

DRA72x Infotainment Applications Processor

Silicon Revision 2.0 and 2.1

1 Device Overview

1.1 Features

- Architecture designed for infotainment applications
- Video, image, and graphics processing support
 - Full-HD video (1920 × 1080p, 60 fps)
 - Multiple video inputs and video outputs
 - 2D and 3D graphics
- Arm[®] Cortex[®]-A15 microprocessor subsystem
- C66x floating-point VLIW DSP cores
 - Fully object-code compatible with C67x and C64x+
 - Up to thirty-two 16 × 16-bit fixed-point multiplies per cycle
- Up to 512KB of on-chip L3 RAM
- Level 3 (L3) and level 4 (L4) interconnects
- DDR3/DDR3L External Memory Interface (EMIF) module
 - Supports up to DDR3-1333 (667 MHz)
 - Up to 2GB across single chip select
- Dual Arm[®] Cortex[®]-M4 Image Processing Units (IPU)
- IVA-HD subsystem
- Display subsystem
 - Display controller with DMA engine and up to three pipelines
 - HDMI[™] encoder: HDMI 1.4a and DVI 1.0 compliant
- 2D-graphics accelerator (BB2D) subsystem
 - Vivante[®] GC320 core
- Video Processing Engine (VPE)
- Single-core PowerVR[™] SGX544 3D GPU
- One Video Input Port (VIP) module
 - Support for up to four multiplexed input ports
- General-Purpose Memory Controller (GPMC)
- Enhanced Direct Memory Access (EDMA) controller
- 2-Port Gigabit Ethernet switch
 - Up to two external ports
- Sixteen 32-bit general-purpose timers
- 32-bit MPU watchdog timer
- Six high speed Inter-Integrated Circuit (I²C[™]) ports
- HDQ/ 1-Wire[®] interface
- Ten configurable UART/IrDA/CIR modules
- Four Multichannel Serial Peripheral Interfaces (McSPI)
- Quad Serial Peripheral Interface (QSPI)
- Media Local Bus subsystem (MLBSS)
- Real-Time Clock subsystem (RTCSS)
- SATA interface
- Eight Multichannel Audio Serial Port (McASP) modules
- SuperSpeed USB 3.0 dual-role device
- High Speed USB 2.0 dual-role device
- High Speed USB 2.0 on-the-go
- Four MultiMedia Card/ Secure Digital[®]/Secure Digital Input Output interfaces (MMC[™]/SD[®]/SDIO)
- PCI-Express[®] (PCIe[®]) revision 3.0 subsystems with two 5-Gbps lanes
 - One 2-lane Gen2-compliant port
 - or two 1-lane Gen2-compliant ports
- Dual Controller Area Network (DCAN) modules
 - CAN 2.0B Protocol
- MIPI[®] Camera Serial Interface 2 (CSI-2)
- Up to 215 General-Purpose I/O (GPIO) pins
- Device security features
 - Hardware crypto accelerators and DMA
 - Firewalls
 - JTAG lock
 - Secure keys
 - Secure ROM and Boot
 - Customer programmable keys (Silicon Revision 2.1)
- Power, reset, and clock management
- On-chip debug with CTools technology
- 28-nm CMOS technology
- 23 mm × 23 mm, 0.8-mm Pitch, 760-Pin BGA (ABC)



1.2 Applications

- Human-Machine Interface (HMI)
- Navigation
- Digital and analog radio
- Rear seat entertainment
- Multimedia playback
- AM/FM/RDS and digital radio decoding
- ADAS and Jacinto 6 integration

1.3 Description

DRA72x (" Jacinto™ 6 Eco") infotainment applications processors are developed on the same architecture as Jacinto 6 devices to meet the intense processing needs of the modern infotainment-enabled automobile experiences.

DRA72x devices offer upward scalability to DRA74x devices, while being pin-compatible across the family, allowing Original-Equipment Manufacturers (OEMs) and Original-Design Manufacturers (ODMs) to quickly implement innovative connectivity technologies, speech recognition, audio streaming, and more. Jacinto 6 and Jacinto 6 Eco devices bring high processing performance through the maximum flexibility of a fully integrated mixed processor solution.

Programmability is provided by a single-core Arm® Cortex®-A15 RISC CPU with Neon™ extensions and a TI C66x VLIW floating-point DSP core. The Arm® processor lets developers keep control functions separate from other algorithms programmed on the DSP and coprocessors, thus reducing the complexity of the system software.

Additionally, TI provides a complete set of development tools for the Arm®, and DSP, including C compilers and a debugging interface for visibility into source code execution.

Cryptographic acceleration is available in all devices. All other supported security features, including support for secure boot, debug security and support for trusted execution environment is available on High-Security (HS) devices. For more information about HS devices, contact your TI representative.

The DRA72x Jacinto 6 Eco processor family is qualified according to the AEC-Q100 standard.

Device Information⁽¹⁾

| PART NUMBER | PACKAGE | BODY SIZE |
|-------------|-------------|-------------------|
| DRA722ABC | FCBGA (760) | 23.0 mm × 23.0 mm |
| DRA724ABC | FCBGA (760) | 23.0 mm × 23.0 mm |
| DRA725ABC | FCBGA (760) | 23.0 mm × 23.0 mm |
| DRA726ABC | FCBGA (760) | 23.0 mm × 23.0 mm |

(1) For more information, see [Section 10, Mechanical, Packaging, and Orderable Information](#).

1.4 Functional Block Diagram

Figure 1-1 is functional block diagram for the device.

