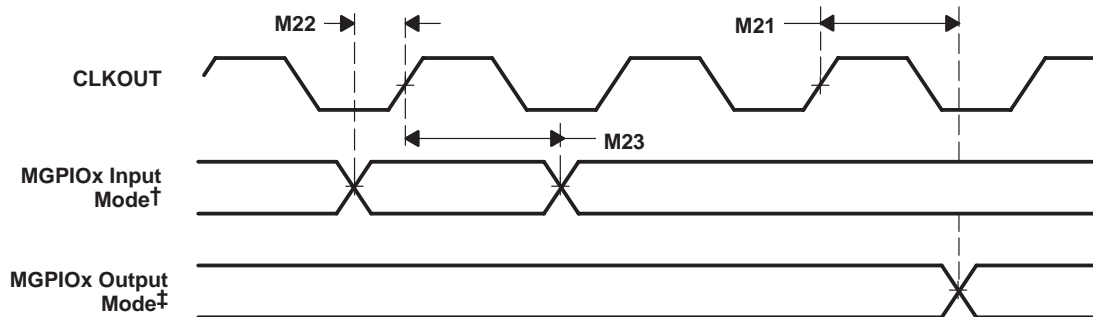
| NO. | | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|------------|--|--------------------------------------|------|
| | | MIN MAX | |
| M22 | $t_{su}(\text{MGPIO-COH})$ Setup time, MGPIOr input mode before CLKOUT high [†] | 7 | ns |
| M23 | $t_h(\text{COH-MGPIO})$ Hold time, MGPIOr input mode after CLKOUT high [†] | 0 | ns |

[†] MGPIOr refers to CLKRx, FSRx, DRx, CLKXx, or FSXx when configured as a general-purpose input.

Table 5–24. McBSP General-Purpose I/O Switching Characteristics

| NO. | PARAMETER | VC5510/5510A-160 VC5510/5510A-200 | UNIT |
|------------|--|--------------------------------------|------|
| | | MIN MAX | |
| M21 | $t_d(\text{COH-MGPIO})$ Delay time, CLKOUT high to MGPIOr output mode [‡] | 0 3 | ns |

[‡] MGPIOr refers to CLKRx, FSRx, CLKXx, FSXx, or DXx when configured as a general-purpose output.



[†] MGPIOr refers to CLKRx, FSRx, DRx, CLKXx, or FSXx when configured as a general-purpose input.

[‡] MGPIOr refers to CLKRx, FSRx, CLKXx, FSXx, or DXx when configured as a general-purpose output.

Figure 5–23. McBSP General-Purpose I/O Timings

5.14.3 McBSP as SPI Master or Slave Timing

Table 5–25 to Table 5–32 assume testing over recommended operating conditions (see Figure 5–24 through Figure 5–27).

Table 5–25. McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 10b, CLKXP = 0)^{†‡}

| NO. | | | VC5510/5510A-160 VC5510/5510A-200 | | | | UNIT |
|-----|-----------------------------|--------------------------------------|--------------------------------------|-----|--------|-----|------|
| | | | MASTER | | SLAVE | | |
| | | | MIN | MAX | MIN | MAX | |
| M30 | t _{su} (DRV-CKXL) | Setup time, DR valid before CLKX low | 4 | | 3 – 6P | | ns |
| M31 | t _h (CKXL-DRV) | Hold time, DR valid after CLKX low | 1 | | 1 + 6P | | ns |
| M32 | t _{su} (BFXL-CKXH) | Setup time, FSX low before CLKX high | | | 10 | | ns |
| M33 | t _c (CKX) | Cycle time, CLKX | 2P | | 16P | | ns |

[†] For all SPI slave modes, CLKG is programmed as 1/2 of the CPU clock by setting CLKSM = CLKGDV = 1.

[‡] P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

Table 5–26. McBSP as SPI Master or Slave Switching Characteristics (CLKSTP = 10b, CLKXP = 0)^{†‡}

| NO. | PARAMETER | | VC5510/5510A-160 VC5510/5510A-200 | | | | UNIT |
|-----|------------------------------|---|--------------------------------------|-------|--------|---------|------|
| | | | MASTER [§] | | SLAVE | | |
| | | | MIN | MAX | MIN | MAX | |
| M24 | t _d (CKXL-FXL) | Delay time, FSX low to CLKX low [¶] | T – 1 | T + 3 | | | ns |
| M25 | t _d (FXL-CKXH) | Delay time, FSX low to CLKX high [#] | C – 2 | C + 2 | | | ns |
| M26 | t _d (CKXH-DXV) | Delay time, CLKX high to DX valid | –2 | 4 | 3P + 2 | 5P+ 8 | ns |
| M27 | t _{dis} (CKXL-DXHZ) | Disable time, DX high impedance following last data bit from CLKX low | C – 2 | C | | | ns |
| M28 | t _{dis} (FXH-DXHZ) | Disable time, DX high impedance following last data bit from FSX high | | | 3P + 8 | 3P + 20 | ns |
| M29 | t _d (FXL-DXV) | Delay time, FSX low to DX valid | | | 3P – 3 | 3P + 20 | ns |

[†] For all SPI slave modes, CLKG is programmed as 1/2 of the CPU clock by setting CLKSM = CLKGDV = 1.

[‡] P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

[§] T = CLKX period = (1 + CLKGDV) * P

C = CLKX low pulse width = T/2 when CLKGDV is odd or zero and = (CLKGDV/2) * P when CLKGDV is even

[¶] FSRP = FSXP = 1. As a SPI master, FSX is inverted to provide active-low slave-enable output. As a slave, the active-low signal input on FSX and FSR is inverted before being used internally.

CLKXM = FSXM = 1, CLKRM = FSRM = 0 for master McBSP

CLKXM = CLKRM = FSXM = FSRM = 0 for slave McBSP

[#] FSX should be low before the rising edge of clock to enable slave devices and then begin a SPI transfer at the rising edge of the master clock (CLKX).

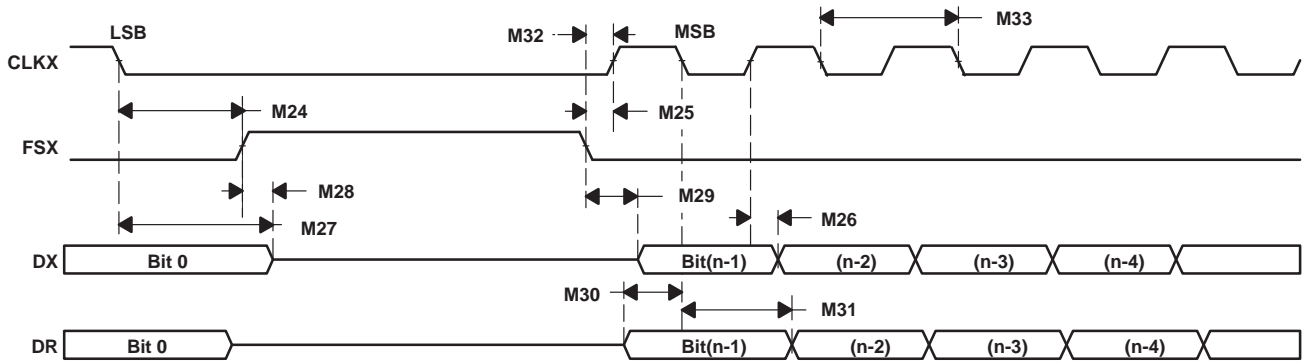


Figure 5–24. McBSP Timing as SPI Master or Slave: CLKSTP = 10b, CLKXP = 0

Table 5–27. McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 11b, CLKXP = 0)^{†‡}

