

# Sitara™ AM335x ARM® Cortex™-A8 Microprocessors (MPUs)

Check for Samples: [AM3359](#), [AM3358](#)

## 1 Device Summary

### 1.1 Features

- **Highlights**
  - Up to 1-GHz Sitara™ ARM® Cortex™-A8 32-Bit RISC Microprocessor
    - NEON™ SIMD Coprocessor
    - 32KB of L1 Instruction and 32KB Data Cache with Single-Error Detection (parity)
    - 256KB of L2 Cache with Error Correcting Code (ECC)
  - mDDR(LPDDR), DDR2, DDR3, DDR3L Support
  - General-Purpose Memory Support (NAND, NOR, SRAM) Supporting Up to 16-bit ECC
  - SGX530 3D Graphics Engine
  - LCD and Touchscreen Controller
  - Programmable Real-Time Unit and Industrial Communication Subsystem (PRU-ICSS)
  - Real-Time Clock (RTC)
  - Up to Two USB 2.0 High-Speed OTG Ports with Integrated PHY
  - 10, 100, 1000 Ethernet Switch Supporting Up to Two Ports
  - Serial Interfaces Including:
    - Two Controller Area Network Ports (CAN)
    - Six UARTs, Two McASPs, Two McSPI, and Three I2C Ports
  - 12-Bit Successive Approximation Register (SAR) ADC
  - Up to Three 32-Bit Enhanced Capture Modules (eCAP)
  - Up to Three Enhanced High-Resolution PWM Modules (eHRPWM)
  - Crypto Hardware Accelerators (AES, SHA, PKA, RNG)
- **MPU Subsystem**
  - Up to 1-GHz ARM® Cortex™-A8 32-Bit RISC Microprocessor
  - NEON™ SIMD Coprocessor
  - 32KB of L1 Instruction Cache with Single-Error Detection (parity)
  - 32KB of L1 Data Cache with Single Error-Detection (parity)
  - 256KB of L2 Cache with Error Correcting Code (ECC)
  - 176KB of On-Chip Boot ROM
  - 64KB of Dedicated RAM
  - Emulation and Debug
    - JTAG
  - Interrupt Controller (up to 128 interrupt requests)
  - **On-Chip Memory (Shared L3 RAM)**
    - 64 KB of General-Purpose On-Chip Memory Controller (OCMC) RAM
    - Accessible to all Masters
    - Supports Retention for Fast Wake-Up
  - **External Memory Interfaces (EMIF)**
    - mDDR(LPDDR), DDR2, DDR3, DDR3L Controller:
      - mDDR: 200-MHz Clock (400-MHz Data Rate)
      - DDR2: 266-MHz Clock (532-MHz Data Rate)
      - DDR3: 400-MHz Clock (800-MHz Data Rate)
      - DDR3L: 400-MHz Clock (800-MHz Data Rate)
      - 16-Bit Data Bus
      - 1 GB of Total Addressable Space
      - Supports One x16 or Two x8 Memory Device Configurations
  - General-Purpose Memory Controller (GPMC)
    - Flexible 8-Bit and 16-Bit Asynchronous Memory Interface with Up to seven Chip Selects (NAND, NOR, Muxed-NOR, SRAM)
    - Uses BCH Code to Support 4-Bit, 8-Bit, or 16-Bit ECC
    - Uses Hamming Code to Support 1-Bit ECC
  - Error Locator Module (ELM)
    - Used in Conjunction with the GPMC to



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- Locate Addresses of Data Errors from Syndrome Polynomials Generated Using a BCH Algorithm
  - Supports 4-Bit, 8-Bit, and 16-Bit per 512-byte Block Error Location Based on BCH Algorithms
- Programmable Real-Time Unit and Industrial Communication Subsystem (PRU-ICSS)
  - Supports protocols such as EtherCAT®, PROFIBUS, PROFINET, EtherNet/IP™, and more
  - Peripherals Inside the PRU-ICSS
    - One UART Port with Flow Control Pins, Supports Up to 12 Mbps
    - Two MII Ethernet Ports that Support Industrial Ethernet, such as EtherCAT
    - One MDIO Port
    - One Enhanced Capture (eCAP) Module
- Power Reset and Clock Management (PRCM) Module
  - Controls the entry and Exit of Stand-By and Deep-Sleep Modes
  - Responsible for Sleep Sequencing, Power Domain Switch-Off Sequencing, Wake-Up Sequencing and Power Domain Switch-On Sequencing
  - Clocks
    - Integrated 15-35 MHz High-Frequency Oscillator Used to Generate a Reference Clock for Various System and Peripheral Clocks
    - Supports Individual Clock Enable and Disable Control for Subsystems and Peripherals to Facilitate Reduced Power Consumption
    - Five ADPLLs to Generate System Clocks (MPU Subsystem, DDR Interface, USB and Peripherals [MMC and SD, UART, SPI, I2C], L3, L4, Ethernet, GFX [SGX530], LCD Pixel Clock)
  - Power
    - Two Non-Switchable Power Domains (Real-Time Clock [RTC], Wake-Up Logic [WAKE-UP])
    - Three Switchable Power Domains (MPU Subsystem [MPU], SGX530 [GFX], Peripherals and Infrastructure [PER])
    - Implements SmartReflex™ Class 2B for Core Voltage Scaling Based On Die Temperature, Process Variation and Performance (Adaptive Voltage Scaling [AVS])
    - Dynamic Voltage Frequency Scaling (DVFS)
- Real-Time Clock (RTC)
  - Real-Time Date (Day-Month-Year-Day of Week) and Time (Hours-Minutes-Seconds) Information
- Internal 32.768-kHz Oscillator, RTC Logic and 1.1-V Internal LDO
- Independent Power-on-Reset (RTC\_PWRONRSTn) Input
- Dedicated Input Pin (EXT\_WAKEUP) for External Wake Events
- Programmable Alarm Can be Used to Generate Internal Interrupts to the PRCM (for Wake Up) or Cortex-A8 (for Event Notification)
- Programmable Alarm Can be Used with External Output (PMIC\_POWER\_EN) to Enable the Power Management IC to Restore Non-RTC Power Domains
- Peripherals
  - Up to Two USB 2.0 High-Speed OTG Ports with Integrated PHY
  - Up to Two Industrial Gigabit Ethernet MACs (10, 100, 1000 Mbps)
    - Integrated Switch
    - Each MAC Supports MII, RMII, RGMII and MDIO Interfaces
    - Ethernet MACs and Switch Can Operate Independent of Other Functions
    - IEEE 1588v2 Precision Time Protocol (PTP)
  - Up to Two Controller-Area Network (CAN) Ports
    - Supports CAN Version 2 Parts A and B
  - Up to Two Multichannel Audio Serial Ports (McASP)
    - Transmit and Receive Clocks Up to 50 MHz
    - Up to Four Serial Data Pins per McASP Port with Independent TX and RX Clocks
    - Supports Time Division Multiplexing (TDM), Inter-IC Sound (I2S), and similar Formats
    - Supports Digital Audio Interface Transmission (SPDIF, IEC60958-1, and AES-3 Formats)
    - FIFO Buffers for Transmit and Receive (256 bytes)
  - Up to Six UARTs
    - All UARTs Support IrDA and CIR Modes
    - All UARTs Support RTS and CTS Flow Control
    - UART1 Supports Full Modem control
  - Up to Two Master and Slave McSPI Serial Interfaces
    - Up to Two Chip Selects
    - Up to 48 MHz
  - Up to Three MMC, SD, and SDIO Ports

- 1-Bit, 4-Bit and 8-Bit MMC, SD, and SDIO Modes
- MMCSD0 has dedicated Power Rail for 1.8-V or 3.3-V Operation
- Up to 48-MHz Data Transfer Rate
- Supports Card Detect and Write Protect
- Complies with MMC4.3 and SD and SDIO 2.0 Specifications
- Up to Three I2C Master and Slave Interfaces
  - Standard Mode (up to 100 kHz)
  - Fast Mode (up to 400 kHz)
- Up to Four Banks of General-Purpose IO (GPIO)
  - 32 GPIOs per Bank (Multiplexed with Other Functional Pins)
  - GPIOs Can be Used as Interrupt Inputs (Up to Two Interrupt Inputs per Bank)
- Up to Three External DMA Event Inputs That Can Also be Used as Interrupt Inputs
- Eight 32-Bit General-Purpose Timers
  - DMTIMER1 is a 1-ms Timer Used for Operating System (OS) Ticks
  - DMTIMER4 - DMTIMER7 are Pinned Out
- One Watchdog Timer
- SGX530 3D Graphics Engine
  - Tile-Based Architecture Delivering Up to 20 Million Polygons per second
  - Universal Scalable Shader Engine is a Multi-Threaded Engine Incorporating Pixel and Vertex Shader Functionality
  - Advanced Shader Feature Set in Excess of Microsoft VS3.0, PS3.0 and OGL2.0
  - Industry Standard API Support of Direct3D Mobile, OGL-ES 1.1 and 2.0, OpenVG 1.0, and OpenMax
  - Fine-Grained Task Switching, Load Balancing and Power Management
  - Advanced Geometry DMA Driven Operation for Minimum CPU Interaction
  - Programmable High-Quality Image Anti-Aliasing
  - Fully Virtualized Memory Addressing for OS Operation in a Unified Memory Architecture
- LCD Controller
  - Up to 24-Bits Data Output; 8-Bits per Pixel (RGB)
  - Resolution Up to 2048x2048 (With Maximum 126-MHz Pixel Clock)
  - Integrated LCD Interface Display Driver (LIDD) Controller
  - Integrated Raster Controller
  - Integrated DMA Engine to Pull Data from the External Frame Buffer without Burdening the Processor via Interrupts or a Firmware Timer
- 512-Word Deep Internal FIFO
- Supported Display Types:
  - Character Displays - Uses LCD Interface Display Driver (LIDD) Controller to Program these Displays
  - Passive Matrix LCD Displays - Uses LCD Raster Display Controller to Provide Timing and Data for Constant Graphics Refresh to a Passive Display
  - Active Matrix LCD Displays - Uses External Frame Buffer Space and the Internal DMA Engine to Drive Streaming Data to the Panel
- 12-Bit Successive Approximation Register (SAR) ADC
  - 200K Samples per Second
  - Input Can be Selected from any of the Eight Analog Inputs Multiplexed Through an 8:1 analog Switch
  - Can be Configured to Operate as a 4-wire, 5-wire, or 8-wire Resistive Touch Screen Controller (TSC) Interface
- Up to Three 32-Bit Enhanced Capture Modules (eCAP)
  - Configurable as Three Capture Inputs or Three Auxiliary PWM Outputs
- Up to Three Enhanced High-Resolution PWM Modules (eHRPWM)
  - Dedicated 16-Bit Time-Base Counter with Time and Frequency Controls
  - Configurable as Six Single-Ended, Six Dual-Edge Symmetric, or Three Dual-Edge Asymmetric Outputs
- Up to Three 32-Bit Enhanced Quadrature Encoder Pulse (eQEP) Modules
- Device Identification
  - Contains Electrical fuse Farm (FuseFarm) of Which Some Bits are Factory Programmable
    - Production ID
    - Device Part Number (Unique JTAG ID)
    - Device Revision (readable by Host ARM)
- Debug Interface Support
  - JTAG and cJTAG for ARM (Cortex-A8 and PRCM), PRU-ICSS Debug
  - Supports Device Boundary Scan
  - Supports IEEE 1500
- DMA
  - On-Chip Enhanced DMA Controller (EDMA) has Three Third-Party Transfer Controllers (TPTC) and One Third-Party Channel Controller (TPCC), Which Supports Up to 64 Programmable Logical Channels and Eight QDMA Channels. EDMA is Used for:
    - Transfers to and from On-Chip Memories

- Transfers to and from External Storage (EMIF, General-Purpose Memory Controller, Slave Peripherals)
- Inter-Processor Communication (IPC)
  - Integrates Hardware-Based Mailbox for IPC and Spinlock for Process Synchronization Between the Cortex-A8, PRCM, and PRU-ICSS
  - Mailbox Registers that Generate Interrupts
    - Four Initiators (Cortex-A8, PRCM, PRU0, PRU1)
  - Spinlock has 128 Software-Assigned Lock Registers
- Security
  - Crypto Hardware Accelerators (AES, SHA, PKA, RNG)
- Boot Modes
  - Boot Mode is Selected via Boot Configuration Pins Latched on the Rising Edge of the PWRONRSTn Reset Input Pin
- Packages:
  - 298-Pin S-PBGA-N298 Via Channel™ package (ZCE Suffix), 0.65-mm Ball Pitch
  - 324-Pin S-PBGA-N324 package (ZCZ Suffix), 0.80-mm Ball Pitch

## 1.2 Applications

- Gaming Peripherals
- Home and Industrial Automation
- Consumer Medical Appliances
- Printers
- Smart Toll Systems
- Connected Vending Machines
- Weighing Scales
- Educational Consoles
- Advanced Toys

### 1.3 Description

The AM335x microprocessors, based on the ARM Cortex-A8, are enhanced with image, graphics processing, peripherals and industrial interface options such as EtherCAT and PROFIBUS. The device supports the following high-level operating systems (HLOSs) that are available free of charge from TI:

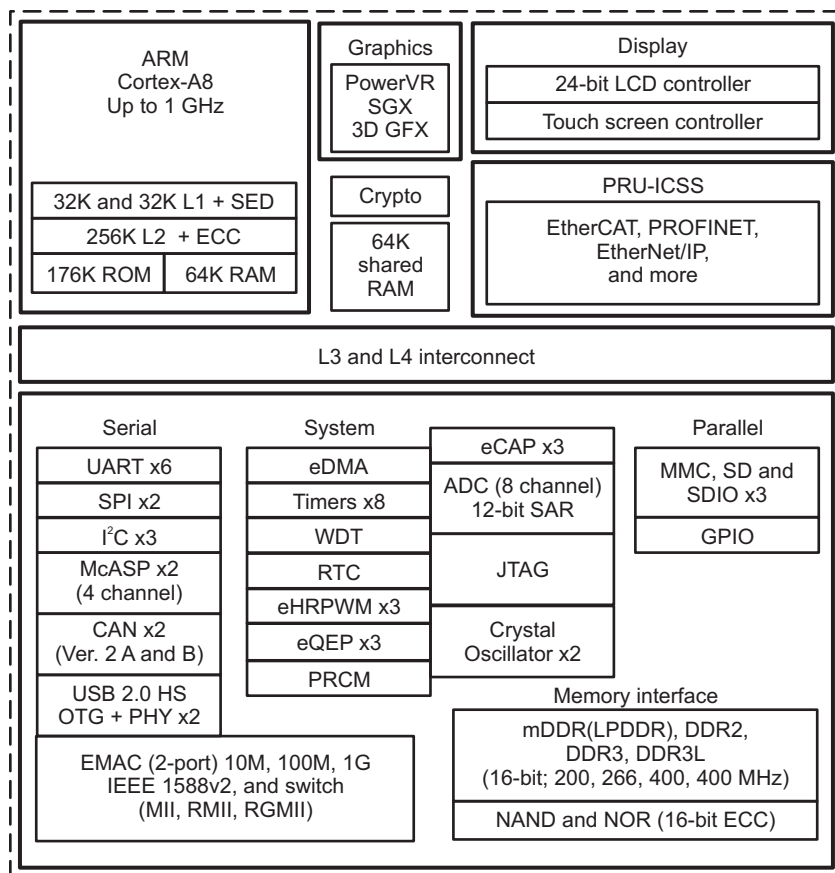
- Linux®
- Android™

The AM335x microprocessor contains these subsystems:

- Microprocessor unit (MPU) subsystem based on the ARM Cortex-A8 microprocessor.
- POWERVR SGX™ Graphics Accelerator subsystem for 3D graphics acceleration to support display and gaming effects.
- The Programmable Real-Time Unit and Industrial Communication Subsystem (PRU-ICSS) is separate from the ARM core, allowing independent operation and clocking for greater efficiency and flexibility. The PRU-ICSS enables additional peripheral interfaces and real-time protocols such as EtherCAT, PROFINET, EtherNet/IP, PROFIBUS, Ethernet Powerlink, Sercos, and others.

## 1.4 Functional Block Diagram

The AM335x microprocessor functional block diagram is shown in [Figure 1-1](#).



**Figure 1-1. AM335x Functional Block Diagram**

|          |                                                                              |                            |          |                                                          |                            |
|----------|------------------------------------------------------------------------------|----------------------------|----------|----------------------------------------------------------|----------------------------|
| <b>1</b> | <b>Device Summary</b>                                                        | <b><a href="#">1</a></b>   | 5.2      | Recommended Clock and Control Signal Transition Behavior | <a href="#">115</a>        |
| 1.1      | Features                                                                     | <a href="#">1</a>          | 5.3      | Controller Area Network (CAN)                            | <a href="#">116</a>        |
| 1.2      | Applications                                                                 | <a href="#">4</a>          | 5.4      | DMTimer                                                  | <a href="#">117</a>        |
| 1.3      | Description                                                                  | <a href="#">5</a>          | 5.5      | Ethernet Media Access Controller (EMAC) and Switch       | <a href="#">118</a>        |
| 1.4      | Functional Block Diagram                                                     | <a href="#">6</a>          | 5.6      | External Memory Interfaces                               | <a href="#">126</a>        |
|          | <b>Revision History</b>                                                      | <b><a href="#">8</a></b>   | 5.7      | Inter-Integrated Circuit (I2C)                           | <a href="#">189</a>        |
| <b>2</b> | <b>Terminal Description</b>                                                  | <b><a href="#">10</a></b>  | 5.8      | JTAG Electrical Data and Timing                          | <a href="#">191</a>        |
| 2.1      | Pin Assignments                                                              | <a href="#">10</a>         | 5.9      | LCD Controller (LCDC)                                    | <a href="#">192</a>        |
| 2.2      | Ball Characteristics                                                         | <a href="#">18</a>         | 5.10     | Multichannel Audio Serial Port (McASP)                   | <a href="#">208</a>        |
| 2.3      | Signal Description                                                           | <a href="#">51</a>         | 5.11     | Multichannel Serial Port Interface (McSPI)               | <a href="#">213</a>        |
| <b>3</b> | <b>Device Operating Conditions</b>                                           | <b><a href="#">80</a></b>  | 5.12     | Multimedia Card (MMC) Interface                          | <a href="#">219</a>        |
| 3.1      | Absolute Maximum Ratings                                                     | <a href="#">80</a>         | 5.13     | Universal Asynchronous Receiver Transmitter (UART)       | <a href="#">222</a>        |
| 3.2      | Recommended Operating Conditions                                             | <a href="#">82</a>         | <b>6</b> | <b>Device and Documentation Support</b>                  | <b><a href="#">225</a></b> |
| 3.3      | DC Electrical Characteristics                                                | <a href="#">90</a>         | 6.1      | Device Support                                           | <a href="#">225</a>        |
| 3.4      | External Capacitors                                                          | <a href="#">94</a>         | 6.2      | Documentation Support                                    | <a href="#">226</a>        |
| 3.5      | Touchscreen Controller and Analog-to-Digital Subsystem Electrical Parameters | <a href="#">97</a>         | <b>7</b> | <b>Mechanical Packaging and Orderable Information</b>    | <b><a href="#">228</a></b> |
| <b>4</b> | <b>Power and Clocking</b>                                                    | <b><a href="#">99</a></b>  | 7.1      | Thermal Data for ZCE and ZCZ Packages                    | <a href="#">228</a>        |
| 4.1      | Power Supplies                                                               | <a href="#">99</a>         | 7.2      | Via Channel                                              | <a href="#">228</a>        |
| 4.2      | Clock Specifications                                                         | <a href="#">106</a>        | 7.3      | Packaging Information                                    | <a href="#">228</a>        |
| <b>5</b> | <b>Peripheral Information and Timings</b>                                    | <b><a href="#">115</a></b> |          |                                                          |                            |
| 5.1      | Parameter Information                                                        | <a href="#">115</a>        |          |                                                          |                            |

## Revision History

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

| Changes from Revision E (January 2013) to Revision F                                                                                                                                                              | Page                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| • Changed device status to Production Data .....                                                                                                                                                                  | <a href="#">1</a>   |
| • Changed ARM speeds features list item .....                                                                                                                                                                     | <a href="#">1</a>   |
| • Changed MPU Subsystem speeds features list item .....                                                                                                                                                           | <a href="#">1</a>   |
| • Changed Features list item for DDR3 .....                                                                                                                                                                       | <a href="#">1</a>   |
| • Changed Features list item for DDR3L .....                                                                                                                                                                      | <a href="#">1</a>   |
| • Changed <a href="#">Figure 1-1</a> , AM335x Functional Block Diagram .....                                                                                                                                      | <a href="#">6</a>   |
| • Changed Type value to I for Mode 2 (uart5_rxd) in <a href="#">Table 2-7</a> , Ball Characteristics (ZCE and ZCZ Packages) .....                                                                                 | <a href="#">37</a>  |
| • Added Footnote (3) in <a href="#">Table 2-7</a> , Ball Characteristics (ZCE and ZCZ Packages) .....                                                                                                             | <a href="#">49</a>  |
| • Changed Footnote (4) in <a href="#">Table 2-7</a> , Ball Characteristics (ZCE and ZCZ Packages) .....                                                                                                           | <a href="#">49</a>  |
| • Added RTC_PORz Signal Name to <a href="#">Table 2-17</a> , Miscellaneous/Miscellaneous Signals Description .....                                                                                                | <a href="#">60</a>  |
| • Deleted ESD-CDM (Charged-Device Model) Corner Terminals Parameter and changed MIN value for Latch-up Performance Parameter in <a href="#">Table 3-1</a> .....                                                   | <a href="#">80</a>  |
| • Changed DDR3, DDR3L value for OPP100 and deleted Footnote (3) in <a href="#">Table 3-2</a> , VDD_CORE Operating Performance Points for ZCZ Package with Device Revision Code "Blank" .....                      | <a href="#">82</a>  |
| • Deleted OPP50 row from <a href="#">Table 3-3</a> , VDD_MPU Operating Performance Points for ZCZ Package with Device Revision Code "Blank" .....                                                                 | <a href="#">82</a>  |
| • Added <a href="#">Table 3-4</a> , Valid Combinations of VDD_CORE and VDD_MPU Operating Performance Points for ZCZ Package with Device Revision Code "Blank" .....                                               | <a href="#">82</a>  |
| • Changed DDR3, DDR3L value for OPP100, deleted Footnote (4) and deleted OPP50 row from <a href="#">Table 3-5</a> , VDD_CORE Operating Performance Points for ZCE Package with Device Revision Code "Blank" ..... | <a href="#">83</a>  |
| • Changed DDR3, DDR3L value for OPP100 and deleted Footnote (3) in <a href="#">Table 3-6</a> , VDD_CORE Operating Performance Points for ZCZ Package with Device Revision Code "A" or Newer .....                 | <a href="#">84</a>  |
| • Changed <a href="#">Table 3-7</a> , VDD_MPU Operating Performance Points for ZCZ Package with Device Revision Code "A" or Newer .....                                                                           | <a href="#">84</a>  |
| • Added <a href="#">Table 3-8</a> , Valid Combinations of VDD_CORE and VDD_MPU Operating Performance Points for ZCZ Package with Device Revision Code "A" or Newer .....                                          | <a href="#">84</a>  |
| • Changed DDR3, DDR3L value for OPP100 and deleted Footnote (4) in <a href="#">Table 3-9</a> , VDD_CORE Operating Performance Points for ZCE Package with Device Revision Code "A" or Newer .....                 | <a href="#">85</a>  |
| • Added VDD_MPU Nitro Description and MAX value in <a href="#">Table 3-10</a> , Maximum Current Ratings at AM335x Power Terminals .....                                                                           | <a href="#">86</a>  |
| • Changed MAX value for VDDS_DDR Supply in <a href="#">Table 3-10</a> , Maximum Current Ratings at AM335x Power Terminals .....                                                                                   | <a href="#">86</a>  |
| • Added paragraphs in the POH section before and after <a href="#">Table 3-11</a> , Reliability Data .....                                                                                                        | <a href="#">87</a>  |
| • Added Operating Condition Nitro to <a href="#">Table 3-11</a> , Reliability Data .....                                                                                                                          | <a href="#">87</a>  |
| • Added MIN, NOM, and MAX for VDD_MPU Nitro mode; deleted values from USB0_ID and USB1_ID; added Footnote (7) in <a href="#">Table 3-12</a> , Recommended Operating Conditions .....                              | <a href="#">87</a>  |
| • Changed $V_{OH}$ , $V_{OL}$ , $I_L$ and $I_{OZ}$ Parameter values in <a href="#">Table 3-13</a> , DC Electrical Characteristics Over Recommended Ranges of Supply Voltage and Operating Temperature .....       | <a href="#">90</a>  |
| • Deleted TYP value for $C_{VDDS\_DDR}$ Parameter in <a href="#">Table 3-15</a> , Power-Supply Decoupling Capacitor Characteristics ...                                                                           | <a href="#">94</a>  |
| • Changed second paragraph in <a href="#">Section 4.2.2.3</a> , OSC1 Internal Oscillator Clock Source .....                                                                                                       | <a href="#">110</a> |
| • Changed second paragraph in <a href="#">Section 4.2.2.4</a> , OSC1 LVCMOS Digital Clock Source .....                                                                                                            | <a href="#">112</a> |
| • Added <a href="#">Section 5.4</a> , DM Timer .....                                                                                                                                                              | <a href="#">117</a> |
| • Added OPP50 MIN values for all parameters and changed OPP100 MIN value for Parameters F13 and F22 in <a href="#">Table 5-21</a> , GPMC and NOR Flash Timing Requirements—Synchronous Mode .....                 | <a href="#">126</a> |
| • Added OPP50 MIN and MAX values and changed MIN values of OPP100 Parameters F7 and F8 in <a href="#">Table 5-22</a> , GPMC and NOR Flash Switching Characteristics—Synchronous Mode .....                        | <a href="#">127</a> |
| • Changed OPP50 MIN and MAX Parameter values in <a href="#">Table 5-26</a> , GPMC and NOR Flash Switching Characteristics—Asynchronous Mode .....                                                                 | <a href="#">136</a> |
| • Changed OPP50 MIN and MAX Parameter values in <a href="#">Table 5-30</a> , GPMC and NAND Flash Switching Characteristics—Asynchronous Mode .....                                                                | <a href="#">145</a> |
| • Changed MIN value for Parameter 1 in <a href="#">Table 5-56</a> , Switching Characteristics for DDR3 Memory Interface .....                                                                                     | <a href="#">170</a> |
| • Added Conditions to Parameter 1 and deleted Footnote in <a href="#">Table 5-58</a> , Compatible JEDEC DDR3 Devices (Per Interface) .....                                                                        | <a href="#">174</a> |
| • Changed Footnote (12) in <a href="#">Table 5-66</a> , CK and ADDR_CTRL Routing Specification .....                                                                                                              | <a href="#">187</a> |
| • Changed Footnote (11) in <a href="#">Table 5-67</a> , DQS[x] and DQ[x] Routing Specification .....                                                                                                              | <a href="#">188</a> |

|                                                                                                                                                                                                  |                     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| • Deleted MIN values for Parameters 9-12 in <a href="#">Table 5-69</a> , Timing Requirements for I2C Input Timings .....                                                                         | <a href="#">189</a> |
| • Added <a href="#">Section 5.8</a> , JTAG Electrical Data and Timing .....                                                                                                                      | <a href="#">191</a> |
| • Changed MIN values of Parameters 5, 6, 8, and 10 and MAX values of Parameters 4, 6, 8, and 10 in <a href="#">Table 5-76</a> , Switching Characteristics for LCD Raster Mode .....              | <a href="#">202</a> |
| • Added OPP50 MIN and MAX Parameter values and changed OPP100 Parameters 6 and 8 MIN values in <a href="#">Table 5-78</a> , Timing Requirements for McASP .....                                  | <a href="#">209</a> |
| • Added OPP50 MIN and MAX Parameter values and changed OPP100 Parameters 13, 14 and 15 MIN values in <a href="#">Table 5-79</a> , Switching Characteristics for McASP .....                      | <a href="#">211</a> |
| • Added OPP50 MIN and MAX Parameter values to <a href="#">Table 5-81</a> , Timing Requirements for McSPI Input Timings—Slave Mode .....                                                          | <a href="#">213</a> |
| • Added OPP50 MIN and MAX Parameter values to <a href="#">Table 5-82</a> , Switching Characteristics for McSPI Output Timings—Slave Mode .....                                                   | <a href="#">213</a> |
| • Changed Input Parameters High Load MAX values in <a href="#">Table 5-83</a> , McSPI Timing Conditions—Master Mode .....                                                                        | <a href="#">216</a> |
| • Added OPP50 MIN and MAX Parameter values and changed OPP100 Parameter 5 MIN values in <a href="#">Table 5-84</a> , Timing Requirements for McSPI Input Timings—Master Mode .....               | <a href="#">216</a> |
| • Added OPP50 MIN and MAX Parameter values and changed OPP100 Parameters 2 and 3 MAX values in <a href="#">Table 5-85</a> , Switching Characteristics for McSPI Output Timings—Master Mode ..... | <a href="#">216</a> |
| • Changed MIN value for Parameters 2 and 4 in <a href="#">Table 5-87</a> , Timing Requirements for MMC[x]_CMD and MMC[x]_DAT[7:0] .....                                                          | <a href="#">219</a> |
| • Added OPP50 MIN, TYP, and MAX Parameter values to <a href="#">Table 5-89</a> , Switching Characteristics for MMC[x]_CMD and MMC[x]_DAT[7:0]—Standard Mode .....                                | <a href="#">220</a> |
| • Added OPP50 MIN, TYP, and MAX Parameter values to <a href="#">Table 5-90</a> , Switching Characteristics for MMC[x]_CMD and MMC[x]_DAT[7:0]—High-Speed Mode .....                              | <a href="#">221</a> |
| • Changed <a href="#">Figure 6-1</a> , AM335x Device Nomenclature .....                                                                                                                          | <a href="#">226</a> |
| • Added paragraph to <a href="#">Section 7.1</a> , Thermal Data for ZCE and ZCZ Packages .....                                                                                                   | <a href="#">228</a> |

## 2 Terminal Description

### 2.1 Pin Assignments

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#### NOTE

The terms "ball", "pin", and "terminal" are used interchangeably throughout the document. An attempt is made to use "ball" only when referring to the physical package.

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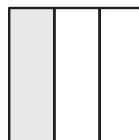
#### 2.1.1 ZCE Package Pin Maps (Top View)

The pin maps below show the pin assignments on the ZCE package in three sections (left, middle, and right).

**Table 2-1. ZCE Pin Map [Section Left - Top View]**

|    | A             | B                 | C                 | D                | E                 | F          |
|----|---------------|-------------------|-------------------|------------------|-------------------|------------|
| 19 | VSS           | I2C0_SCL          | UART1_TXD         | UART1_RTSn       | UART0_RXD         | UART0_CTSn |
| 18 | SPI0_SCLK     | SPI0_D0           | I2C0_SDA          | UART1_RXD        | ECAP0_IN_PWM0_OUT | UART0_RTSn |
| 17 | SPI0_CS0      | SPI0_D1           | EXTINTn           | XXXX             | UART1_CTSn        | UART0_TXD  |
| 16 | WARMRSTn      | SPI0_CS1          | XXXX              | XXXX             | XXXX              | VDDS       |
| 15 | EMU0          | XDMA_EVENT_INTR1  | XDMA_EVENT_INTR0  | XXXX             | PWRONRSTn         | XXXX       |
| 14 | TDO           | TCK               | TMS               | EMU1             | XXXX              | VDDSHV6    |
| 13 | TRSTn         | TDI               | CAP_VBB_MPU       | CAP_VDD_SRAM_MPU | VDDSHV6           | VSS        |
| 12 | AIN7          | AIN5              | VDDS_SRAM_MPU_BB  | VDDS             | VDDSHV6           | VSS        |
| 11 | AIN1          | AIN3              | XXXX              | XXXX             | VDDSHV6           | VDD_CORE   |
| 10 | AIN6          | CAP_VDD_SRAM_CORE | VDDS_SRAM_CORE_BG | VSS              | VSS               | XXXX       |
| 9  | VREFP         | VREFN             | XXXX              | XXXX             | VSS               | VDD_CORE   |
| 8  | AIN2          | AIN0              | AIN4              | VSSA_ADC         | VSS               | VSS        |
| 7  | RTC_KALDO_ENn | RTC_PWRONRSTn     | PMIC_POWER_EN     | VDDA_ADC         | VSS               | VSS        |
| 6  | RTC_XTALIN    | RESERVED          | VDDS_RTC          | CAP_VDD_RTC      | XXXX              | VSS        |
| 5  | RTC_XTALOUT   | EXT_WAKEUP        | VDDS_PLL_DDR      | XXXX             | DDR_A4            | XXXX       |
| 4  | DDR_WEn       | DDR_BA2           | XXXX              | XXXX             | XXXX              | DDR_A12    |
| 3  | DDR_BA0       | DDR_A3            | DDR_A8            | XXXX             | DDR_A15           | DDR_A0     |
| 2  | DDR_A5        | DDR_A9            | DDR_CK            | DDR_A7           | DDR_A10           | DDR_RASn   |
| 1  | VSS           | DDR_A6            | DDR_CKn           | DDR_A2           | DDR_BA1           | DDR_CASn   |

Pin map section location

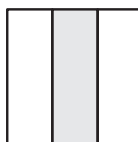


Left

**Table 2-2. ZCE Pin Map [Section Middle - Top View]**

|    | G            | H            | J        | K             | L          | M           |
|----|--------------|--------------|----------|---------------|------------|-------------|
| 19 | MMC0_CLK     | MMC0_DAT3    | MII1_COL | MII1_RX_ER    | MII1_RX_DV | MII1_RX_CLK |
| 18 | MMC0_DAT0    | MMC0_DAT2    | MII1_CRS | RMII1_REF_CLK | MII1_TXD0  | MII1_TXD1   |
| 17 | MMC0_CMD     | MMC0_DAT1    | XXXX     | MII1_TX_EN    | XXXX       | MII1_TXD3   |
| 16 | USB0_DRVVBUS | VDDS_PLL_MPU | XXXX     | VDD_CORE      | XXXX       | VDDS        |
| 15 | VDDSHV4      | VDDSHV4      | VSS      | VDD_CORE      | VSS        | VDDSHV5     |
| 14 | XXXX         | VDDSHV4      | VSS      | XXXX          | VSS        | VDDSHV5     |
| 13 | XXXX         | VDD_CORE     | VDD_CORE | XXXX          | VDD_CORE   | VDD_CORE    |
| 12 | VSS          | VDD_CORE     | VDD_CORE | VSS           | VDD_CORE   | VDD_CORE    |
| 11 | VDD_CORE     | VSS          | VSS      | VSS           | VSS        | VSS         |
| 10 | XXXX         | VSS          | XXXX     | XXXX          | XXXX       | VSS         |
| 9  | VDD_CORE     | VSS          | VSS      | VSS           | VSS        | VSS         |
| 8  | VSS          | VDD_CORE     | VDD_CORE | VSS           | VDD_CORE   | VDD_CORE    |
| 7  | XXXX         | VDD_CORE     | VDD_CORE | XXXX          | VDD_CORE   | VDD_CORE    |
| 6  | XXXX         | VDDS_DDR     | VSS      | XXXX          | VSS        | VDDS_DDR    |
| 5  | VDDS_DDR     | VDDS_DDR     | VSS      | VDDS_DDR      | VSS        | VDDS_DDR    |
| 4  | DDR_A11      | DDR_VREF     | XXXX     | VDDS_DDR      | XXXX       | DDR_D11     |
| 3  | DDR_CKE      | DDR_A14      | XXXX     | DDR_DQM1      | XXXX       | DDR_D10     |
| 2  | DDR_RESETh   | DDR_CSn0     | DDR_A1   | DDR_D8        | DDR_DQSn1  | DDR_D12     |
| 1  | DDR_ODT      | DDR_A13      | DDR_VTP  | DDR_D9        | DDR_DQS1   | DDR_D13     |

Pin map section location

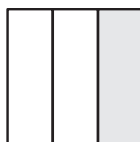


Middle

**Table 2-3. ZCE Pin Map [Section Right - Top View]**

|    | N           | P         | R             | T                 | U          | V             | W              |
|----|-------------|-----------|---------------|-------------------|------------|---------------|----------------|
| 19 | MII1_TX_CLK | MII1_RXD1 | MDC           | USB0_VBUS         | USB0_DP    | USB0_ID       | VSS            |
| 18 | MII1_TXD2   | MII1_RXD0 | VDDA3P3V_USB0 | USB0_CE           | USB0_DM    | GPMC_BEn1     | GPMC_WPn       |
| 17 | MII1_RXD3   | MDIO      | VDDA1P8V_USB0 | XXXX              | GPMC_CSn3  | GPMC_AD15     | GPMC_AD14      |
| 16 | MII1_RXD2   | VSSA_USB  | XXXX          | XXXX              | XXXX       | GPMC_CLK      | GPMC_AD9       |
| 15 | VDDSHV5     | XXXX      | GPMC_WAIT0    | XXXX              | GPMC_CSn2  | GPMC_AD8      | GPMC_AD7       |
| 14 | XXXX        | VSS       | XXXX          | VDDS              | GPMC_AD6   | GPMC_CSn1     | GPMC_AD5       |
| 13 | XXXX        | VSS       | VDDSHV1       | GPMC_AD13         | GPMC_AD12  | GPMC_AD4      | GPMC_AD3       |
| 12 | VSS         | VSS       | VDDSHV1       | GPMC_AD10         | GPMC_AD11  | GPMC_AD2      | XTALOUT        |
| 11 | VDD_CORE    | VDD_CORE  | VDDSHV1       | XXXX              | XXXX       | VSS_OSC       | XTALIN         |
| 10 | XXXX        | XXXX      | VSS           | VSS               | VDDS_OSC   | GPMC_ADVn_ALE | GPMC_AD0       |
| 9  | VDD_CORE    | VDD_CORE  | VDDSHV1       | XXXX              | XXXX       | GPMC_AD1      | GPMC_OEn_REn   |
| 8  | VSS         | VSS       | VDDSHV1       | VDDS_PLL_CORE_LCD | GPMC_WEn   | GPMC_BEn0_CLE | GPMC_CSn0      |
| 7  | XXXX        | VSS       | VDDSHV6       | LCD_HSYNC         | LCD_VSYNC  | LCD_DATA15    | LCD_AC_BIAS_EN |
| 6  | XXXX        | VDDSHV6   | XXXX          | VDDS              | LCD_DATA13 | LCD_DATA12    | LCD_DATA14     |
| 5  | VDDS_DDR    | XXXX      | VPP           | XXXX              | LCD_DATA10 | LCD_DATA11    | LCD_PCLK       |
| 4  | DDR_D0      | DDR_D1    | XXXX          | XXXX              | XXXX       | LCD_DATA8     | LCD_DATA9      |
| 3  | DDR_DQM0    | DDR_D4    | DDR_D7        | XXXX              | LCD_DATA7  | LCD_DATA6     | LCD_DATA5      |
| 2  | DDR_D14     | DDR_D2    | DDR_DQSn0     | DDR_D6            | LCD_DATA1  | LCD_DATA3     | LCD_DATA4      |
| 1  | DDR_D15     | DDR_D3    | DDR_DQS0      | DDR_D5            | LCD_DATA0  | LCD_DATA2     | VSS            |

Pin map section location



Right

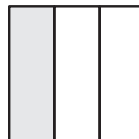
### **2.1.2 ZCZ Package Pin Maps (Top View)**

The pin maps below show the pin assignments on the ZCZ package in three sections (left, middle, and right).

**Table 2-4. ZCZ Pin Map [Section Left - Top View]**

|    | A                | B             | C                 | D                 | E                 | F            |
|----|------------------|---------------|-------------------|-------------------|-------------------|--------------|
| 18 | VSS              | EXTINTn       | ECAP0_IN_PWM0_OUT | UART1_CTSn        | UART0_CTSn        | MMC0_DAT2    |
| 17 | SPI0_SCLK        | SPI0_D0       | I2C0_SDA          | UART1_RTSn        | UART0_RTSn        | MMC0_DAT3    |
| 16 | SPI0_CS0         | SPI0_D1       | I2C0_SCL          | UART1_RXD         | UART0_TXD         | USB0_DRVVBUS |
| 15 | XDMA_EVENT_INTR0 | PWRONRSTn     | SPI0_CS1          | UART1_TXD         | UART0_RXD         | USB1_DRVVBUS |
| 14 | MCASP0_AHCLKX    | EMU1          | EMU0              | XDMA_EVENT_INTR1  | VDDS              | VDDSHV6      |
| 13 | MCASP0_ACLKX     | MCASP0_FSX    | MCASP0_FSR        | MCASP0_AXR1       | VDDSHV6           | VDD_MPU      |
| 12 | TCK              | MCASP0_ACLKR  | MCASP0_AHCLKR     | MCASP0_AXR0       | VDDSHV6           | VDD_MPU      |
| 11 | TDO              | TDI           | TMS               | CAP_VDD_SRAM_MPU  | VDDSHV6           | VDD_MPU      |
| 10 | WARMRSTn         | TRSTn         | CAP_VBB_MPU       | VDDS_SRAM_MPU_BB  | VDDSHV6           | VDD_MPU      |
| 9  | VREFN            | VREFP         | AIN7              | CAP_VDD_SRAM_CORE | VDDS_SRAM_CORE_BG | VDDS         |
| 8  | AIN6             | AIN5          | AIN4              | VDDA_ADC          | VSSA_ADC          | VSS          |
| 7  | AIN3             | AIN2          | AIN1              | VDDS_RTC          | VDDS_PLL_DDR      | VDD_CORE     |
| 6  | RTC_XTALIN       | AIN0          | PMIC_POWER_EN     | CAP_VDD_RTC       | VDDS              | VDD_CORE     |
| 5  | VSS_RTC          | RTC_PWRONRSTn | EXT_WAKEUP        | DDR_A6            | VDDS_DDR          | VDDS_DDR     |
| 4  | RTC_XTALOUT      | RTC_KALDO_ENn | DDR_BA0           | DDR_A8            | DDR_A2            | DDR_A10      |
| 3  | RESERVED         | DDR_BA2       | DDR_A3            | DDR_A15           | DDR_A12           | DDR_A0       |
| 2  | VDD_MPU_MON      | DDR_WEn       | DDR_A4            | DDR_CK            | DDR_A7            | DDR_A11      |
| 1  | VSS              | DDR_A5        | DDR_A9            | DDR_CKn           | DDR_BA1           | DDR_CASn     |

Pin map section location

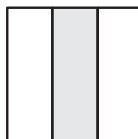


Left

**Table 2-5. ZCZ Pin Map [Section Middle - Top View]**

|    | G          | H             | J          | K           | L           | M         |
|----|------------|---------------|------------|-------------|-------------|-----------|
| 18 | MMC0_CMD   | RMII1_REF_CLK | MII1_TXD3  | MII1_TX_CLK | MII1_RX_CLK | MDC       |
| 17 | MMC0_CLK   | MII1_CRS      | MII1_RX_DV | MII1_TXD0   | MII1_RXD3   | MDIO      |
| 16 | MMC0_DAT0  | MII1_COL      | MII1_TX_EN | MII1_TXD1   | MII1_RXD2   | MII1_RXD0 |
| 15 | MMC0_DAT1  | VDDS_PLL_MPU  | MII1_RX_ER | MII1_TXD2   | MII1_RXD1   | USB0_CE   |
| 14 | VDDSHV6    | VDDSHV4       | VDDSHV4    | VDDSHV5     | VDDSHV5     | VSSA_USB  |
| 13 | VDD_MPU    | VDD_MPU       | VDD_MPU    | VDDS        | VSS         | VDD_CORE  |
| 12 | VSS        | VSS           | VDD_CORE   | VDD_CORE    | VSS         | VSS       |
| 11 | VSS        | VDD_CORE      | VSS        | VSS         | VSS         | VDD_CORE  |
| 10 | VDD_CORE   | VSS           | VSS        | VSS         | VSS         | VSS       |
| 9  | VSS        | VSS           | VSS        | VSS         | VDD_CORE    | VSS       |
| 8  | VSS        | VSS           | VSS        | VDD_CORE    | VDD_CORE    | VSS       |
| 7  | VDD_CORE   | VSS           | VSS        | VSS         | VDD_CORE    | VSS       |
| 6  | VDD_CORE   | VSS           | VSS        | VDD_CORE    | VDD_CORE    | VSS       |
| 5  | VDDS_DDR   | VDDS_DDR      | VDDS_DDR   | VDDS_DDR    | VDDS_DDR    | VPP       |
| 4  | DDR_RASn   | DDR_A14       | DDR_VREF   | DDR_D12     | DDR_D14     | DDR_D1    |
| 3  | DDR_CKE    | DDR_A13       | DDR_VTP    | DDR_D11     | DDR_D13     | DDR_D0    |
| 2  | DDR_RESETh | DDR_CS0       | DDR_DQM1   | DDR_D10     | DDR_DQS1    | DDR_DQM0  |
| 1  | DDR_ODT    | DDR_A1        | DDR_D8     | DDR_D9      | DDR_DQS1    | DDR_D15   |

Pin map section location

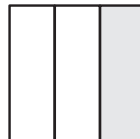


Middle

**Table 2-6. ZCZ Pin Map [Section Right - Top View]**

|    | N             | P         | R                 | T             | U          | V          |
|----|---------------|-----------|-------------------|---------------|------------|------------|
| 18 | USB0_DM       | USB1_CE   | USB1_DM           | USB1_VBUS     | GPMC_BEn1  | VSS        |
| 17 | USB0_DP       | USB1_ID   | USB1_DP           | GPMC_WAIT0    | GPMC_WPn   | GPMC_A11   |
| 16 | VDDA1P8V_USB0 | USB0_ID   | VDDA1P8V_USB1     | GPMC_A10      | GPMC_A9    | GPMC_A8    |
| 15 | VDDA3P3V_USB0 | USB0_VBUS | VDDA3P3V_USB1     | GPMC_A7       | GPMC_A6    | GPMC_A5    |
| 14 | VSSA_USB      | VDDS      | GPMC_A4           | GPMC_A3       | GPMC_A2    | GPMC_A1    |
| 13 | VDD_CORE      | VDDSHV3   | GPMC_A0           | GPMC_CSn3     | GPMC_AD15  | GPMC_AD14  |
| 12 | VDD_CORE      | VDDSHV3   | GPMC_AD13         | GPMC_AD12     | GPMC_AD11  | GPMC_CLK   |
| 11 | VSS           | VDDSHV2   | VDDS_OSC          | GPMC_AD10     | XTALOUT    | VSS_OSC    |
| 10 | VSS           | VDDSHV2   | VDDS_PLL_CORE_LCD | GPMC_AD9      | GPMC_AD8   | XTALIN     |
| 9  | VDD_CORE      | VDDS      | GPMC_AD6          | GPMC_AD7      | GPMC_CSn1  | GPMC_CSn2  |
| 8  | VDD_CORE      | VDDSHV1   | GPMC_AD2          | GPMC_AD3      | GPMC_AD4   | GPMC_AD5   |
| 7  | VSS           | VDDSHV1   | GPMC_ADVn_ALE     | GPMC_OEn_REn  | GPMC_AD0   | GPMC_AD1   |
| 6  | VDDS          | VDDSHV6   | LCD_AC_BIAS_EN    | GPMC_BEn0_CLE | GPMC_WEn   | GPMC_CSn0  |
| 5  | VDDSHV6       | VDDSHV6   | LCD_HSYNC         | LCD_DATA15    | LCD_VSYNC  | LCD_PCLK   |
| 4  | DDR_D5        | DDR_D7    | LCD_DATA3         | LCD_DATA7     | LCD_DATA11 | LCD_DATA14 |
| 3  | DDR_D4        | DDR_D6    | LCD_DATA2         | LCD_DATA6     | LCD_DATA10 | LCD_DATA13 |
| 2  | DDR_D3        | DDR_DQSn0 | LCD_DATA1         | LCD_DATA5     | LCD_DATA9  | LCD_DATA12 |
| 1  | DDR_D2        | DDR_DQS0  | LCD_DATA0         | LCD_DATA4     | LCD_DATA8  | VSS        |

Pin map section location



Right

## 2.2 Ball Characteristics

The AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual (literature number [SPRUH73](#)) and this document may reference internal signal names when discussing peripheral input and output signals since many of the AM335x package terminals can be multiplexed to one of several peripheral signals. The following table has a Pin Name column that lists all device terminal names and a Signal Name column that lists all internal signal names multiplexed to each terminal which provides a cross reference of internal signal names to terminal names. This table also identifies other important terminal characteristics.

1. **BALL NUMBER:** Package ball numbers associated with each signals.
2. **PIN NAME:** The name of the package pin or terminal.  
**Note:** The table does not take into account subsystem terminal multiplexing options.
3. **SIGNAL NAME:** The signal name for that pin in the mode being used.
4. **MODE:** Multiplexing mode number.
  - (a) Mode 0 is the primary mode; this means that when mode 0 is set, the function mapped on the terminal corresponds to the name of the terminal. There is always a function mapped on the primary mode. Notice that primary mode is not necessarily the default mode.  
**Note:** The default mode is the mode at the release of the reset; also see the RESET REL. MODE column.
  - (b) Modes 1 to 7 are possible modes for alternate functions. On each terminal, some modes are effectively used for alternate functions, while some modes are not used and do not correspond to a functional configuration.
5. **TYPE:** Signal direction
  - I = Input
  - O = Output
  - IO = Input and Output
  - D = Open drain
  - DS = Differential
  - A = Analog
  - PWR = Power
  - GND = Ground**Note:** In the safe\_mode, the buffer is configured in high-impedance.
6. **BALL RESET STATE:** State of the terminal while the active low PWRONRSTn terminal is low.
  - 0: The buffer drives  $V_{OL}$  (pulldown or pullup resistor not activated)  
0(PD): The buffer drives  $V_{OL}$  with an active pulldown resistor
  - 1: The buffer drives  $V_{OH}$  (pulldown or pullup resistor not activated)  
1(PU): The buffer drives  $V_{OH}$  with an active pullup resistor
  - Z: High-impedance
  - L: High-impedance with an active pulldown resistor
  - H : High-impedance with an active pullup resistor
7. **BALL RESET REL. STATE:** State of the terminal after the active low PWRONRSTn terminal transitions from low to high.
  - 0: The buffer drives  $V_{OL}$  (pulldown or pullup resistor not activated)  
0(PD): The buffer drives  $V_{OL}$  with an active pulldown resistor
  - 1: The buffer drives  $V_{OH}$  (pulldown or pullup resistor not activated)  
1(PU): The buffer drives  $V_{OH}$  with an active pullup resistor
  - Z: High-impedance.
  - L: High-impedance with an active pulldown resistor
  - H : High-impedance with an active pullup resistor
8. **RESET REL. MODE:** The mode is automatically configured after the active low PWRONRSTn terminal transitions from low to high.

9. **POWER:** The voltage supply that powers the terminal's IO buffers.
10. **HYS:** Indicates if the input buffer is with hysteresis.
11. **BUFFER STRENGTH:** Drive strength of the associated output buffer.
12. **PULLUP OR PULLDOWN TYPE:** Denotes the presence of an internal pullup or pulldown resistor. Pullup and pulldown resistors can be enabled or disabled via software.
13. **IO CELL:** IO cell information.

**Note:** Configuring two terminals to the same input signal is not supported as it can yield unexpected results. This can be easily prevented with the proper software configuration.

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]      | SIGNAL NAME [3]   | MODE [4] | TYPE<br>[5]       | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13]         |
|------------------------|------------------------|-------------------|-------------------|----------|-------------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|-----------------------|
| B8                     | B6                     | AIN0              | AIN0              | 0        | A <sup>(21)</sup> | Z                       | Z                               | 0                      | VDDA_ADC /<br>VDDA_ADC       | NA          | 25                              | NA                           | Analog                |
| A11                    | C7                     | AIN1              | AIN1              | 0        | A <sup>(20)</sup> | Z                       | Z                               | 0                      | VDDA_ADC /<br>VDDA_ADC       | NA          | 25                              | NA                           | Analog                |
| A8                     | B7                     | AIN2              | AIN2              | 0        | A <sup>(20)</sup> | Z                       | Z                               | 0                      | VDDA_ADC /<br>VDDA_ADC       | NA          | 25                              | NA                           | Analog                |
| B11                    | A7                     | AIN3              | AIN3              | 0        | A <sup>(19)</sup> | Z                       | Z                               | 0                      | VDDA_ADC /<br>VDDA_ADC       | NA          | 25                              | NA                           | Analog                |
| C8                     | C8                     | AIN4              | AIN4              | 0        | A <sup>(19)</sup> | Z                       | Z                               | 0                      | VDDA_ADC /<br>VDDA_ADC       | NA          | 25                              | NA                           | Analog                |
| B12                    | B8                     | AIN5              | AIN5              | 0        | A                 | Z                       | Z                               | 0                      | VDDA_ADC /<br>VDDA_ADC       | NA          | NA                              | NA                           | Analog                |
| A10                    | A8                     | AIN6              | AIN6              | 0        | A                 | Z                       | Z                               | 0                      | VDDA_ADC /<br>VDDA_ADC       | NA          | NA                              | NA                           | Analog                |
| A12                    | C9                     | AIN7              | AIN7              | 0        | A                 | Z                       | Z                               | 0                      | VDDA_ADC /<br>VDDA_ADC       | NA          | NA                              | NA                           | Analog                |
| C13                    | C10                    | CAP_VBB_MPU       | CAP_VBB_MPU       | NA       | A                 |                         |                                 |                        |                              |             |                                 |                              |                       |
| D6                     | D6                     | CAP_VDD_RTC       | CAP_VDD_RTC       | NA       | A                 |                         |                                 |                        |                              |             |                                 |                              |                       |
| B10                    | D9                     | CAP_VDD_SRAM_CORE | CAP_VDD_SRAM_CORE | NA       | A                 |                         |                                 |                        |                              |             |                                 |                              |                       |
| D13                    | D11                    | CAP_VDD_SRAM_MPU  | CAP_VDD_SRAM_MPU  | NA       | A                 |                         |                                 |                        |                              |             |                                 |                              |                       |
| F3                     | F3                     | DDR_A0            | ddr_a0            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| J2                     | H1                     | DDR_A1            | ddr_a1            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| D1                     | E4                     | DDR_A2            | ddr_a2            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| B3                     | C3                     | DDR_A3            | ddr_a3            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| E5                     | C2                     | DDR_A4            | ddr_a4            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| A2                     | B1                     | DDR_A5            | ddr_a5            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| B1                     | D5                     | DDR_A6            | ddr_a6            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| D2                     | E2                     | DDR_A7            | ddr_a7            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| C3                     | D4                     | DDR_A8            | ddr_a8            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| B2                     | C1                     | DDR_A9            | ddr_a9            | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| E2                     | F4                     | DDR_A10           | ddr_a10           | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |
| G4                     | F2                     | DDR_A11           | ddr_a11           | 0        | O                 | H                       | 1                               | 0                      | VDDS_DDR /<br>VDDS_DDR       | NA          | 8                               | PU/PD                        | LVC MOS/SSTL/<br>HSTL |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3] | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13]        |
|------------------------|------------------------|--------------|-----------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|----------------------|
| F4                     | E3                     | DDR_A12      | ddr_a12         | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| H1                     | H3                     | DDR_A13      | ddr_a13         | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| H3                     | H4                     | DDR_A14      | ddr_a14         | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| E3                     | D3                     | DDR_A15      | ddr_a15         | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| A3                     | C4                     | DDR_BA0      | ddr_ba0         | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| E1                     | E1                     | DDR_BA1      | ddr_ba1         | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| B4                     | B3                     | DDR_BA2      | ddr_ba2         | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| F1                     | F1                     | DDR_CASn     | ddr_casn        | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| C2                     | D2                     | DDR_CK       | ddr_ck          | 0        | O           | L                       | 0                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| G3                     | G3                     | DDR_CKE      | ddr_cke         | 0        | O           | L                       | 0                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| C1                     | D1                     | DDR_CKn      | ddr_nck         | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| H2                     | H2                     | DDR_CSn0     | ddr_csn0        | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| N4                     | M3                     | DDR_D0       | ddr_d0          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| P4                     | M4                     | DDR_D1       | ddr_d1          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| P2                     | N1                     | DDR_D2       | ddr_d2          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| P1                     | N2                     | DDR_D3       | ddr_d3          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| P3                     | N3                     | DDR_D4       | ddr_d4          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| T1                     | N4                     | DDR_D5       | ddr_d5          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| T2                     | P3                     | DDR_D6       | ddr_d6          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| R3                     | P4                     | DDR_D7       | ddr_d7          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| K2                     | J1                     | DDR_D8       | ddr_d8          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| K1                     | K1                     | DDR_D9       | ddr_d9          | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| M3                     | K2                     | DDR_D10      | ddr_d10         | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]      | SIGNAL NAME [3]             | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13]        |
|------------------------|------------------------|-------------------|-----------------------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|----------------------|
| M4                     | K3                     | DDR_D11           | ddr_d11                     | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| M2                     | K4                     | DDR_D12           | ddr_d12                     | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| M1                     | L3                     | DDR_D13           | ddr_d13                     | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| N2                     | L4                     | DDR_D14           | ddr_d14                     | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| N1                     | M1                     | DDR_D15           | ddr_d15                     | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| N3                     | M2                     | DDR_DQM0          | ddr_dqm0                    | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| K3                     | J2                     | DDR_DQM1          | ddr_dqm1                    | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| R1                     | P1                     | DDR_DQS0          | ddr_dqs0                    | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| L1                     | L1                     | DDR_DQS1          | ddr_dqs1                    | 0        | I/O         | L                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| R2                     | P2                     | DDR_DQSn0         | ddr_dqsn0                   | 0        | I/O         | H                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| L2                     | L2                     | DDR_DQSn1         | ddr_dqsn1                   | 0        | I/O         | H                       | Z                               | 0                      | VDDSDDR /<br>VDDSDDR         | Yes         | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| G1                     | G1                     | DDR_ODT           | ddr_odt                     | 0        | O           | L                       | 0                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| F2                     | G4                     | DDR_RASn          | ddr_rasn                    | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| G2                     | G2                     | DDR_RESEn         | ddr_rese                    | 0        | O           | L                       | 0                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| H4                     | J4                     | DDR_VREF          | ddr_vref                    | 0        | A (17)      | NA                      | NA                              | NA                     | VDDSDDR /<br>VDDSDDR         | NA          | NA                              | NA                           | Analog               |
| J1                     | J3                     | DDR_VTP           | ddr_vtp                     | 0        | I (18)      | NA                      | NA                              | NA                     | VDDSDDR /<br>VDDSDDR         | NA          | NA                              | NA                           | Analog               |
| A4                     | B2                     | DDR_WEn           | ddr_wen                     | 0        | O           | H                       | 1                               | 0                      | VDDSDDR /<br>VDDSDDR         | NA          | 8                               | PU/PD                        | LVCNOS/SSTL/<br>HSTL |
| E18                    | C18                    | ECAP0_IN_PWM0_OUT | ecap0_in_pwm0_out           | 0        | I/O         | Z                       | L                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 4                               | PU/PD                        | LVCNOS               |
|                        |                        |                   | uart3_txd                   | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |                      |
|                        |                        |                   | spi1_cs1                    | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |                      |
|                        |                        |                   | pr1_ecap0_ecap_capin_apwm_o | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |                      |
|                        |                        |                   | spi1_sclk                   | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |                      |
|                        |                        |                   | mmc0_sdwp                   | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |                      |
|                        |                        |                   | xdma_event_intr2            | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |                      |
|                        |                        |                   | gpio0_7                     | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |                      |
| A15                    | C14                    | EMU0              | EMU0                        | 0        | I/O         | H                       | H                               | 0                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCNOS               |
|                        |                        |                   | gpio3_7                     | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |                      |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3]        | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|--------------|------------------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| D14                    | B14                    | EMU1         | EMU1                   | 0        | I/O         | H                       | H                               | 0                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVC MOS       |
|                        |                        |              | gpio3_8                | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| C17                    | B18                    | EXTINTn      | nNMI                   | 0        | I           | Z                       | H                               | 0                      | VDDSHV6 /<br>VDDSHV6         | Yes         | NA                              | PU/PD                        | LVC MOS       |
| B5                     | C5                     | EXT_WAKEUP   | EXT_WAKEUP             | 0        | I           | L                       | Z                               | 0                      | VDDS_RTC /<br>VDDS_RTC       | Yes         | NA                              | NA                           | LVC MOS       |
| NA                     | R13                    | GPMC_A0      | gpmc_a0                | 0        | O           | L                       | L                               | 7                      | NA / VDDSHV3                 | Yes         | 6                               | PU/PD                        | LVC MOS       |
|                        |                        |              | gmii2_txen             | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii2_tctl            | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rmii2_txen             | 3        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpmc_a16               | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii_mt1_clk        | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | ehrpwm1_tripzone_input | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_16               | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| NA                     | V14                    | GPMC_A1      | gpmc_a1                | 0        | O           | L                       | L                               | 7                      | NA / VDDSHV3                 | Yes         | 6                               | PU/PD                        | LVC MOS       |
|                        |                        |              | gmii2_rxdv             | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii2_rctl            | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc2_dat0              | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpmc_a17               | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii1_txd3          | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | ehrpwm0_synco          | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_17               | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| NA                     | U14                    | GPMC_A2      | gpmc_a2                | 0        | O           | L                       | L                               | 7                      | NA / VDDSHV3                 | Yes         | 6                               | PU/PD                        | LVC MOS       |
|                        |                        |              | gmii2_txd3             | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii2_td3             | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc2_dat1              | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpmc_a18               | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii1_txd2          | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | ehrpwm1A               | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_18               | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| NA                     | T14                    | GPMC_A3      | gpmc_a3                | 0        | O           | L                       | L                               | 7                      | NA / VDDSHV3                 | Yes         | 6                               | PU/PD                        | LVC MOS       |
|                        |                        |              | gmii2_txd2             | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii2_td2             | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc2_dat2              | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpmc_a19               | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii1_txd1          | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | ehrpwm1B               | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_19               | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3] | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|--------------|-----------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| NA                     | R14                    | GPMC_A4      | gpmc_a4         | 0        | O           | L                       | L                               | 7                      | NA / VDDSHV3                 | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | gmii2_txd1      | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii2_td1      | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rmii2_txd1      | 3        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpmc_a20        | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii1_txd0   | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | eQEP1A_in       | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_20        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| NA                     | V15                    | GPMC_A5      | gpmc_a5         | 0        | O           | L                       | L                               | 7                      | NA / VDDSHV3                 | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | gmii2_txd0      | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii2_td0      | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rmii2_txd0      | 3        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpmc_a21        | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii1_rxd3   | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | eQEP1B_in       | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_21        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| NA                     | U15                    | GPMC_A6      | gpmc_a6         | 0        | O           | L                       | L                               | 7                      | NA / VDDSHV3                 | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | gmii2_txclk     | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii2_tclk     | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc2_dat4       | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpmc_a22        | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii1_rxd2   | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | eQEP1_index     | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_22        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| NA                     | T15                    | GPMC_A7      | gpmc_a7         | 0        | O           | L                       | L                               | 7                      | NA / VDDSHV3                 | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | gmii2_rxclk     | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii2_rclk     | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc2_dat5       | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpmc_a23        | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii1_rxd1   | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | eQEP1_strobe    | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_23        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1] | ZCZ BALL NUMBER [1] | PIN NAME [2]            | SIGNAL NAME [3]          | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------|---------------------|-------------------------|--------------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| NA                  | V16                 | GPMC_A8                 | gpmc_a8                  | 0        | O        | L                    | L                         | 7                   | NA / VDDSHV3              | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                         | gmii2_rxd3               | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | rgmii2_rd3               | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | mmc2_dat6                | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpmc_a24                 | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | pr1_mii1_rxd0            | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | mcasp0_acllx             | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpio1_24                 | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| NA                  | U16                 | GPMC_A9 <sup>(10)</sup> | gpmc_a9                  | 0        | O        | L                    | L                         | 7                   | NA / VDDSHV3              | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                         | gmii2_rxd2               | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | rgmii2_rd2               | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | mmc2_dat7 / rmii2_crs_dv | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpmc_a25                 | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | pr1_mii_mr1_clk          | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | mcasp0_fsx               | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpio1_25                 | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| NA                  | T16                 | GPMC_A10                | gpmc_a10                 | 0        | O        | L                    | L                         | 7                   | NA / VDDSHV3              | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                         | gmii2_rxd1               | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | rgmii2_rd1               | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | rmii2_rxd1               | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpmc_a26                 | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | pr1_mii1_rxdv            | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | mcasp0_axr0              | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpio1_26                 | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| NA                  | V17                 | GPMC_A11                | gpmc_a11                 | 0        | O        | L                    | L                         | 7                   | NA / VDDSHV3              | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                         | gmii2_rxd0               | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | rgmii2_rd0               | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | rmii2_rxd0               | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpmc_a27                 | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | pr1_mii1_rxer            | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | mcasp0_axr1              | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpio1_27                 | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| W10                 | U7                  | GPMC_AD0                | gpmc_ad0                 | 0        | I/O      | L                    | L                         | 7                   | VDDSHV1 / VDDSHV1         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                         | mmc1_dat0                | 1        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpio1_0                  | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| V9                  | V7                  | GPMC_AD1                | gpmc_ad1                 | 0        | I/O      | L                    | L                         | 7                   | VDDSHV1 / VDDSHV1         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                         | mmc1_dat1                | 1        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                         | gpio1_1                  | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3] | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|--------------|-----------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| V12                    | R8                     | GPMC_AD2     | gpmc_ad2        | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV1         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | mmc1_dat2       | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_2         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| W13                    | T8                     | GPMC_AD3     | gpmc_ad3        | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV1         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | mmc1_dat3       | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_3         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V13                    | U8                     | GPMC_AD4     | gpmc_ad4        | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV1         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | mmc1_dat4       | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_4         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| W14                    | V8                     | GPMC_AD5     | gpmc_ad5        | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV1         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | mmc1_dat5       | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_5         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| U14                    | R9                     | GPMC_AD6     | gpmc_ad6        | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV1         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | mmc1_dat6       | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_6         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| W15                    | T9                     | GPMC_AD7     | gpmc_ad7        | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV1         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | mmc1_dat7       | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_7         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V15                    | U10                    | GPMC_AD8     | gpmc_ad8        | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV2         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | lcd_data23      | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc1_dat0       | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc2_dat4       | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | ehrpwm2A        | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii_mt0_clk | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio0_22        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| W16                    | T10                    | GPMC_AD9     | gpmc_ad9        | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV2         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | lcd_data22      | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc1_dat1       | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc2_dat5       | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | ehrpwm2B        | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_mii0_col    | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio0_23        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1] | ZCZ BALL NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3]        | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------|---------------------|--------------|------------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| T12                 | T11                 | GPMC_AD10    | gpmc_ad10              | 0        | I/O      | L                    | L                         | 7                   | VDDSHV1 / VDDSHV2         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | lcd_data21             | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc1_dat2              | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc2_dat6              | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | ehrpwm2_tripzone_input | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_mii0_txen          | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio0_26               | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| U12                 | U12                 | GPMC_AD11    | gpmc_ad11              | 0        | I/O      | L                    | L                         | 7                   | VDDSHV1 / VDDSHV2         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | lcd_data20             | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc1_dat3              | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc2_dat7              | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | ehrpwm0_synco          | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_mii0_txd3          | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio0_27               | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| U13                 | T12                 | GPMC_AD12    | gpmc_ad12              | 0        | I/O      | L                    | L                         | 7                   | VDDSHV1 / VDDSHV2         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | lcd_data19             | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc1_dat4              | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc2_dat0              | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | eQEP2A_in              | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_mii0_txd2          | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_pru0_pru_r30_14    | 6        | O        |                      |                           |                     |                           |          |                           |                        |               |
| T13                 | R12                 | GPMC_AD13    | gpmc_ad13              | 0        | I/O      | L                    | L                         | 7                   | VDDSHV1 / VDDSHV2         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | lcd_data18             | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc1_dat5              | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc2_dat1              | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | eQEP2B_in              | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_mii0_txd1          | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_pru0_pru_r30_15    | 6        | O        |                      |                           |                     |                           |          |                           |                        |               |
| W17                 | V13                 | GPMC_AD14    | gpmc_ad14              | 0        | I/O      | L                    | L                         | 7                   | VDDSHV1 / VDDSHV2         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | lcd_data17             | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc1_dat6              | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc2_dat2              | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | eQEP2_index            | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_mii0_txd0          | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_pru0_pru_r31_14    | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio1_14               | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]  | SIGNAL NAME [3]             | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|---------------|-----------------------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| V17                    | U13                    | GPMC_AD15     | gpmc_ad15                   | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV2         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | lcd_data16                  | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | mmc1_dat7                   | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | mmc2_dat3                   | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | eQEP2_strobe                | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_ecap0_ecap_capin_apwm_o | 5        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_pru0_pru_r31_15         | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpio1_15                    | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V10                    | R7                     | GPMC_ADVn_ALE | gpmc_advn_ale               | 0        | O           | H                       | H                               | 7                      | VDDSHV1 /<br>VDDSHV1         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | timer4                      | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpio2_2                     | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V8                     | T6                     | GPMC_BEn0_CLE | gpmc_be0n_cle               | 0        | O           | H                       | H                               | 7                      | VDDSHV1 /<br>VDDSHV1         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | timer5                      | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpio2_5                     | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V18                    | U18                    | GPMC_BEn1     | gpmc_be1n                   | 0        | O           | H                       | H                               | 7                      | VDDSHV1 /<br>VDDSHV3         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | gmii2_col                   | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpmc_csn6                   | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | mmc2_dat3                   | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpmc_dir                    | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_mii1_rxlink             | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | mcasp0_aclkr                | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpio1_28                    | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V16                    | V12                    | GPMC_CLK      | gpmc_clk                    | 0        | I/O         | L                       | L                               | 7                      | VDDSHV1 /<br>VDDSHV2         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | lcd_memory_clk              | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpmc_wait1                  | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | mmc2_clk                    | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_mii1_crs                | 4        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_mdio_mdclk              | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | mcasp0_fsr                  | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpio2_1                     | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| W8                     | V6                     | GPMC_CSn0     | gpmc_csn0                   | 0        | O           | H                       | H                               | 7                      | VDDSHV1 /<br>VDDSHV1         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | gpio1_29                    | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1] | ZCZ BALL NUMBER [1] | PIN NAME [2]             | SIGNAL NAME [3]     | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------|---------------------|--------------------------|---------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| V14                 | U9                  | GPMC_CSn1                | gpmc_csn1           | 0        | O        | H                    | H                         | 7                   | VDDSHV1 / VDDSHV1         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gpmc_clk            | 1        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | mmc1_clk            | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_edio_data_in6   | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_edio_data_out6  | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r30_12 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r31_12 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
| U15                 | V9                  | GPMC_CSn2                | gpio1_30            | 7        | I/O      | H                    | H                         | 7                   | VDDSHV1 / VDDSHV1         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gpmc_csn2           | 0        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpmc_be1n           | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | mmc1_cmd            | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_edio_data_in7   | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_edio_data_out7  | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r30_13 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
| U17                 | T13                 | GPMC_CSn3 <sup>(6)</sup> | pr1_pru1_pru_r31_13 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio1_31            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpmc_csn3           | 0        | O        |                      | H                         | H                   | VDDSHV1 / VDDSHV2         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gpmc_a3             | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | rmii2_crs_dv        | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | mmc2_cmd            | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_mii0_crs        | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_mdio_data       | 5        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| W9                  | T7                  | GPMC_OEn_REn             | EMU4                | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio2_0             | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpmc_oen_ren        | 0        | O        | H                    | H                         | 7                   | VDDSHV1 / VDDSHV1         | Yes      | 6                         | PU/PD                  | LVCMOS        |
| R15                 | T17                 | GPMC_WAIT0               | timer7              | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio2_3             | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpmc_wait0          | 0        | I        | H                    | H                         | 7                   | VDDSHV1 / VDDSHV3         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gmii2_crs           | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpmc_csn4           | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | rmii2_crs_dv        | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | mmc1_sdcd           | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_mii1_col        | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | uart4_rxd           | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
| U8                  | U6                  | GPMC_WEn                 | gpio0_30            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpmc_wen            | 0        | O        | H                    | H                         | 7                   | VDDSHV1 / VDDSHV1         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | timer6              | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio2_4             | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]             | SIGNAL NAME [3]     | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|--------------------------|---------------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| W18                    | U17                    | GPMC_WPn                 | gpmc_wpn            | 0        | O           | H                       | H                               | 7                      | VDDSHV1 /<br>VDDSHV3         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                          | gmii2_rxerr         | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpmc_csn5           | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | rmii2_rxerr         | 3        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | mmc2_sdcd           | 4        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_mii1_txen       | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | uart4_txd           | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpio0_31            | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| C18                    | C17                    | I2C0_SDA                 | I2C0_SDA            | 0        | I/OD        | Z                       | H                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 4                               | PU/PD                        | LVCMOS        |
|                        |                        |                          | timer4              | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | uart2_ctsn          | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | eCAP2_in_PWM2_out   | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpio3_5             | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| B19                    | C16                    | I2C0_SCL                 | I2C0_SCL            | 0        | I/OD        | Z                       | H                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 4                               | PU/PD                        | LVCMOS        |
|                        |                        |                          | timer7              | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | uart2_rtsn          | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | eCAP1_in_PWM1_out   | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpio3_6             | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| W7                     | R6                     | LCD_AC_BIAS_EN           | lcd_ac_bias_en      | 0        | O           | Z                       | L                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                          | gpmc_a11            | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_mii1_crs        | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_edio_data_in5   | 3        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_edio_data_out5  | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_pru1_pru_r30_11 | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_pru1_pru_r31_11 | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpio2_25            | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| U1                     | R1                     | LCD_DATA0 <sup>(5)</sup> | lcd_data0           | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                          | gpmc_a0             | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_mii_mt0_clk     | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | ehrpwm2A            | 3        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_pru1_pru_r30_0  | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_pru1_pru_r31_0  | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpio2_6             | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1] | ZCZ BALL NUMBER [1] | PIN NAME [2]             | SIGNAL NAME [3]        | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------|---------------------|--------------------------|------------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| U2                  | R2                  | LCD_DATA1 <sup>(5)</sup> | lcd_data1              | 0        | I/O      | Z                    | Z                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gpmc_a1                | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_mii0_txen          | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | ehrpwm2B               | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r30_1     | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r31_1     | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio2_7                | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| V1                  | R3                  | LCD_DATA2 <sup>(5)</sup> | lcd_data2              | 0        | I/O      | Z                    | Z                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gpmc_a2                | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_mii0_txd3          | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | ehrpwm2_tripzone_input | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r30_2     | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r31_2     | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio2_8                | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| V2                  | R4                  | LCD_DATA3 <sup>(5)</sup> | lcd_data3              | 0        | I/O      | Z                    | Z                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gpmc_a3                | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_mii0_txd2          | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | ehrpwm0_synco          | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r30_3     | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r31_3     | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio2_9                | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| W2                  | T1                  | LCD_DATA4 <sup>(5)</sup> | lcd_data4              | 0        | I/O      | Z                    | Z                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gpmc_a4                | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_mii0_txd1          | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | eQEP2A_in              | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r30_4     | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r31_4     | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio2_10               | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| W3                  | T2                  | LCD_DATA5 <sup>(5)</sup> | lcd_data5              | 0        | I/O      | Z                    | Z                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gpmc_a5                | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_mii0_txd0          | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | eQEP2B_in              | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r30_5     | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r31_5     | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio2_11               | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]             | SIGNAL NAME [3]        | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|--------------------------|------------------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| V3                     | T3                     | LCD_DATA6 <sup>(5)</sup> | lcd_data6              | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                          | gpmc_a6                | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_edio_data_in6      | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | eQEP2_index            | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_edio_data_out6     | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_pru1_pru_r30_6     | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_pru1_pru_r31_6     | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpio2_12               | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| U3                     | T4                     | LCD_DATA7 <sup>(5)</sup> | lcd_data7              | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                          | gpmc_a7                | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_edio_data_in7      | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | eQEP2_strobe           | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_edio_data_out7     | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_pru1_pru_r30_7     | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_pru1_pru_r31_7     | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpio2_13               | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V4                     | U1                     | LCD_DATA8 <sup>(5)</sup> | lcd_data8              | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                          | gpmc_a12               | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | ehrpwm1_tripzone_input | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | mcasp0_acllx           | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | uart5_txd              | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_mii0_rxd3          | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | uart2_ctsn             | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpio2_14               | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| W4                     | U2                     | LCD_DATA9 <sup>(5)</sup> | lcd_data9              | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                          | gpmc_a13               | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | ehrpwm0_synco          | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | mcasp0_fsx             | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | uart5_rxd              | 4        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | pr1_mii0_rxd2          | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | uart2_rtsn             | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                          | gpio2_15               | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]              | SIGNAL NAME [3] | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|---------------------------|-----------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| U5                     | U3                     | LCD_DATA10 <sup>(5)</sup> | lcd_data10      | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                           | gpmc_a14        | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | ehrpwm1A        | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_axr0     | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_mii0_rxd1   | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | uart3_ctsn      | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | gpio2_16        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V5                     | U4                     | LCD_DATA11 <sup>(5)</sup> | lcd_data11      | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                           | gpmc_a15        | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | ehrpwm1B        | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_ahclk    | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_axr2     | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_mii0_rxd0   | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | uart3_rtsn      | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | gpio2_17        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V6                     | V2                     | LCD_DATA12 <sup>(5)</sup> | lcd_data12      | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                           | gpmc_a16        | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | eQEP1A_in       | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_aclkr    | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_axr2     | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_mii0_rxlink | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | uart4_ctsn      | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | gpio0_8         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| U6                     | V3                     | LCD_DATA13 <sup>(5)</sup> | lcd_data13      | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                           | gpmc_a17        | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | eQEP1B_in       | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_fsr      | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_axr3     | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_mii0_rxer   | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | uart4_rtsn      | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | gpio0_9         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]              | SIGNAL NAME [3]      | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|---------------------------|----------------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| W6                     | V4                     | LCD_DATA14 <sup>(5)</sup> | lcd_data14           | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                           | gpmc_a18             | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | eQEP1_index          | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_axr1          | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | uart5_rxd            | 4        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_mii_mr0_clk      | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | uart5_ctsn           | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | gpio0_10             | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| V7                     | T5                     | LCD_DATA15 <sup>(5)</sup> | lcd_data15           | 0        | I/O         | Z                       | Z                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                           | gpmc_a19             | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | eQEP1_strobe         | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_ahclkx        | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | mcasp0_axr3          | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_mii0_rxdv        | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | uart5_rtsn           | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | gpio0_11             | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| T7                     | R5                     | LCD_HSYNC <sup>(7)</sup>  | lcd_hsync            | 0        | O           | Z                       | L                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                           | gpmc_a9              | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | gpmc_a2              | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_edio_data_in3    | 3        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_edio_data_out3   | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_prui_prui_r30_9  | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_prui_prui_r31_9  | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | gpio2_23             | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| W5                     | V5                     | LCD_PCLK                  | lcd_pclk             | 0        | O           | Z                       | L                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |                           | gpmc_a10             | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_mii0_crs         | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_edio_data_in4    | 3        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_edio_data_out4   | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_prui_prui_r30_10 | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | pr1_prui_prui_r31_10 | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |                           | gpio2_24             | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1] | ZCZ BALL NUMBER [1] | PIN NAME [2]             | SIGNAL NAME [3]    | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------|---------------------|--------------------------|--------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| U7                  | U5                  | LCD_VSYNC <sup>(7)</sup> | lcd_vsync          | 0        | O        | Z                    | L                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | gpmc_a8            | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpmc_a1            | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_edio_data_in2  | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_edio_data_out2 | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r30_8 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru1_pru_r31_8 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio2_22           | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| NA                  | B13                 | MCASP0_FSX               | mcasp0_fsx         | 0        | I/O      | L                    | L                         | 7                   | NA / VDDSHV6              | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | ehrpwm0B           | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | spi1_d0            | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | mmc1_sdcd          | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru0_pru_r30_1 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru0_pru_r31_1 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio3_15           | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          |                    |          |          |                      |                           |                     |                           |          |                           |                        |               |
| NA                  | B12                 | MCASP0_ACLKR             | mcasp0_aclkr       | 0        | I/O      | L                    | L                         | 7                   | NA / VDDSHV6              | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | eQEP0A_in          | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | mcasp0_axr2        | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | mcasp1_aclkx       | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | mmc0_sdwp          | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru0_pru_r30_4 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru0_pru_r31_4 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio3_18           | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| NA                  | C12                 | MCASP0_AHCLKR            | mcasp0_ahclkr      | 0        | I/O      | L                    | L                         | 7                   | NA / VDDSHV6              | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |                          | ehrpwm0_synci      | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | mcasp0_axr2        | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | spi1_cs0           | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | eCAP2_in_PWM2_out  | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru0_pru_r30_3 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | pr1_pru0_pru_r31_3 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |                          | gpio3_17           | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]  | SIGNAL NAME [3]        | MODE [4] | TYPE [5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE [7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS [10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE [12] | I/O CELL [13] |
|------------------------|------------------------|---------------|------------------------|----------|----------|-------------------------|------------------------------|------------------------|------------------------------|----------|---------------------------------|---------------------------|---------------|
| NA                     | A14                    | MCASP0_AHCLKX | mcasp0_ahclkx          | 0        | I/O      | L                       | L                            | 7                      | NA / VDDSHV6                 | Yes      | 6                               | PU/PD                     | LVCMOS        |
|                        |                        |               | eQEP0_strobe           | 1        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | mcasp0_axr3            | 2        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | mcasp1_axr1            | 3        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | EMU4                   | 4        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | pr1_pru0_pru_r30_7     | 5        | O        |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | pr1_pru0_pru_r31_7     | 6        | I        |                         |                              |                        |                              |          |                                 |                           |               |
| NA                     | A13                    | MCASP0_ACLKX  | gpio3_21               | 7        | I/O      | L                       | L                            | 7                      | NA / VDDSHV6                 | Yes      | 6                               | PU/PD                     | LVCMOS        |
|                        |                        |               | mcasp0_aclkx           | 0        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | ehrpwm0A               | 1        | O        |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | spi1_sclk              | 3        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | mmc0_sdcd              | 4        | I        |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | pr1_pru0_pru_r30_0     | 5        | O        |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | pr1_pru0_pru_r31_0     | 6        | I        |                         |                              |                        |                              |          |                                 |                           |               |
| NA                     | C13                    | MCASP0_FSR    | gpio3_14               | 7        | I/O      | L                       | L                            | 7                      | NA / VDDSHV6                 | Yes      | 6                               | PU/PD                     | LVCMOS        |
|                        |                        |               | mcasp0_fsr             | 0        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | eQEP0B_in              | 1        | I        |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | mcasp0_axr3            | 2        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | mcasp1_fsx             | 3        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | EMU2                   | 4        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | pr1_pru0_pru_r30_5     | 5        | O        |                         |                              |                        |                              |          |                                 |                           |               |
| NA                     | D12                    | MCASP0_AXR0   | pr1_pru0_pru_r31_5     | 6        | I        | L                       | L                            | 7                      | NA / VDDSHV6                 | Yes      | 6                               | PU/PD                     | LVCMOS        |
|                        |                        |               | gpio3_19               | 7        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | mcasp0_axr0            | 0        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | ehrpwm0_tripzone_input | 1        | I        |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | spi1_d1                | 3        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | mmc2_sdcd              | 4        | I        |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | pr1_pru0_pru_r30_2     | 5        | O        |                         |                              |                        |                              |          |                                 |                           |               |
| NA                     | D13                    | MCASP0_AXR1   | pr1_pru0_pru_r31_2     | 6        | I        | L                       | L                            | 7                      | NA / VDDSHV6                 | Yes      | 6                               | PU/PD                     | LVCMOS        |
|                        |                        |               | gpio3_16               | 7        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | mcasp0_axr1            | 0        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | eQEP0_index            | 1        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | mcasp1_axr0            | 3        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | EMU3                   | 4        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |
|                        |                        |               | pr1_pru0_pru_r30_6     | 5        | O        |                         |                              |                        |                              |          |                                 |                           |               |
| NA                     | D13                    | MCASP0_AXR1   | pr1_pru0_pru_r31_6     | 6        | I        | L                       | L                            | 7                      | NA / VDDSHV6                 | Yes      | 6                               | PU/PD                     | LVCMOS        |
|                        |                        |               | gpio3_20               | 7        | I/O      |                         |                              |                        |                              |          |                                 |                           |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1] | ZCZ BALL NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3] | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------|---------------------|--------------|-----------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| R19                 | M18                 | MDC          | mdio_clk        | 0        | O        | H                    | H                         | 7                   | VDDSHV5 / VDDSHV5         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | timer5          | 1        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart5_txd       | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart3_rtsn      | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc0_sdwp       | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc1_clk        | 5        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc2_clk        | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| P17                 | M17                 | MDIO         | gpio0_1         | 7        | I/O      | H                    | H                         | 7                   | VDDSHV5 / VDDSHV5         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | mdio_data       | 0        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | timer6          | 1        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart5_rxd       | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart3_ctsn      | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc0_sdc        | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc1_cmd        | 5        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| L19                 | J17                 | MII1_RX_DV   | mmc2_cmd        | 6        | I/O      | L                    | L                         | 7                   | VDDSHV5 / VDDSHV5         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | gpio0_0         | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gmii1_rxdv      | 0        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | lcd_memory_clk  | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | rgmii1_rctl     | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart5_txd       | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mcasp1_acllx    | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| K17                 | J16                 | MII1_TX_EN   | mmc2_dat0       | 5        | I/O      | L                    | L                         | 7                   | VDDSHV5 / VDDSHV5         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | mcasp0_aclkr    | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio3_4         | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gmii1_txen      | 0        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | rmii1_txen      | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | rgmii1_tctl     | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | timer4          | 3        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mcasp1_axr0     | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | eQEP0_index     | 5        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc2_cmd        | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio3_3         | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              |                 |          |          |                      |                           |                     |                           |          |                           |                        |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3] | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|--------------|-----------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| K19                    | J15                    | MII1_RX_ER   | gmii1_rxerr     | 0        | I           | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | rmii1_rxerr     | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | spi1_d1         | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | l2c1_SCL        | 3        | I/OD        |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_fsx      | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart5_rtsn      | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart2_txd       | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
| M19                    | L18                    | MII1_RX_CLK  | gpio3_2         | 7        | I/O         | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | gmii1_rxclk     | 0        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart2_txd       | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii1_rclk     | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc0_dat6       | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc1_dat1       | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart1_dsrn      | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
| N19                    | K18                    | MII1_TX_CLK  | mcasp0_fsx      | 6        | I/O         | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | gpio3_10        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gmii1_txclk     | 0        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart2_rxd       | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii1_tclk     | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc0_dat7       | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc1_dat0       | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| J19                    | H16                    | MII1_COL     | uart1_dcdn      | 5        | I           | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | mcasp0_aclcx    | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio3_9         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gmii1_col       | 0        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rmii2_refclk    | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | spi1_sclk       | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart5_rxd       | 3        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_axr2     | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc2_dat3       | 5        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp0_axr2     | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio3_0         | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              |                 |          |             |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3] | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|--------------|-----------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| J18                    | H17                    | MII1_CRS     | gmii1_crs       | 0        | I           | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | rmii1_crs_dv    | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | spi1_d0         | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | I2C1_SDA        | 3        | I/OD        |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_aclkx    | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart5_ctsn      | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart2_rxd       | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
| P18                    | M16                    | MII1_RXD0    | gpio3_1         | 7        | I/O         | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | gmii1_rxd0      | 0        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rmii1_rxd0      | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii1_rd0      | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_ahclkx   | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_ahclkr   | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_aclkr    | 5        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| P19                    | L15                    | MII1_RXD1    | mcasp0_axr3     | 6        | I/O         | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | gpio2_21        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gmii1_rxd1      | 0        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rmii1_rxd1      | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii1_rd1      | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_axr3     | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_fsr      | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| N16                    | L16                    | MII1_RXD2    | eQEP0_strobe    | 5        | I/O         | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | mmc2_clk        | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio2_20        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gmii1_rxd2      | 0        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart3_txd       | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii1_rd2      | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc0_dat4       | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc1_dat3       | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart1_rin       | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp0_axr1     | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio2_19        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              |                 |          |             |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3] | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|--------------|-----------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| N17                    | L17                    | MII1_RXD3    | gmii1_rxd3      | 0        | I           | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | uart3_rxd       | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii1_rd3      | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc0_dat5       | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc1_dat2       | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart1_dtrn      | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp0_axr0     | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio2_18        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| L18                    | K17                    | MII1_TXD0    | gmii1_txd0      | 0        | O           | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | rmii1_txd0      | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii1_td0      | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_axr2     | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_aclkr    | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | eQEP0B_in       | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc1_clk        | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio0_28        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| M18                    | K16                    | MII1_TXD1    | gmii1_txd1      | 0        | O           | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | rmii1_txd1      | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii1_td1      | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_fsr      | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_axr1     | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | eQEP0A_in       | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc1_cmd        | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio0_21        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| N18                    | K15                    | MII1_TXD2    | gmii1_txd2      | 0        | O           | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | dcan0_rx        | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | rgmii1_td2      | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | uart4_txd       | 3        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp1_axr0     | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mmc2_dat2       | 5        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | mcasp0_ahclkx   | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio0_17        | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1] | ZCZ BALL NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3]     | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------|---------------------|--------------|---------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| M17                 | J18                 | MII1_TXD3    | gmii1_txd3          | 0        | O        | L                    | L                         | 7                   | VDDSHV5 / VDDSHV5         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | dcan0_tx            | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | rgmii1_td3          | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart4_rxd           | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mcasp1_fsx          | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc2_dat1           | 5        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mcasp0_fsr          | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| G17                 | G18                 | MMC0_CMD     | gpio0_16            | 7        | I/O      | H                    | H                         | 7                   | VDDSHV4 / VDDSHV4         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | mmc0_cmd            | 0        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpmc_a25            | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart3_rtsn          | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart2_txd           | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | dcan1_rx            | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_pru0_pru_r30_13 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
| G19                 | G17                 | MMC0_CLK     | pr1_pru0_pru_r31_13 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio2_31            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | mmc0_clk            | 0        | I/O      | H                    | H                         | 7                   | VDDSHV4 / VDDSHV4         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | gpmc_a24            | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart3_ctsn          | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart2_rxd           | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | dcan1_tx            | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_pru0_pru_r30_12 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
| G18                 | G16                 | MMC0_DAT0    | pr1_pru0_pru_r31_12 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio2_30            | 7        | I/O      | H                    | H                         | 7                   | VDDSHV4 / VDDSHV4         | Yes      | 6                         | PU/PD                  | LVCMOS        |
|                     |                     |              | mmc0_dat0           | 0        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpmc_a23            | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart5_rtsn          | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart3_txd           | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | uart1_rin           | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_pru0_pru_r30_11 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_pru0_pru_r31_11 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio2_29            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              |                     |          |          |                      |                           |                     |                           |          |                           |                        |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]  | SIGNAL NAME [3]     | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|---------------|---------------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| H17                    | G15                    | MMC0_DAT1     | mmc0_dat1           | 0        | I/O         | H                       | H                               | 7                      | VDDSHV4 /<br>VDDSHV4         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | gpmc_a22            | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | uart5_ctsn          | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | uart3_rxd           | 3        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | uart1_dtrn          | 4        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_pru0_pru_r30_10 | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_pru0_pru_r31_10 | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpio2_28            | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| H18                    | F18                    | MMC0_DAT2     | mmc0_dat2           | 0        | I/O         | H                       | H                               | 7                      | VDDSHV4 /<br>VDDSHV4         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | gpmc_a21            | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | uart4_rtsn          | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | timer6              | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | uart1_dsrn          | 4        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_pru0_pru_r30_9  | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_pru0_pru_r31_9  | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpio2_27            | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| H19                    | F17                    | MMC0_DAT3     | mmc0_dat3           | 0        | I/O         | H                       | H                               | 7                      | VDDSHV4 /<br>VDDSHV4         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | gpmc_a20            | 1        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | uart4_ctsn          | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | timer5              | 3        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | uart1_dcdn          | 4        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_pru0_pru_r30_8  | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | pr1_pru0_pru_r31_8  | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpio2_26            | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| C7                     | C6                     | PMIC_POWER_EN | PMIC_POWER_EN       | 0        | O           | H                       | 1                               | 0                      | VDDS_RTC /<br>VDDS_RTC       | NA          | 6                               | NA                           | LVCMOS        |
| E15                    | B15                    | PWRONRSTn     | porz                | 0        | I           | Z                       | Z                               | 0                      | VDDSHV6 /<br>VDDSHV6 (11)    | Yes         | NA                              | NA                           | LVCMOS        |
| B6                     | A3                     | RESERVED (3)  | testout             | 0        | O           | NA                      | NA                              | NA                     | VDDSHV6 /<br>VDDSHV6         | NA          | NA                              | NA                           | Analog        |
| K18                    | H18                    | RMII1_REF_CLK | rmii1_refclk        | 0        | I/O         | L                       | L                               | 7                      | VDDSHV5 /<br>VDDSHV5         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |               | xdma_event_intr2    | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | spi1_cs0            | 2        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | uart5_txd           | 3        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | mcasp1_axr3         | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | mmc0_pow            | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | mcasp1_ahclkx       | 6        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |               | gpio0_29            | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| A7                     | B4                     | RTC_KALDO_ENn | ENZ_KALDO_1P8V      | 0        | I           | Z                       | Z                               | 0                      | VDDS_RTC /<br>VDDS_RTC       | NA          | NA                              | NA                           | Analog        |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1] | ZCZ BALL NUMBER [1] | PIN NAME [2]  | SIGNAL NAME [3]    | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------|---------------------|---------------|--------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| B7                  | B5                  | RTC_PWRONRSTn | RTC_PORz           | 0        | I        | Z                    | Z                         | 0                   | VDDS_RTC / VDDS_RTC       | Yes      | NA                        | NA                     | LVC MOS       |
| A6                  | A6                  | RTC_XTALIN    | OSC1_IN            | 0        | I        | H                    | H                         | 0                   | VDDS_RTC / VDDS_RTC       | Yes      | NA                        | PU <sup>(1)</sup>      | LVC MOS       |
| A5                  | A4                  | RTC_XTALOUT   | OSC1_OUT           | 0        | O        | Z <sup>(22)</sup>    | Z <sup>(22)</sup>         | 0                   | VDDS_RTC / VDDS_RTC       | NA       | NA <sup>(14)</sup>        | NA                     | LVC MOS       |
| A18                 | A17                 | SPI0_SCLK     | spi0_sclk          | 0        | I/O      | Z                    | H                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVC MOS       |
|                     |                     |               | uart2_rxd          | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | I2C2_SDA           | 2        | I/OD     |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | ehrpwm0A           | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | pr1_uart0_cts_n    | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | pr1_edio_sof       | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | EMU2               | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | gpio0_2            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| A17                 | A16                 | SPI0_CS0      | spi0_cs0           | 0        | I/O      | Z                    | H                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVC MOS       |
|                     |                     |               | mmc2_sdwp          | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | I2C1_SCL           | 2        | I/OD     |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | ehrpwm0_synci      | 3        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | pr1_uart0_txd      | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | pr1_edio_data_in1  | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | pr1_edio_data_out1 | 6        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | gpio0_5            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| B16                 | C15                 | SPI0_CS1      | spi0_cs1           | 0        | I/O      | Z                    | H                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVC MOS       |
|                     |                     |               | uart3_rxd          | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | eCAP1_in_PWM1_out  | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | mmc0_pow           | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | xdma_event_intr2   | 4        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | mmc0_sdcd          | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | EMU4               | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | gpio0_6            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| B18                 | B17                 | SPI0_D0       | spi0_d0            | 0        | I/O      | Z                    | H                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 6                         | PU/PD                  | LVC MOS       |
|                     |                     |               | uart2_txd          | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | I2C2_SCL           | 2        | I/OD     |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | ehrpwm0B           | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | pr1_uart0_rts_n    | 4        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | pr1_edio_latch_in  | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | EMU3               | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |               | gpio0_3            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3]        | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9] | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|--------------|------------------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------|-------------|---------------------------------|------------------------------|---------------|
| B17                    | B16                    | SPI0_D1      | spi0_d1                | 0        | I/O         | Z                       | H                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 6                               | PU/PD                        | LVCMOS        |
|                        |                        |              | mmc1_sdwp              | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | I2C1_SDA               | 2        | I/OD        |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | ehrpwm0_tripzone_input | 3        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_uart0_rxd          | 4        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_edio_data_in0      | 5        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_edio_data_out0     | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio0_4                | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| B14                    | A12                    | TCK          | TCK                    | 0        | I           | H                       | H                               | 0                      | VDDSHV6 /<br>VDDSHV6         | Yes         | NA                              | PU/PD                        | LVCMOS        |
| B13                    | B11                    | TDI          | TDI                    | 0        | I           | H                       | H                               | 0                      | VDDSHV6 /<br>VDDSHV6         | Yes         | NA                              | PU/PD                        | LVCMOS        |
| A14                    | A11                    | TDO          | TDO                    | 0        | O           | H                       | H                               | 0                      | VDDSHV6 /<br>VDDSHV6         | NA          | 4                               | PU/PD                        | LVCMOS        |
| C14                    | C11                    | TMS          | TMS                    | 0        | I           | H                       | H                               | 0                      | VDDSHV6 /<br>VDDSHV6         | Yes         | NA                              | PU/PD                        | LVCMOS        |
| A13                    | B10                    | TRSTn        | nTRST                  | 0        | I           | L                       | L                               | 0                      | VDDSHV6 /<br>VDDSHV6         | Yes         | NA                              | PU/PD                        | LVCMOS        |
| F17                    | E16                    | UART0_TXD    | uart0_txd              | 0        | O           | Z                       | H                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 4                               | PU/PD                        | LVCMOS        |
|                        |                        |              | spi1_cs1               | 1        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | dcan0_rx               | 2        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | I2C2_SCL               | 3        | I/OD        |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | eCAP1_in_PWM1_out      | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_prui_prui_r30_15   | 5        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_prui_prui_r31_15   | 6        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_11               | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
| F19                    | E18                    | UART0_CTSn   | uart0_ctsn             | 0        | I           | Z                       | H                               | 7                      | VDDSHV6 /<br>VDDSHV6         | Yes         | 4                               | PU/PD                        | LVCMOS        |
|                        |                        |              | uart4_rxd              | 1        | I           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | dcan1_tx               | 2        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | I2C1_SDA               | 3        | I/OD        |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | spi1_d0                | 4        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | timer7                 | 5        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | pr1_edc_sync0_out      | 6        | O           |                         |                                 |                        |                              |             |                                 |                              |               |
|                        |                        |              | gpio1_8                | 7        | I/O         |                         |                                 |                        |                              |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1] | ZCZ BALL NUMBER [1] | PIN NAME [2] | SIGNAL NAME [3]      | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------|---------------------|--------------|----------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| E19                 | E15                 | UART0_RXD    | uart0_rxd            | 0        | I        | Z                    | H                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 4                         | PU/PD                  | LVCMOS        |
|                     |                     |              | spi1_cs0             | 1        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | dcan0_tx             | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | I2C2_SDA             | 3        | I/OD     |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | eCAP2_in_PWM2_out    | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_prui_prui_r30_14 | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_prui_prui_r31_14 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio1_10             | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| F18                 | E17                 | UART0_RTSn   | uart0_rtsn           | 0        | O        | Z                    | H                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 4                         | PU/PD                  | LVCMOS        |
|                     |                     |              | uart4_txd            | 1        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | dcan1_rx             | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | I2C1_SCL             | 3        | I/OD     |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | spi1_d1              | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | spi1_cs0             | 5        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_edc_sync1_out    | 6        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio1_9              | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| C19                 | D15                 | UART1_TXD    | uart1_txd            | 0        | O        | Z                    | H                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 4                         | PU/PD                  | LVCMOS        |
|                     |                     |              | mmc2_sdwp            | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | dcan1_rx             | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | I2C1_SCL             | 3        | I/OD     |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_uart0_txd        | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_prui_prui_r31_16 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio0_15             | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| D18                 | D16                 | UART1_RXD    | uart1_rxd            | 0        | I        | Z                    | H                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 4                         | PU/PD                  | LVCMOS        |
|                     |                     |              | mmc1_sdwp            | 1        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | dcan1_tx             | 2        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | I2C1_SDA             | 3        | I/OD     |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_uart0_rxd        | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_prui_prui_r31_16 | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio0_14             | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| D19                 | D17                 | UART1_RTSn   | uart1_rtsn           | 0        | O        | Z                    | H                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 4                         | PU/PD                  | LVCMOS        |
|                     |                     |              | timer5               | 1        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | dcan0_rx             | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | I2C2_SCL             | 3        | I/OD     |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | spi1_cs1             | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_uart0_rts_n      | 5        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | pr1_edc_latch1_in    | 6        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                     |                     |              | gpio0_13             | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL<br>NUMBER [1] | ZCZ BALL<br>NUMBER [1] | PIN NAME [2]  | SIGNAL NAME [3]   | MODE [4] | TYPE<br>[5] | BALL RESET<br>STATE [6] | BALL RESET<br>REL. STATE<br>[7] | RESET REL.<br>MODE [8] | ZCE POWER /<br>ZCZ POWER [9]       | HYS<br>[10] | BUFFER<br>STRENGTH<br>(mA) [11] | PULLUP<br>/DOWN TYPE<br>[12] | I/O CELL [13] |
|------------------------|------------------------|---------------|-------------------|----------|-------------|-------------------------|---------------------------------|------------------------|------------------------------------|-------------|---------------------------------|------------------------------|---------------|
| E17                    | D18                    | UART1_CTSn    | uart1_ctsn        | 0        | I           | Z                       | H                               | 7                      | VDDSHV6 /<br>VDDSHV6               | Yes         | 4                               | PU/PD                        | LVCMOS        |
|                        |                        |               | timer6            | 1        | I/O         |                         |                                 |                        |                                    |             |                                 |                              |               |
|                        |                        |               | dcan0_tx          | 2        | O           |                         |                                 |                        |                                    |             |                                 |                              |               |
|                        |                        |               | I2C2_SDA          | 3        | I/OD        |                         |                                 |                        |                                    |             |                                 |                              |               |
|                        |                        |               | spi1_cs0          | 4        | I/O         |                         |                                 |                        |                                    |             |                                 |                              |               |
|                        |                        |               | pr1_uart0_cts_n   | 5        | I           |                         |                                 |                        |                                    |             |                                 |                              |               |
|                        |                        |               | pr1_edc_latch0_in | 6        | I           |                         |                                 |                        |                                    |             |                                 |                              |               |
|                        |                        |               | gpio0_12          | 7        | I/O         |                         |                                 |                        |                                    |             |                                 |                              |               |
| T18                    | M15                    | USB0_CE       | USB0_CE           | 0        | A           | Z                       | Z                               | 0                      | VDDA*_USB0 /<br>VDDA*_USB0<br>(24) | NA          | NA                              | NA                           | Analog        |
| T19                    | P15                    | USB0_VBUS     | USB0_VBUS         | 0        | A           | Z                       | Z                               | 0                      | VDDA*_USB0 /<br>VDDA*_USB0<br>(24) | NA          | NA                              | NA                           | Analog        |
| U18                    | N18                    | USB0_DM       | USB0_DM           | 0        | A           | Z                       | Z                               | 0 (12)                 | VDDA*_USB0 /<br>VDDA*_USB0<br>(24) | Yes<br>(15) | 8 (15)                          | NA                           | Analog        |
| G16                    | F16                    | USB0_DRVVBUS  | USB0_DRVVBUS      | 0        | O           | L                       | 0(PD)                           | 0                      | VDDSHV6 /<br>VDDSHV6               | Yes         | 4                               | PU/PD                        | LVCMOS        |
|                        |                        |               | gpio0_18          | 7        | I/O         |                         |                                 |                        |                                    |             |                                 |                              |               |
| V19                    | P16                    | USB0_ID       | USB0_ID           | 0        | A           | Z                       | Z                               | 0                      | VDDA*_USB0 /<br>VDDA*_USB0<br>(24) | NA          | NA                              | NA                           | Analog        |
| U19                    | N17                    | USB0_DP       | USB0_DP           | 0        | A           | Z                       | Z                               | 0 (12)                 | VDDA*_USB0 /<br>VDDA*_USB0<br>(24) | Yes<br>(15) | 8 (15)                          | NA                           | Analog        |
| NA                     | P18                    | USB1_CE       | USB1_CE           | 0        | A           | Z                       | Z                               | 0                      | NA /<br>VDDA*_USB1<br>(25)         | NA          | NA                              | NA                           | Analog        |
| NA                     | P17                    | USB1_ID       | USB1_ID           | 0        | A           | Z                       | Z                               | 0                      | NA /<br>VDDA*_USB1<br>(25)         | NA          | NA                              | NA                           | Analog        |
| NA                     | T18                    | USB1_VBUS     | USB1_VBUS         | 0        | A           | Z                       | Z                               | 0                      | NA /<br>VDDA*_USB1<br>(25)         | NA          | NA                              | NA                           | Analog        |
| NA                     | R17                    | USB1_DP       | USB1_DP           | 0        | A           | Z                       | Z                               | 0 (13)                 | NA /<br>VDDA*_USB1<br>(25)         | Yes<br>(16) | 8 (16)                          | NA                           | Analog        |
| NA                     | F15                    | USB1_DRVVBUS  | USB1_DRVVBUS      | 0        | O           | L                       | 0(PD)                           | 0                      | NA / VDDSHV6                       | Yes         | 4                               | PU/PD                        | LVCMOS        |
|                        |                        |               | gpio3_13          | 7        | I/O         |                         |                                 |                        |                                    |             |                                 |                              |               |
| NA                     | R18                    | USB1_DM       | USB1_DM           | 0        | A           | Z                       | Z                               | 0 (13)                 | NA /<br>VDDA*_USB1<br>(25)         | Yes<br>(16) | 8 (16)                          | NA                           | Analog        |
| R17                    | N16                    | VDDA1P8V_USB0 | VDDA1P8V_USB0     | NA       | PWR         |                         |                                 |                        |                                    |             |                                 |                              |               |
| NA                     | R16                    | VDDA1P8V_USB1 | VDDA1P8V_USB1     | NA       | PWR         |                         |                                 |                        |                                    |             |                                 |                              |               |
| R18                    | N15                    | VDDA3P3V_USB0 | VDDA3P3V_USB0     | NA       | PWR         |                         |                                 |                        |                                    |             |                                 |                              |               |
| NA                     | R15                    | VDDA3P3V_USB1 | VDDA3P3V_USB1     | NA       | PWR         |                         |                                 |                        |                                    |             |                                 |                              |               |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1]                                                                                                  | ZCZ BALL NUMBER [1]                                                                    | PIN NAME [2]      | SIGNAL NAME [3]             | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-------------------|-----------------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| D7                                                                                                                   | D8                                                                                     | VDDA_ADC          | VDDA_ADC                    | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| D12, F16, M16, T6, T14                                                                                               | E6, E14, F9, K13, N6, P9, P14                                                          | VDDS              | VDDS                        | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| R8, R9, R11, R12, R13                                                                                                | P7, P8                                                                                 | VDDSHV1           | VDDSHV1                     | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| NA                                                                                                                   | P10, P11                                                                               | VDDSHV2           | VDDSHV2                     | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| NA                                                                                                                   | P12, P13                                                                               | VDDSHV3           | VDDSHV3                     | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| G15, H14, H15                                                                                                        | H14, J14                                                                               | VDDSHV4           | VDDSHV4                     | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| M14, M15, N15                                                                                                        | K14, L14                                                                               | VDDSHV5           | VDDSHV5                     | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| E11, E12, E13, F14, P6, R7                                                                                           | E10, E11, E12, E13, F14, G14, N5, P5, P6                                               | VDDSHV6           | VDDSHV6                     | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| G5, H5, H6, K4, K5, M5, M6, N5                                                                                       | E5, F5, G5, H5, J5, K5, L5                                                             | VDDS_DDR          | VDDS_DDR                    | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| U10                                                                                                                  | R11                                                                                    | VDDS_OSC          | VDDS_OSC                    | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| T8                                                                                                                   | R10                                                                                    | VDDS_PLL_CORE_LCD | VDDS_PLL_CORE_LCD           | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| C5                                                                                                                   | E7                                                                                     | VDDS_PLL_DDR      | VDDS_PLL_DDR                | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| H16                                                                                                                  | H15                                                                                    | VDDS_PLL_MPU      | VDDS_PLL_MPU                | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| C6                                                                                                                   | D7                                                                                     | VDDS_RTC          | VDDS_RTC                    | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| C10                                                                                                                  | E9                                                                                     | VDDS_SRAM_CORE_BG | VDDS_SRAM_CORE_BG           | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| C12                                                                                                                  | D10                                                                                    | VDDS_SRAM_MPU_BB  | VDDS_SRAM_MPU_BB            | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| F9, F11, G9, G11, H7, H8, H12, H13, J7, J8, J12, J13, K15, K16, L7, L8, L12, L13, M7, M8, M12, M13, N9, N11, P9, P11 | F6, F7, G6, G7, G10, H11, J12, K6, K8, K12, L6, L7, L8, L9, M11, M13, N8, N9, N12, N13 | VDD_CORE          | VDD_CORE                    | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| NA                                                                                                                   | F10, F11, F12, F13, G13, H13, J13                                                      | VDD_MPU           | VDD_MPU <sup>(26)</sup>     | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| NA                                                                                                                   | A2                                                                                     | VDD_MPU_MON       | VDD_MPU_MON <sup>(27)</sup> | NA       | A        |                      |                           |                     |                           |          |                           |                        |               |
| R5                                                                                                                   | M5                                                                                     | VPP               | VPP                         | NA       | PWR      |                      |                           |                     |                           |          |                           |                        |               |
| B9                                                                                                                   | A9                                                                                     | VREFN             | VREFN                       | 0        | AP       | Z                    | Z                         | 0                   | VDDA_ADC / VDDA_ADC       | NA       | NA                        | NA                     | Analog        |
| A9                                                                                                                   | B9                                                                                     | VREFP             | VREFP                       | 0        | AP       | Z                    | Z                         | 0                   | VDDA_ADC / VDDA_ADC       | NA       | NA                        | NA                     | Analog        |