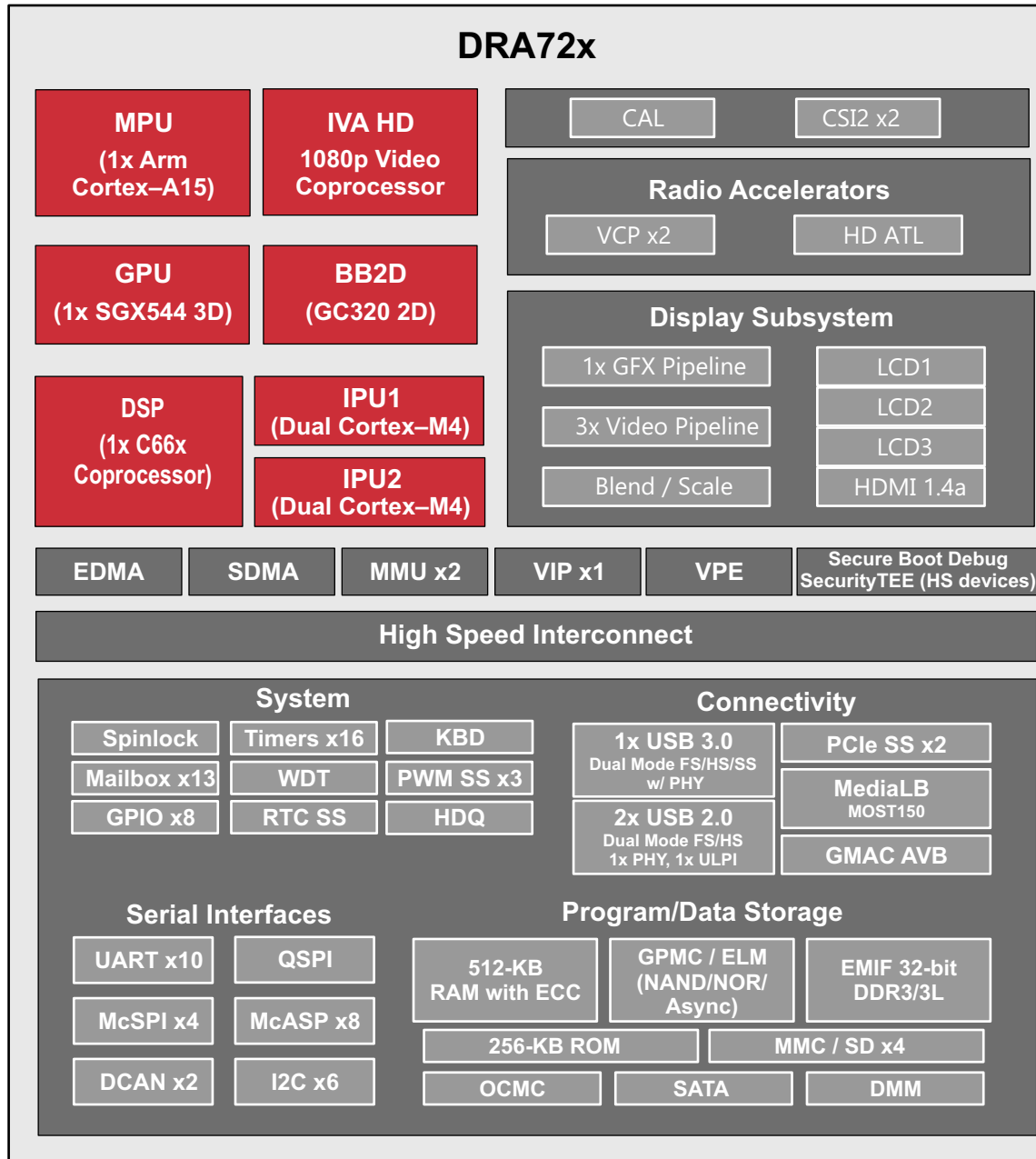


Figure 1-1. DRA72x Block Diagram

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2 Revision History

Changes from June 8, 2018 to February 15, 2019 (from F Revision (June 2018) to G Revision)
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| | |
|--|---------------------|
| • Added Device Security Features for Silicon revision 2.1 in Section 1.1, Features | 1 |
| • Added vpp details for Silicon revision 2.1 in Table 4-1, Unused Balls Specific Connection Requirements , Table 4-2, Ball Characteristics and Table 4-35, Power Supply Signal Descriptions | 9 |
| • Updated porz, resetn and rstoutn signal descriptions in Table 4-30, PRCM Signal Descriptions | 120 |
| • Added clarification note regarding TSHUT feature in Table 5-4, Recommended Operating Conditions | 132 |
| • Updated OPP_HIGH power supply value in note (6) under Table 5-7, Voltage Domains Operating Performance Points | 133 |
| • Updated SYS_32K to FUNC_32K_CLK in Table 5-9, Maximum Supported Frequency | 134 |
| • Added Section 5.8, VPP Specifications for One-Time Programmable (OTP) eFuses for Silicon revision 2.1 | 162 |
| • Updated Section 5.10, Power Supply Sequences | 164 |
| • Updated system clock names in Section 6, Clock Specifications | 173 |
| • Added Section 8.3.7, Loss of Input Power Event | 347 |
| • Updated note for cosmetic marks on package..... | 400 |
| • Added Silicon revision 2.1 in support in Table 9-1, Nomenclature Description | 401 |

Changes from February 16, 2019 to November 15, 2019 (from G Revision (February 2019) to H Revision)
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| | |
|---|---------------------|
| • Added reminders to disable unused pulls and RX pads in Section 4.2, Ball Characteristics | 10 |
| • Removed uart2_rxd for Muxmode 0 | 12 |
| • Added clarification notes for EMU[1:0] connections in Table 4-24, GPIOs Signal Descriptions and Table 4-28, Debug Signal Descriptions | 111 |
| • Updated clock names in Table 5-9, Maximum Supported Frequency | 134 |
| • Updated EMIF_DLL_FCLK max rate in Table 6-15, DLL Characteristics | 186 |
| • Updated GPMC timing table footnotes..... | 223 |
| • Updated timing specification values for GPMC and MMC | 224 |
| • Updated information about WD_TIMER1 in Section 7.12, Timers | 246 |
| • Updated parameter number in Table 7-46, Timing Requirements for QSPI | 261 |
| • Added MII_TXER timing to Section 7.23.1, GMAC MII Timings | 288 |
| • Updated MDIO Timing Diagram and MDIO7 parameter values in Section 7.23.2, GMAC MDIO Interface Timings | 290 |
| • Updated Delay time for MMC2 in Table 7-119, Switching Characteristics for MMC2 - JC64 High Speed DDR Mode | 313 |
| • Added note regarding DDR ECC solutions to Table 8-30, Supported DDR3 Device Combinations | 377 |
| • Added clarifications about validated DDR topology | 386 |

3 Device Comparison

Table 3-1 shows a comparison between devices, highlighting the differences.