| NO. | | | VC5510/5510A-160 VC5510/5510A-200 | | | | UNIT |
|-----|----------------------------|---------------------------------------|--------------------------------------|-----|--------|-----|------|
| | | | MASTER | | SLAVE | | |
| | | | MIN | MAX | MIN | MAX | |
| M39 | t _{su} (DRV-CKXH) | Setup time, DR valid before CLKX high | 4 | | 3 – 6P | | ns |
| M40 | t _h (CKXH-DRV) | Hold time, DR valid after CLKX high | 1 | | 1 +6P | | ns |
| M41 | t _{su} (FXL-CKXH) | Setup time, FSX low before CLKX high | | | 10 | | ns |
| M42 | t _c (CKX) | Cycle time, CLKX | 2P | | 16P | | ns |

[†] For all SPI slave modes, CLKG is programmed as 1/2 of the CPU clock by setting CLKSM = CLKGDV = 1.

[‡] P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

Table 5–28. McBSP as SPI Master or Slave Switching Characteristics (CLKSTP = 11b, CLKXP = 0)^{†‡}

| NO. | PARAMETER | | VC5510/5510A-160 VC5510/5510A-200 | | | | UNIT |
|-----|------------------------------|---|--------------------------------------|--------|--------|---------|------|
| | | | MASTER§ | | SLAVE | | |
| | | | MIN | MAX | MIN | MAX | |
| M34 | t _d (CKXL-FXL) | Delay time, FSX low to CLKX low¶ | C – 1 | C + 3 | | | ns |
| M35 | t _d (FXL-CKXH) | Delay time, FSX low to CLKX high# | T – 2 | T + 2 | | | ns |
| M36 | t _d (CKXL-DXV) | Delay time, CLKX low to DX valid | –2 | 4 | 3P + 2 | 5P + 8 | ns |
| M37 | t _{dis} (CKXL-DXHZ) | Disable time, DX high impedance following last data bit from CLKX low | –2 | 0 | 3P + 8 | 3P + 21 | ns |
| M38 | t _d (FXL-DXV) | Delay time, FSX low to DX valid | D – 2 | D + 10 | 3P – 3 | 3P + 21 | ns |

[†] For all SPI slave modes, CLKG is programmed as 1/2 of the CPU clock by setting CLKSM = CLKGDV = 1.

[‡] P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

[§] T = CLKX period = (1 + CLKGDV) * P

C = CLKX low pulse width = T/2 when CLKGDV is odd or zero and = (CLKGDV/2) * P when CLKGDV is even

D = CLKX high pulse width = T/2 when CLKGDV is odd or zero and = (CLKGDV/2 + 1) * P when CLKGDV is even

[¶] FSRP = FSXP = 1. As a SPI master, FSX is inverted to provide active-low slave-enable output. As a slave, the active-low signal input on FSX and FSR is inverted before being used internally.

CLKXM = FSXM = 1, CLKRM = FSRM = 0 for master McBSP

CLKXM = CLKRM = FSXM = FSRM = 0 for slave McBSP

[#] FSX should be low before the rising edge of clock to enable slave devices and then begin a SPI transfer at the rising edge of the master clock (CLKX).

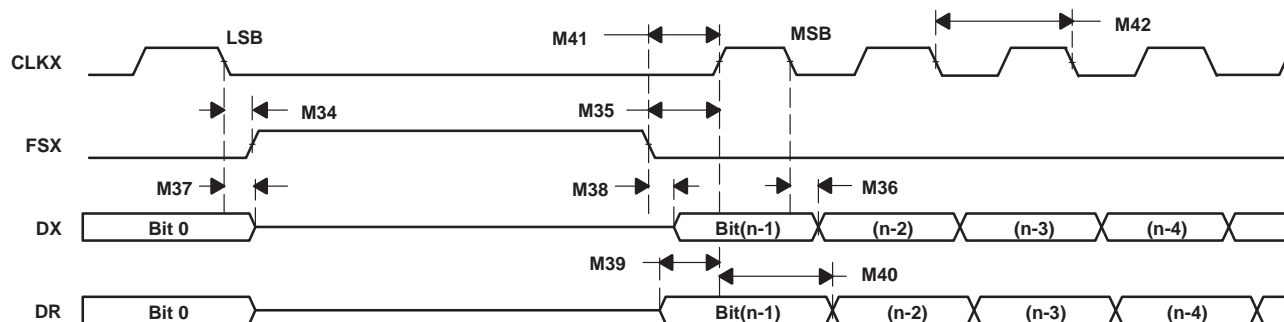
**Figure 5–25. McBSP Timing as SPI Master or Slave: CLKSTP = 11b, CLKXP = 0**

Table 5–29. McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 10b, CLKXP = 1)†‡

| NO. | | | VC5510/5510A-160 VC5510/5510A-200 | | | | UNIT |
|-----|----------------------------|---------------------------------------|--------------------------------------|-----|--------|-----|------|
| | | | MASTER | | SLAVE | | |
| | | | MIN | MAX | MIN | MAX | |
| M49 | t _{su} (DRV-CKXH) | Setup time, DR valid before CLKX high | 4 | | 3 – 6P | | ns |
| M50 | t _h (CKXH-DRV) | Hold time, DR valid after CLKX high | 1 | | 1 + 6P | | ns |
| M51 | t _{su} (FXL-CKXL) | Setup time, FSX low before CLKX low | | | 10 | | ns |
| M52 | t _c (CKX) | Cycle time, CLKX | 2P | | 16P | | ns |

† For all SPI slave modes, CLKG is programmed as 1/2 of the CPU clock by setting CLKSM = CLKGDV = 1.

‡ P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

Table 5–30. McBSP as SPI Master or Slave Switching Characteristics (CLKSTP = 10b, CLKXP = 1)†‡

| NO. | PARAMETER | | VC5510/5510A-160 VC5510/5510A-200 | | | | UNIT |
|-----|------------------------------|--|--------------------------------------|-------|--------|---------|------|
| | | | MASTER§ | | SLAVE | | |
| | | | MIN | MAX | MIN | MAX | |
| M43 | t _d (CKXH-FXL) | Delay time, FSX low to CLKX high¶ | T – 1 | T + 3 | | | ns |
| M44 | t _d (FXL-CKXL) | Delay time, FSX low to CLKX low# | D – 2 | D + 2 | | | ns |
| M45 | t _d (CKXL-DXV) | Delay time, CLKX low to DX valid | –2 | 4 | 3P + 2 | 5P + 8 | ns |
| M46 | t _{dis} (CKXH-DXHZ) | Disable time, DX high impedance following last data bit from CLKX high | D – 2 | D | | | ns |
| M47 | t _{dis} (FXH-DXHZ) | Disable time, DX high impedance following last data bit from FSX high | | | 3P + 8 | 3P + 20 | ns |
| M48 | t _d (FXL-DXV) | Delay time, FSX low to DX valid | | | 3P – 3 | 3P + 20 | ns |

† For all SPI slave modes, CLKG is programmed as 1/2 of the CPU clock by setting CLKSM = CLKGDV = 1.