**Table 2-7. Ball Characteristics (ZCE and ZCZ Packages) (continued)**

| ZCE BALL NUMBER [1]                                                                                                                                                                                                 | ZCZ BALL NUMBER [1]                                                                                                                                                      | PIN NAME [2]     | SIGNAL NAME [3]     | MODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | RESET REL. MODE [8] | ZCE POWER / ZCZ POWER [9] | HYS [10] | BUFFER STRENGTH (mA) [11] | PULLUP /DOWN TYPE [12] | I/O CELL [13] |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|---------------------|----------|----------|----------------------|---------------------------|---------------------|---------------------------|----------|---------------------------|------------------------|---------------|
| A1, A19, D10, E7, E8, E9, E10, F6, F7, F8, F12, F13, G8, G12, H9, H10, H11, J5, J6, J9, J11, J14, J15, K8, K9, K11, K12, L5, L6, L9, L11, L14, L15, M9, M10, M11, N8, N12, P7, P8, P12, P13, P14, R10, T10, W1, W19 | A1, A18, F8, G8, G9, G11, G12, H6, H7, H8, H9, H10, H12, J6, J7, J8, J9, J10, J11, K7, K9, K10, K11, L10, L11, L12, L13, M6, M7, M8, M9, M10, M12, N7, N10, N11, V1, V18 | VSS              | VSS                 | NA       | GND      |                      |                           |                     |                           |          |                           |                        |               |
| D8                                                                                                                                                                                                                  | E8                                                                                                                                                                       | VSSA_ADC         | VSSA_ADC            | NA       | GND      |                      |                           |                     |                           |          |                           |                        |               |
| P16                                                                                                                                                                                                                 | M14, N14                                                                                                                                                                 | VSSA_USB         | VSSA_USB            | NA       | GND      |                      |                           |                     |                           |          |                           |                        |               |
| V11                                                                                                                                                                                                                 | V11                                                                                                                                                                      | VSS_OSC          | VSS_OSC (29)        | NA       | A        |                      |                           |                     |                           |          |                           |                        |               |
| NA                                                                                                                                                                                                                  | A5                                                                                                                                                                       | VSS_RTC          | VSS_RTC (28)        | NA       | A        |                      |                           |                     |                           |          |                           |                        |               |
| A16                                                                                                                                                                                                                 | A10                                                                                                                                                                      | WARMRSTn         | nRESETIN_OUT        | 0        | I/OD (8) | 0                    | 0(PU)                     | 0                   | VDDSHV6 / VDDSHV6         | Yes      | 4                         | PU/PD                  | LVC MOS       |
| C15                                                                                                                                                                                                                 | A15                                                                                                                                                                      | XDMA_EVENT_INTR0 | xdma_event_intr0    | 0        | I        | Z                    | (4)                       | (9)                 | VDDSHV6 / VDDSHV6         | Yes      | 4                         | PU/PD                  | LVC MOS       |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | timer4              | 2        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | clkout1             | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | spi1_cs1            | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | pr1_pru1_pru_r31_16 | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | EMU2                | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | gpio0_19            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| B15                                                                                                                                                                                                                 | D14                                                                                                                                                                      | XDMA_EVENT_INTR1 | xdma_event_intr1    | 0        | I        | Z                    | L                         | 7                   | VDDSHV6 / VDDSHV6         | Yes      | 4                         | PU/PD                  | LVC MOS       |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | tcclk               | 2        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | clkout2             | 3        | O        |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | timer7              | 4        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | pr1_pru0_pru_r31_16 | 5        | I        |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | EMU3                | 6        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
|                                                                                                                                                                                                                     |                                                                                                                                                                          |                  | gpio0_20            | 7        | I/O      |                      |                           |                     |                           |          |                           |                        |               |
| W11                                                                                                                                                                                                                 | V10                                                                                                                                                                      | XTALIN           | OSCO_IN             | 0        | I        | Z                    | Z                         | 0                   | VDDS_OSC / VDDS_OSC       | Yes      | NA                        | PD (2)                 | LVC MOS       |
| W12                                                                                                                                                                                                                 | U11                                                                                                                                                                      | XTALOUT          | OSCO_OUT            | 0        | O        | (23)                 | (23)                      | 0                   | VDDS_OSC / VDDS_OSC       | NA       | NA (14)                   | NA                     | LVC MOS       |

- (1) An internal 10 kohm pull up is turned on when the oscillator is disabled. The oscillator is disabled by default after power is applied.
- (2) An internal 15 kohm pull down is turned on when the oscillator is disabled. The oscillator is enabled by default after power is applied.
- (3) Do not connect anything to this terminal.
- (4) If sysboot[5] is low on the rising edge of PWRONRSTn, this terminal has an internal pull-down turned on after reset is released. If sysboot[5] is high on the rising edge or PWRONRSTn, this terminal will initially be driven low after reset is released then it begins to toggle at the same frequency of the XTALIN terminal.
- (5) LCD\_DATA[15:0] terminals are respectively SYSBOOT[15:0] inputs, latched on the rising edge of PWRONRSTn.
- (6) Mode1 and Mode2 signal assignments for this terminal are only available with silicon revision 2.0 or newer devices.
- (7) Mode2 signal assignment for this terminal is only available with silicon revision 2.0 or newer devices.
- (8) Refer to the External Warm Reset section of the AM335x Technical Reference Manual for more information related to the operation of this terminal.
- (9) Reset Release Mode = 7 if sysboot[5] is low. Mode = 3 if sysboot[5] is high.
- (10) Silicon revision 1.0 devices only provide the MMC2\_DAT7 signal when Mode3 is selected. Silicon revision 2.0 and newer devices implement another level of pin multiplexing which provides the original MMC2\_DAT7 signal or RMII2\_CRS\_DV signal when Mode3 is selected. This new level of pin multiplexing is selected with bit zero of the SMA2 register. For more details refer to Section 1.2 of the AM335x Technical Reference Manual.
- (11) The input voltage thresholds for this input are not a function of VDDSHV6. Please refer to the DC Electrical Characteristics section for details related to electrical parameters associated with this input terminal.
- (12) The internal USB PHY can be configured to multiplex the UART2\_TX or UART2\_RX signals to this terminal. For more details refer to USB GPIO Details section of the AM335x Technical Reference Manual.
- (13) The internal USB PHY can be configured to multiplex the UART3\_TX or UART3\_RX signals to this terminal. For more details refer to USB GPIO Details section of the AM335x Technical Reference Manual.
- (14) This output should only be used to source the recommended crystal circuit.
- (15) This parameter only applies when this USB PHY terminal is operating in UART2 mode.
- (16) This parameter only applies when this USB PHY terminal is operating in UART3 mode.
- (17) This terminal is a analog input used to set the switching threshold of the DDR input buffers to (VDDS\_DDR / 2).
- (18) This terminal is a analog passive signal that connects to an external 49.9 ohm 1%, 20mW reference resistor which is used to calibrate the DDR input/output buffers.
- (19) This terminal is analog input that may also be configured as an open-drain output.
- (20) This terminal is analog input that may also be configured as an open-source or open-drain output.
- (21) This terminal is analog input that may also be configured as an open-source output.
- (22) This terminal is high-Z when the oscillator is disabled. This terminal is driven high if RTC\_XTALIN is less than VIL, driven low if RTC\_XTALIN is greater than VIH, and driven to a unknown value if RTC\_XTALIN is between VIL and VIH when the oscillator is enabled. The oscillator is disabled by default after power is applied.
- (23) This terminal is high-Z when the oscillator is disabled. This terminal is driven high if XTALIN is less than VIL, driven low if XTALIN is greater than VIH, and driven to a unknown value if XTALIN is between VIL and VIH when the oscillator is enabled. The oscillator is enabled by default after power is applied.
- (24) This terminal requires two power supplies, VDDA3p3v\_USB0 and VDDA1p8v\_USB0. The "\*" character in the power supply name is a wild card that represents "3p3v" and "1p8v".
- (25) This terminal requires two power supplies, VDDA3p3v\_USB1 and VDDA1p8v\_USB1. The "\*" character in the power supply name is a wild card that represents "3p3v" and "1p8v".
- (26) This power rail is connected to VDD\_CORE in the ZCE package.
- (27) This terminal provides a Kelvin connection to VDD\_MPU. It can be connected to the power supply feedback input to provide remote sensing which compensates for voltage drop in the PCB power distribution network and package. When the Kelvin connection is not used it should be connected to the same power source as VDD\_MPU.
- (28) This terminal provides a Kelvin ground reference for the external crystal components. If a crystal circuit is connected to the RTC\_XTALIN/RTC\_XTALOUT terminals, the crystal circuit component grounds should only be connected to this terminal and should not be connected to the PCB ground plane. If an external LVCMOS clock source is connected to the XTALIN terminal, this terminal should be connected to VSS.
- (29) This terminal provides a Kelvin ground reference for the external crystal components. If a crystal circuit is connected to the XTALIN/XTALOUT terminals, the crystal circuit component

grounds should only be connected to this terminal and should not be connected to the PCB ground plane. If an external LVCMOS clock source is connected to the XTALIN terminal, this terminal should be connected to VSS.

## 2.3 Signal Description

The AM335x device contains many peripheral interfaces. In order to reduce package size and lower overall system cost while maintaining maximum functionality, many of the AM335x terminals can multiplex up to eight signal functions. Although there are many combinations of pin multiplexing that are possible, only a certain number of sets, called IO Sets, are valid due to timing limitations. These valid IO Sets were carefully chosen to provide many possible application scenarios for the user.

Texas Instruments has developed a Windows-based application called Pin Mux Utility that helps a system designer select the appropriate pin-multiplexing configuration for their AM335x-based product design. The Pin Mux Utility provides a way to select valid IO Sets of specific peripheral interfaces to ensure the pin-multiplexing configuration selected for a design only uses valid IO Sets supported by the AM335x device.

- (1) **SIGNAL NAME:** The signal name
- (2) **DESCRIPTION:** Description of the signal
- (3) **TYPE:** Ball type for this specific function:
  - I = Input
  - O = Output
  - I/O = Input/Output
  - D = Open drain
  - DS = Differential
  - A = Analog
- (4) **BALL:** Package ball location

**Table 2-8. ADC Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]                 | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|---------------------------------|----------|--------------|--------------|
| AIN0            | Analog Input/Output             | A        | B8           | B6           |
| AIN1            | Analog Input/Output             | A        | A11          | C7           |
| AIN2            | Analog Input/Output             | A        | A8           | B7           |
| AIN3            | Analog Input/Output             | A        | B11          | A7           |
| AIN4            | Analog Input/Output             | A        | C8           | C8           |
| AIN5            | Analog Input                    | A        | B12          | B8           |
| AIN6            | Analog Input                    | A        | A10          | A8           |
| AIN7            | Analog Input                    | A        | A12          | C9           |
| VREFN           | Analog Negative Reference Input | AP       | B9           | A9           |
| VREFP           | Analog Positive Reference Input | AP       | A9           | B9           |

**Table 2-9. Debug Subsystem Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]              | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4]  |
|-----------------|------------------------------|----------|--------------|---------------|
| EMU0            | MISC EMULATION PIN           | I/O      | A15          | C14           |
| EMU1            | MISC EMULATION PIN           | I/O      | D14          | B14           |
| EMU2            | MISC EMULATION PIN           | I/O      | A18, C15     | A15, A17, C13 |
| EMU3            | MISC EMULATION PIN           | I/O      | B15, B18     | B17, D13, D14 |
| EMU4            | MISC EMULATION PIN           | I/O      | B16, U17     | A14, C15, T13 |
| nTRST           | JTAG TEST RESET (ACTIVE LOW) | I        | A13          | B10           |
| TCK             | JTAG TEST CLOCK              | I        | B14          | A12           |
| TDI             | JTAG TEST DATA INPUT         | I        | B13          | B11           |
| TDO             | JTAG TEST DATA OUTPUT        | O        | A14          | A11           |
| TMS             | JTAG TEST MODE SELECT        | I        | C14          | C11           |

**Table 2-10. LCD Controller Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]                | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|--------------------------------|----------|--------------|--------------|
| lcd_ac_bias_en  | LCD AC bias enable chip select | O        | W7           | R6           |
| lcd_data0       | LCD data bus                   | I/O      | U1           | R1           |
| lcd_data1       | LCD data bus                   | I/O      | U2           | R2           |
| lcd_data10      | LCD data bus                   | I/O      | U5           | U3           |
| lcd_data11      | LCD data bus                   | I/O      | V5           | U4           |
| lcd_data12      | LCD data bus                   | I/O      | V6           | V2           |
| lcd_data13      | LCD data bus                   | I/O      | U6           | V3           |
| lcd_data14      | LCD data bus                   | I/O      | W6           | V4           |
| lcd_data15      | LCD data bus                   | I/O      | V7           | T5           |
| lcd_data16      | LCD data bus                   | O        | V17          | U13          |

**Table 2-10. LCD Controller Signals Description (continued)**

| SIGNAL NAME [1] | DESCRIPTION [2]     | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|---------------------|----------|--------------|--------------|
| lcd_data17      | LCD data bus        | O        | W17          | V13          |
| lcd_data18      | LCD data bus        | O        | T13          | R12          |
| lcd_data19      | LCD data bus        | O        | U13          | T12          |
| lcd_data2       | LCD data bus        | I/O      | V1           | R3           |
| lcd_data20      | LCD data bus        | O        | U12          | U12          |
| lcd_data21      | LCD data bus        | O        | T12          | T11          |
| lcd_data22      | LCD data bus        | O        | W16          | T10          |
| lcd_data23      | LCD data bus        | O        | V15          | U10          |
| lcd_data3       | LCD data bus        | I/O      | V2           | R4           |
| lcd_data4       | LCD data bus        | I/O      | W2           | T1           |
| lcd_data5       | LCD data bus        | I/O      | W3           | T2           |
| lcd_data6       | LCD data bus        | I/O      | V3           | T3           |
| lcd_data7       | LCD data bus        | I/O      | U3           | T4           |
| lcd_data8       | LCD data bus        | I/O      | V4           | U1           |
| lcd_data9       | LCD data bus        | I/O      | W4           | U2           |
| lcd_hsync       | LCD Horizontal Sync | O        | T7           | R5           |
| lcd_memory_clk  | LCD MCLK            | O        | L19, V16     | J17, V12     |
| lcd_pclk        | LCD pixel clock     | O        | W5           | V5           |
| lcd_vsync       | LCD Vertical Sync   | O        | U7           | U5           |

## 2.3.1 External Memory Interfaces

**Table 2-11. External Memory Interfaces/DDR Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]                                     | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------------------------------------------|----------|--------------|--------------|
| ddr_a0          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | F3           | F3           |
| ddr_a1          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | J2           | H1           |
| ddr_a10         | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | E2           | F4           |
| ddr_a11         | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | G4           | F2           |
| ddr_a12         | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | F4           | E3           |
| ddr_a13         | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | H1           | H3           |
| ddr_a14         | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | H3           | H4           |
| ddr_a15         | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | E3           | D3           |
| ddr_a2          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | D1           | E4           |
| ddr_a3          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | B3           | C3           |
| ddr_a4          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | E5           | C2           |
| ddr_a5          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | A2           | B1           |
| ddr_a6          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | B1           | D5           |
| ddr_a7          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | D2           | E2           |
| ddr_a8          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | C3           | D4           |
| ddr_a9          | DDR SDRAM ROW/COLUMN ADDRESS OUTPUT                 | O        | B2           | C1           |
| ddr_ba0         | DDR SDRAM BANK ADDRESS OUTPUT                       | O        | A3           | C4           |
| ddr_ba1         | DDR SDRAM BANK ADDRESS OUTPUT                       | O        | E1           | E1           |
| ddr_ba2         | DDR SDRAM BANK ADDRESS OUTPUT                       | O        | B4           | B3           |
| ddr_casn        | DDR SDRAM COLUMN ADDRESS STROBE OUTPUT (ACTIVE LOW) | O        | F1           | F1           |
| ddr_ck          | DDR SDRAM CLOCK OUTPUT (Differential+)              | O        | C2           | D2           |
| ddr_cke         | DDR SDRAM CLOCK ENABLE OUTPUT                       | O        | G3           | G3           |
| ddr_csn0        | DDR SDRAM CHIP SELECT OUTPUT                        | O        | H2           | H2           |
| ddr_d0          | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | N4           | M3           |
| ddr_d1          | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | P4           | M4           |
| ddr_d10         | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | M3           | K2           |
| ddr_d11         | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | M4           | K3           |
| ddr_d12         | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | M2           | K4           |
| ddr_d13         | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | M1           | L3           |
| ddr_d14         | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | N2           | L4           |
| ddr_d15         | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | N1           | M1           |
| ddr_d2          | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | P2           | N1           |
| ddr_d3          | DDR SDRAM DATA INPUT/OUTPUT                         | I/O      | P1           | N2           |

**Table 2-11. External Memory Interfaces/DDR Signals Description (continued)**

| SIGNAL NAME [1] | DESCRIPTION [2]                                   | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|---------------------------------------------------|----------|--------------|--------------|
| ddr_d4          | DDR SDRAM DATA INPUT/OUTPUT                       | I/O      | P3           | N3           |
| ddr_d5          | DDR SDRAM DATA INPUT/OUTPUT                       | I/O      | T1           | N4           |
| ddr_d6          | DDR SDRAM DATA INPUT/OUTPUT                       | I/O      | T2           | P3           |
| ddr_d7          | DDR SDRAM DATA INPUT/OUTPUT                       | I/O      | R3           | P4           |
| ddr_d8          | DDR SDRAM DATA INPUT/OUTPUT                       | I/O      | K2           | J1           |
| ddr_d9          | DDR SDRAM DATA INPUT/OUTPUT                       | I/O      | K1           | K1           |
| ddr_dqm0        | DDR WRITE ENABLE / DATA MASK FOR DATA[7:0]        | O        | N3           | M2           |
| ddr_dqm1        | DDR WRITE ENABLE / DATA MASK FOR DATA[15:8]       | O        | K3           | J2           |
| ddr_dqs0        | DDR DATA STROBE FOR DATA[7:0]<br>(Differential+)  | I/O      | R1           | P1           |
| ddr_dqs1        | DDR DATA STROBE FOR DATA[15:8]<br>(Differential+) | I/O      | L1           | L1           |
| ddr_dqs0n       | DDR DATA STROBE FOR DATA[7:0]<br>(Differential-)  | I/O      | R2           | P2           |
| ddr_dqs1n       | DDR DATA STROBE FOR DATA[15:8]<br>(Differential-) | I/O      | L2           | L2           |
| ddr_nck         | DDR SDRAM CLOCK OUTPUT (Differential-)            | O        | C1           | D1           |
| ddr_odt         | ODT OUTPUT                                        | O        | G1           | G1           |
| ddr_rasn        | DDR SDRAM ROW ADDRESS STROBE OUTPUT (ACTIVE LOW)  | O        | F2           | G4           |
| ddr_resen       | DDR3/DDR3L RESET OUTPUT (ACTIVE LOW)              | O        | G2           | G2           |
| ddr_vref        | Voltage Reference Input                           | A        | H4           | J4           |
| ddr_vtp         | VTP Compensation Resistor                         | I        | J1           | J3           |
| ddr_wen         | DDR SDRAM WRITE ENABLE OUTPUT (ACTIVE LOW)        | O        | A4           | B2           |

**Table 2-12. External Memory Interfaces/General Purpose Memory Controller Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| gpmc_a0         | GPMC Address    | O        | U1           | R1, R13      |
| gpmc_a1         | GPMC Address    | O        | U2, U7       | R2, U5, V14  |
| gpmc_a10        | GPMC Address    | O        | W5           | T16, V5      |
| gpmc_a11        | GPMC Address    | O        | W7           | R6, V17      |
| gpmc_a12        | GPMC Address    | O        | V4           | U1           |
| gpmc_a13        | GPMC Address    | O        | W4           | U2           |
| gpmc_a14        | GPMC Address    | O        | U5           | U3           |
| gpmc_a15        | GPMC Address    | O        | V5           | U4           |
| gpmc_a16        | GPMC Address    | O        | V6           | R13, V2      |
| gpmc_a17        | GPMC Address    | O        | U6           | V14, V3      |
| gpmc_a18        | GPMC Address    | O        | W6           | U14, V4      |
| gpmc_a19        | GPMC Address    | O        | V7           | T14, T5      |
| gpmc_a2         | GPMC Address    | O        | T7, V1       | R3, R5, U14  |
| gpmc_a20        | GPMC Address    | O        | H19          | F17, R14     |
| gpmc_a21        | GPMC Address    | O        | H18          | F18, V15     |
| gpmc_a22        | GPMC Address    | O        | H17          | G15, U15     |
| gpmc_a23        | GPMC Address    | O        | G18          | G16, T15     |
| gpmc_a24        | GPMC Address    | O        | G19          | G17, V16     |

**Table 2-12. External Memory Interfaces/General Purpose Memory Controller Signals**  
**Description (continued)**

| SIGNAL NAME [1] | DESCRIPTION [2]                           | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-------------------------------------------|----------|--------------|--------------|
| gpmc_a25        | GPMC Address                              | O        | G17          | G18, U16     |
| gpmc_a26        | GPMC Address                              | O        | NA           | T16          |
| gpmc_a27        | GPMC Address                              | O        | NA           | V17          |
| gpmc_a3         | GPMC Address                              | O        | U17, V2      | R4, T13, T14 |
| gpmc_a4         | GPMC Address                              | O        | W2           | R14, T1      |
| gpmc_a5         | GPMC Address                              | O        | W3           | T2, V15      |
| gpmc_a6         | GPMC Address                              | O        | V3           | T3, U15      |
| gpmc_a7         | GPMC Address                              | O        | U3           | T15, T4      |
| gpmc_a8         | GPMC Address                              | O        | U7           | U5, V16      |
| gpmc_a9         | GPMC Address                              | O        | T7           | R5, U16      |
| gpmc_ad0        | GPMC Address and Data                     | I/O      | W10          | U7           |
| gpmc_ad1        | GPMC Address and Data                     | I/O      | V9           | V7           |
| gpmc_ad10       | GPMC Address and Data                     | I/O      | T12          | T11          |
| gpmc_ad11       | GPMC Address and Data                     | I/O      | U12          | U12          |
| gpmc_ad12       | GPMC Address and Data                     | I/O      | U13          | T12          |
| gpmc_ad13       | GPMC Address and Data                     | I/O      | T13          | R12          |
| gpmc_ad14       | GPMC Address and Data                     | I/O      | W17          | V13          |
| gpmc_ad15       | GPMC Address and Data                     | I/O      | V17          | U13          |
| gpmc_ad2        | GPMC Address and Data                     | I/O      | V12          | R8           |
| gpmc_ad3        | GPMC Address and Data                     | I/O      | W13          | T8           |
| gpmc_ad4        | GPMC Address and Data                     | I/O      | V13          | U8           |
| gpmc_ad5        | GPMC Address and Data                     | I/O      | W14          | V8           |
| gpmc_ad6        | GPMC Address and Data                     | I/O      | U14          | R9           |
| gpmc_ad7        | GPMC Address and Data                     | I/O      | W15          | T9           |
| gpmc_ad8        | GPMC Address and Data                     | I/O      | V15          | U10          |
| gpmc_ad9        | GPMC Address and Data                     | I/O      | W16          | T10          |
| gpmc_adv_n_ale  | GPMC Address Valid / Address Latch Enable | O        | V10          | R7           |
| gpmc_be0n_cle   | GPMC Byte Enable 0 / Command Latch Enable | O        | V8           | T6           |
| gpmc_be1n       | GPMC Byte Enable 1                        | O        | U15, V18     | U18, V9      |
| gpmc_clk        | GPMC Clock                                | I/O      | V14, V16     | U9, V12      |
| gpmc_csn0       | GPMC Chip Select                          | O        | W8           | V6           |
| gpmc_csn1       | GPMC Chip Select                          | O        | V14          | U9           |
| gpmc_csn2       | GPMC Chip Select                          | O        | U15          | V9           |
| gpmc_csn3       | GPMC Chip Select                          | O        | U17          | T13          |
| gpmc_csn4       | GPMC Chip Select                          | O        | R15          | T17          |
| gpmc_csn5       | GPMC Chip Select                          | O        | W18          | U17          |
| gpmc_csn6       | GPMC Chip Select                          | O        | V18          | U18          |
| gpmc_dir        | GPMC Data Direction                       | O        | V18          | U18          |
| gpmc_oen_ren    | GPMC Output / Read Enable                 | O        | W9           | T7           |
| gpmc_wait0      | GPMC Wait 0                               | I        | R15          | T17          |
| gpmc_wait1      | GPMC Wait 1                               | I        | V16          | V12          |
| gpmc_wen        | GPMC Write Enable                         | O        | U8           | U6           |
| gpmc_wpn        | GPMC Write Protect                        | O        | W18          | U17          |

### 2.3.2 General Purpose I/Os

**Table 2-13. General Purpose I/Os/GPIO0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| gpio0_0         | GPIO            | I/O      | P17          | M17          |
| gpio0_1         | GPIO            | I/O      | R19          | M18          |
| gpio0_10        | GPIO            | I/O      | W6           | V4           |
| gpio0_11        | GPIO            | I/O      | V7           | T5           |
| gpio0_12        | GPIO            | I/O      | E17          | D18          |
| gpio0_13        | GPIO            | I/O      | D19          | D17          |
| gpio0_14        | GPIO            | I/O      | D18          | D16          |
| gpio0_15        | GPIO            | I/O      | C19          | D15          |
| gpio0_16        | GPIO            | I/O      | M17          | J18          |
| gpio0_17        | GPIO            | I/O      | N18          | K15          |
| gpio0_18        | GPIO            | I/O      | G16          | F16          |
| gpio0_19        | GPIO            | I/O      | C15          | A15          |
| gpio0_2         | GPIO            | I/O      | A18          | A17          |
| gpio0_20        | GPIO            | I/O      | B15          | D14          |
| gpio0_21        | GPIO            | I/O      | M18          | K16          |
| gpio0_22        | GPIO            | I/O      | V15          | U10          |
| gpio0_23        | GPIO            | I/O      | W16          | T10          |
| gpio0_26        | GPIO            | I/O      | T12          | T11          |
| gpio0_27        | GPIO            | I/O      | U12          | U12          |
| gpio0_28        | GPIO            | I/O      | L18          | K17          |
| gpio0_29        | GPIO            | I/O      | K18          | H18          |
| gpio0_3         | GPIO            | I/O      | B18          | B17          |
| gpio0_30        | GPIO            | I/O      | R15          | T17          |
| gpio0_31        | GPIO            | I/O      | W18          | U17          |
| gpio0_4         | GPIO            | I/O      | B17          | B16          |
| gpio0_5         | GPIO            | I/O      | A17          | A16          |
| gpio0_6         | GPIO            | I/O      | B16          | C15          |
| gpio0_7         | GPIO            | I/O      | E18          | C18          |
| gpio0_8         | GPIO            | I/O      | V6           | V2           |
| gpio0_9         | GPIO            | I/O      | U6           | V3           |

**Table 2-14. General Purpose I/Os/GPIO1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| gpio1_0         | GPIO            | I/O      | W10          | U7           |
| gpio1_1         | GPIO            | I/O      | V9           | V7           |
| gpio1_10        | GPIO            | I/O      | E19          | E15          |
| gpio1_11        | GPIO            | I/O      | F17          | E16          |
| gpio1_12        | GPIO            | I/O      | U13          | T12          |
| gpio1_13        | GPIO            | I/O      | T13          | R12          |
| gpio1_14        | GPIO            | I/O      | W17          | V13          |
| gpio1_15        | GPIO            | I/O      | V17          | U13          |
| gpio1_16        | GPIO            | I/O      | NA           | R13          |
| gpio1_17        | GPIO            | I/O      | NA           | V14          |
| gpio1_18        | GPIO            | I/O      | NA           | U14          |

**Table 2-14. General Purpose IOs/GPIO1 Signals Description (continued)**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| gpio1_19        | GPIO            | I/O      | NA           | T14          |
| gpio1_2         | GPIO            | I/O      | V12          | R8           |
| gpio1_20        | GPIO            | I/O      | NA           | R14          |
| gpio1_21        | GPIO            | I/O      | NA           | V15          |
| gpio1_22        | GPIO            | I/O      | NA           | U15          |
| gpio1_23        | GPIO            | I/O      | NA           | T15          |
| gpio1_24        | GPIO            | I/O      | NA           | V16          |
| gpio1_25        | GPIO            | I/O      | NA           | U16          |
| gpio1_26        | GPIO            | I/O      | NA           | T16          |
| gpio1_27        | GPIO            | I/O      | NA           | V17          |
| gpio1_28        | GPIO            | I/O      | V18          | U18          |
| gpio1_29        | GPIO            | I/O      | W8           | V6           |
| gpio1_3         | GPIO            | I/O      | W13          | T8           |
| gpio1_30        | GPIO            | I/O      | V14          | U9           |
| gpio1_31        | GPIO            | I/O      | U15          | V9           |
| gpio1_4         | GPIO            | I/O      | V13          | U8           |
| gpio1_5         | GPIO            | I/O      | W14          | V8           |
| gpio1_6         | GPIO            | I/O      | U14          | R9           |
| gpio1_7         | GPIO            | I/O      | W15          | T9           |
| gpio1_8         | GPIO            | I/O      | F19          | E18          |
| gpio1_9         | GPIO            | I/O      | F18          | E17          |

**Table 2-15. General Purpose IOs/GPIO2 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| gpio2_0         | GPIO            | I/O      | U17          | T13          |
| gpio2_1         | GPIO            | I/O      | V16          | V12          |
| gpio2_10        | GPIO            | I/O      | W2           | T1           |
| gpio2_11        | GPIO            | I/O      | W3           | T2           |
| gpio2_12        | GPIO            | I/O      | V3           | T3           |
| gpio2_13        | GPIO            | I/O      | U3           | T4           |
| gpio2_14        | GPIO            | I/O      | V4           | U1           |
| gpio2_15        | GPIO            | I/O      | W4           | U2           |
| gpio2_16        | GPIO            | I/O      | U5           | U3           |
| gpio2_17        | GPIO            | I/O      | V5           | U4           |
| gpio2_18        | GPIO            | I/O      | N17          | L17          |
| gpio2_19        | GPIO            | I/O      | N16          | L16          |
| gpio2_2         | GPIO            | I/O      | V10          | R7           |
| gpio2_20        | GPIO            | I/O      | P19          | L15          |
| gpio2_21        | GPIO            | I/O      | P18          | M16          |
| gpio2_22        | GPIO            | I/O      | U7           | U5           |
| gpio2_23        | GPIO            | I/O      | T7           | R5           |
| gpio2_24        | GPIO            | I/O      | W5           | V5           |
| gpio2_25        | GPIO            | I/O      | W7           | R6           |
| gpio2_26        | GPIO            | I/O      | H19          | F17          |
| gpio2_27        | GPIO            | I/O      | H18          | F18          |
| gpio2_28        | GPIO            | I/O      | H17          | G15          |

**Table 2-15. General Purpose IOs/GPIO2 Signals Description (continued)**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| gpio2_29        | GPIO            | I/O      | G18          | G16          |
| gpio2_3         | GPIO            | I/O      | W9           | T7           |
| gpio2_30        | GPIO            | I/O      | G19          | G17          |
| gpio2_31        | GPIO            | I/O      | G17          | G18          |
| gpio2_4         | GPIO            | I/O      | U8           | U6           |
| gpio2_5         | GPIO            | I/O      | V8           | T6           |
| gpio2_6         | GPIO            | I/O      | U1           | R1           |
| gpio2_7         | GPIO            | I/O      | U2           | R2           |
| gpio2_8         | GPIO            | I/O      | V1           | R3           |
| gpio2_9         | GPIO            | I/O      | V2           | R4           |

**Table 2-16. General Purpose IOs/GPIO3 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| gpio3_0         | GPIO            | I/O      | J19          | H16          |
| gpio3_1         | GPIO            | I/O      | J18          | H17          |
| gpio3_10        | GPIO            | I/O      | M19          | L18          |
| gpio3_13        | GPIO            | I/O      | NA           | F15          |
| gpio3_14        | GPIO            | I/O      | NA           | A13          |
| gpio3_15        | GPIO            | I/O      | NA           | B13          |
| gpio3_16        | GPIO            | I/O      | NA           | D12          |
| gpio3_17        | GPIO            | I/O      | NA           | C12          |
| gpio3_18        | GPIO            | I/O      | NA           | B12          |
| gpio3_19        | GPIO            | I/O      | NA           | C13          |
| gpio3_2         | GPIO            | I/O      | K19          | J15          |
| gpio3_20        | GPIO            | I/O      | NA           | D13          |
| gpio3_21        | GPIO            | I/O      | NA           | A14          |
| gpio3_3         | GPIO            | I/O      | K17          | J16          |
| gpio3_4         | GPIO            | I/O      | L19          | J17          |
| gpio3_5         | GPIO            | I/O      | C18          | C17          |
| gpio3_6         | GPIO            | I/O      | B19          | C16          |
| gpio3_7         | GPIO            | I/O      | A15          | C14          |
| gpio3_8         | GPIO            | I/O      | D14          | B14          |
| gpio3_9         | GPIO            | I/O      | N19          | K18          |

### 2.3.3 Miscellaneous

**Table 2-17. Miscellaneous/Miscellaneous Signals Description**

| SIGNAL NAME [1]  | DESCRIPTION [2]                                                    | TYPE [3] | ZCE BALL [4]  | ZCZ BALL [4]  |
|------------------|--------------------------------------------------------------------|----------|---------------|---------------|
| clkout1          | Clock out1                                                         | O        | C15           | A15           |
| clkout2          | Clock out2                                                         | O        | B15           | D14           |
| ENZ_KALDO_1P8V   | Active low enable input for internal CAP_VDD_RTC voltage regulator | I        | A7            | B4            |
| EXT_WAKEUP       | EXT_WAKEUP input                                                   | I        | B5            | C5            |
| nNMI             | External Interrupt to ARM Cortex A8 core                           | I        | C17           | B18           |
| nRESETIN_OUT     | Active low Warm Reset                                              | I/OD     | A16           | A10           |
| OSC0_IN          | High frequency oscillator input                                    | I        | W11           | V10           |
| OSC0_OUT         | High frequency oscillator output                                   | O        | W12           | U11           |
| OSC1_IN          | Low frequency (32.768 KHz) Real Time Clock oscillator input        | I        | A6            | A6            |
| OSC1_OUT         | Low frequency (32.768 KHz) Real Time Clock oscillator output       | O        | A5            | A4            |
| PMIC_POWER_EN    | PMIC_POWER_EN output                                               | O        | C7            | C6            |
| porz             | Active low Power on Reset                                          | I        | E15           | B15           |
| RTC_PORz         | Active low RTC reset input                                         | I        | B7            | B5            |
| tcclk            | Timer Clock In                                                     | I        | B15           | D14           |
| xdma_event_intr0 | External DMA Event or Interrupt 0                                  | I        | C15           | A15           |
| xdma_event_intr1 | External DMA Event or Interrupt 1                                  | I        | B15           | D14           |
| xdma_event_intr2 | External DMA Event or Interrupt 2                                  | I        | B16, E18, K18 | C15, C18, H18 |

### 2.3.3.1 eCAP

**Table 2-18. eCAP/eCAP0 Signals Description**

| SIGNAL NAME [1]   | DESCRIPTION [2]                                   | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-------------------|---------------------------------------------------|----------|--------------|--------------|
| eCAP0_in_PWM0_out | Enhanced Capture 0 input or Auxiliary PWM0 output | I/O      | E18          | C18          |

**Table 2-19. eCAP/eCAP1 Signals Description**

| SIGNAL NAME [1]   | DESCRIPTION [2]                                   | TYPE [3] | ZCE BALL [4]  | ZCZ BALL [4]  |
|-------------------|---------------------------------------------------|----------|---------------|---------------|
| eCAP1_in_PWM1_out | Enhanced Capture 1 input or Auxiliary PWM1 output | I/O      | B16, B19, F17 | C15, C16, E16 |

**Table 2-20. eCAP/eCAP2 Signals Description**

| SIGNAL NAME [1]   | DESCRIPTION [2]                                   | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4]  |
|-------------------|---------------------------------------------------|----------|--------------|---------------|
| eCAP2_in_PWM2_out | Enhanced Capture 2 input or Auxiliary PWM2 output | I/O      | C18, E19     | C12, C17, E15 |

## 2.3.3.2 eHRPWM

**Table 2-21. eHRPWM/eHRPWM0 Signals Description**

| SIGNAL NAME [1]        | DESCRIPTION [2]                                    | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4]     |
|------------------------|----------------------------------------------------|----------|--------------|------------------|
| ehrpwm0A               | eHRPWM0 A output.                                  | O        | A18          | A13, A17         |
| ehrpwm0B               | eHRPWM0 B output.                                  | O        | B18          | B13, B17         |
| ehrpwm0_synci          | Sync input to eHRPWM0 module from an external pin  | I        | A17          | A16, C12         |
| ehrpwm0_synco          | Sync Output from eHRPWM0 module to an external pin | O        | U12, V2, W4  | R4, U12, U2, V14 |
| ehrpwm0_tripzone_input | eHRPWM0 trip zone input                            | I        | B17          | B16, D12         |

**Table 2-22. eHRPWM/eHRPWM1 Signals Description**

| SIGNAL NAME [1]        | DESCRIPTION [2]         | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|------------------------|-------------------------|----------|--------------|--------------|
| ehrpwm1A               | eHRPWM1 A output.       | O        | U5           | U14, U3      |
| ehrpwm1B               | eHRPWM1 B output.       | O        | V5           | T14, U4      |
| ehrpwm1_tripzone_input | eHRPWM1 trip zone input | I        | V4           | R13, U1      |

**Table 2-23. eHRPWM/eHRPWM2 Signals Description**

| SIGNAL NAME [1]        | DESCRIPTION [2]         | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|------------------------|-------------------------|----------|--------------|--------------|
| ehrpwm2A               | eHRPWM2 A output.       | O        | U1, V15      | R1, U10      |
| ehrpwm2B               | eHRPWM2 B output.       | O        | U2, W16      | R2, T10      |
| ehrpwm2_tripzone_input | eHRPWM2 trip zone input | I        | T12, V1      | R3, T11      |

### 2.3.3.3 eQEP

**Table 2-24. eQEP/eQEP0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]         | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-------------------------|----------|--------------|--------------|
| eQEP0A_in       | eQEP0A quadrature input | I        | M18          | B12, K16     |
| eQEP0B_in       | eQEP0B quadrature input | I        | L18          | C13, K17     |
| eQEP0_index     | eQEP0 index.            | I/O      | K17          | D13, J16     |
| eQEP0_strobe    | eQEP0 strobe.           | I/O      | P19          | A14, L15     |

**Table 2-25. eQEP/eQEP1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]         | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-------------------------|----------|--------------|--------------|
| eQEP1A_in       | eQEP1A quadrature input | I        | V6           | R14, V2      |
| eQEP1B_in       | eQEP1B quadrature input | I        | U6           | V15, V3      |
| eQEP1_index     | eQEP1 index.            | I/O      | W6           | U15, V4      |
| eQEP1_strobe    | eQEP1 strobe.           | I/O      | V7           | T15, T5      |

**Table 2-26. eQEP/eQEP2 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]         | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-------------------------|----------|--------------|--------------|
| eQEP2A_in       | eQEP2A quadrature input | I        | U13, W2      | T1, T12      |
| eQEP2B_in       | eQEP2B quadrature input | I        | T13, W3      | R12, T2      |
| eQEP2_index     | eQEP2 index.            | I/O      | V3, W17      | T3, V13      |
| eQEP2_strobe    | eQEP2 strobe.           | I/O      | U3, V17      | T4, U13      |

## 2.3.3.4 Timer

**Table 2-27. Timer/Timer4 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]               | TYPE [3] | ZCE BALL [4]       | ZCZ BALL [4]      |
|-----------------|-------------------------------|----------|--------------------|-------------------|
| timer4          | Timer trigger event / PWM out | I/O      | C15, C18, K17, V10 | A15, C17, J16, R7 |

**Table 2-28. Timer/Timer5 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]               | TYPE [3] | ZCE BALL [4]      | ZCZ BALL [4]      |
|-----------------|-------------------------------|----------|-------------------|-------------------|
| timer5          | Timer trigger event / PWM out | I/O      | D19, H19, R19, V8 | D17, F17, M18, T6 |

**Table 2-29. Timer/Timer6 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]               | TYPE [3] | ZCE BALL [4]      | ZCZ BALL [4]      |
|-----------------|-------------------------------|----------|-------------------|-------------------|
| timer6          | Timer trigger event / PWM out | I/O      | E17, H18, P17, U8 | D18, F18, M17, U6 |

**Table 2-30. Timer/Timer7 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]               | TYPE [3] | ZCE BALL [4]      | ZCZ BALL [4]      |
|-----------------|-------------------------------|----------|-------------------|-------------------|
| timer7          | Timer trigger event / PWM out | I/O      | B15, B19, F19, W9 | C16, D14, E18, T7 |

### 2.3.4 PRU-ICSS

**Table 2-31. PRU-ICSS/eCAP Signals Description**

| SIGNAL NAME [1]             | DESCRIPTION [2]                             | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------------------|---------------------------------------------|----------|--------------|--------------|
| pr1_ecap0_ecap_capin_apwm_o | Enhanced capture input or Auxiliary PWM out | I/O      | E18, V17     | C18, U13     |

**Table 2-32. PRU-ICSS/ECAT Signals Description**

| SIGNAL NAME [1]    | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|--------------------|-----------------|----------|--------------|--------------|
| pr1_edc_latch0_in  | Data In         | I        | E17          | D18          |
| pr1_edc_latch1_in  | Data In         | I        | D19          | D17          |
| pr1_edc_sync0_out  | Data Out        | O        | F19          | E18          |
| pr1_edc_sync1_out  | Data Out        | O        | F18          | E17          |
| pr1_edio_data_in0  | Data In         | I        | B17          | B16          |
| pr1_edio_data_in1  | Data In         | I        | A17          | A16          |
| pr1_edio_data_in2  | Data In         | I        | U7           | U5           |
| pr1_edio_data_in3  | Data In         | I        | T7           | R5           |
| pr1_edio_data_in4  | Data In         | I        | W5           | V5           |
| pr1_edio_data_in5  | Data In         | I        | W7           | R6           |
| pr1_edio_data_in6  | Data In         | I        | V14, V3      | T3, U9       |
| pr1_edio_data_in7  | Data In         | I        | U15, U3      | T4, V9       |
| pr1_edio_data_out0 | Data Out        | O        | B17          | B16          |
| pr1_edio_data_out1 | Data Out        | O        | A17          | A16          |
| pr1_edio_data_out2 | Data Out        | O        | U7           | U5           |
| pr1_edio_data_out3 | Data Out        | O        | T7           | R5           |
| pr1_edio_data_out4 | Data Out        | O        | W5           | V5           |
| pr1_edio_data_out5 | Data Out        | O        | W7           | R6           |
| pr1_edio_data_out6 | Data Out        | O        | V14, V3      | T3, U9       |
| pr1_edio_data_out7 | Data Out        | O        | U15, U3      | T4, V9       |
| pr1_edio_latch_in  | Latch In        | I        | B18          | B17          |
| pr1_edio_sof       | Start of Frame  | O        | A18          | A17          |

**Table 2-33. PRU-ICSS/MDIO Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| pr1_mdio_data   | MDIO Data       | I/O      | U17          | T13          |
| pr1_mdio_mdclk  | MDIO Clk        | O        | V16          | V12          |

**Table 2-34. PRU-ICSS/MII0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]        | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|------------------------|----------|--------------|--------------|
| pr1_mii0_col    | MII Collision Detect   | I        | W16          | T10          |
| pr1_mii0_crs    | MII Carrier Sense      | I        | U17, W5      | T13, V5      |
| pr1_mii0_rxd0   | MII Receive Data bit 0 | I        | V5           | U4           |
| pr1_mii0_rxd1   | MII Receive Data bit 1 | I        | U5           | U3           |
| pr1_mii0_rxd2   | MII Receive Data bit 2 | I        | W4           | U2           |
| pr1_mii0_rxd3   | MII Receive Data bit 3 | I        | V4           | U1           |
| pr1_mii0_rxdv   | MII Receive Data Valid | I        | V7           | T5           |
| pr1_mii0_rxer   | MII Receive Data Error | I        | U6           | V3           |

**Table 2-34. PRU-ICSS/MII0 Signals Description (continued)**

| SIGNAL NAME [1] | DESCRIPTION [2]         | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-------------------------|----------|--------------|--------------|
| pr1_mii0_rxlink | MII Receive Link        | I        | V6           | V2           |
| pr1_mii0_txd0   | MII Transmit Data bit 0 | O        | W17, W3      | T2, V13      |
| pr1_mii0_txd1   | MII Transmit Data bit 1 | O        | T13, W2      | R12, T1      |
| pr1_mii0_txd2   | MII Transmit Data bit 2 | O        | U13, V2      | R4, T12      |
| pr1_mii0_txd3   | MII Transmit Data bit 3 | O        | U12, V1      | R3, U12      |
| pr1_mii0_txen   | MII Transmit Enable     | O        | T12, U2      | R2, T11      |
| pr1_mii_mr0_clk | MII Receive Clock       | I        | W6           | V4           |
| pr1_mii_mt0_clk | MII Transmit Clock      | I        | U1, V15      | R1, U10      |

**Table 2-35. PRU-ICSS/MII1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]         | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-------------------------|----------|--------------|--------------|
| pr1_mii1_col    | MII Collision Detect    | I        | R15          | T17          |
| pr1_mii1_crs    | MII Carrier Sense       | I        | V16, W7      | R6, V12      |
| pr1_mii1_rxd0   | MII Receive Data bit 0  | I        | NA           | V16          |
| pr1_mii1_rxd1   | MII Receive Data bit 1  | I        | NA           | T15          |
| pr1_mii1_rxd2   | MII Receive Data bit 2  | I        | NA           | U15          |
| pr1_mii1_rxd3   | MII Receive Data bit 3  | I        | NA           | V15          |
| pr1_mii1_rxdv   | MII Receive Data Valid  | I        | NA           | T16          |
| pr1_mii1_rxer   | MII Receive Data Error  | I        | NA           | V17          |
| pr1_mii1_rxlink | MII Receive Link        | I        | V18          | U18          |
| pr1_mii1_txd0   | MII Transmit Data bit 0 | O        | NA           | R14          |
| pr1_mii1_txd1   | MII Transmit Data bit 1 | O        | NA           | T14          |
| pr1_mii1_txd2   | MII Transmit Data bit 2 | O        | NA           | U14          |
| pr1_mii1_txd3   | MII Transmit Data bit 3 | O        | NA           | V14          |
| pr1_mii1_txen   | MII Transmit Enable     | O        | W18          | U17          |
| pr1_mii_mr1_clk | MII Receive Clock       | I        | NA           | U16          |
| pr1_mii_mt1_clk | MII Transmit Clock      | I        | NA           | R13          |

**Table 2-36. PRU-ICSS/UART0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]      | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|----------------------|----------|--------------|--------------|
| pr1_uart0_cts_n | UART Clear to Send   | I        | A18, E17     | A17, D18     |
| pr1_uart0_rts_n | UART Request to Send | O        | B18, D19     | B17, D17     |
| pr1_uart0_rxd   | UART Receive Data    | I        | B17, D18     | B16, D16     |
| pr1_uart0_txd   | UART Transmit Data   | O        | A17, C19     | A16, D15     |

### 2.3.4.1 PRU0

**Table 2-37. PRU0/General Purpose Inputs Signals Description**

| SIGNAL NAME [1]     | DESCRIPTION [2]             | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|---------------------|-----------------------------|----------|--------------|--------------|
| pr1_pru0_pru_r31_0  | PRU0 Data In                | I        | NA           | A13          |
| pr1_pru0_pru_r31_1  | PRU0 Data In                | I        | NA           | B13          |
| pr1_pru0_pru_r31_10 | PRU0 Data In                | I        | H17          | G15          |
| pr1_pru0_pru_r31_11 | PRU0 Data In                | I        | G18          | G16          |
| pr1_pru0_pru_r31_12 | PRU0 Data In                | I        | G19          | G17          |
| pr1_pru0_pru_r31_13 | PRU0 Data In                | I        | G17          | G18          |
| pr1_pru0_pru_r31_14 | PRU0 Data In                | I        | W17          | V13          |
| pr1_pru0_pru_r31_15 | PRU0 Data In                | I        | V17          | U13          |
| pr1_pru0_pru_r31_16 | PRU0 Data In Capture Enable | I        | B15, C19     | D14, D15     |
| pr1_pru0_pru_r31_2  | PRU0 Data In                | I        | NA           | D12          |
| pr1_pru0_pru_r31_3  | PRU0 Data In                | I        | NA           | C12          |
| pr1_pru0_pru_r31_4  | PRU0 Data In                | I        | NA           | B12          |
| pr1_pru0_pru_r31_5  | PRU0 Data In                | I        | NA           | C13          |
| pr1_pru0_pru_r31_6  | PRU0 Data In                | I        | NA           | D13          |
| pr1_pru0_pru_r31_7  | PRU0 Data In                | I        | NA           | A14          |
| pr1_pru0_pru_r31_8  | PRU0 Data In                | I        | H19          | F17          |
| pr1_pru0_pru_r31_9  | PRU0 Data In                | I        | H18          | F18          |

**Table 2-38. PRU0/General Purpose Outputs Signals Description**

| SIGNAL NAME [1]     | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|---------------------|-----------------|----------|--------------|--------------|
| pr1_pru0_pru_r30_0  | PRU0 Data Out   | O        | NA           | A13          |
| pr1_pru0_pru_r30_1  | PRU0 Data Out   | O        | NA           | B13          |
| pr1_pru0_pru_r30_10 | PRU0 Data Out   | O        | H17          | G15          |
| pr1_pru0_pru_r30_11 | PRU0 Data Out   | O        | G18          | G16          |
| pr1_pru0_pru_r30_12 | PRU0 Data Out   | O        | G19          | G17          |
| pr1_pru0_pru_r30_13 | PRU0 Data Out   | O        | G17          | G18          |
| pr1_pru0_pru_r30_14 | PRU0 Data Out   | O        | U13          | T12          |
| pr1_pru0_pru_r30_15 | PRU0 Data Out   | O        | T13          | R12          |
| pr1_pru0_pru_r30_2  | PRU0 Data Out   | O        | NA           | D12          |
| pr1_pru0_pru_r30_3  | PRU0 Data Out   | O        | NA           | C12          |
| pr1_pru0_pru_r30_4  | PRU0 Data Out   | O        | NA           | B12          |
| pr1_pru0_pru_r30_5  | PRU0 Data Out   | O        | NA           | C13          |
| pr1_pru0_pru_r30_6  | PRU0 Data Out   | O        | NA           | D13          |
| pr1_pru0_pru_r30_7  | PRU0 Data Out   | O        | NA           | A14          |
| pr1_pru0_pru_r30_8  | PRU0 Data Out   | O        | H19          | F17          |
| pr1_pru0_pru_r30_9  | PRU0 Data Out   | O        | H18          | F18          |

## 2.3.4.2 PRU1

**Table 2-39. PRU1/General Purpose Inputs Signals Description**

| SIGNAL NAME [1]     | DESCRIPTION [2]             | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|---------------------|-----------------------------|----------|--------------|--------------|
| pr1_pru1_pru_r31_0  | PRU1 Data In                | I        | U1           | R1           |
| pr1_pru1_pru_r31_1  | PRU1 Data In                | I        | U2           | R2           |
| pr1_pru1_pru_r31_10 | PRU1 Data In                | I        | W5           | V5           |
| pr1_pru1_pru_r31_11 | PRU1 Data In                | I        | W7           | R6           |
| pr1_pru1_pru_r31_12 | PRU1 Data In                | I        | V14          | U9           |
| pr1_pru1_pru_r31_13 | PRU1 Data In                | I        | U15          | V9           |
| pr1_pru1_pru_r31_14 | PRU1 Data In                | I        | E19          | E15          |
| pr1_pru1_pru_r31_15 | PRU1 Data In                | I        | F17          | E16          |
| pr1_pru1_pru_r31_16 | PRU1 Data In Capture Enable | I        | C15, D18     | A15, D16     |
| pr1_pru1_pru_r31_2  | PRU1 Data In                | I        | V1           | R3           |
| pr1_pru1_pru_r31_3  | PRU1 Data In                | I        | V2           | R4           |
| pr1_pru1_pru_r31_4  | PRU1 Data In                | I        | W2           | T1           |
| pr1_pru1_pru_r31_5  | PRU1 Data In                | I        | W3           | T2           |
| pr1_pru1_pru_r31_6  | PRU1 Data In                | I        | V3           | T3           |
| pr1_pru1_pru_r31_7  | PRU1 Data In                | I        | U3           | T4           |
| pr1_pru1_pru_r31_8  | PRU1 Data In                | I        | U7           | U5           |
| pr1_pru1_pru_r31_9  | PRU1 Data In                | I        | T7           | R5           |

**Table 2-40. PRU1/General Purpose Outputs Signals Description**

| SIGNAL NAME [1]     | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|---------------------|-----------------|----------|--------------|--------------|
| pr1_pru1_pru_r30_0  | PRU1 Data Out   | O        | U1           | R1           |
| pr1_pru1_pru_r30_1  | PRU1 Data Out   | O        | U2           | R2           |
| pr1_pru1_pru_r30_10 | PRU1 Data Out   | O        | W5           | V5           |
| pr1_pru1_pru_r30_11 | PRU1 Data Out   | O        | W7           | R6           |
| pr1_pru1_pru_r30_12 | PRU1 Data Out   | O        | V14          | U9           |
| pr1_pru1_pru_r30_13 | PRU1 Data Out   | O        | U15          | V9           |
| pr1_pru1_pru_r30_14 | PRU1 Data Out   | O        | E19          | E15          |
| pr1_pru1_pru_r30_15 | PRU1 Data Out   | O        | F17          | E16          |
| pr1_pru1_pru_r30_2  | PRU1 Data Out   | O        | V1           | R3           |
| pr1_pru1_pru_r30_3  | PRU1 Data Out   | O        | V2           | R4           |
| pr1_pru1_pru_r30_4  | PRU1 Data Out   | O        | W2           | T1           |
| pr1_pru1_pru_r30_5  | PRU1 Data Out   | O        | W3           | T2           |
| pr1_pru1_pru_r30_6  | PRU1 Data Out   | O        | V3           | T3           |
| pr1_pru1_pru_r30_7  | PRU1 Data Out   | O        | U3           | T4           |
| pr1_pru1_pru_r30_8  | PRU1 Data Out   | O        | U7           | U5           |
| pr1_pru1_pru_r30_9  | PRU1 Data Out   | O        | T7           | R5           |

### 2.3.5 Removable Media Interfaces

**Table 2-41. Removable Media Interfaces/MMC0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]             | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4]  |
|-----------------|-----------------------------|----------|--------------|---------------|
| mmc0_clk        | MMC/SD/SDIO Clock           | I/O      | G19          | G17           |
| mmc0_cmd        | MMC/SD/SDIO Command         | I/O      | G17          | G18           |
| mmc0_dat0       | MMC/SD/SDIO Data Bus        | I/O      | G18          | G16           |
| mmc0_dat1       | MMC/SD/SDIO Data Bus        | I/O      | H17          | G15           |
| mmc0_dat2       | MMC/SD/SDIO Data Bus        | I/O      | H18          | F18           |
| mmc0_dat3       | MMC/SD/SDIO Data Bus        | I/O      | H19          | F17           |
| mmc0_dat4       | MMC/SD/SDIO Data Bus        | I/O      | N16          | L16           |
| mmc0_dat5       | MMC/SD/SDIO Data Bus        | I/O      | N17          | L17           |
| mmc0_dat6       | MMC/SD/SDIO Data Bus        | I/O      | M19          | L18           |
| mmc0_dat7       | MMC/SD/SDIO Data Bus        | I/O      | N19          | K18           |
| mmc0_pow        | MMC/SD Power Switch Control | O        | B16, K18     | C15, H18      |
| mmc0_sdcd       | SD Card Detect              | I        | B16, P17     | A13, C15, M17 |
| mmc0_sdwp       | SD Write Protect            | I        | E18, R19     | B12, C18, M18 |

**Table 2-42. Removable Media Interfaces/MMC1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]      | TYPE [3] | ZCE BALL [4]  | ZCZ BALL [4] |
|-----------------|----------------------|----------|---------------|--------------|
| mmc1_clk        | MMC/SD/SDIO Clock    | I/O      | L18, R19, V14 | K17, M18, U9 |
| mmc1_cmd        | MMC/SD/SDIO Command  | I/O      | M18, P17, U15 | K16, M17, V9 |
| mmc1_dat0       | MMC/SD/SDIO Data Bus | I/O      | N19, V15, W10 | K18, U10, U7 |
| mmc1_dat1       | MMC/SD/SDIO Data Bus | I/O      | M19, V9, W16  | L18, T10, V7 |
| mmc1_dat2       | MMC/SD/SDIO Data Bus | I/O      | N17, T12, V12 | L17, R8, T11 |
| mmc1_dat3       | MMC/SD/SDIO Data Bus | I/O      | N16, U12, W13 | L16, T8, U12 |
| mmc1_dat4       | MMC/SD/SDIO Data Bus | I/O      | U13, V13      | T12, U8      |
| mmc1_dat5       | MMC/SD/SDIO Data Bus | I/O      | T13, W14      | R12, V8      |
| mmc1_dat6       | MMC/SD/SDIO Data Bus | I/O      | U14, W17      | R9, V13      |
| mmc1_dat7       | MMC/SD/SDIO Data Bus | I/O      | V17, W15      | T9, U13      |
| mmc1_sdcd       | SD Card Detect       | I        | R15           | B13, T17     |
| mmc1_sdwp       | SD Write Protect     | I        | B17, D18      | B16, D16     |

**Table 2-43. Removable Media Interfaces/MMC2 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]      | TYPE [3] | ZCE BALL [4]  | ZCZ BALL [4]  |
|-----------------|----------------------|----------|---------------|---------------|
| mmc2_clk        | MMC/SD/SDIO Clock    | I/O      | P19, R19, V16 | L15, M18, V12 |
| mmc2_cmd        | MMC/SD/SDIO Command  | I/O      | K17, P17, U17 | J16, M17, T13 |
| mmc2_dat0       | MMC/SD/SDIO Data Bus | I/O      | L19, U13      | J17, T12, V14 |
| mmc2_dat1       | MMC/SD/SDIO Data Bus | I/O      | M17, T13      | J18, R12, U14 |
| mmc2_dat2       | MMC/SD/SDIO Data Bus | I/O      | N18, W17      | K15, T14, V13 |
| mmc2_dat3       | MMC/SD/SDIO Data Bus | I/O      | J19, V17, V18 | H16, U13, U18 |
| mmc2_dat4       | MMC/SD/SDIO Data Bus | I/O      | V15           | U10, U15      |
| mmc2_dat5       | MMC/SD/SDIO Data Bus | I/O      | W16           | T10, T15      |
| mmc2_dat6       | MMC/SD/SDIO Data Bus | I/O      | T12           | T11, V16      |
| mmc2_dat7       | MMC/SD/SDIO Data Bus | I/O      | U12           | U12           |
| mmc2_sdcd       | SD Card Detect       | I        | W18           | D12, U17      |
| mmc2_sdwp       | SD Write Protect     | I        | A17, C19      | A16, D15      |

## 2.3.6 Serial Communication Interfaces

### 2.3.6.1 CAN

**Table 2-44. CAN/DCAN0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]     | TYPE [3] | ZCE BALL [4]  | ZCZ BALL [4]  |
|-----------------|---------------------|----------|---------------|---------------|
| dcan0_rx        | DCAN0 Receive Data  | I        | D19, F17, N18 | D17, E16, K15 |
| dcan0_tx        | DCAN0 Transmit Data | O        | E17, E19, M17 | D18, E15, J18 |

**Table 2-45. CAN/DCAN1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]     | TYPE [3] | ZCE BALL [4]  | ZCZ BALL [4]  |
|-----------------|---------------------|----------|---------------|---------------|
| dcan1_rx        | DCAN1 Receive Data  | I        | C19, F18, G17 | D15, E17, G18 |
| dcan1_tx        | DCAN1 Transmit Data | O        | D18, F19, G19 | D16, E18, G17 |

### 2.3.6.2 GEMAC\_CPSW

**Table 2-46. GEMAC\_CPSW/MDIO Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| mdio_clk        | MDIO Clk        | O        | R19          | M18          |
| mdio_data       | MDIO Data       | I/O      | P17          | M17          |

**Table 2-47. GEMAC\_CPSW/MII1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]         | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-------------------------|----------|--------------|--------------|
| gmii1_col       | MII Collision           | I        | J19          | H16          |
| gmii1_crs       | MII Carrier Sense       | I        | J18          | H17          |
| gmii1_rxclk     | MII Receive Clock       | I        | M19          | L18          |
| gmii1_rxd0      | MII Receive Data bit 0  | I        | P18          | M16          |
| gmii1_rxd1      | MII Receive Data bit 1  | I        | P19          | L15          |
| gmii1_rxd2      | MII Receive Data bit 2  | I        | N16          | L16          |
| gmii1_rxd3      | MII Receive Data bit 3  | I        | N17          | L17          |
| gmii1_rxdv      | MII Receive Data Valid  | I        | L19          | J17          |
| gmii1_rxer      | MII Receive Data Error  | I        | K19          | J15          |
| gmii1_txclk     | MII Transmit Clock      | I        | N19          | K18          |
| gmii1_txd0      | MII Transmit Data bit 0 | O        | L18          | K17          |
| gmii1_txd1      | MII Transmit Data bit 1 | O        | M18          | K16          |
| gmii1_txd2      | MII Transmit Data bit 2 | O        | N18          | K15          |
| gmii1_txd3      | MII Transmit Data bit 3 | O        | M17          | J18          |
| gmii1_txen      | MII Transmit Enable     | O        | K17          | J16          |

**Table 2-48. GEMAC\_CPSW/MII2 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]         | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-------------------------|----------|--------------|--------------|
| gmii2_col       | MII Collision           | I        | V18          | U18          |
| gmii2_crs       | MII Carrier Sense       | I        | R15          | T17          |
| gmii2_rxclk     | MII Receive Clock       | I        | NA           | T15          |
| gmii2_rxd0      | MII Receive Data bit 0  | I        | NA           | V17          |
| gmii2_rxd1      | MII Receive Data bit 1  | I        | NA           | T16          |
| gmii2_rxd2      | MII Receive Data bit 2  | I        | NA           | U16          |
| gmii2_rxd3      | MII Receive Data bit 3  | I        | NA           | V16          |
| gmii2_rxdv      | MII Receive Data Valid  | I        | NA           | V14          |
| gmii2_rxer      | MII Receive Data Error  | I        | W18          | U17          |
| gmii2_txclk     | MII Transmit Clock      | I        | NA           | U15          |
| gmii2_txd0      | MII Transmit Data bit 0 | O        | NA           | V15          |
| gmii2_txd1      | MII Transmit Data bit 1 | O        | NA           | R14          |
| gmii2_txd2      | MII Transmit Data bit 2 | O        | NA           | T14          |
| gmii2_txd3      | MII Transmit Data bit 3 | O        | NA           | U14          |
| gmii2_txen      | MII Transmit Enable     | O        | NA           | R13          |

**Table 2-49. GEMAC\_CPSW/RGMII1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]     | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|---------------------|----------|--------------|--------------|
| rgmii1_rclk     | RGMII Receive Clock | I        | M19          | L18          |

**Table 2-49. GEMAC\_CPSW/RGMII1 Signals Description (continued)**

| SIGNAL NAME [1] | DESCRIPTION [2]           | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|---------------------------|----------|--------------|--------------|
| rgmii1_rctl     | RGMII Receive Control     | I        | L19          | J17          |
| rgmii1_rd0      | RGMII Receive Data bit 0  | I        | P18          | M16          |
| rgmii1_rd1      | RGMII Receive Data bit 1  | I        | P19          | L15          |
| rgmii1_rd2      | RGMII Receive Data bit 2  | I        | N16          | L16          |
| rgmii1_rd3      | RGMII Receive Data bit 3  | I        | N17          | L17          |
| rgmii1_tclk     | RGMII Transmit Clock      | O        | N19          | K18          |
| rgmii1_tctl     | RGMII Transmit Control    | O        | K17          | J16          |
| rgmii1_td0      | RGMII Transmit Data bit 0 | O        | L18          | K17          |
| rgmii1_td1      | RGMII Transmit Data bit 1 | O        | M18          | K16          |
| rgmii1_td2      | RGMII Transmit Data bit 2 | O        | N18          | K15          |
| rgmii1_td3      | RGMII Transmit Data bit 3 | O        | M17          | J18          |

**Table 2-50. GEMAC\_CPSW/RGMII2 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]           | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|---------------------------|----------|--------------|--------------|
| rgmii2_rclk     | RGMII Receive Clock       | I        | NA           | T15          |
| rgmii2_rctl     | RGMII Receive Control     | I        | NA           | V14          |
| rgmii2_rd0      | RGMII Receive Data bit 0  | I        | NA           | V17          |
| rgmii2_rd1      | RGMII Receive Data bit 1  | I        | NA           | T16          |
| rgmii2_rd2      | RGMII Receive Data bit 2  | I        | NA           | U16          |
| rgmii2_rd3      | RGMII Receive Data bit 3  | I        | NA           | V16          |
| rgmii2_tclk     | RGMII Transmit Clock      | O        | NA           | U15          |
| rgmii2_tctl     | RGMII Transmit Control    | O        | NA           | R13          |
| rgmii2_td0      | RGMII Transmit Data bit 0 | O        | NA           | V15          |
| rgmii2_td1      | RGMII Transmit Data bit 1 | O        | NA           | R14          |
| rgmii2_td2      | RGMII Transmit Data bit 2 | O        | NA           | T14          |
| rgmii2_td3      | RGMII Transmit Data bit 3 | O        | NA           | U14          |

**Table 2-51. GEMAC\_CPSW/RMII1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]                 | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|---------------------------------|----------|--------------|--------------|
| rmii1_crs_dv    | RMII Carrier Sense / Data Valid | I        | J18          | H17          |
| rmii1_refclk    | RMII Reference Clock            | I/O      | K18          | H18          |
| rmii1_rxd0      | RMII Receive Data bit 0         | I        | P18          | M16          |
| rmii1_rxd1      | RMII Receive Data bit 1         | I        | P19          | L15          |
| rmii1_rxer      | RMII Receive Data Error         | I        | K19          | J15          |
| rmii1_txd0      | RMII Transmit Data bit 0        | O        | L18          | K17          |
| rmii1_txd1      | RMII Transmit Data bit 1        | O        | M18          | K16          |
| rmii1_txen      | RMII Transmit Enable            | O        | K17          | J16          |

**Table 2-52. GEMAC\_CPSW/RMII2 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]                 | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|---------------------------------|----------|--------------|--------------|
| rmii2_crs_dv    | RMII Carrier Sense / Data Valid | I        | R15, U17     | T13, T17     |
| rmii2_refclk    | RMII Reference Clock            | I/O      | J19          | H16          |
| rmii2_rxd0      | RMII Receive Data bit 0         | I        | NA           | V17          |
| rmii2_rxd1      | RMII Receive Data bit 1         | I        | NA           | T16          |

**Table 2-52. GEMAC\_CPSW/RMII2 Signals Description (continued)**

| <b>SIGNAL NAME [1]</b> | <b>DESCRIPTION [2]</b>   | <b>TYPE [3]</b> | <b>ZCE BALL [4]</b> | <b>ZCZ BALL [4]</b> |
|------------------------|--------------------------|-----------------|---------------------|---------------------|
| rmii2_rxer             | RMII Receive Data Error  | I               | W18                 | U17                 |
| rmii2_txd0             | RMII Transmit Data bit 0 | O               | NA                  | V15                 |
| rmii2_txd1             | RMII Transmit Data bit 1 | O               | NA                  | R14                 |
| rmii2_txen             | RMII Transmit Enable     | O               | NA                  | R13                 |

### 2.3.6.3 I2C

**Table 2-53. I2C/I2C0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| I2C0_SCL        | I2C0 Clock      | I/OD     | B19          | C16          |
| I2C0_SDA        | I2C0 Data       | I/OD     | C18          | C17          |

**Table 2-54. I2C/I2C1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4]       | ZCZ BALL [4]       |
|-----------------|-----------------|----------|--------------------|--------------------|
| I2C1_SCL        | I2C1 Clock      | I/OD     | A17, C19, F18, K19 | A16, D15, E17, J15 |
| I2C1_SDA        | I2C1 Data       | I/OD     | B17, D18, F19, J18 | B16, D16, E18, H17 |

**Table 2-55. I2C/I2C2 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4]  | ZCZ BALL [4]  |
|-----------------|-----------------|----------|---------------|---------------|
| I2C2_SCL        | I2C2 Clock      | I/OD     | B18, D19, F17 | B17, D17, E16 |
| I2C2_SDA        | I2C2 Data       | I/OD     | A18, E17, E19 | A17, D18, E15 |

### 2.3.6.4 McASP

**Table 2-56. McASP/MCASP0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]              | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4]          |
|-----------------|------------------------------|----------|--------------|-----------------------|
| mcasp0_aclkr    | McASP0 Receive Bit Clock     | I/O      | L19, V18, V6 | B12, J17, U18, V2     |
| mcasp0_aclkx    | McASP0 Transmit Bit Clock    | I/O      | N19, V4      | A13, K18, U1, V16     |
| mcasp0_ahclkr   | McASP0 Receive Master Clock  | I/O      | V5           | C12, U4               |
| mcasp0_ahclkx   | McASP0 Transmit Master Clock | I/O      | N18, V7      | A14, K15, T5          |
| mcasp0_axr0     | McASP0 Serial Data (IN/OUT)  | I/O      | N17, U5      | D12, L17, T16, U3     |
| mcasp0_axr1     | McASP0 Serial Data (IN/OUT)  | I/O      | N16, W6      | D13, L16, V17, V4     |
| mcasp0_axr2     | McASP0 Serial Data (IN/OUT)  | I/O      | J19, V5, V6  | B12, C12, H16, U4, V2 |
| mcasp0_axr3     | McASP0 Serial Data (IN/OUT)  | I/O      | P18, U6, V7  | A14, C13, M16, T5, V3 |
| mcasp0_fsr      | McASP0 Receive Frame Sync    | I/O      | M17, U6, V16 | C13, J18, V12, V3     |
| mcasp0_fsx      | McASP0 Transmit Frame Sync   | I/O      | M19, W4      | B13, L18, U16, U2     |

**Table 2-57. McASP/MCASP1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]              | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4]  |
|-----------------|------------------------------|----------|--------------|---------------|
| mcasp1_aclkr    | McASP1 Receive Bit Clock     | I/O      | L18, P18     | K17, M16      |
| mcasp1_aclkx    | McASP1 Transmit Bit Clock    | I/O      | J18, L19     | B12, H17, J17 |
| mcasp1_ahclkr   | McASP1 Receive Master Clock  | I/O      | P18          | M16           |
| mcasp1_ahclkx   | McASP1 Transmit Master Clock | I/O      | K18, P18     | H18, M16      |
| mcasp1_axr0     | McASP1 Serial Data (IN/OUT)  | I/O      | K17, N18     | D13, J16, K15 |
| mcasp1_axr1     | McASP1 Serial Data (IN/OUT)  | I/O      | M18          | A14, K16      |
| mcasp1_axr2     | McASP1 Serial Data (IN/OUT)  | I/O      | J19, L18     | H16, K17      |
| mcasp1_axr3     | McASP1 Serial Data (IN/OUT)  | I/O      | K18, P19     | H18, L15      |
| mcasp1_fsr      | McASP1 Receive Frame Sync    | I/O      | M18, P19     | K16, L15      |
| mcasp1_fsx      | McASP1 Transmit Frame Sync   | I/O      | K19, M17     | C13, J15, J18 |

## 2.3.6.5 SPI

**Table 2-58. SPI/SPI0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|-----------------|----------|--------------|--------------|
| spi0_cs0        | SPI Chip Select | I/O      | A17          | A16          |
| spi0_cs1        | SPI Chip Select | I/O      | B16          | C15          |
| spi0_d0         | SPI Data        | I/O      | B18          | B17          |
| spi0_d1         | SPI Data        | I/O      | B17          | B16          |
| spi0_sclk       | SPI Clock       | I/O      | A18          | A17          |

**Table 2-59. SPI/SPI1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2] | TYPE [3] | ZCE BALL [4]       | ZCZ BALL [4]            |
|-----------------|-----------------|----------|--------------------|-------------------------|
| spi1_cs0        | SPI Chip Select | I/O      | E17, E19, F18, K18 | C12, D18, E15, E17, H18 |
| spi1_cs1        | SPI Chip Select | I/O      | C15, D19, E18, F17 | A15, C18, D17, E16      |
| spi1_d0         | SPI Data        | I/O      | F19, J18           | B13, E18, H17           |
| spi1_d1         | SPI Data        | I/O      | F18, K19           | D12, E17, J15           |
| spi1_sclk       | SPI Clock       | I/O      | E18, J19           | A13, C18, H16           |

## 2.3.6.6 UART

**Table 2-60. UART/UART0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]      | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|----------------------|----------|--------------|--------------|
| uart0_ctsn      | UART Clear to Send   | I        | F19          | E18          |
| uart0_rtsn      | UART Request to Send | O        | F18          | E17          |
| uart0_rxd       | UART Receive Data    | I        | E19          | E15          |
| uart0_txd       | UART Transmit Data   | O        | F17          | E16          |

**Table 2-61. UART/UART1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]          | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|--------------------------|----------|--------------|--------------|
| uart1_ctsn      | UART Clear to Send       | I        | E17          | D18          |
| uart1_dcdn      | UART Data Carrier Detect | I        | H19, N19     | F17, K18     |
| uart1_dsrn      | UART Data Set Ready      | I        | H18, M19     | F18, L18     |
| uart1_dtrn      | UART Data Terminal Ready | O        | H17, N17     | G15, L17     |
| uart1_rin       | UART Ring Indicator      | I        | G18, N16     | G16, L16     |
| uart1_rtsn      | UART Request to Send     | O        | D19          | D17          |
| uart1_rxd       | UART Receive Data        | I        | D18          | D16          |
| uart1_txd       | UART Transmit Data       | O        | C19          | D15          |

**Table 2-62. UART/UART2 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]      | TYPE [3] | ZCE BALL [4]       | ZCZ BALL [4]       |
|-----------------|----------------------|----------|--------------------|--------------------|
| uart2_ctsn      | UART Clear to Send   | I        | C18, V4            | C17, U1            |
| uart2_rtsn      | UART Request to Send | O        | B19, W4            | C16, U2            |
| uart2_rxd       | UART Receive Data    | I        | A18, G19, J18, N19 | A17, G17, H17, K18 |
| uart2_txd       | UART Transmit Data   | O        | B18, G17, K19, M19 | B17, G18, J15, L18 |

**Table 2-63. UART/UART3 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]      | TYPE [3] | ZCE BALL [4]  | ZCZ BALL [4]  |
|-----------------|----------------------|----------|---------------|---------------|
| uart3_ctsn      | UART Clear to Send   | I        | G19, P17, U5  | G17, M17, U3  |
| uart3_rtsn      | UART Request to Send | O        | G17, R19, V5  | G18, M18, U4  |
| uart3_rxd       | UART Receive Data    | I        | B16, H17, N17 | C15, G15, L17 |
| uart3_txd       | UART Transmit Data   | O        | E18, G18, N16 | C18, G16, L16 |

**Table 2-64. UART/UART4 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]      | TYPE [3] | ZCE BALL [4]  | ZCZ BALL [4]  |
|-----------------|----------------------|----------|---------------|---------------|
| uart4_ctsn      | UART Clear to Send   | I        | H19, V6       | F17, V2       |
| uart4_rtsn      | UART Request to Send | O        | H18, U6       | F18, V3       |
| uart4_rxd       | UART Receive Data    | I        | F19, M17, R15 | E18, J18, T17 |
| uart4_txd       | UART Transmit Data   | O        | F18, N18, W18 | E17, K15, U17 |

**Table 2-65. UART/UART5 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]      | TYPE [3] | ZCE BALL [4]      | ZCZ BALL [4]      |
|-----------------|----------------------|----------|-------------------|-------------------|
| uart5_ctsn      | UART Clear to Send   | I        | H17, J18, W6      | G15, H17, V4      |
| uart5_rtsn      | UART Request to Send | O        | G18, K19, V7      | G16, J15, T5      |
| uart5_rxd       | UART Receive Data    | I        | J19, P17, W4, W6  | H16, M17, U2, V4  |
| uart5_txd       | UART Transmit Data   | O        | K18, L19, R19, V4 | H18, J17, M18, U1 |

### 2.3.6.7 USB

**Table 2-66. USB/USB0 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]                        | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|----------------------------------------|----------|--------------|--------------|
| USB0_CE         | USB0 Active high Charger Enable output | A        | T18          | M15          |
| USB0_DM         | USB0 Data minus                        | A        | U18          | N18          |
| USB0_DP         | USB0 Data plus                         | A        | U19          | N17          |
| USB0_DRVVBUS    | USB0 Active high VBUS control output   | O        | G16          | F16          |
| USB0_ID         | USB0 OTG ID (Micro-A or Micro-B Plug)  | A        | V19          | P16          |
| USB0_VBUS       | USB0 VBUS                              | A        | T19          | P15          |

**Table 2-67. USB/USB1 Signals Description**

| SIGNAL NAME [1] | DESCRIPTION [2]                        | TYPE [3] | ZCE BALL [4] | ZCZ BALL [4] |
|-----------------|----------------------------------------|----------|--------------|--------------|
| USB1_CE         | USB1 Active high Charger Enable output | A        | NA           | P18          |
| USB1_DM         | USB1 Data minus                        | A        | NA           | R18          |
| USB1_DP         | USB1 Data plus                         | A        | NA           | R17          |
| USB1_DRVVBUS    | USB1 Active high VBUS control output   | O        | NA           | F15          |
| USB1_ID         | USB1 OTG ID (Micro-A or Micro-B Plug)  | A        | NA           | P17          |
| USB1_VBUS       | USB1 VBUS                              | A        | NA           | T18          |

### 3 Device Operating Conditions

#### 3.1 Absolute Maximum Ratings

**Table 3-1. Absolute Maximum Ratings Over Junction Temperature Range (Unless Otherwise Noted)<sup>(1)(2)</sup>**

| PARAMETER                                                       |                                                                  | MIN                                                                   | MAX  | UNIT |
|-----------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------------|------|------|
| VDD_MPU <sup>(3)</sup>                                          | Supply voltage for the MPU core domain                           | -0.5                                                                  | 1.5  | V    |
| VDD_CORE                                                        | Supply voltage range for the core domain                         | -0.5                                                                  | 1.5  | V    |
| CAP_VDD_RTC <sup>(4)</sup>                                      | Supply voltage range for the RTC core domain                     | -0.5                                                                  | 1.5  | V    |
| VPP <sup>(5)</sup>                                              | Supply voltage range for the FUSE ROM domain                     | -0.5                                                                  | 2.2  | V    |
| VDDS_RTC                                                        | Supply voltage range for the RTC domain                          | -0.5                                                                  | 2.1  | V    |
| VDDS_OSC                                                        | Supply voltage range for the System oscillator                   | -0.5                                                                  | 2.1  | V    |
| VDDS_SRAM_CORE_BG                                               | Supply voltage range for the Core SRAM LDOs                      | -0.5                                                                  | 2.1  | V    |
| VDDS_SRAM_MPU_BB                                                | Supply voltage range for the MPU SRAM LDOs                       | -0.5                                                                  | 2.1  | V    |
| VDDS_PLL_DDR                                                    | Supply voltage range for the DPLL DDR                            | -0.5                                                                  | 2.1  | V    |
| VDDS_PLL_CORE_LCD                                               | Supply voltage range for the DPLL Core and LCD                   | -0.5                                                                  | 2.1  | V    |
| VDDS_PLL_MPU                                                    | Supply voltage range for the DPLL MPU                            | -0.5                                                                  | 2.1  | V    |
| VDDS_DDR                                                        | Supply voltage range for the DDR IO domain                       | -0.5                                                                  | 2.1  | V    |
| VDDS                                                            | Supply voltage range for all dual-voltage IO domains             | -0.5                                                                  | 2.1  | V    |
| VDDA1P8V_USB0                                                   | Supply voltage range for USBPHY                                  | -0.5                                                                  | 2.1  | V    |
| VDDA1P8V_USB1 <sup>(6)</sup>                                    | Supply voltage range for USBPHY                                  | -0.5                                                                  | 2.1  | V    |
| VDDA_ADC                                                        | Supply voltage range for ADC                                     | -0.5                                                                  | 2.1  | V    |
| VDDSHV1                                                         | Supply voltage range for the dual-voltage IO domain              | -0.5                                                                  | 3.8  | V    |
| VDDSHV2 <sup>(6)</sup>                                          | Supply voltage range for the dual-voltage IO domain              | -0.5                                                                  | 3.8  | V    |
| VDDSHV3 <sup>(6)</sup>                                          | Supply voltage range for the dual-voltage IO domain              | -0.5                                                                  | 3.8  | V    |
| VDDSHV4                                                         | Supply voltage range for the dual-voltage IO domain              | -0.5                                                                  | 3.8  | V    |
| VDDSHV5                                                         | Supply voltage range for the dual-voltage IO domain              | -0.5                                                                  | 3.8  | V    |
| VDDSHV6                                                         | Supply voltage range for the dual-voltage IO domain              | -0.5                                                                  | 3.8  | V    |
| VDDA3P3V_USB0                                                   | Supply voltage range for USBPHY                                  | -0.5                                                                  | 4    | V    |
| VDDA3P3V_USB1 <sup>(6)</sup>                                    | Supply voltage range for USBPHY                                  | -0.5                                                                  | 4    | V    |
| USB0_VBUS <sup>(7)</sup>                                        | Supply voltage range for USB VBUS comparator input               | -0.5                                                                  | 5.25 | V    |
| USB1_VBUS <sup>(6)(7)</sup>                                     | Supply voltage range for USB VBUS comparator input               | -0.5                                                                  | 5.25 | V    |
| DDR_VREF                                                        | Supply voltage range for the DDR SSTL and HSTL reference voltage | -0.3                                                                  | 1.1  | V    |
| Steady State Max. Voltage at all IO pins <sup>(8)</sup>         |                                                                  | -0.5V to IO supply voltage + 0.3 V                                    |      |      |
| USB0_ID <sup>(9)</sup>                                          | Steady state maximum voltage range for the USB ID input          | -0.5                                                                  | 2.1  | V    |
| USB1_ID <sup>(6)(9)</sup>                                       | Steady state maximum voltage range for the USB ID input          | -0.5                                                                  | 2.1  | V    |
| Transient Overshoot and Undershoot specification at IO terminal |                                                                  | 25% of corresponding IO supply voltage for up to 30% of signal period |      |      |
| Storage temperature range, T <sub>stg</sub> <sup>(10)</sup>     |                                                                  | -55                                                                   | 155  | °C   |
| Electrostatic Discharge (ESD) Performance                       | ESD-HBM (Human Body Model) <sup>(11)</sup>                       | ±2000                                                                 |      | V    |
|                                                                 | ESD-CDM (Charged-Device Model) <sup>(12)</sup>                   | ±500                                                                  |      |      |
| Latch-up Performance <sup>(13)</sup>                            | Class II (105°C)                                                 | 45                                                                    |      | mA   |

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) All voltage values are with respect to their associated VSS or VSSA\_x.