Table 3-1. Device Comparison

| FEATURES | | DEVICE | | | |
|--|---------------------------|-------------------------------------|-----------------|-----------------|-----------------|
| | | DRA722 | DRA724 | DRA725 | DRA726 |
| Features | | | | | |
| CTRL_WKUP_STD_FUSE_DIE_ID_2[31:24] Base PN register bit field value ⁽²⁾ | | DRA722: 0 (0x0) | DRA724: 1 (0x1) | DRA725: 2 (0x2) | DRA726: 4 (0x4) |
| Processors/Accelerators | | | | | |
| Speed Grades | | H | J | L | P |
| Arm Single Cortex-A15 Microprocessor (MPU) Subsystem | MPU core 0 | Yes | | | |
| C66x VLIW DSP | DSP1 | Yes | | | |
| BitBLT 2D Hardware Acceleration Engine (BB2D) | BB2D | Yes | | | |
| Display Subsystem | VOUT1 | Yes | | | |
| | VOUT2 | Yes | | | |
| | VOUT3 | Yes | | | |
| | HDMI | Yes | | | |
| Dual Arm Cortex-M4 Image Processing Unit (IPU) | IPU1 | Yes | | | |
| | IPU2 | Yes | | | |
| Image Video Accelerator (IVA) | IVA | Yes | | | |
| SGX544 Single-Core 3D Graphics Processing Unit (GPU) | GPU | Yes | | | |
| Video Input Port (VIP) | VIP1 | vin1a | Yes | | |
| | | vin1b | Yes | | |
| | | vin2a | Yes | | |
| | | vin2b | Yes | | |
| Video Processing Engine (VPE) | VPE | Yes | | | |
| Program/Data Storage | | | | | |
| On-Chip Shared Memory (RAM) | OCMC_RAM1 | 512KB | | | |
| General-Purpose Memory Controller (GPMC) | GPMC | Yes | | | |
| DDR3 Memory Controller | EMIF1 | up to 2GB across single chip select | | | |
| | SECDED/ECC ⁽¹⁾ | No | | | |
| Dynamic Memory Manager (DMM) | DMM | Yes | | | |
| Radio Support | | | | | |
| Audio Tracking Logic (ATL) | ATL | Yes | | | |
| Viterbi Coprocessor (VCP) | VCP1 | Yes | | | |
| | VCP2 | Yes | | | |
| Peripherals | | | | | |
| Dual Controller Area Network (DCAN) Interface | DCAN1 | Yes | | | |
| | DCAN2 | Yes | | | |
| Enhanced DMA (EDMA) | EDMA | Yes | | | |
| System DMA (DMA_SYSTEM) | DMA_SYSTEM | Yes | | | |
| Ethernet Subsystem (Ethernet SS) | GMAC_SW[0] | MII, RMII, or RGMII | | | |
| | GMAC_SW[1] | MII, RMII, or RGMII | | | |
| General-Purpose I/O (GPIO) | GPIO | Up to 215 | | | |
| Inter-Integrated Circuit (I2C) Interface | I2C | 6 | | | |
| System Mailbox Module | MAILBOX | 13 | | | |
| Media Local Bus Subsystem (MLBSS) | MLB | Yes | | | |

Table 3-1. Device Comparison (continued)

| FEATURES | | DEVICE | | | |
|--|---|---|--------|--------|--------|
| | | DRA722 | DRA724 | DRA725 | DRA726 |
| Camera Adaptation Layer (CAL) Camera Serial Interface 2 (CSI2) | CSI2_0 | 1 CLK + 4 Data | | | |
| | CSI2_1 | 1 CLK + 2 Data | | | |
| Multichannel Audio Serial Port (McASP) | McASP1 | 16 serializers | | | |
| | McASP2 | 16 serializers | | | |
| | McASP3 | 4 serializers | | | |
| | McASP4 | 4 serializers | | | |
| | McASP5 | 4 serializers | | | |
| | McASP6 | 4 serializers | | | |
| | McASP7 | 4 serializers | | | |
| | McASP8 | 4 serializers | | | |
| MultiMedia Card/Secure Digital/Secure Digital Input Output Interface (MMC/SD/SDIO) | MMC1 | 1x UHSI 4b | | | |
| | MMC2 | 1x eMMC™ 8b | | | |
| | MMC3 | 1x SDIO 8b | | | |
| | MMC4 | 1x SDIO 4b | | | |
| PCI-Express 3.0 Port with Integrated PHY | PCIe_SS1 | Up to two lanes (second lane shared with PCIe_SS2 and USB1) | | | |
| | PCIe_SS2 | Single lane (shared with PCIe_SS1 and USB1) | | | |
| Serial Advanced Technology Attachment (SATA) | SATA | Yes | | | |
| Real-Time Clock Subsystem (RTCSS) | RTCSS | Yes | | | |
| Multichannel Serial Peripheral Interface (McSPI) | McSPI | 4 | | | |
| HDQ1W | HDQ1W | Yes | | | |
| Quad SPI (QSPI) | QSPI | Yes | | | |
| Spinlock Module | SPINLOCK | Yes | | | |
| Keyboard Controller (KBD) | KBD | Yes | | | |
| Timers, General-Purpose | TIMERS GP | 16 | | | |
| Timer, Watchdog | WD TIMER | Yes | | | |
| Pulse-Width Modulation Subsystem (PWMSS) | PWMSS1 | Yes | | | |
| | PWMSS2 | Yes | | | |
| | PWMSS3 | Yes | | | |
| Universal Asynchronous Receiver/Transmitter (UART) | UART | 10 | | | |
| Universal Serial Bus (USB3.0) | USB1 (SuperSpeed, Dual-Role-Device [DRD]) | Yes | | | |
| Universal Serial Bus (USB2.0) | USB2 (High Speed, Dual-Role-Device [DRD], with embedded HS PHY) | Yes | | | |
| | USB3 (High Speed, OTG2.0, with ULPI) | Yes | | | |
| | USB4 (High Speed, OTG2.0, with ULPI) | No | | | |

(1) ECC is not available on this device, but signal names are retained for consistency with the DRA7xx family of devices.

(2) For more details about the CTRL_WKUP_STD_FUSE_DIE_ID_2 register and Base PN bit field, see the *DRA72x Technical Reference Manual*.

3.1 Related Products

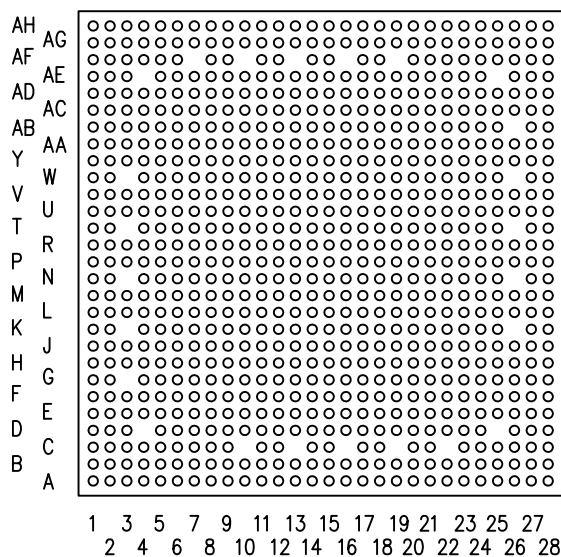
Automotive Processors

DRAx Infotainment SoCs The "Jacinto 6" family of infotainment processors (DRA7xx), paired with robust software and ecosystem offering bring unprecedented feature-rich, in-vehicle infotainment, instrument cluster and telematics features to the next generation automobiles.

4 Terminal Configuration and Functions

4.1 Terminal Assignment

Figure 4-1 shows the ball locations for the 760 plastic ball grid array (PBGA) package and is used in conjunction with Table 4-2 through Table 4-35 to locate signal names and ball grid numbers.