‡ P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

§ T = CLKX period = (1 + CLKGDV) * P

D = CLKX high pulse width = T/2 when CLKGDV is odd or zero and = (CLKGDV/2 + 1) * P when CLKGDV is even

¶ FSRP = FSXP = 1. As a SPI master, FSX is inverted to provide active-low slave-enable output. As a slave, the active-low signal input on FSX and FSR is inverted before being used internally.

CLKXM = FSXM = 1, CLKRM = FSRM = 0 for master McBSP

CLKXM = CLKRM = FSXM = FSRM = 0 for slave McBSP

FSX should be low before the rising edge of clock to enable slave devices and then begin a SPI transfer at the rising edge of the master clock (CLKX).

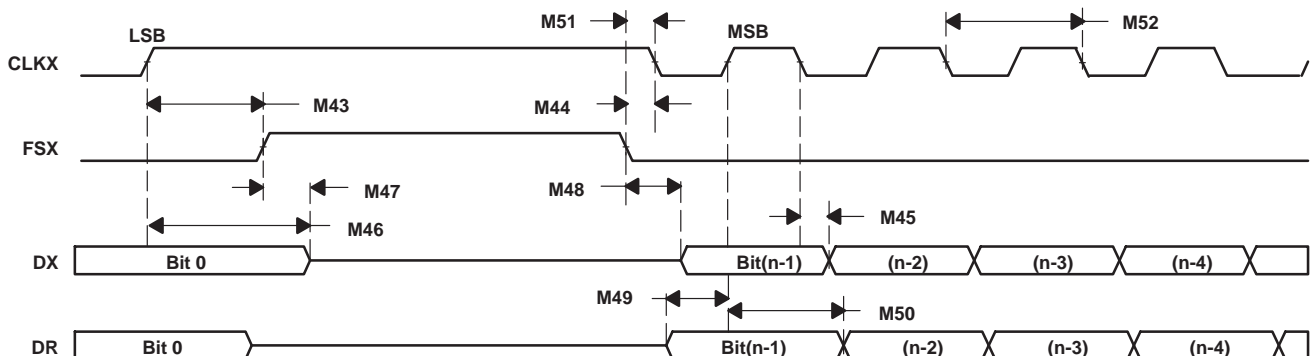
**Figure 5–26. McBSP Timing as SPI Master or Slave: CLKSTP = 10b, CLKXP = 1**

Table 5–31. McBSP as SPI Master or Slave Timing Requirements (CLKSTP = 11b, CLKXP = 1)†‡

| NO. | | | VC5510/5510A-160 VC5510/5510A-200 | | | | UNIT |
|-----|----------------------------|--------------------------------------|--------------------------------------|-----|--------|-----|------|
| | | | MASTER | | SLAVE | | |
| | | | MIN | MAX | MIN | MAX | |
| M58 | t _{su} (DRV-CKXL) | Setup time, DR valid before CLKX low | 4 | | 3 – 6P | | ns |
| M59 | t _h (CKXL-DRV) | Hold time, DR valid after CLKX low | 1 | | 1 + 6P | | ns |
| M60 | t _{su} (FXL-CKXL) | Setup time, FSX low before CLKX low | | | 10 | | ns |
| M61 | t _c (CKX) | Cycle time, CLKX | 2P | | 16P | | ns |

† For all SPI slave modes, CLKG is programmed as 1/2 of the CPU clock by setting CLKSM = CLKGDV = 1.

‡ P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

Table 5–32. McBSP as SPI Master or Slave Switching Characteristics (CLKSTP = 11b, CLKXP = 1)†‡

| NO. | PARAMETER | | VC5510/5510A-160 VC5510/5510A-200 | | | | UNIT |
|-----|------------------------------|--|--------------------------------------|-------|--------|---------|------|
| | | | MASTER§ | | SLAVE | | |
| | | | MIN | MAX | MIN | MAX | |
| M53 | t _d (CKXH-FXL) | Delay time, FSX low to CLKX high¶ | D – 1 | D + 3 | | | ns |
| M54 | t _d (FXL-CKXL) | Delay time, FSX low to CLKX low# | T – 2 | T + 2 | | | ns |
| M55 | t _d (CKXH-DXV) | Delay time, CLKX high to DX valid | –2 | 4 | 3P + 2 | 5P + 8 | ns |
| M56 | t _{dis} (CKXH-DXHZ) | Disable time, DX high impedance following last data bit from CLKX high | –2 | 0 | 3P + 8 | 3P + 21 | ns |
| M57 | t _d (FXL-DXV) | Delay time, FSX low to DX valid | C – 2 | C +10 | 3P – 3 | 3P + 21 | ns |

† For all SPI slave modes, CLKG is programmed as 1/2 of the CPU clock by setting CLKSM = CLKGDV = 1.

‡ P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

§ T = CLKX period = (1 + CLKGDV) * P

C = CLKX low pulse width = T/2 when CLKGDV is odd or zero and = (CLKGDV/2) * P when CLKGDV is even

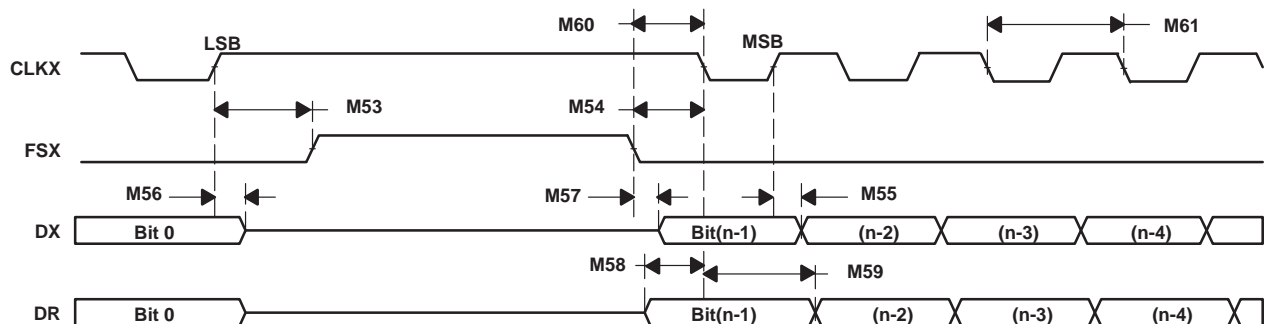
D = CLKX high pulse width = T/2 when CLKGDV is odd or zero and = (CLKGDV/2 + 1) * P when CLKGDV is even

¶ FSRP = FSXP = 1. As a SPI master, FSX is inverted to provide active-low slave-enable output. As a slave, the active-low signal input on FSX and FSR is inverted before being used internally.

CLKXM = FSXM = 1, CLKRM = FSRM = 0 for master McBSP

CLKXM = CLKRM = FSXM = FSRM = 0 for slave McBSP

FSX should be low before the rising edge of clock to enable slave devices and then begin a SPI transfer at the rising edge of the master clock (CLKX).

**Figure 5–27. McBSP Timing as SPI Master or Slave: CLKSTP = 11b, CLKXP = 1**

5.15 Enhanced Host-Port Interface (EHPI) Timing

Table 5–33 and Table 5–34 assume testing over recommended operating conditions (see Figure 5–28 through Figure 5–32).