(3) Not available on the ZCE package. VDD\_MPU is merged with VDD\_CORE on the ZCE package.

(4) This supply is sourced from an internal LDO when RTC\_KALDO\_ENn is low. If RTC\_KALDO\_ENn is high, this supply must be sourced

from an external power supply.

- (5) During functional operation, this pin is a no connect.
- (6) Not available on the ZCE package.
- (7) This terminal is connected to a fail-safe IO and does not have a dependence on any IO supply voltage.
- (8) This parameter applies to all IO terminals which are not fail-safe and the requirement applies to all values of IO supply voltage. For example, if the voltage applied to a specific IO supply is 0 volts the valid input voltage range for any IO powered by that supply will be -0.5 to +0.3 volts. Special attention should be applied anytime peripheral devices are not powered from the same power sources used to power the respective IO supply. It is important the attached peripheral never sources a voltage outside the valid input voltage range, including power supply ramp-up and ramp-down sequences.
- (9) This terminal is connected to analog circuits in the respective USB PHY. The circuit sources a known current while measuring the voltage to determine if the terminal is connected to VSSA\_USB with a resistance less than 10  $\Omega$  or greater than 100 k $\Omega$ . The terminal should be connected to ground for USB host operation or open-circuit for USB peripheral operation, and should never be connected to any external voltage source.
- (10) For tape and reel the storage temperature range is [-10°C; +50°C] with a maximum relative humidity of 70%. It is recommended returning to ambient room temperature before usage.
- (11) Based on JEDEC JESD22-A114E [*Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)*].
- (12) Based on JEDEC JESD22-C101C [*Field-Induced Charged-Device Model Test Method for Electrostatic-Discharge-Withstand Thresholds of Microelectronic Components*].
- (13) Based on JEDEC JESD78D [*IC Latch-Up Test*].

Fail-safe IO terminals are designed such they do not have dependencies on the respective IO power supply voltage. This allows external voltage sources to be connected to these IO terminals when the respective IO power supplies are turned off. The USB0\_VBUS and USB1\_VBUS are the only fail-safe IO terminals. All other IO terminals are not fail-safe and the voltage applied to them should be limited to the value defined by the **Steady State Max. Voltage at all IO pins** parameter in [Table 3-1](#).

## 3.2 Recommended Operating Conditions

Device Operating Performance Points are defined in [Table 3-2](#) through [Table 3-9](#).

**Table 3-2. VDD\_CORE Operating Performance Points for ZCZ Package with Device Revision Code "Blank"<sup>(1)</sup>**

| VDD_CORE<br>OPP<br>Device Rev.<br>"Blank" | VDD_CORE |         |         | DDR3,<br>DDR3L <sup>(2)</sup> | DDR2 <sup>(2)</sup> | mDDR <sup>(2)</sup> | L3 and L4              |
|-------------------------------------------|----------|---------|---------|-------------------------------|---------------------|---------------------|------------------------|
|                                           | MIN      | NOM     | MAX     |                               |                     |                     |                        |
| OPP100                                    | 1.056 V  | 1.100 V | 1.144 V | 400 MHz                       | 266 MHz             | 200 MHz             | 200 MHz and<br>100 MHz |
| OPP50                                     | 0.912 V  | 0.950 V | 0.988 V | -                             | 125 MHz             | 90 MHz              | 100 MHz and<br>50 MHz  |

(1) Frequencies in this table indicate maximum performance for a given OPP condition.

(2) This parameter represents the maximum memory clock frequency. Since data is transferred on both edges of the clock, double-data rate (DDR), the maximum data rate is two times the maximum memory clock frequency defined in this table.

**Table 3-3. VDD\_MPU Operating Performance Points for ZCZ Package with Device Revision Code "Blank"<sup>(1)</sup>**

| VDD_MPU OPP<br>Device Rev. "Blank" | VDD_MPU |         |         | ARM (A8) |
|------------------------------------|---------|---------|---------|----------|
|                                    | MIN     | NOM     | MAX     |          |
| Turbo                              | 1.210 V | 1.260 V | 1.326 V | 720 MHz  |
| OPP120                             | 1.152 V | 1.200 V | 1.248 V | 600 MHz  |
| OPP100 <sup>(2)</sup>              | 1.056 V | 1.100 V | 1.144 V | 500 MHz  |
| OPP100 <sup>(3)</sup>              | 1.056 V | 1.100 V | 1.144 V | 275 MHz  |

(1) Frequencies in this table indicate maximum performance for a given OPP condition.

(2) Applies to all orderable AM335\_ZCZ\_50 (500-MHz speed grade) or higher devices.

(3) Applies to all orderable AM335\_ZCZ\_27 (275-MHz speed grade) devices.

**Table 3-4. Valid Combinations of VDD\_CORE and VDD\_MPU Operating Performance Points for ZCZ Package with Device Revision Code "Blank"**

| VDD_CORE | VDD_MPU |
|----------|---------|
| OPP50    | OPP100  |
| OPP100   | OPP100  |
| OPP100   | OPP120  |
| OPP100   | Turbo   |

**Table 3-5. VDD\_CORE Operating Performance Points for ZCE Package  
with Device Revision Code "Blank"<sup>(1)</sup>**

| VDD_CORE<br>OPP<br>Device Rev.<br>"Blank" | VDD_MPU <sup>(2)</sup> |         |         | ARM (A8) | DDR3,<br>DDR3L <sup>(3)</sup> | DDR2 <sup>(3)</sup> | mDDR <sup>(3)</sup> | L3 and L4              |
|-------------------------------------------|------------------------|---------|---------|----------|-------------------------------|---------------------|---------------------|------------------------|
|                                           | MIN                    | NOM     | MAX     |          |                               |                     |                     |                        |
| OPP100                                    | 1.056 V                | 1.100 V | 1.144 V | 500 MHz  | 400 MHz                       | 266 MHz             | 200 MHz             | 200 MHz and<br>100 MHz |
| OPP100                                    | 1.056 V                | 1.100 V | 1.144 V | 275 MHz  | 400 MHz                       | 266 MHz             | 200 MHz             | 200 MHz and<br>100 MHz |

(1) Frequencies in this table indicate maximum performance for a given OPP condition.

(2) VDD\_MPU is merged with VDD\_CORE on the ZCE package.

(3) This parameter represents the maximum memory clock frequency. Since data is transferred on both edges of the clock, double-data rate (DDR), the maximum data rate is two times the maximum memory clock frequency defined in this table.

**Table 3-6. VDD\_CORE Operating Performance Points for ZCZ Package  
with Device Revision Code "A" or Newer<sup>(1)</sup>**

| VDD_CORE<br>OPP<br>Rev "A" or<br>Newer | VDD_CORE |         |         | DDR3,<br>DDR3L <sup>(2)</sup> | DDR2 <sup>(2)</sup> | mDDR <sup>(2)</sup> | L3 and L4              |
|----------------------------------------|----------|---------|---------|-------------------------------|---------------------|---------------------|------------------------|
|                                        | MIN      | NOM     | MAX     |                               |                     |                     |                        |
| OPP100                                 | 1.056 V  | 1.100 V | 1.144 V | 400 MHz                       | 266 MHz             | 200 MHz             | 200 MHz and<br>100 MHz |
| OPP50                                  | 0.912 V  | 0.950 V | 0.988 V | -                             | 125 MHz             | 90 MHz              | 100 MHz and<br>50 MHz  |

(1) Frequencies in this table indicate maximum performance for a given OPP condition.

(2) This parameter represents the maximum memory clock frequency. Since data is transferred on both edges of the clock, double-data rate (DDR), the maximum data rate is two times the maximum memory clock frequency defined in this table.

**Table 3-7. VDD\_MPU Operating Performance Points for ZCZ Package  
with Device Revision Code "A" or Newer<sup>(1)</sup>**

| VDD_MPU OPP<br>Rev "A" or Newer | VDD_MPU |         |         | ARM (A8) |
|---------------------------------|---------|---------|---------|----------|
|                                 | MIN     | NOM     | MAX     |          |
| Nitro                           | 1.272 V | 1.325 V | 1.378 V | 1 GHz    |
| Turbo                           | 1.210 V | 1.260 V | 1.326 V | 800 MHz  |
| OPP120                          | 1.152 V | 1.200 V | 1.248 V | 720 MHz  |
| OPP100 <sup>(2)</sup>           | 1.056 V | 1.100 V | 1.144 V | 600 MHz  |
| OPP100 <sup>(3)</sup>           | 1.056 V | 1.100 V | 1.144 V | 300 MHz  |
| OPP50                           | 0.912 V | 0.950 V | 0.988 V | 300 MHz  |

(1) Frequencies in this table indicate maximum performance for a given OPP condition.

(2) Applies to all orderable AM335\_\_ZCZ\_60 (600 MHz speed grade) or higher devices.

(3) Applies to all orderable AM335\_\_ZCZ\_30 (300 MHz speed grade) devices.

**Table 3-8. Valid Combinations of VDD\_CORE and  
VDD\_MPU Operating Performance Points for ZCZ  
Package with Device Revision Code "A" or Newer**

| VDD_CORE | VDD_MPU |
|----------|---------|
| OPP50    | OPP50   |
| OPP50    | OPP100  |
| OPP100   | OPP50   |
| OPP100   | OPP100  |
| OPP100   | OPP120  |
| OPP100   | Turbo   |
| OPP100   | Nitro   |

**Table 3-9. VDD\_CORE Operating Performance Points for ZCE Package  
with Device Revision Code "A" or Newer<sup>(1)</sup>**

| VDD_CORE<br>OPP<br>Rev "A" or<br>newer | VDD_MPU <sup>(2)</sup> |         |         | ARM (A8) | DDR3,<br>DDR3L <sup>(3)</sup> | DDR2 <sup>(3)</sup> | mDDR <sup>(3)</sup> | L3 and L4              |
|----------------------------------------|------------------------|---------|---------|----------|-------------------------------|---------------------|---------------------|------------------------|
|                                        | MIN                    | NOM     | MAX     |          |                               |                     |                     |                        |
| OPP100                                 | 1.056 V                | 1.100 V | 1.144 V | 600 MHz  | 400 MHz                       | 266 MHz             | 200 MHz             | 200 MHz and<br>100 MHz |
| OPP100                                 | 1.056 V                | 1.100 V | 1.144 V | 300 MHz  | 400 MHz                       | 266 MHz             | 200 MHz             | 200 MHz and<br>100 MHz |
| OPP50                                  | 0.912 V                | 0.950 V | 0.988 V | 300 MHz  | -                             | 125 MHz             | 90 MHz              | 100 MHz and<br>50 MHz  |

(1) Frequencies in this table indicate maximum performance for a given OPP condition.

(2) VDD\_MPU is merged with VDD\_CORE on the ZCE package.

(3) This parameter represents the maximum memory clock frequency. Since data is transferred on both edges of the clock, double-data rate (DDR), the maximum data rate is two times the maximum memory clock frequency defined in this table.

Table 3-10 summarizes the power consumption at the AM335x power terminals.

**Table 3-10. Maximum Current Ratings at AM335x Power Terminals<sup>(1)</sup>**

| PARAMETER                    |                                                            |            | MAX  | UNIT |
|------------------------------|------------------------------------------------------------|------------|------|------|
| SUPPLY NAME                  | DESCRIPTION                                                |            |      |      |
| VDD_CORE <sup>(2)</sup>      | Maximum current rating for the core domain; OPP100         |            | 400  | mA   |
|                              | Maximum current rating for the core domain; OPP50          |            | 250  | mA   |
| VDD_MPU <sup>(2)</sup>       | Maximum current rating for the MPU domain; Nitro           | at 1 GHz   | 1000 | mA   |
|                              | Maximum current rating for the MPU domain; Turbo           | at 800 MHz | 800  | mA   |
|                              |                                                            | at 720 MHz | 720  |      |
|                              | Maximum current rating for the MPU domain; OPP120          | at 720 MHz | 720  | mA   |
|                              |                                                            | at 600 MHz | 600  |      |
|                              | Maximum current rating for the MPU domain; OPP100          | at 600 MHz | 600  | mA   |
|                              |                                                            | at 500 MHz | 500  |      |
|                              |                                                            | at 300 MHz | 380  | mA   |
|                              |                                                            | at 275 MHz | 350  |      |
|                              | Maximum current rating for the MPU domain; OPP50           | at 300 MHz | 330  | mA   |
|                              |                                                            | at 275 MHz | 300  |      |
| CAP_VDD_RTC <sup>(3)</sup>   | Maximum current rating for RTC domain input and LDO output |            | 2    | mA   |
| VDDS_RTC                     | Maximum current rating for the RTC domain                  |            | 5    | mA   |
| VDDS_DDR                     | Maximum current rating for DDR IO domain                   |            | 250  | mA   |
| VDDS                         | Maximum current rating for all dual-voltage IO domains     |            | 50   | mA   |
| VDDS_SRAM_CORE_BG            | Maximum current rating for core SRAM LDOs                  |            | 10   | mA   |
| VDDS_SRAM_MPU_BB             | Maximum current rating for MPU SRAM LDOs                   |            | 10   | mA   |
| VDDS_PLL_DDR                 | Maximum current rating for the DPLL DDR                    |            | 10   | mA   |
| VDDS_PLL_CORE_LCD            | Maximum current rating for the DPLL Core and LCD           |            | 20   | mA   |
| VDDS_PLL_MPU                 | Maximum current rating for the DPLL MPU                    |            | 10   | mA   |
| VDDS_OSC                     | Maximum current rating for the system oscillator IOs       |            | 5    | mA   |
| VDDA1P8V_USB0                | Maximum current rating for USBPHY 1.8 V                    |            | 25   | mA   |
| VDDA1P8V_USB1 <sup>(4)</sup> | Maximum current rating for USBPHY 1.8 V                    |            | 25   | mA   |
| VDDA3P3V_USB0                | Maximum current rating for USBPHY 3.3 V                    |            | 40   | mA   |
| VDDA3P3V_USB1 <sup>(4)</sup> | Maximum current rating for USBPHY 3.3 V                    |            | 40   | mA   |
| VDDA_ADC                     | Maximum current rating for ADC                             |            | 10   | mA   |
| VDDSHV1 <sup>(5)</sup>       | Maximum current rating for dual-voltage IO domain          |            | 50   | mA   |
| VDDSHV2 <sup>(4)</sup>       | Maximum current rating for dual-voltage IO domain          |            | 50   | mA   |
| VDDSHV3 <sup>(4)</sup>       | Maximum current rating for dual-voltage IO domain          |            | 50   | mA   |
| VDDSHV4                      | Maximum current rating for dual-voltage IO domain          |            | 50   | mA   |
| VDDSHV5                      | Maximum current rating for dual-voltage IO domain          |            | 50   | mA   |
| VDDSHV6                      | Maximum current rating for dual-voltage IO domain          |            | 100  | mA   |

(1) Current ratings specified in this table are worst-case estimates. Actual application power supply estimates could be lower. For more information, see the *AM335x Power Consumption Summary* application report (literature number [SPRABN5](#)).

(2) VDD\_MPU is merged with VDD\_CORE and is not available separately on the ZCE package. The maximum current rating for VDD\_CORE on the ZCE package is the sum of VDD\_CORE and VDD\_MPU shown in this table.

(3) This supply is sourced from an internal LDO when RTC\_KALDO\_ENn is low. If RTC\_KALDO\_ENn is high, this supply must be sourced from an external power supply.

(4) Not available on the ZCE package.

(5) VDDSHV1 and VDDSHV2 are merged in the ZCE package. The maximum current rating for VDDSHV1 on the ZCE package is the sum of VDDSHV1 and VDDSHV2 shown in this table.

The power-on hours (POH) information in [Table 3-11](#) is provided solely for your convenience and does not extend or modify the warranty provided under TI's standard terms and conditions for TI semiconductor products.

To avoid significant degradation, the device power-on hours (POH) must be limited to the following:

**Table 3-11. Reliability Data**

| OPERATING<br>CONDITION | COMMERCIAL                         |                                  | INDUSTRIAL                         |                                  | EXTENDED                           |                                  |
|------------------------|------------------------------------|----------------------------------|------------------------------------|----------------------------------|------------------------------------|----------------------------------|
|                        | JUNCTION TEMP<br>(T <sub>j</sub> ) | LIFETIME<br>(POH) <sup>(1)</sup> | JUNCTION TEMP<br>(T <sub>j</sub> ) | LIFETIME<br>(POH) <sup>(1)</sup> | JUNCTION TEMP<br>(T <sub>j</sub> ) | LIFETIME<br>(POH) <sup>(1)</sup> |
| Nitro                  | 0°C to 90°C                        | 100K                             | -40°C to 90°C                      | 100K                             | -40°C to 105°C                     | 37K                              |
| Turbo                  | 0°C to 90°C                        | 100K                             | -40°C to 90°C                      | 100K                             | -40°C to 105°C                     | 80K                              |
| OPP120                 | 0°C to 90°C                        | 100K                             | -40°C to 90°C                      | 100K                             | -40°C to 105°C                     | 100K                             |
| OPP100                 | 0°C to 90°C                        | 100K                             | -40°C to 90°C                      | 100K                             | -40°C to 105°C                     | 100K                             |
| OPP50                  | 0°C to 90°C                        | 100K                             | -40°C to 90°C                      | 100K                             | -40°C to 105°C                     | 100K                             |

(1) POH = Power-on hours when the device is fully functional.

#### NOTE

Logic functions and parameter values are not assured out of the range specified in the recommended operating conditions.

The above notations cannot be deemed a warranty or deemed to extend or modify the warranty under TI's standard terms and conditions for TI semiconductor products.

The device is used under the recommended operating conditions described in [Table 3-12](#).

**Table 3-12. Recommended Operating Conditions**

| PARAMETER                  |                                                      | MIN   | NOM   | MAX   | UNIT |
|----------------------------|------------------------------------------------------|-------|-------|-------|------|
| SUPPLY NAME                | DESCRIPTION                                          |       |       |       |      |
| VDD_CORE <sup>(1)</sup>    | Supply voltage range for core domain; OPP100         | 1.056 | 1.100 | 1.144 | V    |
|                            | Supply voltage range for core domain; OPP50          | 0.912 | 0.950 | 0.988 |      |
| VDD_MPU <sup>(1)(2)</sup>  | Supply voltage range for MPU domain; Nitro           | 1.272 | 1.325 | 1.378 | V    |
|                            | Supply voltage range for MPU domain; Turbo           | 1.210 | 1.260 | 1.326 |      |
|                            | Supply voltage range for MPU domain; OPP120          | 1.152 | 1.200 | 1.248 |      |
|                            | Supply voltage range for MPU domain; OPP100          | 1.056 | 1.100 | 1.144 |      |
|                            | Supply voltage range for MPU domain; OPP50           | 0.912 | 0.950 | 0.988 |      |
| CAP_VDD_RTC <sup>(3)</sup> | Supply voltage range for RTC domain input            | 0.900 | 1.100 | 1.250 | V    |
| VDDS_RTC                   | Supply voltage range for RTC domain                  | 1.710 | 1.800 | 1.890 | V    |
| VDDS_DDR                   | Supply voltage range for DDR IO domain (DDR2)        | 1.710 | 1.800 | 1.890 | V    |
|                            | Supply voltage range for DDR IO domain (DDR3)        | 1.425 | 1.500 | 1.575 |      |
|                            | Supply voltage range for DDR IO domain (DDR3L)       | 1.283 | 1.350 | 1.418 |      |
| VDDS <sup>(4)</sup>        | Supply voltage range for all dual-voltage IO domains | 1.710 | 1.800 | 1.890 | V    |
| VDDS_SRAM_CORE_BG          | Supply voltage range for Core SRAM LDOs, Analog      | 1.710 | 1.800 | 1.890 | V    |

**Table 3-12. Recommended Operating Conditions (continued)**

| PARAMETER                        |                                                                   | MIN   | NOM   | MAX   | UNIT |
|----------------------------------|-------------------------------------------------------------------|-------|-------|-------|------|
| SUPPLY NAME                      | DESCRIPTION                                                       |       |       |       |      |
| VDDS_SRAM_MPU_BB                 | Supply voltage range for MPU SRAM LDOs, Analog                    | 1.710 | 1.800 | 1.890 | V    |
| VDDS_PLL_DDR <sup>(5)</sup>      | Supply voltage range for DPLL DDR, Analog                         | 1.710 | 1.800 | 1.890 | V    |
| VDDS_PLL_CORE_LCD <sup>(5)</sup> | Supply voltage range for DPLL CORE and LCD, Analog                | 1.710 | 1.800 | 1.890 | V    |
| VDDS_PLL_MPU <sup>(5)</sup>      | Supply voltage range for DPLL MPU, Analog                         | 1.710 | 1.800 | 1.890 | V    |
| VDDS_OSC                         | Supply voltage range for system oscillator IO's, Analog           | 1.710 | 1.800 | 1.890 | V    |
| VDDA1P8V_USB0 <sup>(5)</sup>     | Supply voltage range for USBPHY and PER DPLL, Analog, 1.8V        | 1.710 | 1.800 | 1.890 | V    |
| VDDA1P8V_USB1 <sup>(6)</sup>     | Supply voltage range for USB PHY, Analog, 1.8V                    | 1.710 | 1.800 | 1.890 | V    |
| VDDA3P3V_USB0                    | Supply voltage range for USB PHY, Analog, 3.3V                    | 3.135 | 3.300 | 3.465 | V    |
| VDDA3P3V_USB1 <sup>(6)</sup>     | Supply voltage range for USB PHY, Analog, 3.3V                    | 3.135 | 3.300 | 3.465 | V    |
| VDDA_ADC                         | Supply voltage range for ADC, Analog                              | 1.710 | 1.800 | 1.890 | V    |
| VDDSHV1                          | Supply voltage range for dual-voltage IO domain (1.8-V operation) | 1.710 | 1.800 | 1.890 | V    |
| VDDSHV2 <sup>(6)</sup>           | Supply voltage range for dual-voltage IO domain (1.8-V operation) | 1.710 | 1.800 | 1.890 | V    |
| VDDSHV3 <sup>(6)</sup>           | Supply voltage range for dual-voltage IO domain (1.8-V operation) | 1.710 | 1.800 | 1.890 | V    |
| VDDSHV4                          | Supply voltage range for dual-voltage IO domain (1.8-V operation) | 1.710 | 1.800 | 1.890 | V    |
| VDDSHV5                          | Supply voltage range for dual-voltage IO domain (1.8-V operation) | 1.710 | 1.800 | 1.890 | V    |
| VDDSHV6                          | Supply voltage range for dual-voltage IO domain (1.8-V operation) | 1.710 | 1.800 | 1.890 | V    |
| VDDSHV1                          | Supply voltage range for dual-voltage IO domain (3.3-V operation) | 3.135 | 3.300 | 3.465 | V    |
| VDDSHV2 <sup>(6)</sup>           | Supply voltage range for dual-voltage IO domain (3.3-V operation) | 3.135 | 3.300 | 3.465 | V    |
| VDDSHV3 <sup>(6)</sup>           | Supply voltage range for dual-voltage IO domain (3.3-V operation) | 3.135 | 3.300 | 3.465 | V    |
| VDDSHV4                          | Supply voltage range for dual-voltage IO domain (3.3-V operation) | 3.135 | 3.300 | 3.465 | V    |
| VDDSHV5                          | Supply voltage range for dual-voltage IO domain (3.3-V operation) | 3.135 | 3.300 | 3.465 | V    |
| VDDSHV6                          | Supply voltage range for dual-voltage IO domain (3.3-V operation) | 3.135 | 3.300 | 3.465 | V    |

**Table 3-12. Recommended Operating Conditions (continued)**

| PARAMETER                                   |                                                                         | MIN           | NOM           | MAX           | UNIT |
|---------------------------------------------|-------------------------------------------------------------------------|---------------|---------------|---------------|------|
| SUPPLY NAME                                 | DESCRIPTION                                                             |               |               |               |      |
| DDR_VREF                                    | Voltage range for DDR SSTL and HSTL reference input (DDR2, DDR3, DDR3L) | 0.49*VDDS_DDR | 0.50*VDDS_DDR | 0.51*VDDS_DDR | V    |
| USB0_VBUS                                   | Voltage range for USB VBUS comparator input                             | 0.000         | 5.000         | 5.250         | V    |
| USB1_VBUS <sup>(6)</sup>                    | Voltage range for USB VBUS comparator input                             | 0.000         | 5.000         | 5.250         | V    |
| USB0_ID                                     | Voltage range for the USB ID input                                      | (7)           |               |               | V    |
| USB1_ID <sup>(6)</sup>                      | Voltage range for the USB ID input                                      | (7)           |               |               | V    |
| Operating Temperature Range, T <sub>j</sub> | Commercial Temperature                                                  | 0             |               | 90            | °C   |
|                                             | Industrial Temperature                                                  | -40           |               | 90            |      |
|                                             | Extended Temperature                                                    | -40           |               | 105           |      |

- (1) The supply voltage defined by OPP100 should be applied to this power domain before the device is released from reset.
- (2) Not available on the ZCE package. VDD\_MPU is merged with VDD\_CORE on the ZCE package.
- (3) This supply is sourced from an internal LDO when RTC\_KALDO\_ENn is low. If RTC\_KALDO\_ENn is high, this supply must be sourced from an external power supply.
- (4) VDDS should be supplied irrespective of 1.8-V or 3.3-V mode of operation of the dual-voltage I/Os.
- (5) For more details on power supply requirements, see [Section 4.1.4](#).
- (6) Not available on the ZCE package.
- (7) This terminal is connected to analog circuits in the respective USB PHY. The circuit sources a known current while measuring the voltage to determine if the terminal is connected to VSSA\_USB with a resistance less than 10 Ω or greater than 100 kΩ. The terminal should be connected to ground for USB host operation or open-circuit for USB peripheral operation, and should never be connected to any external voltage source.

### 3.3 DC Electrical Characteristics

Table 3-13 summarizes the dc electrical characteristics.

Note: The interfaces or signals described in Table 3-13 correspond to the interfaces or signals available in multiplexing mode 0. All interfaces or signals multiplexed on the terminals described in Table 3-13 have the same dc electrical characteristics.

**Table 3-13. DC Electrical Characteristics Over Recommended Ranges of Supply Voltage and Operating Temperature (Unless Otherwise Noted)**

| PARAMETER                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                      |                        | MIN                 | NOM | MAX | UNIT |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------------|-----|-----|------|
| DDR_RESETh,DDR_CSn0,DDR_CKE,DDR_CK,DDR_CKn,DDR_CASn,DDR_RASn,DDR_WEn,DDR_BA0,DDR_BA1,DDR_BA2,DDR_A0,DDR_A1,DDR_A2,DDR_A3,DDR_A4,DDR_A5,DDR_A6,DDR_A7,DDR_A8,DDR_A9,DDR_A10,DDR_A11,DDR_A12,DDR_A13,DDR_A14,DDR_A15,DDR_ODT,DDR_D0,DDR_D1,DDR_D2,DDR_D3,DDR_D4,DDR_D5,DDR_D6,DDR_D7,DDR_D8,DDR_D9,DDR_D10,DDR_D11,DDR_D12,DDR_D13,DDR_D14,DDR_D15,DDR_DQM0,DDR_DQM1,DDR_DQS0,DDR_DQSn0,DDR_DQS1,DDR_DQSn1 pins (mDDR - LVCMOS mode) |                                                                                                                                                                                                      |                        |                     |     |     |      |
| V <sub>IH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | High-level input voltage                                                                                                                                                                             |                        | 0.65 *<br>VDDSD_DDR |     |     | V    |
| V <sub>IL</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | Low-level input voltage                                                                                                                                                                              |                        | 0.35 *<br>VDDSD_DDR |     |     | V    |
| V <sub>HYS</sub>                                                                                                                                                                                                                                                                                                                                                                                                                   | Hysteresis voltage at an input                                                                                                                                                                       |                        | 0.070.25            |     |     | V    |
| V <sub>OH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | High level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                               | I <sub>OH</sub> = 8 mA | VDDSD_DDR - 0.4     |     |     | V    |
| V <sub>OL</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | Low level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                                | I <sub>OL</sub> = 8 mA | 0.4                 |     |     | V    |
| I <sub>I</sub>                                                                                                                                                                                                                                                                                                                                                                                                                     | Input leakage current, Receiver disabled, pullup or pulldown inhibited                                                                                                                               |                        | 10                  |     |     | μA   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                    | Input leakage current, Receiver disabled, pullup enabled                                                                                                                                             |                        | -240-80             |     |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                    | Input leakage current, Receiver disabled, pulldown enabled                                                                                                                                           |                        | 80240               |     |     |      |
| I <sub>OZ</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | Total leakage current through the terminal connection of a driver-receiver combination that may include a pullup or pulldown. The driver output is disabled and the pullup or pulldown is inhibited. |                        | 10                  |     |     | μA   |
| DDR_RESETh,DDR_CSn0,DDR_CKE,DDR_CK,DDR_CKn,DDR_CASn,DDR_RASn,DDR_WEn,DDR_BA0,DDR_BA1,DDR_BA2,DDR_A0,DDR_A1,DDR_A2,DDR_A3,DDR_A4,DDR_A5,DDR_A6,DDR_A7,DDR_A8,DDR_A9,DDR_A10,DDR_A11,DDR_A12,DDR_A13,DDR_A14,DDR_A15,DDR_ODT,DDR_D0,DDR_D1,DDR_D2,DDR_D3,DDR_D4,DDR_D5,DDR_D6,DDR_D7,DDR_D8,DDR_D9,DDR_D10,DDR_D11,DDR_D12,DDR_D13,DDR_D14,DDR_D15,DDR_DQM0,DDR_DQM1,DDR_DQS0,DDR_DQSn0,DDR_DQS1,DDR_DQSn1 pins (DDR2 - SSTL mode)   |                                                                                                                                                                                                      |                        |                     |     |     |      |
| V <sub>IH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | High-level input voltage                                                                                                                                                                             |                        | DDR_VREF + 0.125    |     |     | V    |
| V <sub>IL</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | Low-level input voltage                                                                                                                                                                              |                        | DDR_VREF - 0.125    |     |     | V    |
| V <sub>HYS</sub>                                                                                                                                                                                                                                                                                                                                                                                                                   | Hysteresis voltage at an input                                                                                                                                                                       |                        | NA                  |     |     | V    |
| V <sub>OH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | High-level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                               | I <sub>OH</sub> = 8 mA | VDDSD_DDR - 0.4     |     |     | V    |
| V <sub>OL</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | Low-level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                                | I <sub>OL</sub> = 8 mA | 0.4                 |     |     | V    |
| I <sub>I</sub>                                                                                                                                                                                                                                                                                                                                                                                                                     | Input leakage current, Receiver disabled, pullup or pulldown inhibited                                                                                                                               |                        | 10                  |     |     | μA   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                    | Input leakage current, Receiver disabled, pullup enabled                                                                                                                                             |                        | -240-80             |     |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                    | Input leakage current, Receiver disabled, pulldown enabled                                                                                                                                           |                        | 80240               |     |     |      |
| I <sub>OZ</sub>                                                                                                                                                                                                                                                                                                                                                                                                                    | Total leakage current through the terminal connection of a driver-receiver combination that may include a pullup or pulldown. The driver output is disabled and the pullup or pulldown is inhibited. |                        | 10                  |     |     | μA   |

**Table 3-13. DC Electrical Characteristics Over Recommended Ranges of Supply Voltage and Operating Temperature (Unless Otherwise Noted) (continued)**

| PARAMETER                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                      |                        | MIN                           | NOM             | MAX   | UNIT |     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------------------------|-----------------|-------|------|-----|
| DDR_RESETh,DDR_CS0,DDR_CKE,DDR_CK,DDR_CKn,DDR_CASn,DDR_RASn,DDR_WEn,DDR_BA0,DDR_BA1,DDR_BA2,DDR_A0,DDR_A1,DDR_A2,DDR_A3,DDR_A4,DDR_A5,DDR_A6,DDR_A7,DDR_A8,DDR_A9,DDR_A10,DDR_A11,DDR_A12,DDR_A13,DDR_A14,DDR_A15,DDR_ODT,DDR_D0,DDR_D1,DDR_D2,DDR_D3,DDR_D4,DDR_D5,DDR_D6,DDR_D7,DDR_D8,DDR_D9,DDR_D10,DDR_D11,DDR_D12,DDR_D13,DDR_D14,DDR_D15,DDR_DQM0,DDR_DQM1,DDR_DQS0,DDR_DQSn0,DDR_DQS1,DDR_DQSn1 pins (DDR3, DDR3L - HSTL mode) |                                                                                                                                                                                                      |                        |                               |                 |       |      |     |
| V <sub>IH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | High-level input voltage                                                                                                                                                                             |                        | V <sub>DDS_DDR</sub> = 1.5 V  | DDR_VREF + 0.1  |       | V    |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                      |                        | V <sub>DDS_DDR</sub> = 1.35 V | DDR_VREF + 0.09 |       |      |     |
| V <sub>IL</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | Low-level input voltage                                                                                                                                                                              |                        | V <sub>DDS_DDR</sub> = 1.5 V  | DDR_VREF - 0.1  |       | V    |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                      |                        | V <sub>DDS_DDR</sub> = 1.35 V | DDR_VREF - 0.09 |       |      |     |
| V <sub>HYS</sub>                                                                                                                                                                                                                                                                                                                                                                                                                       | Hysteresis voltage at an input                                                                                                                                                                       |                        | NA                            |                 |       | V    |     |
| V <sub>OH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | High-level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                               | I <sub>OH</sub> = 8 mA | V <sub>DDS_DDR</sub> - 0.4    |                 |       | V    |     |
| V <sub>OL</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | Low-level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                                | I <sub>OL</sub> = 8 mA |                               |                 | 0.4   | V    |     |
| I <sub>I</sub>                                                                                                                                                                                                                                                                                                                                                                                                                         | Input leakage current, Receiver disabled, pullup or pulldown inhibited                                                                                                                               |                        |                               |                 | 10    | μA   |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        | Input leakage current, Receiver disabled, pullup enabled                                                                                                                                             |                        | -240                          |                 | -80   |      |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        | Input leakage current, Receiver disabled, pulldown enabled                                                                                                                                           |                        | 80                            |                 | 240   |      |     |
| I <sub>OZ</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | Total leakage current through the terminal connection of a driver-receiver combination that may include a pullup or pulldown. The driver output is disabled and the pullup or pulldown is inhibited. |                        |                               |                 | 10    | μA   |     |
| ECAP0_IN_PWM0_OUT,UART0_CTSn,UART0_RTSn,UART0_RXD,UART0_TXD,UART1_CTSn,UART1_RTSn,UART1_RXD,UART1_TXD,I2C0_SDA,I2C0_SCL,XDMA_EVENT_INTR0,XDMA_EVENT_INTR1,WARMRSTn,PWRONRSTn,EXTINTn,TMS,TDO,USB0_DRVVBUS,USB1_DRVVBUS (V <sub>DDSHV6</sub> = 1.8 V)                                                                                                                                                                                   |                                                                                                                                                                                                      |                        |                               |                 |       |      |     |
| V <sub>IH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | High-level input voltage                                                                                                                                                                             |                        | 0.65 * V <sub>DDSHV6</sub>    |                 |       | V    |     |
| V <sub>IL</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | Low-level input voltage                                                                                                                                                                              |                        | 0.35 * V <sub>DDSHV6</sub>    |                 |       | V    |     |
| V <sub>HYS</sub>                                                                                                                                                                                                                                                                                                                                                                                                                       | Hysteresis voltage at an input                                                                                                                                                                       |                        | 0.18                          |                 | 0.305 | V    |     |
| V <sub>OH</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | High-level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                               | I <sub>OH</sub> = 4 mA | V <sub>DDSHV6</sub> - 0.45    |                 |       | V    |     |
| V <sub>OL</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | Low-level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                                | I <sub>OL</sub> = 4 mA |                               |                 | 0.45  | V    |     |
| I <sub>I</sub>                                                                                                                                                                                                                                                                                                                                                                                                                         | Input leakage current, Receiver disabled, pullup or pulldown inhibited                                                                                                                               |                        |                               |                 | 8     | μA   |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        | Input leakage current, Receiver disabled, pullup enabled                                                                                                                                             |                        | -161                          |                 | -100  |      | -52 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        | Input leakage current, Receiver disabled, pulldown enabled                                                                                                                                           |                        | 52                            |                 | 100   |      | 170 |
| I <sub>OZ</sub>                                                                                                                                                                                                                                                                                                                                                                                                                        | Total leakage current through the terminal connection of a driver-receiver combination that may include a pullup or pulldown. The driver output is disabled and the pullup or pulldown is inhibited. |                        |                               |                 | 8     | μA   |     |

**Table 3-13. DC Electrical Characteristics Over Recommended Ranges of Supply Voltage and Operating Temperature (Unless Otherwise Noted) (continued)**

| PARAMETER                                                                                                                                                                                                                                |                                                                                                                                                                                                      |                        | MIN            | NOM  | MAX | UNIT   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------------|------|-----|--------|
| ECAP0_IN_PWM0_OUT,UART0_CTSn,UART0_RTSn,UART0_RXD,UART0_TXD,UART1_CTSn,UART1_RTSn,UART1_RXD,UART1_TXD,I2C0_SDA,I2C0_SCL,XDMA_EVENT_INTR0,XDMA_EVENT_INTR1,WARMRSTn,PWRONRSTn,EXTINTn,TMS,TDO,USB0_DRVVBUS,USB1_DRVVBUS (VDDSHV6 = 3.3 V) |                                                                                                                                                                                                      |                        |                |      |     |        |
| V <sub>IH</sub>                                                                                                                                                                                                                          | High-level input voltage                                                                                                                                                                             |                        | 2              |      |     | V      |
| V <sub>IL</sub>                                                                                                                                                                                                                          | Low-level input voltage                                                                                                                                                                              |                        | 0.8            |      |     | V      |
| V <sub>HYS</sub>                                                                                                                                                                                                                         | Hysteresis voltage at an input                                                                                                                                                                       |                        | 0.265          |      |     | 0.44 V |
| V <sub>OH</sub>                                                                                                                                                                                                                          | High-level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                               | I <sub>OH</sub> = 4 mA | VDDSHV6 - 0.45 |      |     | V      |
| V <sub>OL</sub>                                                                                                                                                                                                                          | Low-level output voltage, driver enabled, pullup or pulldown disbaled                                                                                                                                | I <sub>OL</sub> = 4 mA | 0.45           |      |     | V      |
| I <sub>I</sub>                                                                                                                                                                                                                           | Input leakage current, Receiver disabled, pullup or pulldown inhibited                                                                                                                               |                        | 18             |      |     | μA     |
|                                                                                                                                                                                                                                          | Input leakage current, Receiver disabled, pullup enabled                                                                                                                                             |                        | -243           | -100 | -19 |        |
|                                                                                                                                                                                                                                          | Input leakage current, Receiver disabled, pulldown enabled                                                                                                                                           |                        | 51             | 110  | 210 |        |
| I <sub>OZ</sub>                                                                                                                                                                                                                          | Total leakage current through the terminal connection of a driver-receiver combination that may include a pullup or pulldown. The driver output is disabled and the pullup or pulldown is inhibited. |                        | 18             |      |     | μA     |
| TCK (VDDSHV6 = 1.8 V)                                                                                                                                                                                                                    |                                                                                                                                                                                                      |                        |                |      |     |        |
| V <sub>IH</sub>                                                                                                                                                                                                                          | High-level input voltage                                                                                                                                                                             |                        | 1.45           |      |     | V      |
| V <sub>IL</sub>                                                                                                                                                                                                                          | Low-level input voltage                                                                                                                                                                              |                        | 0.46           |      |     | V      |
| V <sub>HYS</sub>                                                                                                                                                                                                                         | Hysteresis voltage at an input                                                                                                                                                                       |                        | 0.4            |      |     | V      |
| I <sub>I</sub>                                                                                                                                                                                                                           | Input leakage current, Receiver disabled, pullup or pulldown inhibited                                                                                                                               |                        | 8              |      |     | μA     |
|                                                                                                                                                                                                                                          | Input leakage current, Receiver disabled, pullup enabled                                                                                                                                             |                        | -161           | -100 | -52 |        |
|                                                                                                                                                                                                                                          | Input leakage current, Receiver disabled, pulldown enabled                                                                                                                                           |                        | 52             | 100  | 170 |        |
| TCK (VDDSHV6 = 3.3 V)                                                                                                                                                                                                                    |                                                                                                                                                                                                      |                        |                |      |     |        |
| V <sub>IH</sub>                                                                                                                                                                                                                          | High-level input voltage                                                                                                                                                                             |                        | 2.15           |      |     | V      |
| V <sub>IL</sub>                                                                                                                                                                                                                          | Low-level input voltage                                                                                                                                                                              |                        | 0.46           |      |     | V      |
| V <sub>HYS</sub>                                                                                                                                                                                                                         | Hysteresis voltage at an input                                                                                                                                                                       |                        | 0.4            |      |     | V      |
| I <sub>I</sub>                                                                                                                                                                                                                           | Input leakage current, Receiver disabled, pullup or pulldown inhibited                                                                                                                               |                        | 18             |      |     | μA     |
|                                                                                                                                                                                                                                          | Input leakage current, Receiver disabled, pullup enabled                                                                                                                                             |                        | -243           | -100 | -19 |        |
|                                                                                                                                                                                                                                          | Input leakage current, Receiver disabled, pulldown enabled                                                                                                                                           |                        | 51             | 110  | 210 |        |
| PWRONRSTn (VDDSHV6 = 1.8 V or 3.3 V) <sup>(1)</sup>                                                                                                                                                                                      |                                                                                                                                                                                                      |                        |                |      |     |        |
| V <sub>IH</sub>                                                                                                                                                                                                                          | High-level input voltage                                                                                                                                                                             |                        | 1.35           |      |     | V      |
| V <sub>IL</sub>                                                                                                                                                                                                                          | Low-level input voltage                                                                                                                                                                              |                        | 0.5            |      |     | V      |
| V <sub>HYS</sub>                                                                                                                                                                                                                         | Hysteresis voltage at an input                                                                                                                                                                       |                        | 0.07           |      |     | V      |
| I <sub>I</sub>                                                                                                                                                                                                                           | Input leakage current                                                                                                                                                                                | V <sub>I</sub> = 1.8 V | 0.1            |      |     | μA     |
|                                                                                                                                                                                                                                          |                                                                                                                                                                                                      | V <sub>I</sub> = 3.3 V | 2              |      |     |        |

(1) The input voltage thresholds for this input are not a function of VDDSHV6.

**Table 3-13. DC Electrical Characteristics Over Recommended Ranges of Supply Voltage and Operating Temperature (Unless Otherwise Noted) (continued)**

| PARAMETER                                             |                                                                                                                                                                                                      | MIN                    | NOM               | MAX               | UNIT |
|-------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------------|-------------------|------|
| <b>All other LVCMOS pins (VDDSHVx = 1.8 V; x=1-6)</b> |                                                                                                                                                                                                      |                        |                   |                   |      |
| V <sub>IH</sub>                                       | High-level input voltage                                                                                                                                                                             | 0.65 *<br>VDDSHVx      |                   |                   | V    |
| V <sub>IL</sub>                                       | Low-level input voltage                                                                                                                                                                              |                        |                   | 0.35 *<br>VDDSHVx | V    |
| V <sub>HYS</sub>                                      | Hysteresis voltage at an input                                                                                                                                                                       | 0.18                   |                   | 0.305             | V    |
| V <sub>OH</sub>                                       | High-level output voltage, driver enabled, pullup or pulldown disabled                                                                                                                               | I <sub>OH</sub> = 6 mA | VDDSHVx -<br>0.45 |                   | V    |
| V <sub>OL</sub>                                       | Low-level output voltage, driver enabled, pullup or pulldown disabled                                                                                                                                | I <sub>OL</sub> = 6 mA |                   | 0.45              | V    |
| I <sub>I</sub>                                        | Input leakage current, Receiver disabled, pullup or pulldown inhibited                                                                                                                               |                        |                   | 8                 | μA   |
|                                                       | Input leakage current, Receiver disabled, pullup enabled                                                                                                                                             | -161                   | -100              | -52               |      |
|                                                       | Input leakage current, Receiver disabled, pulldown enabled                                                                                                                                           | 52                     | 100               | 170               |      |
| I <sub>OZ</sub>                                       | Total leakage current through the terminal connection of a driver-receiver combination that may include a pullup or pulldown. The driver output is disabled and the pullup or pulldown is inhibited. |                        |                   | 8                 | μA   |
| <b>All other LVCMOS pins (VDDSHVx = 3.3 V; x=1-6)</b> |                                                                                                                                                                                                      |                        |                   |                   |      |
| V <sub>IH</sub>                                       | High-level input voltage                                                                                                                                                                             | 2                      |                   |                   | V    |
| V <sub>IL</sub>                                       | Low-level input voltage                                                                                                                                                                              |                        |                   | 0.8               | V    |
| V <sub>HYS</sub>                                      | Hysteresis voltage at an input                                                                                                                                                                       | 0.265                  |                   | 0.44              | V    |
| V <sub>OH</sub>                                       | High-level output voltage, driver enabled, pullup or pulldown disabled                                                                                                                               | I <sub>OH</sub> = 6 mA | VDDSHVx -<br>0.45 |                   | V    |
| V <sub>OL</sub>                                       | Low-level output voltage, driver enabled, pullup or pulldown disabled                                                                                                                                | I <sub>OL</sub> = 6 mA |                   | 0.45              | V    |
| I <sub>I</sub>                                        | Input leakage current, Receiver disabled, pullup or pulldown inhibited                                                                                                                               |                        |                   | 18                | μA   |
|                                                       | Input leakage current, Receiver disabled, pullup enabled                                                                                                                                             | -243                   | -100              | -19               |      |
|                                                       | Input leakage current, Receiver disabled, pulldown enabled                                                                                                                                           | 51                     | 110               | 210               |      |
| I <sub>OZ</sub>                                       | Total leakage current through the terminal connection of a driver-receiver combination that may include a pullup or pulldown. The driver output is disabled and the pullup or pulldown is inhibited. |                        |                   | 18                | μA   |

### 3.4 External Capacitors

To improve module performance, decoupling capacitors are required to suppress the switching noise generated by high frequency and to stabilize the supply voltage. A decoupling capacitor is most effective when it is close to the device, because this minimizes the inductance of the circuit board wiring and interconnects.

#### 3.4.1 Voltage Decoupling Capacitors

Table 3-14 summarizes the Core voltage decoupling characteristics.

##### 3.4.1.1 Core Voltage Decoupling Capacitors

To improve module performance, decoupling capacitors are required to suppress high-frequency switching noise and to stabilize the supply voltage. A decoupling capacitor is most effective when located close to the AM335x device, because this minimizes the inductance of the circuit board wiring and interconnects.

**Table 3-14. Core Voltage Decoupling Characteristics**

| PARAMETER                              | TYP   | UNIT |
|----------------------------------------|-------|------|
| C <sub>VDD_CORE</sub> <sup>(1)</sup>   | 10.08 | μF   |
| C <sub>VDD_MPU</sub> <sup>(2)(3)</sup> | 10.05 | μF   |

(1) The typical value corresponds to 1 cap of 10 μF and 8 caps of 10 nF.

(2) Not available on the ZCE package. VDD\_MPU is merged with VDD\_CORE on the ZCE package.

(3) The typical value corresponds to 1 cap of 10 μF and 5 caps of 10 nF.

##### 3.4.1.2 IO and Analog Voltage Decoupling Capacitors

Table 3-15 summarizes the power-supply decoupling capacitor recommendations.

**Table 3-15. Power-Supply Decoupling Capacitor Characteristics**

| PARAMETER                                 | TYP            | UNIT |
|-------------------------------------------|----------------|------|
| C <sub>VDDA_ADC</sub>                     | 10             | nF   |
| C <sub>VDDA1P8V_USB0</sub>                | 10             | nF   |
| C <sub>CVDDA3P3V_USB0</sub>               | 10             | nF   |
| C <sub>VDDA1P8V_USB1</sub> <sup>(1)</sup> | 10             | nF   |
| C <sub>VDDA3P3V_USB1</sub> <sup>(1)</sup> | 10             | nF   |
| C <sub>VDDS</sub> <sup>(2)</sup>          | 10.04          | μF   |
| C <sub>VDDS_DDR</sub>                     | <sup>(4)</sup> |      |
| C <sub>VDDS_OSC</sub>                     | 10             | nF   |
| C <sub>VDDS_PLL_DDR</sub>                 | 10             | nF   |
| C <sub>VDDS_PLL_CORE_LCD</sub>            | 10             | nF   |
| C <sub>VDDS_SRAM_CORE_BG</sub>            | 10             | nF   |
| C <sub>VDDS_SRAM_MPU_BB</sub>             | 10             | nF   |
| C <sub>VDDS_PLL_MPU</sub>                 | 10             | nF   |
| C <sub>VDDS_RTC</sub>                     | 10             | nF   |
| C <sub>VDDSHV1</sub> <sup>(5)</sup>       | 10.02          | μF   |
| C <sub>VDDSHV2</sub> <sup>(1)(5)</sup>    | 10.02          | μF   |
| C <sub>VDDSHV3</sub> <sup>(1)(5)</sup>    | 10.02          | μF   |

**Table 3-15. Power-Supply Decoupling Capacitor Characteristics (continued)**

| PARAMETER                           | TYP   | UNIT |
|-------------------------------------|-------|------|
| C <sub>VDDSHV4</sub> <sup>(5)</sup> | 10.02 | μF   |
| C <sub>VDDSHV5</sub> <sup>(5)</sup> | 10.02 | μF   |
| C <sub>VDDSHV6</sub> <sup>(3)</sup> | 10.06 | μF   |

(1) Not available on the ZCE package.

(2) Typical values consist of 1 cap of 10 μF and 4 caps of 10 nF.

(3) Typical values consist of 1 cap of 10 μF and 6 caps of 10 nF.

(4) For more details on decoupling capacitor requirements for the mDDR(LPDDR), DDR2, DDR3, DDR3L memory interface, see [Section 5.6.2.1.2.6](#) and [Section 5.6.2.1.2.7](#) when using mDDR(LPDDR) memory devices, [Section 5.6.2.2.2.6](#) and [Section 5.6.2.2.2.7](#) when using DDR2 memory devices, or [Section 5.6.2.3.3.6](#) and [Section 5.6.2.3.3.7](#) when using DDR3 or DDR3L memory devices.

(5) Typical values consist of 1 cap of 10 μF and 2 caps of 10 nF.

### 3.4.2 Output Capacitors

Internal low dropout output (LDO) regulators require external capacitors to stabilize their outputs. These capacitors should be placed as close as possible to the respective terminals of the AM335x device. [Table 3-16](#) summarizes the LDO output capacitor recommendations.

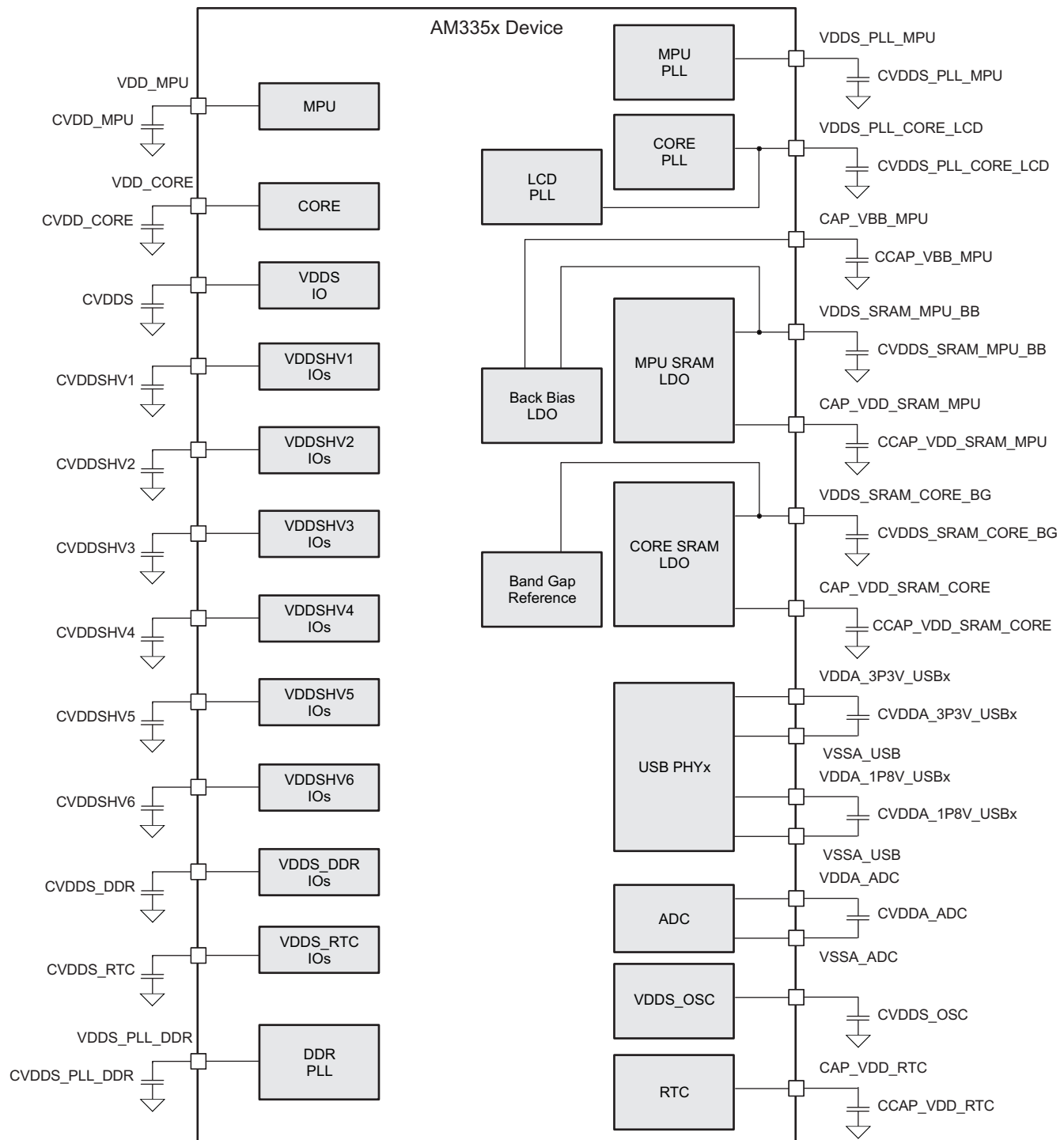
**Table 3-16. Output Capacitor Characteristics**

| PARAMETER                                     | TYP | UNIT |
|-----------------------------------------------|-----|------|
| C <sub>CAP_VDD_SRAM_CORE</sub> <sup>(1)</sup> | 1   | μF   |
| C <sub>CAP_VDD_RTC</sub> <sup>(1)(2)</sup>    | 1   | μF   |
| C <sub>CAP_VDD_SRAM_MPU</sub> <sup>(1)</sup>  | 1   | μF   |
| C <sub>CAP_VBB_MPU</sub> <sup>(1)</sup>       | 1   | μF   |

(1) LDO regulator outputs should not be used as a power source for any external components.

(2) The CAP\_VDD\_RTC terminal operates as an input to the RTC core voltage domain when the RTC\_KLDO\_ENn terminal is high.

Figure 3-1 illustrates an example of the external capacitors.



- A. Decoupling capacitors must be placed as closed as possible to the power terminal. Choose the ground located closest to the power pin for each decoupling capacitor. In case of interconnecting powers, first insert the decoupling capacitor and then interconnect the powers.
- B. The decoupling capacitor value depends on the board characteristics.

### Figure 3-1. External Capacitors

### 3.5 Touchscreen Controller and Analog-to-Digital Subsystem Electrical Parameters

The touchscreen controller (TSC) and analog-to-digital converter (ADC) subsystem (TSC\_ADC) is an 8-channel general-purpose ADC with optional support for interleaving TSC conversions for 4-wire, 5-wire, or 8-wire resistive panels. The TSC\_ADC subsystem can be configured for use in one of the following applications:

- 8 general-purpose ADC channels
- 4-wire TSC with 4 general-purpose ADC channels
- 5-wire TSC with 3 general-purpose ADC channels
- 8-wire TSC.

Table 3-17 summarizes the TSC\_ADC subsystem electrical parameters.

**Table 3-17. TSC\_ADC Electrical Parameters**

| PARAMETER                        | CONDITION                                                                                                                                                        | MIN                        | NOM | MAX                        | UNIT |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-----|----------------------------|------|
| Analog Input                     |                                                                                                                                                                  |                            |     |                            |      |
| VREFP <sup>(1)</sup>             |                                                                                                                                                                  | $(0.5 * VDDA\_ADC) + 0.25$ |     | VDDA_ADC                   | V    |
| VREFN <sup>(1)</sup>             |                                                                                                                                                                  | 0                          |     | $(0.5 * VDDA\_ADC) - 0.25$ | V    |
| VREFP + VREFN <sup>(1)</sup>     |                                                                                                                                                                  | VDDA_ADC                   |     |                            | V    |
| Full-scale Input Range           | Internal Voltage Reference                                                                                                                                       | 0                          |     | VDDA_ADC                   | V    |
|                                  | External Voltage Reference                                                                                                                                       | VREFN                      |     | VREFP                      |      |
| Differential Non-Linearity (DNL) | Internal Voltage Reference:<br>VDDA_ADC = 1.8V<br>External Voltage Reference:<br>VREFP - VREFN = 1.8V                                                            | -1                         | 0.5 | 1                          | LSB  |
| Integral Non-Linearity (INL)     | Source impedance = 50 Ω<br>Internal Voltage Reference:<br>VDDA_ADC = 1.8V<br>External Voltage Reference:<br>VREFP - VREFN = 1.8V                                 | -2                         | ±1  | 2                          | LSB  |
|                                  | Source Impedance = 1k Ω<br>Internal Voltage Reference:<br>VDDA_ADC = 1.8V<br>External Voltage Reference:<br>VREFP - VREFN = 1.8V                                 | ±1                         |     |                            | LSB  |
| Gain Error                       | Internal Voltage Reference:<br>VDDA_ADC = 1.8V<br>External Voltage Reference:<br>VREFP - VREFN = 1.8V                                                            | ±2                         |     |                            | LSB  |
| Offset Error                     | Internal Voltage Reference:<br>VDDA_ADC = 1.8V<br>External Voltage Reference:<br>VREFP - VREFN = 1.8V                                                            | ±2                         |     |                            | LSB  |
| Input Sampling Capacitance       |                                                                                                                                                                  | 5.5                        |     |                            | pF   |
| Signal-to-Noise Ratio (SNR)      | Internal Voltage Reference:<br>VDDA_ADC = 1.8V<br>External Voltage Reference:<br>VREFP - VREFN = 1.8V<br>Input Signal: 30 kHz sine wave at<br>-0.5 dB Full Scale | 70                         |     |                            | dB   |
| Total Harmonic Distortion (THD)  | Internal Voltage Reference:<br>VDDA_ADC = 1.8V<br>External Voltage Reference:<br>VREFP - VREFN = 1.8V<br>Input Signal: 30 kHz sine wave at<br>-0.5 dB Full Scale | 75                         |     |                            | dB   |

**Table 3-17. TSC\_ADC Electrical Parameters (continued)**

| PARAMETER                                                      | CONDITION                                                                                                                                               | MIN | NOM                                    | MAX | UNIT             |
|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----|----------------------------------------|-----|------------------|
| Spurious Free Dynamic Range                                    | Internal Voltage Reference: VDDA_ADC = 1.8V<br>External Voltage Reference: VREFP - VREFN = 1.8V<br>Input Signal: 30 kHz sine wave at -0.5 dB Full Scale |     | 80                                     |     | dB               |
| Signal-to-Noise Plus Distortion                                | Internal Voltage Reference: VDDA_ADC = 1.8V<br>External Voltage Reference: VREFP - VREFN = 1.8V<br>Input Signal: 30 kHz sine wave at -0.5 dB Full Scale |     | 69                                     |     | dB               |
| VREFP and VREFN Input Impedance                                |                                                                                                                                                         |     | 20                                     |     | kΩ               |
| Input Impedance of AIN[7:0] <sup>(2)</sup>                     | f = input frequency                                                                                                                                     |     | [1/((65.97 x 10 <sup>-12</sup> ) x f)] |     | Ω                |
| Sampling Dynamics                                              |                                                                                                                                                         |     |                                        |     |                  |
| Conversion Time                                                |                                                                                                                                                         |     | 15                                     |     | ADC Clock Cycles |
| Acquisition Time                                               |                                                                                                                                                         |     | 2                                      |     | ADC Clock Cycles |
| Sampling Rate                                                  | ADC Clock = 3 MHz                                                                                                                                       |     | 200                                    |     | kSPS             |
| Channel-to-Channel Isolation                                   |                                                                                                                                                         |     | 100                                    |     | dB               |
| Touchscreen Switch Drivers                                     |                                                                                                                                                         |     |                                        |     |                  |
| Pull-Up and Pull-Down Switch ON Resistance (Ron)               |                                                                                                                                                         |     | 2                                      |     | Ω                |
| Pull-Up and Pull-Down Switch Current Leakage I <sub>leak</sub> | Source impedance = 500 Ω                                                                                                                                |     |                                        | 0.5 | uA               |
| Drive Current                                                  |                                                                                                                                                         |     |                                        | 25  | mA               |
| Touchscreen Resistance                                         |                                                                                                                                                         |     |                                        | 6   | kΩ               |
| Pen Touch Detect                                               |                                                                                                                                                         |     |                                        | 2   | kΩ               |

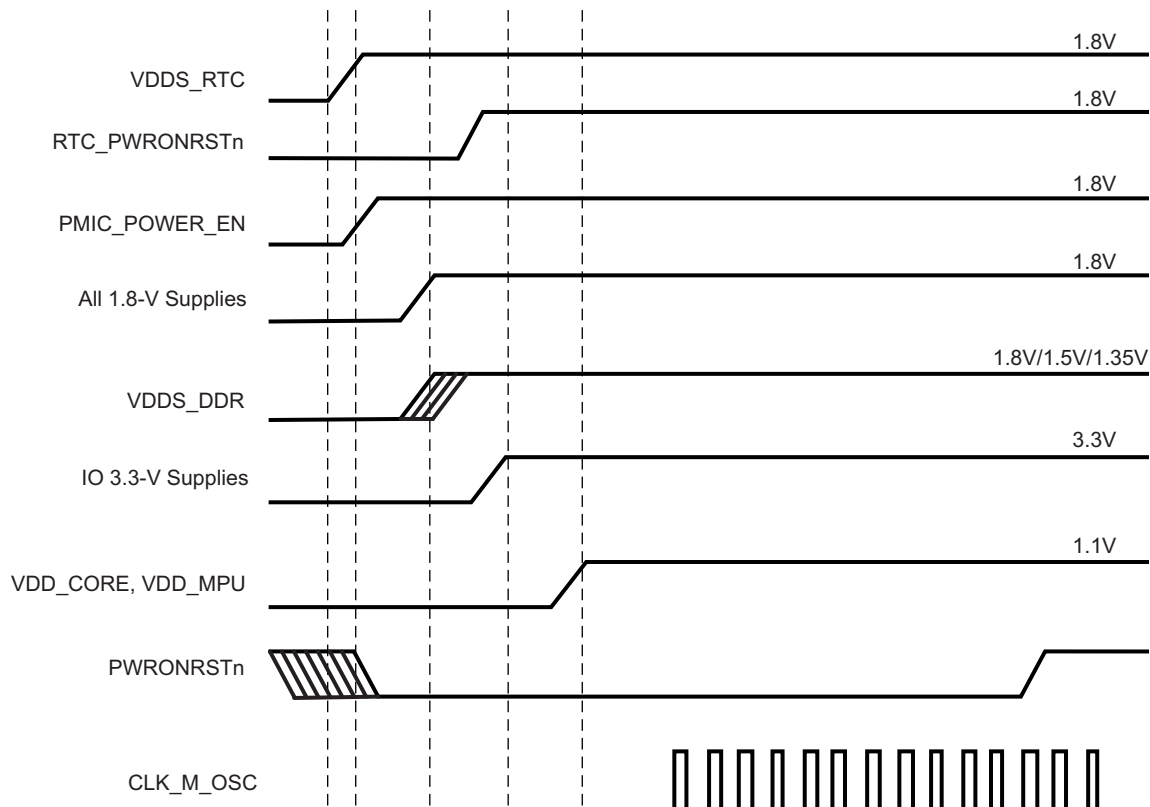
(1) VREFP and VREFN must be tied to ground if the internal voltage reference is used.

(2) This parameter is valid when the respective AIN terminal is configured to operate as a general-purpose ADC input.

## 4 Power and Clocking

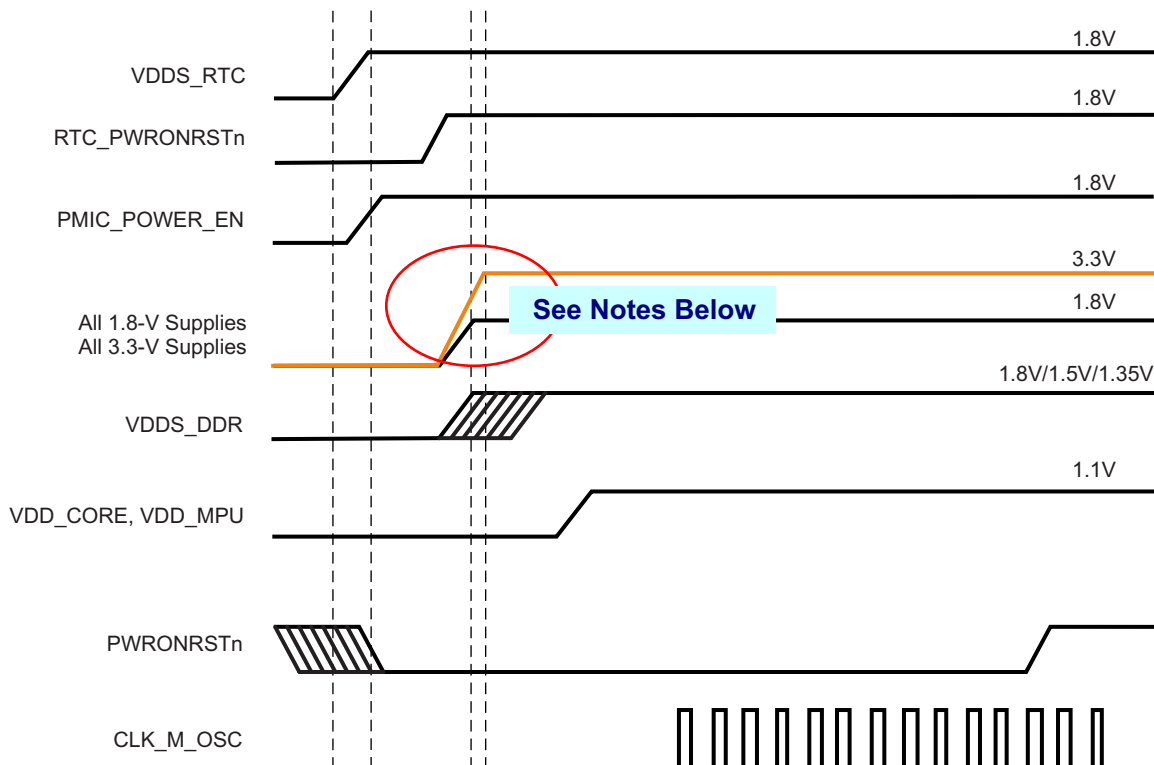
### 4.1 Power Supplies

#### 4.1.1 Power-Up Sequencing



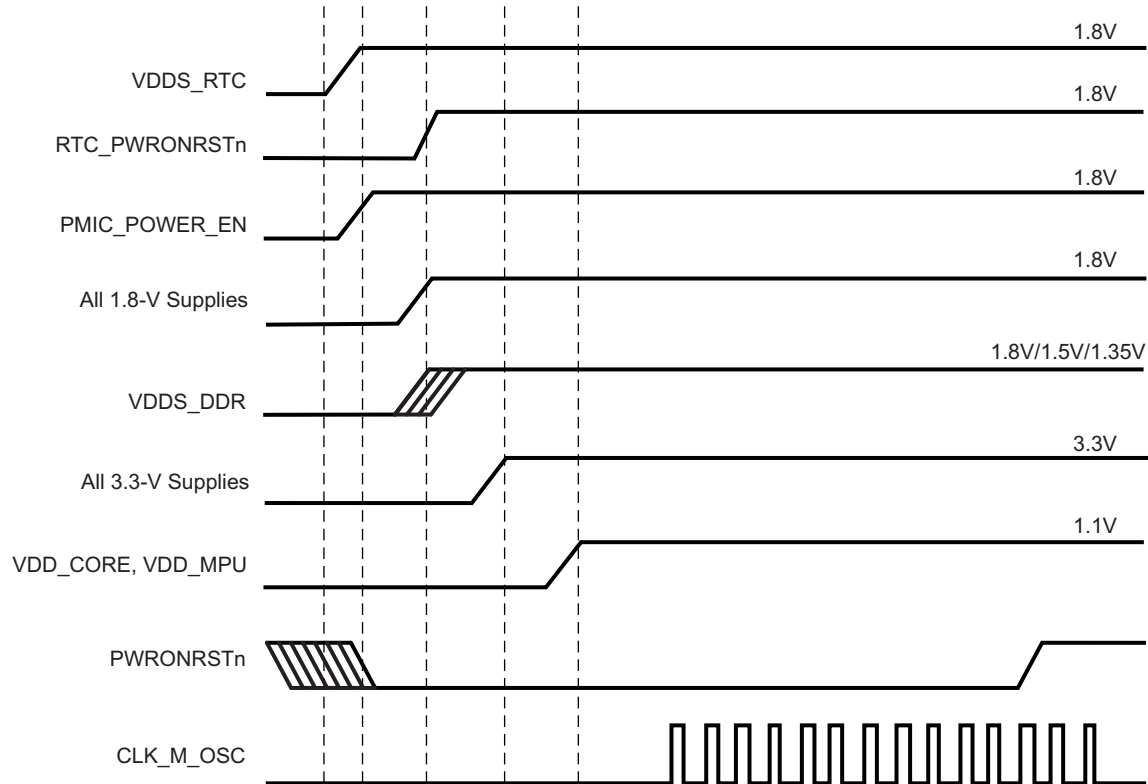
- RTC\_PWRONRSTn should be asserted for at least 1 ms to provide enough time for the internal RTC LDO output to reach a valid level before RTC reset is released.
- When using the ZCZ package option, VDD\_MPU and VDD\_CORE power inputs may be powered from the same source if the application only uses operating performance points (OPPs) that define a common power supply voltage for VDD\_MPU and VDD\_CORE. The ZCE package option has the VDD\_MPU domain merged with the VDD\_CORE domain.
- If a USB port is not used, the respective VDDA1P8V\_USB terminal may be connected to any 1.8-V power supply and the respective VDDA3P3V\_USB terminal may be connected to any 3.3-V power supply. If the system does not have a 3.3-V power supply, the VDDA3P3V\_USB terminal may be connected to ground.
- If the system uses mDDR or DDR2 memory devices, VDDSD\_DDR can be ramped simultaneously with the other 1.8-V IO power supplies.
- VDDSD\_RTC can be ramped independent of other power supplies if PMIC\_POWER\_EN functionality is not required. If VDDSD\_RTC is ramped after VDD\_CORE, there might be a small amount of additional leakage current on VDD\_CORE. The power sequence shown provides the lowest leakage option.
- To configure VDDSHVx [1-6] as 1.8 V, power up the respective VDDSHVx [1-6] to 1.8 V following the recommended sequence. To configure VDDSHVx [1-6] as 3.3 V, power up the respective VDDSHVx [1-6] to 3.3 V following the recommended sequence.

**Figure 4-1. Preferred Power-Supply Sequencing with Dual-Voltage IOs Configured as 3.3 V**



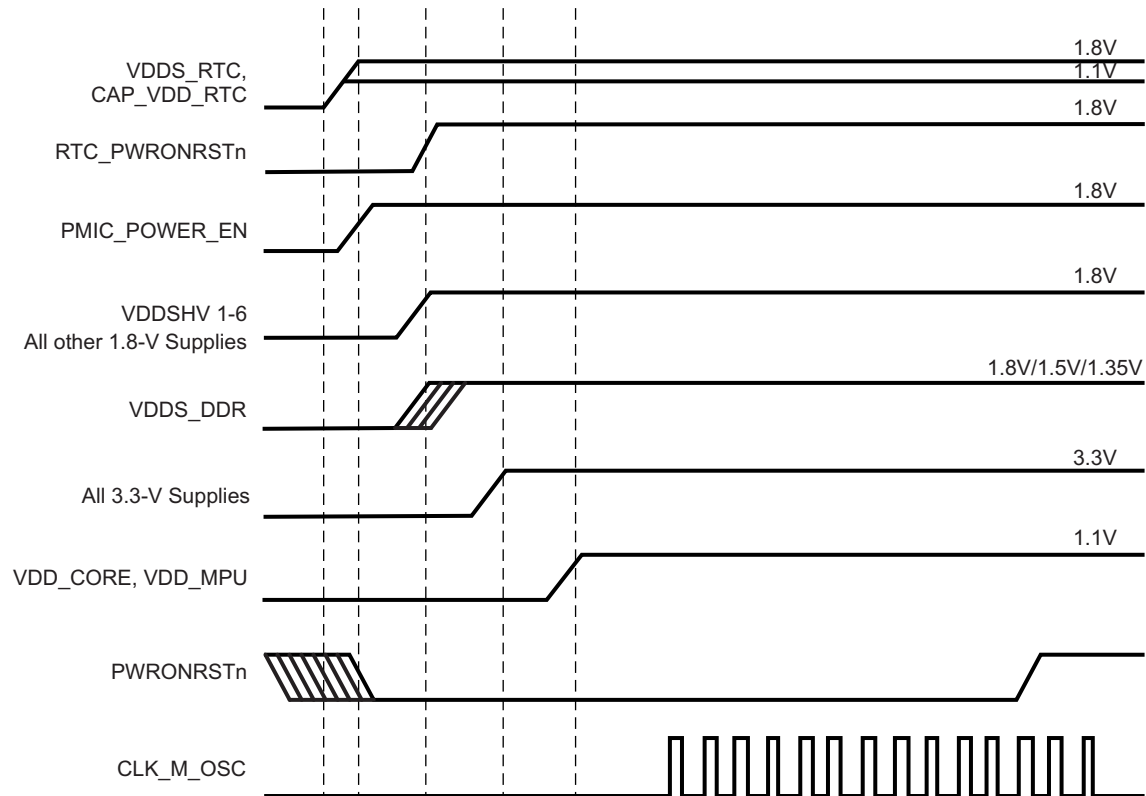
- RTC\_PWRONRSTn should be asserted for at least 1 ms to provide enough time for the internal RTC LDO output to reach a valid level before RTC reset is released.
- The 3.3-V IO power supplies may be ramped simultaneously with the 1.8-V IO power supplies if the voltage sourced by any 3.3-V power supplies does not exceed the voltage sourced by any 1.8-V power supply by more than 2 V. Serious reliability issues may occur if the system power supply design allows any 3.3-V IO power supplies to exceed any 1.8-V IO power supplies by more than 2 V.
- When using the ZCZ package option, VDD\_MPU and VDD\_CORE power inputs may be powered from the same source if the application only uses operating performance points (OPPs) that define a common power supply voltage for VDD\_MPU and VDD\_CORE. The ZCE package option has the VDD\_MPU domain merged with the VDD\_CORE domain.
- If a USB port is not used, the respective VDDA1P8V\_USB terminal may be connected to any 1.8-V power supply and the respective VDDA3P3V\_USB terminal may be connected to any 3.3-V power supply. If the system does not have a 3.3-V power supply, the VDDA3P3V\_USB terminal may be connected to ground.
- If the system uses mDDR or DDR2 memory devices, VDDS\_DDR can be ramped simultaneously with the other 1.8-V IO power supplies.
- VDDS\_RTC can be ramped independent of other power supplies if PMIC\_POWER\_EN functionality is not required. If VDDS\_RTC is ramped after VDD\_CORE, there might be a small amount of additional leakage current on VDD\_CORE. The power sequence shown provides the lowest leakage option.
- To configure VDDSHVx [1-6] as 1.8 V, power up the respective VDDSHVx [1-6] to 1.8 V following the recommended sequence. To configure VDDSHVx [1-6] as 3.3 V, power up the respective VDDSHVx [1-6] to 3.3 V following the recommended sequence.