SPRS906_BALL_01

Figure 4-1. ABC S-PBGA-N760 Package (Bottom View)

NOTE

The following bottom balls are not pinned out: AF7, AF10, AF13, AF16, AF19, AE4, AE25, AB26, W3, W26, T3, T26, N3, N26, K3, K26, G3, D4, D25, C10, C13, C16, C19, C22.

These balls do not exist on the package.

NOTE

The following bottom balls are not connected: AH11, AH12, AG2, AG8, AG11, AG12, AF4, AF6, AF8, AF9, AE3, AE5, AE6, AE8, AE9, AD3, AD8, AD9, Y15, Y16, V18, V19, U18, U19, U22, U23, U24, U25, U26, U27, U28, T22, T23, T27, T28, R20, R22, R23, R24, R25, R26, R27, R28, P19, P22, P23, P24, P25, P26, P27, N20, N22, N23, N27, N28, M20, M21, M22, M23, M24, M25, M26, M27, M28, L20, L21, L22, L23, L24, L25, L26, L27, L28, K20, K21, K22, K23, K27, K28, J20, J21, J22, J23, J24, J25, J26, J27, H20, H21, H22, H23, H24, H25, H26, H27, H28, G22, G23, G24, G25, G26, G27, G28, F24, F25, F26, F27, F28, E24, E26, E27, E28.

These balls can be connected as desired, including to VSS. For users designing DRA74x / DRA75x compatible PCB, please refer to DRA75x/DRA74x Data Manual for appropriate requirements.

4.1.1 Unused Balls Connection Requirements

This section describes the connection requirements of the unused and reserved balls.

NOTE

The following balls are reserved: A27, Y5, Y10, B28

These balls must be left unconnected.

NOTE

All unused power supply balls must be supplied with the voltages specified in the [Section 5.4, Recommended Operating Conditions](#), unless alternative tie-off options are included in [Section 4.4, Signal Descriptions](#).

Table 4-1. Unused Balls Specific Connection Requirements

| BALLS | CONNECTION REQUIREMENTS |
|--|--|
| AE15 , AC15 , AE14 , D20 , AD17 , AC16 , V27 , AH25 , AE27 , AD27 , Y28 | These balls must be connected to GND through an external pull resistor if unused. |
| E20 , D21 , E23 , C20 , C21 , V28 , F18 , AG25 , AE28 , AD28 , Y27 , F17 , C25 | These balls must be connected to the corresponding power supply through an external pull resistor if unused. |
| K14 (vpp) | This ball must be left unconnected if unused |
| AF14 (rtc_iso) | This ball should be connected to the corresponding power supply through an external pull resistor if unused; or can be connected to F22 (porz) when RTC unused (level translation may be needed) |
| AB17 (rtc_porz) | This ball should be connected to VSS when RTC is unused; or can be connected to F22 (porz) when RTC unused (level translation may be needed) |

NOTE

All other unused signal balls **with** a Pad Configuration register can be left unconnected with their internal pullup or pulldown resistor enabled.

NOTE

All other unused signal balls **without** a Pad Configuration register can be left unconnected.

4.2 Ball Characteristics

[Table 4-2](#) describes the terminal characteristics and the signals multiplexed on each ball. The following list describes the table column headers:

- BALL NUMBER:**This column lists ball numbers on the bottom side associated with each signal on the bottom.
- BALL NAME:** This column lists mechanical name from package device (name is taken from muxmode 0).
- SIGNAL NAME:**This column lists names of signals multiplexed on each ball (also notice that the name of the ball is the signal name in muxmode 0).

NOTE

[Table 4-2](#) does not take into account the subsystem multiplexing signals. Subsystem multiplexing signals are described in [Section 4.4, Signal Descriptions](#).

NOTE

In driver off mode, the buffer is configured in high-impedance.

NOTE

In some cases [Table 4-2](#) may present more than one signal name per muxmode for the same ball. First signal in the list is the dominant function as selected via CTRL_CORE_PAD_* register.

All other signals are virtual functions that present alternate multiplexing options. This virtual functions are controlled via CTRL_CORE_ALT_SELECT_MUX or CTRL_CORE_VIP_MUX_SELECT register. For more information on how to use these options, see *Pad Configuration Registers* section, *Control Module* chapter in the device TRM.

4. MUXMODE: Multiplexing mode number:

- a. MUXMODE 0 is the primary mode; this means that when MUXMODE=0 is set, the function mapped on the pin corresponds to the name of the pin. The primary muxmode is not necessarily the default muxmode.
-

NOTE

The default mode is the mode at the release of the reset; also see the RESET REL. MUXMODE column.

- b. MUXMODE 1 through 15 are possible muxmodes for alternate functions. On each pin, some muxmodes are effectively used for alternate functions, while some muxmodes are not used. Only MUXMODE values which correspond to defined functions should be used.
- c. An empty box means Not Applicable.

5. TYPE: Signal type and direction:

- I = Input
 - O = Output
 - IO = Input or Output
 - D = Open drain
 - DS = Differential Signaling
 - A = Analog
 - PWR = Power
 - GND = Ground
 - CAP = LDO Capacitor
-

NOTE

The RX buffer within the pad logic should be disabled on all pins that are not being used as an input. For more information, see the *Control Module / Control Module Functional Description / PAD Functional Multiplexing and Configuration* section in the device TRM.

6. BALL RESET STATE: The state of the terminal at power-on reset:

- drive 0 (OFF): The buffer drives V_{OL} (pulldown or pullup resistor not activated)
- drive 1 (OFF): The buffer drives V_{OH} (pulldown or pullup resistor not activated)
- OFF: High-impedance
- PD: High-impedance with an active pulldown resistor
- PU: High-impedance with an active pullup resistor
- An empty box means Not Applicable

NOTE

Designs that contain pullup or pulldown resistors, either on the board or in attached devices that oppose internal pullup or pulldown resistors, that are active while the device is held in reset, must not remain in reset for long periods of time.

7. **BALL RESET REL. STATE:** The state of the terminal at the deactivation of the rstoutn signal (also mapped to the PRCM SYS_WARM_OUT_RST signal)
- drive 0 (OFF): The buffer drives V_{OL} (pulldown or pullup resistor not activated)
 - drive clk (OFF): The buffer drives a toggling clock (pulldown or pullup resistor not activated)
 - drive 1 (OFF): The buffer drives V_{OH} (pulldown or pullup resistor not activated)
 - OFF: High-impedance
 - PD: High-impedance with an active pulldown resistor
 - PU: High-impedance with an active pullup resistor
 - An empty box means Not Applicable
-

NOTE

For more information on the CORE_PWRON_RET_RST reset signal and its reset sources, see *Power, Reset, and Clock Management* chapter in the device TRM.