Table 5–33. EHPI Timing Requirements

| NO. | | | VC5510/5510A-160 VC5510/5510A-200 | | UNIT |
|-----|-----------------------|---|--------------------------------------|-----|------|
| | | | MIN | MAX | |
| E11 | $t_{su}(HASL-HDSL)$ | Setup time, \overline{HAS} low before \overline{HDS} low | 4 | | ns |
| E12 | $t_h(HDSL-HASL)$ | Hold time, \overline{HAS} low after \overline{HDS} low | 3 | | ns |
| E13 | $t_{su}(HCNTLV-HDSL)$ | Setup time, (HR/\overline{W} , $HA[19:0]$, $HCNTL[1:0]$) valid before \overline{HDS} low | 4 | | ns |
| E14 | $t_h(HDSL-HCNTLIV)$ | Hold time, (HR/\overline{W} , $HA[19:0]$, $HCNTL[1:0]$) invalid after \overline{HDS} low | 4 | | ns |
| E15 | $t_w(HDSL)$ | Pulse duration, \overline{HDS} low | 4P [†] | | ns |
| E16 | $t_w(HDSH)$ | Pulse duration, \overline{HDS} high | 4P [†] | | ns |
| E17 | $t_{su}(HDV-HDSH)$ | Setup time, HD bus write data valid before \overline{HDS} high | 5 | | ns |
| E18 | $t_h(HDSH-HDIV)$ | Hold time, HD bus write data invalid after \overline{HDS} high | 3 | | ns |
| E19 | $t_{su}(HCNTLV-HASL)$ | Setup time, (HR/\overline{W} , $HCNTL[1:0]$) valid before \overline{HAS} low | 5 | | ns |
| E20 | $t_h(HASL-HCNTLIV)$ | Hold time, (HR/\overline{W} , $HCNTL[1:0]$) valid after \overline{HAS} low | 3 | | ns |

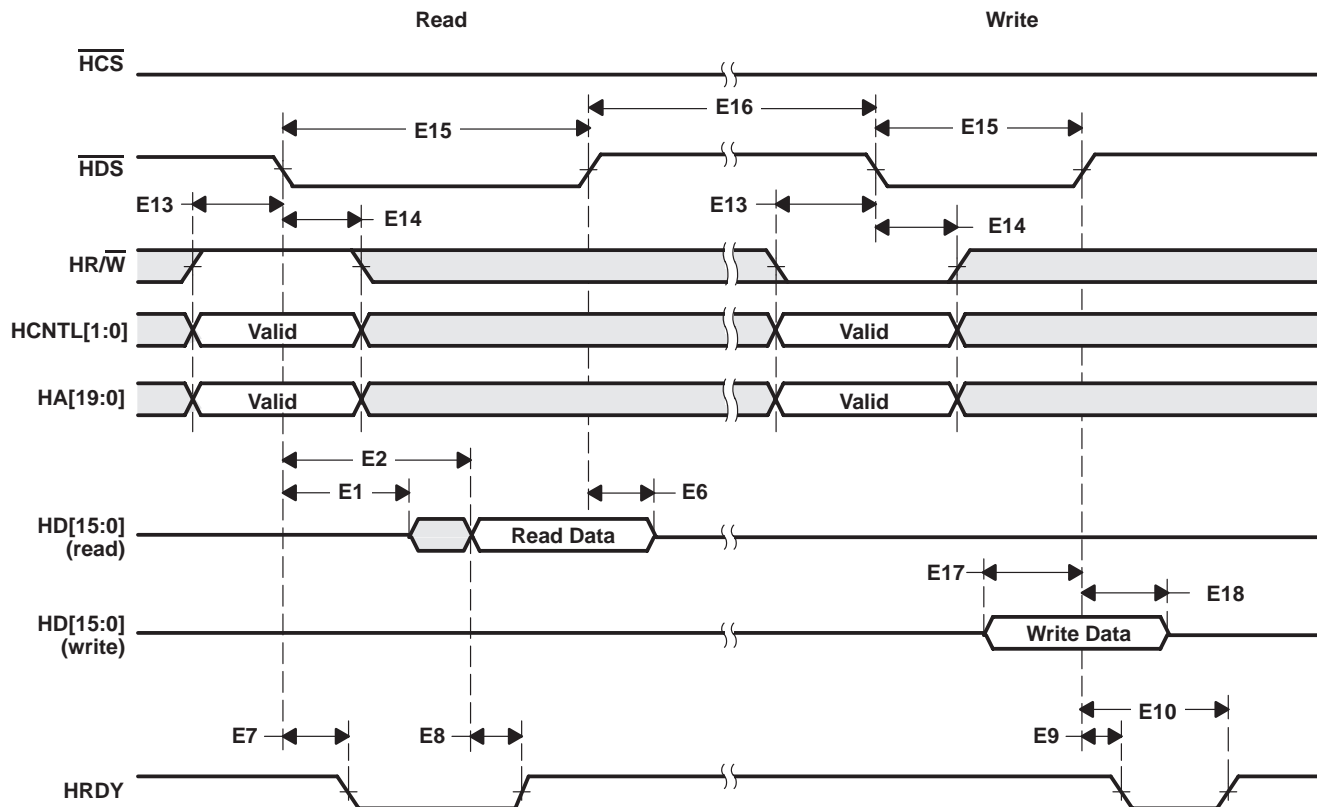
[†] P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

Table 5–34. EHPI Switching Characteristics

| NO. | PARAMETER | | VC5510/5510A-160 VC5510/5510A-200 | | UNIT |
|-----|----------------------|---|--------------------------------------|-------------------|------|
| | | | MIN | MAX | |
| E1 | $t_d(HDSL-HDD)M$ | Delay time, \overline{HDS} low to HD bus read data driven (memory access) | 6 | 16 | ns |
| E2 | $t_d(HDSL-HDV1)M$ | Delay time, \overline{HDS} low to HD bus read data valid (memory access) | 14P+10 ^{†‡} | | ns |
| E4 | $t_d(HDSL-HDD)R$ | Delay time, \overline{HDS} low to HD bus read data driven (register access) | 6 | 16 | ns |
| E5 | $t_d(HDSL-HDV)R$ | Delay time, \overline{HDS} low to HD bus read data valid (register access) | | 16 | ns |
| E6 | $t_{dis}(HDSH-HDIV)$ | Disable time, \overline{HDS} high to HD bus read data invalid | 6 | 16 | ns |
| E7 | $t_d(HDSL-HRDYL)$ | Delay time, \overline{HDS} low to $HRDY$ low (during reads) | | P+10 [†] | ns |
| E8 | $t_d(HDV-HRDYH)$ | Delay time, HD bus valid to $HRDY$ high (during reads) | 2 | | ns |
| E9 | $t_d(HDSH-HRDYL)$ | Delay time, \overline{HDS} high to $HRDY$ low (during writes) | | 16 | ns |
| E10 | $t_d(HDSH-HRDYH)$ | Delay time, \overline{HDS} high to $HRDY$ high (during writes) | 14P+10 [†] | | ns |