**Figure 4-2. Alternate Power-Supply Sequencing with Dual-Voltage IOs Configured as 3.3 V**



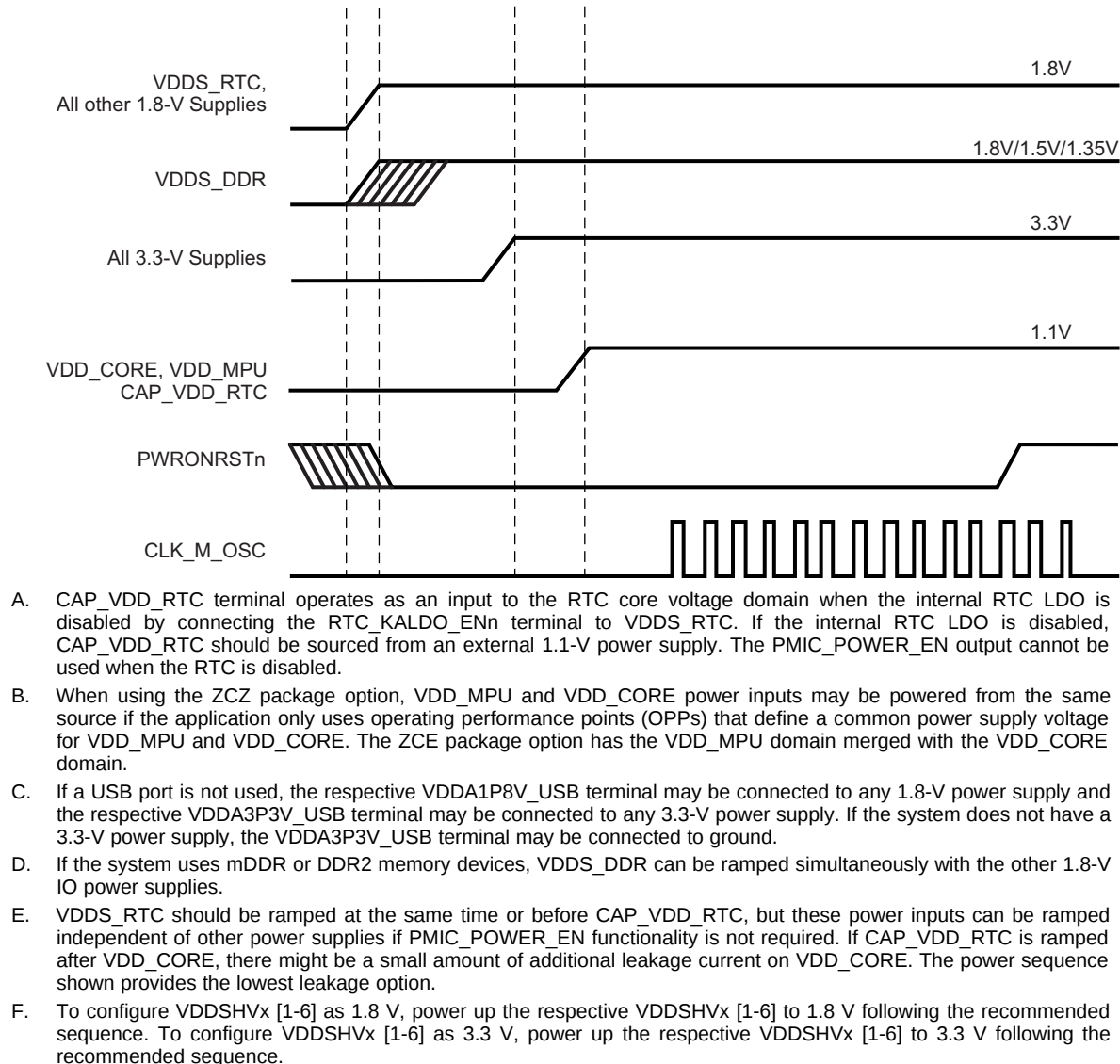
- A. RTC\_PWRONRSTn should be asserted for at least 1 ms to provide enough time for the internal RTC LDO output to reach a valid level before RTC reset is released.
- B. When using the ZCZ package option, VDD\_MPU and VDD\_CORE power inputs may be powered from the same source if the application only uses operating performance points (OPPs) that define a common power supply voltage for VDD\_MPU and VDD\_CORE. The ZCE package option has the VDD\_MPU domain merged with the VDD\_CORE domain.
- C. If a USB port is not used, the respective VDDA1P8V\_USB terminal may be connected to any 1.8-V power supply and the respective VDDA3P3V\_USB terminal may be connected to any 3.3-V power supply. If the system does not have a 3.3-V power supply, the VDDA3P3V\_USB terminal may be connected to ground.
- D. If the system uses mDDR or DDR2 memory devices, VDDS\_DDR can be ramped simultaneously with the other 1.8-V IO power supplies.
- E. VDDS\_RTC can be ramped independent of other power supplies if PMIC\_POWER\_EN functionality is not required. If VDDS\_RTC is ramped after VDD\_CORE, there might be a small amount of additional leakage current on VDD\_CORE. The power sequence shown provides the lowest leakage option.
- F. To configure VDDSHVx [1-6] as 1.8 V, power up the respective VDDSHVx [1-6] to 1.8 V following the recommended sequence. To configure VDDSHVx [1-6] as 3.3 V, power up the respective VDDSHVx [1-6] to 3.3 V following the recommended sequence.

**Figure 4-3. Power-Supply Sequencing with Dual-Voltage I/Os Configured as 1.8 V**



- RTC\_PWRONRSTn should be asserted for at least 1 ms to provide enough time for the internal RTC LDO output to reach a valid level before RTC reset is released.
- The CAP\_VDD\_RTC terminal operates as an input to the RTC core voltage domain when the internal RTC LDO is disabled by connecting the RTC\_KALDO\_ENn terminal to VDDSD\_RTC. If the internal RTC LDO is disabled, CAP\_VDD\_RTC should be sourced from an external 1.1-V power supply.
- When using the ZCZ package option, VDD\_MPU and VDD\_CORE power inputs may be powered from the same source if the application only uses operating performance points (OPPs) that define a common power supply voltage for VDD\_MPU and VDD\_CORE. The ZCE package option has the VDD\_MPU domain merged with the VDD\_CORE domain.
- If a USB port is not used, the respective VDDA1P8V\_USB terminal may be connected to any 1.8-V power supply and the respective VDDA3P3V\_USB terminal may be connected to any 3.3-V power supply. If the system does not have a 3.3-V power supply, the VDDA3P3V\_USB terminal may be connected to ground.
- If the system uses mDDR or DDR2 memory devices, VDDSD\_DDR can be ramped simultaneously with the other 1.8-V IO power supplies.
- VDDSD\_RTC should be ramped at the same time or before CAP\_VDD\_RTC, but these power inputs can be ramped independent of other power supplies if PMIC\_POWER\_EN functionality is not required. If CAP\_VDD\_RTC is ramped after VDD\_CORE, there might be a small amount of additional leakage current on VDD\_CORE. The power sequence shown provides the lowest leakage option.
- To configure VDDSHVx [1-6] as 1.8 V, power up the respective VDDSHVx [1-6] to 1.8 V following the recommended sequence. To configure VDDSHVx [1-6] as 3.3 V, power up the respective VDDSHVx [1-6] to 3.3 V following the recommended sequence.

**Figure 4-4. Power-Supply Sequencing with Internal RTC LDO Disabled**



**Figure 4-5. Power-Supply Sequencing with RTC Feature Disabled**

#### 4.1.2 Power-Down Sequencing

PWRONRSTn input terminal should be taken low, which stops all internal clocks before power supplies are turned off. All other external clocks to the device should be shut off.

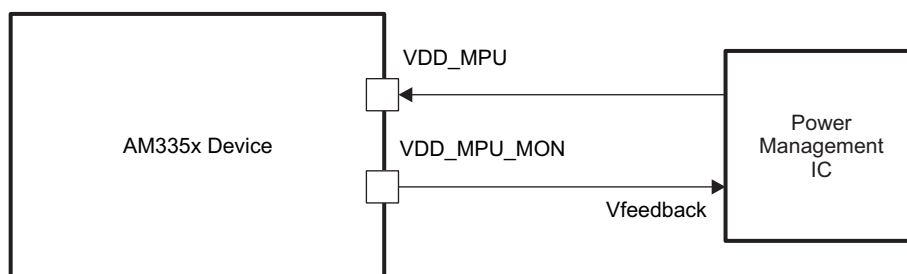
The preferred way to sequence power down is to have all the power supplies ramped down sequentially in the exact reverse order of the power-up sequencing. In other words, the power supply that has been ramped up first should be the last one that should be ramped down. This ensures there would be no spurious current paths during the power-down sequence. The VDDS power supply must ramp down after all 3.3-V VDDSHVx [1-6] power supplies.

If it is desired to ramp down VDDS and VDDSHVx [1-6] simultaneously, it should always be ensured that the difference between VDDS and VDDSHVx [1-6] during the entire power-down sequence is <2 V. Any violation of this could cause reliability risks for the device. Further, it is recommended to maintain VDDS ≥1.5V as all the other supplies fully ramp down to minimize in-rush currents.

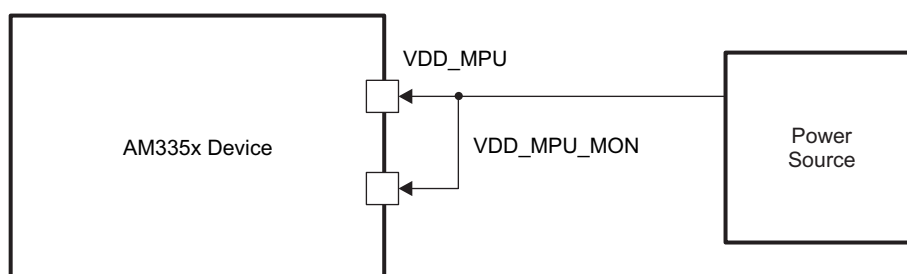
If none of the VDDSHVx [1-6] power supplies are configured as 3.3 V, the VDDS power supply may ramp down along with the VDDSHVx [1-6] supplies or after all the VDDSHVx [1-6] supplies have ramped down. It is recommended to maintain VDDS  $\geq 1.5\text{V}$  as all the other supplies fully ramp down to minimize in-rush currents.

### 4.1.3 VDD\_MPU\_MON Connections

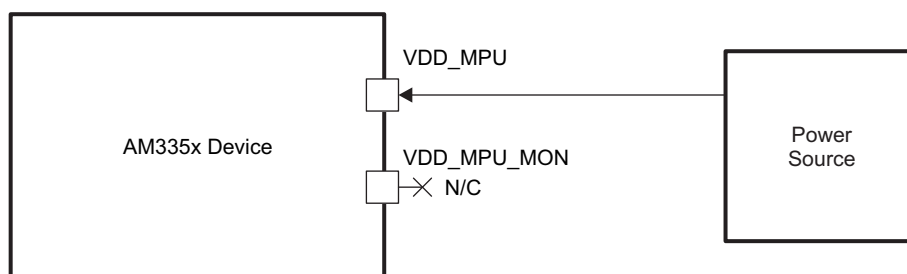
Figure 4-6 shows the VDD\_MPU\_MON connectivity. VDD\_MPU\_MON connectivity is available only on the ZCZ package.



Connection for VDD\_MPU\_MON if voltage monitoring is used



Preferred connection for VDD\_MPU\_MON if voltage monitoring is NOT used



Optional connection for VDD\_MPU\_MON if voltage monitoring is NOT used

**Figure 4-6. VDD\_MPU\_MON Connectivity**

#### 4.1.4 Digital Phase-Locked Loop Power Supply Requirements

The digital phase-locked loop (DPLL) provides all interface clocks and functional clocks to the processor of the AM335x device. The AM335x device integrates 5 different DPLLs—Core DPLL, Per DPLL, Display DPLL, DDR DPLL, MPU DPLL.

Figure 4-7 illustrates the power supply connectivity implemented in the AM335x device. Table 4-1 provides the power supply requirements for the DPLL.

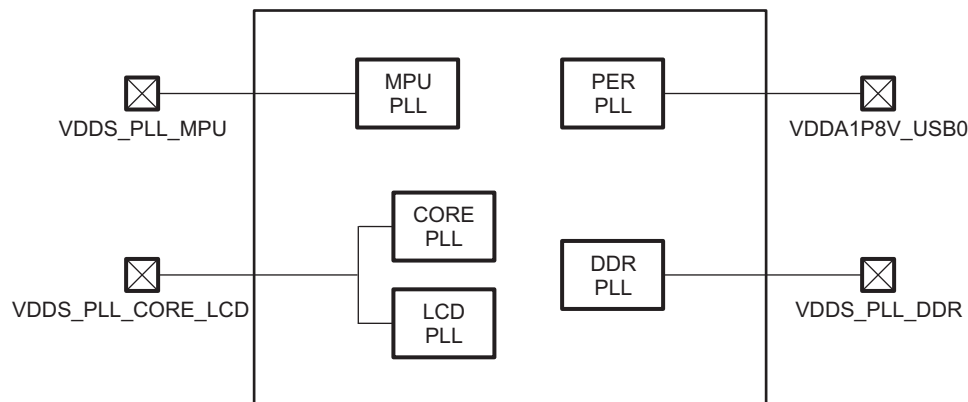


Figure 4-7. DPLL Power Supply Connectivity

Table 4-1. DPLL Power Supply Requirements

| SUPPLY NAME       | DESCRIPTION                                                | MIN  | NOM | MAX  | UNITS    |
|-------------------|------------------------------------------------------------|------|-----|------|----------|
| VDDA1P8V_USB0     | Supply voltage range for USBPHY and PER DPLL, Analog, 1.8V | 1.71 | 1.8 | 1.89 | V        |
|                   | Max. peak-to-peak supply noise                             |      |     | 50   | mV (p-p) |
| VDDS_PLL_MPU      | Supply voltage range for DPLL MPU, Analog                  | 1.71 | 1.8 | 1.89 | V        |
|                   | Max. peak-to-peak supply noise                             |      |     | 50   | mV (p-p) |
| VDDS_PLL_CORE_LCD | Supply voltage range for DPLL CORE and LCD, Analog         | 1.71 | 1.8 | 1.89 | V        |
|                   | Max. peak-to-peak supply noise                             |      |     | 50   | mV (p-p) |
| VDDS_PLL_DDR      | Supply voltage range for DPLL DDR, Analog                  | 1.71 | 1.8 | 1.89 | V        |
|                   | Max. peak-to-peak supply noise                             |      |     | 50   | mV (p-p) |

## 4.2 Clock Specifications

### 4.2.1 Input Clock Specifications

The AM335x device has two clock inputs. Each clock input passes through an internal oscillator which can be connected to an external crystal circuit (oscillator mode) or external LVCMOS square-wave digital clock source (bypass mode). The oscillators automatically operate in bypass mode when their input is connected to an external LVCMOS square-wave digital clock source. The oscillator associated with a specific clock input must be enabled when the clock input is being used in either oscillator mode or bypass mode.

The OSC1 oscillator provides a 32.768-kHz reference clock to the real-time clock (RTC) and is connected to the RTC\_XTALIN and RTC\_XTALOUT terminals. This clock source is referred to as the 32K oscillator (CLK\_32K\_RTC) in the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)). OSC1 is disabled by default after power is applied. This clock input is optional and may not be required if the RTC is configured to receive a clock from the internal 32k RC oscillator (CLK\_RC32K) or peripheral PLL (CLK\_32KHZ) which receives a reference clock from the OSC0 input.

The OSC0 oscillator provides a 19.2-MHz, 24-MHz, 25-MHz, or 26-MHz reference clock which is used to clock all non-RTC functions and is connected to the XTALIN and XTALOUT terminals. This clock source is referred to as the master oscillator (CLK\_M\_OSC) in the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)). OSC0 is enabled by default after power is applied.

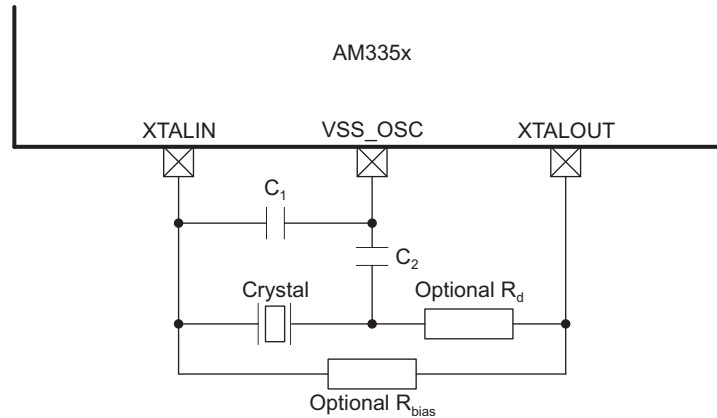
For more information related to recommended circuit topologies and crystal oscillator circuit requirements for these clock inputs, see [Section 4.2.2](#).

### 4.2.2 Input Clock Requirements

#### 4.2.2.1 OSC0 Internal Oscillator Clock Source

[Figure 4-8](#) shows the recommended crystal circuit. It is recommended that pre-production printed circuit board (PCB) designs include the two optional resistors  $R_{bias}$  and  $R_d$  in case they are required for proper oscillator operation when combined with production crystal circuit components. In most cases,  $R_{bias}$  is not required and  $R_d$  is a 0- $\Omega$  resistor. These resistors may be removed from production PCB designs after evaluating oscillator performance with production crystal circuit components installed on pre-production PCBs.

The XTALIN terminal has a 15 - 40 k $\Omega$  internal pull-down resistor which is enabled when OSC0 is disabled. This internal resistor prevents the XTALIN terminal from floating to an invalid logic level which may increase leakage current through the oscillator input buffer.



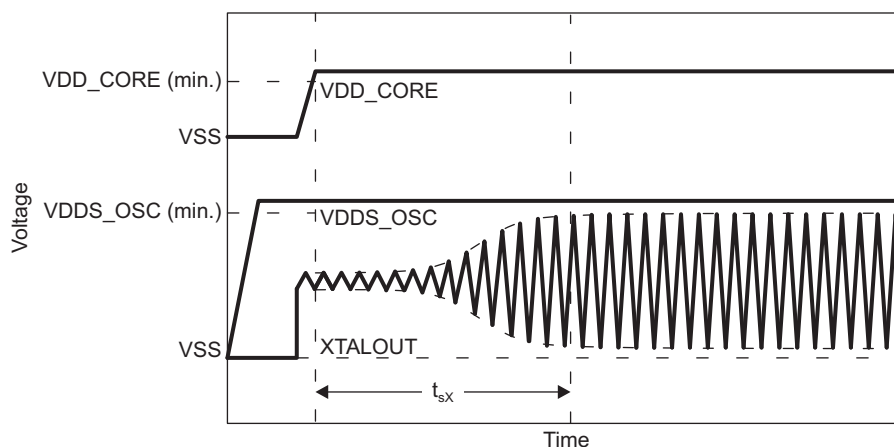
- A. Oscillator components (Crystal,  $C_1$ ,  $C_2$ , optional  $R_{bias}$  and  $R_d$ ) must be located close to the AM335x package. Parasitic capacitance to the printed circuit board (PCB) ground and other signals should be minimized to reduce noise coupled into the oscillator. The VSS\_OSC terminal provides a Kelvin ground reference for the external crystal components. External crystal component grounds should only be connected to the VSS\_OSC terminal and should not be connected to the PCB ground plane.
- B.  $C_1$  and  $C_2$  represent the total capacitance of the respective PCB trace, load capacitor, and other components (excluding the crystal) connected to each crystal terminal. The value of capacitors  $C_1$  and  $C_2$  should be selected to provide the total load capacitance,  $C_L$ , specified by the crystal manufacturer. The total load capacitance is  $C_L = [(C_1 * C_2) / (C_1 + C_2)] + C_{shunt}$ , where  $C_{shunt}$  is the crystal shunt capacitance ( $C_0$ ) specified by the crystal manufacturer plus any mutual capacitance ( $C_{pkg} + C_{PCB}$ ) seen across the AM335x XTALIN and XTALOUT signals. For recommended values of crystal circuit components, see [Table 4-2](#).

**Figure 4-8. OSC0 Crystal Circuit Schematic**
**Table 4-2. OSC0 Crystal Circuit Requirements**

| NAME        | DESCRIPTION                               |                                                                                                                                      | MIN   | TYP                       | MAX  | UNIT     |
|-------------|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------|---------------------------|------|----------|
| $f_{xtal}$  | Crystal parallel resonance frequency      | Fundamental mode oscillation only                                                                                                    |       | 19.2, 24.0, 25.0, or 26.0 |      | MHz      |
|             | Crystal frequency stability and tolerance |                                                                                                                                      | -50.0 |                           | 50.0 | ppm      |
| $C_{C1}$    | $C_1$ capacitance                         |                                                                                                                                      | 12.0  |                           | 24.0 | pF       |
| $C_{C2}$    | $C_2$ capacitance                         |                                                                                                                                      | 12.0  |                           | 24.0 | pF       |
| $C_{shunt}$ | Shunt capacitance                         |                                                                                                                                      |       |                           | 5.0  | pF       |
| ESR         | Crystal effective series resistance       | $f_{xtal} = 19.2$ MHz, oscillator has nominal negative resistance of 272 $\Omega$ and worst-case negative resistance of 163 $\Omega$ |       |                           | 54.4 | $\Omega$ |
|             |                                           | $f_{xtal} = 24.0$ MHz, oscillator has nominal negative resistance of 240 $\Omega$ and worst-case negative resistance of 144 $\Omega$ |       |                           | 48.0 | $\Omega$ |
|             |                                           | $f_{xtal} = 25.0$ MHz, oscillator has nominal negative resistance of 233 $\Omega$ and worst-case negative resistance of 140 $\Omega$ |       |                           | 46.6 | $\Omega$ |
|             |                                           | $f_{xtal} = 26.0$ MHz, oscillator has nominal negative resistance of 227 $\Omega$ and worst-case negative resistance of 137 $\Omega$ |       |                           | 45.3 | $\Omega$ |

**Table 4-3. OSC0 Crystal Circuit Characteristics**

| NAME              | DESCRIPTION                                                                                                                                                                                                                                                                     | MIN                                                   | TYP | MAX  | UNIT |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|-----|------|------|
| C <sub>pkg</sub>  | Shunt capacitance of package                                                                                                                                                                                                                                                    | ZCE package                                           |     | 0.01 | pF   |
|                   |                                                                                                                                                                                                                                                                                 | ZCZ package                                           |     | 0.01 | pF   |
| P <sub>xtal</sub> | The actual values of the ESR, f <sub>xtal</sub> , and C <sub>L</sub> should be used to yield a typical crystal power dissipation value. Using the maximum values specified for ESR, f <sub>xtal</sub> , and C <sub>L</sub> parameters yields a maximum power dissipation value. | $P_{xtal} = 0.5 ESR (2 \pi f_{xtal} C_L VDD_{OSC})^2$ |     |      |      |
| t <sub>sX</sub>   | Start-up time                                                                                                                                                                                                                                                                   | 1.5                                                   |     |      | ms   |



**Figure 4-9. OSC0 Start-up Time**

#### 4.2.2.2 OSC0 LVC MOS Digital Clock Source

Figure 4-10 shows the recommended oscillator connections when OSC0 is connected to an LVC MOS square-wave digital clock source. The LVC MOS clock source is connected to the XTALIN terminal. In this mode of operation, the XTALOUT terminal should not be used to source any external components. The printed circuit board design should provide a mechanism to disconnect the XTALOUT terminal from any external components or signal traces that may couple noise into OSC0 via the XTALOUT terminal.

The XTALIN terminal has a 15 - 40 k $\Omega$  internal pull-down resistor which is enabled when OSC0 is disabled. This internal resistor prevents the XTALIN terminal from floating to an invalid logic level which may increase leakage current through the oscillator input buffer.

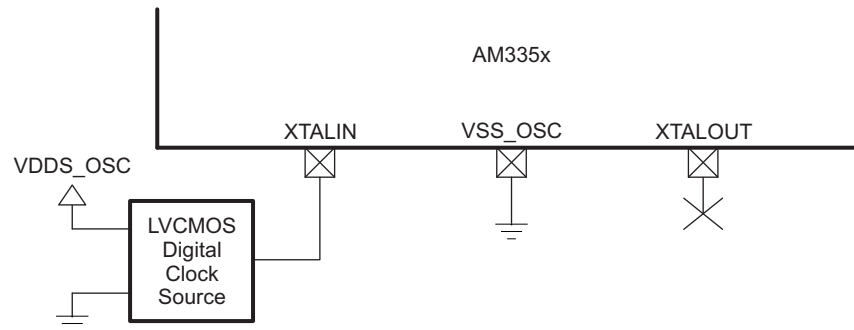


Figure 4-10. OSC0 LVC MOS Circuit Schematic

Table 4-4. OSC0 LVC MOS Reference Clock Requirements

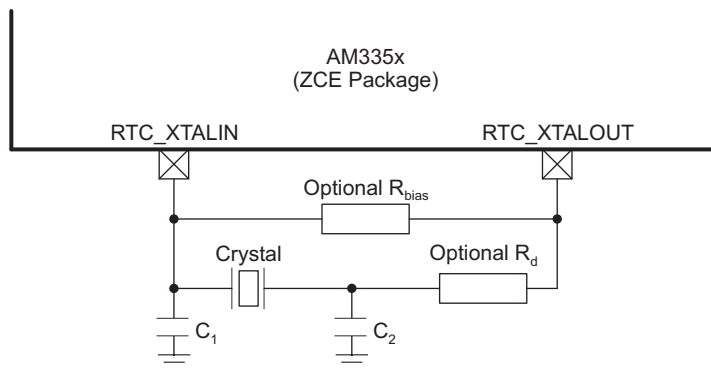
| NAME              | DESCRIPTION                                                               | MIN | TYP                    | MAX | UNIT |
|-------------------|---------------------------------------------------------------------------|-----|------------------------|-----|------|
| $f_{(XTALIN)}$    | Frequency, LVC MOS reference clock                                        |     | 19.2, 24, 25,<br>or 26 |     | MHz  |
|                   | Frequency, LVC MOS reference clock stability and tolerance <sup>(1)</sup> | -50 |                        | 50  | ppm  |
| $t_{dc(XTALIN)}$  | Duty cycle, LVC MOS reference clock period                                | 45  |                        | 55  | %    |
| $t_{jpp(XTALIN)}$ | Jitter peak-to-peak, LVC MOS reference clock period                       | -1  |                        | 1   | %    |
| $t_{R(XTALIN)}$   | Time, LVC MOS reference clock rise                                        |     |                        | 5   | ns   |
| $t_{F(XTALIN)}$   | Time, LVC MOS reference clock fall                                        |     |                        | 5   | ns   |

(1) Initial accuracy, temperature drift, and aging effects should be combined when evaluating a reference clock for this requirement.

#### 4.2.2.3 OSC1 Internal Oscillator Clock Source

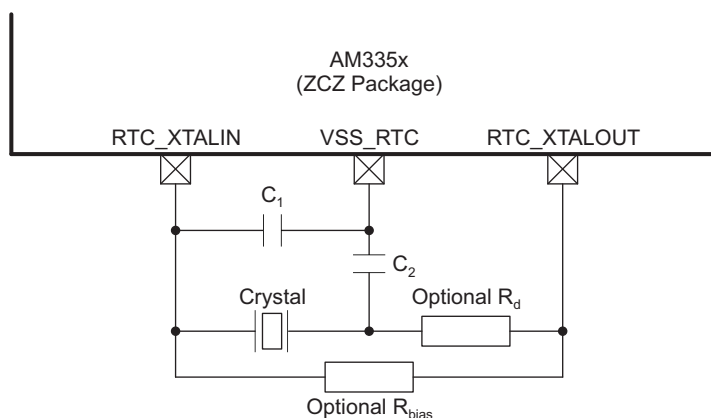
Figure 4-11 shows the recommended crystal circuit for OSC1 of the ZCE package and Figure 4-12 shows the recommended crystal circuit for OSC1 of the ZCZ package. It is recommended that pre-production printed circuit board (PCB) designs include the two optional resistors  $R_{bias}$  and  $R_d$  in case they are required for proper oscillator operation when combined with production crystal circuit components. In most cases,  $R_{bias}$  is not required and  $R_d$  is a 0- $\Omega$  resistor. These resistors may be removed from production PCB designs after evaluating oscillator performance with production crystal circuit components installed on pre-production PCBs.

The RTC\_XTALIN terminal has a 10 - 40 k $\Omega$  internal pull-up resistor which is enabled when OSC1 is disabled. This internal resistor prevents the RTC\_XTALIN terminal from floating to an invalid logic level which may increase leakage current through the oscillator input buffer.



- A. Oscillator components (Crystal,  $C_1$ ,  $C_2$ , optional  $R_{bias}$  and  $R_d$ ) must be located close to the AM335x package. Parasitic capacitance to the printed circuit board (PCB) ground and other signals should be minimized to reduce noise coupled into the oscillator.
- B.  $C_1$  and  $C_2$  represent the total capacitance of the respective PCB trace, load capacitor, and other components (excluding the crystal) connected to each crystal terminal. The value of capacitors  $C_1$  and  $C_2$  should be selected to provide the total load capacitance,  $C_L$ , specified by the crystal manufacturer. The total load capacitance is  $C_L = [(C_1 * C_2) / (C_1 + C_2)] + C_{shunt}$ , where  $C_{shunt}$  is the crystal shunt capacitance ( $C_0$ ) specified by the crystal manufacturer plus any mutual capacitance ( $C_{pkg} + C_{PCB}$ ) seen across the AM335x RTC\_XTALIN and RTC\_XTALOUT signals. For recommended values of crystal circuit components, see [Table 4-5](#).

**Figure 4-11. OSC1 (ZCE Package) Crystal Circuit Schematic**



- A. Oscillator components (Crystal,  $C_1$ ,  $C_2$ , optional  $R_{bias}$  and  $R_d$ ) must be located close to the AM335x package. Parasitic capacitance to the printed circuit board (PCB) ground and other signals should be minimized to reduce noise coupled into the oscillator.
- B.  $C_1$  and  $C_2$  represent the total capacitance of the respective PCB trace, load capacitor, and other components (excluding the crystal) connected to each crystal terminal. The value of capacitors  $C_1$  and  $C_2$  should be selected to provide the total load capacitance,  $C_L$ , specified by the crystal manufacturer. The total load capacitance is  $C_L = [(C_1 * C_2) / (C_1 + C_2)] + C_{shunt}$ , where  $C_{shunt}$  is the crystal shunt capacitance ( $C_0$ ) specified by the crystal manufacturer plus any mutual capacitance ( $C_{pkg} + C_{PCB}$ ) seen across the AM335x RTC\_XTALIN and RTC\_XTALOUT signals. For recommended values of crystal circuit components, see [Table 4-5](#).

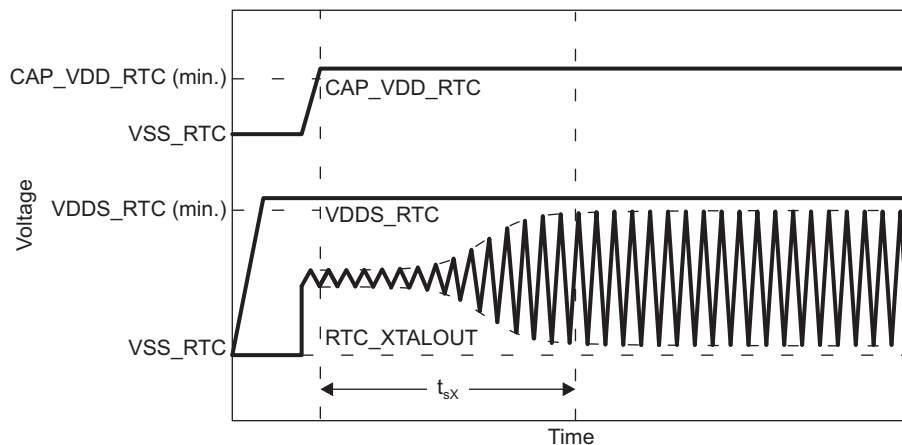
**Figure 4-12. OSC1 (ZCZ Package) Crystal Circuit Schematic**

**Table 4-5. OSC1 Crystal Circuit Requirements**

| NAME               | DESCRIPTION                               |                                                                                                                                   | MIN   | TYP    | MAX  | UNIT |
|--------------------|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-------|--------|------|------|
| f <sub>xtal</sub>  | Crystal parallel resonance frequency      | Fundamental mode oscillation only                                                                                                 |       | 32.768 |      | kHz  |
|                    | Crystal frequency stability and tolerance | Maximum RTC error = 10.512 minutes per year                                                                                       | -20.0 |        | 20.0 | ppm  |
|                    |                                           | Maximum RTC error = 26.28 minutes per year                                                                                        | -50.0 |        | 50.0 | ppm  |
| C <sub>C1</sub>    | C <sub>1</sub> capacitance                |                                                                                                                                   | 12.0  |        | 24.0 | pF   |
| C <sub>C2</sub>    | C <sub>2</sub> capacitance                |                                                                                                                                   | 12.0  |        | 24.0 | pF   |
| C <sub>shunt</sub> | Shunt capacitance                         |                                                                                                                                   |       |        | 1.5  | pF   |
| ESR                | Crystal effective series resistance       | f <sub>xtal</sub> = 32.768 kHz, oscillator has nominal negative resistance of 725 kΩ and worst-case negative resistance of 250 kΩ |       |        | 80   | kΩ   |

**Table 4-6. OSC1 Crystal Circuit Characteristics**

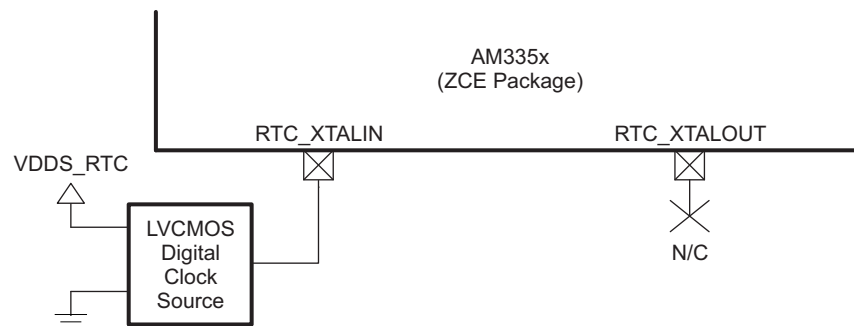
| NAME              | DESCRIPTION                                                                                                                                                                                                                                                                     |             | MIN | TYP                                                                                                   | MAX | UNIT |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----|-------------------------------------------------------------------------------------------------------|-----|------|
| C <sub>pkg</sub>  | Shunt capacitance of package                                                                                                                                                                                                                                                    | ZCE package |     | 0.17                                                                                                  |     | pF   |
|                   |                                                                                                                                                                                                                                                                                 | ZCZ package |     | 0.01                                                                                                  |     | pF   |
| P <sub>xtal</sub> | The actual values of the ESR, f <sub>xtal</sub> , and C <sub>L</sub> should be used to yield a typical crystal power dissipation value. Using the maximum values specified for ESR, f <sub>xtal</sub> , and C <sub>L</sub> parameters yields a maximum power dissipation value. |             |     | P <sub>xtal</sub> = 0.5 ESR (2 π f <sub>xtal</sub> C <sub>L</sub> VDD <sub>S_RTC</sub> ) <sup>2</sup> |     |      |
| t <sub>sX</sub>   | Start-up time                                                                                                                                                                                                                                                                   |             |     | 2                                                                                                     |     | s    |


**Figure 4-13. OSC1 Start-up Time**

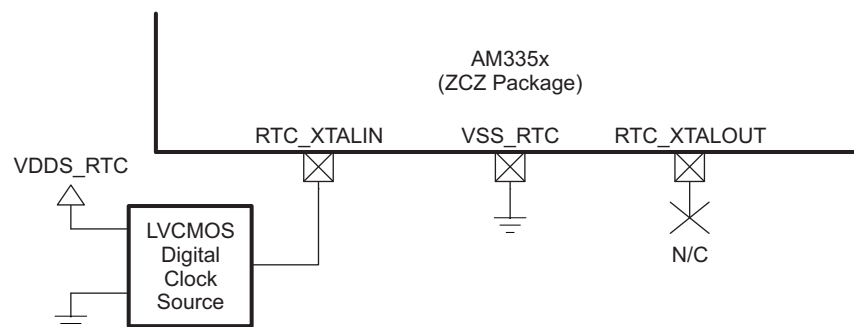
#### 4.2.2.4 OSC1 LVC MOS Digital Clock Source

Figure 4-14 shows the recommended oscillator connections when OSC1 of the ZCE package is connected to an LVC MOS square-wave digital clock source and Figure 4-15 shows the recommended oscillator connections when OSC1 of the ZCZ package is connected to an LVC MOS square-wave digital clock source. The LVC MOS clock source is connected to the RTC\_XTALIN terminal. In this mode of operation, the RTC\_XTALOUT terminal should not be used to source any external components. The printed circuit board design should provide a mechanism to disconnect the RTC\_XTALOUT terminal from any external components or signal traces that may couple noise into OSC1 via the RTC\_XTALOUT terminal.

The RTC\_XTALIN terminal has a 10 - 40 k $\Omega$  internal pull-up resistor which is enabled when OSC1 is disabled. This internal resistor prevents the RTC\_XTALIN terminal from floating to an invalid logic level which may increase leakage current through the oscillator input buffer.



**Figure 4-14. OSC1 (ZCE Package) LVC MOS Circuit Schematic**



**Figure 4-15. OSC1 (ZCZ Package) LVC MOS Circuit Schematic**

**Table 4-7. OSC1 LVC MOS Reference Clock Requirements**

| NAME                   | DESCRIPTION                                                               | MIN | TYP    | MAX | UNIT |
|------------------------|---------------------------------------------------------------------------|-----|--------|-----|------|
| $f_{(RTC\_XTALIN)}$    | Frequency, LVC MOS reference clock                                        |     | 32.768 |     | MHz  |
|                        | Frequency, LVC MOS reference clock stability and tolerance <sup>(1)</sup> | -20 |        | 20  | ppm  |
|                        |                                                                           | -50 |        | 50  | ppm  |
| $t_{dc}(RTC\_XTALIN)$  | Duty cycle, LVC MOS reference clock period                                | 45  |        | 55  | %    |
| $t_{jpp}(RTC\_XTALIN)$ | Jitter peak-to-peak, LVC MOS reference clock period                       | -1  |        | 1   | %    |
| $t_R(RTC\_XTALIN)$     | Time, LVC MOS reference clock rise                                        |     |        | 5   | ns   |
| $t_F(RTC\_XTALIN)$     | Time, LVC MOS reference clock fall                                        |     |        | 5   | ns   |

(1) Initial accuracy, temperature drift, and aging effects should be combined when evaluating a reference clock for this requirement.

#### 4.2.2.5 OSC1 Not Used

Figure 4-16 shows the recommended oscillator connections when OSC1 of the ZCE package is not used and Figure 4-17 shows the recommended oscillator connections when OSC1 of the ZCZ package is not used. An internal 10 k $\Omega$  pull-up on the RTC\_XTALIN terminal is turned on when OSC1 is disabled to prevent this input from floating to an invalid logic level which may increase leakage current through the oscillator input buffer. OSC1 is disabled by default after power is applied. Therefore, both RTC\_XTALIN and RTC\_XTALOUT terminals should be a no connect (NC) when OSC1 is not used.

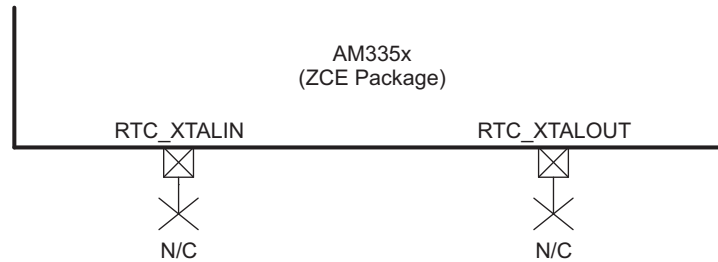


Figure 4-16. OSC1 (ZCE Package) Not Used Schematic

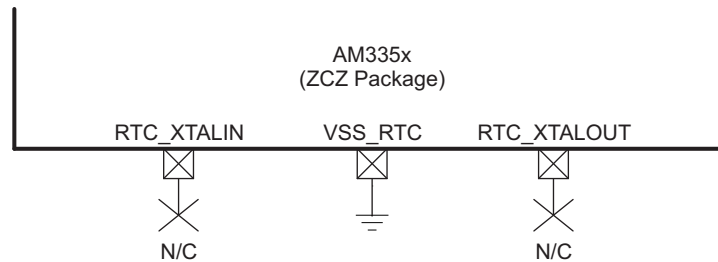


Figure 4-17. OSC1 (ZCZ Package) Not Used Schematic

### 4.2.3 Output Clock Specifications

The AM335x device has two clock output signals. The CLKOUT1 signal is always a replica of the OSC0 input clock which is referred to as the master oscillator (CLK\_M\_OSC) in the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)). The CLKOUT2 signal can be configured to output the OSC1 input clock, which is referred to as the 32K oscillator (CLK\_32K\_RTC) in the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)), or four other internal clocks. For more information related to configuring these clock output signals, see the *CLKOUT Signals* section of the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).

### 4.2.4 Output Clock Characteristics

#### NOTE

The AM335x CLKOUT1 and CLKOUT2 clock outputs should not be used as a synchronous clock for any of the peripheral interfaces because they were not timing closed to any other signals. These clock outputs also were not designed to source any time critical external circuits that require a low jitter reference clock. The jitter performance of these outputs is unpredictable due to complex combinations of many system variables. For example, CLKOUT2 may be sourced from several PLLs with each PLL supporting many configurations that yield different jitter performance. There are also other unpredictable contributors to jitter performance such as application specific noise or crosstalk into the clock circuits. Therefore, there are no plans to specify jitter performance for these outputs.

#### 4.2.4.1 CLKOUT1

The CLKOUT1 signal can be output on the XDMA\_EVENT\_INTR0 terminal. This terminal connects to one of seven internal signals via configurable multiplexers. The XDMA\_EVENT\_INTR0 multiplexer must be configured for Mode 3 to connect the CLKOUT1 signal to the XDMA\_EVENT\_INTR0 terminal.

The default reset configuration of the XDMA\_EVENT\_INTR0 multiplexer is selected by the logic level applied to the LCD\_DATA5 terminal on the rising edge of PWRONRSTn. The XDMA\_EVENT\_INTR0 multiplexer is configured to Mode 7 if the LCD\_DATA5 terminal is low on the rising edge of PWRONRSTn or Mode 3 if the LCD\_DATA5 terminal is high on the rising edge of PWRONRSTn. This allows the CLKOUT1 signal to be output on the XDMA\_EVENT\_INTR0 terminal without software intervention. In this mode, the output is held low while PWRONRSTn is active and begins to toggle after PWRONRSTn is released.

#### 4.2.4.2 CLKOUT2

The CLKOUT2 signal can be output on the XDMA\_EVENT\_INTR1 terminal. This terminal connects to one of seven internal signals via configurable multiplexers. The XDMA\_EVENT\_INTR1 multiplexer must be configured for Mode 3 to connect the CLKOUT2 signal to the XDMA\_EVENT\_INTR1 terminal.

The default reset configuration of the XDMA\_EVENT\_INTR1 multiplexer is always Mode 7. Software must configure the XDMA\_EVENT\_INTR1 multiplexer to Mode 3 for the CLKOUT2 signal to be output on the XDMA\_EVENT\_INTR1 terminal.

## 5 Peripheral Information and Timings

The AM335x device contains many peripheral interfaces. In order to reduce package size and lower overall system cost while maintaining maximum functionality, many of the AM335x terminals can multiplex up to eight signal functions. Although there are many combinations of pin multiplexing that are possible, only a certain number of sets, called IO Sets, are valid due to timing limitations. These valid IO Sets were carefully chosen to provide many possible application scenarios for the user.

Texas Instruments has developed a Windows-based application called Pin Mux Utility that helps a system designer select the appropriate pin-multiplexing configuration for their AM335x-based product design. The Pin Mux Utility provides a way to select valid IO Sets of specific peripheral interfaces to ensure the pin-multiplexing configuration selected for a design only uses valid IO Sets supported by the AM335x device.

### 5.1 Parameter Information

The data provided in the following Timing Requirements and Switching Characteristics tables assumes the device is operating within the Recommended Operating Conditions defined in [Section 3](#), unless otherwise noted.

#### 5.1.1 Timing Parameters and Board Routing Analysis

The timing parameter values specified in this data manual do *not* include delays by board routings. As a good board design practice, such delays must *always* be taken into account. Timing values may be adjusted by increasing or decreasing such delays. TI recommends utilizing the available IO buffer information specification (IBIS) models to analyze the timing characteristics correctly. If needed, external logic hardware such as buffers may be used to compensate any timing differences.

The timing parameter values specified in this data manual assume the SLEWCTRL bit in each pad control register is configured for fast mode (0b).

For the mDDR(LPDDR), DDR2, DDR3, DDR3L memory interface, it is *not* necessary to use the IBIS models to analyze timing characteristics. TI provides a PCB routing rules solution that describes the routing rules to ensure the mDDR(LPDDR), DDR2, DDR3, DDR3L memory interface timings are met.

### 5.2 Recommended Clock and Control Signal Transition Behavior

All clocks and control signals **must** transition between  $V_{IH}$  and  $V_{IL}$  (or between  $V_{IL}$  and  $V_{IH}$ ) in a monotonic manner.

## 5.3 Controller Area Network (CAN)

For more information, see the Controller Area Network (CAN) section of the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).

### 5.3.1 DCAN Electrical Data and Timing

**Table 5-1. Timing Requirements for DCANx Receive**

(see [Figure 5-1](#))

| NO. |                         |                                  | MIN           | MAX           | UNIT |
|-----|-------------------------|----------------------------------|---------------|---------------|------|
|     | $f_{\text{baud(baud)}}$ | Maximum programmable baud rate   |               | 1             | Mbps |
| 1   | $t_{w(RX)}$             | Pulse duration, receive data bit | $H - 2^{(1)}$ | $H + 2^{(1)}$ | ns   |

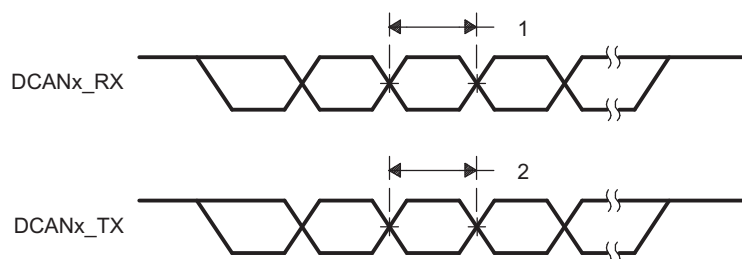
(1) H = period of baud rate, 1/programmed baud rate.

**Table 5-2. Switching Characteristics for DCANx Transmit**

(see [Figure 5-1](#))

| NO. |                         | PARAMETER                         | MIN           | MAX           | UNIT |
|-----|-------------------------|-----------------------------------|---------------|---------------|------|
|     | $f_{\text{baud(baud)}}$ | Maximum programmable baud rate    |               | 1             | Mbps |
| 2   | $t_{w(TX)}$             | Pulse duration, transmit data bit | $H - 2^{(1)}$ | $H + 2^{(1)}$ | ns   |

(1) H = period of baud rate, 1/programmed baud rate.



**Figure 5-1. DCANx Timings**

## 5.4 DMTimer

### 5.4.1 DMTimer Electrical Data and Timing

**Table 5-3. Timing Requirements for DMTimer [1-7]**

(see [Figure 5-2](#))

| NO. |                 |                    | MIN          | MAX | UNIT |
|-----|-----------------|--------------------|--------------|-----|------|
| 1   | $t_{c(TCLKIN)}$ | Cycle time, TCLKIN | $4P+1^{(1)}$ |     | ns   |

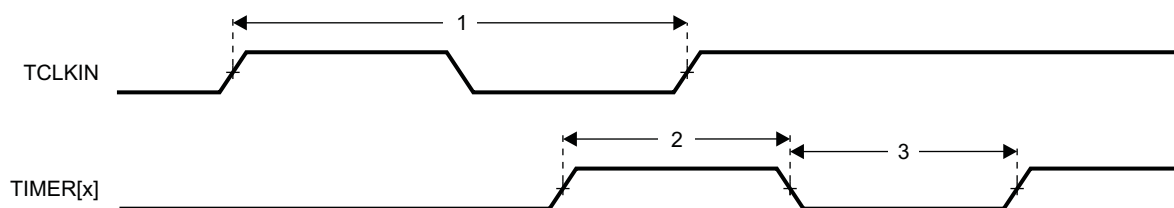
(1) P = period of PICKOCP (interface clock).

**Table 5-4. Switching Characteristics for DMTimer [4-7]**

(see [Figure 5-2](#))

| NO. |                  | PARAMETER            | MIN          | MAX | UNIT |
|-----|------------------|----------------------|--------------|-----|------|
| 2   | $t_{w(TIMERxH)}$ | Pulse duration, high | $4P-3^{(1)}$ |     | ns   |
| 3   | $t_{w(TIMERxL)}$ | Pulse duration, low  | $4P-3^{(1)}$ |     | ns   |

(1) P = period of PICKTIMER (functional clock).


**Figure 5-2. Timer Timing**

## 5.5 Ethernet Media Access Controller (EMAC) and Switch

### 5.5.1 Ethernet MAC and Switch Electrical Data and Timing

The Ethernet MAC and Switch implemented in the AM335x device supports GMII mode, but the AM335x design does not pin out 9 of the 24 GMII signals. This was done to reduce the total number of package terminals. Therefore, the AM335x device does not support GMII mode. MII mode is supported with the remaining GMII signals.

The *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)) and this document may reference internal signal names when discussing peripheral input and output signals since many of the AM335x package terminals can be multiplexed to one of several peripheral signals. For example, the AM335x terminal names for port 1 of the Ethernet MAC and switch have been changed from GMII to MII to indicate their Mode 0 function, but the internal signal is named GMII. However, documents that describe the Ethernet switch reference these signals by their internal signal name. For a cross-reference of internal signal names to terminal names, see [Table 2-7](#).

Operation of the Ethernet MAC and switch is not supported for OPP50.

**Table 5-5. Ethernet MAC and Switch Timing Conditions**

| TIMING CONDITION PARAMETER |                         | MIN              | TYP | MAX              | UNIT |
|----------------------------|-------------------------|------------------|-----|------------------|------|
| <b>Input Conditions</b>    |                         |                  |     |                  |      |
| $t_R$                      | Input signal rise time  | 1 <sup>(1)</sup> |     | 5 <sup>(1)</sup> | ns   |
| $t_F$                      | Input signal fall time  | 1 <sup>(1)</sup> |     | 5 <sup>(1)</sup> | ns   |
| <b>Output Condition</b>    |                         |                  |     |                  |      |
| $C_{LOAD}$                 | Output load capacitance | 3                |     | 30               | pF   |

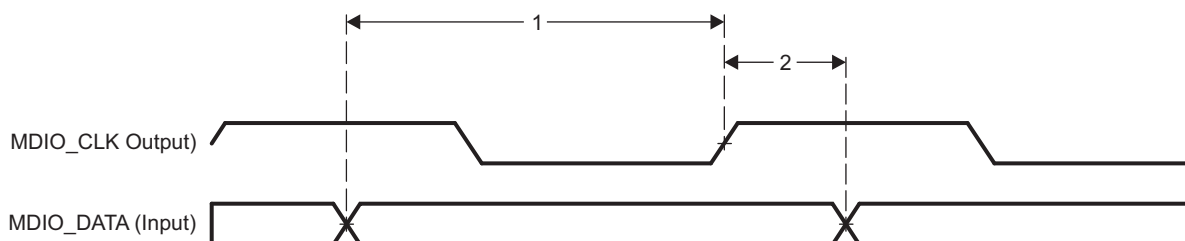
(1) Except when specified otherwise.

#### 5.5.1.1 Ethernet MAC/Switch MDIO Electrical Data and Timing

**Table 5-6. Timing Requirements for MDIO\_DATA**

(see [Figure 5-3](#))

| NO. |                    |                                        | MIN | TYP | MAX | UNIT |
|-----|--------------------|----------------------------------------|-----|-----|-----|------|
| 1   | $t_{su}(MDIO-MDC)$ | Setup time, MDIO valid before MDC high | 90  |     |     | ns   |
| 2   | $t_h(MDIO-MDC)$    | Hold time, MDIO valid from MDC high    | 0   |     |     | ns   |

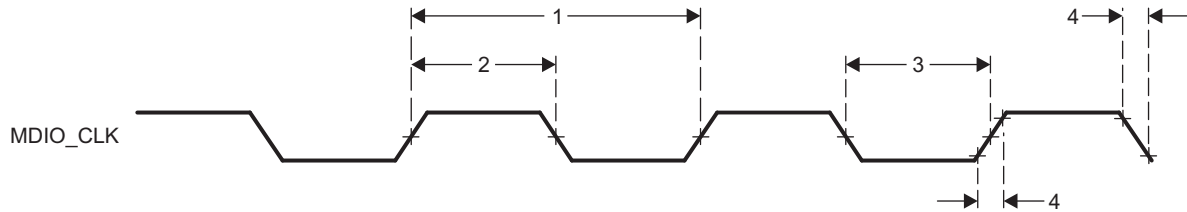


**Figure 5-3. MDIO\_DATA Timing - Input Mode**

**Table 5-7. Switching Characteristics for MDIO\_CLK**

(see [Figure 5-4](#))

| NO. | PARAMETER   |                          | MIN | TYP | MAX | UNIT |
|-----|-------------|--------------------------|-----|-----|-----|------|
| 1   | $t_c(MDC)$  | Cycle time, MDC          | 400 |     |     | ns   |
| 2   | $t_w(MDCH)$ | Pulse duration, MDC high | 160 |     |     | ns   |
| 3   | $t_w(MDCL)$ | Pulse duration, MDC low  | 160 |     |     | ns   |
| 4   | $t_t(MDC)$  | Transition time, MDC     |     |     | 5   | ns   |

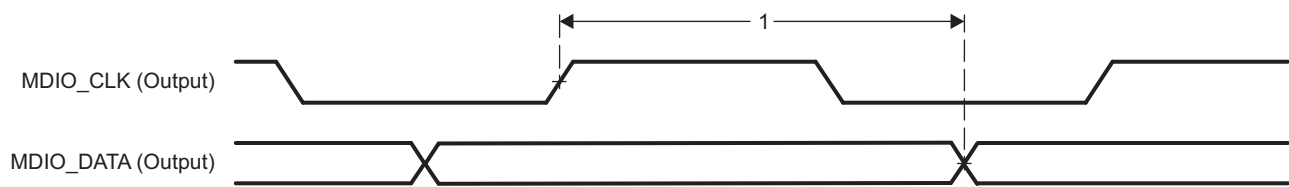


**Figure 5-4. MDIO\_CLK Timing**

**Table 5-8. Switching Characteristics for MDIO\_DATA**

(see [Figure 5-5](#))

| NO. | PARAMETER         |                                    | MIN | TYP | MAX | UNIT |
|-----|-------------------|------------------------------------|-----|-----|-----|------|
| 1   | $t_{d(MDC-MDIO)}$ | Delay time, MDC high to MDIO valid | 10  |     | 390 | ns   |



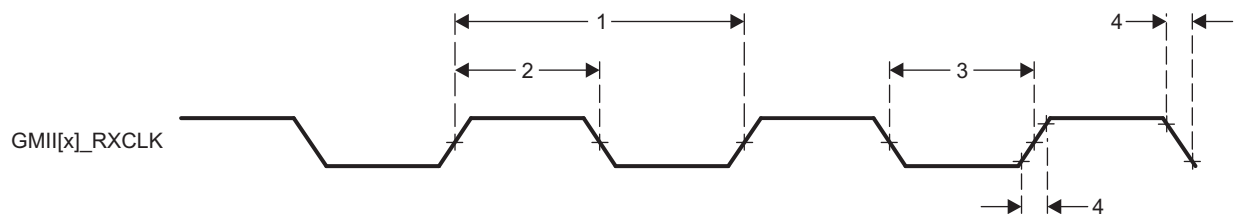
**Figure 5-5. MDIO\_DATA Timing - Output Mode**

#### 5.5.1.2 Ethernet MAC and Switch MII Electrical Data and Timing

**Table 5-9. Timing Requirements for GMII[x]\_RXCLK - MII Mode**

(see [Figure 5-6](#))

| NO. |                 |                             | 10 Mbps |     |        | 100 Mbps |     |        | UNIT |
|-----|-----------------|-----------------------------|---------|-----|--------|----------|-----|--------|------|
|     |                 |                             | MIN     | TYP | MAX    | MIN      | TYP | MAX    |      |
| 1   | $t_c(RX\_CLK)$  | Cycle time, RX_CLK          | 399.96  |     | 400.04 | 39.996   |     | 40.004 | ns   |
| 2   | $t_w(RX\_CLKH)$ | Pulse Duration, RX_CLK high | 140     |     | 260    | 14       |     | 26     | ns   |
| 3   | $t_w(RX\_CLKL)$ | Pulse Duration, RX_CLK low  | 140     |     | 260    | 14       |     | 26     | ns   |
| 4   | $t_t(RX\_CLK)$  | Transition time, RX_CLK     |         |     | 5      |          |     | 5      | ns   |

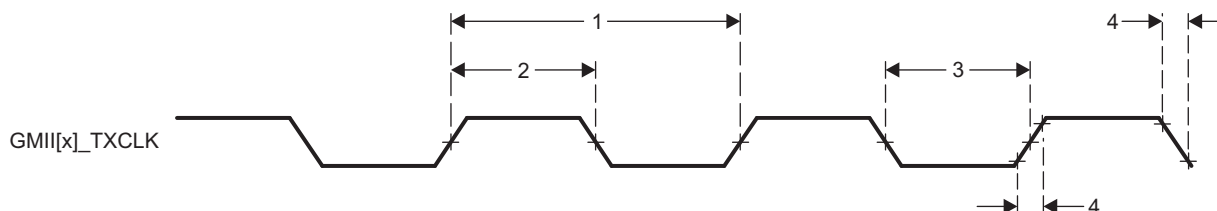


**Figure 5-6. GMII[x]\_RXCLK Timing - MII Mode**

**Table 5-10. Timing Requirements for GMII[x]\_TXCLK - MII Mode**

(see [Figure 5-7](#))

| NO. |                   |                             | 10 Mbps |     |        | 100 Mbps |     |        | UNIT |
|-----|-------------------|-----------------------------|---------|-----|--------|----------|-----|--------|------|
|     |                   |                             | MIN     | TYP | MAX    | MIN      | TYP | MAX    |      |
| 1   | $t_{c(TX\_CLK)}$  | Cycle time, TX_CLK          | 399.96  |     | 400.04 | 39.996   |     | 40.004 | ns   |
| 2   | $t_{w(TX\_CLKH)}$ | Pulse Duration, TX_CLK high | 140     |     | 260    | 14       |     | 26     | ns   |
| 3   | $t_{w(TX\_CLKL)}$ | Pulse Duration, TX_CLK low  | 140     |     | 260    | 14       |     | 26     | ns   |
| 4   | $t_{t(TX\_CLK)}$  | Transition time, TX_CLK     |         |     | 5      |          |     | 5      | ns   |

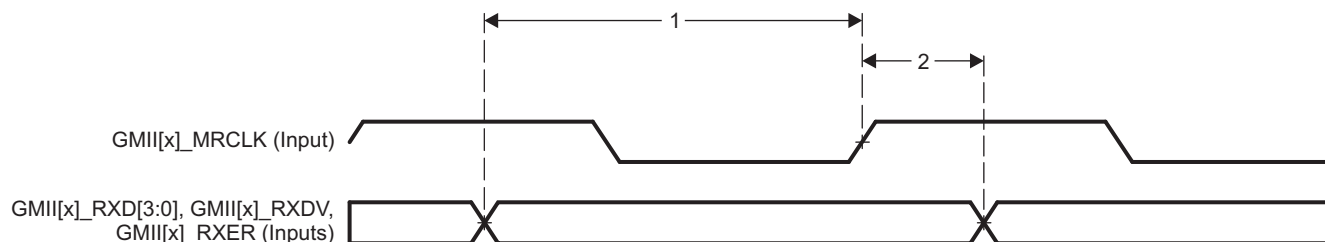


**Figure 5-7. GMII[x]\_TXCLK Timing - MII Mode**

**Table 5-11. Timing Requirements for GMII[x]\_RXD[3:0], GMII[x]\_RXDV, and GMII[x]\_RXER - MII Mode**

(see [Figure 5-8](#))

| NO. |                          |                                          | 10 Mbps |     |     | 100 Mbps |     |     | UNIT |
|-----|--------------------------|------------------------------------------|---------|-----|-----|----------|-----|-----|------|
|     |                          |                                          | MIN     | TYP | MAX | MIN      | TYP | MAX |      |
| 1   | $t_{su(RXD-RX\_CLK)}$    | Setup time, RXD[3:0] valid before RX_CLK | 8       |     |     | 8        |     |     | ns   |
|     | $t_{su(RX\_DV-RX\_CLK)}$ | Setup time, RX_DV valid before RX_CLK    |         |     |     |          |     |     |      |
|     | $t_{su(RX\_ER-RX\_CLK)}$ | Setup time, RX_ER valid before RX_CLK    |         |     |     |          |     |     |      |
| 2   | $t_{h(RX\_CLK-RXD)}$     | Hold time RXD[3:0] valid after RX_CLK    | 8       |     |     | 8        |     |     | ns   |
|     | $t_{h(RX\_CLK-RX\_DV)}$  | Hold time RX_DV valid after RX_CLK       |         |     |     |          |     |     |      |
|     | $t_{h(RX\_CLK-RX\_ER)}$  | Hold time RX_ER valid after RX_CLK       |         |     |     |          |     |     |      |

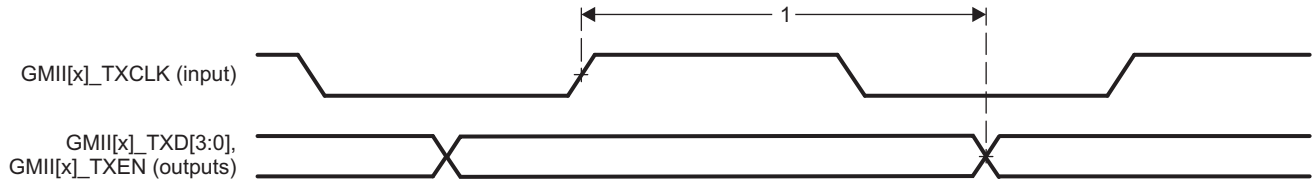


**Figure 5-8. GMII[x]\_RXD[3:0], GMII[x]\_RXDV, GMII[x]\_RXER Timing - MII Mode**

**Table 5-12. Switching Characteristics for GMII[x]\_TXD[3:0], and GMII[x]\_TXEN - MII Mode**

(see [Figure 5-9](#))

| NO. | PARAMETER               |                                           | 10 Mbps |     |     | 100 Mbps |     |     | UNIT |
|-----|-------------------------|-------------------------------------------|---------|-----|-----|----------|-----|-----|------|
|     |                         |                                           | MIN     | TYP | MAX | MIN      | TYP | MAX |      |
| 1   | $t_{d(TX\_CLK-TXD)}$    | Delay time, TX_CLK high to TXD[3:0] valid | 5       |     | 25  | 5        |     | 25  | ns   |
|     | $t_{d(TX\_CLK-TX\_EN)}$ | Delay time, TX_CLK to TX_EN valid         |         |     |     |          |     |     |      |

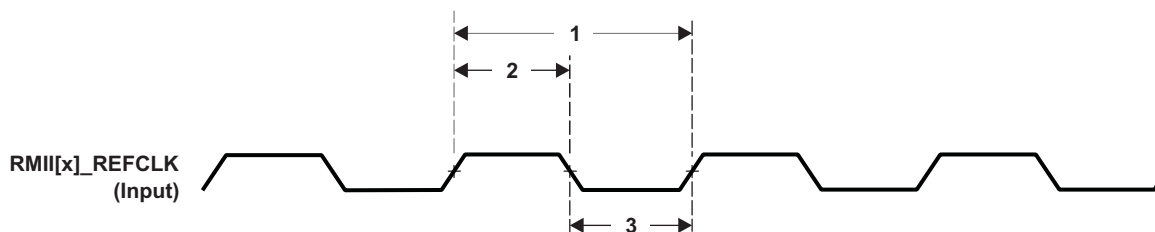

**Figure 5-9. GMII[x]\_TXD[3:0], GMII[x]\_TXEN Timing - MII Mode**

### 5.5.1.3 Ethernet MAC and Switch RMII Electrical Data and Timing

**Table 5-13. Timing Requirements for RMII[x]\_REFCLK - RMII Mode**

(see [Figure 5-10](#))

| NO. |                    |                              | MIN    | TYP | MAX    | UNIT |
|-----|--------------------|------------------------------|--------|-----|--------|------|
| 1   | $t_{c(REF\_CLK)}$  | Cycle time, REF_CLK          | 19.999 |     | 20.001 | ns   |
| 2   | $t_{w(REF\_CLKH)}$ | Pulse Duration, REF_CLK high | 7      |     | 13     | ns   |
| 3   | $t_{w(REF\_CLKL)}$ | Pulse Duration, REF_CLK low  | 7      |     | 13     | ns   |

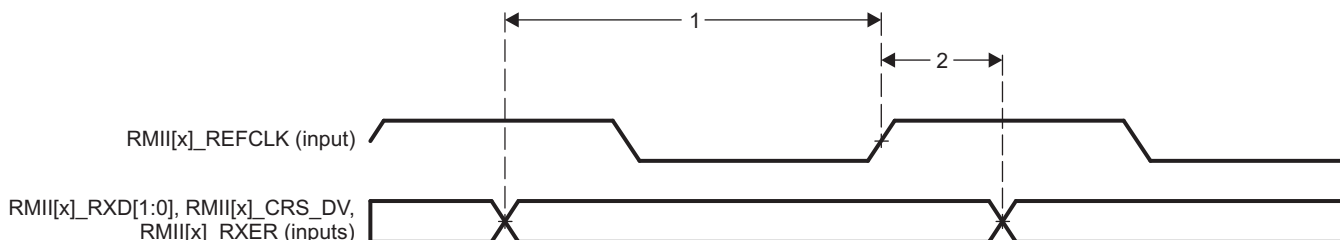


**Figure 5-10. RMII[x]\_REFCLK Timing - RMII Mode**

**Table 5-14. Timing Requirements for RMII[x]\_RXD[1:0], RMII[x]\_CRS\_DV, and RMII[x]\_RXER - RMII Mode**

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

| NO. |                            |                                           | MIN | TYP | MAX | UNIT |
|-----|----------------------------|-------------------------------------------|-----|-----|-----|------|
| 1   | $t_{su(RXD-REF\_CLK)}$     | Setup time, RXD[1:0] valid before REF_CLK | 4   |     |     | ns   |
|     | $t_{su(CRS\_DV-REF\_CLK)}$ | Setup time, CRS_DV valid before REF_CLK   |     |     |     |      |
|     | $t_{su(RX\_ER-REF\_CLK)}$  | Setup time, RX_ER valid before REF_CLK    |     |     |     |      |
| 2   | $t_h(REF\_CLK-RXD)$        | Hold time RXD[1:0] valid after REF_CLK    | 2   |     |     | ns   |
|     | $t_h(REF\_CLK-CRS\_DV)$    | Hold time, CRS_DV valid after REF_CLK     |     |     |     |      |
|     | $t_h(REF\_CLK-RX\_ER)$     | Hold time, RX_ER valid after REF_CLK      |     |     |     |      |

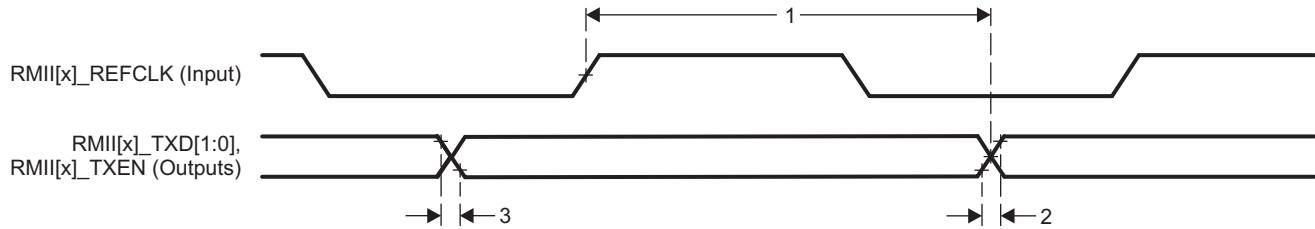


**Figure 5-11. RMII[x]\_RXD[1:0], RMII[x]\_CRS\_DV, RMII[x]\_RXER Timing - RMII Mode**

**Table 5-15. Switching Characteristics for RMII[x]\_TXD[1:0], and RMII[x]\_TXEN - RMII Mode**

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

| NO. | PARAMETER              |                                            | MIN | TYP | MAX | UNIT |
|-----|------------------------|--------------------------------------------|-----|-----|-----|------|
| 1   | $t_{d(REF\_CLK-TXD)}$  | Delay time, REF_CLK high to TXD[1:0] valid | 2   |     | 13  | ns   |
|     | $t_{d(REF\_CLK-TXEN)}$ | Delay time, REF_CLK to TXEN valid          |     |     |     |      |
| 2   | $t_{r(TXD)}$           | Rise time, TXD outputs                     | 1   |     | 5   | ns   |
|     | $t_{r(TX\_EN)}$        | Rise time, TX_EN output                    |     |     |     |      |
| 3   | $t_{f(TXD)}$           | Fall time, TXD outputs                     | 1   |     | 5   | ns   |
|     | $t_{f(TX\_EN)}$        | Fall time, TX_EN output                    |     |     |     |      |



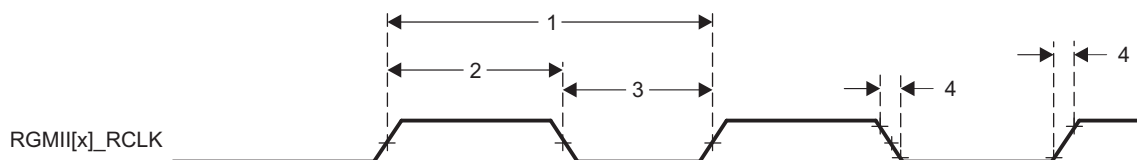
**Figure 5-12. RMII[x]\_TXD[1:0], RMII[x]\_TXEN Timing - RMII Mode**

### 5.5.1.4 Ethernet MAC and Switch RGMII Electrical Data and Timing

**Table 5-16. Timing Requirements for RGMII[x]\_RCLK - RGMII Mode**

(see [Figure 5-13](#))

| NO. |               |                          | 10 Mbps |     |      | 100 Mbps |     |      | 1000 Mbps |     |      | UNIT |
|-----|---------------|--------------------------|---------|-----|------|----------|-----|------|-----------|-----|------|------|
|     |               |                          | MIN     | TYP | MAX  | MIN      | TYP | MAX  | MIN       | TYP | MAX  |      |
| 1   | $t_{c(RXC)}$  | Cycle time, RXC          | 360     |     | 440  | 36       |     | 44   | 7.2       |     | 8.8  | ns   |
| 2   | $t_{w(RXCH)}$ | Pulse duration, RXC high | 160     |     | 240  | 16       |     | 24   | 3.6       |     | 4.4  | ns   |
| 3   | $t_{w(RXCL)}$ | Pulse duration, RXC low  | 160     |     | 240  | 16       |     | 24   | 3.6       |     | 4.4  | ns   |
| 4   | $t_{t(RXC)}$  | Transition time, RXC     |         |     | 0.75 |          |     | 0.75 |           |     | 0.75 | ns   |

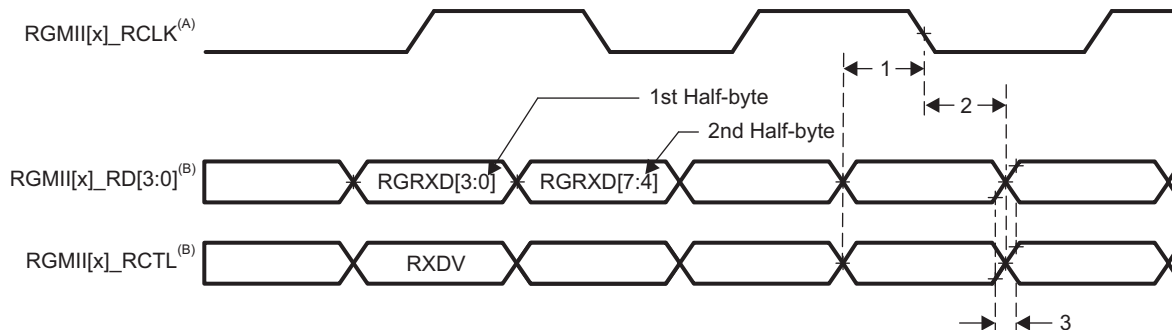


**Figure 5-13. RGMII[x]\_RCLK Timing - RGMII Mode**

**Table 5-17. Timing Requirements for RGMII[x]\_RD[3:0], and RGMII[x]\_RCTL - RGMII Mode**

(see [Figure 5-14](#))

| NO. |                       |                                                  | 10 Mbps |     |      | 100 Mbps |     |      | 1000 Mbps |     |      | UNIT |
|-----|-----------------------|--------------------------------------------------|---------|-----|------|----------|-----|------|-----------|-----|------|------|
|     |                       |                                                  | MIN     | TYP | MAX  | MIN      | TYP | MAX  | MIN       | TYP | MAX  |      |
| 1   | $t_{su(RD-RXC)}$      | Setup time, RD[3:0] valid before RXC high or low | 1       |     |      | 1        |     |      | 1         |     |      | ns   |
|     | $t_{su(RX\_CTL-RXC)}$ | Setup time, RX_CTL valid before RXC high or low  | 1       |     |      | 1        |     |      | 1         |     |      |      |
| 2   | $t_{h(RXC-RD)}$       | Hold time, RD[3:0] valid after RXC high or low   | 1       |     |      | 1        |     |      | 1         |     |      | ns   |
|     | $t_{h(RXC-RX\_CTL)}$  | Hold time, RX_CTL valid after RXC high or low    | 1       |     |      | 1        |     |      | 1         |     |      |      |
| 3   | $t_{t(RD)}$           | Transition time, RD                              |         |     | 0.75 |          |     | 0.75 |           |     | 0.75 | ns   |
|     | $t_{t(RX\_CTL)}$      | Transition time, RX_CTL                          |         |     | 0.75 |          |     | 0.75 |           |     | 0.75 |      |



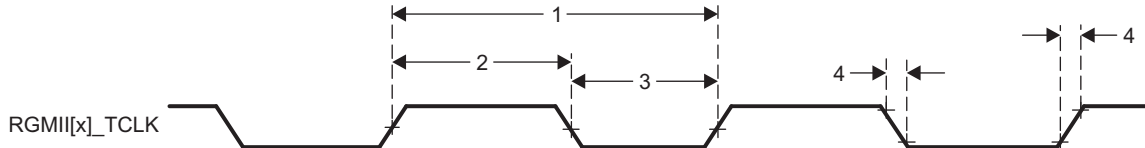
- RGMII[x]\_RCLK must be externally delayed relative to the RGMII[x]\_RD[3:0] and RGMII[x]\_RCTL signals to meet the respective timing requirements.
- Data and control information is received using both edges of the clocks. RGMII[x]\_RD[3:0] carries data bits 3-0 on the rising edge of RGMII[x]\_RCLK and data bits 7-4 on the falling edge of RGMII[x]\_RCLK. Similarly, RGMII[x]\_RCTL carries RXDV on rising edge of RGMII[x]\_RCLK and RXERR on falling edge of RGMII[x]\_RCLK.

**Figure 5-14. RGMII[x]\_RD[3:0], RGMII[x]\_RCTL Timing - RGMII Mode**

**Table 5-18. Switching Characteristics for RGMII[x]\_TCLK - RGMII Mode**

(see Figure 5-15)

| NO. | PARAMETER     |                          | 10 Mbps |     |      | 100 Mbps |     |      | 1000 Mbps |     |      | UNIT |
|-----|---------------|--------------------------|---------|-----|------|----------|-----|------|-----------|-----|------|------|
|     |               |                          | MIN     | TYP | MAX  | MIN      | TYP | MAX  | MIN       | TYP | MAX  |      |
| 1   | $t_{c(TXC)}$  | Cycle time, TXC          | 360     |     | 440  | 36       |     | 44   | 7.2       |     | 8.8  | ns   |
| 2   | $t_{w(TXCH)}$ | Pulse duration, TXC high | 160     |     | 240  | 16       |     | 24   | 3.6       |     | 4.4  | ns   |
| 3   | $t_{w(TXCL)}$ | Pulse duration, TXC low  | 160     |     | 240  | 16       |     | 24   | 3.6       |     | 4.4  | ns   |
| 4   | $t_t(TXC)$    | Transition time, TXC     |         |     | 0.75 |          |     | 0.75 |           |     | 0.75 | ns   |

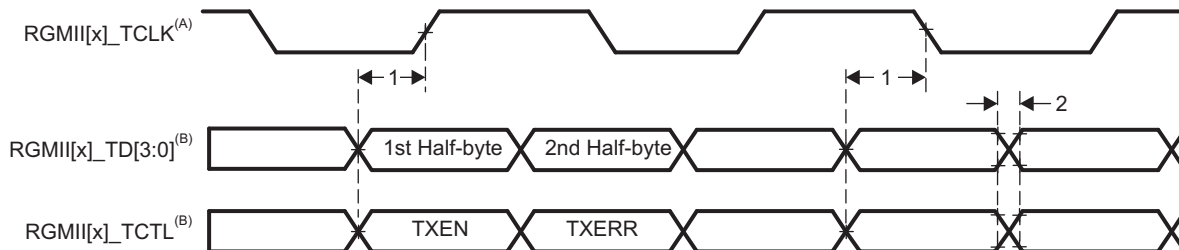


**Figure 5-15. RGMII[x]\_TCLK Timing - RGMII Mode**

**Table 5-19. Switching Characteristics for RGMII[x]\_TD[3:0], and RGMII[x]\_TCTL - RGMII Mode**

(see Figure 5-16)

| NO. | PARAMETER             |                           | 10 Mbps |     |      | 100 Mbps |     |      | 1000 Mbps |     |      | UNIT |
|-----|-----------------------|---------------------------|---------|-----|------|----------|-----|------|-----------|-----|------|------|
|     |                       |                           | MIN     | TYP | MAX  | MIN      | TYP | MAX  | MIN       | TYP | MAX  |      |
| 1   | $t_{sk(TD-TXC)}$      | TD to TXC output skew     | -0.5    |     | 0.5  | -0.5     |     | 0.5  | -0.5      |     | 0.5  | ns   |
|     | $t_{sk(TX\_CTL-TXC)}$ | TX_CTL to TXC output skew | -0.5    |     | 0.5  | -0.5     |     | 0.5  | -0.5      |     | 0.5  |      |
| 2   | $t_t(TD)$             | Transition time, TD       |         |     | 0.75 |          |     | 0.75 |           |     | 0.75 | ns   |
|     | $t_t(TX\_CTL)$        | Transition time, TX_CTL   |         |     | 0.75 |          |     | 0.75 |           |     | 0.75 |      |



- A. The Ethernet MAC and switch implemented in the AM335x device supports internal delay mode, but timing closure was not performed for this mode of operation. Therefore, the AM335x device does not support internal delay mode.
- B. Data and control information is transmitted using both edges of the clocks. RGMII[x]\_TD[3:0] carries data bits 3-0 on the rising edge of RGMII[x]\_TCLK and data bits 7-4 on the falling edge of RGMII[x]\_TCLK. Similarly, RGMII[x]\_TCTL carries TXEN on rising edge of RGMII[x]\_TCLK and TXERR of falling edge of RGMII[x]\_TCLK.

**Figure 5-16. RGMII[x]\_TD[3:0], RGMII[x]\_TCTL Timing - RGMII Mode**

## 5.6 External Memory Interfaces

The device includes the following external memory interfaces:

- General-purpose memory controller (GPMC)
- mDDR(LPDDR), DDR2, DDR3, DDR3L Memory Interface (EMIF)

### 5.6.1 General-Purpose Memory Controller (GPMC)

#### NOTE

For more information, see the Memory Subsystem and General-Purpose Memory Controller section of the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).

The GPMC is the unified memory controller used to interface external memory devices such as:

- Asynchronous SRAM-like memories and ASIC devices
- Asynchronous page mode and synchronous burst NOR flash
- NAND flash

#### 5.6.1.1 GPMC and NOR Flash—Synchronous Mode

[Table 5-21](#) and [Table 5-22](#) assume testing over the recommended operating conditions and electrical characteristic conditions below (see [Figure 5-17](#) through [Figure 5-21](#)).

**Table 5-20. GPMC and NOR Flash Timing Conditions—Synchronous Mode**

| TIMING CONDITION PARAMETER |                         | MIN | TYP | MAX | UNIT |
|----------------------------|-------------------------|-----|-----|-----|------|
| <b>Input Conditions</b>    |                         |     |     |     |      |
| $t_R$                      | Input signal rise time  | 1   |     | 5   | ns   |
| $t_F$                      | Input signal fall time  | 1   |     | 5   | ns   |
| <b>Output Condition</b>    |                         |     |     |     |      |
| $C_{LOAD}$                 | Output load capacitance | 3   |     | 30  | pF   |

**Table 5-21. GPMC and NOR Flash Timing Requirements—Synchronous Mode**

| NO. |                      |                                                                                            | OPP100 |     | OPP50 |     | UNIT |
|-----|----------------------|--------------------------------------------------------------------------------------------|--------|-----|-------|-----|------|
|     |                      |                                                                                            | MIN    | MAX | MIN   | MAX |      |
| F12 | $t_{su(dV-clkH)}$    | Setup time, input data gpmc_ad[15:0] valid before output clock gpmc_clk high               | 3.2    |     | 13.2  |     | ns   |
| F13 | $t_{h(clkH-dV)}$     | Hold time, input data gpmc_ad[15:0] valid after output clock gpmc_clk high                 | 4.74   |     | 2.75  |     | ns   |
| F21 | $t_{su(waitV-clkH)}$ | Setup time, input wait gpmc_wait[x] <sup>(1)</sup> valid before output clock gpmc_clk high | 3.2    |     | 13.2  |     | ns   |
| F22 | $t_{h(clkH-waitV)}$  | Hold time, input wait gpmc_wait[x] <sup>(1)</sup> valid after output clock gpmc_clk high   | 4.74   |     | 2.75  |     | ns   |

(1) In gpmc\_wait[x], x is equal to 0 or 1.