8. **BALL RESET REL. MUXMODE:** This muxmode is automatically configured at the release of the rstoutn signal (also mapped to the PRCM SYS_WARM_OUT_RST signal).
An empty box means Not Applicable.
9. **IO VOLTAGE VALUE:** This column describes the IO voltage value (VDDS supply).
An empty box means Not Applicable.
10. **POWER:** The voltage supply that powers the terminal IO buffers.
An empty box means Not Applicable.
11. **HYS:** Indicates if the input buffer is with hysteresis:
- Yes: With hysteresis
 - No: Without hysteresis
 - An empty box: Not Applicable
-

NOTE

For more information, see the hysteresis values in [Section 5.7](#), *Electrical Characteristics*.

12. **BUFFER TYPE:** Drive strength of the associated output buffer.
An empty box means Not Applicable.
-

NOTE

For programmable buffer strength:

- The default value is given in [Table 4-2](#).
 - A note describes all possible values according to the selected muxmode.
-

13. **PULLUP / PULLDOWN TYPE:** Denotes the presence of an internal pullup or pulldown resistor. Pullup and pulldown resistors can be enabled or disabled via software.
- PU: Internal pullup
 - PD: Internal pulldown
 - PU/PD: Internal pullup and pulldown
 - PUx/PDy: Programmable internal pullup and pulldown
 - PDy: Programmable internal pulldown
 - An empty box means No pull

NOTE

Internal pullup or pulldown resistors must be disabled when opposed by an external pullup or pulldown resistor on the board or within an attached device.

14. **DSIS:** The deselected input state (DSIS) indicates the state driven on the peripheral input (logic "0" or logic "1") when the peripheral pin function is not selected by any of the PINCNTLx registers.
- 0: Logic 0 driven on the peripheral's input signal port.
 - 1: Logic 1 driven on the peripheral's input signal port.
 - blank: Pin state driven on the peripheral's input signal port.
-

NOTE

Configuring two pins to the same input signal is not supported as it can yield unexpected results. This can be easily prevented with the proper software configuration (Hi-Z mode is not an input signal).

NOTE

When a pad is set into a multiplexing mode which is not defined by pin multiplexing, that pad's behavior is undefined. This should be avoided.

NOTE

Some of the EMIF1 signals have an additional state change at the release of porz. The state that the signals change to at the release of porz is as follows:

drive 0 (OFF) for: ddr1_csn0, ddr1_ck, ddr1_nck, ddr1_casn, ddr1_rasn, ddr1_wen, ddr1_ba[2:0], ddr1_a[15:0].

OFF for: ddr1_ecc_d[7:0], ddr1_dqm[3:0], ddr1_dqm_ecc, ddr1_dqs[3:0], ddr1_dqsn[3:0], ddr1_dqs_ecc, ddr1_dqsn_ecc, ddr1_d[31:0].

NOTE

ECC is not available on this device, but signal names are retained for consistency with the DRA7xx family of devices.

NOTE

Dual rank support is not available on this device, but signal names are retained for consistency with the DRA7xx family of devices.