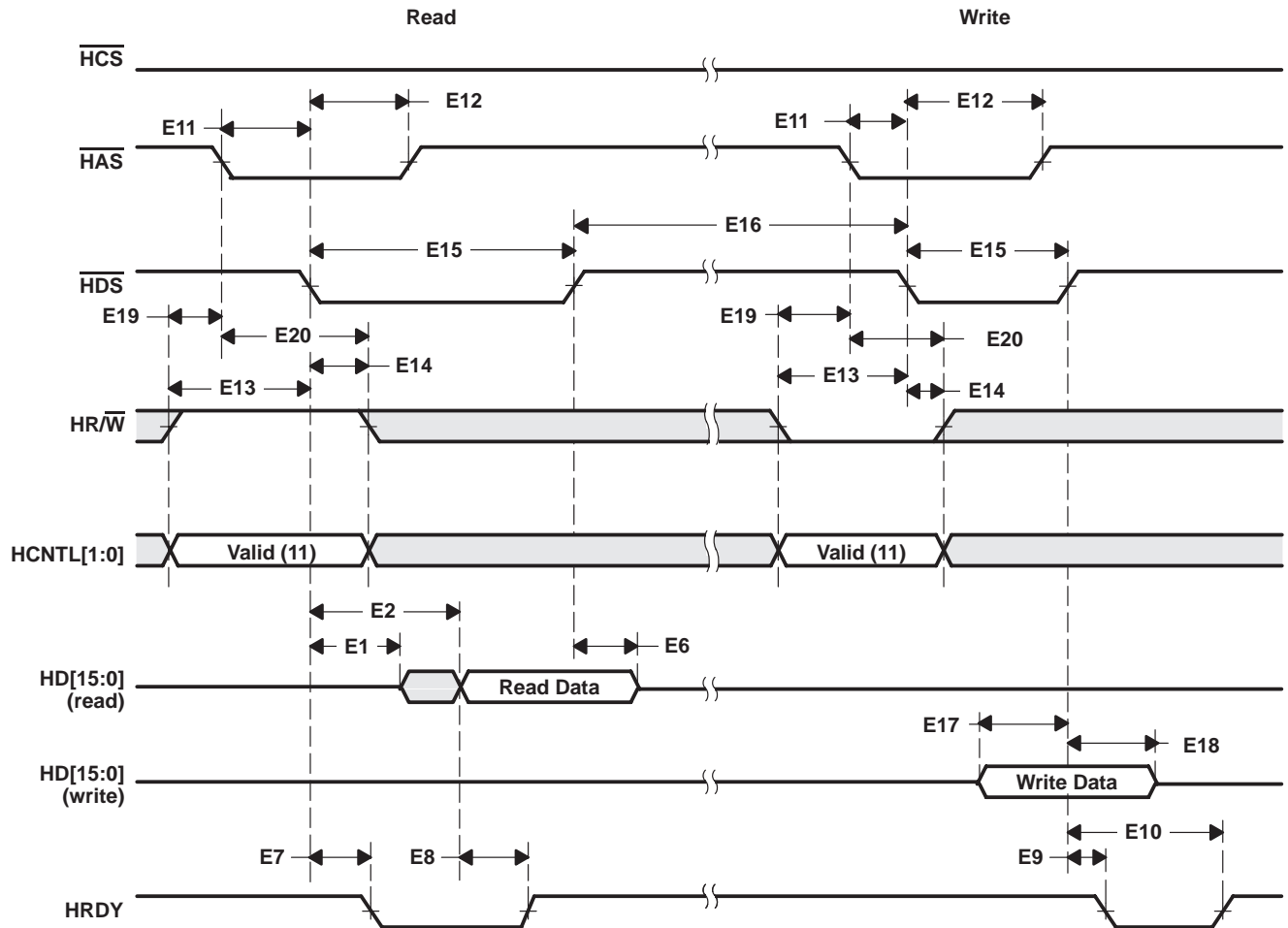
[†] P = 1/CPU clock frequency in ns. For example, when running parts at 200 MHz, use P = 5 ns.

[‡] EHPI latency is dependent on the number of DMA channels active, their priorities and their source/destination ports. The latency shown assumes no competing CPU or DMA activity to the memory resource being accessed by the EHPI.



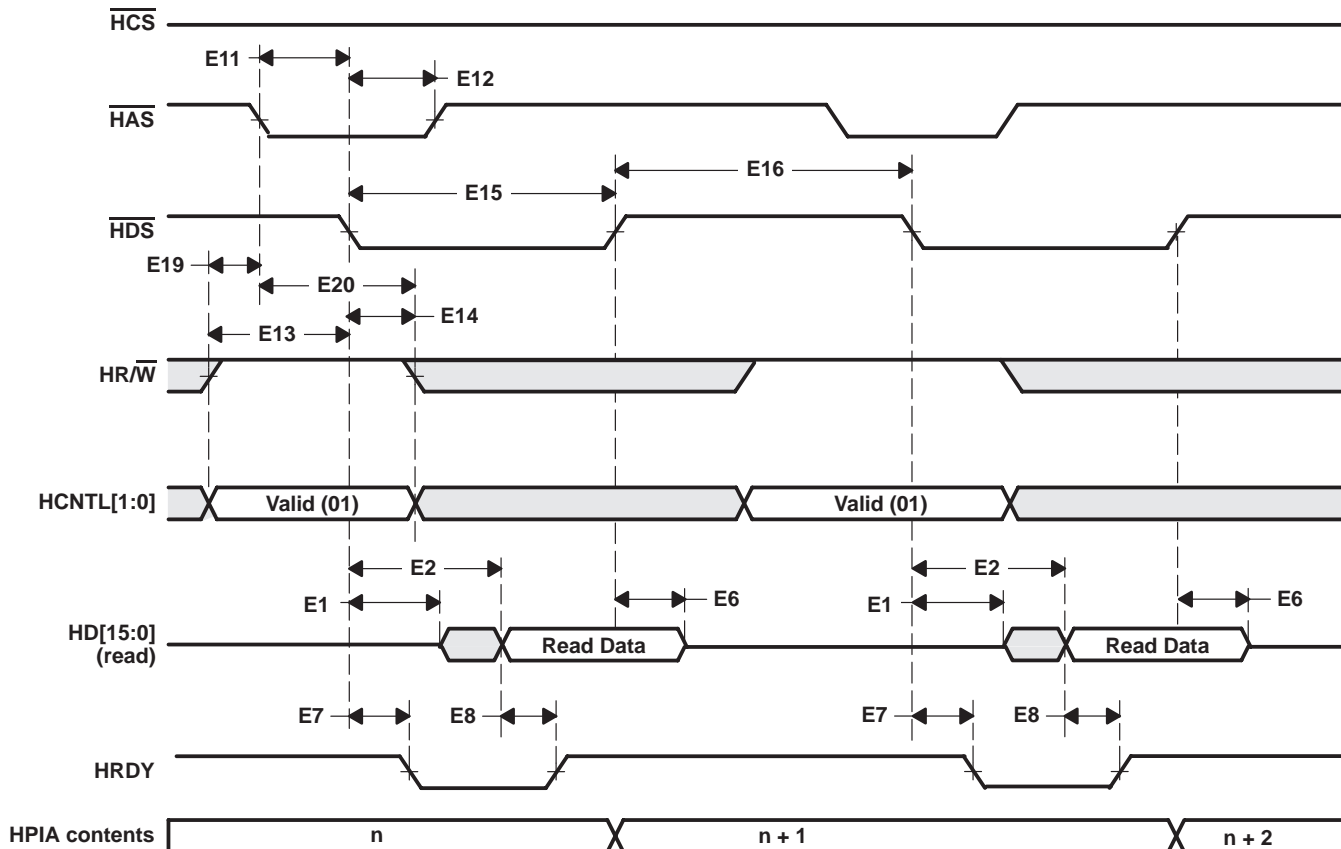
- NOTES: A. As of revision 2.1, the byte-enable function on the EHPI (as controlled by pins $\overline{\text{HBE0}}$ and $\overline{\text{HBE1}}$) is no longer supported. These pins must always be driven low either by an external device, by external pulldown resistors or by using the on-chip pulldown circuitry controlled by the HPE bit in the System Register (SYSR).
- B. The falling edge of $\overline{\text{HCS}}$ must occur concurrent with or before the falling edge of $\overline{\text{HDS}}$. The rising edge of $\overline{\text{HCS}}$ must occur concurrent with or after the rising edge of $\overline{\text{HDS}}$. If $\overline{\text{HDS1}}$ and/or $\overline{\text{HDS2}}$ are tied low and $\overline{\text{HCS}}$ is used as a strobe, the timing requirements shown for $\overline{\text{HDS}}$ apply to $\overline{\text{HCS}}$. Operation with $\overline{\text{HCS}}$ as a strobe is not recommended because $\overline{\text{HCS}}$ gates output of HRDY (when $\overline{\text{HCS}}$ is high HRDY is not driven).