**Table 5-22. GPMC and NOR Flash Switching Characteristics—Synchronous Mode<sup>(2)</sup>**

| NO. | PARAMETER                     |                                                                                                                                                              | OPP100                  |                         | OPP50                   |                          | UNIT |
|-----|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|--------------------------|------|
|     |                               |                                                                                                                                                              | MIN                     | MAX                     | MIN                     | MAX                      |      |
| F0  | $1 / t_{c(\text{clk})}$       | Frequency <sup>(15)</sup> , output clock gpmc_clk                                                                                                            |                         | 100                     |                         | 50                       | MHz  |
| F1  | $t_{w(\text{clkH})}$          | Typical pulse duration, output clock gpmc_clk high                                                                                                           | 0.5P <sup>(12)</sup>    | 0.5P <sup>(12)</sup>    | 0.5P <sup>(12)</sup>    | 0.5P <sup>(12)</sup>     | ns   |
| F1  | $t_{w(\text{clkL})}$          | Typical pulse duration, output clock gpmc_clk low                                                                                                            | 0.5P <sup>(12)</sup>    | 0.5P <sup>(12)</sup>    | 0.5P <sup>(12)</sup>    | 0.5P <sup>(12)</sup>     | ns   |
|     | $t_{dc(\text{clk})}$          | Duty cycle error, output clock gpmc_clk                                                                                                                      | -500                    | 500                     | -500                    | 500                      | ps   |
|     | $t_{j(\text{clk})}$           | Jitter standard deviation <sup>(16)</sup> , output clock gpmc_clk                                                                                            |                         | 33.33                   |                         | 33.33                    | ps   |
|     | $t_{R(\text{clk})}$           | Rise time, output clock gpmc_clk                                                                                                                             |                         | 2                       |                         | 2                        | ns   |
|     | $t_{F(\text{clk})}$           | Fall time, output clock gpmc_clk                                                                                                                             |                         | 2                       |                         | 2                        | ns   |
|     | $t_{R(\text{do})}$            | Rise time, output data gpmc_ad[15:0]                                                                                                                         |                         | 2                       |                         | 2                        | ns   |
|     | $t_{F(\text{do})}$            | Fall time, output data gpmc_ad[15:0]                                                                                                                         |                         | 2                       |                         | 2                        | ns   |
| F2  | $t_{d(\text{clkH-csnV})}$     | Delay time, output clock gpmc_clk rising edge to output chip select gpmc_csn[x] <sup>(11)</sup> transition                                                   | F <sup>(6)</sup> - 2.2  | F <sup>(6)</sup> + 4.5  | F <sup>(6)</sup> - 3.2  | F <sup>(6)</sup> + 9.5   | ns   |
| F3  | $t_{d(\text{clkH-csnIV})}$    | Delay time, output clock gpmc_clk rising edge to output chip select gpmc_csn[x] <sup>(11)</sup> invalid                                                      | E <sup>(5)</sup> - 2.2  | E <sup>(5)</sup> + 4.5  | E <sup>(5)</sup> - 3.2  | E <sup>(5)</sup> + 9.5   | ns   |
| F4  | $t_{d(\text{aV-clk})}$        | Delay time, output address gpmc_a[27:1] valid to output clock gpmc_clk first edge                                                                            | B <sup>(2)</sup> - 4.5  | B <sup>(2)</sup> + 2.3  | B <sup>(2)</sup> - 5.5  | B <sup>(2)</sup> + 12.3  | ns   |
| F5  | $t_{d(\text{clkH-aIV})}$      | Delay time, output clock gpmc_clk rising edge to output address gpmc_a[27:1] invalid                                                                         | -2.3                    | 4.5                     | -3.3                    | 14.5                     | ns   |
| F6  | $t_{d(\text{be[x]nV-clk})}$   | Delay time, output lower byte enable and command latch enable gpmc_be0n_cle, output upper byte enable gpmc_be1n valid to output clock gpmc_clk first edge    | B <sup>(2)</sup> - 1.9  | B <sup>(2)</sup> + 2.3  | B <sup>(2)</sup> - 2.9  | B <sup>(2)</sup> + 12.3  | ns   |
| F7  | $t_{d(\text{clkH-be[x]nIV})}$ | Delay time, output clock gpmc_clk rising edge to output lower byte enable and command latch enable gpmc_be0n_cle, output upper byte enable gpmc_be1n invalid | D <sup>(4)</sup> - 2.3  | D <sup>(4)</sup> + 1.9  | D <sup>(4)</sup> - 3.3  | D <sup>(4)</sup> + 11.9  | ns   |
| F8  | $t_{d(\text{clkH-advn})}$     | Delay time, output clock gpmc_clk rising edge to output address valid and address latch enable gpmc_advn_ale transition                                      | G <sup>(7)</sup> - 2.3  | G <sup>(7)</sup> + 4.5  | G <sup>(7)</sup> - 3.3  | G <sup>(7)</sup> + 9.5   | ns   |
| F9  | $t_{d(\text{clkH-advnIV})}$   | Delay time, output clock gpmc_clk rising edge to output address valid and address latch enable gpmc_advn_ale invalid                                         | D <sup>(4)</sup> - 2.3  | D <sup>(4)</sup> + 3.5  | D <sup>(4)</sup> - 3.3  | D <sup>(4)</sup> + 9.5   | ns   |
| F10 | $t_{d(\text{clkH-oen})}$      | Delay time, output clock gpmc_clk rising edge to output enable gpmc_oen transition                                                                           | H <sup>(8)</sup> - 2.3  | H <sup>(8)</sup> + 3.5  | H <sup>(8)</sup> - 3.3  | H <sup>(8)</sup> + 8.5   | ns   |
| F11 | $t_{d(\text{clkH-oenIV})}$    | Delay time, output clock gpmc_clk rising edge to output enable gpmc_oen invalid                                                                              | E <sup>(5)</sup> - 2.3  | E <sup>(5)</sup> + 3.5  | E <sup>(5)</sup> - 3.3  | E <sup>(5)</sup> + 8.5   | ns   |
| F14 | $t_{d(\text{clkH-wen})}$      | Delay time, output clock gpmc_clk rising edge to output write enable gpmc_wen transition                                                                     | I <sup>(9)</sup> - 2.3  | I <sup>(9)</sup> + 4.5  | I <sup>(9)</sup> - 3.3  | I <sup>(9)</sup> + 9.5   | ns   |
| F15 | $t_{d(\text{clkH-do})}$       | Delay time, output clock gpmc_clk rising edge to output data gpmc_ad[15:0] transition                                                                        | J <sup>(10)</sup> - 2.3 | J <sup>(10)</sup> + 1.9 | J <sup>(10)</sup> - 3.3 | J <sup>(10)</sup> + 11.9 | ns   |
| F17 | $t_{d(\text{clkH-be[x]n})}$   | Delay time, output clock gpmc_clk rising edge to output lower byte enable and command latch enable gpmc_be0n_cle transition                                  | J <sup>(10)</sup> - 2.3 | J <sup>(10)</sup> + 1.9 | J <sup>(10)</sup> - 3.3 | J <sup>(10)</sup> + 11.9 | ns   |
| F18 | $t_{w(\text{csnV})}$          | Pulse duration, output chip select gpmc_csn[x] <sup>(11)</sup> low                                                                                           | Read                    | A <sup>(1)</sup>        | A <sup>(1)</sup>        |                          | ns   |
|     |                               |                                                                                                                                                              | Write                   | A <sup>(1)</sup>        | A <sup>(1)</sup>        |                          | ns   |
| F19 | $t_{w(\text{be[x]nV})}$       | Pulse duration, output lower byte enable and command latch enable gpmc_be0n_cle, output upper byte enable gpmc_be1n low                                      | Read                    | C <sup>(3)</sup>        | C <sup>(3)</sup>        |                          | ns   |
|     |                               |                                                                                                                                                              | Write                   | C <sup>(3)</sup>        | C <sup>(3)</sup>        |                          | ns   |
| F20 | $t_{w(\text{advnV})}$         | Pulse duration, output address valid and address latch enable gpmc_advn_ale low                                                                              | Read                    | K <sup>(13)</sup>       | K <sup>(13)</sup>       |                          | ns   |
|     |                               |                                                                                                                                                              | Write                   | K <sup>(13)</sup>       | K <sup>(13)</sup>       |                          | ns   |

- (1) For single read:  $A = (CSRdOffTime - CSOnTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 For burst read:  $A = (CSRdOffTime - CSOnTime + (n - 1) * PageBurstAccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 For burst write:  $A = (CSWrOffTime - CSOnTime + (n - 1) * PageBurstAccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 With n being the page burst access number.
- (2)  $B = ClkActivationTime * GPMC\_FCLK^{(14)}$
- (3) For single read:  $C = RdCycleTime * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 For burst read:  $C = (RdCycleTime + (n - 1) * PageBurstAccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 For burst write:  $C = (WrCycleTime + (n - 1) * PageBurstAccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 With n being the page burst access number.
- (4) For single read:  $D = (RdCycleTime - AccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 For burst read:  $D = (RdCycleTime - AccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 For burst write:  $D = (WrCycleTime - AccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$
- (5) For single read:  $E = (CSRdOffTime - AccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 For burst read:  $E = (CSRdOffTime - AccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
 For burst write:  $E = (CSWrOffTime - AccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$
- (6) For csn falling edge (CS activated):
  - Case GpmcFCLKDivider = 0:
    - $F = 0.5 * CSExtraDelay * GPMC\_FCLK^{(14)}$
  - Case GpmcFCLKDivider = 1:
    - $F = 0.5 * CSExtraDelay * GPMC\_FCLK^{(14)}$  if (ClkActivationTime and CSOnTime are odd) or (ClkActivationTime and CSOnTime are even)
    - $F = (1 + 0.5 * CSExtraDelay) * GPMC\_FCLK^{(14)}$  otherwise
  - Case GpmcFCLKDivider = 2:
    - $F = 0.5 * CSExtraDelay * GPMC\_FCLK^{(14)}$  if ((CSOnTime - ClkActivationTime) is a multiple of 3)
    - $F = (1 + 0.5 * CSExtraDelay) * GPMC\_FCLK^{(14)}$  if ((CSOnTime - ClkActivationTime - 1) is a multiple of 3)
    - $F = (2 + 0.5 * CSExtraDelay) * GPMC\_FCLK^{(14)}$  if ((CSOnTime - ClkActivationTime - 2) is a multiple of 3)
- (7) For ADV falling edge (ADV activated):
  - Case GpmcFCLKDivider = 0:
    - $G = 0.5 * ADVExtraDelay * GPMC\_FCLK^{(14)}$
  - Case GpmcFCLKDivider = 1:
    - $G = 0.5 * ADVExtraDelay * GPMC\_FCLK^{(14)}$  if (ClkActivationTime and ADVOnTime are odd) or (ClkActivationTime and ADVOnTime are even)
    - $G = (1 + 0.5 * ADVExtraDelay) * GPMC\_FCLK^{(14)}$  otherwise
  - Case GpmcFCLKDivider = 2:
    - $G = 0.5 * ADVExtraDelay * GPMC\_FCLK^{(14)}$  if ((ADVOnTime - ClkActivationTime) is a multiple of 3)
    - $G = (1 + 0.5 * ADVExtraDelay) * GPMC\_FCLK^{(14)}$  if ((ADVOnTime - ClkActivationTime - 1) is a multiple of 3)
    - $G = (2 + 0.5 * ADVExtraDelay) * GPMC\_FCLK^{(14)}$  if ((ADVOnTime - ClkActivationTime - 2) is a multiple of 3)

For ADV rising edge (ADV deactivated) in Reading mode:

  - Case GpmcFCLKDivider = 0:
    - $G = 0.5 * ADVExtraDelay * GPMC\_FCLK^{(14)}$
  - Case GpmcFCLKDivider = 1:
    - $G = 0.5 * ADVExtraDelay * GPMC\_FCLK^{(14)}$  if (ClkActivationTime and ADVRdOffTime are odd) or (ClkActivationTime and ADVRdOffTime are even)
    - $G = (1 + 0.5 * ADVExtraDelay) * GPMC\_FCLK^{(14)}$  otherwise
  - Case GpmcFCLKDivider = 2:
    - $G = 0.5 * ADVExtraDelay * GPMC\_FCLK^{(14)}$  if ((ADVRdOffTime - ClkActivationTime) is a multiple of 3)
    - $G = (1 + 0.5 * ADVExtraDelay) * GPMC\_FCLK^{(14)}$  if ((ADVRdOffTime - ClkActivationTime - 1) is a multiple of 3)
    - $G = (2 + 0.5 * ADVExtraDelay) * GPMC\_FCLK^{(14)}$  if ((ADVRdOffTime - ClkActivationTime - 2) is a multiple of 3)

For ADV rising edge (ADV deactivated) in Writing mode:

  - Case GpmcFCLKDivider = 0:
    - $G = 0.5 * ADVExtraDelay * GPMC\_FCLK^{(14)}$
  - Case GpmcFCLKDivider = 1:
    - $G = 0.5 * ADVExtraDelay * GPMC\_FCLK^{(14)}$  if (ClkActivationTime and ADVWrOffTime are odd) or (ClkActivationTime and ADVWrOffTime are even)
    - $G = (1 + 0.5 * ADVExtraDelay) * GPMC\_FCLK^{(14)}$  otherwise
  - Case GpmcFCLKDivider = 2:
    - $G = 0.5 * ADVExtraDelay * GPMC\_FCLK^{(14)}$  if ((ADVWrOffTime - ClkActivationTime) is a multiple of 3)
    - $G = (1 + 0.5 * ADVExtraDelay) * GPMC\_FCLK^{(14)}$  if ((ADVWrOffTime - ClkActivationTime - 1) is a multiple of 3)
    - $G = (2 + 0.5 * ADVExtraDelay) * GPMC\_FCLK^{(14)}$  if ((ADVWrOffTime - ClkActivationTime - 2) is a multiple of 3)- (8) For OE falling edge (OE activated) and IO DIR rising edge (Data Bus input direction):
  - Case GpmcFCLKDivider = 0:
    - $H = 0.5 * OEEExtraDelay * GPMC\_FCLK^{(14)}$
  - Case GpmcFCLKDivider = 1:
    - $H = 0.5 * OEEExtraDelay * GPMC\_FCLK^{(14)}$  if (ClkActivationTime and OEOnTime are odd) or (ClkActivationTime and OEOnTime are even)
    - $H = (1 + 0.5 * OEEExtraDelay) * GPMC\_FCLK^{(14)}$  otherwise
  - Case GpmcFCLKDivider = 2:

- $H = 0.5 * OEEExtraDelay * GPMC\_FCLK^{(14)}$  if  $((OEOnTime - ClkActivationTime)$  is a multiple of 3)
- $H = (1 + 0.5 * OEEExtraDelay) * GPMC\_FCLK^{(14)}$  if  $((OEOnTime - ClkActivationTime - 1)$  is a multiple of 3)
- $H = (2 + 0.5 * OEEExtraDelay) * GPMC\_FCLK^{(14)}$  if  $((OEOnTime - ClkActivationTime - 2)$  is a multiple of 3)

For OE rising edge (OE deactivated):

- Case GpmcFCLKDivider = 0:
  - $H = 0.5 * OEEExtraDelay * GPMC\_FCLK^{(14)}$
- Case GpmcFCLKDivider = 1:
  - $H = 0.5 * OEEExtraDelay * GPMC\_FCLK^{(14)}$  if  $(ClkActivationTime$  and  $OEOffTime$  are odd) or  $(ClkActivationTime$  and  $OEOffTime$  are even)
  - $H = (1 + 0.5 * OEEExtraDelay) * GPMC\_FCLK^{(14)}$  otherwise
- Case GpmcFCLKDivider = 2:
  - $H = 0.5 * OEEExtraDelay * GPMC\_FCLK^{(14)}$  if  $((OEOffTime - ClkActivationTime)$  is a multiple of 3)
  - $H = (1 + 0.5 * OEEExtraDelay) * GPMC\_FCLK^{(14)}$  if  $((OEOffTime - ClkActivationTime - 1)$  is a multiple of 3)
  - $H = (2 + 0.5 * OEEExtraDelay) * GPMC\_FCLK^{(14)}$  if  $((OEOffTime - ClkActivationTime - 2)$  is a multiple of 3)

(9) For WE falling edge (WE activated):

- Case GpmcFCLKDivider = 0:
  - $I = 0.5 * WEExtraDelay * GPMC\_FCLK^{(14)}$
- Case GpmcFCLKDivider = 1:
  - $I = 0.5 * WEExtraDelay * GPMC\_FCLK^{(14)}$  if  $(ClkActivationTime$  and  $WEOnTime$  are odd) or  $(ClkActivationTime$  and  $WEOnTime$  are even)
  - $I = (1 + 0.5 * WEExtraDelay) * GPMC\_FCLK^{(14)}$  otherwise
- Case GpmcFCLKDivider = 2:
  - $I = 0.5 * WEExtraDelay * GPMC\_FCLK^{(14)}$  if  $((WEOnTime - ClkActivationTime)$  is a multiple of 3)
  - $I = (1 + 0.5 * WEExtraDelay) * GPMC\_FCLK^{(14)}$  if  $((WEOnTime - ClkActivationTime - 1)$  is a multiple of 3)
  - $I = (2 + 0.5 * WEExtraDelay) * GPMC\_FCLK^{(14)}$  if  $((WEOnTime - ClkActivationTime - 2)$  is a multiple of 3)

For WE rising edge (WE deactivated):

- Case GpmcFCLKDivider = 0:
  - $I = 0.5 * WEExtraDelay * GPMC\_FCLK^{(14)}$
- Case GpmcFCLKDivider = 1:
  - $I = 0.5 * WEExtraDelay * GPMC\_FCLK^{(14)}$  if  $(ClkActivationTime$  and  $WEOffTime$  are odd) or  $(ClkActivationTime$  and  $WEOffTime$  are even)
  - $I = (1 + 0.5 * WEExtraDelay) * GPMC\_FCLK^{(14)}$  otherwise
- Case GpmcFCLKDivider = 2:
  - $I = 0.5 * WEExtraDelay * GPMC\_FCLK^{(14)}$  if  $((WEOffTime - ClkActivationTime)$  is a multiple of 3)
  - $I = (1 + 0.5 * WEExtraDelay) * GPMC\_FCLK^{(14)}$  if  $((WEOffTime - ClkActivationTime - 1)$  is a multiple of 3)
  - $I = (2 + 0.5 * WEExtraDelay) * GPMC\_FCLK^{(14)}$  if  $((WEOffTime - ClkActivationTime - 2)$  is a multiple of 3)

(10)  $J = GPMC\_FCLK^{(14)}$

(11) In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5. In gpmc\_wait[x], x is equal to 0 or 1.

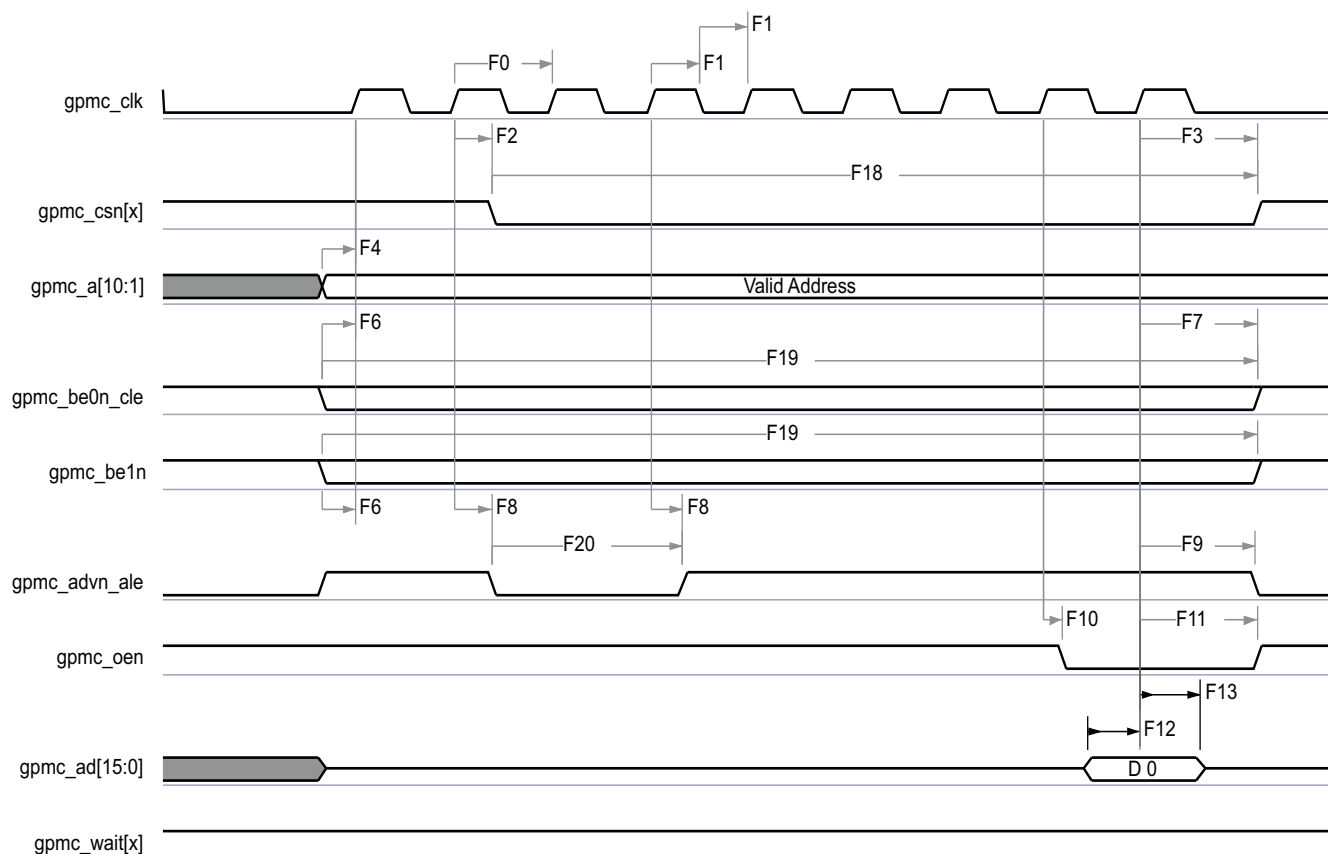
(12)  $P = gpmc\_clk$  period in ns

(13) For read:  $K = (ADVrOffTime - ADVOnTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
For write:  $K = (ADVwOffTime - ADVOnTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$

(14)  $GPMC\_FCLK$  is general-purpose memory controller internal functional clock period in ns.

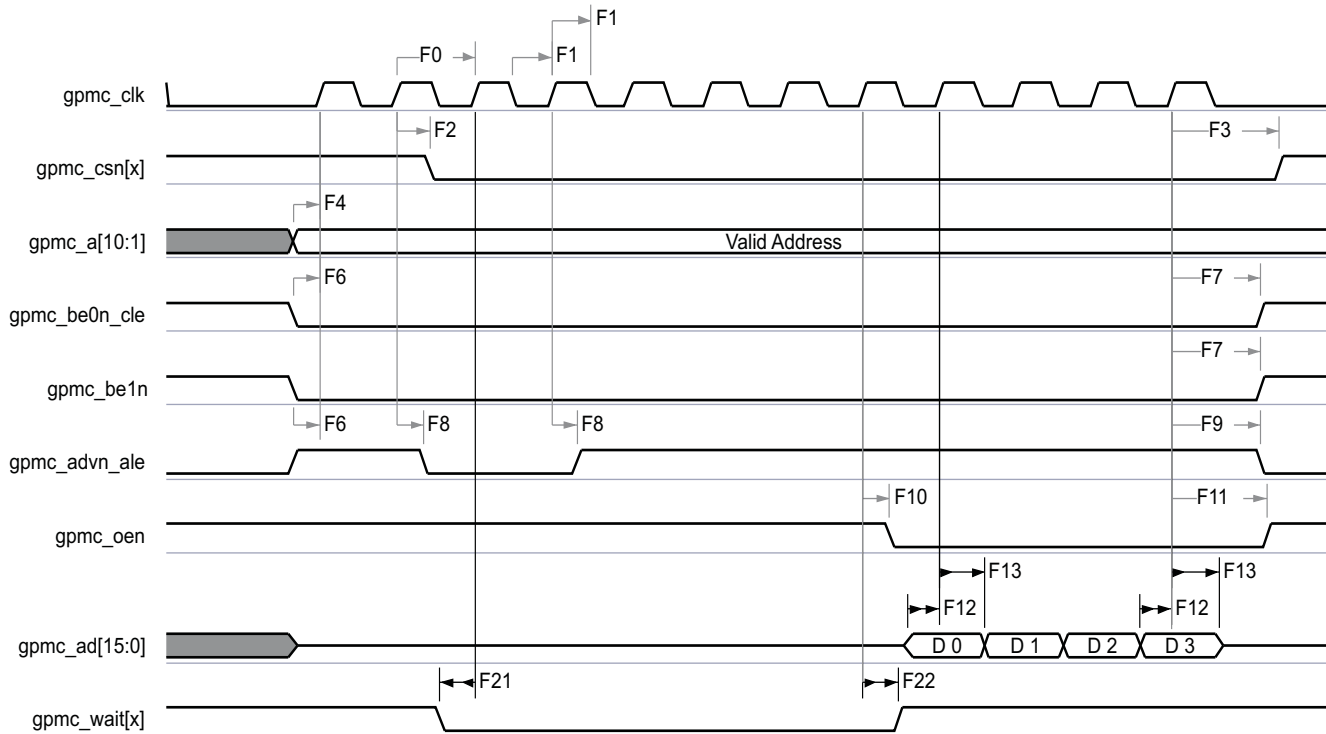
(15) Related to the gpmc\_clk output clock maximum and minimum frequencies programmable in the GPMC module by setting the GPMC\_CONFIG1\_CSx configuration register bit field GpmcFCLKDivider.

(16) The jitter probability density can be approximated by a Gaussian function.



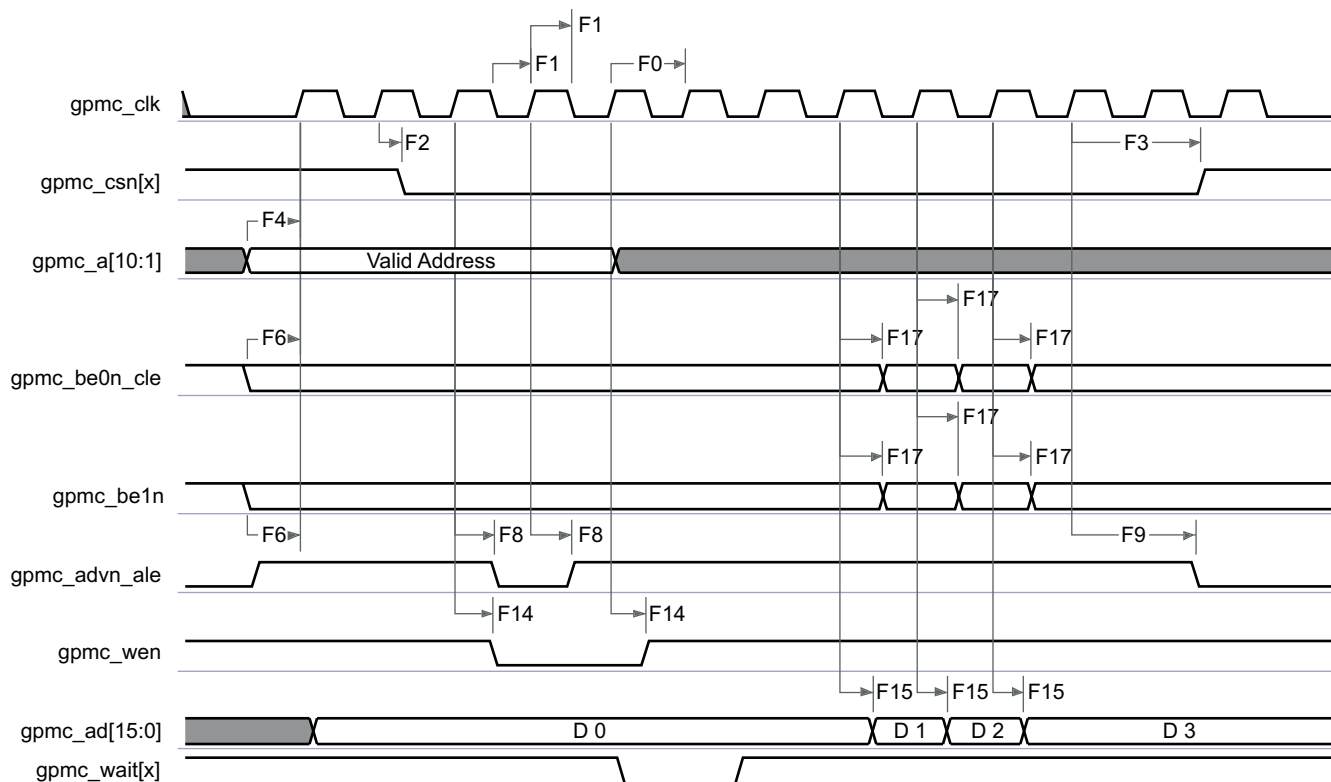
- In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5.
- In gpmc\_wait[x], x is equal to 0 or 1.

**Figure 5-17. GPMC and NOR Flash—Synchronous Single Read—(GpmcFCLKDivider = 0)**



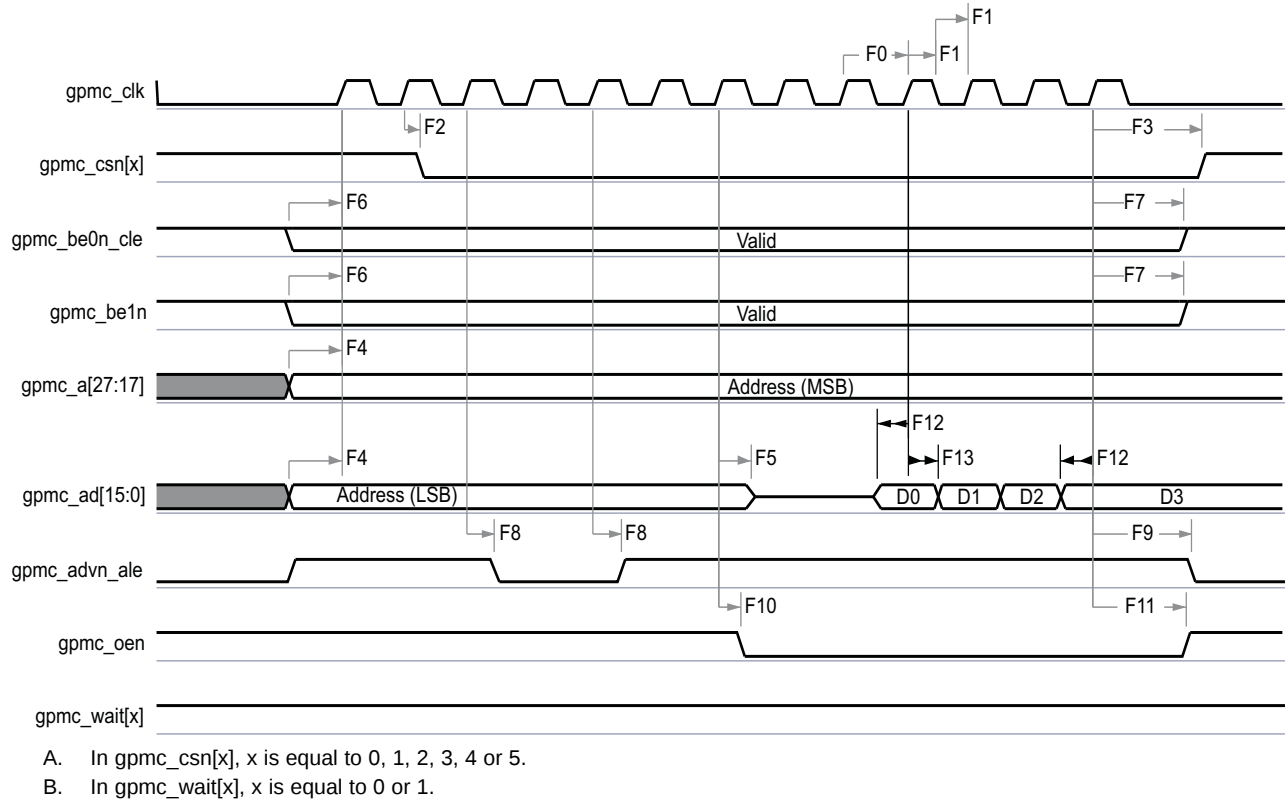
- A. In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5.  
B. In gpmc\_wait[x], x is equal to 0 or 1.

**Figure 5-18. GPMC and NOR Flash—Synchronous Burst Read—4x16-bit (GpmcFCLKDivider = 0)**

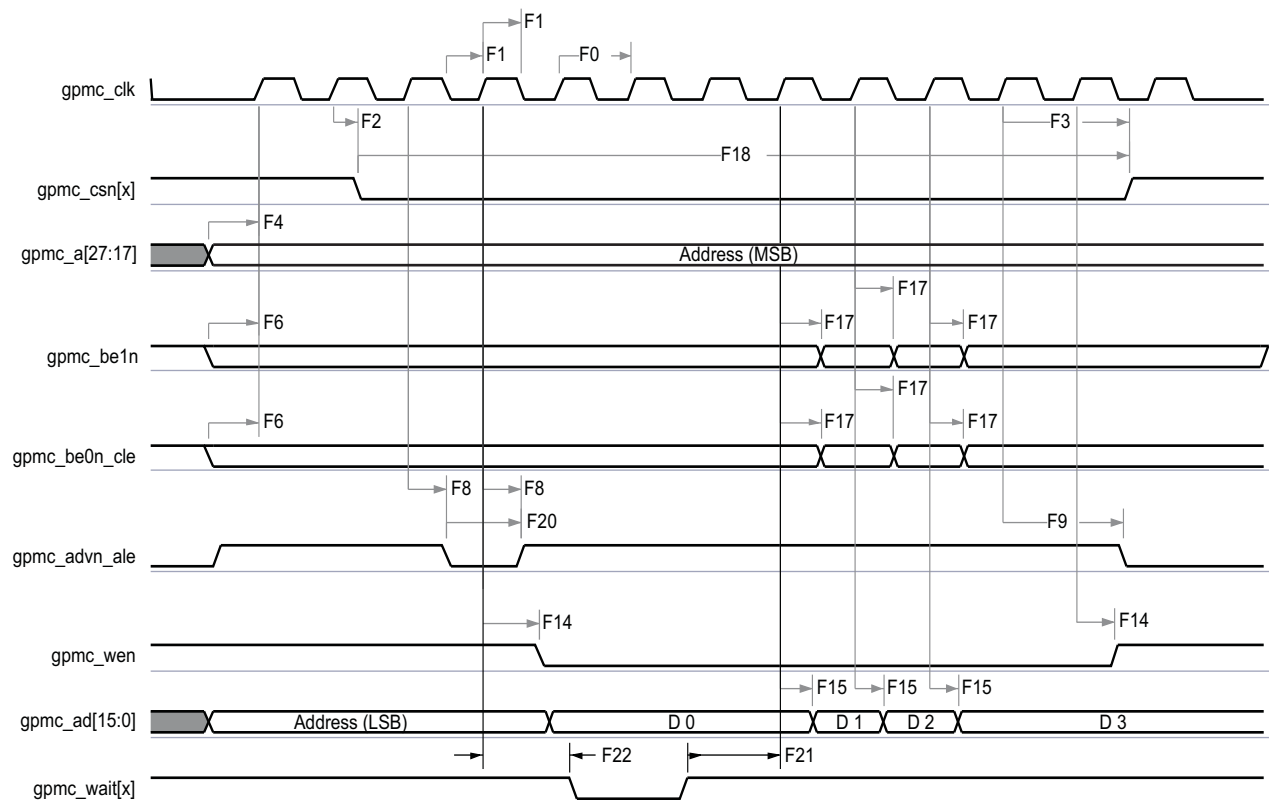


- A. In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5.
- B. In gpmc\_wait[x], x is equal to 0 or 1.

**Figure 5-19. GPMC and NOR Flash—Synchronous Burst Write—(GpmcFCLKDivider > 0)**



**Figure 5-20. GPMC and Multiplexed NOR Flash—Synchronous Burst Read**



- A. In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5.
- B. In gpmc\_wait[x], x is equal to 0 or 1.

**Figure 5-21. GPMC and Multiplexed NOR Flash—Synchronous Burst Write**

### 5.6.1.2 GPMC and NOR Flash—Asynchronous Mode

Table 5-24 and Table 5-25 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 5-22 through Figure 5-27).

**Table 5-23. GPMC and NOR Flash Timing Conditions—Asynchronous Mode**

| TIMING CONDITION PARAMETER |                         | MIN | TYP | MAX | UNIT |
|----------------------------|-------------------------|-----|-----|-----|------|
| <b>Input Conditions</b>    |                         |     |     |     |      |
| t <sub>R</sub>             | Input signal rise time  | 1   |     | 5   | ns   |
| t <sub>F</sub>             | Input signal fall time  | 1   |     | 5   | ns   |
| <b>Output Condition</b>    |                         |     |     |     |      |
| C <sub>LOAD</sub>          | Output load capacitance | 3   |     | 30  | pF   |

**Table 5-24. GPMC and NOR Flash Internal Timing Parameters—Asynchronous Mode<sup>(1)(2)</sup>**

| NO. |                                                                                                                                                                                    | OPP100 |     | OPP50 |     | UNIT |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----|-------|-----|------|
|     |                                                                                                                                                                                    | MIN    | MAX | MIN   | MAX |      |
| FI1 | Delay time, output data gpmc_ad[15:0] generation from internal functional clock GPMC_FCLK <sup>(3)</sup>                                                                           |        | 6.5 |       | 6.5 | ns   |
| FI2 | Delay time, input data gpmc_ad[15:0] capture from internal functional clock GPMC_FCLK <sup>(3)</sup>                                                                               |        | 4   |       | 4   | ns   |
| FI3 | Delay time, output chip select gpmc_csn[x] generation from internal functional clock GPMC_FCLK <sup>(3)</sup>                                                                      |        | 6.5 |       | 6.5 | ns   |
| FI4 | Delay time, output address gpmc_a[27:1] generation from internal functional clock GPMC_FCLK <sup>(3)</sup>                                                                         |        | 6.5 |       | 6.5 | ns   |
| FI5 | Delay time, output address gpmc_a[27:1] valid from internal functional clock GPMC_FCLK <sup>(3)</sup>                                                                              |        | 6.5 |       | 6.5 | ns   |
| FI6 | Delay time, output lower-byte enable and command latch enable gpmc_be0n_cle, output upper-byte enable gpmc_be1n generation from internal functional clock GPMC_FCLK <sup>(3)</sup> |        | 6.5 |       | 6.5 | ns   |
| FI7 | Delay time, output enable gpmc_oen generation from internal functional clock GPMC_FCLK <sup>(3)</sup>                                                                              |        | 6.5 |       | 6.5 | ns   |
| FI8 | Delay time, output write enable gpmc_wen generation from internal functional clock GPMC_FCLK <sup>(3)</sup>                                                                        |        | 6.5 |       | 6.5 | ns   |
| FI9 | Skew, internal functional clock GPMC_FCLK <sup>(3)</sup>                                                                                                                           |        | 100 |       | 100 | ps   |

(1) The internal parameters table must be used to calculate data access time stored in the corresponding CS register bit field.

(2) Internal parameters are referred to the GPMC functional internal clock which is not provided externally.

(3) GPMC\_FCLK is general-purpose memory controller internal functional clock.

**Table 5-25. GPMC and NOR Flash Timing Requirements—Asynchronous Mode**

| NO.                 |                      |                                       | OPP100 |                  | OPP50 |                  | UNIT |
|---------------------|----------------------|---------------------------------------|--------|------------------|-------|------------------|------|
|                     |                      |                                       | MIN    | MAX              | MIN   | MAX              |      |
| FA5 <sup>(1)</sup>  | $t_{acc(d)}$         | Data access time                      |        | H <sup>(5)</sup> |       | H <sup>(5)</sup> | ns   |
| FA20 <sup>(2)</sup> | $t_{acc1-pgmode(d)}$ | Page mode successive data access time |        | P <sup>(4)</sup> |       | P <sup>(4)</sup> | ns   |
| FA21 <sup>(3)</sup> | $t_{acc2-pgmode(d)}$ | Page mode first data access time      |        | H <sup>(5)</sup> |       | H <sup>(5)</sup> | ns   |

- (1) The FA5 parameter illustrates the amount of time required to internally sample input data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after FA5 functional clock cycles, input data is internally sampled by active functional clock edge. FA5 value must be stored inside the AccessTime register bit field.
- (2) The FA20 parameter illustrates amount of time required to internally sample successive input page data. It is expressed in number of GPMC functional clock cycles. After each access to input page data, next input page data is internally sampled by active functional clock edge after FA20 functional clock cycles. The FA20 value must be stored in the PageBurstAccessTime register bit field.
- (3) The FA21 parameter illustrates amount of time required to internally sample first input page data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after FA21 functional clock cycles, first input page data is internally sampled by active functional clock edge. FA21 value must be stored inside the AccessTime register bit field.
- (4)  $P = \text{PageBurstAccessTime} * (\text{TimeParaGranularity} + 1) * \text{GPMC\_FCLK}$ <sup>(6)</sup>
- (5)  $H = \text{AccessTime} * (\text{TimeParaGranularity} + 1) * \text{GPMC\_FCLK}$ <sup>(6)</sup>
- (6) GPMC\_FCLK is general-purpose memory controller internal functional clock period in ns.

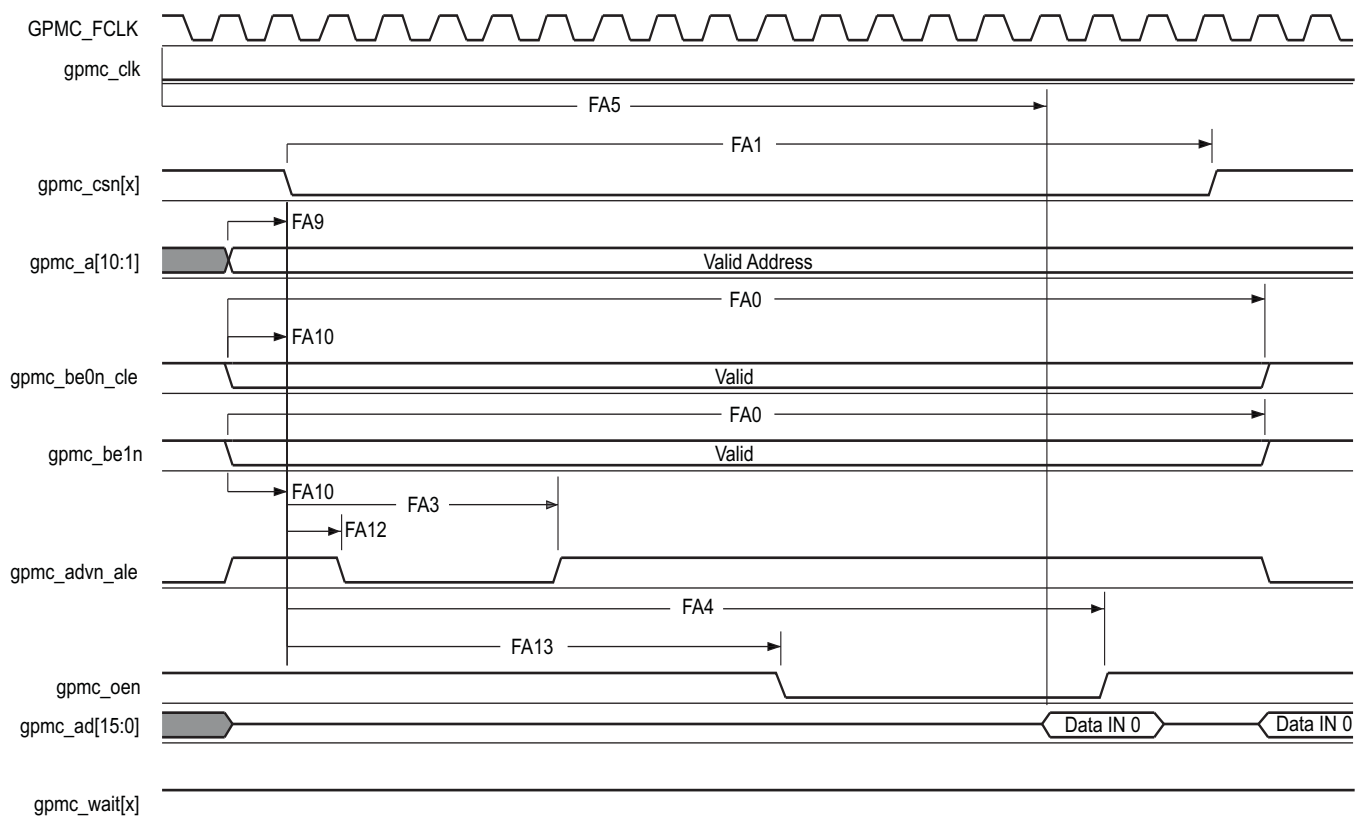
**Table 5-26. GPMC and NOR Flash Switching Characteristics—Asynchronous Mode**

| NO.  | PARAMETER                     |                                                                                                                                                                               |       | OPP100                  |                         | OPP50                 |                       | UNIT |
|------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------------|-------------------------|-----------------------|-----------------------|------|
|      |                               |                                                                                                                                                                               |       | MIN                     | MAX                     | MIN                   | MAX                   |      |
|      | t <sub>R(d)</sub>             | Rise time, output data gpmc_ad[15:0]                                                                                                                                          |       |                         | 2                       |                       | 2                     | ns   |
|      | t <sub>F(d)</sub>             | Fall time, output data gpmc_ad[15:0]                                                                                                                                          |       |                         | 2                       |                       | 2                     | ns   |
| FA0  | t <sub>w</sub> (be[x]nV)      | Pulse duration, output lower-byte enable and command latch enable gpmc_be0n_cle, output upper-byte enable gpmc_be1n valid time                                                | Read  | N <sup>(12)</sup>       |                         | N <sup>(12)</sup>     |                       | ns   |
|      |                               |                                                                                                                                                                               | Write | N <sup>(12)</sup>       |                         | N <sup>(12)</sup>     |                       |      |
| FA1  | t <sub>w</sub> (csnV)         | Pulse duration, output chip select gpmc_csn[x] <sup>(13)</sup> low                                                                                                            | Read  | A <sup>(1)</sup>        |                         | A <sup>(1)</sup>      |                       | ns   |
|      |                               |                                                                                                                                                                               | Write | A <sup>(1)</sup>        |                         | A <sup>(1)</sup>      |                       |      |
| FA3  | t <sub>d</sub> (csnV-advnIV)  | Delay time, output chip select gpmc_csn[x] <sup>(13)</sup> valid to output address valid and address latch enable gpmc_advn_ale invalid                                       | Read  | B <sup>(2)</sup> - 0.2  | B <sup>(2)</sup> + 2.0  | B <sup>(2)</sup> - 5  | B <sup>(2)</sup> + 5  | ns   |
|      |                               |                                                                                                                                                                               | Write | B <sup>(2)</sup> - 0.2  | B <sup>(2)</sup> + 2.0  | B <sup>(2)</sup> - 5  | B <sup>(2)</sup> + 5  |      |
| FA4  | t <sub>d</sub> (csnV-oenIV)   | Delay time, output chip select gpmc_csn[x] <sup>(13)</sup> valid to output enable gpmc_oen invalid (Single read)                                                              |       | C <sup>(3)</sup> - 0.2  | C <sup>(3)</sup> + 2.0  | C <sup>(3)</sup> - 5  | C <sup>(3)</sup> + 5  | ns   |
| FA9  | t <sub>d</sub> (aV-csnV)      | Delay time, output address gpmc_a[27:1] valid to output chip select gpmc_csn[x] <sup>(13)</sup> valid                                                                         |       | J <sup>(9)</sup> - 0.2  | J <sup>(9)</sup> + 2.0  | J <sup>(9)</sup> - 5  | J <sup>(9)</sup> + 5  | ns   |
| FA10 | t <sub>d</sub> (be[x]nV-csnV) | Delay time, output lower-byte enable and command latch enable gpmc_be0n_cle, output upper-byte enable gpmc_be1n valid to output chip select gpmc_csn[x] <sup>(13)</sup> valid |       | J <sup>(9)</sup> - 0.2  | J <sup>(9)</sup> + 2.0  | J <sup>(9)</sup> - 5  | J <sup>(9)</sup> + 5  | ns   |
| FA12 | t <sub>d</sub> (csnV-advnV)   | Delay time, output chip select gpmc_csn[x] <sup>(13)</sup> valid to output address valid and address latch enable gpmc_advn_ale valid                                         |       | K <sup>(10)</sup> - 0.2 | K <sup>(10)</sup> + 2.0 | K <sup>(10)</sup> - 5 | K <sup>(10)</sup> + 5 | ns   |
| FA13 | t <sub>d</sub> (csnV-oenV)    | Delay time, output chip select gpmc_csn[x] <sup>(13)</sup> valid to output enable gpmc_oen valid                                                                              |       | L <sup>(11)</sup> - 0.2 | L <sup>(11)</sup> + 2.0 | L <sup>(11)</sup> - 5 | L <sup>(11)</sup> + 5 | ns   |
| FA16 | t <sub>w</sub> (aIV)          | Pulse durationm output address gpmc_a[26:1] invalid between 2 successive read and write accesses                                                                              |       | G <sup>(7)</sup>        |                         | G <sup>(7)</sup>      |                       | ns   |
| FA18 | t <sub>d</sub> (csnV-oenIV)   | Delay time, output chip select gpmc_csn[x] <sup>(13)</sup> valid to output enable gpmc_oen invalid (Burst read)                                                               |       | I <sup>(8)</sup> - 0.2  | I <sup>(8)</sup> + 2.0  | I <sup>(8)</sup> - 5  | I <sup>(8)</sup> + 5  | ns   |
| FA20 | t <sub>w</sub> (aV)           | Pulse duration, output address gpmc_a[27:1] valid - 2nd, 3rd, and 4th accesses                                                                                                |       | D <sup>(4)</sup>        |                         | D <sup>(4)</sup>      |                       | ns   |
| FA25 | t <sub>d</sub> (csnV-wenV)    | Delay time, output chip select gpmc_csn[x] <sup>(13)</sup> valid to output write enable gpmc_wen valid                                                                        |       | E <sup>(5)</sup> - 0.2  | E <sup>(5)</sup> + 2.0  | E <sup>(5)</sup> - 5  | E <sup>(5)</sup> + 5  | ns   |

**Table 5-26. GPMC and NOR Flash Switching Characteristics—Asynchronous Mode (continued)**

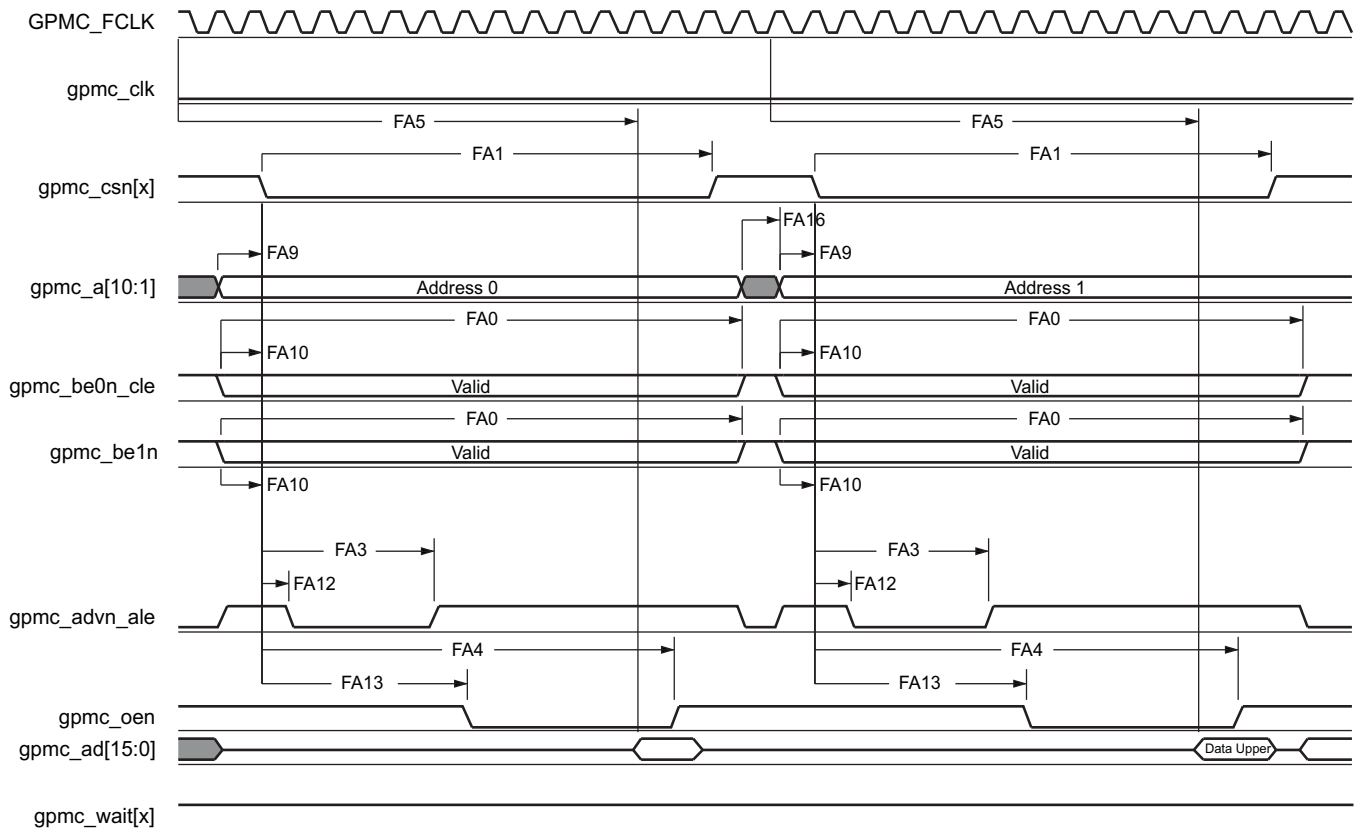
| NO.  | PARAMETER          |                                                                                                          | OPP100          |                 | OPP50         |               | UNIT |
|------|--------------------|----------------------------------------------------------------------------------------------------------|-----------------|-----------------|---------------|---------------|------|
|      |                    |                                                                                                          | MIN             | MAX             | MIN           | MAX           |      |
| FA27 | $t_{d(csnV-wenV)}$ | Delay time, output chip select gpmc_csn[x] <sup>(13)</sup> valid to output write enable gpmc_wen invalid | $F^{(6)} - 0.2$ | $F^{(6)} + 2.0$ | $F^{(6)} - 5$ | $F^{(6)} + 5$ | ns   |
| FA28 | $t_{d(wenV-dV)}$   | Delay time, output write enable gpmc_wen valid to output data gpmc_ad[15:0] valid                        |                 | 2.0             |               | 5             | ns   |
| FA29 | $t_{d(dV-csnV)}$   | Delay time, output data gpmc_ad[15:0] valid to output chip select gpmc_csn[x] <sup>(13)</sup> valid      | $J^{(9)} - 0.2$ | $J^{(9)} + 2.0$ | $J^{(9)} - 5$ | $J^{(9)} + 5$ | ns   |
| FA37 | $t_{d(oenV-alV)}$  | Delay time, output enable gpmc_oen valid to output address gpmc_ad[15:0] phase end                       |                 | 2.0             |               | 5             | ns   |

- (1) For single read:  $A = (CSRdOffTime - CSOnTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
For single write:  $A = (CSWrOffTime - CSOnTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
For burst read:  $A = (CSRdOffTime - CSOnTime + (n - 1) * PageBurstAccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
For burst write:  $A = (CSWrOffTime - CSOnTime + (n - 1) * PageBurstAccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
with n being the page burst access number
- (2) For reading:  $B = ((ADVrdOffTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (ADVExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$   
For writing:  $B = ((ADVWrOffTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (ADVExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$
- (3)  $C = ((OEOffTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (OEExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$
- (4)  $D = PageBurstAccessTime * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$
- (5)  $E = ((WEOnTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (WEExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$
- (6)  $F = ((WEOffTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (WEExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$
- (7)  $G = Cycle2CycleDelay * GPMC\_FCLK^{(14)}$
- (8)  $I = ((OEOffTime + (n - 1) * PageBurstAccessTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (OEExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$
- (9)  $J = (CSOnTime * (TimeParaGranularity + 1) + 0.5 * CSEExtraDelay) * GPMC\_FCLK^{(14)}$
- (10)  $K = ((ADVOnTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (ADVExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$
- (11)  $L = ((OEOnTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (OEExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$
- (12) For single read:  $N = RdCycleTime * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
For single write:  $N = WrCycleTime * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
For burst read:  $N = (RdCycleTime + (n - 1) * PageBurstAccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$   
For burst write:  $N = (WrCycleTime + (n - 1) * PageBurstAccessTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$
- (13) In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5.
- (14) GPMC\_FCLK is general-purpose memory controller internal functional clock period in ns.



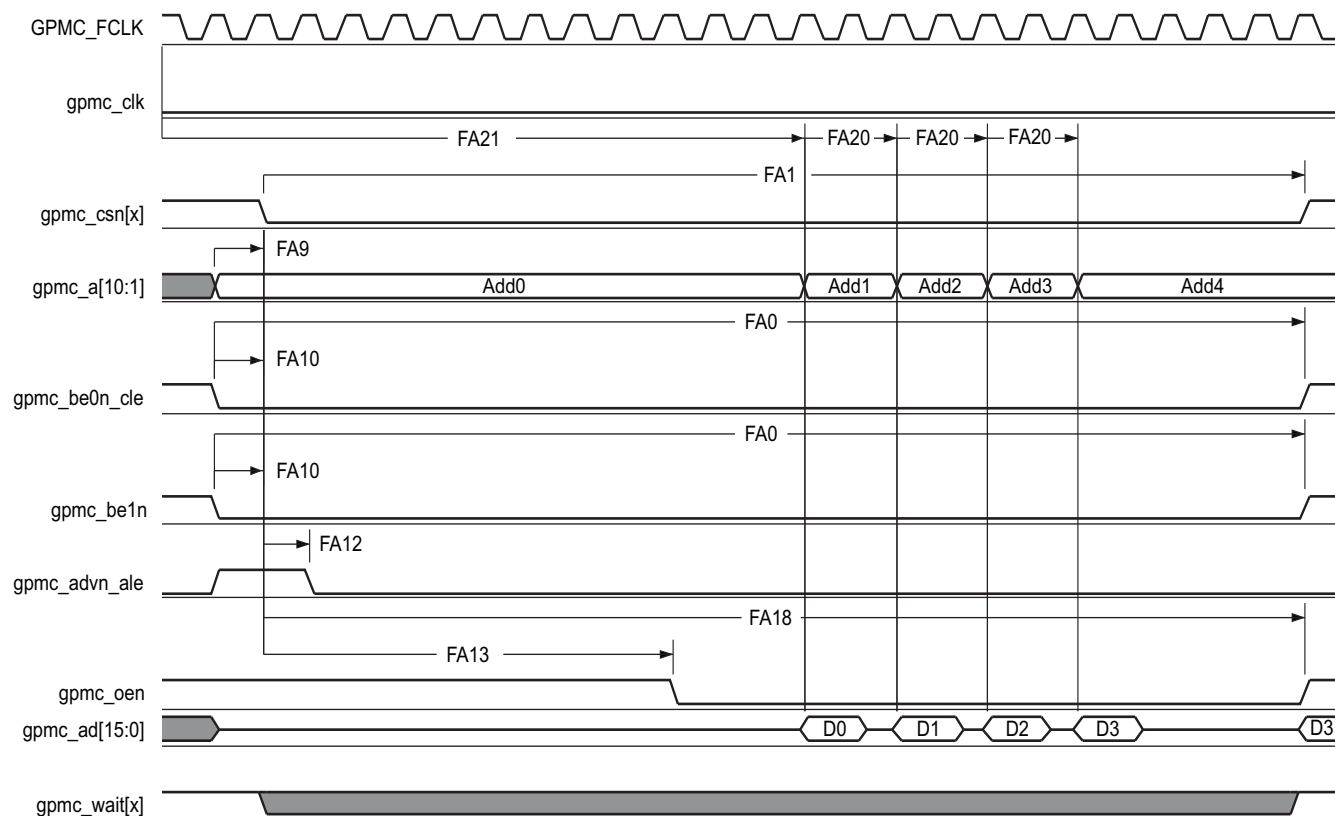
- In `gpmc_csn[x]`, `x` is equal to 0, 1, 2, 3, 4 or 5. In `gpmc_wait[x]`, `x` is equal to 0 or 1.
- `FA5` parameter illustrates amount of time required to internally sample input data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after `FA5` functional clock cycles, input data will be internally sampled by active functional clock edge. `FA5` value must be stored inside `AccessTime` register bits field.
- `GPMC_FCLK` is an internal clock (GPMC functional clock) not provided externally.

**Figure 5-22. GPMC and NOR Flash—Asynchronous Read—Single Word**



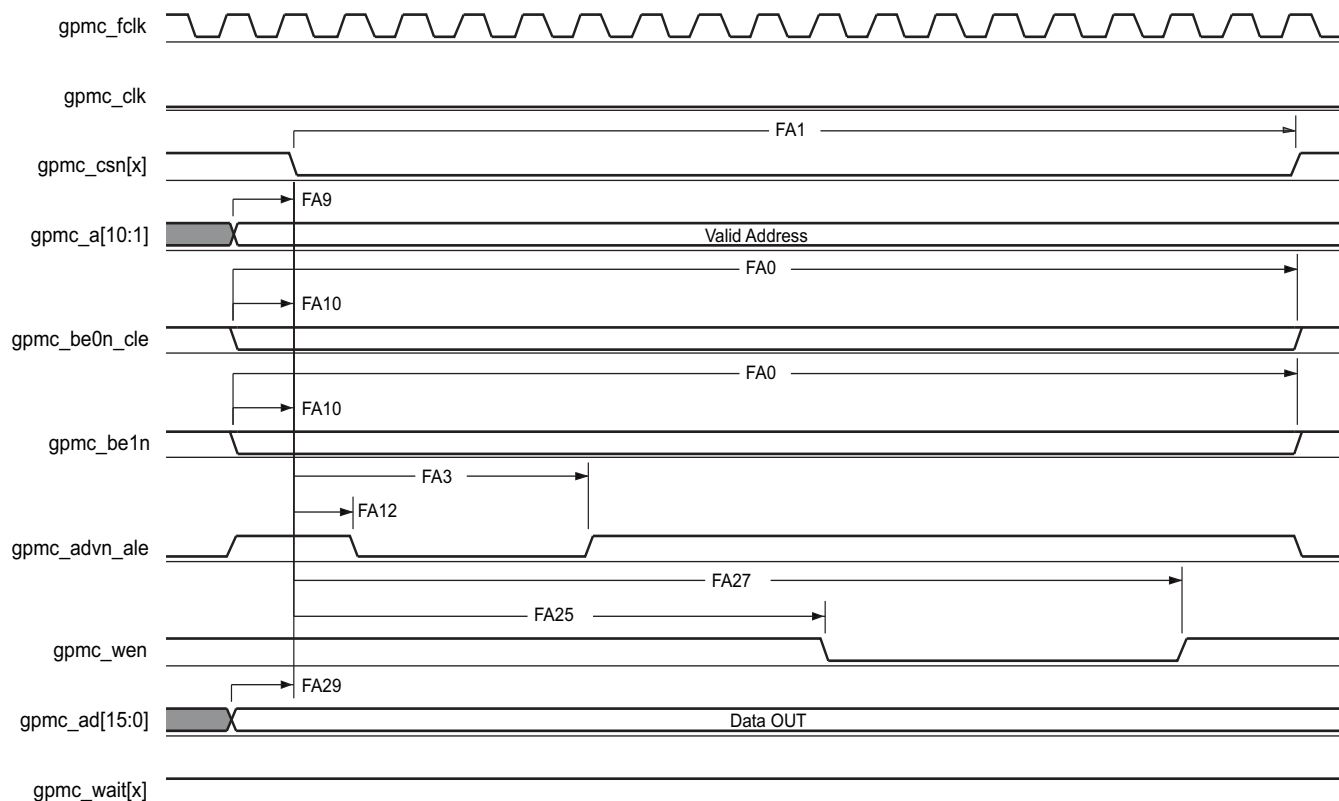
- In `gpmc_csn[x]`, `x` is equal to 0, 1, 2, 3, 4 or 5. In `gpmc_wait[x]`, `x` is equal to 0 or 1.
- FA5** parameter illustrates amount of time required to internally sample input data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after **FA5** functional clock cycles, input data will be internally sampled by active functional clock edge. **FA5** value must be stored inside AccessTime register bits field.
- GPMC\_FCLK is an internal clock (GPMC functional clock) not provided externally.

**Figure 5-23. GPMC and NOR Flash—Asynchronous Read—32-bit**



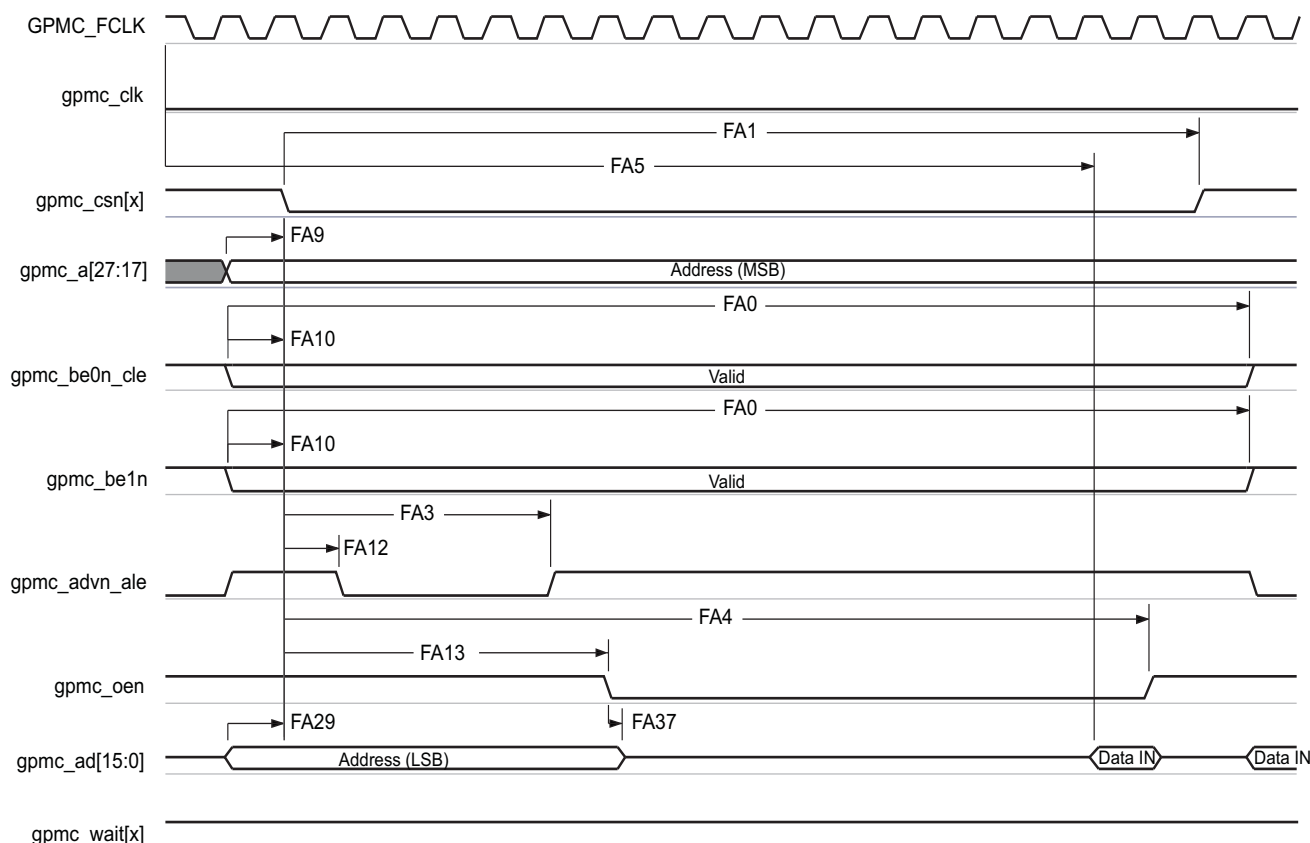
- A. In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5. In gpmc\_wait[x], x is equal to 0 or 1.
- B. FA21 parameter illustrates amount of time required to internally sample first input page data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after FA21 functional clock cycles, first input page data will be internally sampled by active functional clock edge. FA21 calculation must be stored inside AccessTime register bits field.
- C. FA20 parameter illustrates amount of time required to internally sample successive input page data. It is expressed in number of GPMC functional clock cycles. After each access to input page data, next input page data will be internally sampled by active functional clock edge after FA20 functional clock cycles. FA20 is also the duration of address phases for successive input page data (excluding first input page data). FA20 value must be stored in PageBurstAccessTime register bits field.
- D. GPMC\_FCLK is an internal clock (GPMC functional clock) not provided externally.

**Figure 5-24. GPMC and NOR Flash—Asynchronous Read—Page Mode 4x16-bit**



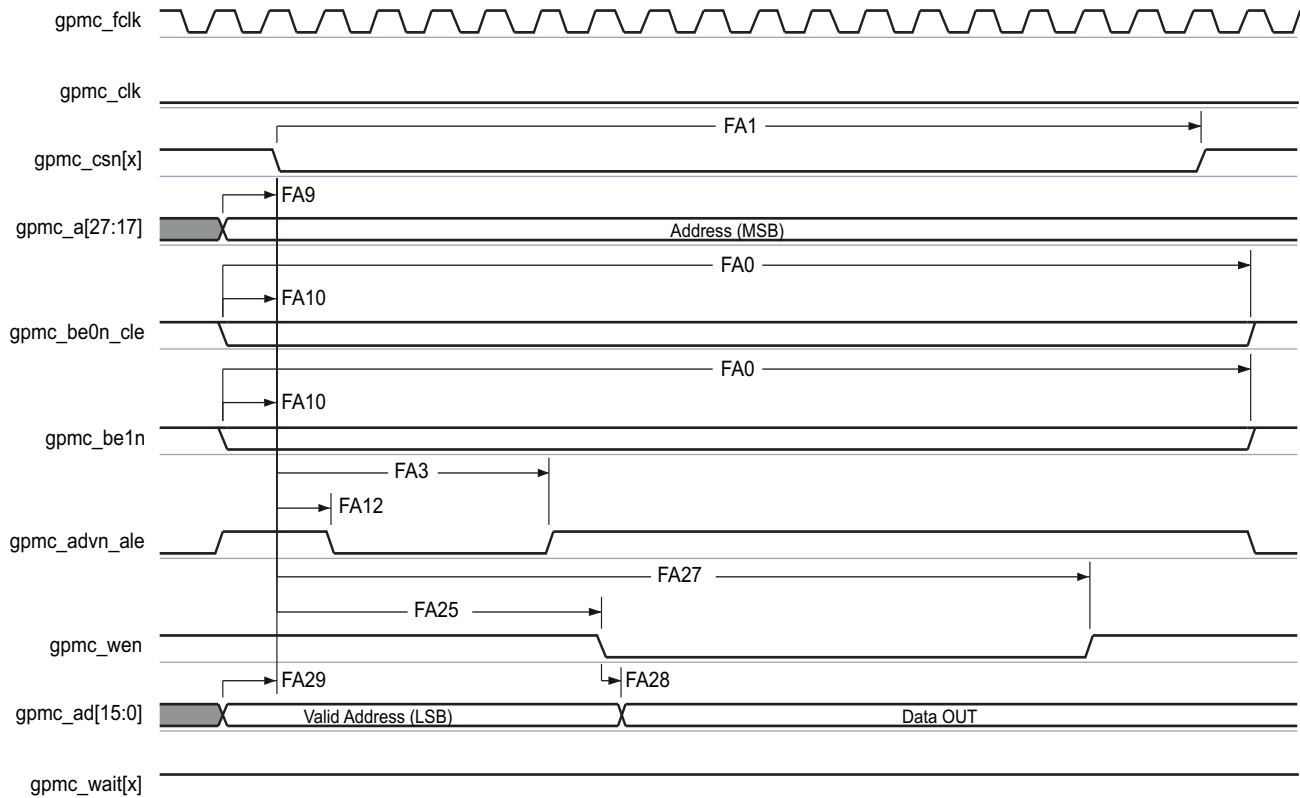
A. In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5. In gpmc\_wait[x], x is equal to 0 or 1.

**Figure 5-25. GPMC and NOR Flash—Asynchronous Write—Single Word**



- In `gpmc_csn[x]`, `x` is equal to 0, 1, 2, 3, 4 or 5. In `gpmc_wait[x]`, `x` is equal to 0 or 1.
- FA5 parameter illustrates amount of time required to internally sample input data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after FA5 functional clock cycles, input data will be internally sampled by active functional clock edge. FA5 value must be stored inside AccessTime register bits field.
- GPMC\_FCLK is an internal clock (GPMC functional clock) not provided externally.

**Figure 5-26. GPMC and Multiplexed NOR Flash—Asynchronous Read—Single Word**



A. In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5. In gpmc\_wait[x], x is equal to 0 or 1.

**Figure 5-27. GPMC and Multiplexed NOR Flash—Asynchronous Write—Single Word**

### 5.6.1.3 GPMC and NAND Flash—Asynchronous Mode

Table 5-28 and Table 5-29 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 5-28 through Figure 5-31).

**Table 5-27. GPMC and NAND Flash Timing Conditions—Asynchronous Mode**

| TIMING CONDITION PARAMETER |                         | MIN | TYP | MAX | UNIT |
|----------------------------|-------------------------|-----|-----|-----|------|
| <b>Input Conditions</b>    |                         |     |     |     |      |
| $t_R$                      | Input signal rise time  | 1   |     | 5   | ns   |
| $t_F$                      | Input signal fall time  | 1   |     | 5   | ns   |
| <b>Output Condition</b>    |                         |     |     |     |      |
| $C_{LOAD}$                 | Output load capacitance | 3   |     | 30  | pF   |

**Table 5-28. GPMC and NAND Flash Internal Timing Parameters—Asynchronous Mode<sup>(1)(2)</sup>**

| NO.   |                                                                                                                                                | OPP100 |     | OPP50 |     | UNIT |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----|-------|-----|------|
|       |                                                                                                                                                | MIN    | MAX | MIN   | MAX |      |
| GNFI1 | Delay time, output data gpmc_ad[15:0] generation from internal functional clock GPMC_FCLK <sup>(3)</sup>                                       |        | 6.5 |       | 6.5 | ns   |
| GNFI2 | Delay time, input data gpmc_ad[15:0] capture from internal functional clock GPMC_FCLK <sup>(3)</sup>                                           |        | 4.0 |       | 4.0 | ns   |
| GNFI3 | Delay time, output chip select gpmc_csn[x] generation from internal functional clock GPMC_FCLK <sup>(3)</sup>                                  |        | 6.5 |       | 6.5 | ns   |
| GNFI4 | Delay time, output address valid and address latch enable gpmc_advn_ale generation from internal functional clock GPMC_FCLK <sup>(3)</sup>     |        | 6.5 |       | 6.5 | ns   |
| GNFI5 | Delay time, output lower-byte enable and command latch enable gpmc_be0n_cle generation from internal functional clock GPMC_FCLK <sup>(3)</sup> |        | 6.5 |       | 6.5 | ns   |
| GNFI6 | Delay time, output enable gpmc_oen generation from internal functional clock GPMC_FCLK <sup>(3)</sup>                                          |        | 6.5 |       | 6.5 | ns   |
| GNFI7 | Delay time, output write enable gpmc_wen generation from internal functional clock GPMC_FCLK <sup>(3)</sup>                                    |        | 6.5 |       | 6.5 | ns   |
| GNFI8 | Skew, functional clock GPMC_FCLK <sup>(3)</sup>                                                                                                |        | 100 |       | 100 | ps   |

(1) Internal parameters table must be used to calculate data access time stored in the corresponding CS register bit field.

(2) Internal parameters are referred to the GPMC functional internal clock which is not provided externally.

(3) GPMC\_FCLK is general-purpose memory controller internal functional clock.

**Table 5-29. GPMC and NAND Flash Timing Requirements—Asynchronous Mode**

| NO.                  |              |                                       | OPP100 |                  | OPP50 |                  | UNIT |
|----------------------|--------------|---------------------------------------|--------|------------------|-------|------------------|------|
|                      |              |                                       | MIN    | MAX              | MIN   | MAX              |      |
| GNF12 <sup>(1)</sup> | $t_{acc(d)}$ | Access time, input data gpmc_ad[15:0] |        | J <sup>(2)</sup> |       | J <sup>(2)</sup> | ns   |

(1) The GNF12 parameter illustrates the amount of time required to internally sample input data. It is expressed in number of GPMC functional clock cycles. From start of the read cycle and after GNF12 functional clock cycles, input data is internally sampled by the active functional clock edge. The GNF12 value must be stored inside AccessTime register bit field.

(2)  $J = \text{AccessTime} * (\text{TimeParaGranularity} + 1) * \text{GPMC\_FCLK}^{(3)}$

(3) GPMC\_FCLK is general-purpose memory controller internal functional clock period in ns.

**Table 5-30. GPMC and NAND Flash Switching Characteristics—Asynchronous Mode**

| NO.   | PARAMETER            |                                                                                                                             | OPP100                  |                         | OPP50                 |                       | UNIT |
|-------|----------------------|-----------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-----------------------|-----------------------|------|
|       |                      |                                                                                                                             | MIN                     | MAX                     | MIN                   | MAX                   |      |
|       | $t_{R(d)}$           | Rise time, output data gpmc_ad[15:0]                                                                                        |                         | 2                       |                       | 2                     | ns   |
|       | $t_{F(d)}$           | Fall time, output data gpmc_ad[15:0]                                                                                        |                         | 2                       |                       | 2                     | ns   |
| GNF0  | $t_{w(wenV)}$        | Pulse duration, output write enable gpmc_wen valid                                                                          | A <sup>(1)</sup>        |                         | A <sup>(1)</sup>      |                       | ns   |
| GNF1  | $t_{d(csnV-wenV)}$   | Delay time, output chip select gpmc_csn[x] <sup>(13)</sup> valid to output write enable gpmc_wen valid                      | B <sup>(2)</sup> - 0.2  | B <sup>(2)</sup> + 2.0  | B <sup>(2)</sup> - 5  | B <sup>(2)</sup> + 5  | ns   |
| GNF2  | $t_{w(cleH-wenV)}$   | Delay time, output lower-byte enable and command latch enable gpmc_be0n_cle high to output write enable gpmc_wen valid      | C <sup>(3)</sup> - 0.2  | C <sup>(3)</sup> + 2.0  | C <sup>(3)</sup> - 5  | C <sup>(3)</sup> + 5  | ns   |
| GNF3  | $t_{w(wenV-dV)}$     | Delay time, output data gpmc_ad[15:0] valid to output write enable gpmc_wen valid                                           | D <sup>(4)</sup> - 0.2  | D <sup>(4)</sup> + 2.0  | D <sup>(4)</sup> - 5  | D <sup>(4)</sup> + 5  | ns   |
| GNF4  | $t_{w(wenIV-dIV)}$   | Delay time, output write enable gpmc_wen invalid to output data gpmc_ad[15:0] invalid                                       | E <sup>(5)</sup> - 0.2  | E <sup>(5)</sup> + 5    | E <sup>(5)</sup> - 5  | E <sup>(5)</sup> + 5  | ns   |
| GNF5  | $t_{w(wenIV-cleIV)}$ | Delay time, output write enable gpmc_wen invalid to output lower-byte enable and command latch enable gpmc_be0n_cle invalid | F <sup>(6)</sup> - 0.2  | F <sup>(6)</sup> + 2.0  | F <sup>(6)</sup> - 5  | F <sup>(6)</sup> + 5  | ns   |
| GNF6  | $t_{w(wenIV-csnIV)}$ | Delay time, output write enable gpmc_wen invalid to output chip select gpmc_csn[x] <sup>(13)</sup> invalid                  | G <sup>(7)</sup> - 0.2  | G <sup>(7)</sup> + 2.0  | G <sup>(7)</sup> - 5  | G <sup>(7)</sup> + 5  | ns   |
| GNF7  | $t_{w(aleH-wenV)}$   | Delay time, output address valid and address latch enable gpmc_advn_ale high to output write enable gpmc_wen valid          | C <sup>(3)</sup> - 0.2  | C <sup>(3)</sup> + 2.0  | C <sup>(3)</sup> - 5  | C <sup>(3)</sup> + 5  | ns   |
| GNF8  | $t_{w(wenIV-aleIV)}$ | Delay time, output write enable gpmc_wen invalid to output address valid and address latch enable gpmc_advn_ale invalid     | F <sup>(6)</sup> - 0.2  | F <sup>(6)</sup> + 2.0  | F <sup>(6)</sup> - 5  | F <sup>(6)</sup> + 5  | ns   |
| GNF9  | $t_{c(wen)}$         | Cycle time, write                                                                                                           |                         | H <sup>(8)</sup>        |                       | H <sup>(8)</sup>      | ns   |
| GNF10 | $t_{d(csnV-oenV)}$   | Delay time, output chip select gpmc_csn[x] <sup>(13)</sup> valid to output enable gpmc_oen valid                            | I <sup>(9)</sup> - 0.2  | I <sup>(9)</sup> + 2.0  | I <sup>(9)</sup> - 5  | I <sup>(9)</sup> + 5  | ns   |
| GNF13 | $t_{w(oenV)}$        | Pulse duration, output enable gpmc_oen valid                                                                                |                         | K <sup>(10)</sup>       |                       | K <sup>(10)</sup>     | ns   |
| GNF14 | $t_{c(oen)}$         | Cycle time, read                                                                                                            |                         | L <sup>(11)</sup>       |                       | L <sup>(11)</sup>     | ns   |
| GNF15 | $t_{w(oenIV-csnIV)}$ | Delay time, output enable gpmc_oen invalid to output chip select gpmc_csn[x] <sup>(13)</sup> invalid                        | M <sup>(12)</sup> - 0.2 | M <sup>(12)</sup> + 2.0 | M <sup>(12)</sup> - 5 | M <sup>(12)</sup> + 5 | ns   |

(1)  $A = (WEOffTime - WEOnTime) * (TimeParaGranularity + 1) * GPMC\_FCLK^{(14)}$ 

(2)  $B = ((WEOnTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (WEEExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$ 

(3)  $C = ((WEOnTime - ADVOnTime) * (TimeParaGranularity + 1) + 0.5 * (WEEExtraDelay - ADVExtraDelay)) * GPMC\_FCLK^{(14)}$ 

(4)  $D = (WEOnTime * (TimeParaGranularity + 1) + 0.5 * WEEExtraDelay) * GPMC\_FCLK^{(14)}$ 

(5)  $E = ((WRCycleTime - WEOffTime) * (TimeParaGranularity + 1) - 0.5 * WEEExtraDelay) * GPMC\_FCLK^{(14)}$ 

(6)  $F = ((ADVWroffTime - WEOffTime) * (TimeParaGranularity + 1) + 0.5 * (ADVExtraDelay - WEEExtraDelay)) * GPMC\_FCLK^{(14)}$ 

(7)  $G = ((CSWroffTime - WEOffTime) * (TimeParaGranularity + 1) + 0.5 * (CSEExtraDelay - WEEExtraDelay)) * GPMC\_FCLK^{(14)}$ 

(8)  $H = WRCycleTime * (1 + TimeParaGranularity) * GPMC\_FCLK^{(14)}$ 

(9)  $I = ((OEOnTime - CSOnTime) * (TimeParaGranularity + 1) + 0.5 * (OEEExtraDelay - CSEExtraDelay)) * GPMC\_FCLK^{(14)}$ 

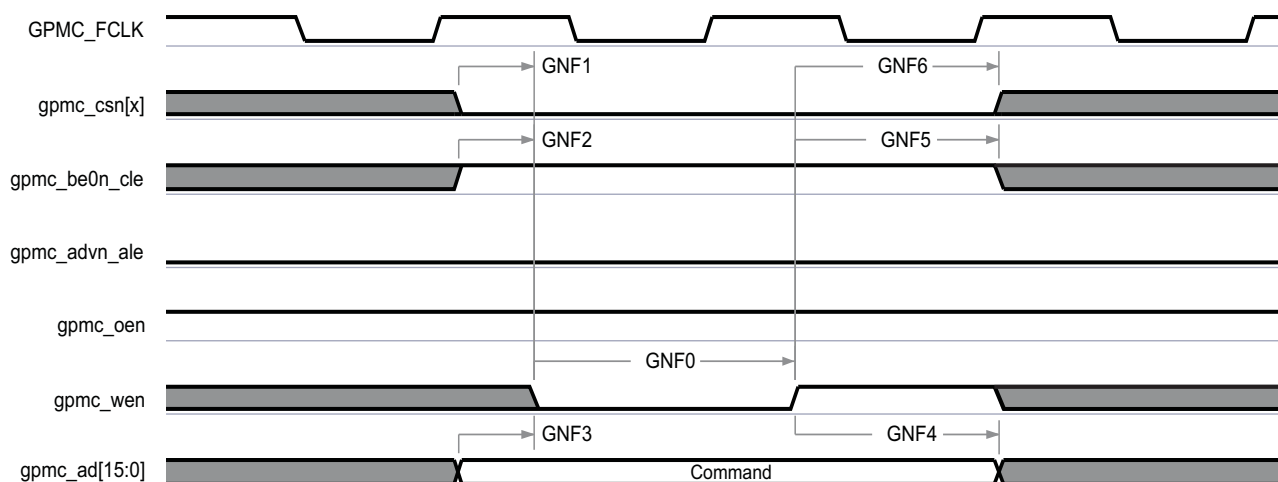
(10)  $K = (OEOffTime - OEOnTime) * (1 + TimeParaGranularity) * GPMC\_FCLK^{(14)}$ 

(11)  $L = RdCycleTime * (1 + TimeParaGranularity) * GPMC\_FCLK^{(14)}$ 

(12)  $M = ((CSRdOffTime - OEOffTime) * (TimeParaGranularity + 1) + 0.5 * (CSEExtraDelay - OEEExtraDelay)) * GPMC\_FCLK^{(14)}$ 

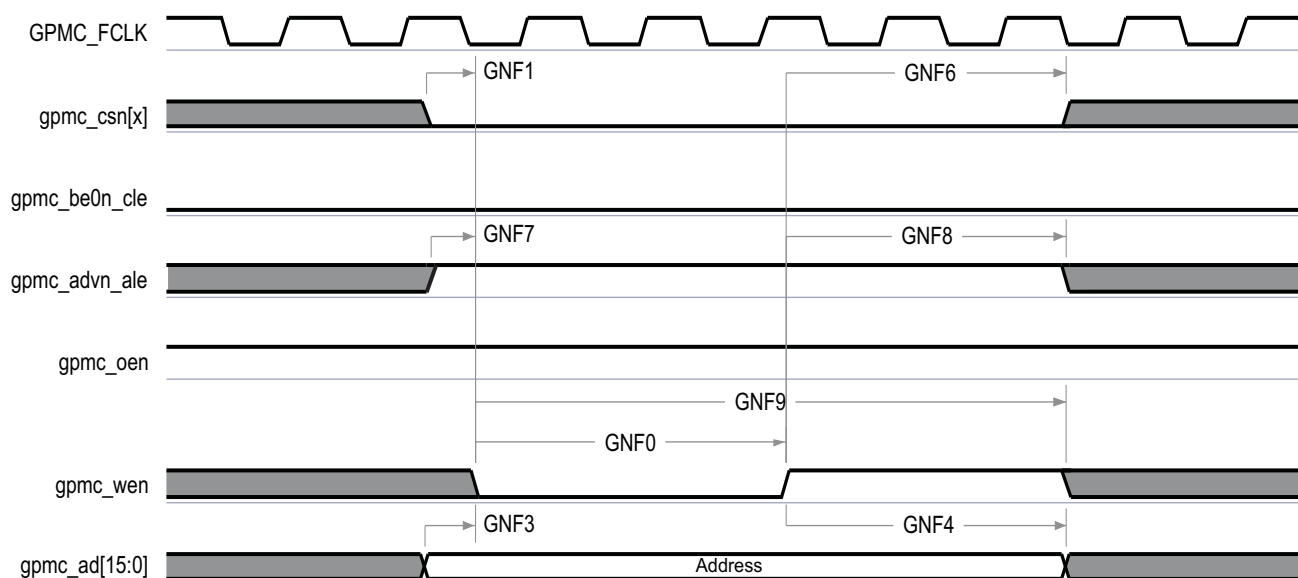
(13) In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5.

(14) GPMC\_FCLK is general-purpose memory controller internal functional clock period in ns.



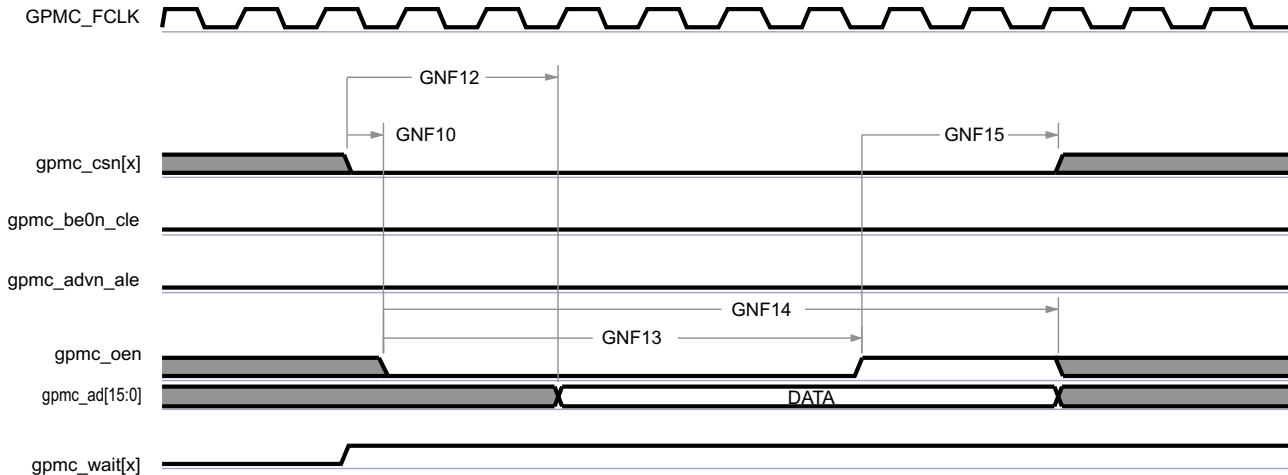
(1) In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5.

**Figure 5-28. GPMC and NAND Flash—Command Latch Cycle**



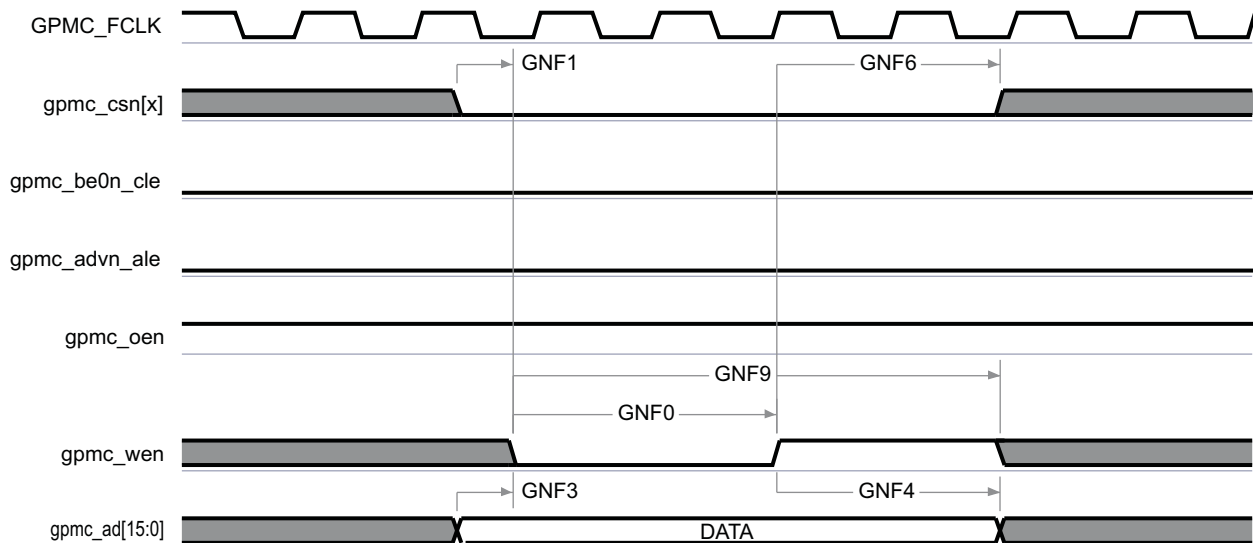
(1) In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5.

**Figure 5-29. GPMC and NAND Flash—Address Latch Cycle**



- (1) GNF12 parameter illustrates amount of time required to internally sample input data. It is expressed in number of GPMC functional clock cycles. From start of read cycle and after GNF12 functional clock cycles, input data will be internally sampled by active functional clock edge. GNF12 value must be stored inside AccessTime register bits field.
- (2) GPMC\_FCLK is an internal clock (GPMC functional clock) not provided externally.
- (3) In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5. In gpmc\_wait[x], x is equal to 0 or 1.

**Figure 5-30. GPMC and NAND Flash—Data Read Cycle**



- (1) In gpmc\_csn[x], x is equal to 0, 1, 2, 3, 4 or 5.

**Figure 5-31. GPMC and NAND Flash—Data Write Cycle**

## 5.6.2 mDDR(LPDDR), DDR2, DDR3, DDR3L Memory Interface

The device has a dedicated interface to mDDR(LPDDR), DDR2, DDR3, and DDR3L SDRAM. It supports JEDEC standard compliant mDDR(LPDDR), DDR2, DDR3, and DDR3L SDRAM devices with a 16-bit data path to external SDRAM memory.

For more details on the mDDR(LPDDR), DDR2, DDR3, and DDR3L memory interface, see the EMIF section of the *AM335x Sitara ARM Cortex A-8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).

### 5.6.2.1 mDDR(LPDDR) Routing Guidelines

It is common to find industry references to mobile double data rate (mDDR) when discussing JEDEC defined low-power double-data rate (LPDDR) memory devices. The following guidelines use LPDDR when referencing JEDEC defined low-power double-data rate memory devices.

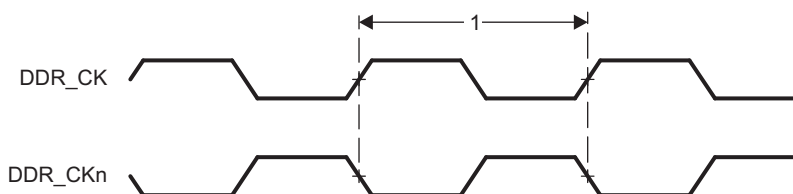
#### 5.6.2.1.1 Board Designs

TI only supports board designs that follow the guidelines outlined in this document. The switching characteristics and the timing diagram for the LPDDR memory interface are shown in [Table 5-31](#) and [Figure 5-32](#).

**Table 5-31. Switching Characteristics for LPDDR Memory Interface**

| NO. | PARAMETER                             |                                | MIN | MAX | UNIT |
|-----|---------------------------------------|--------------------------------|-----|-----|------|
| 1   | $t_{c(DDR\_CK)}$<br>$t_{c(DDR\_CKn)}$ | Cycle time, DDR_CK and DDR_CKn | 5   | (1) | ns   |

(1) The JEDEC JESD209B specification only defines the maximum clock period for LPDDR333 and faster speed bin LPDDR memory devices. To determine the maximum clock period, see the respective LPDDR memory data sheet.



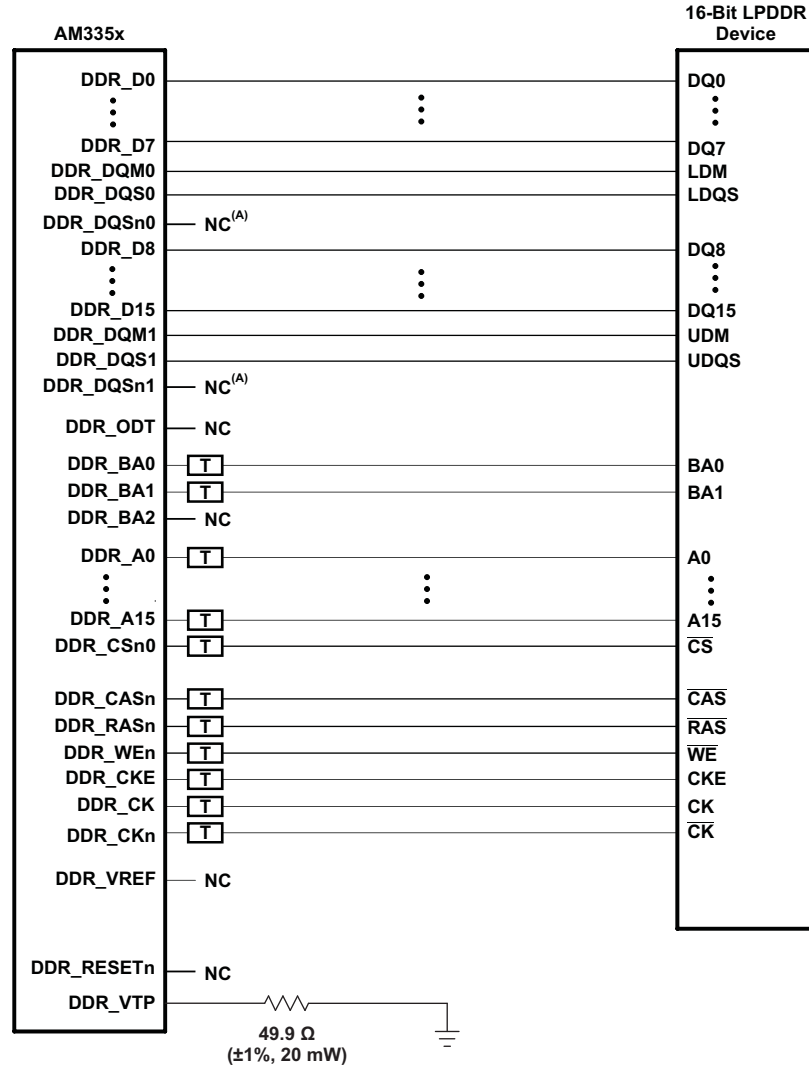
**Figure 5-32. LPDDR Memory Interface Clock Timing**

#### 5.6.2.1.2 LPDDR Interface

This section provides the timing specification for the LPDDR interface as a PCB design and manufacturing specification. The design rules constrain PCB trace length, PCB trace skew, signal integrity, cross-talk, and signal timing. These rules, when followed, result in a reliable LPDDR memory system without the need for a complex timing closure process. For more information regarding the guidelines for using this LPDDR specification, see the *Understanding TI's PCB Routing Rule-Based DDR Timing Specification* application report (literature number [SPRAAV0](#)). This application report provides generic guidelines and approach. All the specifications provided in the data manual take precedence over the generic guidelines and must be adhered to for a reliable LPDDR interface operation.