Table 4-2. Ball Characteristics⁽¹⁾

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|------------------|------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|------------------|------------------------|-----------|
| K9 | cap_vbbldo_dsp | cap_vbbldo_dsp | | CAP | | | | | | | | | |
| Y14 | cap_vbbldo_gpu | cap_vbbldo_gpu | | CAP | | | | | | | | | |
| J10 | cap_vbbldo_iva | cap_vbbldo_iva | | CAP | | | | | | | | | |
| J16 | cap_vbbldo_mpu | cap_vbbldo_mpu | | CAP | | | | | | | | | |
| T20 | cap_vddram_core1 | cap_vddram_core1 | | CAP | | | | | | | | | |
| L9 | cap_vddram_core3 | cap_vddram_core3 | | CAP | | | | | | | | | |
| J19 | cap_vddram_core4 | cap_vddram_core4 | | CAP | | | | | | | | | |
| J9 | cap_vddram_dsp | cap_vddram_dsp | | CAP | | | | | | | | | |
| Y13 | cap_vddram_gpu | cap_vddram_gpu | | CAP | | | | | | | | | |
| K16 | cap_vddram_iva | cap_vddram_iva | | CAP | | | | | | | | | |
| K19 | cap_vddram_mpu | cap_vddram_mpu | | CAP | | | | | | | | | |
| AE1 | csi2_0_dx0 | csi2_0_dx0 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AF1 | csi2_0_dx1 | csi2_0_dx1 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AF2 | csi2_0_dx2 | csi2_0_dx2 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AH4 | csi2_0_dx3 | csi2_0_dx3 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AH3 | csi2_0_dx4 | csi2_0_dx4 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AD2 | csi2_0_dy0 | csi2_0_dy0 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AE2 | csi2_0_dy1 | csi2_0_dy1 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AF3 | csi2_0_dy2 | csi2_0_dy2 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AG4 | csi2_0_dy3 | csi2_0_dy3 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AG3 | csi2_0_dy4 | csi2_0_dy4 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AG5 | csi2_1_dx0 | csi2_1_dx0 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AG6 | csi2_1_dx1 | csi2_1_dx1 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AH7 | csi2_1_dx2 | csi2_1_dx2 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AH5 | csi2_1_dy0 | csi2_1_dy0 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AH6 | csi2_1_dy1 | csi2_1_dy1 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |
| AG7 | csi2_1_dy2 | csi2_1_dy2 | 0 | I | | | | 1.8 | vdda_csi | Yes | LVC MOS CS12 | PU/PD | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| G19 | dcan1_rx | dcan1_rx | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart8_txd | 2 | O | | | | | | | | | 0 |
| | | mmc2_sdwp | 3 | I | | | | | | | | | |
| | | sata1_led | 4 | O | | | | | | | | | |
| | | hdmi1_cec | 6 | IO | | | | | | | | | |
| | | gpio1_15 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| G20 | dcan1_tx | dcan1_tx | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart8_rxd | 2 | I | | | | | | | | | 1 |
| | | mmc2_sdcld | 3 | I | | | | | | | | | 1 |
| | | hdmi1_hpd | 6 | IO | | | | | | | | | |
| | | gpio1_14 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | AD20 | ddr1_a0 | ddr1_a0 | | | | | | | | | 0 |
| AC19 | ddr1_a1 | ddr1_a1 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AC20 | ddr1_a2 | ddr1_a2 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AB19 | ddr1_a3 | ddr1_a3 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AF21 | ddr1_a4 | ddr1_a4 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AH22 | ddr1_a5 | ddr1_a5 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AG23 | ddr1_a6 | ddr1_a6 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AE21 | ddr1_a7 | ddr1_a7 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AF22 | ddr1_a8 | ddr1_a8 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AE22 | ddr1_a9 | ddr1_a9 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AD21 | ddr1_a10 | ddr1_a10 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AD22 | ddr1_a11 | ddr1_a11 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AC21 | ddr1_a12 | ddr1_a12 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AF18 | ddr1_a13 | ddr1_a13 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |
| AE17 | ddr1_a14 | ddr1_a14 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVCMOS DDR | PuX/PDy | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|------------------|------------------------|-----------|
| AD18 | ddr1_a15 | ddr1_a15 | 0 | O | PD | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AF17 | ddr1_ba0 | ddr1_ba0 | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AE18 | ddr1_ba1 | ddr1_ba1 | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AB18 | ddr1_ba2 | ddr1_ba2 | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AC18 | ddr1_casn | ddr1_casn | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AG24 | ddr1_ck | ddr1_ck | 0 | O | PD | drive 0 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AG22 | ddr1_cke | ddr1_cke | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AH23 | ddr1_csn0 | ddr1_csn0 | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AB16 | ddr1_csn1 | ddr1_csn1 | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AF25 | ddr1_d0 | ddr1_d0 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AF26 | ddr1_d1 | ddr1_d1 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AG26 | ddr1_d2 | ddr1_d2 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AH26 | ddr1_d3 | ddr1_d3 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AF24 | ddr1_d4 | ddr1_d4 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AE24 | ddr1_d5 | ddr1_d5 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AF23 | ddr1_d6 | ddr1_d6 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AE23 | ddr1_d7 | ddr1_d7 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AC23 | ddr1_d8 | ddr1_d8 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AF27 | ddr1_d9 | ddr1_d9 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AG27 | ddr1_d10 | ddr1_d10 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AF28 | ddr1_d11 | ddr1_d11 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AE26 | ddr1_d12 | ddr1_d12 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AC25 | ddr1_d13 | ddr1_d13 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|------------------|------------------------|-----------|
| AC24 | ddr1_d14 | ddr1_d14 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AD25 | ddr1_d15 | ddr1_d15 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| V20 | ddr1_d16 | ddr1_d16 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| W20 | ddr1_d17 | ddr1_d17 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AB28 | ddr1_d18 | ddr1_d18 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AC28 | ddr1_d19 | ddr1_d19 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AC27 | ddr1_d20 | ddr1_d20 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| Y19 | ddr1_d21 | ddr1_d21 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AB27 | ddr1_d22 | ddr1_d22 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| Y20 | ddr1_d23 | ddr1_d23 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AA23 | ddr1_d24 | ddr1_d24 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| Y22 | ddr1_d25 | ddr1_d25 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| Y23 | ddr1_d26 | ddr1_d26 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AA24 | ddr1_d27 | ddr1_d27 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| Y24 | ddr1_d28 | ddr1_d28 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AA26 | ddr1_d29 | ddr1_d29 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AA25 | ddr1_d30 | ddr1_d30 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AA28 | ddr1_d31 | ddr1_d31 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AD23 | ddr1_dqm0 | ddr1_dqm0 | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AB23 | ddr1_dqm1 | ddr1_dqm1 | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AC26 | ddr1_dqm2 | ddr1_dqm2 | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AA27 | ddr1_dqm3 | ddr1_dqm3 | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| V26 | ddr1_dqm_ecc | ddr1_dqm_ecc | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|------------------|------------------------|-----------|