Figure 5–28. EHPI Nonmultiplexed Read/Write Timings



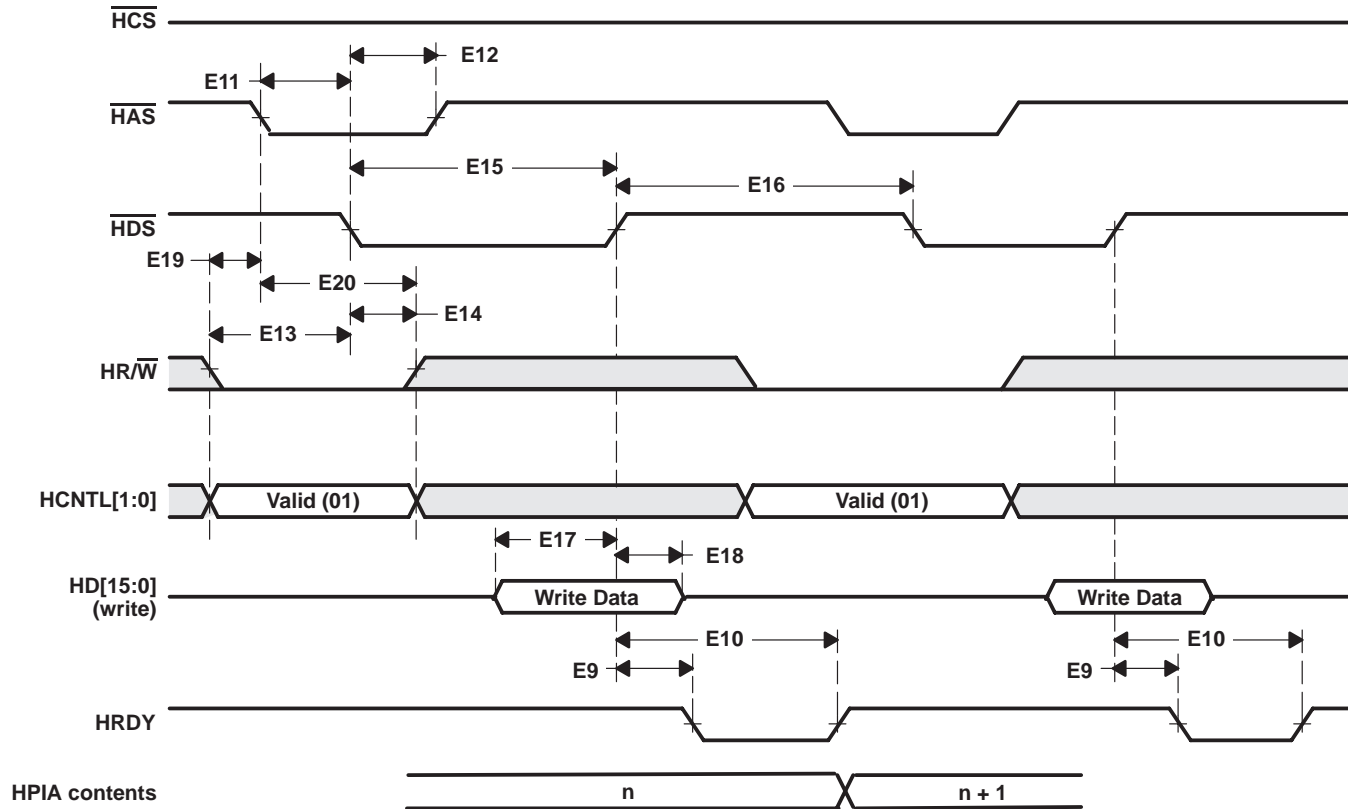
- NOTES: A. As of revision 2.1, the byte-enable function on the EHPI (as controlled by pins $\overline{\text{HBE0}}$ and $\overline{\text{HBE1}}$) is no longer supported. These pins must always be driven low either by an external device, by external pulldown resistors or by using the on-chip pulldown circuitry controlled by the HPE bit in the System Register (SYSR).
- B. The falling edge of $\overline{\text{HCS}}$ must occur concurrent with or before the falling edge of $\overline{\text{HDS}}$. The rising edge of $\overline{\text{HCS}}$ must occur concurrent with or after the rising edge of $\overline{\text{HDS}}$. If HDS1 and/or HDS2 are tied low and $\overline{\text{HCS}}$ is used as a strobe, the timing requirements shown for $\overline{\text{HDS}}$ apply to $\overline{\text{HCS}}$. Operation with $\overline{\text{HCS}}$ as a strobe is not recommended because $\overline{\text{HCS}}$ gates output of HRDY (when $\overline{\text{HCS}}$ is high HRDY is not driven).

Figure 5–29. EHPI Multiplexed Memory (HPID) Access Read/Write Timings Without Autoincrement