##### 5.6.2.1.2.1 LPDDR Interface Schematic

[Figure 5-33](#) shows the schematic connections for 16-bit interface on AM335x device using one x16 LPDDR device. The AM335x LPDDR memory interface only supports 16-bit wide mode of operation. The AM335x° device can only source one load connected to the DQS[x] and DQ[x] net class signals and one load connected to the CK and ADDR\_CTRL net class signals. For more information related to net classes, see [Section 5.6.2.1.2.8](#).



- A. Enable internal weak pulldown on these pins. For details, see the EMIF section of the *AM335x Sitara ARM Cortex A-8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).
- B. For all the termination requirements, see [Section 5.6.2.1.2.9](#).

**Figure 5-33. 16-Bit LPDDR Interface Using One 16-Bit LPDDR Device**

#### 5.6.2.1.2.2 Compatible JEDEC LPDDR Devices

Table 5-32 shows the parameters of the JEDEC LPDDR devices that are compatible with this interface. Generally, the LPDDR interface is compatible with x16 LPDDR400 speed grade LPDDR devices.

**Table 5-32. Compatible JEDEC LPDDR Devices (Per Interface)<sup>(1)</sup>**

| NO. | PARAMETER                         | MIN      | MAX | UNIT      |
|-----|-----------------------------------|----------|-----|-----------|
| 1   | JEDEC LPDDR device speed grade    | LPDDR400 |     |           |
| 2   | JEDEC LPDDR device bit width      | x16      | x16 | Bits      |
| 3   | JEDEC LPDDR device count          |          | 1   | Devices   |
| 4   | JEDEC LPDDR device terminal count |          | 60  | Terminals |

(1) If the LPDDR interface is operated with a clock frequency less than 200 MHz, lower-speed grade LPDDR devices may be used if the minimum clock period specified for the LPDDR device is less than or equal to the minimum clock period selected for the AM335x LPDDR interface.

#### 5.6.2.1.2.3 PCB Stackup

The minimum stackup required for routing the AM335x device is a four-layer stackup as shown in Table 5-33. Additional layers may be added to the PCB stackup to accommodate other circuitry, enhance signal integrity and electromagnetic interference performance, or to reduce the size of the PCB footprint.

**Table 5-33. Minimum PCB Stackup<sup>(1)</sup>**

| LAYER | TYPE   | DESCRIPTION           |
|-------|--------|-----------------------|
| 1     | Signal | Top signal routing    |
| 2     | Plane  | Ground                |
| 3     | Plane  | Split Power Plane     |
| 4     | Signal | Bottom signal routing |

(1) All signals that have critical signal integrity requirements should be routed first on layer 1. It may not be possible to route all of these signals on layer 1 which requires some to be routed on layer 4. When this is done, the signal routes on layer 4 should not cross splits in the power plane.

Complete stackup specifications are provided in [Table 5-34](#).

**Table 5-34. PCB Stackup Specifications<sup>(1)</sup>**

| NO. | PARAMETER                                                               |             | MIN     | TYP   | MAX     | UNIT |
|-----|-------------------------------------------------------------------------|-------------|---------|-------|---------|------|
| 1   | PCB routing and plane layers                                            |             | 4       |       |         |      |
| 2   | Signal routing layers                                                   |             | 2       |       |         |      |
| 3   | Full ground layers under LPDDR routing region                           |             | 1       |       |         |      |
| 4   | Number of ground plane cuts allowed within LPDDR routing region         |             |         |       | 0       |      |
| 5   | Full VDDS_DDR power reference layers under LPDDR routing region         |             | 1       |       |         |      |
| 6   | Number of layers between LPDDR routing layer and reference ground plane |             |         |       | 0       |      |
| 7   | PCB routing feature size                                                |             |         | 4     |         | mils |
| 8   | PCB trace width, w                                                      |             |         | 4     |         | mils |
| 9   | PCB BGA escape via pad size <sup>(2)</sup>                              |             |         | 18    | 20      | mils |
| 10  | PCB BGA escape via hole size <sup>(2)</sup>                             |             |         | 10    |         | mils |
| 11  | AM335x BGA pad size                                                     | ZCZ package |         | 0.5   |         | mm   |
|     |                                                                         | ZCE package |         | 0.4   |         |      |
| 13  | Single-ended impedance, $Z_o$ <sup>(3)</sup>                            |             | 50      |       | 75      | ohms |
| 14  | Impedance control <sup>(4)(5)</sup>                                     |             | $Z_o-5$ | $Z_o$ | $Z_o+5$ | ohms |

(1) For the LPDDR device BGA pad size, see the LPDDR device manufacturer documentation.

(2) A 20-10 via may be used if enough power routing resources are available. An 18-10 via allows for more flexible power routing to the AM335x device.

(3)  $Z_o$  is the nominal single-ended impedance selected for the PCB.

(4) This parameter specifies the AC characteristic impedance tolerance for each segment of a PCB signal trace relative to the chosen  $Z_o$  defined by the single-ended impedance parameter.

(5) Tighter impedance control is required to ensure flight time skew is minimal.

#### 5.6.2.1.2.4 Placement

Figure 5-34 shows the required placement for the LPDDR devices. The dimensions for this figure are defined in Table 5-35. The placement does not restrict the side of the PCB on which the devices are mounted. The ultimate purpose of the placement is to limit the maximum trace lengths and allow for proper routing space. For single-memory LPDDR systems, the second LPDDR device is omitted from the placement.

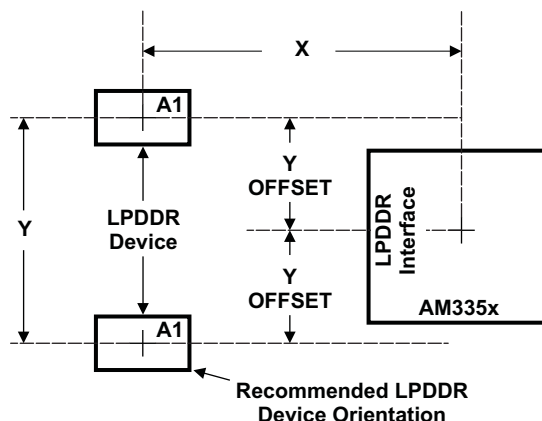


Figure 5-34. AM335x Device and LPDDR Device Placement

Table 5-35. Placement Specifications<sup>(1)</sup>

| NO. | PARAMETER                                                                 | MIN | MAX  | UNIT |
|-----|---------------------------------------------------------------------------|-----|------|------|
| 1   | X <sup>(2)(3)</sup>                                                       |     | 1750 | mils |
| 2   | Y <sup>(2)(3)</sup>                                                       |     | 1280 | mils |
| 3   | Y Offset <sup>(2)(3)(4)</sup>                                             |     | 650  | mils |
| 4   | Clearance from non-LPDDR signal to LPDDR keepout region <sup>(5)(6)</sup> | 4   |      | w    |

(1) LPDDR keepout region to encompass entire LPDDR routing area.

(2) For dimension definitions, see Figure 5-34.

(3) Measurements from center of AM335x device to center of LPDDR device.

(4) For single-memory systems, it is recommended that Y offset be as small as possible.

(5) w is defined as the signal trace width.

(6) Non-LPDDR signals allowed within LPDDR keepout region provided they are separated from LPDDR routing layers by a ground plane.

#### 5.6.2.1.2.5 LPDDR Keepout Region

The region of the PCB used for the LPDDR circuitry must be isolated from other signals. The LPDDR keepout region is defined for this purpose and is shown in Figure 5-35. This region should encompass all LPDDR circuitry and the region size varies with component placement and LPDDR routing. Additional clearances required for the keepout region are shown in Table 5-35. Non-LPDDR signals should not be routed on the same signal layer as LPDDR signals within the LPDDR keepout region. Non-LPDDR signals may be routed in the region provided they are routed on layers separated from LPDDR signal layers by a ground layer. No breaks should be allowed in the reference ground or VDDS\_DDR power plane in this region. In addition, the VDDS\_DDR power plane should cover the entire keepout region.

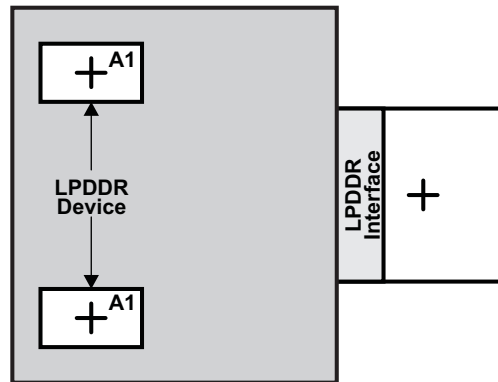


Figure 5-35. LPDDR Keepout Region

#### 5.6.2.1.2.6 Bulk Bypass Capacitors

Bulk bypass capacitors are required for moderate speed bypassing of the LPDDR and other circuitry. Table 5-36 contains the minimum numbers and capacitance required for the bulk bypass capacitors. Note that this table only covers the bypass needs of the AM335x LPDDR interface and LPDDR devices. Additional bulk bypass capacitance may be needed for other circuitry.

Table 5-36. Bulk Bypass Capacitors<sup>(1)</sup>

| NO. | PARAMETER                                            | MIN | MAX | UNIT    |
|-----|------------------------------------------------------|-----|-----|---------|
| 1   | AM335x VDDS_DDR bulk bypass capacitor count          | 1   |     | Devices |
| 2   | AM335x VDDS_DDR bulk bypass total capacitance        | 10  |     | μF      |
| 3   | LPDDR#1 bulk bypass capacitor count                  | 1   |     | Devices |
| 4   | LPDDR#1 bulk bypass total capacitance                | 10  |     | μF      |
| 5   | LPDDR#2 bulk bypass capacitor count <sup>(2)</sup>   | 1   |     | Devices |
| 6   | LPDDR#2 bulk bypass total capacitance <sup>(2)</sup> | 10  |     | μF      |

(1) These devices should be placed near the device they are bypassing, but preference should be given to the placement of the high-speed (HS) bypass capacitors.

(2) Only used when two LPDDR devices are used.

### 5.6.2.1.2.7 High-Speed Bypass Capacitors

High-speed (HS) bypass capacitors are critical for proper LPDDR interface operation. It is particularly important to minimize the parasitic series inductance of the HS bypass capacitors, AM335x device LPDDR power, and AM335x device LPDDR ground connections. [Table 5-37](#) contains the specification for the HS bypass capacitors as well as for the power connections on the PCB.

**Table 5-37. High-Speed Bypass Capacitors**

| NO. | PARAMETER                                                                  | MIN | MAX  | UNIT    |
|-----|----------------------------------------------------------------------------|-----|------|---------|
| 1   | HS bypass capacitor package size <sup>(1)</sup>                            |     | 0402 | 10 mils |
| 2   | Distance from HS bypass capacitor to device being bypassed                 |     | 250  | mils    |
| 3   | Number of connection vias for each HS bypass capacitor <sup>(2)</sup>      | 2   |      | Vias    |
| 4   | Trace length from bypass capacitor contact to connection via               |     | 30   | mils    |
| 5   | Number of connection vias for each AM335x VDDSD_DDR and VSS terminal       | 1   |      | Vias    |
| 6   | Trace length from AM335x VDDSD_DDR and VSS terminal to connection via      |     | 35   | mils    |
| 7   | Number of connection vias for each LPDDR device power and ground terminal  | 1   |      | Vias    |
| 8   | Trace length from LPDDR device power and ground terminal to connection via |     | 35   | mils    |
| 9   | AM335x VDDSD_DDR HS bypass capacitor count <sup>(3)</sup>                  | 10  |      | Devices |
| 10  | AM335x VDDSD_DDR HS bypass capacitor total capacitance                     | 0.6 |      | μF      |
| 11  | LPDDR device HS bypass capacitor count <sup>(3)(4)</sup>                   | 8   |      | Devices |
| 12  | LPDDR device HS bypass capacitor total capacitance <sup>(4)</sup>          | 0.4 |      | μF      |

(1) LxW, 10-mil units; for example, a 0402 is a 40x20-mil surface-mount capacitor.

(2) An additional HS bypass capacitor can share the connection vias only if it is mounted on the opposite side of the board.

(3) These devices should be placed as close as possible to the device being bypassed.

(4) Per LPDDR device.

### 5.6.2.1.2.8 Net Classes

[Table 5-38](#) lists the clock net classes for the LPDDR interface. [Table 5-39](#) lists the signal net classes, and associated clock net classes, for the signals in the LPDDR interface. These net classes are used for the termination and routing rules that follow.

**Table 5-38. Clock Net Class Definitions**

| CLOCK NET CLASS | AM335x PIN NAMES   |
|-----------------|--------------------|
| CK              | DDR_CK and DDR_CKn |
| DQS0            | DDR_DQS0           |
| DQS1            | DDR_DQS1           |

**Table 5-39. Signal Net Class Definitions**

| SIGNAL NET CLASS | ASSOCIATED CLOCK NET CLASS | AM335x PIN NAMES                                                         |
|------------------|----------------------------|--------------------------------------------------------------------------|
| ADDR_CTRL        | CK                         | DDR_BA[1:0], DDR_A[15:0], DDR_CSn0, DDR_CASn, DDR_RASn, DDR_WEn, DDR_CKE |
| DQ0              | DQS0                       | DDR_D[7:0], DDR_DQM0                                                     |
| DQ1              | DQS1                       | DDR_D[15:8], DDR_DQM1                                                    |

#### 5.6.2.1.2.9 LPDDR Signal Termination

There is no specific need for adding terminations on the LPDDR interface. However, system designers may evaluate the need for serial terminators for EMI and overshoot reduction. Placement of serial terminations for DQS[x] and DQ[x] net class signals should be determined based on PCB analysis. Placement of serial terminations for ADDR\_CTRL net class signals should be close to the AM335x device. [Table 5-40](#) shows the specifications for the serial terminators in such cases.

**Table 5-40. LPDDR Signal Terminations**

| No. | Parameter                                | Min | Typ | Max                           | Unit |
|-----|------------------------------------------|-----|-----|-------------------------------|------|
| 1   | CK net class <sup>(1)</sup>              | 0   | 22  | Z <sub>0</sub> <sup>(2)</sup> | ohms |
| 2   | ADDR_CTRL net class <sup>(1)(3)(4)</sup> | 0   | 22  | Z <sub>0</sub> <sup>(2)</sup> | ohms |
| 3   | DQS0, DQS1, DQ0, and DQ1 net classes     | 0   | 22  | Z <sub>0</sub> <sup>(2)</sup> | ohms |

(1) Only series termination is permitted.

(2) Z<sub>0</sub> is the LPDDR PCB trace characteristic impedance.

(3) Series termination values larger than typical only recommended to address EMI issues.

(4) Series termination values should be uniform across net class.

### 5.6.2.1.3 LPDDR CK and ADDR\_CTRL Routing

Figure 5-36 shows the topology of the routing for the CK and ADDR\_CTRL net classes. The length of signal path AB and AC should be minimized with emphasis to minimize lengths C and D such that length A is the majority of the total length of signal path AB and AC.

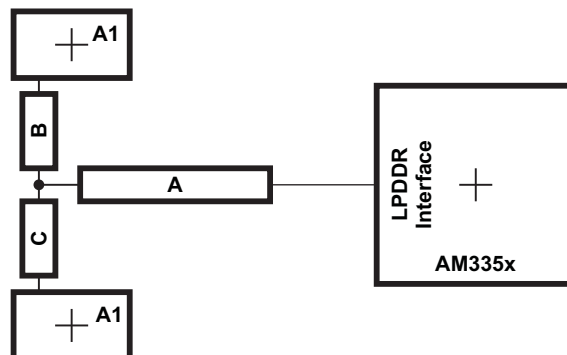


Figure 5-36. CK and ADDR\_CTRL Routing and Topology

Table 5-41. CK and ADDR\_CTRL Routing Specification<sup>(1)(2)</sup>

| NO. | PARAMETER                                                                  | MIN      | TYP   | MAX      | UNIT |
|-----|----------------------------------------------------------------------------|----------|-------|----------|------|
| 1   | Center-to-center CK spacing                                                |          |       | 2w       |      |
| 2   | CK differential pair skew length mismatch <sup>(2)(3)</sup>                |          |       | 25       | mils |
| 3   | CK B-to-CK C skew length mismatch                                          |          |       | 25       | mils |
| 4   | Center-to-center CK to other LPDDR trace spacing <sup>(4)</sup>            | 4w       |       |          |      |
| 5   | CK and ADDR_CTRL nominal trace length <sup>(5)</sup>                       | CACLM-50 | CACLM | CACLM+50 | mils |
| 6   | ADDR_CTRL-to-CK skew length mismatch                                       |          |       | 100      | mils |
| 7   | ADDR_CTRL-to-ADDR_CTRL skew length mismatch                                |          |       | 100      | mils |
| 8   | Center-to-center ADDR_CTRL to other LPDDR trace spacing <sup>(4)</sup>     | 4w       |       |          |      |
| 9   | Center-to-center ADDR_CTRL to other ADDR_CTRL trace spacing <sup>(4)</sup> | 3w       |       |          |      |
| 10  | ADDR_CTRL A-to-B and ADDR_CTRL A-to-C skew length mismatch <sup>(2)</sup>  |          |       | 100      | mils |
| 11  | ADDR_CTRL B-to-C skew length mismatch                                      |          |       | 100      | mils |

(1) CK represents the clock net class, and ADDR\_CTRL represents the address and control signal net class.

(2) Series terminator, if used, should be located closest to the AM335x device.

(3) Differential impedance should be  $Z_o \times 2$ , where  $Z_o$  is the single-ended impedance defined in Table 5-34.

(4) Center-to-center spacing is allowed to fall to minimum (w) for up to 500 mils of routed length to accommodate BGA escape and routing congestion.

(5) CACLM is the longest Manhattan distance of the CK and ADDR\_CTRL net classes.

Figure 5-37 shows the topology and routing for the DQS[x] and DQ[x] net classes; the routes are point to point. Skew matching across bytes is not needed nor recommended.

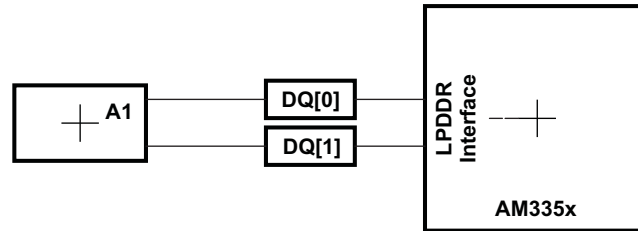


Figure 5-37. DQS[x] and DQ[x] Routing and Topology

Table 5-42. DQS[x] and DQ[x] Routing Specification<sup>(1)</sup>

| NO. | PARAMETER                                                               | MIN     | TYP  | MAX     | UNIT |
|-----|-------------------------------------------------------------------------|---------|------|---------|------|
| 1   | Center-to-center DQS[x] spacing                                         |         |      | 2w      |      |
| 2   | Center-to-center DDR_DQS[x] to other LPDDR trace spacing <sup>(2)</sup> | 4w      |      |         |      |
| 3   | DQS[x] and DQ[x] nominal trace length <sup>(3)</sup>                    | DQLM-50 | DQLM | DQLM+50 | mils |
| 4   | DQ[x]-to-DQS[x] skew length mismatch <sup>(3)</sup>                     |         |      | 100     | mils |
| 5   | DQ[x]-to-DQ[x] skew length mismatch <sup>(3)</sup>                      |         |      | 100     | mils |
| 6   | Center-to-center DQ[x] to other LPDDR trace spacing <sup>(2)(4)</sup>   | 4w      |      |         |      |
| 7   | Center-to-center DQ[x] to other DQ[x] trace spacing <sup>(2)(5)</sup>   | 3w      |      |         |      |

(1) DQS[x] represents the DQS0 and DQS1 clock net classes, and DQ[x] represents the DQ0 and DQ1 signal net classes.

(2) Center-to-center spacing is allowed to fall to minimum (w) for up to 500 mils of routed length to accommodate BGA escape and routing congestion.

(3) There is no requirement for skew matching between data bytes; that is, from net classes DQS0 and DQ0 to net classes DQS1 and DQ1.

(4) Signals from one DQ net class should be considered other LPDDR traces to another DQ net class.

(5) DQLM is the longest Manhattan distance of each of the DQS[x] and DQ[x] net classes.

## 5.6.2.2 DDR2 Routing Guidelines

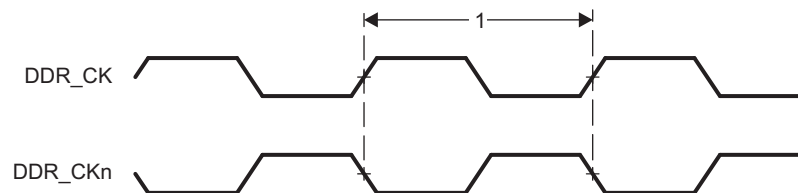
### 5.6.2.2.1 Board Designs

TI only supports board designs that follow the guidelines outlined in this document. The switching characteristics and the timing diagram for the DDR2 memory interface are shown in [Table 5-43](#) and [Figure 5-38](#).

**Table 5-43. Switching Characteristics for DDR2 Memory Interface**

| NO. | PARAMETER                             |                                | MIN  | MAX              | UNIT |
|-----|---------------------------------------|--------------------------------|------|------------------|------|
| 1   | $t_{c(DDR\_CK)}$<br>$t_{c(DDR\_CKn)}$ | Cycle time, DDR_CK and DDR_CKn | 3.75 | 8 <sup>(1)</sup> | ns   |

(1) The JEDEC JESD79-2F specification defines the maximum clock period of 8 ns for all standard-speed bin DDR2 memory devices. Therefore, all standard-speed bin DDR2 memory devices are required to operate at 125 MHz.



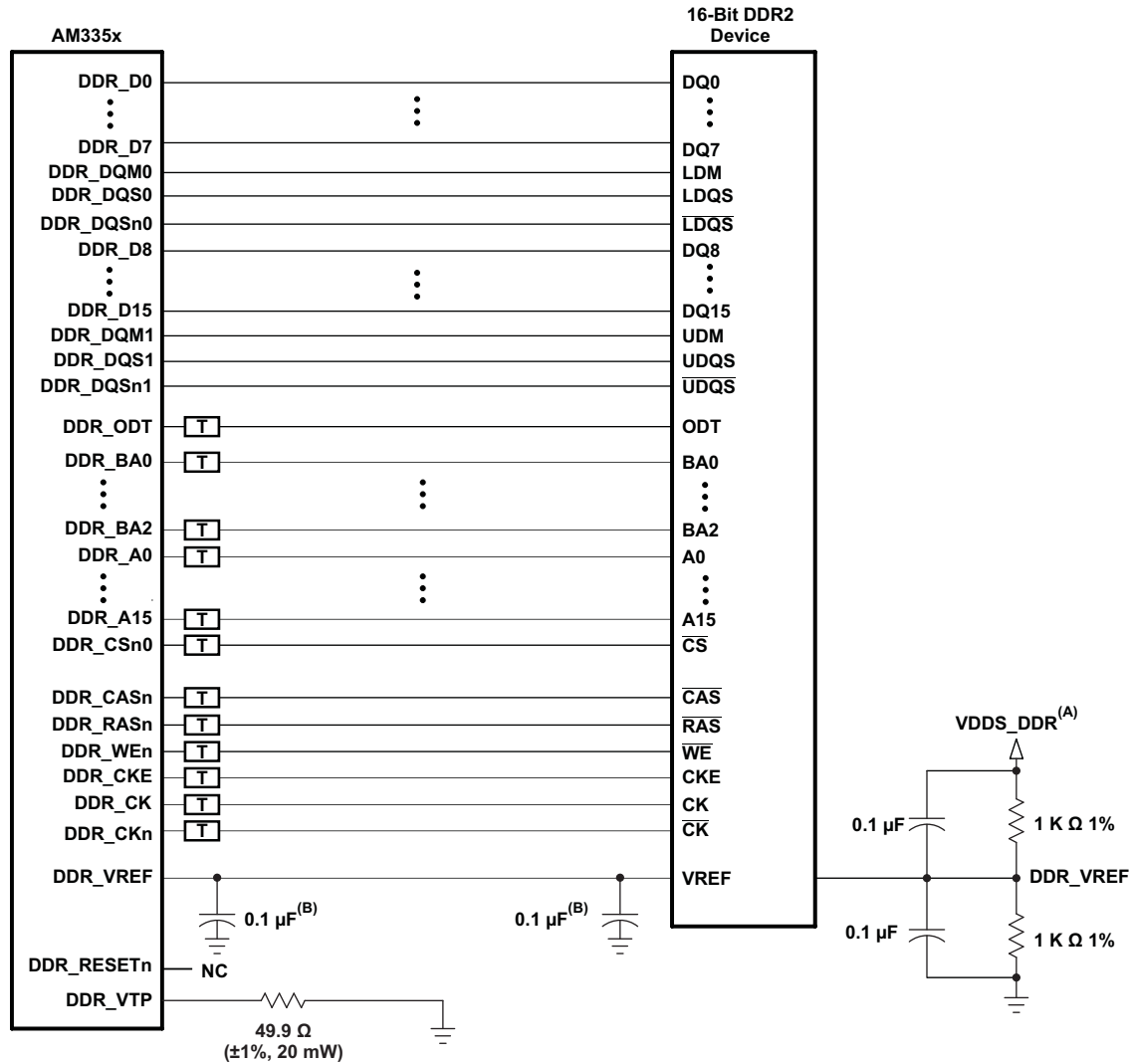
**Figure 5-38. DDR2 Memory Interface Clock Timing**

### 5.6.2.2.2 DDR2 Interface

This section provides the timing specification for the DDR2 interface as a PCB design and manufacturing specification. The design rules constrain PCB trace length, PCB trace skew, signal integrity, cross-talk, and signal timing. These rules, when followed, result in a reliable DDR2 memory system without the need for a complex timing closure process. For more information regarding the guidelines for using this DDR2 specification, see the *Understanding TI's PCB Routing Rule-Based DDR Timing Specification* application report (literature number [SPRAAV0](#)). This application report provides generic guidelines and approach. All the specifications provided in the data manual take precedence over the generic guidelines and must be adhered to for a reliable DDR2 interface operation.

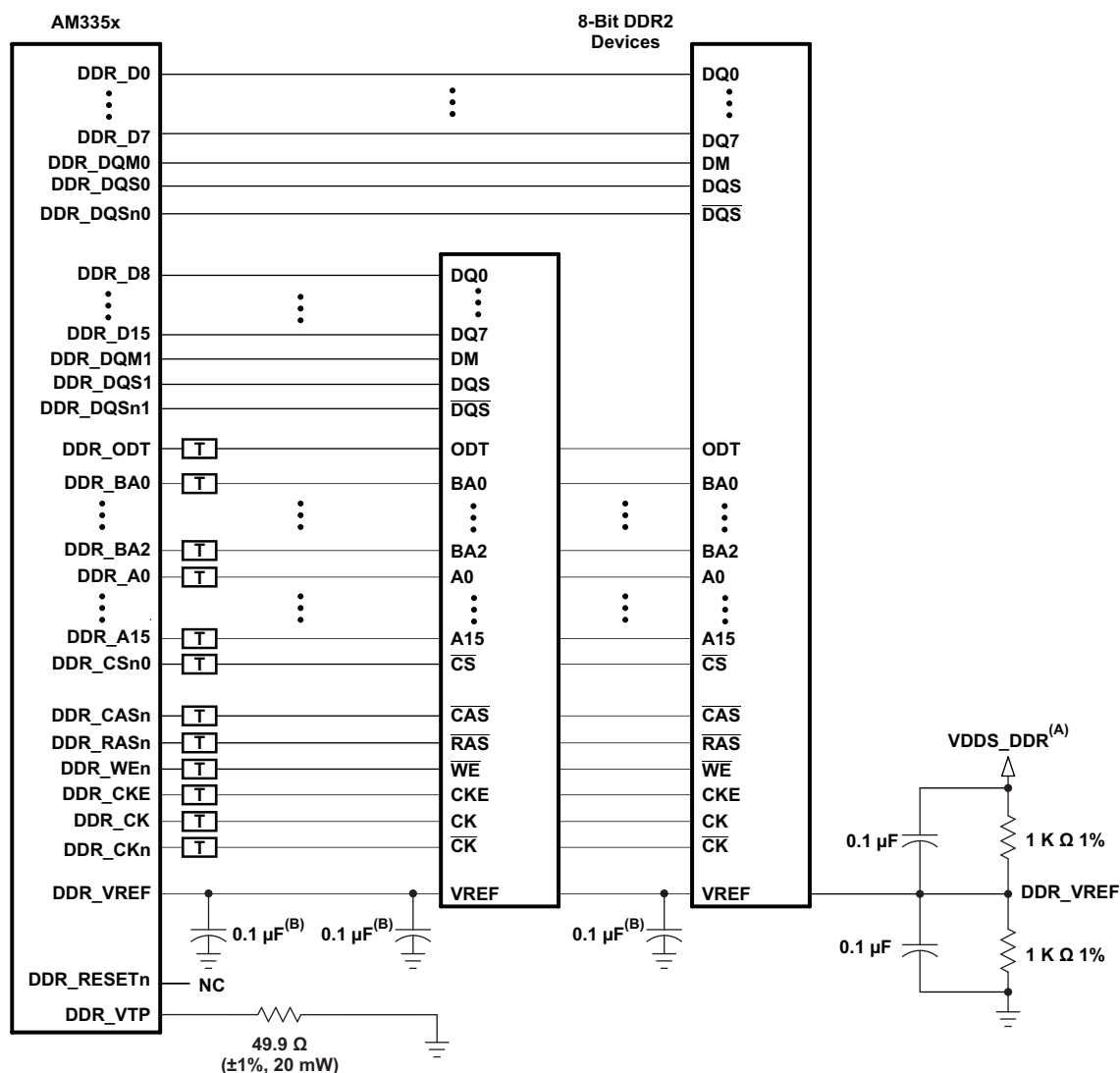
#### 5.6.2.2.2.1 DDR2 Interface Schematic

[Figure 5-39](#) shows the schematic connections for 16-bit interface on AM335x device using one x16 DDR2 device and [Figure 5-40](#) shows the schematic connections for 16-bit interface on AM335x using two x8 DDR2 devices. The AM335x DDR2 memory interface only supports 16-bit wide mode of operation. The AM335x device can only source one load connected to the DQS[x] and DQ[x] net class signals and two loads connected to the CK and ADDR\_CTRL net class signals. For more information related to net classes, see [Section 5.6.2.2.2.8](#).



- A. VDDSDDR is the power supply for the DDR2 memories and the AM335x DDR2 interface.
- B. One of these capacitors can be eliminated if the divider and its capacitors are placed near a DDR\_VREF pin.
- C. For all the termination requirements, see [Section 5.6.2.2.9](#).

**Figure 5-39. 16-Bit DDR2 Interface Using One 16-Bit DDR2 Device**



- A. VDDSDDR is the power supply for the DDR2 memories and the AM335x DDR2 interface.
- B. One of these capacitors can be eliminated if the divider and its capacitors are placed near a DDR\_VREF pin.
- C. For all the termination requirements, see [Section 5.6.2.2.9](#).

**Figure 5-40. 16-Bit DDR2 Interface Using Two 8-Bit DDR2 Devices**

#### 5.6.2.2.2 Compatible JEDEC DDR2 Devices

Table 5-44 shows the parameters of the JEDEC DDR2 devices that are compatible with this interface. Generally, the DDR2 interface is compatible with x16 or x8 DDR2-533 speed grade DDR2 devices.

**Table 5-44. Compatible JEDEC DDR2 Devices (Per Interface)<sup>(1)</sup>**

| NO. | PARAMETER                                       | MIN      | MAX | UNIT      |
|-----|-------------------------------------------------|----------|-----|-----------|
| 1   | JEDEC DDR2 device speed grade <sup>(2)</sup>    | DDR2-533 |     |           |
| 2   | JEDEC DDR2 device bit width                     | x8       | x16 | Bits      |
| 3   | JEDEC DDR2 device count                         | 1        | 2   | Devices   |
| 4   | JEDEC DDR2 device terminal count <sup>(3)</sup> | 60       | 84  | Terminals |

- (1) If the DDR2 interface is operated with a clock frequency less than 266 MHz, lower-speed grade DDR2 devices may be used if the minimum clock period specified for the DDR2 device is less than or equal to the minimum clock period selected for the AM335x DDR2 interface.
- (2) Higher DDR2 speed grades are supported due to inherent JEDEC DDR2 backwards compatibility.
- (3) 92-terminal devices are also supported for legacy reasons. New designs will migrate to 84-terminal DDR2 devices. Electrically, the 92- and 84-terminal DDR2 devices are the same.

#### 5.6.2.2.3 PCB Stackup

The minimum stackup required for routing the AM335x device is a four-layer stackup as shown in Table 5-45. Additional layers may be added to the PCB stackup to accommodate other circuitry, enhance signal integrity and electromagnetic interference performance, or to reduce the size of the PCB footprint.

**Table 5-45. Minimum PCB Stackup<sup>(1)</sup>**

| LAYER | TYPE   | DESCRIPTION           |
|-------|--------|-----------------------|
| 1     | Signal | Top signal routing    |
| 2     | Plane  | Ground                |
| 3     | Plane  | Split Power Plane     |
| 4     | Signal | Bottom signal routing |

- (1) All signals that have critical signal integrity requirements should be routed first on layer 1. It may not be possible to route all of these signals on layer 1 which requires some to be routed on layer 4. When this is done, the signal routes on layer 4 should not cross splits in the power plane.

Complete stackup specifications are provided in [Table 5-46](#).

**Table 5-46. PCB Stackup Specifications<sup>(1)</sup>**

| NO. | PARAMETER                                                              |             | MIN     | TYP   | MAX     | UNIT |
|-----|------------------------------------------------------------------------|-------------|---------|-------|---------|------|
| 1   | PCB routing and plane layers                                           |             | 4       |       |         |      |
| 2   | Signal routing layers                                                  |             | 2       |       |         |      |
| 3   | Full ground layers under DDR2 routing region                           |             | 1       |       |         |      |
| 4   | Number of ground plane cuts allowed within DDR2 routing region         |             |         |       | 0       |      |
| 5   | Full VDDS_DDR power reference layers under DDR2 routing region         |             | 1       |       |         |      |
| 6   | Number of layers between DDR2 routing layer and reference ground plane |             |         |       | 0       |      |
| 7   | PCB routing feature size                                               |             |         | 4     |         | mils |
| 8   | PCB trace width, w                                                     |             |         | 4     |         | mils |
| 9   | PCB BGA escape via pad size <sup>(2)</sup>                             |             |         | 18    | 20      | mils |
| 10  | PCB BGA escape via hole size <sup>(2)</sup>                            |             |         | 10    |         | mils |
| 11  | AM335x BGA pad size                                                    | ZCZ package |         | 0.5   |         | mm   |
|     |                                                                        | ZCE package |         | 0.4   |         |      |
| 13  | Single-ended impedance, $Z_0$ <sup>(3)</sup>                           |             | 50      |       | 75      | ohms |
| 14  | Impedance control <sup>(4)(5)</sup>                                    |             | $Z_0-5$ | $Z_0$ | $Z_0+5$ | ohms |

(1) For the DDR2 device BGA pad size, see the DDR2 device manufacturer documentation.

(2) A 20-10 via may be used if enough power routing resources are available. An 18-10 via allows for more flexible power routing to the AM335x device.

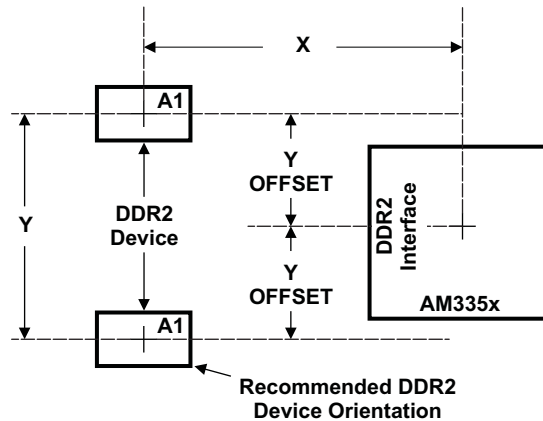
(3)  $Z_0$  is the nominal singled-ended impedance selected for the PCB.

(4) This parameter specifies the AC characteristic impedance tolerance for each segment of a PCB signal trace relative to the chosen  $Z_0$  defined by the single-ended impedance parameter.

(5) Tighter impedance control is required to ensure flight time skew is minimal.

#### 5.6.2.2.4 Placement

Figure 5-41 shows the required placement for the DDR2 devices. The dimensions for this figure are defined in Table 5-47. The placement does not restrict the side of the PCB on which the devices are mounted. The ultimate purpose of the placement is to limit the maximum trace lengths and allow for proper routing space. For single-memory DDR2 systems, the second DDR2 device is omitted from the placement.



**Figure 5-41. AM335x Device and DDR2 Device Placement**

**Table 5-47. Placement Specifications<sup>(1)</sup>**

| NO. | PARAMETER                                                               | MIN | MAX  | UNIT |
|-----|-------------------------------------------------------------------------|-----|------|------|
| 1   | X <sup>(2)(3)</sup>                                                     |     | 1750 | mils |
| 2   | Y <sup>(2)(3)</sup>                                                     |     | 1280 | mils |
| 3   | Y Offset <sup>(2)(3)(4)</sup>                                           |     | 650  | mils |
| 4   | Clearance from non-DDR2 signal to DDR2 keepout region <sup>(5)(6)</sup> | 4   |      | w    |

(1) DDR2 keepout region to encompass entire DDR2 routing area.

(2) For dimension definitions, see Figure 5-41.

(3) Measurements from center of AM335x device to center of DDR2 device.

(4) For single-memory systems, it is recommended that Y offset be as small as possible.

(5) w is defined as the signal trace width.

(6) Non-DDR2 signals allowed within DDR2 keepout region provided they are separated from DDR2 routing layers by a ground plane.

#### 5.6.2.2.2.5 DDR2 Keepout Region

The region of the PCB used for the DDR2 circuitry must be isolated from other signals. The DDR2 keepout region is defined for this purpose and is shown in Figure 5-42. This region should encompass all DDR2 circuitry and the region size varies with component placement and DDR2 routing. Additional clearances required for the keepout region are shown in Table 5-47. Non-DDR2 signals should not be routed on the same signal layer as DDR2 signals within the DDR2 keepout region. Non-DDR2 signals may be routed in the region provided they are routed on layers separated from DDR2 signal layers by a ground layer. No breaks should be allowed in the reference ground or VDDS\_DDR power plane in this region. In addition, the VDDS\_DDR power plane should cover the entire keepout region.

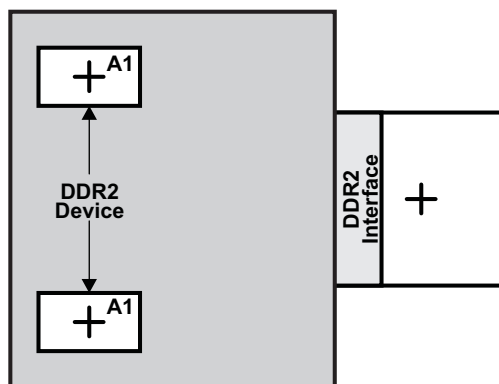


Figure 5-42. DDR2 Keepout Region

#### 5.6.2.2.2.6 Bulk Bypass Capacitors

Bulk bypass capacitors are required for moderate speed bypassing of the DDR2 and other circuitry. Table 5-48 contains the minimum numbers and capacitance required for the bulk bypass capacitors. Note that this table only covers the bypass needs of the AM335x DDR2 interface and DDR2 devices. Additional bulk bypass capacitance may be needed for other circuitry.

Table 5-48. Bulk Bypass Capacitors<sup>(1)</sup>

| NO. | PARAMETER                                           | MIN | MAX | UNIT    |
|-----|-----------------------------------------------------|-----|-----|---------|
| 1   | AM335x VDDS_DDR bulk bypass capacitor count         | 1   |     | Devices |
| 2   | AM335x VDDS_DDR bulk bypass total capacitance       | 10  |     | μF      |
| 3   | DDR2#1 bulk bypass capacitor count                  | 1   |     | Devices |
| 4   | DDR2#1 bulk bypass total capacitance                | 10  |     | μF      |
| 5   | DDR2#2 bulk bypass capacitor count <sup>(2)</sup>   | 1   |     | Devices |
| 6   | DDR2#2 bulk bypass total capacitance <sup>(2)</sup> | 10  |     | μF      |

(1) These devices should be placed near the device they are bypassing, but preference should be given to the placement of the high-speed (HS) bypass capacitors.

(2) Only used when two DDR2 devices are used.

### 5.6.2.2.2.7 High-Speed Bypass Capacitors

High-speed (HS) bypass capacitors are critical for proper DDR2 interface operation. It is particularly important to minimize the parasitic series inductance of the HS bypass capacitors, AM335x device DDR2 power, and AM335x device DDR2 ground connections. [Table 5-49](#) contains the specification for the HS bypass capacitors as well as for the power connections on the PCB.

**Table 5-49. High-Speed Bypass Capacitors**

| NO. | PARAMETER                                                                 | MIN | MAX  | UNIT    |
|-----|---------------------------------------------------------------------------|-----|------|---------|
| 1   | HS bypass capacitor package size <sup>(1)</sup>                           |     | 0402 | 10 mils |
| 2   | Distance from HS bypass capacitor to device being bypassed                |     | 250  | mils    |
| 3   | Number of connection vias for each HS bypass capacitor <sup>(2)</sup>     | 2   |      | Vias    |
| 4   | Trace length from bypass capacitor contact to connection via              |     | 30   | mils    |
| 5   | Number of connection vias for each AM335x VDDSD_DDR and VSS terminal      | 1   |      | Vias    |
| 6   | Trace length from AM335x VDDSD_DDR and VSS terminal to connection via     |     | 35   | mils    |
| 7   | Number of connection vias for each DDR2 device power and ground terminal  | 1   |      | Vias    |
| 8   | Trace length from DDR2 device power and ground terminal to connection via |     | 35   | mils    |
| 9   | AM335x VDDSD_DDR HS bypass capacitor count <sup>(3)</sup>                 | 10  |      | Devices |
| 10  | AM335x VDDSD_DDR HS bypass capacitor total capacitance                    | 0.6 |      | μF      |
| 11  | DDR2 device HS bypass capacitor count <sup>(3)(4)</sup>                   | 8   |      | Devices |
| 12  | DDR2 device HS bypass capacitor total capacitance <sup>(4)</sup>          | 0.4 |      | μF      |

(1) LxW, 10-mil units; for example, a 0402 is a 40x20-mil surface-mount capacitor.

(2) An additional HS bypass capacitor can share the connection vias only if it is mounted on the opposite side of the board.

(3) These devices should be placed as close as possible to the device being bypassed.

(4) Per DDR2 device.

### 5.6.2.2.2.8 Net Classes

[Table 5-50](#) lists the clock net classes for the DDR2 interface. [Table 5-51](#) lists the signal net classes, and associated clock net classes, for the signals in the DDR2 interface. These net classes are used for the termination and routing rules that follow.

**Table 5-50. Clock Net Class Definitions**

| CLOCK NET CLASS | AM335x PIN NAMES       |
|-----------------|------------------------|
| CK              | DDR_CK and DDR_CKn     |
| DQS0            | DDR_DQS0 and DDR_DQSn0 |
| DQS1            | DDR_DQS1 and DDR_DQSn1 |

**Table 5-51. Signal Net Class Definitions**

| SIGNAL NET CLASS | ASSOCIATED CLOCK NET CLASS | AM335x PIN NAMES                                                                  |
|------------------|----------------------------|-----------------------------------------------------------------------------------|
| ADDR_CTRL        | CK                         | DDR_BA[2:0], DDR_A[15:0], DDR_CSn0, DDR_CASn, DDR_RASn, DDR_WEn, DDR_CKE, DDR_ODT |
| DQ0              | DQS0                       | DDR_D[7:0], DDR_DQM0                                                              |
| DQ1              | DQS1                       | DDR_D[15:8], DDR_DQM1                                                             |

#### 5.6.2.2.2.9 DDR2 Signal Termination

Signal terminations are required on the CK and ADDR\_CTRL net class signals. Serial terminations should be used on the CK and ADDR\_CTRL lines and is the preferred termination scheme. On-device terminations (ODTs) are required on the DQS[x] and DQ[x] net class signals. They should be enabled to ensure signal integrity. Table 5-52 shows the specifications for the series terminators. Placement of serial terminations for ADDR\_CTRL net class signals should be close to the AM335x device.

**Table 5-52. DDR2 Signal Terminations**

| NO. | PARAMETER                                           | MIN | TYP | MAX               | UNIT |
|-----|-----------------------------------------------------|-----|-----|-------------------|------|
| 1   | CK net class <sup>(1)</sup>                         | 0   |     | 10                | ohms |
| 2   | ADDR_CTRL net class <sup>(1)(2)(3)</sup>            | 0   | 22  | Zo <sup>(4)</sup> | ohms |
| 3   | DQS0, DQS1, DQ0, and DQ1 net classes <sup>(5)</sup> | NA  |     | NA                | ohms |

(1) Only series termination is permitted.

(2) Series termination values larger than typical only recommended to address EMI issues.

(3) Series termination values should be uniform across net class.

(4) Zo is the DDR2 PCB trace characteristic impedance.

(5) No external termination resistors are allowed and ODT must be used for these net classes.

If the DDR2 interface is operated at a lower frequency (<200-MHz clock rate), on-device terminations are not specifically required for the DQS[x] and DQ[x] net class signals and serial terminations for the CK and ADDR\_CTRL net class signals are not mandatory. System designers may evaluate the need for serial terminators for EMI and overshoot reduction. Placement of serial terminations for DQS[x] and DQ[x] net class signals should be determined based on PCB analysis. Placement of serial terminations for ADDR\_CTRL net class signals should be close to the AM335x device. Table 5-53 shows the specifications for the serial terminators in such cases.

**Table 5-53. Lower-Frequency DDR2 Signal Terminations**

| NO. | PARAMETER                                | MIN | TYP | MAX               | UNIT |
|-----|------------------------------------------|-----|-----|-------------------|------|
| 1   | CK net class <sup>(1)</sup>              | 0   | 22  | Zo <sup>(2)</sup> | ohms |
| 2   | ADDR_CTRL net class <sup>(1)(3)(4)</sup> | 0   | 22  | Zo <sup>(2)</sup> | ohms |
| 3   | DQS0, DQS1, DQ0, and DQ1 net classes     | 0   | 22  | Zo <sup>(2)</sup> | ohms |

(1) Only series termination is permitted.

(2) Zo is the DDR2 PCB trace characteristic impedance.

(3) Series termination values larger than typical only recommended to address EMI issues.

(4) Series termination values should be uniform across net class.

#### 5.6.2.2.2.10 DDR\_VREF Routing

DDR\_VREF is used as a reference by the input buffers of the DDR2 memories as well as the AM335x device. DDR\_VREF is intended to be half the DDR2 power supply voltage and should be created using a resistive divider as shown in [Figure 5-39](#) and [Figure 5-40](#). Other methods of creating DDR\_VREF are not recommended. [Figure 5-43](#) shows the layout guidelines for DDR\_VREF.

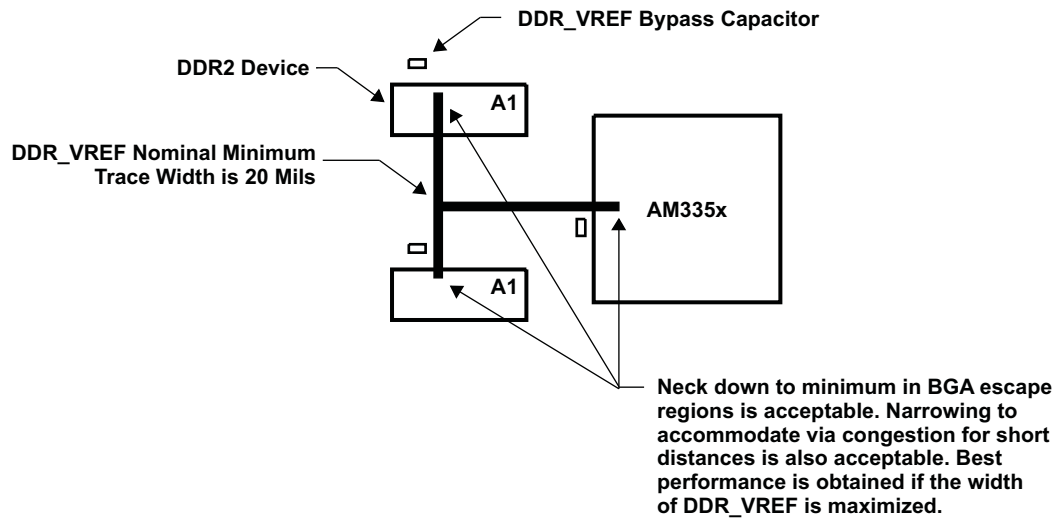


Figure 5-43. DDR\_VREF Routing and Topology

### 5.6.2.2.3 DDR2 CK and ADDR\_CTRL Routing

Figure 5-44 shows the topology of the routing for the CK and ADDR\_CTRL net classes. The length of signal path AB and AC should be minimized with emphasis to minimize lengths C and D such that length A is the majority of the total length of signal path AB and AC.

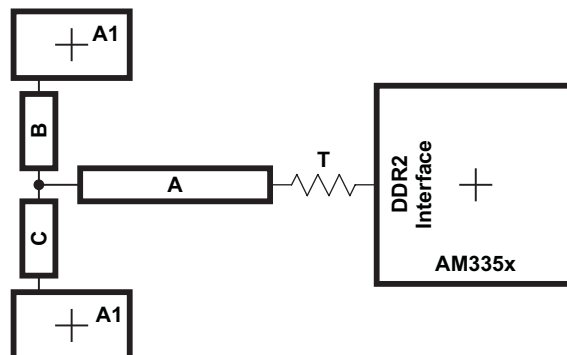


Figure 5-44. CK and ADDR\_CTRL Routing and Topology

Table 5-54. CK and ADDR\_CTRL Routing Specification<sup>(1)(2)</sup>

| NO. | PARAMETER                                                                  | MIN      | TYP   | MAX      | UNIT |
|-----|----------------------------------------------------------------------------|----------|-------|----------|------|
| 1   | Center-to-center CK spacing                                                |          |       | 2w       |      |
| 2   | CK differential pair skew length mismatch <sup>(2)(3)</sup>                |          |       | 25       | mils |
| 3   | CK B-to-CK C skew length mismatch                                          |          |       | 25       | mils |
| 4   | Center-to-center CK to other DDR2 trace spacing <sup>(4)</sup>             | 4w       |       |          |      |
| 5   | CK and ADDR_CTRL nominal trace length <sup>(5)</sup>                       | CACLM-50 | CACLM | CACLM+50 | mils |
| 6   | ADDR_CTRL-to-CK skew length mismatch                                       |          |       | 100      | mils |
| 7   | ADDR_CTRL-to-ADDR_CTRL skew length mismatch                                |          |       | 100      | mils |
| 8   | Center-to-center ADDR_CTRL to other DDR2 trace spacing <sup>(4)</sup>      | 4w       |       |          |      |
| 9   | Center-to-center ADDR_CTRL to other ADDR_CTRL trace spacing <sup>(4)</sup> | 3w       |       |          |      |
| 10  | ADDR_CTRL A-to-B and ADDR_CTRL A-to-C skew length mismatch <sup>(2)</sup>  |          |       | 100      | mils |
| 11  | ADDR_CTRL B-to-C skew length mismatch                                      |          |       | 100      | mils |

(1) CK represents the clock net class, and ADDR\_CTRL represents the address and control signal net class.

(2) Series terminator, if used, should be located closest to the AM335x device.

(3) Differential impedance should be  $Z_o \times 2$ , where  $Z_o$  is the single-ended impedance defined in Table 5-46.

(4) Center-to-center spacing is allowed to fall to minimum (w) for up to 500 mils of routed length to accommodate BGA escape and routing congestion.

(5) CACLM is the longest Manhattan distance of the CK and ADDR\_CTRL net classes.

Figure 5-45 shows the topology and routing for the DQS[x] and DQ[x] net classes; the routes are point to point. Skew matching across bytes is not needed nor recommended.

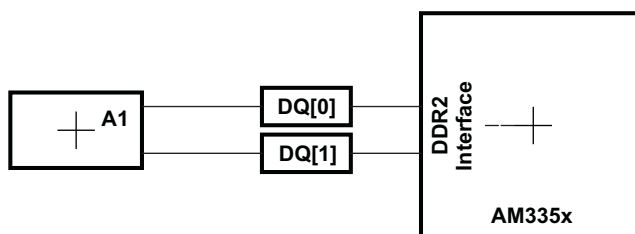


Figure 5-45. DQS[x] and DQ[x] Routing and Topology

**Table 5-55. DQS[x] and DQ[x] Routing Specification<sup>(1)</sup>**

| NO. | PARAMETER                                                              | MIN     | TYP  | MAX     | UNIT |
|-----|------------------------------------------------------------------------|---------|------|---------|------|
| 1   | Center-to-center DQS[x] spacing                                        |         |      | 2w      |      |
| 2   | DQS[x] differential pair skew length mismatch <sup>(2)</sup>           |         |      | 25      | mils |
| 3   | Center-to-center DDR_DQS[x] to other DDR2 trace spacing <sup>(3)</sup> | 4w      |      |         |      |
| 4   | DQS[x] and DQ[x] nominal trace length <sup>(4)</sup>                   | DQLM-50 | DQLM | DQLM+50 | mils |
| 5   | DQ[x]-to-DQS[x] skew length mismatch <sup>(4)</sup>                    |         |      | 100     | mils |
| 6   | DQ[x]-to-DQ[x] skew length mismatch <sup>(4)</sup>                     |         |      | 100     | mils |
| 7   | Center-to-center DQ[x] to other DDR2 trace spacing <sup>(3)(5)</sup>   | 4w      |      |         |      |
| 8   | Center-to-center DQ[x] to other DQ[x] trace spacing <sup>(3)(6)</sup>  | 3w      |      |         |      |

(1) DQS[x] represents the DQS0 and DQS1 clock net classes, and DQ[x] represents the DQ0 and DQ1 signal net classes.

(2) Differential impedance should be  $Z_o \times 2$ , where  $Z_o$  is the single-ended impedance defined in [Table 5-46](#).

(3) Center-to-center spacing is allowed to fall to minimum (w) for up to 500 mils of routed length to accommodate BGA escape and routing congestion.

(4) There is no requirement for skew matching between data bytes; that is, from net classes DQS0 and DQ0 to net classes DQS1 and DQ1.

(5) Signals from one DQ net class should be considered other DDR2 traces to another DQ net class.

(6) DQLM is the longest Manhattan distance of each of the DQS[x] and DQ[x] net classes.

### 5.6.2.3 DDR3 and DDR3L Routing Guidelines

#### NOTE

All references to DDR3 in this section apply to DDR3 and DDR3L devices, unless otherwise noted.

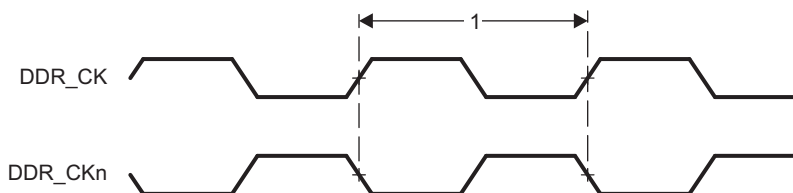
#### 5.6.2.3.1 Board Designs

TI only supports board designs utilizing DDR3 memory that follow the guidelines in this document. The switching characteristics and timing diagram for the DDR3 memory interface are shown in [Table 5-56](#) and [Figure 5-46](#).

**Table 5-56. Switching Characteristics for DDR3 Memory Interface**

| NO. | PARAMETER                             |                                | MIN | MAX                | UNIT |
|-----|---------------------------------------|--------------------------------|-----|--------------------|------|
| 1   | $t_{c(DDR\_CK)}$<br>$t_{c(DDR\_CKn)}$ | Cycle time, DDR_CK and DDR_CKn | 2.5 | 3.3 <sup>(1)</sup> | ns   |

(1) The JEDEC JESD79-3F Standard defines the maximum clock period of 3.3 ns for all standard-speed bin DDR3 and DDR3L memory devices. Therefore, all standard-speed bin DDR3 and DDR3L memory devices are required to operate at 303 MHz.



**Figure 5-46. DDR3 Memory Interface Clock Timing**

#### 5.6.2.3.1.1 DDR3 versus DDR2

This specification only covers AM335x PCB designs that utilize DDR3 memory. Designs using DDR2 memory should use the DDR2 routing guidelines described in [Section 5.6.2.2](#). While similar, the two memory systems have different requirements. It is currently not possible to design one PCB that meets the requirements of both DDR2 and DDR3.

#### 5.6.2.3.2 DDR3 Device Combinations

Since there are several possible combinations of device counts and single-side or dual-side mounting, [Table 5-57](#) summarizes the supported device configurations.

**Table 5-57. Supported DDR3 Device Combinations**

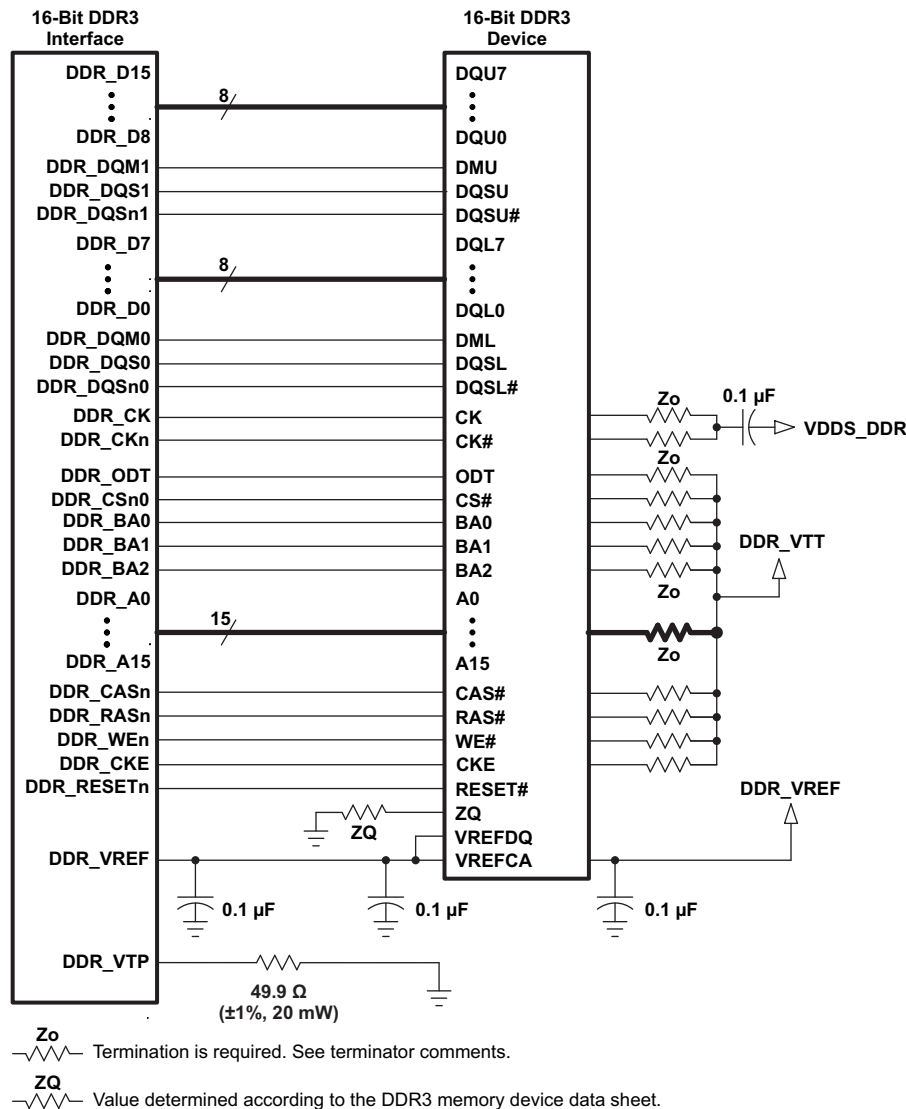
| NUMBER OF DDR3 DEVICES | DDR3 DEVICE WIDTH (BITS) | MIRRORED?        | DDR3 EMIF WIDTH (BITS) |
|------------------------|--------------------------|------------------|------------------------|
| 1                      | 16                       | N                | 16                     |
| 2                      | 8                        | Y <sup>(1)</sup> | 16                     |

(1) Two DDR3 devices are mirrored when one device is placed on the top of the board and the second device is placed on the bottom of the board.

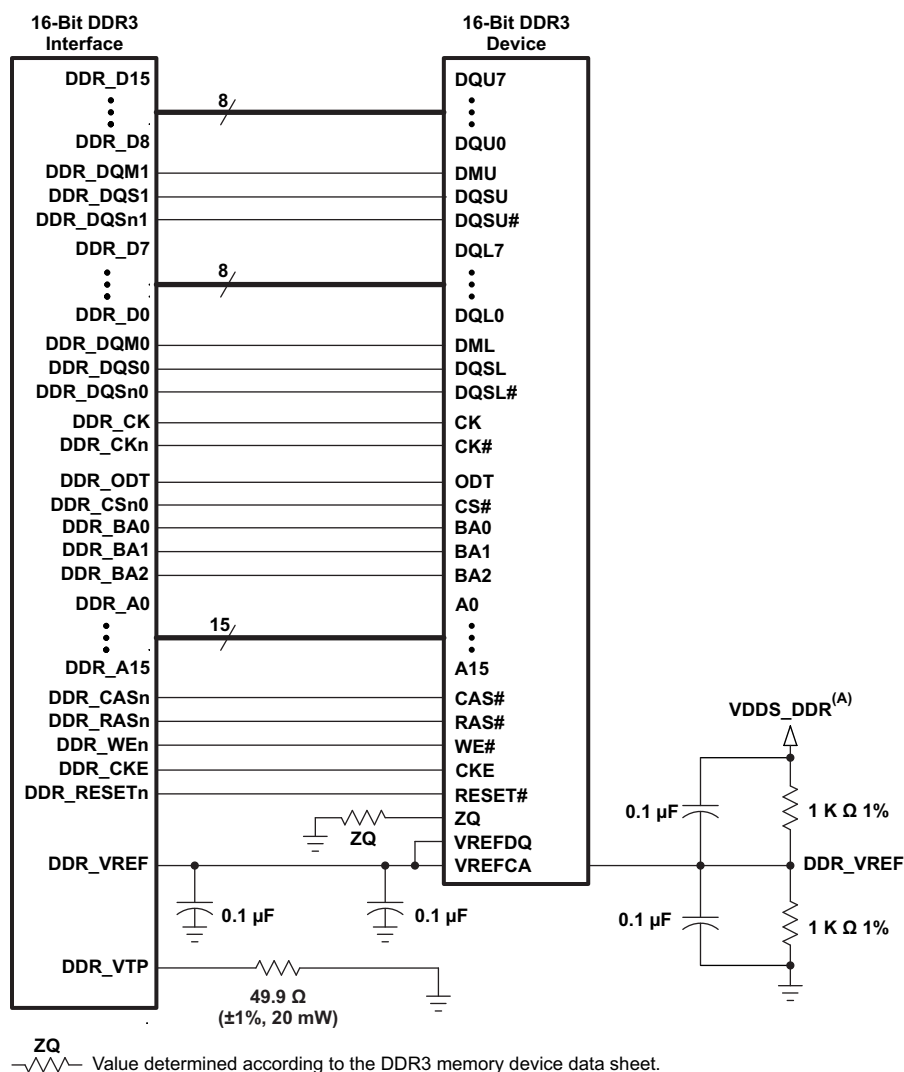
### 5.6.2.3.3 DDR3 Interface

#### 5.6.2.3.3.1 DDR3 Interface Schematic

The DDR3 interface schematic varies, depending upon the width of the DDR3 devices used. [Figure 5-47](#) shows the schematic connections for 16-bit interface on AM335x device using one x16 DDR3 device and [Figure 5-49](#) shows the schematic connections for 16-bit interface on AM335x device using two x8 DDR3 devices. The AM335x DDR3 memory interface only supports 16-bit wide mode of operation. The AM335x device can only source one load connected to the DQS[x] and DQ[x] net class signals and two loads connected to the CK and ADDR\_CTRL net class signals. For more information related to net classes, see [Section 5.6.2.3.3.8](#).



**Figure 5-47. 16-Bit DDR3 Interface Using One 16-Bit DDR3 Device with  $V_{TT}$  Termination**



ZQ  
—ZQ— Value determined according to the DDR3 memory device data sheet.

- A. VDDS\_DDR is the power supply for the DDR3 memories and the AM335x DDR3 interface.

**Figure 5-48. 16-Bit DDR3 Interface Using One 16-Bit DDR3 Device without V<sub>TT</sub> Termination**



### 5.6.2.3.3.2 Compatible JEDEC DDR3 Devices

Table 5-58 shows the parameters of the JEDEC DDR3 devices that are compatible with this interface.

**Table 5-58. Compatible JEDEC DDR3 Devices (Per Interface)**

| NO. | PARAMETER                              | CONDITION                                      | MIN       | MAX | UNIT    |
|-----|----------------------------------------|------------------------------------------------|-----------|-----|---------|
| 1   | JEDEC DDR3 device speed grade          | $t_{C(DDR\_CK)}$ and $t_{C(DDR\_CKn)} = 3.3ns$ | DDR3-800  |     |         |
|     |                                        | $t_{C(DDR\_CK)}$ and $t_{C(DDR\_CKn)} = 2.5ns$ | DDR3-1600 |     |         |
| 2   | JEDEC DDR3 device bit width            |                                                | x8        | x16 | Bits    |
| 3   | JEDEC DDR3 device count <sup>(1)</sup> |                                                | 1         | 2   | Devices |

(1) For valid DDR3 device configurations and device counts, see [Section 5.6.2.3.3.1](#), [Figure 5-47](#), and [Figure 5-49](#).

### 5.6.2.3.3.3 PCB Stackup

The minimum stackup for routing the DDR3 interface is a four-layer stack up as shown in [Table 5-59](#). Additional layers may be added to the PCB stackup to accommodate other circuitry, enhance signal integrity and electromagnetic interference performance, or to reduce the size of the PCB footprint.

**Table 5-59. Minimum PCB Stackup<sup>(1)</sup>**

| LAYER | TYPE   | DESCRIPTION           |
|-------|--------|-----------------------|
| 1     | Signal | Top signal routing    |
| 2     | Plane  | Ground                |
| 3     | Plane  | Split Power Plane     |
| 4     | Signal | Bottom signal routing |

(1) All signals that have critical signal integrity requirements should be routed first on layer 1. It may not be possible to route all of these signals on layer 1 which requires some to be routed on layer 4. When this is done, the signal routes on layer 4 should not cross splits in the power plane.

**Table 5-60. PCB Stackup Specifications<sup>(1)</sup>**

| NO. | PARAMETER                                                                         |             | MIN     | TYP   | MAX     | UNIT |
|-----|-----------------------------------------------------------------------------------|-------------|---------|-------|---------|------|
| 1   | PCB routing and plane layers                                                      |             | 4       |       |         |      |
| 2   | Signal routing layers                                                             |             | 2       |       |         |      |
| 3   | Full ground reference layers under DDR3 routing region <sup>(2)</sup>             |             | 1       |       |         |      |
| 4   | Full VDDS_DDR power reference layers under the DDR3 routing region <sup>(2)</sup> |             | 1       |       |         |      |
| 5   | Number of reference plane cuts allowed within DDR3 routing region <sup>(3)</sup>  |             |         |       | 0       |      |
| 6   | Number of layers between DDR3 routing layer and reference plane <sup>(4)</sup>    |             |         |       | 0       |      |
| 7   | PCB routing feature size                                                          |             |         | 4     |         | mils |
| 8   | PCB trace width, w                                                                |             |         | 4     |         | mils |
| 9   | PCB BGA escape via pad size <sup>(5)</sup>                                        |             |         | 18    | 20      | mils |
| 10  | PCB BGA escape via hole size                                                      |             |         | 10    |         | mils |
| 11  | AM335x BGA pad size                                                               | ZCZ package |         | 0.5   |         | mm   |
|     |                                                                                   | ZCE package |         | 0.4   |         |      |
| 13  | Single-ended impedance, $Z_0$ <sup>(6)</sup>                                      |             | 50      |       | 75      | ohms |
| 14  | Impedance control <sup>(7)(8)</sup>                                               |             | $Z_0-5$ | $Z_0$ | $Z_0+5$ | ohms |

(1) For the DDR3 device BGA pad size, see the DDR3 device manufacturer documentation.

(2) Ground reference layers are preferred over power reference layers. Be sure to include bypass caps to accommodate reference layer return current as the trace routes switch routing layers.

(3) No traces should cross reference plane cuts within the DDR3 routing region. High-speed signal traces crossing reference plane cuts create large return current paths which can lead to excessive crosstalk and EMI radiation.

(4) Reference planes are to be directly adjacent to the signal plane to minimize the size of the return current loop.

(5) An 18-mil pad assumes Via Channel is the most economical BGA escape. A 20-mil pad may be used if additional layers are available for power routing. An 18-mil pad is required for minimum layer count escape.

(6)  $Z_0$  is the nominal single-ended impedance selected for the PCB.

(7) This parameter specifies the AC characteristic impedance tolerance for each segment of a PCB signal trace relative to the chosen  $Z_0$  defined by the single-ended impedance parameter.

(8) Tighter impedance control is required to ensure flight time skew is minimal.

#### 5.6.2.3.3.4 Placement

Figure 5-50 shows the required placement for the AM335x device as well as the DDR3 devices. The dimensions for this figure are defined in Table 5-61. The placement does not restrict the side of the PCB on which the devices are mounted. The ultimate purpose of the placement is to limit the maximum trace lengths and allow for proper routing space.

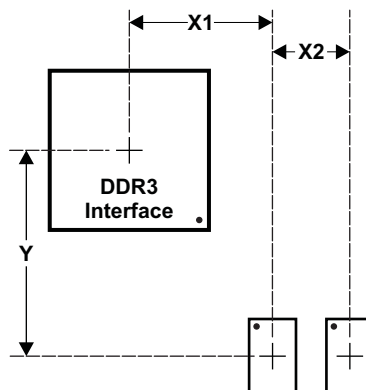


Figure 5-50. Placement Specifications

Table 5-61. Placement Specifications<sup>(1)</sup>

| NO. | PARAMETER                                                               | MIN | MAX  | UNIT |
|-----|-------------------------------------------------------------------------|-----|------|------|
| 1   | X1 <sup>(2)(3)(4)</sup>                                                 |     | 1000 | mils |
| 2   | X2 <sup>(2)(3)</sup>                                                    |     | 600  | mils |
| 3   | Y Offset <sup>(2)(3)(4)</sup>                                           |     | 1500 | mils |
| 4   | Clearance from non-DDR3 signal to DDR3 keepout region <sup>(5)(6)</sup> | 4   |      | w    |

(1) DDR3 keepout region to encompass entire DDR3 routing area.

(2) For dimension definitions, see Figure 5-50.

(3) Measurements from center of AM335x device to center of DDR3 device.

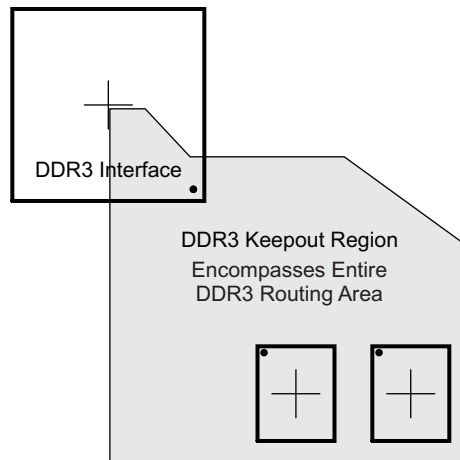
(4) Minimizing X1 and Y improves timing margins.

(5) w is defined as the signal trace width.

(6) Non-DDR3 signals allowed within DDR3 keepout region provided they are separated from DDR3 routing layers by a ground plane.

### 5.6.2.3.3.5 DDR3 Keepout Region

The region of the PCB used for DDR3 circuitry must be isolated from other signals. The DDR3 keepout region is defined for this purpose and is shown in Figure 5-51. This region should encompass all DDR3 circuitry and the region size varies with component placement and DDR3 routing. Additional clearances required for the keepout region are shown in Table 5-61. Non-DDR3 signals should not be routed on the same signal layer as DDR3 signals within the DDR3 keepout region. Non-DDR3 signals may be routed in the region provided they are routed on layers separated from DDR3 signal layers by a ground layer. No breaks should be allowed in the reference ground or VDDS\_DDR power plane in this region. In addition, the VDDS\_DDR power plane should cover the entire keepout region.



**Figure 5-51. DDR3 Keepout Region**

### 5.6.2.3.3.6 Bulk Bypass Capacitors

Bulk bypass capacitors are required for moderate speed bypassing of the DDR3 and other circuitry. Table 5-62 contains the minimum numbers and capacitance required for the bulk bypass capacitors. Note that this table only covers the bypass needs of the AM335x DDR3 interface and DDR3 devices. Additional bulk bypass capacitance may be needed for other circuitry.

**Table 5-62. Bulk Bypass Capacitors<sup>(1)</sup>**

| NO. | PARAMETER                                           | MIN | MAX | UNIT    |
|-----|-----------------------------------------------------|-----|-----|---------|
| 1   | AM335x VDDS_DDR bulk bypass capacitor count         | 2   |     | Devices |
| 2   | AM335x VDDS_DDR bulk bypass total capacitance       | 20  |     | μF      |
| 3   | DDR3#1 bulk bypass capacitor count                  | 2   |     | Devices |
| 4   | DDR3#1 bulk bypass total capacitance                | 20  |     | μF      |
| 5   | DDR3#2 bulk bypass capacitor count <sup>(2)</sup>   | 2   |     | Devices |
| 6   | DDR3#2 bulk bypass total capacitance <sup>(2)</sup> | 20  |     | μF      |

(1) These devices should be placed near the devices they are bypassing, but preference should be given to the placement of the high-speed (HS) bypass capacitors and DDR3 signal routing.

(2) Only used when two DDR3 devices are used.

### 5.6.2.3.3.7 High-Speed Bypass Capacitors

High-speed (HS) bypass capacitors are critical for proper DDR3 interface operation. It is particularly important to minimize the parasitic series inductance of the HS bypass capacitors, AM335x device DDR3 power, and AM335x device DDR3 ground connections. Table 5-63 contains the specification for the HS bypass capacitors as well as for the power connections on the PCB. Generally speaking, it is good to:

1. Fit as many HS bypass capacitors as possible.
2. Minimize the distance from the bypass cap to the power terminals being bypassed.
3. Use the smallest physical sized capacitors possible with the highest capacitance readily available.
4. Connect the bypass capacitor pads to their vias using the widest traces possible and using the largest hole size via possible.
5. Minimize via sharing. Note the limits on via sharing shown in Table 5-63.

**Table 5-63. High-Speed Bypass Capacitors**

| NO. | PARAMETER                                                                                            | MIN  | TYP  | MAX  | UNIT    |
|-----|------------------------------------------------------------------------------------------------------|------|------|------|---------|
| 1   | HS bypass capacitor package size <sup>(1)</sup>                                                      |      | 0201 | 0402 | 10 mils |
| 2   | Distance, HS bypass capacitor to AM335x VDDSDDR and VSS terminal being bypassed <sup>(2)(3)(4)</sup> |      |      | 400  | mils    |
| 3   | AM335x VDDSDDR HS bypass capacitor count                                                             | 20   |      |      | Devices |
| 4   | AM335x VDDSDDR HS bypass capacitor total capacitance                                                 | 1    |      |      | μF      |
| 5   | Trace length from AM335x VDDSDDR and VSS terminal to connection via <sup>(2)</sup>                   |      | 35   | 70   | mils    |
| 6   | Distance, HS bypass capacitor to DDR3 device being bypassed <sup>(5)</sup>                           |      |      | 150  | mils    |
| 7   | DDR3 device HS bypass capacitor count <sup>(6)</sup>                                                 | 12   |      |      | Devices |
| 8   | DDR3 device HS bypass capacitor total capacitance <sup>(6)</sup>                                     | 0.85 |      |      | μF      |
| 9   | Number of connection vias for each HS bypass capacitor <sup>(7)(8)</sup>                             | 2    |      |      | Vias    |
| 10  | Trace length from bypass capacitor connect to connection via <sup>(2)(8)</sup>                       |      | 35   | 100  | mils    |
| 11  | Number of connection vias for each DDR3 device power and ground terminal <sup>(9)</sup>              | 1    |      |      | Vias    |
| 12  | Trace length from DDR3 device power and ground terminal to connection via <sup>(2)(7)</sup>          |      | 35   | 60   | mils    |

(1) LxW, 10-mil units; for example, a 0402 is a 40x20-mil surface-mount capacitor.

(2) Closer and shorter is better.

(3) Measured from the nearest AM335x VDDSDDR and ground terminal to the center of the capacitor package.

(4) Three of these capacitors should be located underneath the AM335x device, between the cluster of VDDSDDR and ground terminals, between the DDR3 interfaces on the package.

(5) Measured from the DDR3 device power and ground terminal to the center of the capacitor package.

(6) Per DDR3 device.

(7) An additional HS bypass capacitor can share the connection vias only if it is mounted on the opposite side of the board. No sharing of vias is permitted on the same side of the board.

(8) An HS bypass capacitor may share a via with a DDR3 device mounted on the same side of the PCB. A wide trace should be used for the connection and the length from the capacitor pad to the DDR3 device pad should be less than 150 mils.

(9) Up to a total of two pairs of DDR3 power and ground terminals may share a via.

### 5.6.2.3.3.7.1 Return Current Bypass Capacitors

Use additional bypass capacitors if the return current reference plane changes due to DDR3 signals hopping from one signal layer to another. The bypass capacitor here provides a path for the return current to hop planes along with the signal. As many of these return current bypass capacitors should be used as possible. Since these are returns for signal current, the signal via size may be used for these capacitors.

### 5.6.2.3.3.8 Net Classes

Table 5-64 lists the clock net classes for the DDR3 interface. Table 5-65 lists the signal net classes, and associated clock net classes, for signals in the DDR3 interface. These net classes are used for the termination and routing rules that follow.

**Table 5-64. Clock Net Class Definitions**

| CLOCK NET CLASS | AM335x PIN NAMES       |
|-----------------|------------------------|
| CK              | DDR_CK and DDR_CKn     |
| DQS0            | DDR_DQS0 and DDR_DQSn0 |
| DQS1            | DDR_DQS1 and DDR_DQSn1 |

**Table 5-65. Signal Net Class Definitions**

| SIGNAL NET CLASS | ASSOCIATED CLOCK NET CLASS | AM335x PIN NAMES                                                                  |
|------------------|----------------------------|-----------------------------------------------------------------------------------|
| ADDR_CTRL        | CK                         | DDR_BA[2:0], DDR_A[15:0], DDR_CSn0, DDR_CASn, DDR_RASn, DDR_WEn, DDR_CKE, DDR_ODT |
| DQ0              | DQS0                       | DDR_D[7:0], DDR_DQM0                                                              |
| DQ1              | DQS1                       | DDR_D[15:8], DDR_DQM1                                                             |

### 5.6.2.3.3.9 DDR3 Signal Termination

Signal terminations are required for the CK and ADDR\_CTRL net class signals. On-device terminations (ODTs) are required on the DQS[x] and DQ[x] net class signals. Detailed termination specifications are covered in the routing rules in the following sections.

Figure 5-48 provides an example DDR3 schematic with a single 16-bit DDR3 memory device that does not have  $V_{TT}$  termination on the address and control signals. A typical DDR3 point-to-point topology may provide acceptable signal integrity without  $V_{TT}$  termination. System performance should be verified by performing signal integrity analysis using specific PCB design details before implementing this topology.

### 5.6.2.3.3.10 DDR\_VREF Routing

DDR\_VREF is used as a reference by the input buffers of the DDR3 memories as well as the AM335x device. DDR\_VREF is intended to be half the DDR3 power supply voltage and is typically generated with a voltage divider connected to the VDDSDDR power supply. It should be routed as a nominal 20-mil wide trace with 0.1  $\mu$ F bypass capacitors near each device connection. Narrowing of DDR\_VREF is allowed to accommodate routing congestion.

### 5.6.2.3.3.11 VTT

Like DDR\_VREF, the nominal value of the VTT supply is half the DDR3 supply voltage. Unlike DDR\_VREF, VTT is expected to source and sink current, specifically the termination current for the ADDR\_CTRL net class Thevenin terminators. VTT is needed at the end of the address bus and it should be routed as a power sub-plane. VTT should be bypassed near the terminator resistors.

### 5.6.2.3.4 DDR3 CK and ADDR\_CTRL Topologies and Routing Definition

The CK and ADDR\_CTRL net classes are routed similarly and are length matched to minimize skew between them. CK is a bit more complicated because it runs at a higher transition rate and is differential. The following subsections show the topology and routing for various DDR3 configurations for CK and ADDR\_CTRL. The figures in the following subsections define the terms for the routing specification detailed in Table 5-66.

#### 5.6.2.3.4.1 Two DDR3 Devices

Two DDR3 devices are supported on the DDR3 interface consisting of two x8 DDR3 devices arranged as one 16-bit bank. These two devices may be mounted on a single side of the PCB, or may be mirrored in a pair to save board space at a cost of increased routing complexity and parts on the backside of the PCB.

##### 5.6.2.3.4.1.1 CK and ADDR\_CTRL Topologies, Two DDR3 Devices

Figure 5-52 shows the topology of the CK net classes and Figure 5-53 shows the topology for the corresponding ADDR\_CTRL net classes.

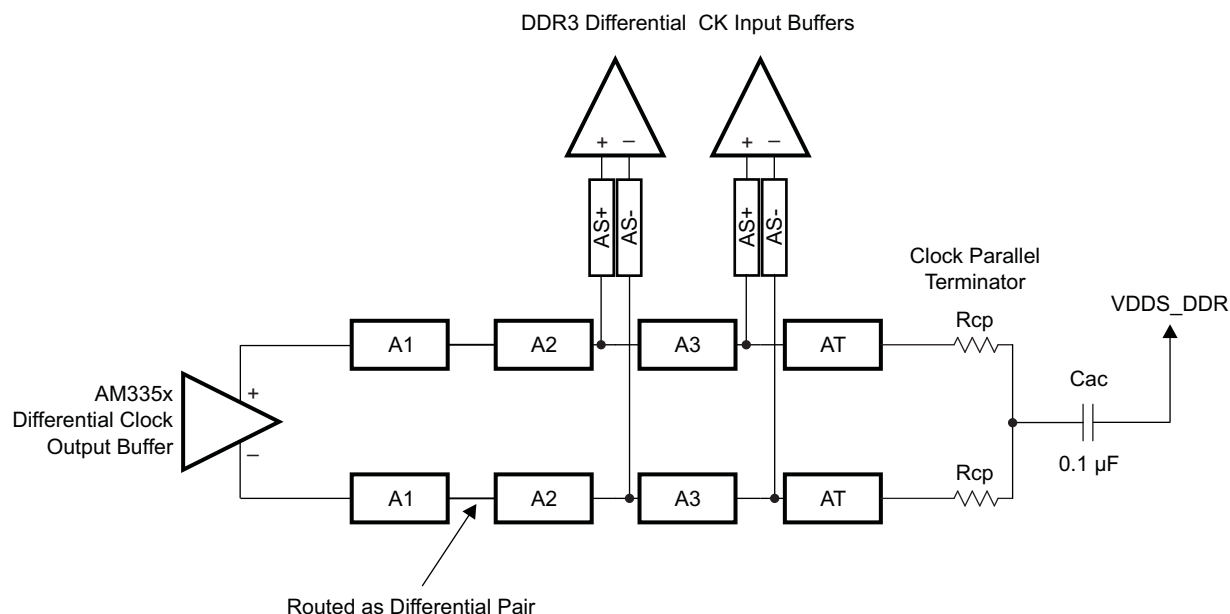


Figure 5-52. CK Topology for Two DDR3 Devices

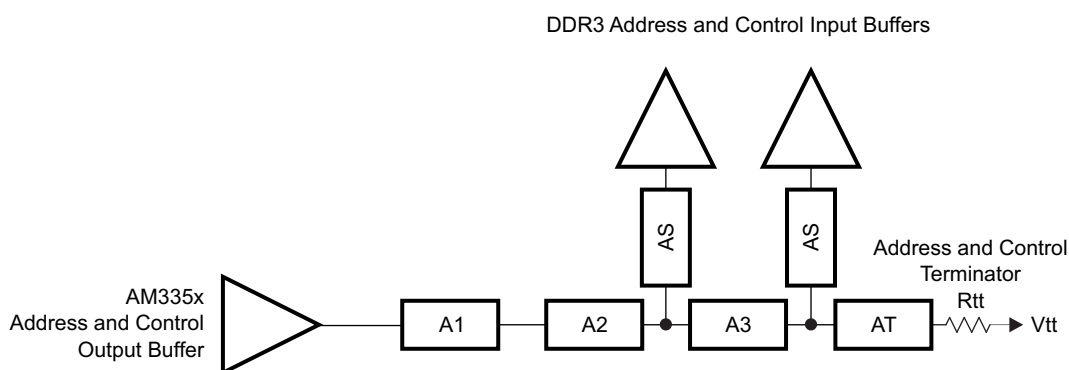


Figure 5-53. ADDR\_CTRL Topology for Two DDR3 Devices

##### 5.6.2.3.4.1.2 CK and ADDR\_CTRL Routing, Two DDR3 Devices

Figure 5-54 shows the CK routing for two DDR3 devices placed on the same side of the PCB. Figure 5-55 shows the corresponding ADDR\_CTRL routing.

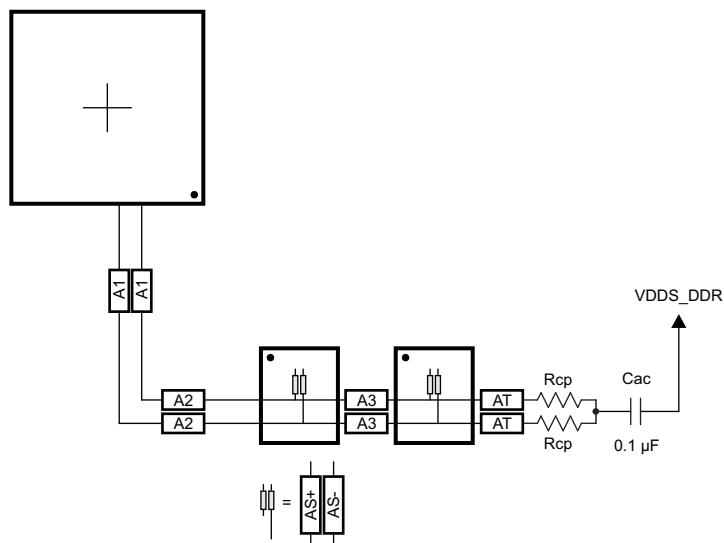


Figure 5-54. CK Routing for Two Single-Side DDR3 Devices

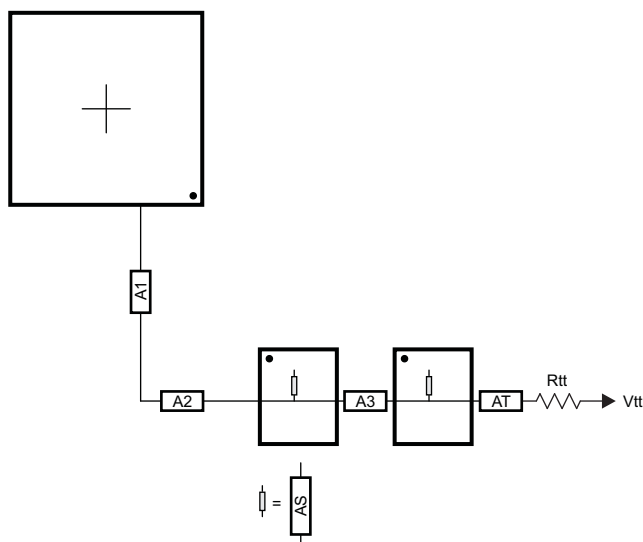
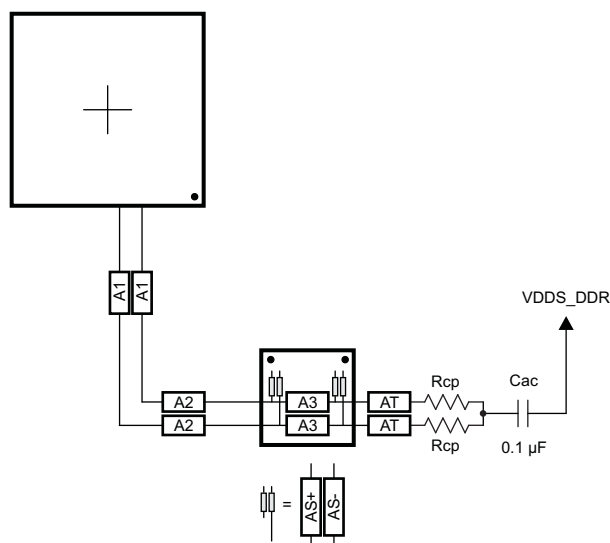
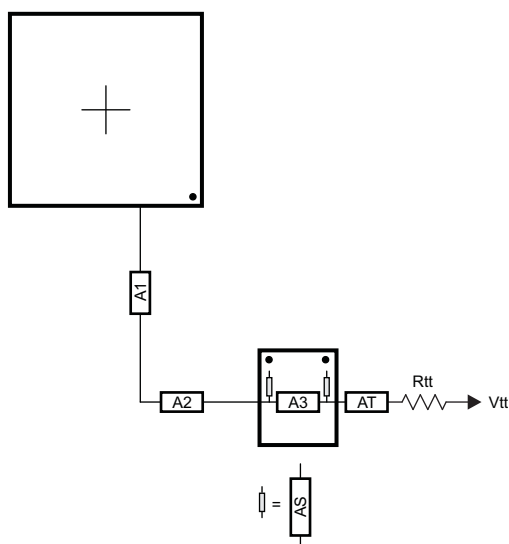


Figure 5-55. ADDR\_CTRL Routing for Two Single-Side DDR3 Devices

To save PCB space, the two DDR3 memories may be mounted as a mirrored pair at a cost of increased routing and assembly complexity. [Figure 5-56](#) and [Figure 5-57](#) show the routing for CK and ADDR\_CTRL, respectively, for two DDR3 devices mirrored in a single-pair configuration.