| AH25 | ddr1_dqs0 | ddr1_dqs0 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| AE27 | ddr1_dqs1 | ddr1_dqs1 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| AD27 | ddr1_dqs2 | ddr1_dqs2 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| Y28 | ddr1_dqs3 | ddr1_dqs3 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| AG25 | ddr1_dqsn0 | ddr1_dqsn0 | 0 | IO | PU | PU | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| AE28 | ddr1_dqsn1 | ddr1_dqsn1 | 0 | IO | PU | PU | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| AD28 | ddr1_dqsn2 | ddr1_dqsn2 | 0 | IO | PU | PU | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| Y27 | ddr1_dqsn3 | ddr1_dqsn3 | 0 | IO | PU | PU | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| V28 | ddr1_dqsn_ecc | ddr1_dqsn_ecc | 0 | IO | PU | PU | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| V27 | ddr1_dqs_ecc | ddr1_dqs_ecc | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | | LVC MOS DDR | PuX/PDy | |
| W22 | ddr1_ecc_d0 | ddr1_ecc_d0 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| V23 | ddr1_ecc_d1 | ddr1_ecc_d1 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| W19 | ddr1_ecc_d2 | ddr1_ecc_d2 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| W23 | ddr1_ecc_d3 | ddr1_ecc_d3 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| Y25 | ddr1_ecc_d4 | ddr1_ecc_d4 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| V24 | ddr1_ecc_d5 | ddr1_ecc_d5 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| V25 | ddr1_ecc_d6 | ddr1_ecc_d6 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| Y26 | ddr1_ecc_d7 | ddr1_ecc_d7 | 0 | IO | PD | PD | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AH24 | ddr1_nck | ddr1_nck | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AE20 | ddr1_odt0 | ddr1_odt0 | 0 | O | PD | drive 0 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AC17 | ddr1_odt1 | ddr1_odt1 | 0 | O | PD | drive 0 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AF20 | ddr1_rasn | ddr1_rasn | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |
| AG21 | ddr1_rst | ddr1_rst | 0 | O | PD | drive 0 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | PuX/PDy | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|-------------------------|------------------------|-----------|
| Y18 | ddr1_vref0 | ddr1_vref0 | 0 | PWR | OFF | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | | |
| AH21 | ddr1_wen | ddr1_wen | 0 | O | PU | drive 1 (OFF) | | 1.35/1.5 | vdds_ddr1 | No | LVC MOS DDR | Pu/PDy | |
| G21 | emu0 | emu0 | 0 | IO | PU | PU | 0 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVC MOS | PU/PD | |
| | | gpio8_30 | 14 | IO | | | | | | | | | |
| D24 | emu1 | emu1 | 0 | IO | PU | PU | 0 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVC MOS | PU/PD | |
| | | gpio8_31 | 14 | IO | | | | | | | | | |
| AC5 | gpio6_10 | gpio6_10 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVC MOS | PU/PD | |
| | | mdio_mclk | 1 | O | | | | | | | | | 1 |
| | | i2c3_sda | 2 | IO | | | | | | | | | 1 |
| | | usb3_ulpi_d7 | 3 | IO | | | | | | | | | 0 |
| | | vin2b_hsync1 | 4 | I | | | | | | | | | |
| | | vin1a_clk0 | 9 | I | | | | | | | | | 0 |
| | | ehrpwm2A | 10 | O | | | | | | | | | |
| | | gpio6_10 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AB4 | gpio6_11 | gpio6_11 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVC MOS | PU/PD | |
| | | mdio_d | 1 | IO | | | | | | | | | 1 |
| | | i2c3_scl | 2 | IO | | | | | | | | | 1 |
| | | usb3_ulpi_d6 | 3 | IO | | | | | | | | | 0 |
| | | vin2b_vsync1 | 4 | I | | | | | | | | | |
| | | vin1a_de0 | 9 | I | | | | | | | | | 0 |
| | | ehrpwm2B | 10 | O | | | | | | | | | |
| | | gpio6_11 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| E21 | gpio6_14 | gpio6_14 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVC MOS | PU/PD | |
| | | mcasp1_axr8 | 1 | IO | | | | | | | | | 0 |
| | | dcan2_tx | 2 | IO | | | | | | | | | 1 |
| | | uart10_rxd | 3 | I | | | | | | | | | 1 |
| | | vout2_hsync | 6 | O | | | | | | | | | |
| | | vin2a_hsync0 | 8 | I | | | | | | | | | |
| | | vin1a_hsync0 | | | | | | | | | | | |
| | | i2c3_sda | 9 | IO | | | | | | | | | 1 |
| | | timer1 | 10 | IO | | | | | | | | | |
| | | gpio6_14 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| F20 | gpio6_15 | gpio6_15 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | mcasp1_axr9 | 1 | IO | | | | | | | | | 0 |
| | | dcan2_rx | 2 | IO | | | | | | | | | 1 |
| | | uart10_txd | 3 | O | | | | | | | | | |
| | | vout2_vsync | 6 | O | | | | | | | | | |
| | | vin2a_vsync0 | 8 | I | | | | | | | | | |
| | | vin1a_vsync0 | | | | | | | | | | | |
| | | i2c3_scl | 9 | IO | | | | | | | | | 1 |
| | | timer2 | 10 | IO | | | | | | | | | |
| | | gpio6_15 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| F21 | gpio6_16 | gpio6_16 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | mcasp1_axr10 | 1 | IO | | | | | | | | | 0 |
| | | vout2_fld | 6 | O | | | | | | | | | |
| | | vin2a_fld0 | 8 | I | | | | | | | | | |
| | | vin1a_fld0 | | | | | | | | | | | |
| | | clkout1 | 9 | O | | | | | | | | | |
| | | timer3 | 10 | IO | | | | | | | | | |
| | | gpio6_16 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| R6 | gpmc_a0 | gpmc_a0 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin1a_d16 | 2 | I | | | | | | | | | 0 |
| | | vout3_d16 | 3 | O | | | | | | | | | |
| | | vin2a_d0 | 4 | I | | | | | | | | | |
| | | vin1a_d0 | | | | | | | | | | | |
| | | vin1b_d0 | 6 | I | | | | | | | | | 0 |
| | | i2c4_scl | 7 | IO | | | | | | | | | 1 |
| | | uart5_rxd | 8 | I | | | | | | | | | 1 |
| | | gpio7_3 | 14 | IO | | | | | | | | | |
| | | gpmc_a26 | | | | | | | | | | | |
| gpmc_a16 | | | | | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|----------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| T9 | gpmc_a1 | gpmc_a1 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin1a_d17 | 2 | I | | | | | | | | | 0 |
| | | vout3_d17 | 3 | O | | | | | | | | | |
| | | vin2a_d1 vin1a_d1 | 4 | I | | | | | | | | | |
| | | vin1b_d1 | 6 | I | | | | | | | | | 0 |
| | | i2c4_sda | 7 | IO | | | | | | | | | 1 |
| | | uart5_txd | 8 | O | | | | | | | | | |
| | | gpio7_4 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| T6 | gpmc_a2 | gpmc_a2 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin1a_d18 | 2 | I | | | | | | | | | 0 |
| | | vout3_d18 | 3 | O | | | | | | | | | |
| | | vin2a_d2 vin1a_d2 | 4 | I | | | | | | | | | |
| | | vin1b_d2 | 6 | I | | | | | | | | | 0 |
| | | uart7_rxd | 7 | I | | | | | | | | | 1 |
| | | uart5_ctsn | 8 | I | | | | | | | | | 1 |
| | | gpio7_5 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| T7 | gpmc_a3 | gpmc_a3 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | qspi1_cs2 | 1 | O | | | | | | | | | 1 |
| | | vin1a_d19 | 2 | I | | | | | | | | | 0 |