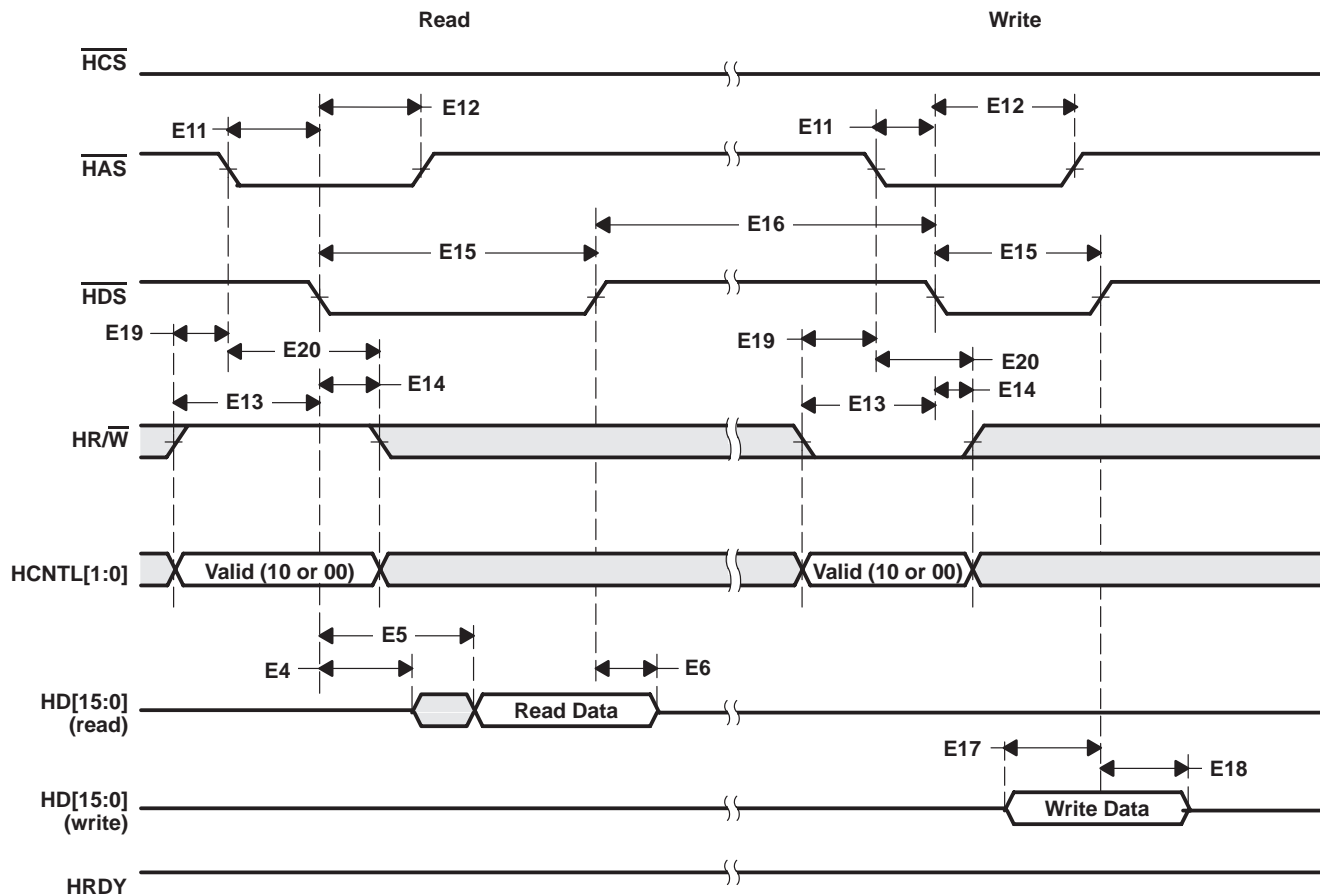
- NOTES:
- A. As of revision 2.1, the byte-enable function on the EHPI (as controlled by pins $\overline{\text{HBE0}}$ and $\overline{\text{HBE1}}$) is no longer supported. These pins must always be driven low either by an external device, by external pulldown resistors or by using the on-chip pulldown circuitry controlled by the HPE bit in the System Register (SYSR).
 - B. During autoincrement mode, although the EHPI internally increments the memory address, reads of the HPIA register by the host will always indicate the base address.
 - C. The falling edge of $\overline{\text{HCS}}$ must occur concurrent with or before the falling edge of $\overline{\text{HDS}}$. The rising edge of $\overline{\text{HCS}}$ must occur concurrent with or after the rising edge of $\overline{\text{HDS}}$. If $\overline{\text{HDS1}}$ and/or $\overline{\text{HDS2}}$ are tied low and $\overline{\text{HCS}}$ is used as a strobe, the timing requirements shown for $\overline{\text{HDS}}$ apply to $\overline{\text{HCS}}$. Operation with $\overline{\text{HCS}}$ as a strobe is not recommended because $\overline{\text{HCS}}$ gates output of $\overline{\text{HRDY}}$ (when $\overline{\text{HCS}}$ is high $\overline{\text{HRDY}}$ is not driven).

Figure 5–30. EHPI Multiplexed Memory (HPID) Access Read Timings With Autoincrement



- NOTES:
- A. As of revision 2.1, the byte-enable function on the EHPI (as controlled by pins $\overline{HBE0}$ and $\overline{HBE1}$) is no longer supported. These pins must always be driven low either by an external device, by external pulldown resistors or by using the on-chip pulldown circuitry controlled by the HPE bit in the System Register (SYSR).
 - B. During autoincrement mode, although the EHPI internally increments the memory address, reads of the HPIA register by the host will always indicate the base address.
 - C. The falling edge of \overline{HCS} must occur concurrent with or before the falling edge of \overline{HDS} . The rising edge of \overline{HCS} must occur concurrent with or after the rising edge of \overline{HDS} . If HDS1 and/or HDS2 are tied low and \overline{HCS} is used as a strobe, the timing requirements shown for \overline{HDS} apply to \overline{HCS} . Operation with \overline{HCS} as a strobe is not recommended because \overline{HCS} gates output of HRDY (when \overline{HCS} is high HRDY is not driven).

Figure 5–31. EHPI Multiplexed Memory (HPID) Access Write Timings With Autoincrement



- NOTES:
- As of revision 2.1, the byte-enable function on the EHPI (as controlled by pins $\overline{\text{HBE0}}$ and $\overline{\text{HBE1}}$) is no longer supported. These pins must always be driven low either by an external device, by external pulldown resistors or by using the on-chip pulldown circuitry controlled by the HPE bit in the System Register (SYSR).
 - During auto-increment mode, although the EHPI internally increments the memory address, reads of the HPIA register by the host will always indicate the base address.
 - The falling edge of $\overline{\text{HCS}}$ must occur concurrent with or before the falling edge of $\overline{\text{HDS}}$. The rising edge of $\overline{\text{HCS}}$ must occur concurrent with or after the rising edge of $\overline{\text{HDS}}$. If $\overline{\text{HDS1}}$ and/or $\overline{\text{HDS2}}$ are tied low and $\overline{\text{HCS}}$ is used as a strobe, the timing requirements shown for $\overline{\text{HDS}}$ apply to $\overline{\text{HCS}}$. Operation with $\overline{\text{HCS}}$ as a strobe is not recommended because $\overline{\text{HCS}}$ gates output of $\overline{\text{HRDY}}$ (when $\overline{\text{HCS}}$ is high $\overline{\text{HRDY}}$ is not driven).

Figure 5–32. EHPI Multiplexed Register Access Read/Write Timings

6 Mechanical Data

6.1 Package Thermal Resistance Characteristics

Table 6–1 and Table 6–2 provide the thermal resistance characteristics for the recommended package types used on the TMS320VC5510/5510A DSPs.

Table 6–1. Thermal Resistance Characteristics (Ambient)

| $R_{\theta JA}$ (°C/W) | BOARD TYPE† | AIRFLOW (LFM) |
|------------------------|-------------|---------------|
| 26 | High-K | 0 |
| 22 | High-K | 150 |
| 20 | High-K | 250 |
| 50 | Low-K | 0 |
| 35 | Low-K | 150 |
| 29 | Low-K | 250 |

† Board types are as defined by JEDEC. Reference JEDEC Standard JESD51-9, Test Boards for Area Array Surface Mount Package Thermal Measurements.