**Figure 5-56. CK Routing for Two Mirrored DDR3 Devices**



**Figure 5-57. ADDR\_CTRL Routing for Two Mirrored DDR3 Devices**

#### 5.6.2.3.4.2 One DDR3 Device

A single DDR3 device is supported on the DDR3 interface consisting of one x16 DDR3 device arranged as one 16-bit bank.

##### 5.6.2.3.4.2.1 CK and ADDR\_CTRL Topologies, One DDR3 Device

Figure 5-58 shows the topology of the CK net classes and Figure 5-59 shows the topology for the corresponding ADDR\_CTRL net classes.

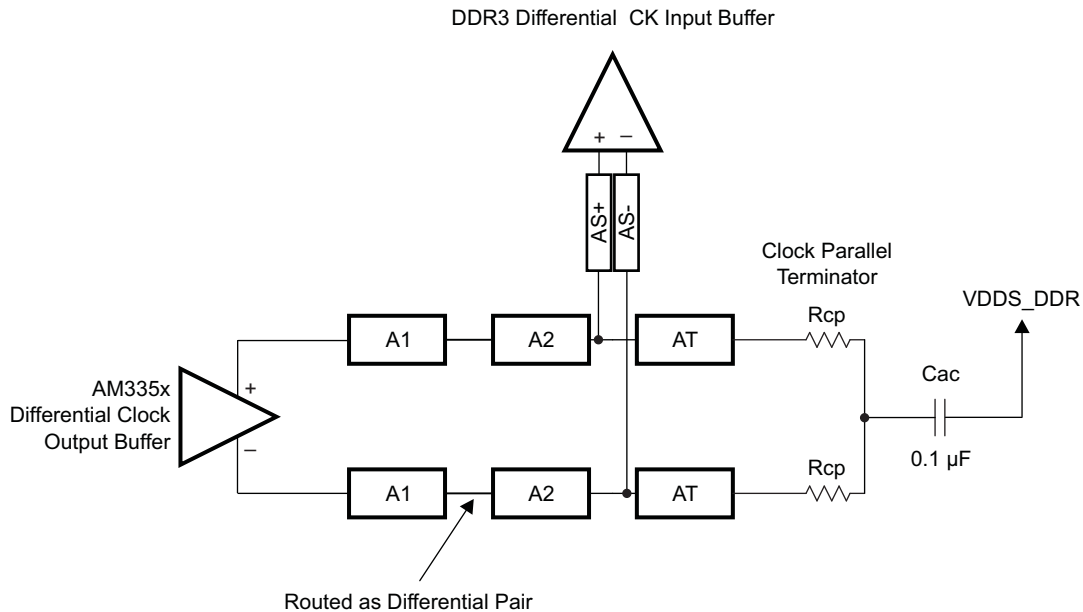


Figure 5-58. CK Topology for One DDR3 Device

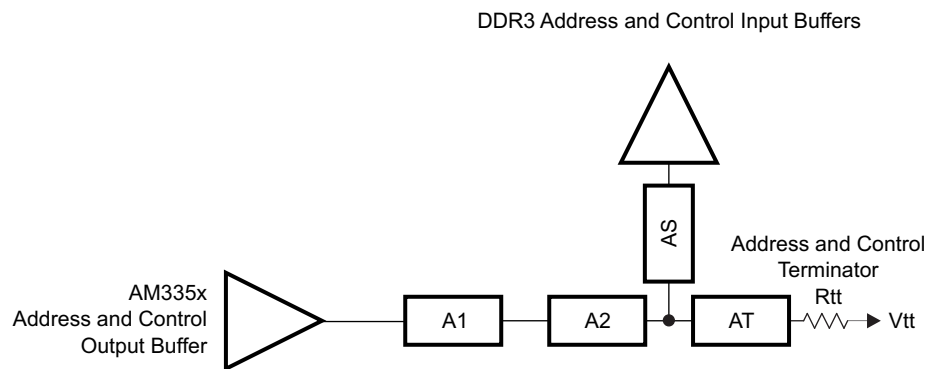


Figure 5-59. ADDR\_CTRL Topology for One DDR3 Device

#### 5.6.2.3.4.2.2 CK and ADDR\_CTRL Routing, One DDR3 Device

Figure 5-60 shows the CK routing for one DDR3 device. Figure 5-61 shows the corresponding ADDR\_CTRL routing.

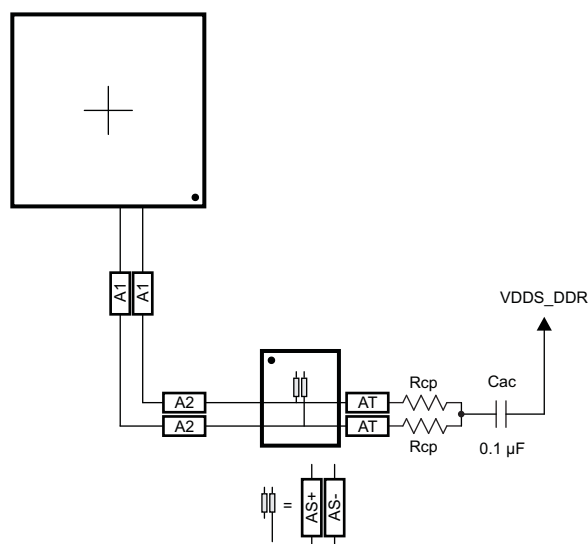


Figure 5-60. CK Routing for One DDR3 Device

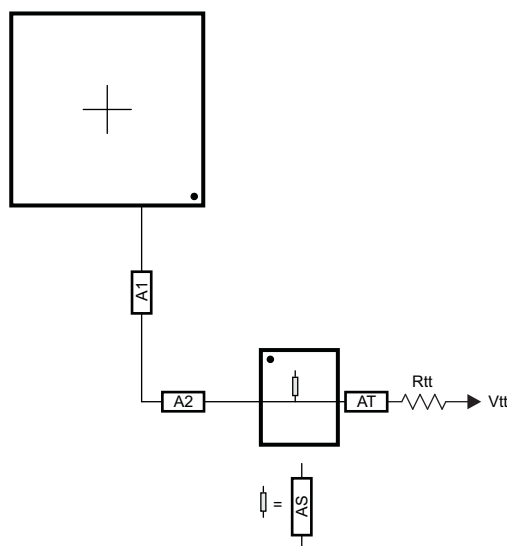


Figure 5-61. ADDR\_CTRL Routing for One DDR3 Device

#### 5.6.2.3.5 Data Topologies and Routing Definition

No matter the number of DDR3 devices used, the data line topology is always point to point, so its definition is simple.

##### 5.6.2.3.5.1 DQS[x] and DQ[x] Topologies, Any Number of Allowed DDR3 Devices

DQS[x] lines are point-to-point differential, and DQ[x] lines are point-to-point singled ended. Figure 5-62 and Figure 5-63 show these topologies.

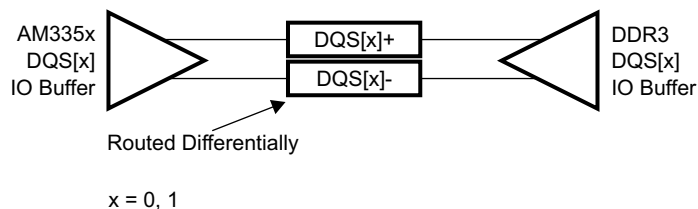


Figure 5-62. DQS[x] Topology

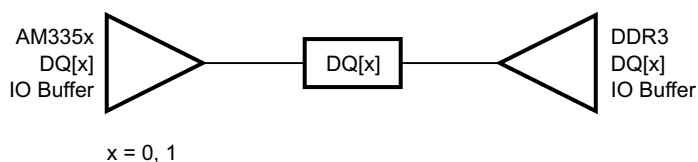


Figure 5-63. DQ[x] Topology

#### 5.6.2.3.5.2 DQS[x] and DQ[x] Routing, Any Number of Allowed DDR3 Devices

Figure 5-64 and Figure 5-65 show the DQS[x] and DQ[x] routing.

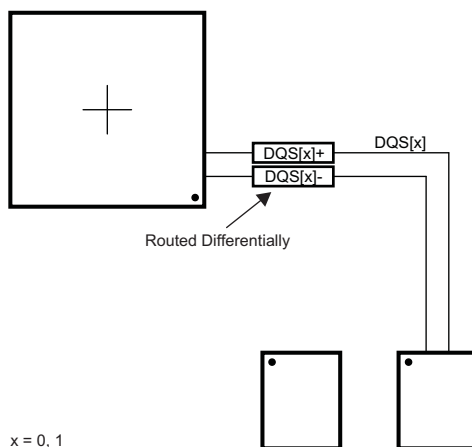


Figure 5-64. DQS[x] Routing With Any Number of Allowed DDR3 Devices

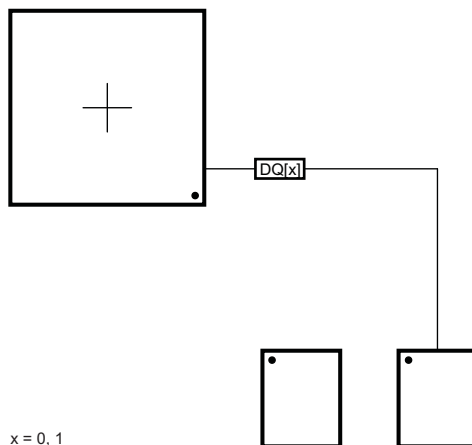


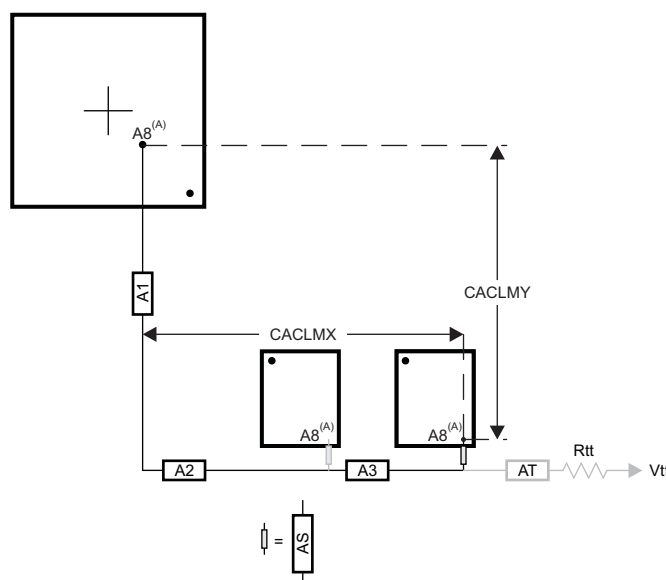
Figure 5-65. DQ[x] Routing With Any Number of Allowed DDR3 Devices

### 5.6.2.3.6 Routing Specification

#### 5.6.2.3.6.1 CK and ADDR\_CTRL Routing Specification

Skew within the CK and ADDR\_CTRL net classes directly reduces setup and hold margin and, thus, this skew must be controlled. The only way to practically match lengths on a PCB is to lengthen the shorter traces up to the length of the longest net in the net class and its associated clock. A metric to establish this maximum length is Manhattan distance. The Manhattan distance between two points on a PCB is the length between the points when connecting them only with horizontal or vertical segments. A reasonable trace route length is to within a percentage of its Manhattan distance. CACLM is defined as Clock Address Control Longest Manhattan distance.

Given the clock and address pin locations on the AM335x device and the DDR3 memories, the maximum possible Manhattan distance can be determined given the placement. Figure 5-66 shows this distance for two loads. It is from this distance that the specifications on the lengths of the transmission lines for the address bus are determined. CACLM is determined similarly for other address bus configurations; that is, it is based on the longest net of the CK and ADDR\_CTRL net class. For CK and ADDR\_CTRL routing, these specifications are contained in Table 5-66.



- A. It is very likely that the longest CK and ADDR\_CTRL Manhattan distance will be for Address Input 8 (A8) on the DDR3 memories. CACLM is based on the longest Manhattan distance due to the device placement. Verify the net class that satisfies this criteria and use as the baseline for CK and ADDR\_CTRL skew matching and length control.

The length of shorter CK and ADDR\_CTRL stubs as well as the length of the terminator stub are not included in this length calculation. Non-included lengths are grayed out in the figure.

Assuming A8 is the longest, CALM = CACLMY + CACLMX + 300 mils.

The extra 300 mils allows for routing down lower than the DDR3 memories and returning up to reach A8.

**Figure 5-66. CACLM for Two Address Loads on One Side of PCB**

**Table 5-66. CK and ADDR\_CTRL Routing Specification<sup>(1)(2)(3)</sup>**

| NO. | PARAMETER              | MIN | TYP | MAX  | UNIT |
|-----|------------------------|-----|-----|------|------|
| 1   | A1+A2 length           |     |     | 2500 | mils |
| 2   | A1+A2 skew             |     |     | 25   | mils |
| 3   | A3 length              |     |     | 660  | mils |
| 4   | A3 skew <sup>(4)</sup> |     |     | 25   | mils |
| 5   | A3 skew <sup>(5)</sup> |     |     | 125  | mils |
| 6   | AS length              |     |     | 100  | mils |

**Table 5-66. CK and ADDR\_CTRL Routing Specification<sup>(1)(2)(3)</sup> (continued)**

| NO. | PARAMETER                                                                   | MIN               | TYP            | MAX               | UNIT |
|-----|-----------------------------------------------------------------------------|-------------------|----------------|-------------------|------|
| 7   | AS skew                                                                     |                   |                | 25                | mils |
| 8   | AS+ and AS- length                                                          |                   |                | 70                | mils |
| 9   | AS+ and AS- skew                                                            |                   |                | 5                 | mils |
| 10  | AT length <sup>(6)</sup>                                                    |                   | 500            |                   | mils |
| 11  | AT skew <sup>(7)</sup>                                                      |                   | 100            |                   | mils |
| 12  | AT skew <sup>(8)</sup>                                                      |                   |                | 5                 | mils |
| 13  | CK and ADDR_CTRL nominal trace length <sup>(9)</sup>                        | CACLM-50          | CACLM          | CACLM+50          | mils |
| 14  | Center-to-center CK to other DDR3 trace spacing <sup>(10)</sup>             | 4w                |                |                   |      |
| 15  | Center-to-center ADDR_CTRL to other DDR3 trace spacing <sup>(10)(11)</sup>  | 4w                |                |                   |      |
| 16  | Center-to-center ADDR_CTRL to other ADDR_CTRL trace spacing <sup>(10)</sup> | 3w                |                |                   |      |
| 17  | CK center-to-center spacing <sup>(12)</sup>                                 |                   |                |                   |      |
| 18  | CK spacing to other net <sup>(10)</sup>                                     | 4w                |                |                   |      |
| 19  | Rcp <sup>(13)</sup>                                                         | Z <sub>0</sub> -1 | Z <sub>0</sub> | Z <sub>0</sub> +1 | ohms |
| 20  | Rtt <sup>(13)(14)</sup>                                                     | Z <sub>0</sub> -5 | Z <sub>0</sub> | Z <sub>0</sub> +5 | ohms |

(1) CK represents the clock net class, and ADDR\_CTRL represents the address and control signal net class.

(2) The use of vias should be minimized.

(3) Additional bypass capacitors are required when using the VDDS\_DDR plane as the reference plane to allow the return current to jump between the VDDS\_DDR plane and the ground plane when the net class switches layers at a via.

(4) Mirrored configuration (one DDR3 device on top of the board and one DDR3 device on the bottom).

(5) Non-mirrored configuration (all DDR3 memories on same side of PCB).

(6) While this length can be increased for convenience, its length should be minimized.

(7) ADDR\_CTRL net class only (not CK net class). Minimizing this skew is recommended, but not required.

(8) CK net class only.

(9) CACLM is the longest Manhattan distance of the CK and ADDR\_CTRL net classes + 300 mils. For definition, see [Section 5.6.2.3.6.1](#) and [Figure 5-66](#).

(10) Center-to-center spacing is allowed to fall to minimum (w) for up to 1250 mils of routed length.

(11) Signals from one DQ net class should be considered other DDR3 traces to another DQ net class.

(12) CK spacing set to ensure proper differential impedance. Differential impedance should be Z<sub>0</sub> × 2, where Z<sub>0</sub> is the single-ended impedance defined in [Table 5-60](#).

(13) Source termination (series resistor at driver) is specifically not allowed.

(14) Termination values should be uniform across the net class.

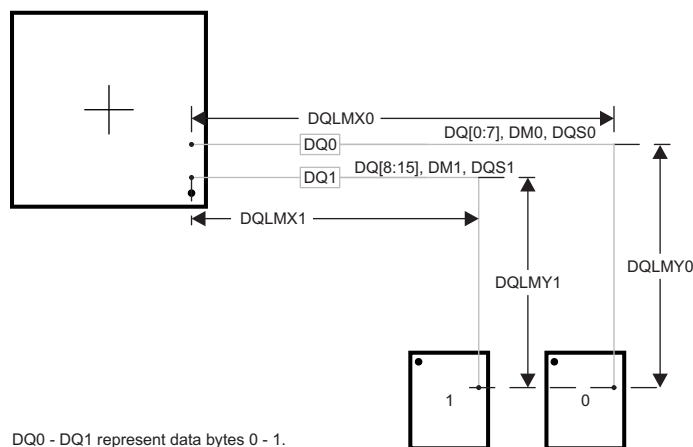
### 5.6.2.3.6.2 DQS[x] and DQ[x] Routing Specification

Skew within the DQS[x] and DQ[x] net classes directly reduces setup and hold margin and, thus, this skew must be controlled. The only way to practically match lengths on a PCB is to lengthen the shorter traces up to the length of the longest net in the net class and its associated clock. DQLMn is defined as DQ Longest Manhattan distance n, where n is the byte number. For a 16-bit interface, there are two DQLMs, DQLM0-DQLM1.

#### NOTE

It is not required, nor is it recommended, to match the lengths across all bytes. Length matching is only required within each byte.

Given the DQS[x] and DQ[x] pin locations on the AM335x device and the DDR3 memories, the maximum possible Manhattan distance can be determined given the placement. [Figure 5-67](#) shows this distance for a two-load case. It is from this distance that the specifications on the lengths of the transmission lines for the data bus are determined. For DQS[x] and DQ[x] routing, these specifications are contained in [Table 5-67](#).



DQ0 - DQ1 represent data bytes 0 - 1.

There are two DQLMs, one for each byte (16-bit interface). Each DQLM is the longest Manhattan distance of the byte; therefore:

$$DQLM0 = DQLMX0 + DQLMY0$$

$$DQLM1 = DQLMX1 + DQLMY1$$

**Figure 5-67. DQLM for Any Number of Allowed DDR3 Devices**

**Table 5-67. DQS[x] and DQ[x] Routing Specification<sup>(1)(2)</sup>**

| NO. | PARAMETER                                                              | MIN | TYP | MAX   | UNIT |
|-----|------------------------------------------------------------------------|-----|-----|-------|------|
| 1   | DQ0 nominal length <sup>(3)(4)</sup>                                   |     |     | DQLM0 | mils |
| 2   | DQ1 nominal length <sup>(3)(5)</sup>                                   |     |     | DQLM1 | mils |
| 3   | DQ[x] skew <sup>(6)</sup>                                              |     |     | 25    | mils |
| 4   | DQS[x] skew                                                            |     |     | 5     | mils |
| 5   | DQS[x]-to-DQ[x] skew <sup>(6)(7)</sup>                                 |     |     | 25    | mils |
| 6   | Center-to-center DQ[x] to other DDR3 trace spacing <sup>(8)(9)</sup>   | 4w  |     |       |      |
| 7   | Center-to-center DQ[x] to other DQ[x] trace spacing <sup>(8)(10)</sup> | 3w  |     |       |      |
| 8   | DQS[x] center-to-center spacing <sup>(11)</sup>                        |     |     |       |      |
| 9   | DQS[x] center-to-center spacing to other net <sup>(8)</sup>            | 4w  |     |       |      |

(1) DQS[x] represents the DQS0 and DQS1 clock net classes, and DQ[x] represents the DQ0 and DQ1 signal net classes.

(2) External termination disallowed. Data termination should use built-in ODT functionality.

(3) DQLMn is the longest Manhattan distance of a byte. For definition, see [Section 5.6.2.3.6.2](#) and [Figure 5-67](#).

(4) DQLM0 is the longest Manhattan length for the DQ0 net class.

(5) DQLM1 is the longest Manhattan length for the DQ1 net class.

(6) Length matching is only done within a byte. Length matching across bytes is not required.

(7) Each DQS clock net class is length matched to its associated DQ signal net class.

(8) Center-to-center spacing is allowed to fall to minimum for up to 1250 mils of routed length.

(9) Other DDR3 trace spacing means signals that are not part of the same DQ[x] signal net class.

(10) This applies to spacing within same DQ[x] signal net class.

(11) DQS[x] pair spacing is set to ensure proper differential impedance. Differential impedance should be  $Z_0 \times 2$ , where  $Z_0$  is the single-ended impedance defined in [Table 5-60](#).

## 5.7 Inter-Integrated Circuit (I2C)

For more information, see the Inter-Integrated Circuit (I2C) section of the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).

### 5.7.1 I2C Electrical Data and Timing

**Table 5-68. I2C Timing Conditions - Slave Mode**

| TIMING CONDITION PARAMETER |                                   | STANDARD MODE |     | FAST MODE |     | UNIT |
|----------------------------|-----------------------------------|---------------|-----|-----------|-----|------|
|                            |                                   | MIN           | MAX | MIN       | MAX |      |
| Output Condition           |                                   |               |     |           |     |      |
| C <sub>b</sub>             | Capacitive load for each bus line |               | 400 |           | 400 | pF   |

**Table 5-69. Timing Requirements for I2C Input Timings**

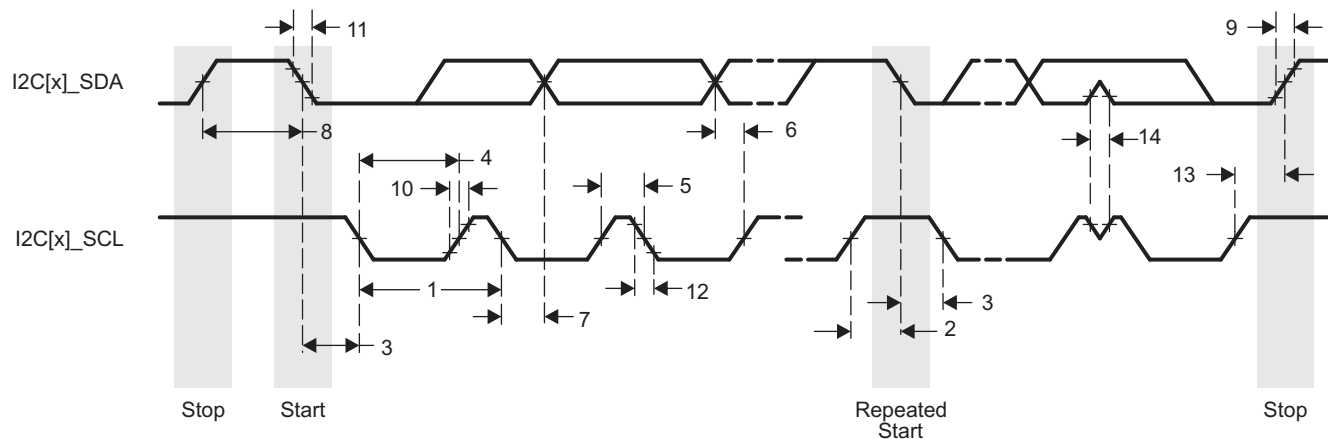
(see [Figure 5-68](#))

| NO. |                     |                                                                               | STANDARD MODE    |                     | FAST MODE          |                    | UNIT |
|-----|---------------------|-------------------------------------------------------------------------------|------------------|---------------------|--------------------|--------------------|------|
|     |                     |                                                                               | MIN              | MAX                 | MIN                | MAX                |      |
| 1   | $t_{c(SCL)}$        | Cycle time, SCL                                                               | 10               |                     | 2.5                |                    | us   |
| 2   | $t_{su(SCLH-SDAL)}$ | Setup Time, SCL high before SDA low (for a repeated START condition)          | 4.7              |                     | 0.6                |                    | us   |
| 3   | $t_{h(SDAL-SCLL)}$  | Hold time, SCL low after SDA low (for a START and a repeated START condition) | 4                |                     | 0.6                |                    | us   |
| 4   | $t_{w(SCLL)}$       | Pulse duration, SCL low                                                       | 4.7              |                     | 1.3                |                    | us   |
| 5   | $t_{w(SCLH)}$       | Pulse duration, SCL high                                                      | 4                |                     | 0.6                |                    | us   |
| 6   | $t_{su(SDAV-SCLH)}$ | Setup time, SDA valid before SCL high                                         | 250              |                     | 100 <sup>(1)</sup> |                    | ns   |
| 7   | $t_{h(SCLL-SDAV)}$  | Hold time, SDA valid after SCL low                                            | 0 <sup>(2)</sup> | 3.45 <sup>(3)</sup> | 0 <sup>(2)</sup>   | 0.9 <sup>(3)</sup> | us   |
| 8   | $t_{w(SDAH)}$       | Pulse duration, SDA high between STOP and START conditions                    | 4.7              |                     | 1.3                |                    | us   |
| 9   | $t_r(SDA)$          | Rise time, SDA                                                                |                  | 1000                |                    | 300                | ns   |
| 10  | $t_r(SCL)$          | Rise time, SCL                                                                |                  | 1000                |                    | 300                | ns   |
| 11  | $t_f(SDA)$          | Fall time, SDA                                                                |                  | 300                 |                    | 300                | ns   |
| 12  | $t_f(SCL)$          | Fall time, SCL                                                                |                  | 300                 |                    | 300                | ns   |
| 13  | $t_{su(SCLH-SDAH)}$ | Setup time, high before SDA high (for STOP condition)                         | 4                |                     | 0.6                |                    | us   |
| 14  | $t_{w(SP)}$         | Pulse duration, spike (must be suppressed)                                    | 0                | 50                  | 0                  | 50                 | ns   |

(1) A fast-mode I2C-bus™ device can be used in a standard-mode I2C-bus system, but the requirement  $t_{su(SDA-SCLH)} \geq 250$  ns must then be met. This is automatically the case if the device does not stretch the LOW period of the SCL signal. If such a device stretches the LOW period of the SCL signal, it must output the next data bit to the SDA line  $t_{r\_max} + t_{su(SDA-SCLH)} = 1000 + 250 = 1250$  ns (according to the standard-mode I2C-Bus Specification) before the SCL line is released.

(2) A device must internally provide a hold time of at least 300 ns for the SDA signal (referred to the  $V_{IHmin}$  of the SCL signal) to bridge the undefined region of the falling edge of SCL.

(3) The maximum  $t_{h(SDA-SCLL)}$  has only to be met if the device does not stretch the low period  $[t_{w(SCLL)}]$  of the SCL signal.

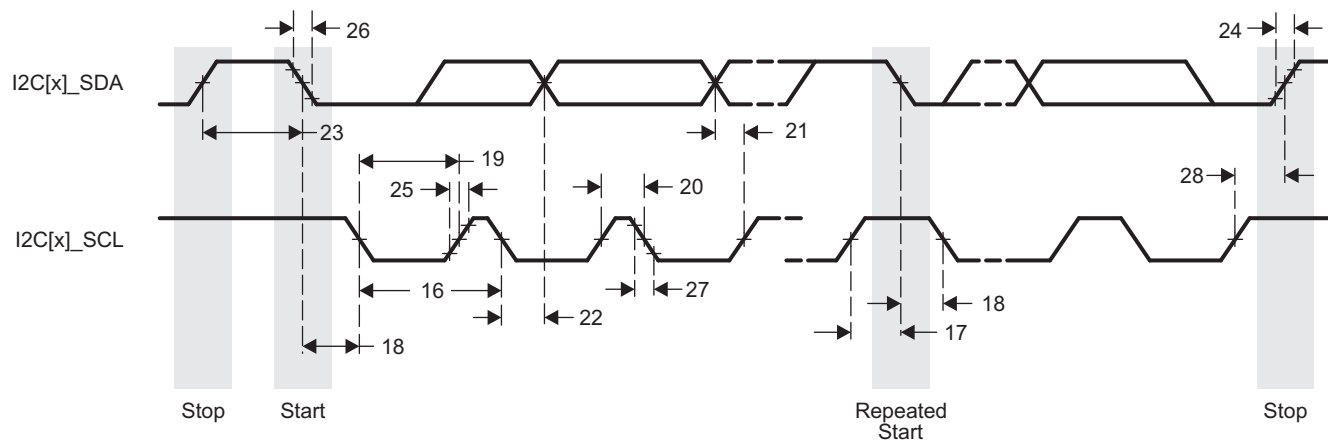


**Figure 5-68. I2C Receive Timing**

**Table 5-70. Switching Characteristics for I2C Output Timings**

(see [Figure 5-69](#))

| NO. | PARAMETER           |                                                                               | STANDARD MODE |      | FAST MODE |     | UNIT |
|-----|---------------------|-------------------------------------------------------------------------------|---------------|------|-----------|-----|------|
|     |                     |                                                                               | MIN           | MAX  | MIN       | MAX |      |
| 15  | $t_{c(SCL)}$        | Cycle time, SCL                                                               | 10            |      | 2.5       |     | us   |
| 16  | $t_{su(SCLH-SDAL)}$ | Setup Time, SCL high before SDA low (for a repeated START condition)          | 4.7           |      | 0.6       |     | us   |
| 17  | $t_{h(SDAL-SCLL)}$  | Hold time, SCL low after SDA low (for a START and a repeated START condition) | 4             |      | 0.6       |     | us   |
| 18  | $t_{w(SCLL)}$       | Pulse duration, SCL low                                                       | 4.7           |      | 1.3       |     | us   |
| 19  | $t_{w(SCLH)}$       | Pulse duration, SCL high                                                      | 4             |      | 0.6       |     | us   |
| 20  | $t_{su(SDAV-SCLH)}$ | Setup time, SDA valid before SCL high                                         | 250           |      | 100       |     | ns   |
| 21  | $t_{h(SCLL-SDAV)}$  | Hold time, SDA valid after SCL low                                            | 0             | 3.45 | 0         | 0.9 | us   |
| 22  | $t_{w(SDAH)}$       | Pulse duration, SDA high between STOP and START conditions                    | 4.7           |      | 1.3       |     | us   |
| 23  | $t_r(SDA)$          | Rise time, SDA                                                                |               | 1000 |           | 300 | ns   |
| 24  | $t_r(SCL)$          | Rise time, SCL                                                                |               | 1000 |           | 300 | ns   |
| 25  | $t_f(SDA)$          | Fall time, SDA                                                                |               | 300  |           | 300 | ns   |
| 26  | $t_f(SCL)$          | Fall time, SCL                                                                |               | 300  |           | 300 | ns   |
| 27  | $t_{su(SCLH-SDAH)}$ | Setup time, high before SDA high (for STOP condition)                         | 4             |      | 0.6       |     | us   |



**Figure 5-69. I2C Transmit Timing**

## 5.8 JTAG Electrical Data and Timing

**Table 5-71. Timing Requirements for JTAG**

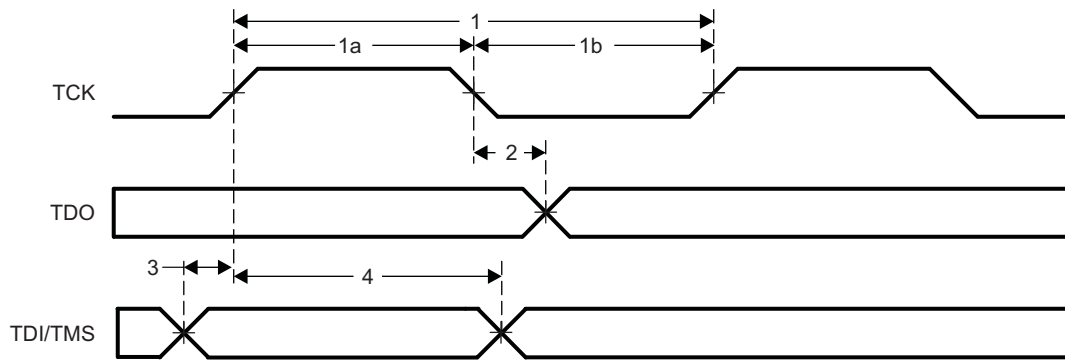
(see [Figure 5-70](#))

| NO. |                    |                                          | OPP100 |     | OPP50 |     | UNIT |
|-----|--------------------|------------------------------------------|--------|-----|-------|-----|------|
|     |                    |                                          | MIN    | MAX | MIN   | MAX |      |
| 1   | $t_{c(TCK)}$       | Cycle time, TCK                          | 81.5   |     | 104.5 |     | ns   |
| 1a  | $t_{w(TCKH)}$      | Pulse duration, TCK high (40% of $t_c$ ) | 32.6   |     | 41.8  |     | ns   |
| 1b  | $t_{w(TCKL)}$      | Pulse duration, TCK low (40% of $t_c$ )  | 32.6   |     | 41.8  |     | ns   |
| 3   | $t_{su(TDI-TCKH)}$ | Input setup time, TDI valid to TCK high  | 3      |     | 3     |     | ns   |
|     | $t_{su(TMS-TCKH)}$ | Input setup time, TMS valid to TCK high  | 3      |     | 3     |     | ns   |
| 4   | $t_h(TCKH-TDI)$    | Input hold time, TDI valid from TCK high | 8.05   |     | 8.05  |     | ns   |
|     | $t_h(TCKH-TMS)$    | Input hold time, TMS valid from TCK high | 8.05   |     | 8.05  |     | ns   |

**Table 5-72. Switching Characteristics for JTAG**

(see [Figure 5-70](#))

| NO. | PARAMETER       |                                  | OPP100 |      | OPP50 |      | UNIT |
|-----|-----------------|----------------------------------|--------|------|-------|------|------|
|     |                 |                                  | MIN    | MAX  | MIN   | MAX  |      |
| 2   | $t_d(TCKL-TDO)$ | Delay time, TCK low to TDO valid | 3      | 27.6 | 4     | 36.8 | ns   |


**Figure 5-70. JTAG Timing**

## 5.9 LCD Controller (LCDC)

The LCD controller consists of two independent controllers, the raster controller and the LCD interface display driver (LIDD) controller. Each controller operates independently from the other and only one of them is active at any given time.

- The raster controller handles the synchronous LCD interface. It provides timing and data for constant graphics refresh to a passive display. It supports a wide variety of monochrome and full-color display types and sizes by use of programmable timing controls, a built-in palette, and a gray-scale and serializer. Graphics data is processed and stored in frame buffers. A frame buffer is a contiguous memory block in the system. A built-in DMA engine supplies the graphics data to the raster engine which, in turn, outputs to the external LCD device.
- The LIDD controller supports the asynchronous LCD interface. It provides full-timing programmability of control signals (CS, WE, OE, ALE) and output data.

The maximum resolution for the LCD controller is 2048 x 2048 pixels. The maximum frame rate is determined by the image size in combination with the pixel clock rate.

**Table 5-73. LCD Controller Timing Conditions**

| TIMING CONDITION PARAMETER |                         |             | MIN | TYP | MAX | UNIT |
|----------------------------|-------------------------|-------------|-----|-----|-----|------|
| <b>Output Condition</b>    |                         |             |     |     |     |      |
| C <sub>LOAD</sub>          | Output load capacitance | LIDD mode   | 5   |     | 60  | pF   |
|                            |                         | Raster mode | 3   |     | 30  | pF   |

### 5.9.1 LCD Interface Display Driver (LIDD Mode)

**Table 5-74. Timing Requirements for LCD LIDD Mode**

(see [Figure 5-72](#) through [Figure 5-80](#))

| NO. | PARAMETER                                                                                             | OPP100 |     | UNIT |
|-----|-------------------------------------------------------------------------------------------------------|--------|-----|------|
|     |                                                                                                       | MIN    | MAX |      |
| 16  | t <sub>su</sub> (LCD_DATA-LCD_MEMORY_CLK) Setup time, LCD_DATA[15:0] valid before LCD_MEMORY_CLK high | 18     |     | ns   |
| 17  | t <sub>h</sub> (LCD_MEMORY_CLK-LCD_DATA) Hold time, LCD_DATA[15:0] valid after LCD_MEMORY_CLK high    | 0      |     | ns   |
| 18  | t <sub>t</sub> (LCD_DATA) Transition time, LCD_DATA[15:0]                                             | 1      | 3   | ns   |

**Table 5-75. Switching Characteristics for LCD LIDD Mode**

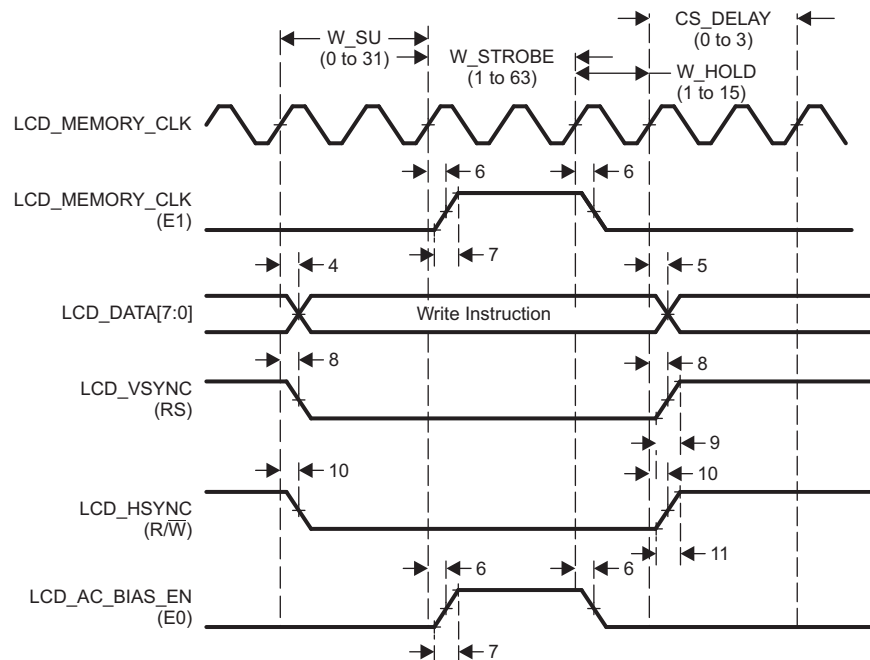
(see [Figure 5-72](#) through [Figure 5-80](#))

| NO. | PARAMETER                                                                                                   | OPP100             |                    | UNIT |
|-----|-------------------------------------------------------------------------------------------------------------|--------------------|--------------------|------|
|     |                                                                                                             | MIN                | MAX                |      |
| 1   | t <sub>c</sub> (LCD_MEMORY_CLK) Cycle time, LCD_MEMORY_CLK                                                  | 23.7               |                    | ns   |
| 2   | t <sub>w</sub> (LCD_MEMORY_CLKH) Pulse duration, LCD_MEMORY_CLK high                                        | 0.45t <sub>c</sub> | 0.55t <sub>c</sub> | ns   |
| 3   | t <sub>w</sub> (LCD_MEMORY_CLKL) Pulse duration, LCD_MEMORY_CLK low                                         | 0.45t <sub>c</sub> | 0.55t <sub>c</sub> | ns   |
| 4   | t <sub>d</sub> (LCD_MEMORY_CLK-LCD_DATAV) Delay time, LCD_MEMORY_CLK high to LCD_DATA[15:0] valid (write)   |                    | 7                  | ns   |
| 5   | t <sub>d</sub> (LCD_MEMORY_CLK-LCD_DATAI) Delay time, LCD_MEMORY_CLK high to LCD_DATA[15:0] invalid (write) | 0                  |                    | ns   |
| 6   | t <sub>d</sub> (LCD_MEMORY_CLK-LCD_AC_BIAS_EN) Delay time, LCD_MEMORY_CLK high to LCD_AC_BIAS_EN            | 0                  | 6.8                | ns   |
| 7   | t <sub>t</sub> (LCD_AC_BIAS_EN) Transition time, LCD_AC_BIAS_EN                                             | 1                  | 10                 | ns   |
| 8   | t <sub>d</sub> (LCD_MEMORY_CLK-LCD_VSYNC) Delay time, LCD_MEMORY_CLK high to LCD_VSYNC                      | 0                  | 7                  | ns   |
| 9   | t <sub>t</sub> (LCD_VSYNC) Transition time, LCD_VSYNC                                                       | 1                  | 10                 | ns   |
| 10  | t <sub>d</sub> (LCD_MEMORY_CLK-LCD_HSYNC) Delay time, LCD_MEMORY_CLK high to LCD_HSYNC                      | 0                  | 7                  | ns   |

**Table 5-75. Switching Characteristics for LCD LIDD Mode (continued)**

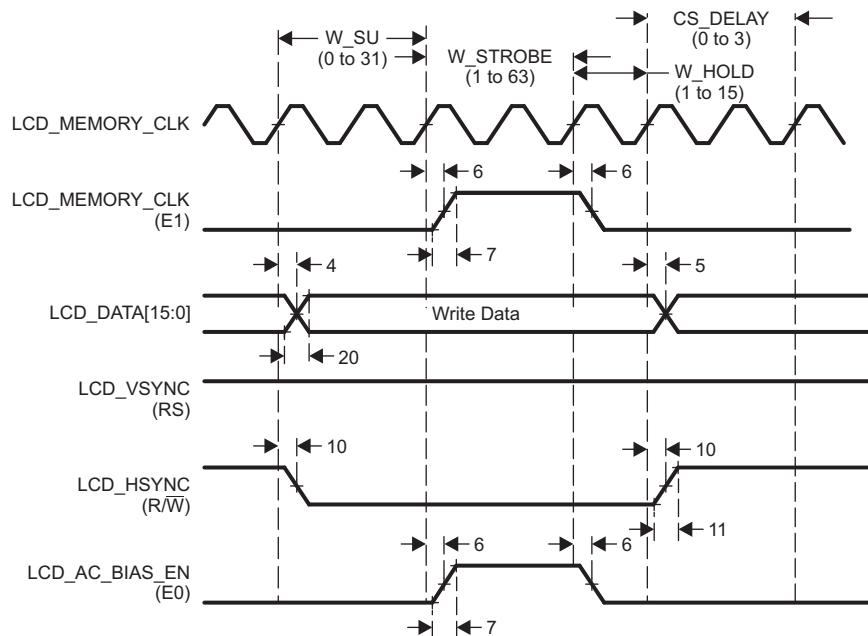
(see [Figure 5-72](#) through [Figure 5-80](#))

| NO. | PARAMETER                                 |                                                          | OPP100 |     | UNIT |
|-----|-------------------------------------------|----------------------------------------------------------|--------|-----|------|
|     |                                           |                                                          | MIN    | MAX |      |
| 11  | t <sub>i</sub> (LCD_HSYNC)                | Transition time, LCD_HSYNC                               | 1      | 10  | ns   |
| 12  | t <sub>d</sub> (LCD_MEMORY_CLK-LCD_PCLK)  | Delay time, LCD_MEMORY_CLK high to LCD_PCLK              | 0      | 7   | ns   |
| 13  | t <sub>i</sub> (LCD_PCLK)                 | Transition time, LCD_PCLK                                | 1      | 10  | ns   |
| 14  | t <sub>d</sub> (LCD_MEMORY_CLK-LCD_DATAZ) | Delay time, LCD_MEMORY_CLK high to LCD_DATA[15:0] high-Z | 0      | 7   | ns   |
| 15  | t <sub>d</sub> (LCD_MEMORY_CLK-LCD_DATA)  | Delay time, LCD_MEMORY_CLK high to LCD_DATA[15:0] driven | 0      | 7   | ns   |
| 19  | t <sub>i</sub> (LCD_MEMORY_CLK)           | Transition time, LCD_MEMORY_CLK                          | 1      | 2.5 | ns   |
| 20  | t <sub>i</sub> (LCD_DATA)                 | Transition time, LCD_DATA                                | 1      | 10  | ns   |



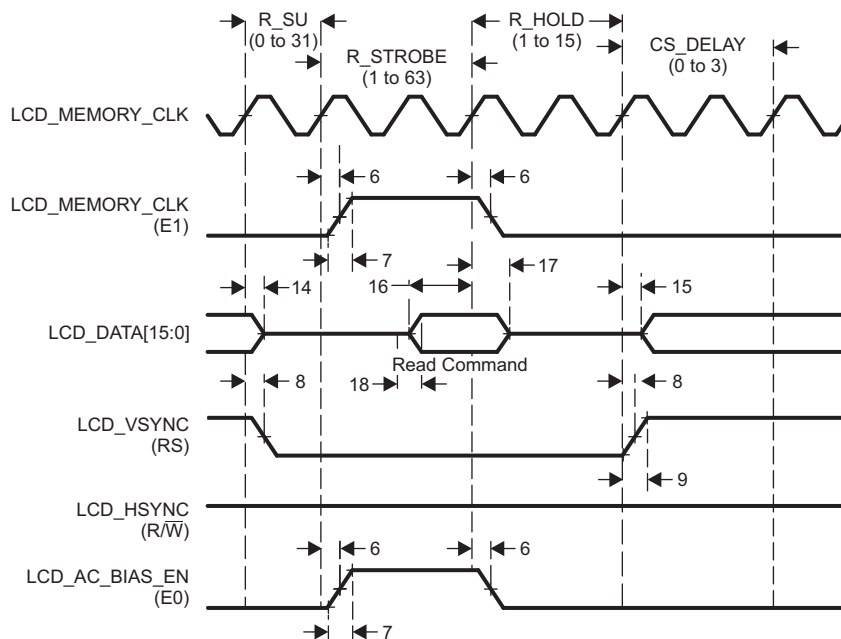
- A. Hitachi mode performs asynchronous operations that do not require an external LCD\_MEMORY\_CLK. The first LCD\_MEMORY\_CLK waveform is only shown as a reference of the internal clock that sequences the other signals. The second LCD\_MEMORY\_CLK waveform is shown as E1 since the LCD\_MEMORY\_CLK signal is used to implement the E1 function in Hitachi mode.

**Figure 5-71. Command Write in Hitachi Mode**



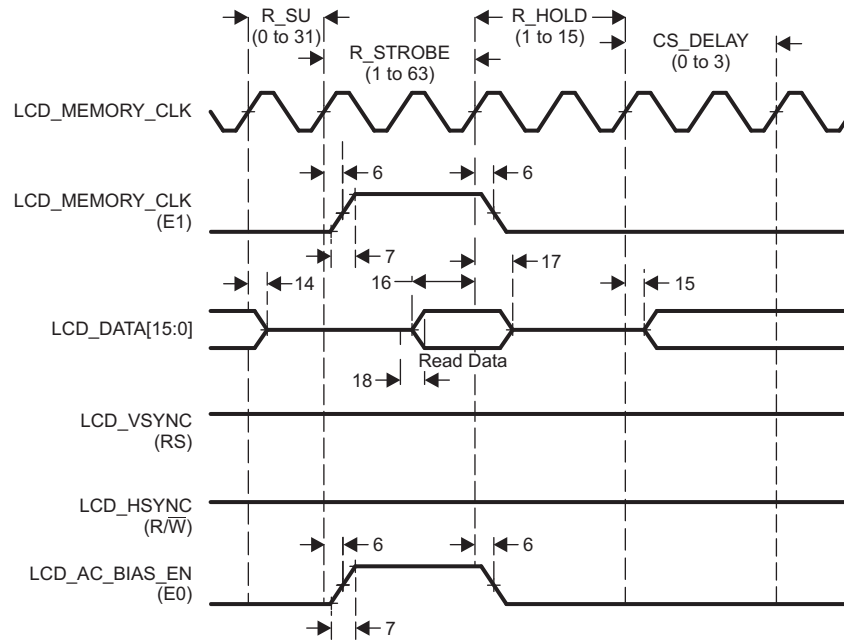
- A. Hitachi mode performs asynchronous operations that do not require an external LCD\_MEMORY\_CLK. The first LCD\_MEMORY\_CLK waveform is only shown as a reference of the internal clock that sequences the other signals. The second LCD\_MEMORY\_CLK waveform is shown as E1 since the LCD\_MEMORY\_CLK signal is used to implement the E1 function in Hitachi mode.

**Figure 5-72. Data Write in Hitachi Mode**



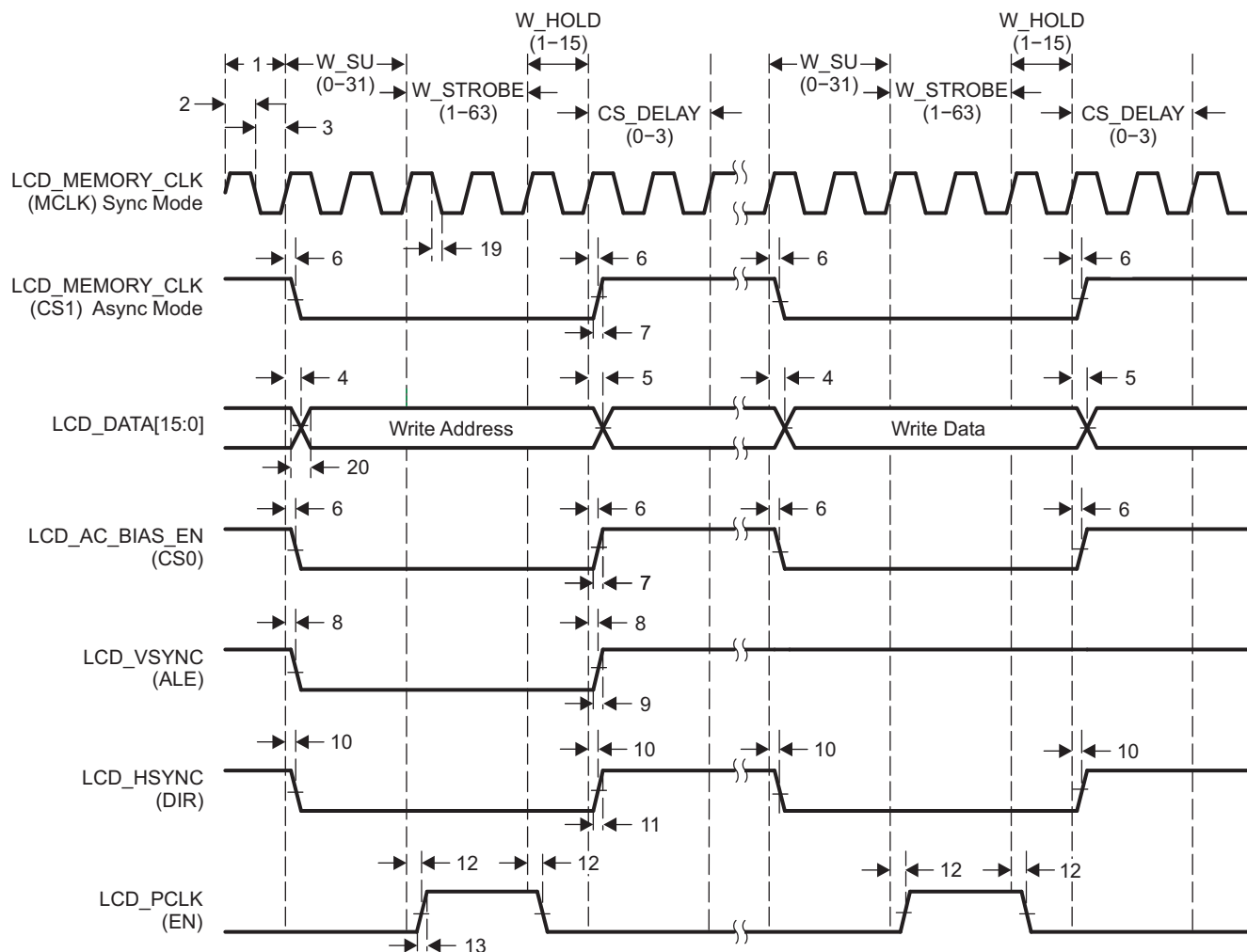
- A. Hitachi mode performs asynchronous operations that do not require an external LCD\_MEMORY\_CLK. The first LCD\_MEMORY\_CLK waveform is only shown as a reference of the internal clock that sequences the other signals. The second LCD\_MEMORY\_CLK waveform is shown as E1 since the LCD\_MEMORY\_CLK signal is used to implement the E1 function in Hitachi mode.

**Figure 5-73. Command Read in Hitachi Mode**



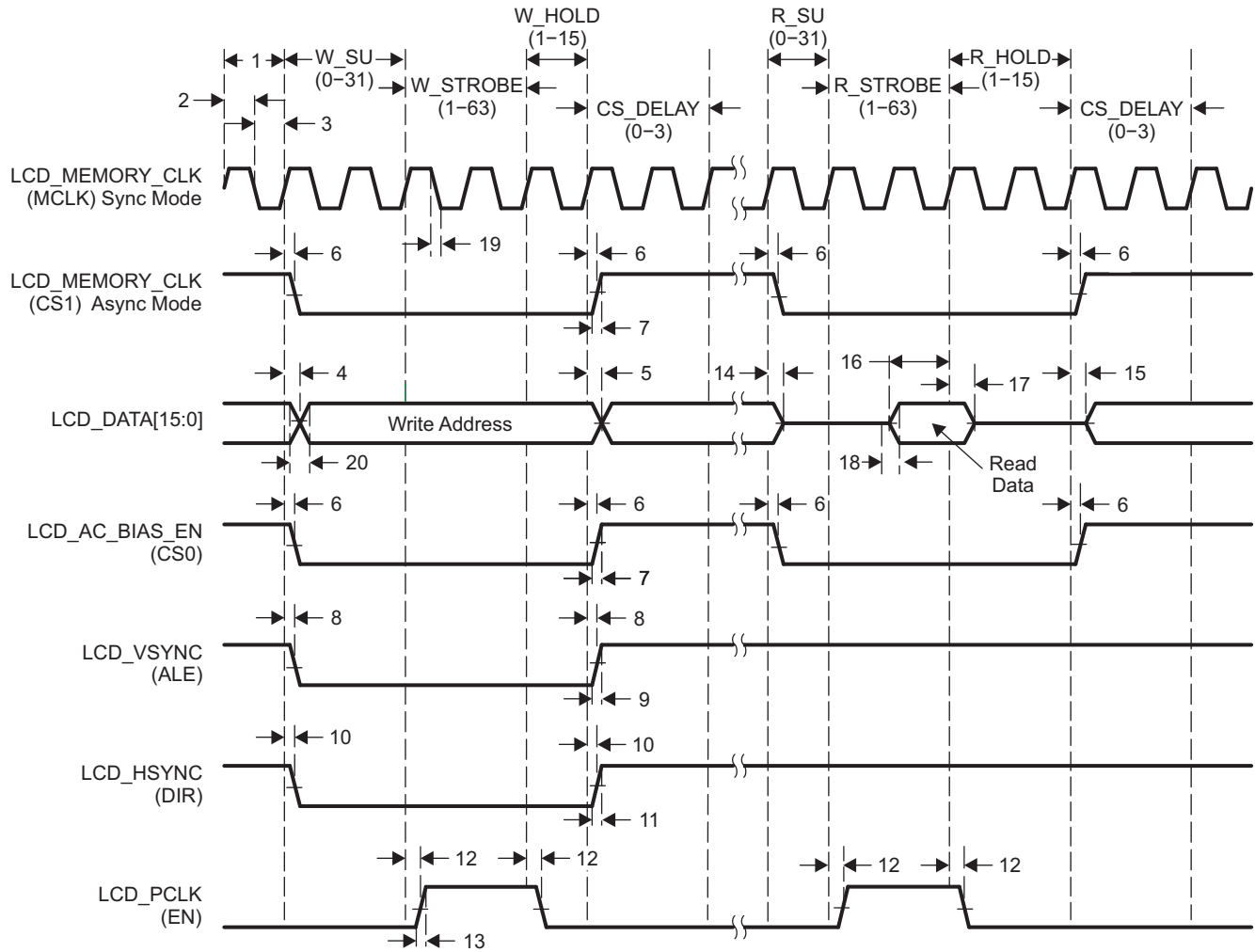
- A. Hitachi mode performs asynchronous operations that do not require an external LCD\_MEMORY\_CLK. The first LCD\_MEMORY\_CLK waveform is only shown as a reference of the internal clock that sequences the other signals. The second LCD\_MEMORY\_CLK waveform is shown as E1 since the LCD\_MEMORY\_CLK signal is used to implement the E1 function in Hitachi mode.

**Figure 5-74. Data Read in Hitachi Mode**



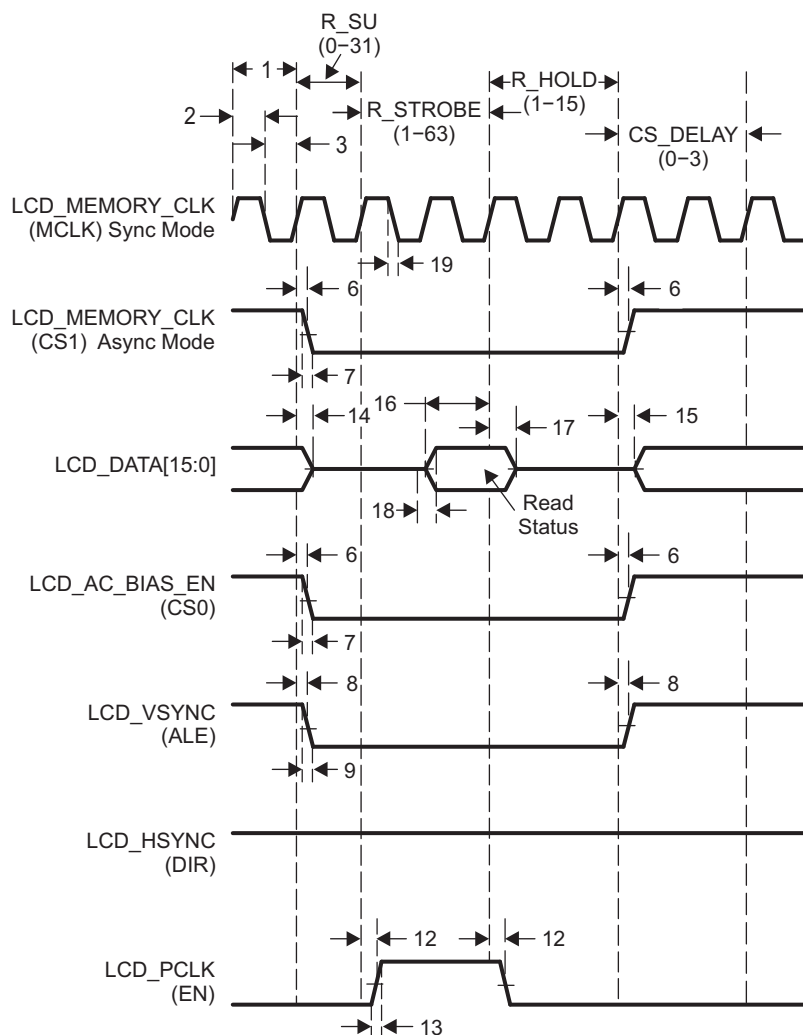
- A. Motorola mode can be configured to perform asynchronous operations or synchronous operations. When configured in asynchronous mode, LCD\_MEMORY\_CLK is not required, so it performs the CS1 function. When configured in synchronous mode, LCD\_MEMORY\_CLK performs the MCLK function. LCD\_MEMORY\_CLK is also shown as a reference of the internal clock that sequences the other signals.

**Figure 5-75. Micro-Interface Graphic Display Motorola Write**



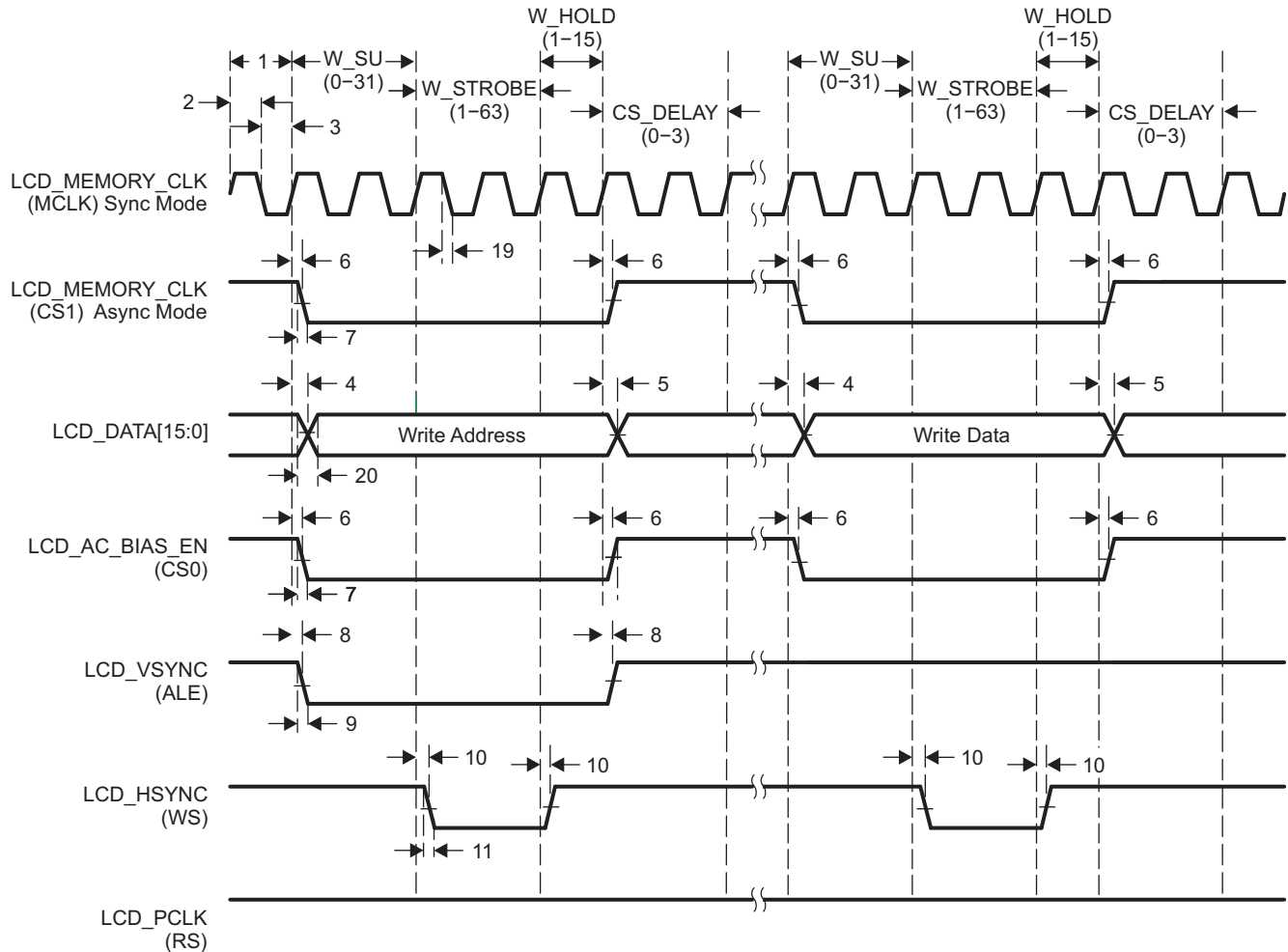
- A. Motorola mode can be configured to perform asynchronous operations or synchronous operations. When configured in asynchronous mode, LCD\_MEMORY\_CLK is not required, so it performs the CS1 function. When configured in synchronous mode, LCD\_MEMORY\_CLK performs the MCLK function. LCD\_MEMORY\_CLK is also shown as a reference of the internal clock that sequences the other signals.

**Figure 5-76. Micro-Interface Graphic Display Motorola Read**



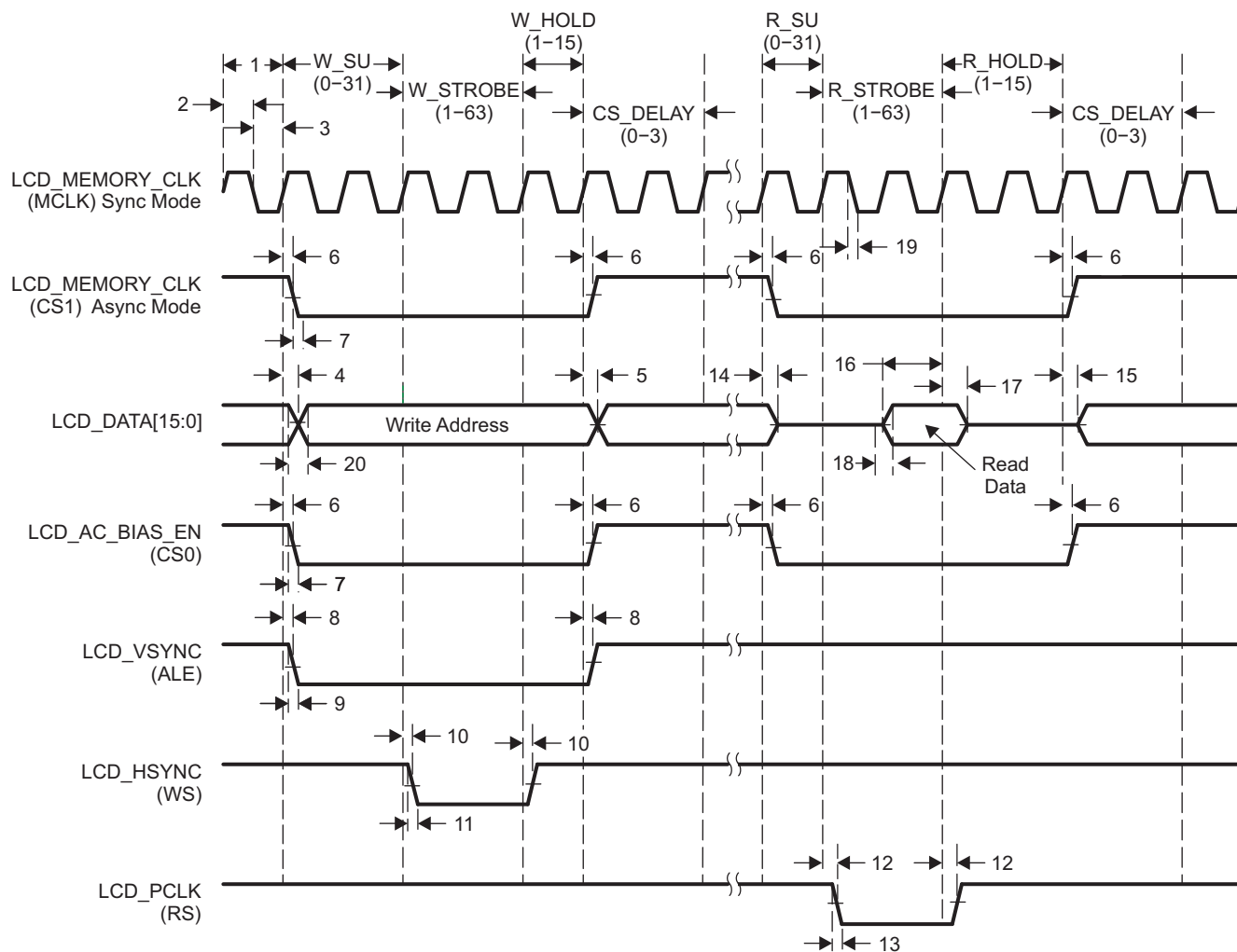
- A. Motorola mode can be configured to perform asynchronous operations or synchronous operations. When configured in asynchronous mode, LCD\_MEMORY\_CLK is not required, so it performs the CS1 function. When configured in synchronous mode, LCD\_MEMORY\_CLK performs the MCLK function. LCD\_MEMORY\_CLK is also shown as a reference of the internal clock that sequences the other signals.

**Figure 5-77. Micro-Interface Graphic Display Motorola Status**



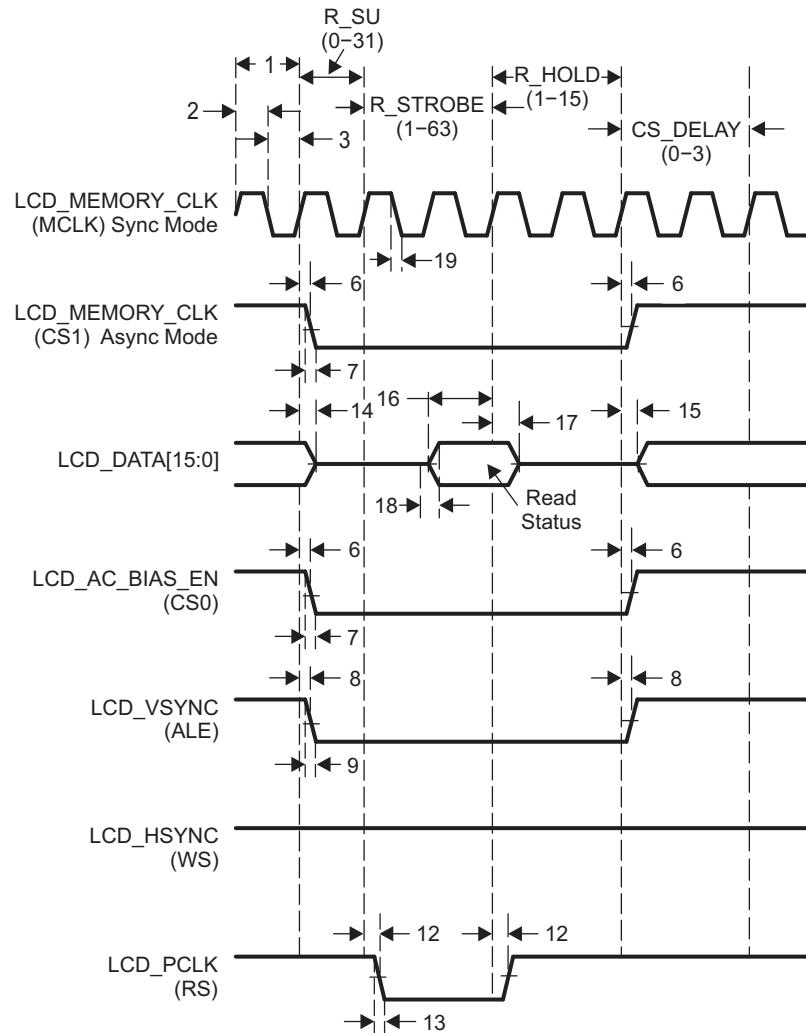
- A. Intel mode can be configured to perform asynchronous operations or synchronous operations. When configured in asynchronous mode, LCD\_MEMORY\_CLK is not required, so it performs the CS1 function. When configured in synchronous mode, LCD\_MEMORY\_CLK performs the MCLK function. LCD\_MEMORY\_CLK is also shown as a reference of the internal clock that sequences the other signals.

**Figure 5-78. Micro-Interface Graphic Display Intel Write**



- A. Intel mode can be configured to perform asynchronous operations or synchronous operations. When configured in asynchronous mode, LCD\_MEMORY\_CLK is not required, so it performs the CS1 function. When configured in synchronous mode, LCD\_MEMORY\_CLK performs the MCLK function. LCD\_MEMORY\_CLK is also shown as a reference of the internal clock that sequences the other signals.

**Figure 5-79. Micro-Interface Graphic Display Intel Read**



- A. Intel mode can be configured to perform asynchronous operations or synchronous operations. When configured in asynchronous mode, LCD\_MEMORY\_CLK is not required, so it performs the CS1 function. When configured in synchronous mode, LCD\_MEMORY\_CLK performs the MCLK function. LCD\_MEMORY\_CLK is also shown as a reference of the internal clock that sequences the other signals.

**Figure 5-80. Micro-Interface Graphic Display Intel Status**

## 5.9.2 LCD Raster Mode

**Table 5-76. Switching Characteristics for LCD Raster Mode**

(see [Figure 5-82](#) through [Figure 5-85](#))

| NO. | PARAMETER                                                                            | OPP50     |           | OPP100    |           | UNIT |
|-----|--------------------------------------------------------------------------------------|-----------|-----------|-----------|-----------|------|
|     |                                                                                      | MIN       | MAX       | MIN       | MAX       |      |
| 1   | $t_{c(LCD\_PCLK)}$ Cycle time, pixel clock                                           | 15.8      |           | 7.9       |           | ns   |
| 2   | $t_{w(LCD\_PCLKH)}$ Pulse duration, pixel clock high                                 | $0.45t_c$ | $0.55t_c$ | $0.45t_c$ | $0.55t_c$ | ns   |
| 3   | $t_{w(LCD\_PCLKL)}$ Pulse duration, pixel clock low                                  | $0.45t_c$ | $0.55t_c$ | $0.45t_c$ | $0.55t_c$ | ns   |
| 4   | $t_{d(LCD\_PCLK-LCD\_DATAV)}$ Delay time, LCD_PCLK to LCD_DATA[23:0] valid (write)   |           | 3.0       |           | 1.9       | ns   |
| 5   | $t_{d(LCD\_PCLK-LCD\_DATAI)}$ Delay time, LCD_PCLK to LCD_DATA[23:0] invalid (write) | -3.0      |           | -1.7      |           | ns   |
| 6   | $t_{d(LCD\_PCLK-LCD\_AC\_BIAS\_EN)}$ Delay time, LCD_PCLK to LCD_AC_BIAS_EN          | -3.0      | 3.0       | -1.7      | 1.9       | ns   |
| 7   | $t_{i(LCD\_AC\_BIAS\_EN)}$ Transition time, LCD_AC_BIAS_EN                           | 0.5       | 2.4       | 0.5       | 2.4       | ns   |
| 8   | $t_{d(LCD\_PCLK-LCD\_VSYNC)}$ Delay time, LCD_PCLK to LCD_VSYNC                      | -3.0      | 3.0       | -1.7      | 1.9       | ns   |
| 9   | $t_{i(LCD\_VSYNC)}$ Transition time, LCD_VSYNC                                       | 0.5       | 2.4       | 0.5       | 2.4       | ns   |
| 10  | $t_{d(LCD\_PCLK-LCD\_HSYNC)}$ Delay time, LCD_PCLK to LCD_HSYNC                      | -3.0      | 3.0       | -1.7      | 1.9       | ns   |
| 11  | $t_{i(LCD\_HSYNC)}$ Transition time, LCD_HSYNC                                       | 0.5       | 2.4       | 0.5       | 2.4       | ns   |
| 12  | $t_{i(LCD\_PCLK)}$ Transition time, LCD_PCLK                                         | 0.5       | 2.4       | 0.5       | 2.4       | ns   |
| 13  | $t_{i(LCD\_DATA)}$ Transition time, LCD_DATA                                         | 0.5       | 2.4       | 0.5       | 2.4       | ns   |

Frame-to-frame timing is derived through the following parameters in the LCD (RASTER\_TIMING\_1) register:

- Vertical front porch (VFP)
- Vertical sync pulse width (VSW)
- Vertical back porch (VBP)
- Lines per panel (LPP\_B10 + LPP)

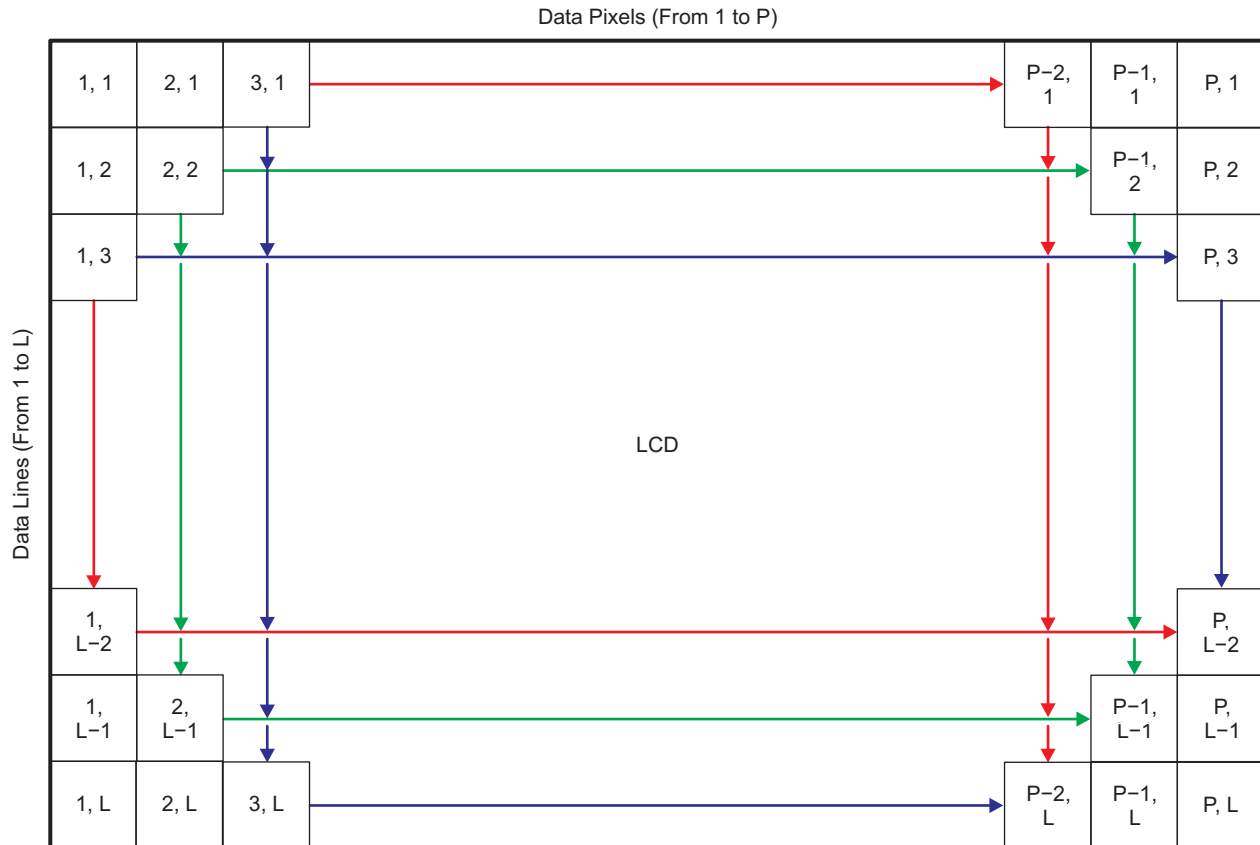
Line-to-line timing is derived through the following parameters in the LCD (RASTER\_TIMING\_0) register:

- Horizontal front porch (HFP)
- Horizontal sync pulse width (HSW)
- Horizontal back porch (HBP)
- Pixels per panel (PPLMSB + PPLLSB)

LCD\_AC\_BIAS\_EN timing is derived through the following parameter in the LCD (RASTER\_TIMING\_2) register:

- AC bias frequency (ACB)

The display format produced in raster mode is shown in [Figure 5-81](#). An entire frame is delivered one line at a time. The first line delivered starts at data pixel (1, 1) and ends at data pixel (P, 1). The last line delivered starts at data pixel (1, L) and ends at data pixel (P, L). The beginning of each new frame is denoted by the activation of IO signal LCD\_VSYNC. The beginning of each new line is denoted by the activation of IO signal LCD\_HSYNC.



**Figure 5-81. LCD Raster-Mode Display Format**

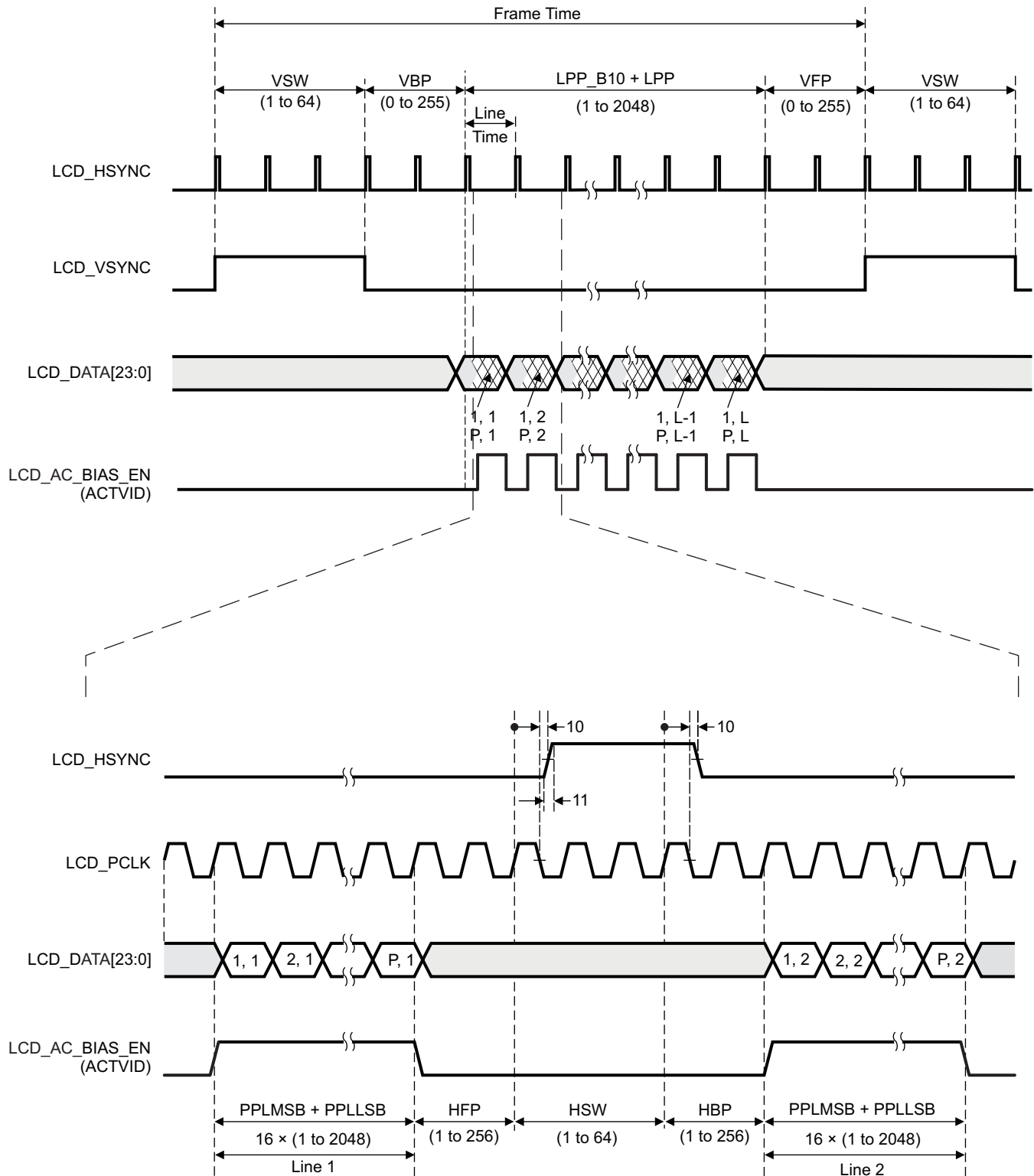
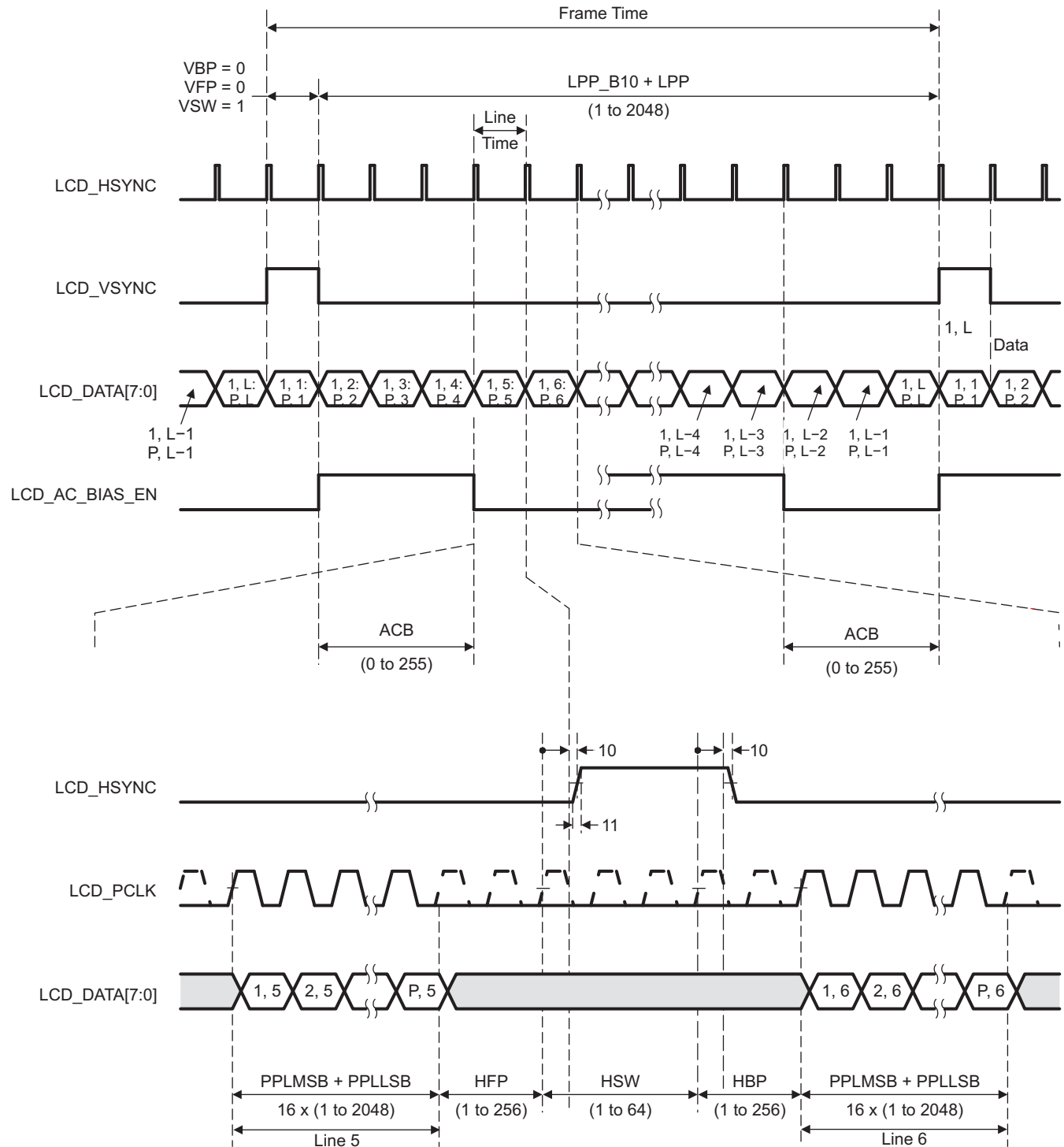
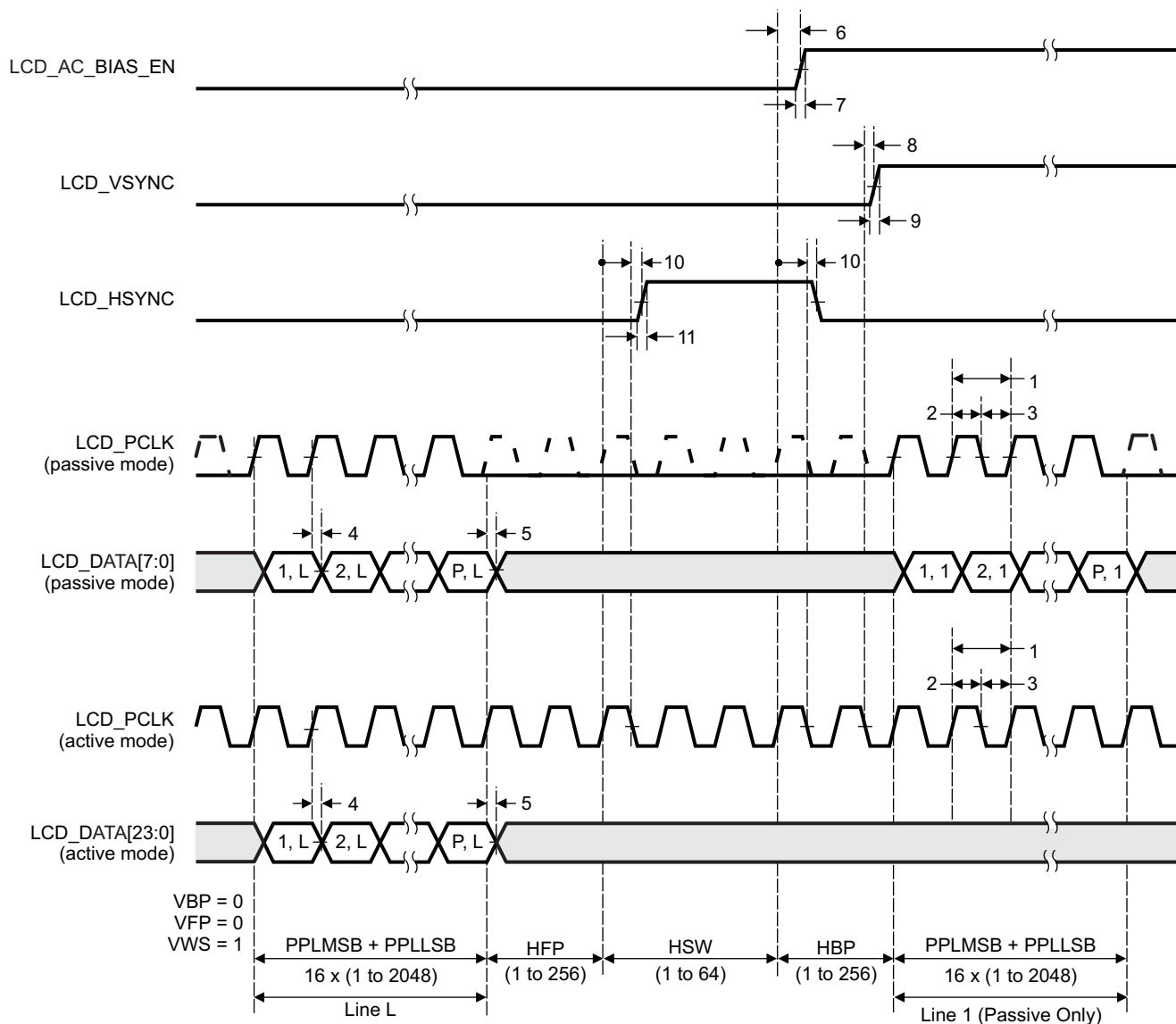


Figure 5-82. LCD Raster-Mode Active



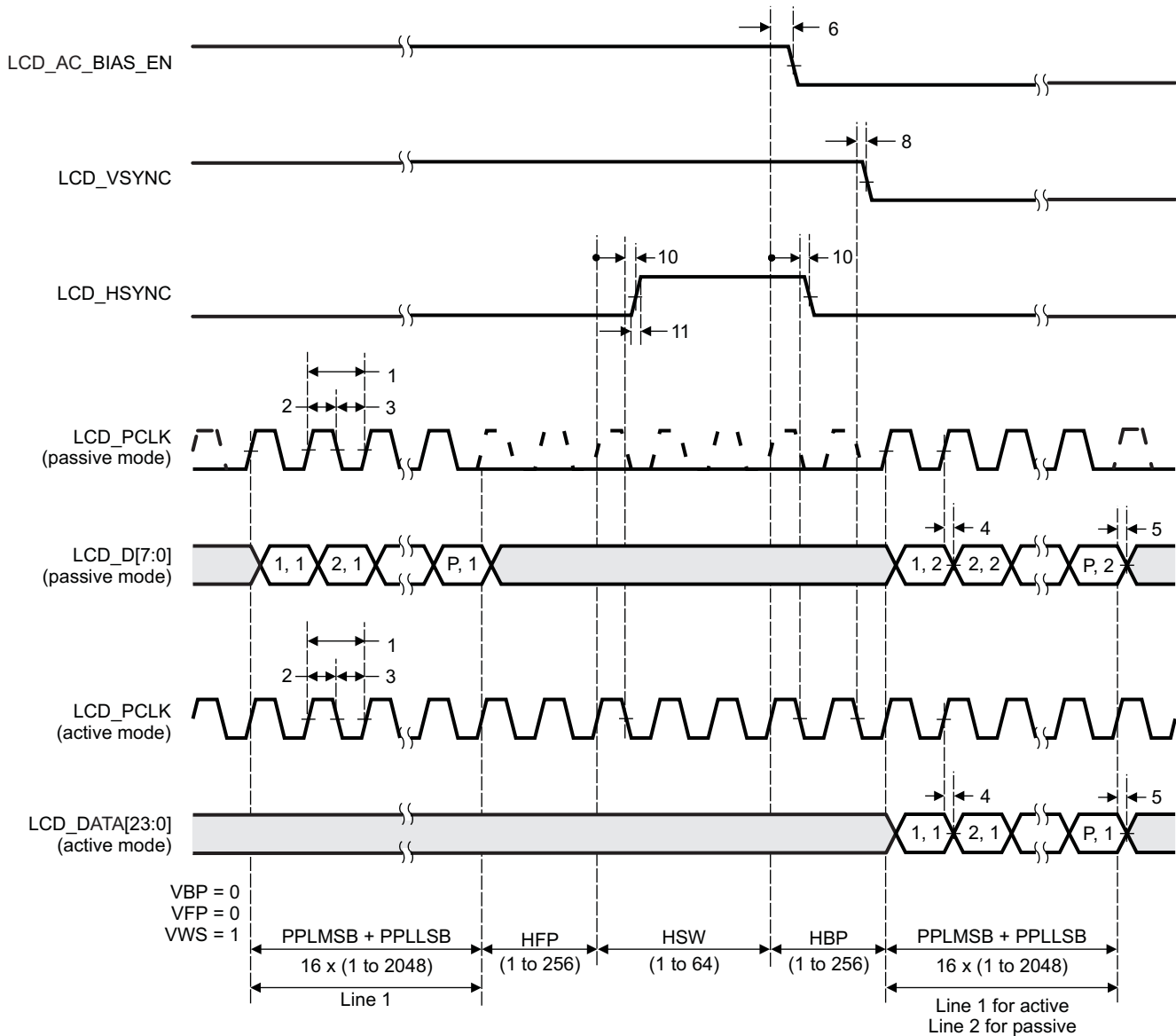
A. The dashed portion of LCD\_PCLK is only shown as a reference of the internal clock that sequences the other signals.