Table 6–2. Thermal Resistance Characteristics (Case)

| $R_{\theta JC}$ (°C/W) | BOARD TYPE† |
|------------------------|--------------------|
| 6 | 2s JEDEC Test Card |

† Board types are as defined by JEDEC. Reference JEDEC Standard JESD51-9, Test Boards for Area Array Surface Mount Package Thermal Measurements.

6.2 Packaging Information

The following packaging information reflects the most current released data available for the designated device(s). This data is subject to change without notice and without revision of this document.

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|--------------------|---------------|------------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TMS320VC5510AGGW1 | ACTIVE | BGA MICROSTAR | GGW | 240 | 126 | TBD | SNPB | Level-3-220C-168 HR | 0 to 85 | VC5510AGGW1 TMS320 | Samples |
| TMS320VC5510AGGW2 | ACTIVE | BGA MICROSTAR | GGW | 240 | 126 | TBD | SNPB | Level-3-220C-168 HR | 0 to 85 | VC5510AGGW2 TMS320 | Samples |
| TMS320VC5510AGGWA1 | ACTIVE | BGA MICROSTAR | GGW | 240 | 126 | TBD | SNPB | Level-3-220C-168 HR | -40 to 85 | VC5510AGGWA1 TMS320 | Samples |
| TMS320VC5510AGGWA2 | ACTIVE | BGA MICROSTAR | GGW | 240 | 126 | TBD | SNPB | Level-3-220C-168 HR | -40 to 85 | VC5510AGGWA2 TMS320 | Samples |
| TMS320VC5510AZGW1 | ACTIVE | BGA MICROSTAR | ZGW | 240 | 126 | Green (RoHS & no Sb/Br) | SNAGCU | Level-3-260C-168 HR | 0 to 85 | VC5510AZGW1 TMS320 | Samples |
| TMS320VC5510AZGW2 | ACTIVE | BGA MICROSTAR | ZGW | 240 | 126 | Green (RoHS & no Sb/Br) | SNAGCU | Level-3-260C-168 HR | 0 to 85 | VC5510AZGW2 TMS320 | Samples |
| TMS320VC5510AZGWA1 | ACTIVE | BGA MICROSTAR | ZGW | 240 | 126 | Green (RoHS & no Sb/Br) | SNAGCU | Level-3-260C-168 HR | -40 to 85 | VC5510AZGWA1 TMS320 | Samples |
| TMS320VC5510AZGWA2 | ACTIVE | BGA MICROSTAR | ZGW | 240 | 126 | Green (RoHS & no Sb/Br) | SNAGCU | Level-3-260C-168 HR | -40 to 85 | VC5510AZGWA2 TMS320 | Samples |
| TMS320VC5510GGW1 | OBSOLETE | BGA MICROSTAR | GGW | 240 | | TBD | Call TI | Call TI | | | |
| TMS320VC5510GGW21 | OBSOLETE | BGA MICROSTAR | GGW | 240 | | TBD | Call TI | Call TI | | | |
| TMS320VC5510GGWA1 | OBSOLETE | BGA MICROSTAR | GGW | 240 | | TBD | Call TI | Call TI | | VC5510GGWA1 TMS320 | |

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

ACTIVE: Product device recommended for new designs.

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

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

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

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

⁽⁴⁾ There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

⁽⁵⁾ Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

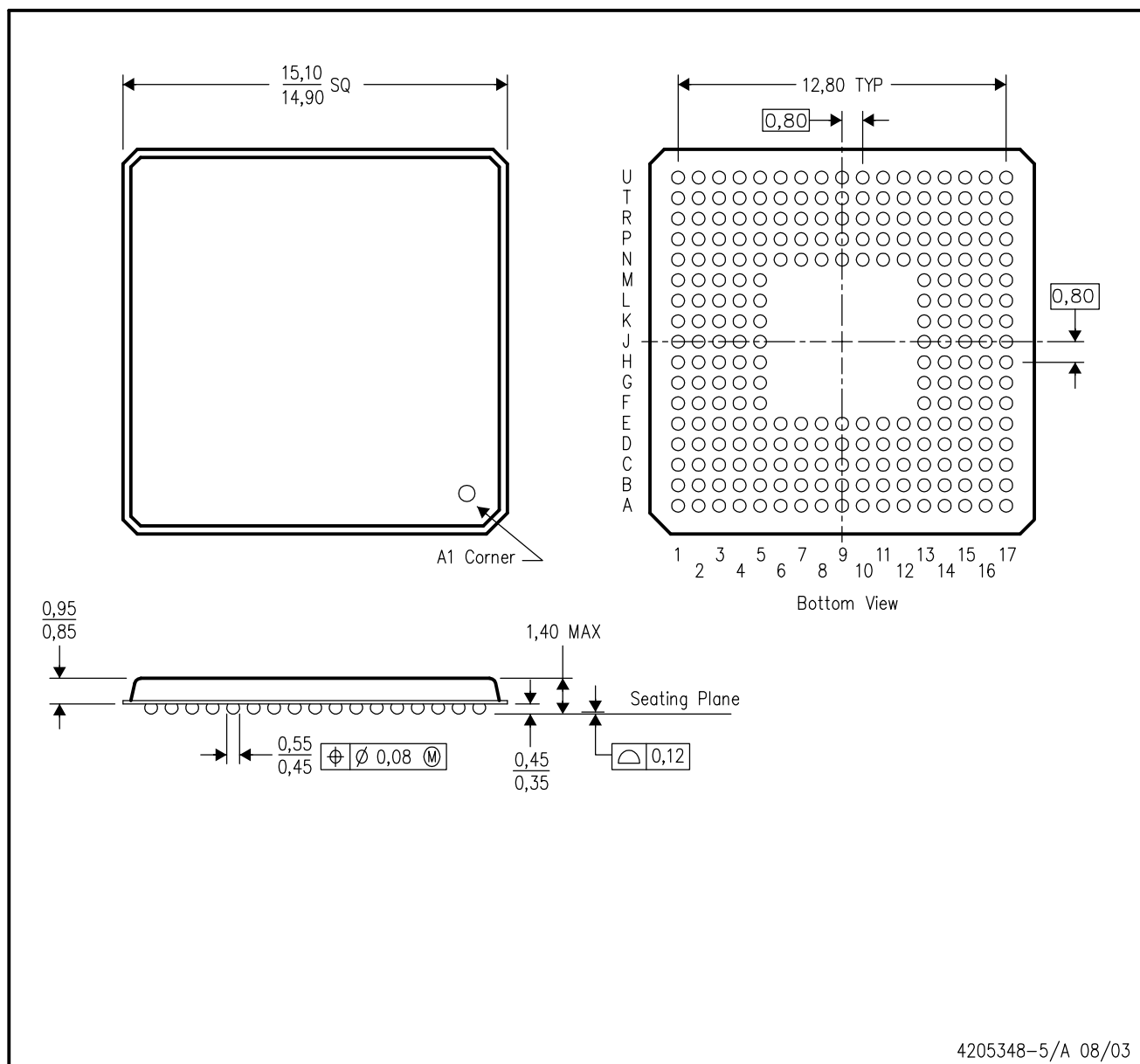
⁽⁶⁾ Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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ZGW (S-PBGA-N240)

PLASTIC BALL GRID ARRAY



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. MicroStar BGA™ configuration
 - D. This package is lead-free.

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