**Figure 5-83. LCD Raster-Mode Passive**



A. The dashed portion of LCD\_PCLK is only shown as a reference of the internal clock that sequences the other signals.

**Figure 5-84. LCD Raster-Mode Control Signal Activation**



A. The dashed portion of LCD\_PCLK is only shown as a reference of the internal clock that sequences the other signals.

### Figure 5-85. LCD Raster-Mode Control Signal Deactivation

## 5.10 Multichannel Audio Serial Port (McASP)

The multichannel audio serial port (McASP) functions as a general-purpose audio serial port optimized for the needs of multichannel audio applications. The McASP is useful for time-division multiplexed (TDM) stream, Inter-Integrated Sound (I2S) protocols, and inter-component digital audio interface transmission (DIT).

### 5.10.1 McASP Device-Specific Information

The device includes two multichannel audio serial port (McASP) interface peripherals (McASP0 and McASP1). The McASP module consists of a transmit and receive section. These sections can operate completely independently with different data formats, separate master clocks, bit clocks, and frame syncs or, alternatively, the transmit and receive sections may be synchronized. The McASP module also includes shift registers that may be configured to operate as either transmit data or receive data.

The transmit section of the McASP can transmit data in either a time-division-multiplexed (TDM) synchronous serial format or in a digital audio interface (DIT) format where the bit stream is encoded for SPDIF, AES-3, IEC-60958, CP-430 transmission. The receive section of the McASP peripheral supports the TDM synchronous serial format.

The McASP module can support one transmit data format (either a TDM format or DIT format) and one receive format at a time. All transmit shift registers use the same format and all receive shift registers use the same format; however, the transmit and receive formats need not be the same. Both the transmit and receive sections of the McASP also support burst mode, which is useful for non-audio data (for example, passing control information between two devices).

The McASP peripheral has additional capability for flexible clock generation and error detection/handling, as well as error management.

The device McASP0 and McASP1 modules have up to four serial data pins each. The McASP FIFO size is 256 bytes and two DMA and two interrupt requests are supported. Buffers are used transparently to better manage DMA, which can be leveraged to manage data flow more efficiently.

For more detailed information on and the functionality of the McASP peripheral, see the Multichannel Audio Serial Port (McASP) section of the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).

## 5.10.2 McASP Electrical Data and Timing

**Table 5-77. McASP Timing Conditions**

| TIMING CONDITION PARAMETER |                         | MIN              | TYP | MAX              | UNIT |
|----------------------------|-------------------------|------------------|-----|------------------|------|
| <b>Input Conditions</b>    |                         |                  |     |                  |      |
| $t_R$                      | Input signal rise time  | 1 <sup>(1)</sup> |     | 4 <sup>(1)</sup> | ns   |
| $t_F$                      | Input signal fall time  | 1 <sup>(1)</sup> |     | 4 <sup>(1)</sup> | ns   |
| <b>Output Condition</b>    |                         |                  |     |                  |      |
| $C_{LOAD}$                 | Output load capacitance | 15               |     | 30               | pF   |

(1) Except when specified otherwise.

**Table 5-78. Timing Requirements for McASP<sup>(1)</sup>**

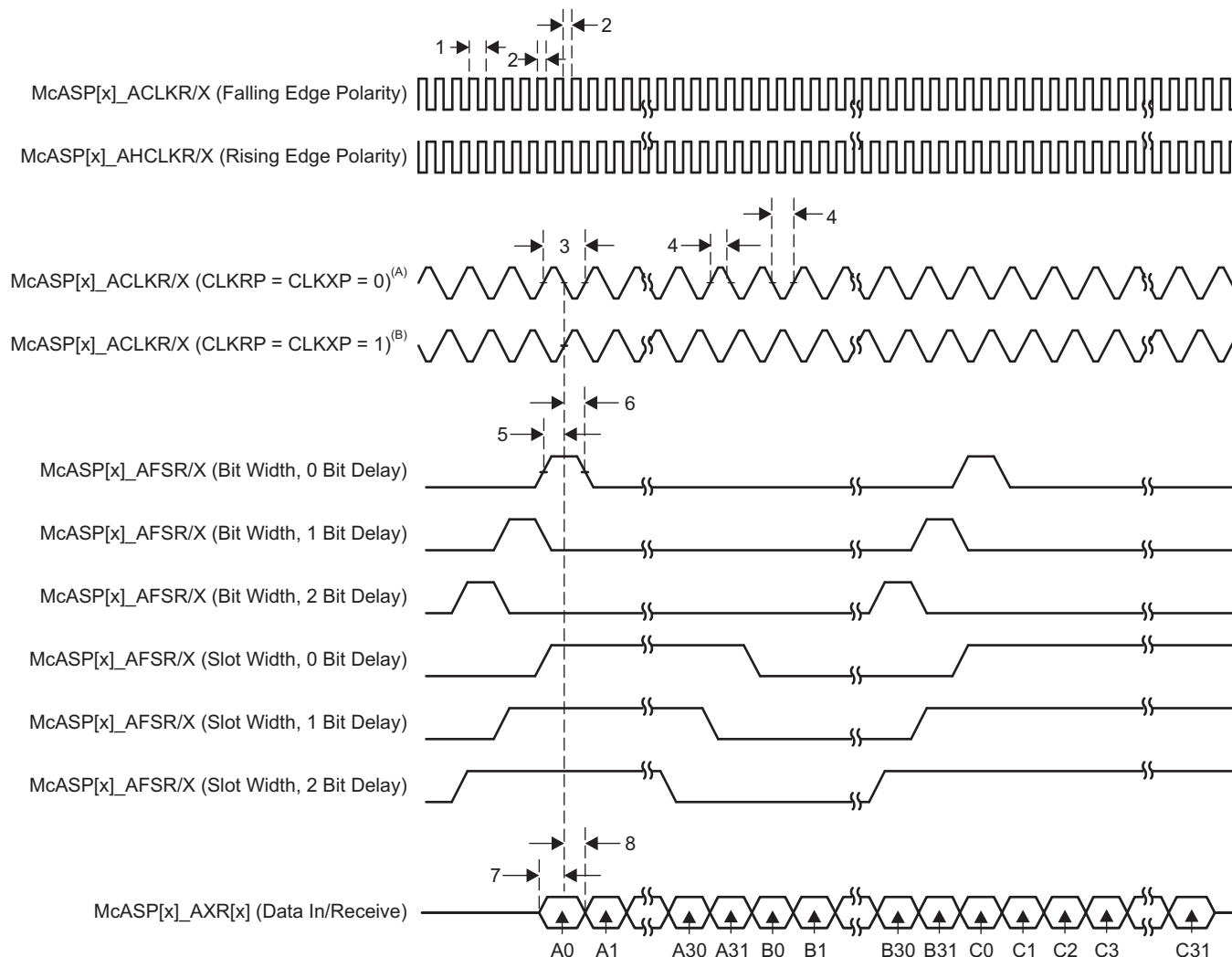
(see Figure 5-86)

| NO. |                        |                                                                                                  | OPP100                    |      | OPP50                     |      | UNIT |
|-----|------------------------|--------------------------------------------------------------------------------------------------|---------------------------|------|---------------------------|------|------|
|     |                        |                                                                                                  | MIN                       | MAX  | MIN                       | MAX  |      |
| 1   | $t_{c(AHCLKRX)}$       | Cycle time, McASP[x]_AHCLKR and McASP[x]_AHCLKX                                                  | 20                        |      | 40                        |      | ns   |
| 2   | $t_{w(AHCLKRX)}$       | Pulse duration, McASP[x]_AHCLKR and McASP[x]_AHCLKX high or low                                  | 0.5P - 2.5 <sup>(2)</sup> |      | 0.5P - 2.5 <sup>(2)</sup> |      | ns   |
| 3   | $t_{c(ACLKRX)}$        | Cycle time, McASP[x]_ACLKR and McASP[x]_ACLKX                                                    | 20                        |      | 40                        |      | ns   |
| 4   | $t_{w(ACLKRX)}$        | Pulse duration, McASP[x]_ACLKR and McASP[x]_ACLKX high or low                                    | 0.5R - 2.5 <sup>(3)</sup> |      | 0.5R - 2.5 <sup>(3)</sup> |      | ns   |
| 5   | $t_{su(AFSRX-ACLKRX)}$ | Setup time, McASP[x]_AFSR and McASP[x]_AFSX input valid before McASP[x]_ACLKR and McASP[x]_ACLKX | ACLKR and ACLKX int       | 11.5 | ACLKR and ACLKX int       | 15.5 | ns   |
|     |                        |                                                                                                  | ACLKR and ACLKX ext in    | 4    | ACLKR and ACLKX ext in    | 6    |      |
|     |                        |                                                                                                  | ACLKR and ACLKX ext out   | 4    | ACLKR and ACLKX ext out   | 6    |      |
| 6   | $t_{h(ACLKRX-AFSRX)}$  | Hold time, McASP[x]_AFSR and McASP[x]_AFSX input valid after McASP[x]_ACLKR and McASP[x]_ACLKX   | ACLKR and ACLKX int       | -1   | ACLKR and ACLKX int       | -1   | ns   |
|     |                        |                                                                                                  | ACLKR and ACLKX ext in    | 0.4  | ACLKR and ACLKX ext in    | 0.4  |      |
|     |                        |                                                                                                  | ACLKR and ACLKX ext out   | 0.4  | ACLKR and ACLKX ext out   | 0.4  |      |
| 7   | $t_{su(AXR-ACLKRX)}$   | Setup time, McASP[x]_AXR input valid before McASP[x]_ACLKR and McASP[x]_ACLKX                    | ACLKR and ACLKX int       | 11.5 | ACLKR and ACLKX int       | 15.5 | ns   |
|     |                        |                                                                                                  | ACLKR and ACLKX ext in    | 4    | ACLKR and ACLKX ext in    | 6    |      |
|     |                        |                                                                                                  | ACLKR and ACLKX ext out   | 4    | ACLKR and ACLKX ext out   | 6    |      |
| 8   | $t_{h(ACLKRX-AXR)}$    | Hold time, McASP[x]_AXR input valid after McASP[x]_ACLKR and McASP[x]_ACLKX                      | ACLKR and ACLKX int       | -1   | ACLKR and ACLKX int       | -1   | ns   |
|     |                        |                                                                                                  | ACLKR and ACLKX ext in    | 0.4  | ACLKR and ACLKX ext in    | 0.4  |      |
|     |                        |                                                                                                  | ACLKR and ACLKX ext out   | 0.4  | ACLKR and ACLKX ext out   | 0.4  |      |

(1) ACLKR internal: ACLKRCTL.CLKRM = 1, PDIR.ACLKR = 1  
 ACLKR external input: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 0  
 ACLKR external output: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 1  
 ACLKX internal: ACLKXCTL.CLKXM = 1, PDIR.ACLKX = 1  
 ACLKX external input: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 0  
 ACLKX external output: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 1

(2) P = McASP[x]\_AHCLKR and McASP[x]\_AHCLKX period in nano seconds (ns).

(3) R = McASP[x]\_ACLKR and McASP[x]\_ACLKX period in ns.



- A. For CLKRP = CLKXP = 0, the McASP transmitter is configured for rising edge (to shift data out) and the McASP receiver is configured for falling edge (to shift data in).
- B. For CLKRP = CLKXP = 1, the McASP transmitter is configured for falling edge (to shift data out) and the McASP receiver is configured for rising edge (to shift data in).

**Figure 5-86. McASP Input Timing**

**Table 5-79. Switching Characteristics for McASP<sup>(1)</sup>**

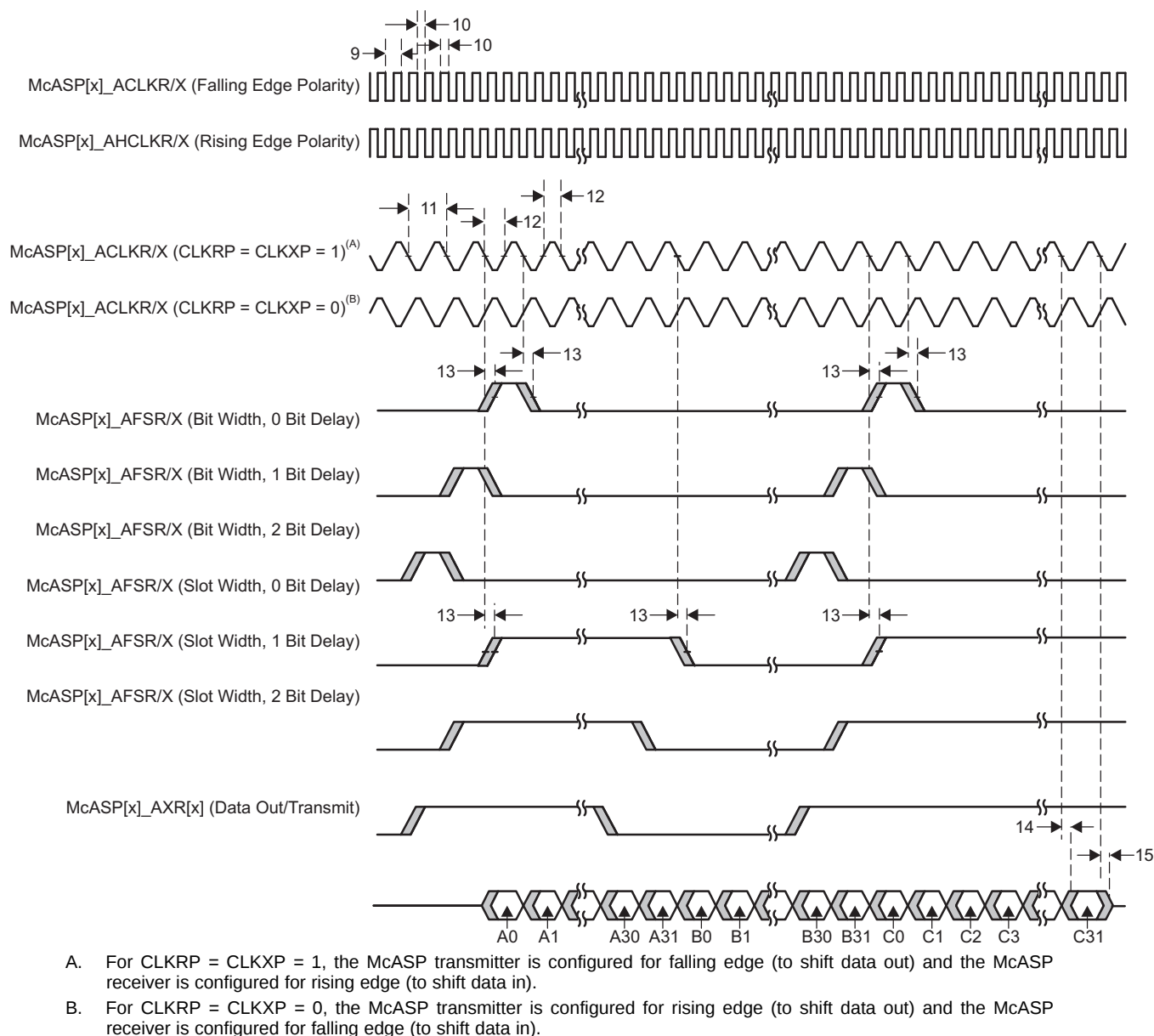
(see Figure 5-87)

| NO. |                       |                                                                                                                               |                         | OPP100                    |      | OPP50                     |     | UNIT |
|-----|-----------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------|---------------------------|------|---------------------------|-----|------|
|     |                       |                                                                                                                               |                         | MIN                       | MAX  | MIN                       | MAX |      |
| 9   | $t_{c(AHCLKRX)}$      | Cycle time, McASP[x]_AHCLKR and McASP[x]_AHCLKX                                                                               |                         | 20 <sup>(2)</sup>         |      | 40                        |     | ns   |
| 10  | $t_{w(AHCLKRX)}$      | Pulse duration, McASP[x]_AHCLKR and McASP[x]_AHCLKX high or low                                                               |                         | 0.5P - 2.5 <sup>(3)</sup> |      | 0.5P - 2.5 <sup>(3)</sup> |     | ns   |
| 11  | $t_{c(ACLKRX)}$       | Cycle time, McASP[x]_ACLKR and McASP[x]_ACLKX                                                                                 |                         | 20                        |      | 40                        |     | ns   |
| 12  | $t_{w(ACLKRX)}$       | Pulse duration, McASP[x]_ACLKR and McASP[x]_ACLKX high or low                                                                 |                         | 0.5P - 2.5 <sup>(3)</sup> |      | 0.5P - 2.5 <sup>(3)</sup> |     | ns   |
| 13  | $t_{d(ACLKRX-AFSRX)}$ | Delay time, McASP[x]_ACLKR and McASP[x]_ACLKX transmit edge to McASP[x]_AFSR and McASP[x]_AFSX output valid                   | ACLKR and ACLKX int     | 0                         | 6    | 0                         | 6   | ns   |
|     |                       |                                                                                                                               | ACLKR and ACLKX ext in  | 2                         | 13.5 | 2                         | 18  |      |
|     |                       | Delay time, McASP[x]_ACLKR and McASP[x]_ACLKX transmit edge to McASP[x]_AFSR and McASP[x]_AFSX output valid with Pad Loopback | ACLKR and ACLKX ext out | 2                         | 13.5 | 2                         | 18  |      |
| 14  | $t_{d(ACLKX-AXR)}$    | Delay time, McASP[x]_ACLKX transmit edge to McASP[x]_AXR output valid                                                         | ACLKX int               | 0                         | 6    | 0                         | 6   | ns   |
|     |                       |                                                                                                                               | ACLKX ext in            | 2                         | 13.5 | 2                         | 18  |      |
|     |                       | Delay time, McASP[x]_ACLKX transmit edge to McASP[x]_AXR output valid with Pad Loopback                                       | ACLKX ext out           | 2                         | 13.5 | 2                         | 18  |      |
| 15  | $t_{dis(ACLKX-AXR)}$  | Disable time, McASP[x]_ACLKX transmit edge to McASP[x]_AXR output high impedance                                              | ACLKX int               | 0                         | 6    | 0                         | 6   | ns   |
|     |                       |                                                                                                                               | ACLKX ext in            | 2                         | 13.5 | 2                         | 18  |      |
|     |                       | Disable time, McASP[x]_ACLKX transmit edge to McASP[x]_AXR output high impedance with Pad Loopback                            | ACLKX ext out           | 2                         | 13.5 | 2                         | 18  |      |

(1) ACLKR internal: ACLKRCTL.CLKRM = 1, PDIR.ACLKR = 1  
 ACLKR external input: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 0  
 ACLKR external output: ACLKRCTL.CLKRM = 0, PDIR.ACLKR = 1  
 ACLKX internal: ACLKXCTL.CLKXM = 1, PDIR.ACLKX = 1  
 ACLKX external input: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 0  
 ACLKX external output: ACLKXCTL.CLKXM = 0, PDIR.ACLKX = 1

(2) 50 MHz

(3) P = AHCLKR and AHCLKX period.



**Figure 5-87. McASP Output Timing**

## 5.11 Multichannel Serial Port Interface (McSPI)

For more information, see the Multichannel Serial Port Interface (McSPI) section of the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).

### 5.11.1 McSPI Electrical Data and Timing

The following timings are applicable to the different configurations of McSPI in master or slave mode for any McSPI and any channel (n).

#### 5.11.1.1 McSPI—Slave Mode

**Table 5-80. McSPI Timing Conditions—Slave Mode**

| TIMING CONDITION PARAMETER |                         | MIN | MAX | UNIT |
|----------------------------|-------------------------|-----|-----|------|
| <b>Input Conditions</b>    |                         |     |     |      |
| $t_r$                      | Input signal rise time  |     | 5   | ns   |
| $t_f$                      | Input signal fall time  |     | 5   | ns   |
| <b>Output Condition</b>    |                         |     |     |      |
| $C_{load}$                 | Output load capacitance |     | 20  | pF   |

**Table 5-81. Timing Requirements for McSPI Input Timings—Slave Mode**

(see [Figure 5-88](#))

| NO. |                       |                                                                                | OPP100              |                     | OPP50               |                     | UNIT |
|-----|-----------------------|--------------------------------------------------------------------------------|---------------------|---------------------|---------------------|---------------------|------|
|     |                       |                                                                                | MIN                 | MAX                 | MIN                 | MAX                 |      |
| 1   | $t_{c(SPICLK)}$       | Cycle time, SPI_CLK                                                            | 62.5                |                     | 124.8               |                     | ns   |
| 2   | $t_{w(SPICLK)}$       | Typical Pulse duration, SPI_CLK low                                            | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup> | ns   |
| 3   | $t_{w(SPICLKH)}$      | Typical Pulse duration, SPI_CLK high                                           | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup> | ns   |
| 4   | $t_{su(SIMO-SPICLK)}$ | Setup time, SPI_D[x] (SIMO) valid before SPI_CLK active edge <sup>(2)(3)</sup> | 12.92               |                     | 12.92               |                     | ns   |
| 5   | $t_{h(SPICLK-SIMO)}$  | Hold time, SPI_D[x] (SIMO) valid after SPI_CLK active edge <sup>(2)(3)</sup>   | 12.92               |                     | 12.92               |                     | ns   |
| 8   | $t_{su(CS-SPICLK)}$   | Setup time, SPI_CS valid before SPI_CLK first edge <sup>(2)</sup>              | 12.92               |                     | 12.92               |                     | ns   |
| 9   | $t_{h(SPICLK-CS)}$    | Hold time, SPI_CS valid after SPI_CLK last edge <sup>(2)</sup>                 | 12.92               |                     | 12.92               |                     | ns   |

(1) P = SPI\_CLK period.

(2) This timing applies to all configurations regardless of MCSPIX\_CLK polarity and which clock edges are used to drive output data and capture input data.

(3) Pins SPIx\_D0 and SPIx\_D1 can function as SIMO or SOMI.

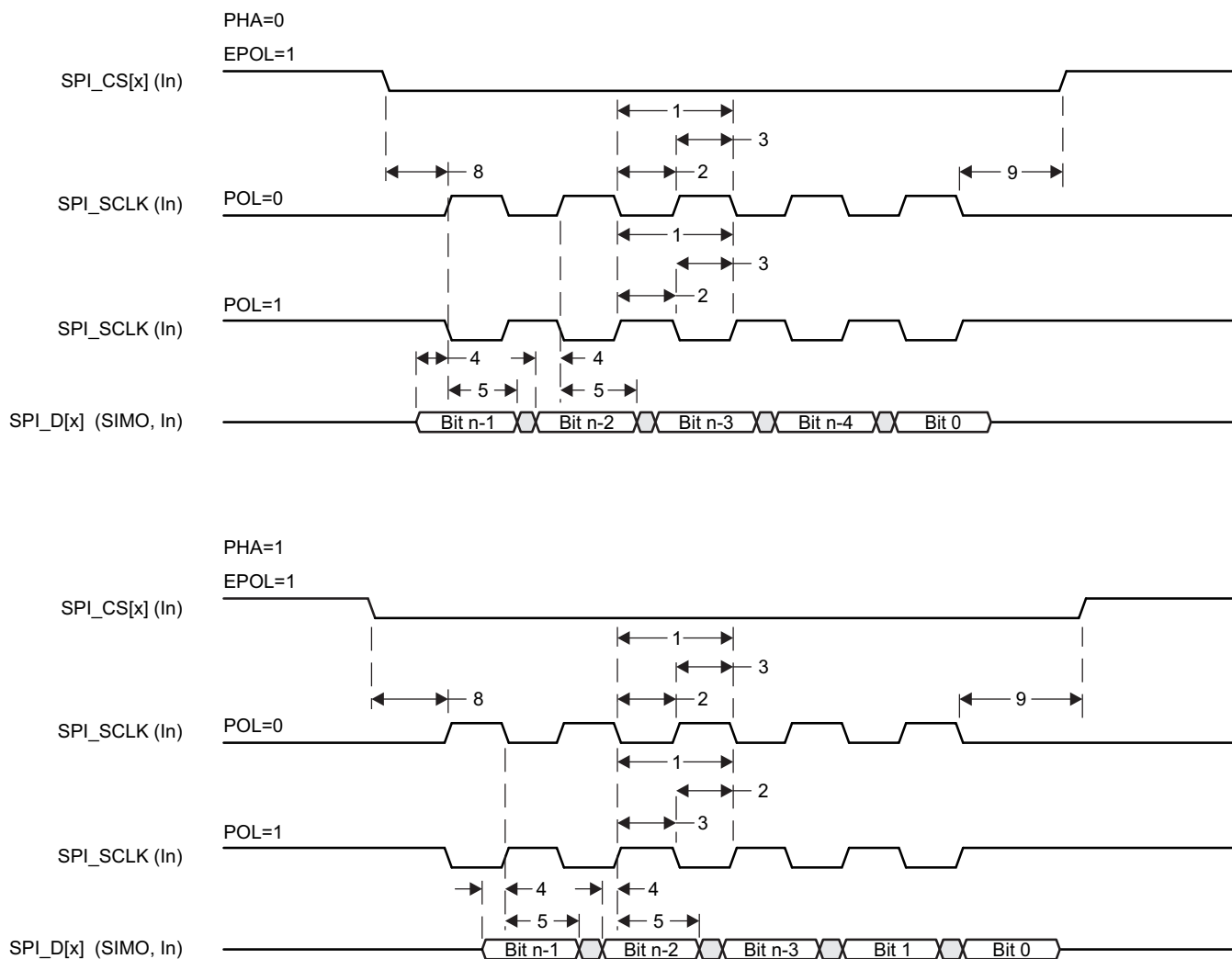
**Table 5-82. Switching Characteristics for McSPI Output Timings—Slave Mode**

(see [Figure 5-89](#))

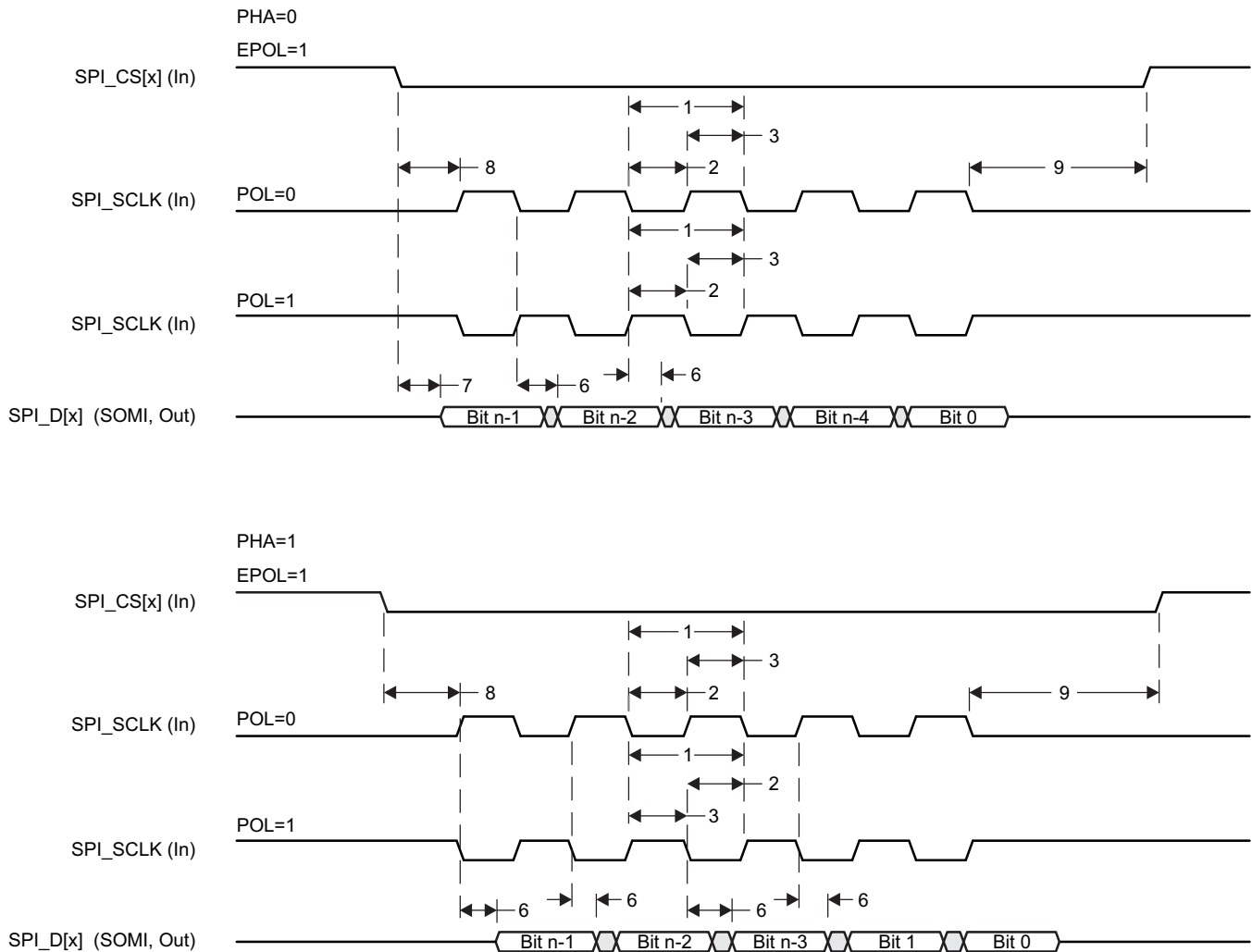
| NO. | PARAMETER          |                                                                                 | OPP100 |       | OPP50 |       | UNIT |
|-----|--------------------|---------------------------------------------------------------------------------|--------|-------|-------|-------|------|
|     |                    |                                                                                 | MIN    | MAX   | MIN   | MAX   |      |
| 6   | $t_d(SPICLK-SOMI)$ | Delay time, SPI_CLK active edge to SPI_D[x] (SOMI) transition <sup>(1)(2)</sup> | -4.00  | 17.12 | -4.00 | 17.12 | ns   |
| 7   | $t_d(CS-SOMI)$     | Delay time, SPI_CS active edge to SPI_D[x] (SOMI) transition <sup>(1)(2)</sup>  |        | 17.12 |       | 17.12 | ns   |

(1) This timing applies to all configurations regardless of MCSPIX\_CLK polarity and which clock edges are used to drive output data and capture input data.

(2) Pins SPIx\_D0 and SPIx\_D1 can function as SIMO or SOMI.



**Figure 5-88. SPI Slave Mode Receive Timing**



**Figure 5-89. SPI Slave Mode Transmit Timing**

## 5.11.1.2 McSPI—Master Mode

Table 5-83. McSPI Timing Conditions—Master Mode

| TIMING CONDITION PARAMETER |                         | LOW LOAD |     | HIGH LOAD |     | UNIT |
|----------------------------|-------------------------|----------|-----|-----------|-----|------|
|                            |                         | MIN      | MAX | MIN       | MAX |      |
| Input Conditions           |                         |          |     |           |     |      |
| t <sub>r</sub>             | Input signal rise time  | 8        |     | 8         |     | ns   |
| t <sub>f</sub>             | Input signal fall time  | 8        |     | 8         |     | ns   |
| Output Condition           |                         |          |     |           |     |      |
| C <sub>load</sub>          | Output load capacitance | 5        |     | 25        |     | pF   |

Table 5-84. Timing Requirements for McSPI Input Timings—Master Mode

(see Figure 5-90)

| NO. |                                             |                                                                                   | OPP100   |     |           |     | OPP50    |     |           |     | UNIT |
|-----|---------------------------------------------|-----------------------------------------------------------------------------------|----------|-----|-----------|-----|----------|-----|-----------|-----|------|
|     |                                             |                                                                                   | LOW LOAD |     | HIGH LOAD |     | LOW LOAD |     | HIGH LOAD |     |      |
|     |                                             |                                                                                   | MIN      | MAX | MIN       | MAX | MIN      | MAX | MIN       | MAX |      |
| 4   | t <sub>SU</sub> (SOMI-SPICLK <sub>H</sub> ) | Setup time, SPI_D[x]<br>(SOMI) valid before<br>SPI_CLK active edge <sup>(1)</sup> | 2.29     |     | 3.02      |     | 2.29     |     | 3.02      |     | ns   |
| 5   | t <sub>H</sub> (SPICLK <sub>H</sub> -SOMI)  | Hold time, SPI_D[x]<br>(SOMI) valid after<br>SPI_CLK active edge <sup>(1)</sup>   | 4.7      |     | 4.7       |     | 4.7      |     | 4.7       |     | ns   |

(1) Pins SPIx\_D0 and SPIx\_D1 can function as SIMO or SOMI.

Table 5-85. Switching Characteristics for McSPI Output Timings—Master Mode

(see Figure 5-91)

| NO. | PARAMETER                    |                                                                              | OPP100                      |                        |                     |                         | OPP50               |                        |                     |                         | UNIT |
|-----|------------------------------|------------------------------------------------------------------------------|-----------------------------|------------------------|---------------------|-------------------------|---------------------|------------------------|---------------------|-------------------------|------|
|     |                              |                                                                              | LOW LOAD                    |                        | HIGH LOAD           |                         | LOW LOAD            |                        | HIGH LOAD           |                         |      |
|     |                              |                                                                              | MIN                         | MAX                    | MIN                 | MAX                     | MIN                 | MAX                    | MIN                 | MAX                     |      |
| 1   | t <sub>C</sub> (SPICLK)      | Cycle time, SPI_CLK                                                          | 20.8                        |                        | 20.8                |                         | 41.6                |                        | 41.6                |                         | ns   |
| 2   | t <sub>w</sub> (SPICLKL)     | Typical Pulse duration, SPI_CLK low                                          | 0.5P <sup>(1)</sup>         | 0.5P <sup>(1)</sup>    | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup>     | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup>    | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup>     | ns   |
| 3   | t <sub>w</sub> (SPICLKH)     | Typical Pulse duration, SPI_CLK high                                         | 0.5P <sup>(1)</sup>         | 0.5P <sup>(1)</sup>    | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup>     | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup>    | 0.5P <sup>(1)</sup> | 0.5P <sup>(1)</sup>     | ns   |
|     | t <sub>r</sub> (SPICLK)      | Rising time, SPI_CLK                                                         |                             | 3.82                   |                     | 3.82                    |                     | 3.82                   |                     | 3.82                    | ns   |
|     | t <sub>f</sub> (SPICLK)      | Falling time, SPI_CLK                                                        |                             | 3.44                   |                     | 3.44                    |                     | 3.44                   |                     | 3.44                    | ns   |
| 6   | t <sub>d</sub> (SPICLK-SIMO) | Delay time, SPI_CLK active edge to SPI_D[x] (SIMO) transition <sup>(2)</sup> | -3.57                       | 3.57                   | -4.62               | 4.62                    | -3.57               | 3.57                   | -4.62               | 4.62                    | ns   |
| 7   | t <sub>d</sub> (CS-SIMO)     | Delay time, SPI_CS active edge to SPI_D[x] (SIMO) transition <sup>(2)</sup>  |                             | 3.57                   |                     | 4.62                    |                     | 3.57                   |                     | 4.62                    | ns   |
| 8   | t <sub>d</sub> (CS-SPICLK)   | Delay time, SPI_CS active to SPI_CLK first edge                              | Mode 1 and 3 <sup>(3)</sup> | A - 4.2 <sup>(4)</sup> |                     | A - 2.54 <sup>(4)</sup> |                     | A - 4.2 <sup>(4)</sup> |                     | A - 2.54 <sup>(4)</sup> | ns   |
|     |                              |                                                                              | Mode 0 and 2 <sup>(3)</sup> | B - 4.2 <sup>(5)</sup> |                     | B - 2.54 <sup>(5)</sup> |                     | B - 4.2 <sup>(5)</sup> |                     | B - 2.54 <sup>(5)</sup> | ns   |
| 9   | t <sub>d</sub> (SPICLK-CS)   | Delay time, SPI_CLK last edge to SPI_CS inactive                             | Mode 1 and 3 <sup>(3)</sup> | B - 4.2 <sup>(5)</sup> |                     | B - 2.54 <sup>(5)</sup> |                     | B - 4.2 <sup>(5)</sup> |                     | B - 2.54 <sup>(5)</sup> | ns   |
|     |                              |                                                                              | Mode 0 and 2 <sup>(3)</sup> | A - 4.2 <sup>(4)</sup> |                     | A - 2.54 <sup>(4)</sup> |                     | A - 4.2 <sup>(4)</sup> |                     | A - 2.54 <sup>(4)</sup> | ns   |

(1) P = SPI\_CLK period.

(2) Pins SPIx\_D0 and SPIx\_D1 can function as SIMO or SOMI.

(3) The polarity of SPIx\_CLK and the active edge (rising or falling) on which mcspx\_simo is driven and mcspx\_somi is latched is all software configurable:

- SPIx\_CLK(1) phase programmable with the bit PHA of MCSPI\_CH(i)CONF register: PHA = 1 (Modes 1 and 3).
- SPIx\_CLK(1) phase programmable with the bit PHA of MCSPI\_CH(i)CONF register: PHA = 0 (Modes 0 and 2).

(4) Case P = 20.8 ns, A = (TCS+1)\*TSPICLKREF (TCS is a bit field of MCSPI\_CH(i)CONF register).

Case P > 20.8 ns, A = (TCS+0.5)\*Fratio\*TSPICLKREF (TCS is a bit field of MCSPI\_CH(i)CONF register).

Note: P = SPI\_CLK clock period.

(5) B = (TCS+0.5)\*TSPICLKREF\*Fratio (TCS is a bit field of MCSPI\_CH(i)CONF register, Fratio: Even≥2).

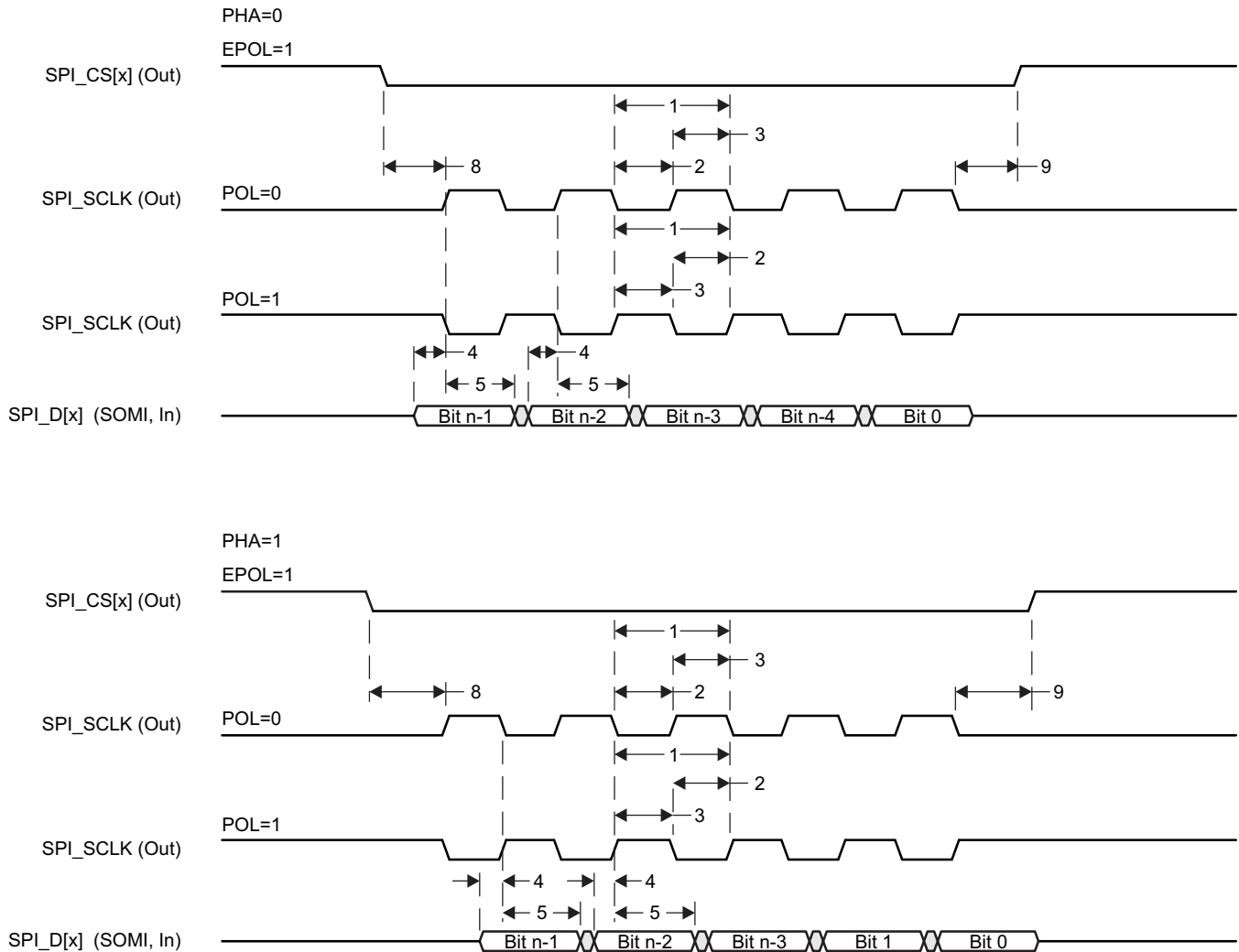
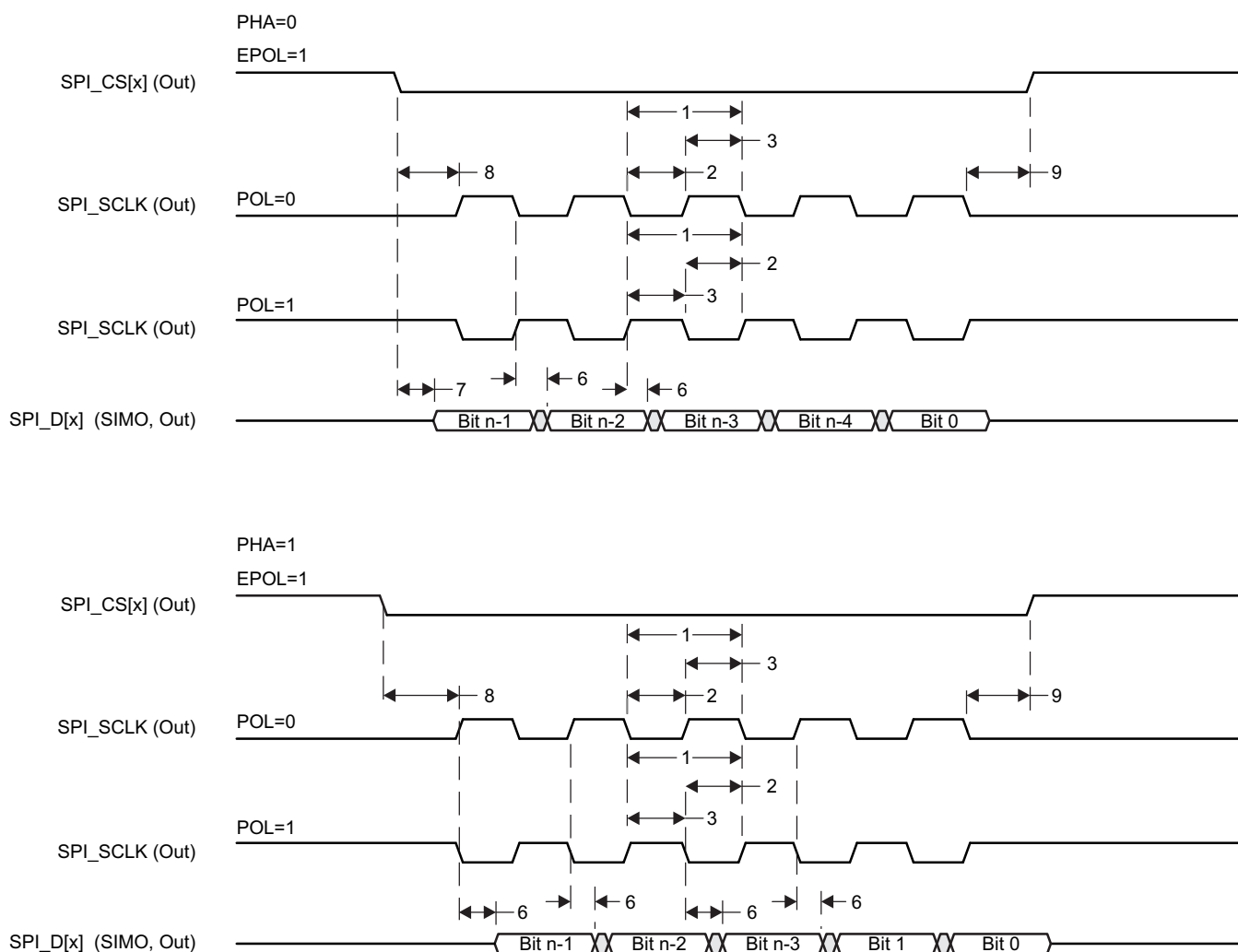


Figure 5-90. SPI Master Mode Receive Timing



**Figure 5-91. SPI Master Mode Transmit Timing**

## 5.12 Multimedia Card (MMC) Interface

For more information, see the Multimedia Card (MMC) section of the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).

### 5.12.1 MMC Electrical Data and Timing

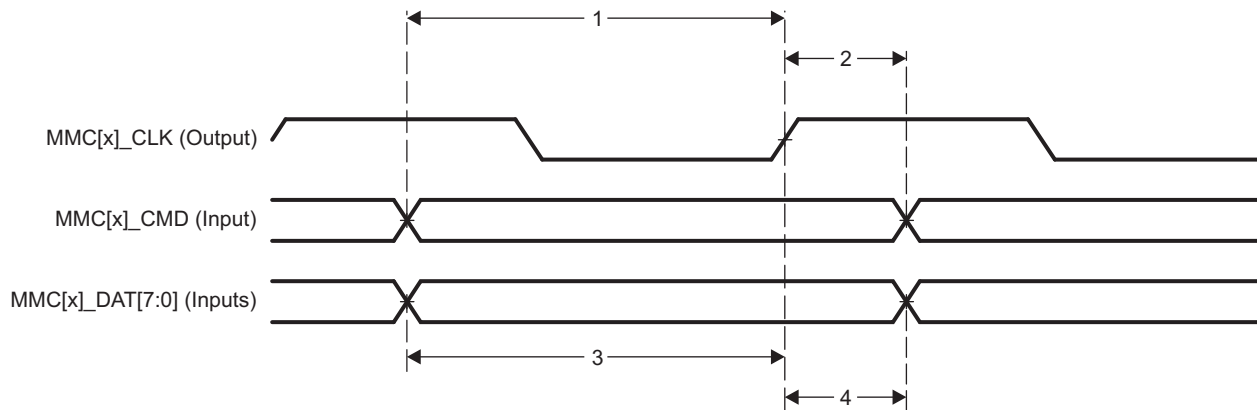
**Table 5-86. MMC Timing Conditions**

| TIMING CONDITION PARAMETER |                         | MIN | TYP | MAX | UNIT |
|----------------------------|-------------------------|-----|-----|-----|------|
| <b>Input Conditions</b>    |                         |     |     |     |      |
| $t_r$                      | Input signal rise time  | 1   |     | 5   | ns   |
| $t_f$                      | Input signal fall time  | 1   |     | 5   | ns   |
| <b>Output Condition</b>    |                         |     |     |     |      |
| $C_{load}$                 | Output load capacitance | 3   |     | 30  | pF   |

**Table 5-87. Timing Requirements for MMC[x]\_CMD and MMC[x]\_DAT[7:0]**

(see [Figure 5-92](#))

| NO. |                     |                                                             | MIN  | TYP | MAX | UNIT |
|-----|---------------------|-------------------------------------------------------------|------|-----|-----|------|
| 1   | $t_{su}(CMDV-CLKH)$ | Setup time, MMC_CMD valid before MMC_CLK rising clock edge  | 4.1  |     |     | ns   |
| 2   | $t_h(CLKH-CMDV)$    | Hold time, MMC_CMD valid after MMC_CLK rising clock edge    | 3.76 |     |     | ns   |
| 3   | $t_{su}(DATV-CLKH)$ | Setup time, MMC_DATx valid before MMC_CLK rising clock edge | 4.1  |     |     | ns   |
| 4   | $t_h(CLKH-DATV)$    | Hold time, MMC_DATx valid after MMC_CLK rising clock edge   | 3.76 |     |     | ns   |



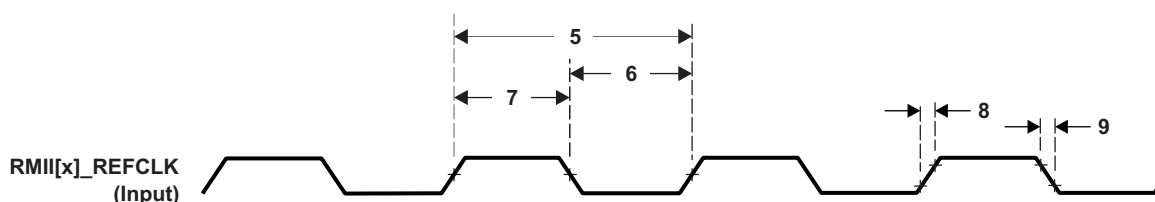
**Figure 5-92. MMC[x]\_CMD and MMC[x]\_DAT[7:0] Input Timing**

**Table 5-88. Switching Characteristics for MMC[x]\_CLK**

(see [Figure 5-93](#))

| NO. | PARAMETER      |                                        | STANDARD MODE                      |     |     | HIGH-SPEED MODE                    |     |     | UNIT |
|-----|----------------|----------------------------------------|------------------------------------|-----|-----|------------------------------------|-----|-----|------|
|     |                |                                        | MIN                                | TYP | MAX | MIN                                | TYP | MAX |      |
| 5   | $f_{op}(CLK)$  | Operating frequency, MMC_CLK           |                                    |     | 24  |                                    |     | 48  | MHz  |
|     | $t_{cop}(CLK)$ | Operating period: MMC_CLK              | 41.7                               |     |     | 20.8                               |     |     | ns   |
|     | $f_{id}(CLK)$  | Identification mode frequency, MMC_CLK |                                    |     | 400 |                                    |     | 400 | kHz  |
|     | $t_{cid}(CLK)$ | Identification mode period: MMC_CLK    | 2500                               |     |     | 2500                               |     |     | ns   |
| 6   | $t_{w}(CLKL)$  | Pulse duration, MMC_CLK low            | $(0.5 \cdot P) - t_{f(CLK)}^{(1)}$ |     |     | $(0.5 \cdot P) - t_{f(CLK)}^{(1)}$ |     |     | ns   |
| 7   | $t_{w}(CLKH)$  | Pulse duration, MMC_CLK high           | $(0.5 \cdot P) - t_{r(CLK)}^{(1)}$ |     |     | $(0.5 \cdot P) - t_{r(CLK)}^{(1)}$ |     |     | ns   |
| 8   | $t_r(CLK)$     | Rise time, All Signals (10% to 90%)    |                                    |     | 2.2 |                                    |     | 2.2 | ns   |
| 9   | $t_f(CLK)$     | Fall time, All Signals (10% to 90%)    |                                    |     | 2.2 |                                    |     | 2.2 | ns   |

(1) P = MMC\_CLK period.

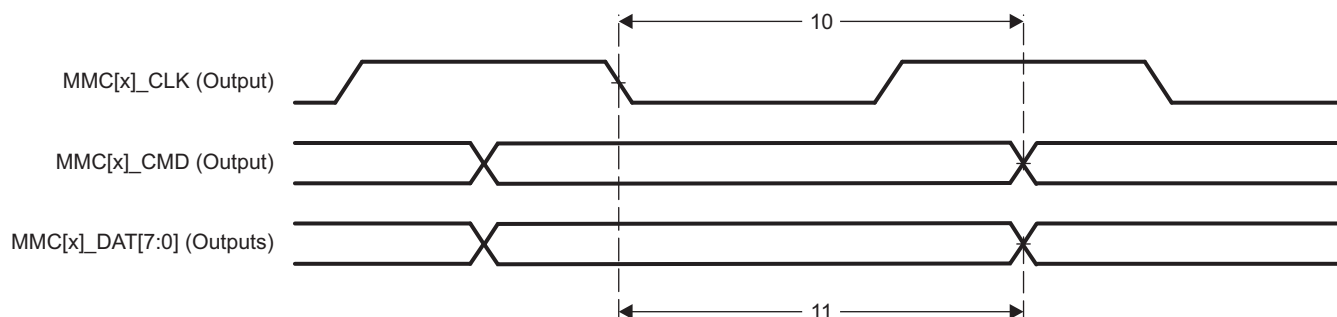


**Figure 5-93. MMC[x]\_CLK Timing**

**Table 5-89. Switching Characteristics for MMC[x]\_CMD and MMC[x]\_DAT[7:0]—Standard Mode**

(see [Figure 5-94](#))

| NO. | PARAMETER       |                                                               | OPP100 |     |     | OPP50 |     |      | UNIT |
|-----|-----------------|---------------------------------------------------------------|--------|-----|-----|-------|-----|------|------|
|     |                 |                                                               | MIN    | TYP | MAX | MIN   | TYP | MAX  |      |
| 10  | $t_d(CLKL-CMD)$ | Delay time, MMC_CLK falling clock edge to MMC_CMD transition  | -4     |     | 14  | -4    |     | 17.5 | ns   |
| 11  | $t_d(CLKL-DAT)$ | Delay time, MMC_CLK falling clock edge to MMC_DATx transition | -4     |     | 14  | -4    |     | 17.5 | ns   |

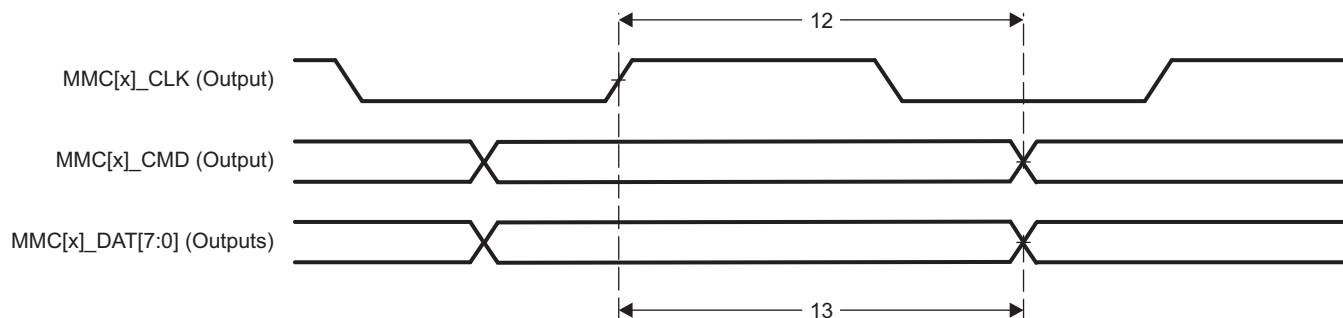


**Figure 5-94. MMC[x]\_CMD and MMC[x]\_DAT[7:0] Output Timing—Standard Mode**

**Table 5-90. Switching Characteristics for MMC[x]\_CMD and MMC[x]\_DAT[7:0]—High-Speed Mode**

(see [Figure 5-95](#))

| NO. | PARAMETER                |                                                              | OPP100 |     |     | OPP50 |     |      | UNIT |
|-----|--------------------------|--------------------------------------------------------------|--------|-----|-----|-------|-----|------|------|
|     |                          |                                                              | MIN    | TYP | MAX | MIN   | TYP | MAX  |      |
| 12  | $t_{d(\text{CLKL-CMD})}$ | Delay time, MMC_CLK rising clock edge to MMC_CMD transition  | 2.5    |     | 14  | 2.5   |     | 17.5 | ns   |
| 13  | $t_{d(\text{CLKL-DAT})}$ | Delay time, MMC_CLK rising clock edge to MMC_DATx transition | 2.5    |     | 14  | 2.5   |     | 17.5 | ns   |



**Figure 5-95. MMC[x]\_CMD and MMC[x]\_DAT[7:0] Output Timing—High Speed Mode**

## 5.13 Universal Asynchronous Receiver Transmitter (UART)

For more information, see the Universal Asynchronous Receiver Transmitter (UART) section of the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual* (literature number [SPRUH73](#)).

### 5.13.1 UART Electrical Data and Timing

**Table 5-91. Timing Requirements for UARTx Receive**

(see [Figure 5-96](#))

| NO. |             | MIN                                        | MAX                                       | UNIT |
|-----|-------------|--------------------------------------------|-------------------------------------------|------|
| 3   | $t_{w(RX)}$ | Pulse width, receive start, stop, data bit | 0.96U <sup>(1)</sup> 1.05U <sup>(1)</sup> | ns   |

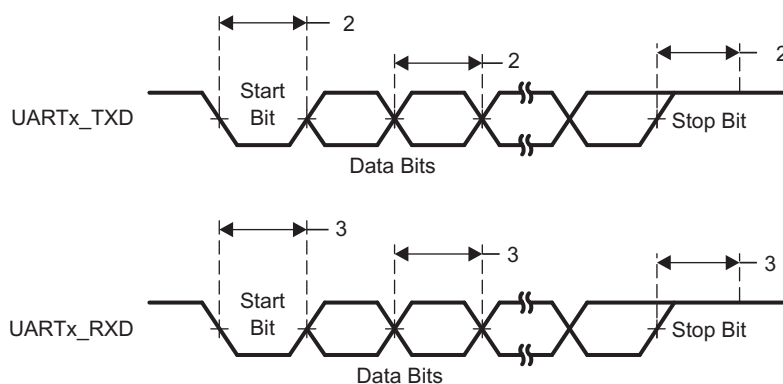
(1) U = UART baud time = 1/programmed baud rate.

**Table 5-92. Switching Characteristics for UARTx Transmit**

(see [Figure 5-96](#))

| NO. | PARAMETER               | MIN                                         | MAX                                       | UNIT |
|-----|-------------------------|---------------------------------------------|-------------------------------------------|------|
| 1   | $f_{\text{baud(baud)}}$ | Maximum programmable baud rate              | 3.6864                                    | MHz  |
| 2   | $t_{w(TX)}$             | Pulse width, transmit start, stop, data bit | U - 2 <sup>(1)</sup> U + 2 <sup>(1)</sup> | ns   |

(1) U = UART baud time = 1/programmed baud rate.



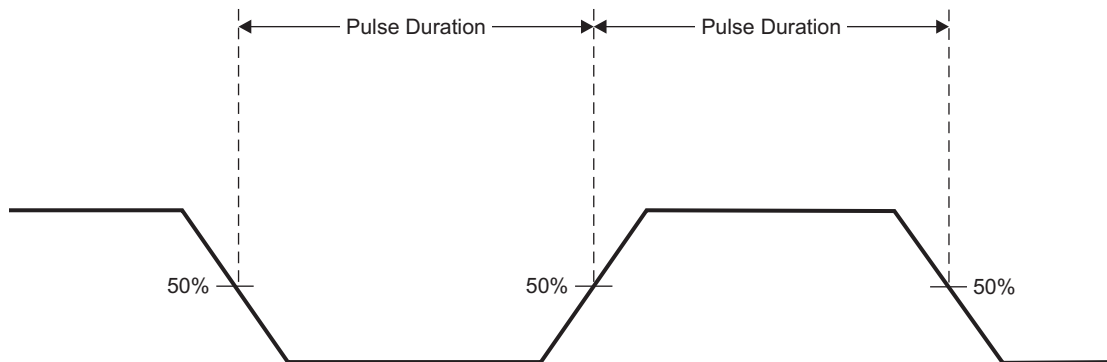
**Figure 5-96. UART Timings**

### 5.13.2 UART IrDA Interface

The IrDA module operates in three different modes:

- Slow infrared (SIR) ( $\leq 115.2$  Kbps)
- Medium infrared (MIR) (0.576 Mbps and 1.152 Mbps)
- Fast infrared (FIR) (4 Mbps).

Figure 5-97 illustrates the UART IrDA pulse parameters. Table 5-93 and Table 5-94 list the signaling rates and pulse durations for UART IrDA receive and transmit modes.



**Figure 5-97. UART IrDA Pulse Parameters**

**Table 5-93. UART IrDA—Signaling Rate and Pulse Duration—Receive Mode**

| SIGNALING RATE        | ELECTRICAL PULSE DURATION |       | UNIT |
|-----------------------|---------------------------|-------|------|
|                       | MIN                       | MAX   |      |
| SIR                   |                           |       |      |
| 2.4 Kbps              | 1.41                      | 88.55 | μs   |
| 9.6 Kbps              | 1.41                      | 22.13 | μs   |
| 19.2 Kbps             | 1.41                      | 11.07 | μs   |
| 38.4 Kbps             | 1.41                      | 5.96  | μs   |
| 57.6 Kbps             | 1.41                      | 4.34  | μs   |
| 115.2 Kbps            | 1.41                      | 2.23  | μs   |
| MIR                   |                           |       |      |
| 0.576 Mbps            | 297.2                     | 518.8 | ns   |
| 1.152 Mbps            | 149.6                     | 258.4 | ns   |
| FIR                   |                           |       |      |
| 4 Mbps (Single pulse) | 67                        | 164   | ns   |
| 4 Mbps (Double pulse) | 190                       | 289   | ns   |

**Table 5-94. UART IrDA—Signaling Rate and Pulse Duration—Transmit Mode**

| SIGNALING RATE        | ELECTRICAL PULSE DURATION |      | UNIT |
|-----------------------|---------------------------|------|------|
|                       | MIN                       | MAX  |      |
| SIR                   |                           |      |      |
| 2.4 Kbps              | 78.1                      | 78.1 | μs   |
| 9.6 Kbps              | 19.5                      | 19.5 | μs   |
| 19.2 Kbps             | 9.75                      | 9.75 | μs   |
| 38.4 Kbps             | 4.87                      | 4.87 | μs   |
| 57.6 Kbps             | 3.25                      | 3.25 | μs   |
| 115.2 Kbps            | 1.62                      | 1.62 | μs   |
| MIR                   |                           |      |      |
| 0.576 Mbps            | 414                       | 419  | ns   |
| 1.152 Mbps            | 206                       | 211  | ns   |
| FIR                   |                           |      |      |
| 4 Mbps (Single pulse) | 123                       | 128  | ns   |
| 4 Mbps (Double pulse) | 248                       | 253  | ns   |

## 6 Device and Documentation Support

### 6.1 Device Support

#### 6.1.1 Development Support

TI offers an extensive line of development tools, including tools to evaluate the performance of the processors, generate code, develop algorithm implementations, and fully integrate and debug software and hardware modules. The tool's support documentation is electronically available within the Code Composer Studio™ Integrated Development Environment (IDE).

The following products support development of AM335x device applications:

**Software Development Tools:** Code Composer Studio™ Integrated Development Environment (IDE): including Editor C/C++/Assembly Code Generation, and Debug plus additional development tools Scalable, Real-Time Foundation Software (DSP/BIOS™), which provides the basic run-time target software needed to support any AM335x device application.

**Hardware Development Tools:** Extended Development System (XDS™) Emulator

For a complete listing of development-support tools for the AM335x microprocessor platform, visit the Texas Instruments website at [www.ti.com](http://www.ti.com). For information on pricing and availability, contact the nearest TI field sales office or authorized distributor.

#### 6.1.2 Device Nomenclature

To designate the stages in the product development cycle, TI assigns prefixes to the part numbers of all microprocessors (MPUs) and support tools. Each device has one of three prefixes: X, P, or null (no prefix) (for example, XAM3358AZCE). 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 (TMDX) through fully qualified production devices and tools (TMDS).

Device development evolutionary flow:

- X** Experimental device that is not necessarily representative of the final device's electrical specifications and may not use production assembly flow.
- P** Prototype device that is not necessarily the final silicon die and may not necessarily meet final electrical specifications.
- null** Production version of the silicon die that is fully qualified.

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.

X and P devices and TMDX development-support tools are shipped against the following disclaimer:

"Developmental product is intended for internal evaluation purposes."

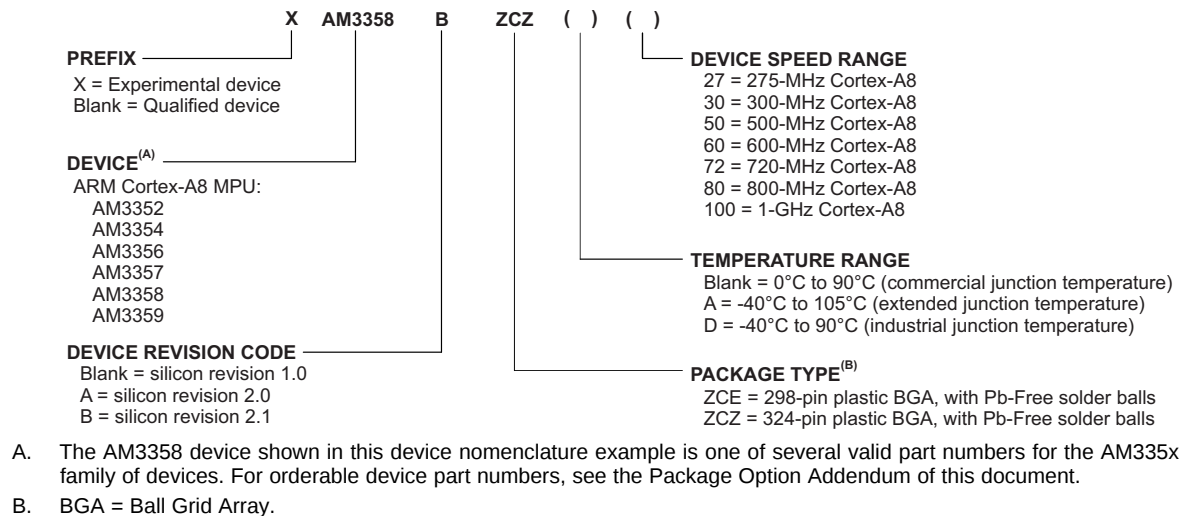
Production devices and TMDS development-support tools have been characterized fully, and the quality and reliability of the device have been demonstrated fully. TI's standard warranty applies.

Predictions show that prototype devices (X or P) 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.

TI device nomenclature also includes a suffix with the device family name. This suffix indicates the package type (for example, ZCE), the temperature range (for example, blank is the default commercial temperature range), and the device speed range, in megahertz (for example, 27 is 275 MHz). Figure 6-1 provides a legend for reading the complete device name for any AM335x device.

For orderable part numbers of AM335x devices in the ZCE and ZCZ package types, see the Package Option Addendum of this document, the TI website ([www.ti.com](http://www.ti.com)), or contact your TI sales representative.

For additional description of the device nomenclature markings on the die, see the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Silicon Errata* (literature number [SPRZ360](#)).



**Figure 6-1. AM335x Device Nomenclature**

## 6.2 Documentation Support

### 6.2.1 Related Documentation from Texas Instruments

The following documents describe the AM335x MPU. Copies of these documents are available on the Internet at [www.ti.com](http://www.ti.com). Tip: Enter the literature number in the search box.

The current documentation that describes the AM335x MPU, related peripherals, and other technical collateral, is available in the product folder at: [www.ti.com](http://www.ti.com).

**[SPRUH73](#) AM335x ARM Cortex-A8 Microprocessors (MPUs) Technical Reference Manual.** Collection of documents providing detailed information on the AM335x device including power, reset, and clock control, interrupts, memory map, and switch fabric interconnect. Detailed information on the microprocessor unit (MPU) subsystem as well as a functional description of the peripherals supported on AM335x devices is also included.

**[SPRZ360](#) AM335x ARM Cortex-A8 Microprocessors (MPUs) Silicon Errata.** Describes the known exceptions to the functional specifications for the AM335x ARM Cortex-A8 Microprocessors.

### 6.2.2 Community Resources

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

**[TI E2E Community](#) TI's Engineer-to-Engineer (E2E) Community.** Created to foster collaboration among engineers. At [e2e.ti.com](http://e2e.ti.com), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**[TI Embedded Processors Wiki](#) Texas Instruments Embedded Processors Wiki.** Established to help

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

### 6.2.3 Related Documentation from Other Sources

The following documents are related to the AM335x MPU. Copies of these documents can be obtained directly from the internet or from your Texas Instruments representative.

**Cortex-A8 Technical Reference Manual.** This is the technical reference manual for the Cortex-A8 processor. A copy of this document can be obtained via the internet at <http://infocenter.arm.com>. To determine the revision of the Cortex-A8 core used on your device, see the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Silicon Errata* (literature number [SPRZ360](#)).

**ARM Core Cortex™-A8 (AT400/AT401) Errata Notice.** Provides a list of advisories for the different revisions of the Cortex-A8 processor. Contact your TI representative for a copy of this document. To determine the revision of the Cortex-A8 core used on your device, see the *AM335x ARM Cortex-A8 Microprocessors (MPUs) Silicon Errata* (literature number [SPRZ360](#)).

## 7 Mechanical Packaging and Orderable Information

### 7.1 Thermal Data for ZCE and ZCZ Packages

Failure to maintain a junction temperature within the range specified in [Table 3-12](#) reduces operating lifetime, reliability, and performance—and may cause irreversible damage to the system. Therefore, the product design cycle should include thermal analysis to verify the maximum operating junction temperature of the device. It is important this thermal analysis is performed using specific system use cases and conditions. TI provides an application report to aid users in overcoming some of the existing challenges of producing a good thermal design. For more information, see *AM335x Thermal Considerations* (literature number [SPRABT1](#)).

[Table 7-1](#) provides thermal characteristics for the packages used on this device.

#### NOTE

[Table 7-1](#) provides simulation data and may not represent actual use-case values.

**Table 7-1. Thermal Resistance Characteristics (PBGA Package) [ZCE and ZCZ]**

| NAME          | DESCRIPTION                                   | AIR FLOW <sup>(1)</sup> | ZCE (°C/W) <sup>(2)</sup> | ZCZ (°C/W) <sup>(2)</sup> |
|---------------|-----------------------------------------------|-------------------------|---------------------------|---------------------------|
| $\Theta_{JC}$ | Junction-to-case (1S0P) <sup>(3)</sup>        | NA                      | 10.3                      | 10.2                      |
| $\Theta_{JB}$ | Junction-to-board (2S2P) <sup>(3)</sup>       | NA                      | 11.6                      | 12.1                      |
| $\Theta_{JA}$ | Junction-to-free air (2S2P) <sup>(3)</sup>    | 0.0                     | 24.7                      | 24.2                      |
|               |                                               | 1.0                     | 20.5                      | 20.1                      |
|               |                                               | 2.0                     | 19.7                      | 19.3                      |
|               |                                               | 3.0                     | 19.2                      | 18.8                      |
| $\Psi_{JT}$   | Junction-to-package top (2S2P) <sup>(3)</sup> | 0.0                     | 0.4                       | 0.3                       |
|               |                                               | 1.0                     | 0.6                       | 0.6                       |
|               |                                               | 2.0                     | 0.7                       | 0.7                       |
|               |                                               | 3.0                     | 0.9                       | 0.8                       |
| $\Psi_{JB}$   | Junction-to-board (2S2P) <sup>(3)</sup>       | 0.0                     | 11.9                      | 12.7                      |
|               |                                               | 1.0                     | 11.7                      | 12.3                      |
|               |                                               | 2.0                     | 11.7                      | 12.3                      |
|               |                                               | 3.0                     | 11.6                      | 12.2                      |

(1) m/s = meters per second.

(2) °C/W = degrees celsius per watt.

(3) The board types are defined by JEDEC (reference JEDEC standard JESD51-9, *Test Board for Area Array Surface Mount Package Thermal Measurements*).

### 7.2 Via Channel

The ZCE package has been specially engineered with Via Channel™ technology. This allows larger than normal PCB via and trace sizes and reduced PCB signal layers to be used in a PCB design with the 0.65-mm pitch package, and substantially reduces PCB costs. It allows PCB routing in only two signal layers (four layers total) due to the increased layer efficiency of the Via Channel™ BGA technology.

Via Channel™ technology implemented on the ZCE package makes it possible to build an AM335x-based product with a 4-layer PCB, but a 4-layer PCB may not meet system performance goals. Therefore, system performance using a 4-layer PCB design must be evaluated during product design.

### 7.3 Packaging Information

The following packaging information and addendum reflect the most current data available for the designated devices. This data is subject to change without notice and without revision of this document.

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| AM3352BZCE30     | ACTIVE        | NFBGA        | ZCE                | 298  | 160            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3352BZCE30            | <a href="#">Samples</a> |
| AM3352BZCE30R    | ACTIVE        | NFBGA        | ZCE                | 298  | 1000           | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  |              | AM3352BZCE30            | <a href="#">Samples</a> |
| AM3352BZCE60     | ACTIVE        | NFBGA        | ZCE                | 298  | 160            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3352BZCE60            | <a href="#">Samples</a> |
| AM3352BZCEA30    | ACTIVE        | NFBGA        | ZCE                | 298  | 160            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3352BZCEA30           | <a href="#">Samples</a> |
| AM3352BZCEA30R   | ACTIVE        | NFBGA        | ZCE                | 298  | 1000           | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3352BZCEA30           | <a href="#">Samples</a> |
| AM3352BZCEA60    | ACTIVE        | NFBGA        | ZCE                | 298  | 160            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3352BZCEA60           | <a href="#">Samples</a> |
| AM3352BZCEA60R   | ACTIVE        | NFBGA        | ZCE                | 298  | 1000           | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3352BZCEA60           | <a href="#">Samples</a> |
| AM3352BZCED30    | ACTIVE        | NFBGA        | ZCE                | 298  | 160            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3352BZCED30           | <a href="#">Samples</a> |
| AM3352BZCED60    | ACTIVE        | NFBGA        | ZCE                | 298  | 160            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3352BZCED60           | <a href="#">Samples</a> |
| AM3352BZCZ100    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3352BZCZ100           | <a href="#">Samples</a> |
| AM3352BZCZ30     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3352BZCZ30            | <a href="#">Samples</a> |
| AM3352BZCZ60     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3352BZCZ60            | <a href="#">Samples</a> |
| AM3352BZCZ80     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3352BZCZ80            | <a href="#">Samples</a> |
| AM3352BZCZA100   | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3352BZCZA100          | <a href="#">Samples</a> |
| AM3352BZCZA30    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3352BZCZA30           | <a href="#">Samples</a> |
| AM3352BZCZA60    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3352BZCZA60           | <a href="#">Samples</a> |
| AM3352BZCZA80    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3352BZCZA80           | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| AM3352BZCZD30    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3352BZCZD30           | <a href="#">Samples</a> |
| AM3352BZCZD60    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3352BZCZD60           | <a href="#">Samples</a> |
| AM3352BZCZD80    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3352BZCZD80           | <a href="#">Samples</a> |
| AM3354BZCE60     | ACTIVE        | NFBGA        | ZCE                | 298  | 160            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3354BZCE60            | <a href="#">Samples</a> |
| AM3354BZCEA60    | ACTIVE        | NFBGA        | ZCE                | 298  | 160            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3354BZCEA60           | <a href="#">Samples</a> |
| AM3354BZCED60    | ACTIVE        | NFBGA        | ZCE                | 298  | 160            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3354BZCED60           | <a href="#">Samples</a> |
| AM3354BZCZ100    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3354BZCZ100           | <a href="#">Samples</a> |
| AM3354BZCZ60     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3354BZCZ60            | <a href="#">Samples</a> |
| AM3354BZCZ80     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3354BZCZ80            | <a href="#">Samples</a> |
| AM3354BZCZA100   | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3354BZCZA100          | <a href="#">Samples</a> |
| AM3354BZCZA60    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3354BZCZA60           | <a href="#">Samples</a> |
| AM3354BZCZA80    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3354BZCZA80           | <a href="#">Samples</a> |
| AM3354BZCZA80R   | ACTIVE        | NFBGA        | ZCZ                | 324  | 1000           | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  |              | AM3354BZCZA80           | <a href="#">Samples</a> |
| AM3354BZCZD60    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3354BZCZD60           | <a href="#">Samples</a> |
| AM3354BZCZD80    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3354BZCZD80           | <a href="#">Samples</a> |
| AM3356BZCZ30     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3356BZCZ30            | <a href="#">Samples</a> |
| AM3356BZCZ60     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3356BZCZ60            | <a href="#">Samples</a> |
| AM3356BZCZ80     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3356BZCZ80            | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| AM3356BZCZA30    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3356BZCZA30           | <a href="#">Samples</a> |
| AM3356BZCZA60    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3356BZCZA60           | <a href="#">Samples</a> |
| AM3356BZCZA80    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3356BZCZA80           | <a href="#">Samples</a> |
| AM3356BZCZD30    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3356BZCZD30           | <a href="#">Samples</a> |
| AM3356BZCZD60    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3356BZCZD60           | <a href="#">Samples</a> |
| AM3357BZCZA30    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3357BZCZA30           | <a href="#">Samples</a> |
| AM3357BZCZA60    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3357BZCZA60           | <a href="#">Samples</a> |
| AM3357BZCZA80    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3357BZCZA80           | <a href="#">Samples</a> |
| AM3357BZCZD30    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3357BZCZD30           | <a href="#">Samples</a> |
| AM3357BZCZD60    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 90    | AM3357BZCZD60           | <a href="#">Samples</a> |
| AM3358BZCZ100    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3358BZCZ100           | <a href="#">Samples</a> |
| AM3358BZCZ60     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3358BZCZ60            | <a href="#">Samples</a> |
| AM3358BZCZ80     | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | 0 to 90      | AM3358BZCZ80            | <a href="#">Samples</a> |
| AM3358BZCZA100   | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3358BZCZA100          | <a href="#">Samples</a> |
| AM3358BZCZA80    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3358BZCZA80           | <a href="#">Samples</a> |
| AM3359BZCZA80    | ACTIVE        | NFBGA        | ZCZ                | 324  | 126            | Green (RoHS<br>& no Sb/Br) | SNAGCU                  | Level-3-260C-168 HR  | -40 to 105   | AM3359BZCZA80           | <a href="#">Samples</a> |

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

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

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

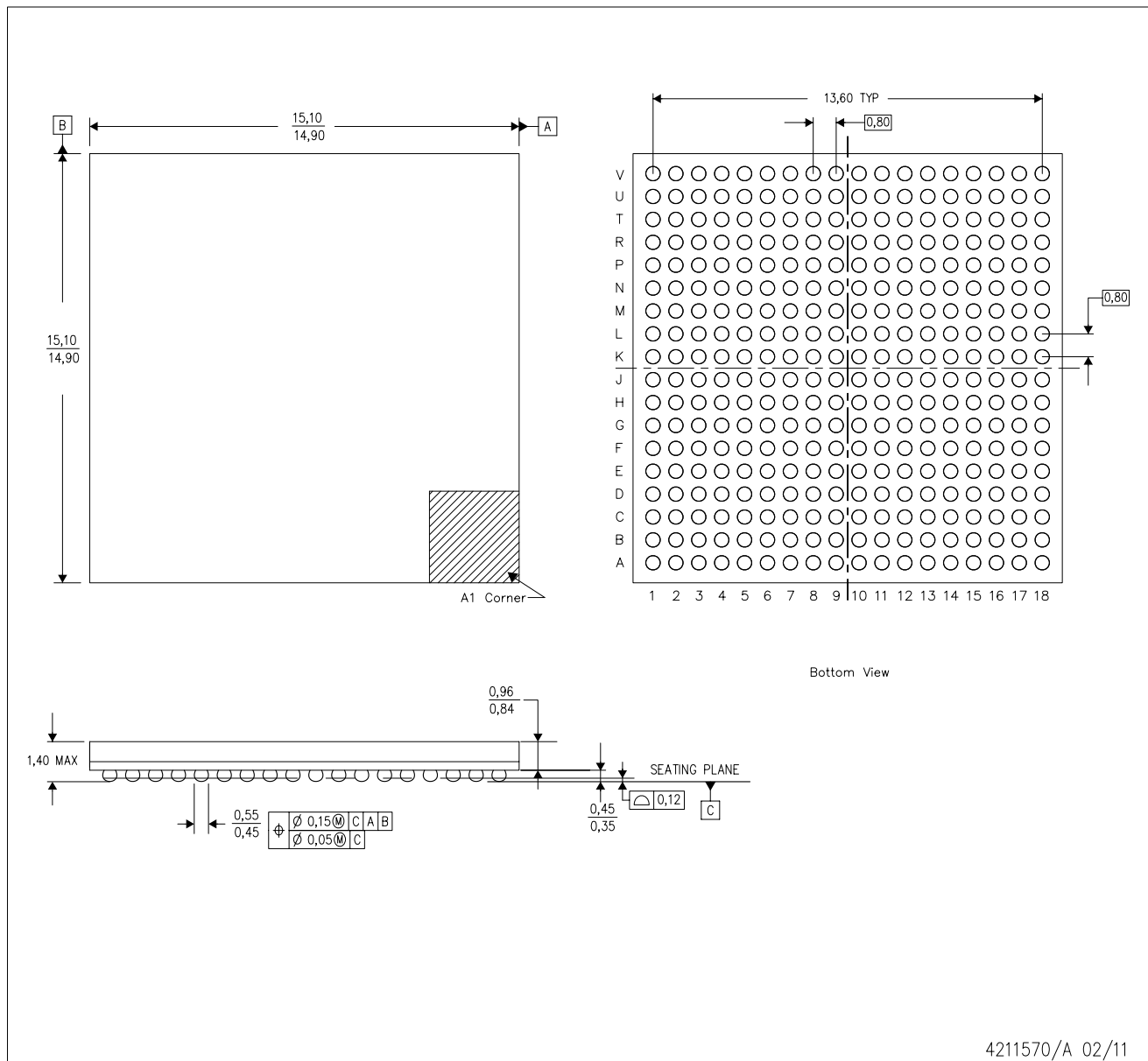
<sup>(6)</sup> Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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ZCZ (S-PBGA-N324)

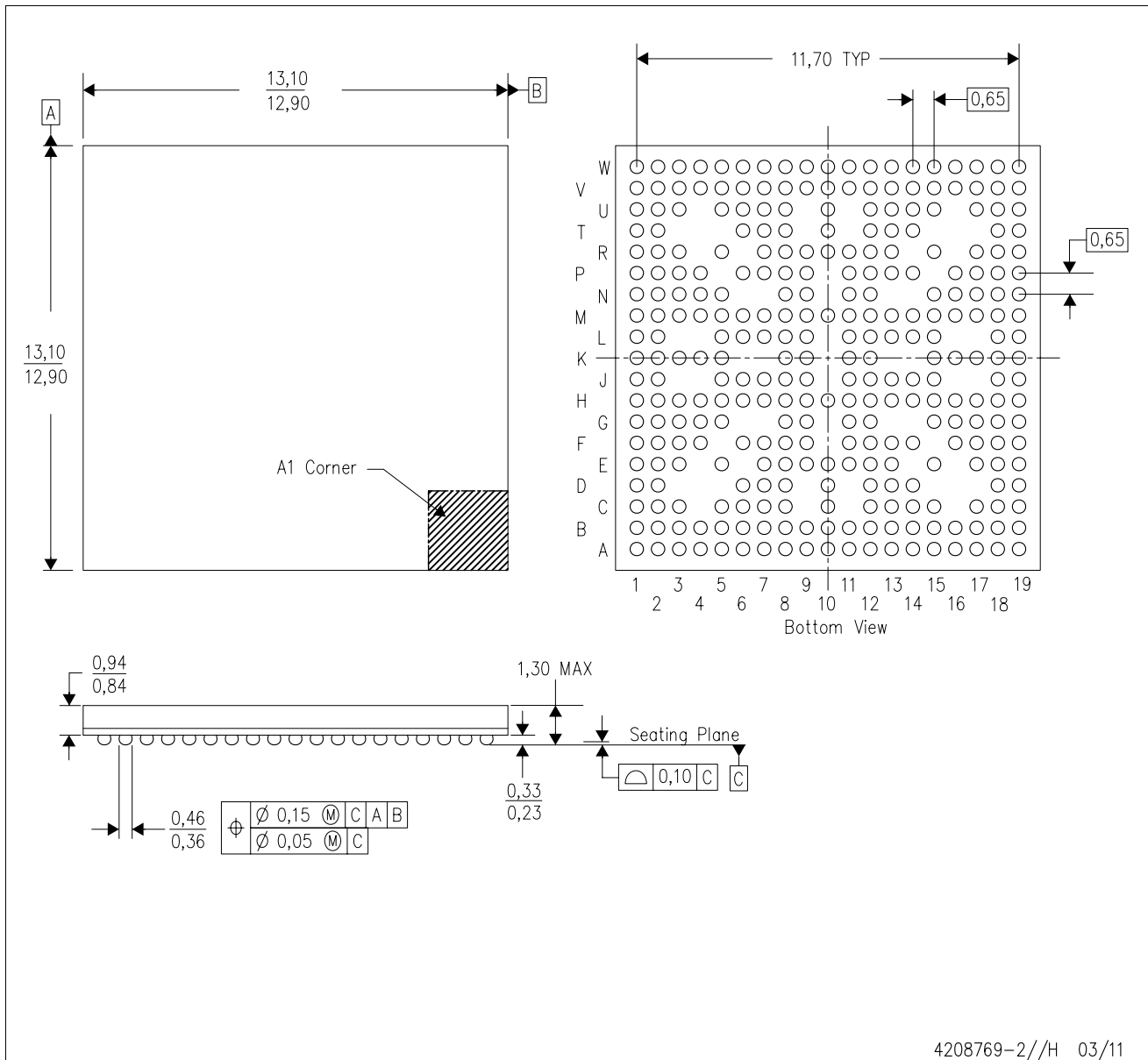
PLASTIC BALL GRID ARRAY



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. This is a Pb-free solder ball design.

ZCE (S-PBGA-N298)

# PLASTIC BALL GRID ARRAY



- NOTES: A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.  
B. This drawing is subject to change without notice.  
C. This is a Pb-free solder ball design.

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