| | | vout3_d19 | 3 | O | | | | | | | | | |
| | | vin2a_d3 vin1a_d3 | 4 | I | | | | | | | | | |
| | | vin1b_d3 | 6 | I | | | | | | | | | 0 |
| | | uart7_txd | 7 | O | | | | | | | | | |
| | | uart5_rtsn | 8 | O | | | | | | | | | |
| | | gpio7_6 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | | | | |
|-----------------|---------------|-----------------|-------------|-----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|---------------------|-------|---------------------|-------|--|
| P6 | gpmc_a4 | gpmc_a4 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | | | | | |
| | | qspi1_cs3 | 1 | O | | | | | | | | | | 1 | | | |
| | | vin1a_d20 | 2 | I | | | | | | | | | | 0 | | | |
| | | vout3_d20 | 3 | O | | | | | | | | | | | | | |
| | | vin2a_d4 | 4 | I | | | | | | | | | | | | | |
| | | vin1a_d4 | 6 | I | | | | | | | | | | 0 | | | |
| | | i2c5_scl | 7 | IO | | | | | | | | | | 1 | | | |
| | | uart6_rxd | 8 | I | | | | | | | | | | 1 | | | |
| | | gpio1_26 | 14 | IO | | | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | | | |
| | | R9 | gpmc_a5 | gpmc_a5 | 0 | O | PD | PD | 15 | 1.8/3.3 | | | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| vin1a_d21 | 2 | | | I | | | | | | | | 0 | | | | | |
| vout3_d21 | 3 | | | O | | | | | | | | | | | | | |
| vin2a_d5 | 4 | | | I | | | | | | | | | | | | | |
| vin1a_d5 | 6 | | | I | | | | | | | | 0 | | | | | |
| i2c5_sda | 7 | | | IO | | | | | | | | 1 | | | | | |
| uart6_txd | 8 | | | O | | | | | | | | | | | | | |
| gpio1_27 | 14 | | | IO | | | | | | | | | | | | | |
| Driver off | 15 | | | I | | | | | | | | | | | | | |
| R5 | gpmc_a6 | | | gpmc_a6 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | | | |
| | | | | vin1a_d22 | 2 | I | | | | | | | | | | | |
| | | vout3_d22 | 3 | O | | | | | | | | | | | | | |
| | | vin2a_d6 | 4 | I | | | | | | | | | | | | | |
| | | vin1a_d6 | 6 | I | | | | | | | | 0 | | | | | |
| | | uart8_rxd | 7 | I | | | | | | | | 1 | | | | | |
| | | uart6_ctsn | 8 | I | | | | | | | | 1 | | | | | |
| | | gpio1_28 | 14 | IO | | | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| P5 | gpmc_a7 | gpmc_a7 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin1a_d23 | 2 | I | | | | | | | | | 0 |
| | | vout3_d23 | 3 | O | | | | | | | | | |
| | | vin2a_d7 | 4 | I | | | | | | | | | |
| | | vin1a_d7 | | | | | | | | | | | |
| | | vin1b_d7 | 6 | I | | | | | | | | | 0 |
| | | uart8_txd | 7 | O | | | | | | | | | |
| | | uart6_rtsn | 8 | O | | | | | | | | | |
| | | gpio1_29 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| N7 | gpmc_a8 | gpmc_a8 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin1a_hsync0 | 2 | I | | | | | | | | | 0 |
| | | vout3_hsync | 3 | O | | | | | | | | | |
| | | vin1b_hsync1 | 6 | I | | | | | | | | | 0 |
| | | timer12 | 7 | IO | | | | | | | | | |
| | | spi4_sclk | 8 | IO | | | | | | | | | 0 |
| | | gpio1_30 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| R4 | gpmc_a9 | gpmc_a9 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin1a_vsync0 | 2 | I | | | | | | | | | 0 |
| | | vout3_vsync | 3 | O | | | | | | | | | |
| | | vin1b_vsync1 | 6 | I | | | | | | | | | 0 |
| | | timer11 | 7 | IO | | | | | | | | | |
| | | spi4_d1 | 8 | IO | | | | | | | | | 0 |
| | | gpio1_31 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| N9 | gpmc_a10 | gpmc_a10 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin1a_de0 | 2 | I | | | | | | | | | 0 |
| | | vout3_de | 3 | O | | | | | | | | | |
| | | vin1b_clk1 | 6 | I | | | | | | | | | 0 |
| | | timer10 | 7 | IO | | | | | | | | | |
| | | spi4_d0 | 8 | IO | | | | | | | | | 0 |
| | | gpio2_0 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| P9 | gpmc_a11 | gpmc_a11 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin1a_fld0 | 2 | I | | | | | | | | | 0 |
| | | vout3_fld | 3 | O | | | | | | | | | |
| | | vin2a_fld0 | 4 | I | | | | | | | | | |
| | | vin1a_fld0 | | | | | | | | | | | |
| | | vin1b_de1 | 6 | I | | | | | | | | | 0 |
| | | timer9 | 7 | IO | | | | | | | | | |
| | | spi4_cs0 | 8 | IO | | | | | | | | | 1 |
| | | gpio2_1 | 14 | IO | | | | | | | | | |
| | Driver off | 15 | I | | | | | | | | | | |
| P4 | gpmc_a12 | gpmc_a12 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin2a_clk0 | 4 | I | | | | | | | | | |
| | | vin1a_clk0 | | | | | | | | | | | |
| | | gpmc_a0 | 5 | O | | | | | | | | | |
| | | vin1b_fld1 | 6 | I | | | | | | | | | 0 |
| | | timer8 | 7 | IO | | | | | | | | | |
| | | spi4_cs1 | 8 | IO | | | | | | | | | 1 |
| | | dma_evt1 | 9 | I | | | | | | | | | 0 |
| | | gpio2_2 | 14 | IO | | | | | | | | | |
| | Driver off | 15 | I | | | | | | | | | | |
| R3 | gpmc_a13 | gpmc_a13 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | qspi1_rtclk | 1 | I | | | | | | | | | 0 |
| | | vin2a_hsync0 | 4 | I | | | | | | | | | |
| | | vin1a_hsync0 | | | | | | | | | | | |
| | | timer7 | 7 | IO | | | | | | | | | |
| | | spi4_cs2 | 8 | IO | | | | | | | | | 1 |
| | | dma_evt2 | 9 | I | | | | | | | | | 0 |
| | | gpio2_3 | 14 | IO | | | | | | | | | |
| | | | Driver off | 15 | I | | | | | | | | |
| T2 | gpmc_a14 | gpmc_a14 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | qspi1_d3 | 1 | IO | | | | | | | | | 0 |
| | | vin2a_vsync0 | 4 | I | | | | | | | | | |
| | | vin1a_vsync0 | | | | | | | | | | | |
| | | timer6 | 7 | IO | | | | | | | | | |
| | | spi4_cs3 | 8 | IO | | | | | | | | | 1 |
| | | gpio2_4 | 14 | IO | | | | | | | | | |
| | | | Driver off | 15 | I | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-------------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| U2 | gpmc_a15 | gpmc_a15 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | qspi1_d2 | 1 | IO | | | | | | | | | 0 |
| | | vin2a_d8 vin1a_d8 | 4 | I | | | | | | | | | |
| | | timer5 | 7 | IO | | | | | | | | | |
| | | gpio2_5 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| U1 | gpmc_a16 | gpmc_a16 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | qspi1_d0 | 1 | IO | | | | | | | | | 0 |
| | | vin2a_d9 vin1a_d9 | 4 | I | | | | | | | | | |
| | | gpio2_6 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| P3 | gpmc_a17 | gpmc_a17 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | qspi1_d1 | 1 | IO | | | | | | | | | 0 |
| | | vin2a_d10 vin1a_d10 | 4 | I | | | | | | | | | |
| | | gpio2_7 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| R2 | gpmc_a18 | gpmc_a18 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | qspi1_sclk | 1 | IO | | | | | | | | | |
| | | vin2a_d11 vin1a_d11 | 4 | I | | | | | | | | | |
| | | gpio2_8 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| K7 ⁽⁹⁾ | gpmc_a19 | gpmc_a19 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | mmc2_dat4 | 1 | IO | | | | | | | | | 1 |
| | | gpmc_a13 | 2 | O | | | | | | | | | |
| | | vin2a_d12 vin1a_d12 | 4 | I | | | | | | | | | |
| | | vin2b_d0 vin1b_d0 | 6 | I | | | | | | | | | |
| | | gpio2_9 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-------------------|---------------|--------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|---|
| M7 ⁽⁹⁾ | gpmc_a20 | gpmc_a20 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | mmc2_dat5 | 1 | IO | | | | | | | | | | 1 |
| | | gpmc_a14 | 2 | O | | | | | | | | | | |
| | | vin2a_d13 vin1a_d13 | 4 | I | | | | | | | | | | |
| | | vin2b_d1 vin1b_d1 | 6 | I | | | | | | | | | | |
| | | gpio2_10 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| J5 ⁽⁹⁾ | gpmc_a21 | gpmc_a21 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | mmc2_dat6 | 1 | IO | | | | | | | | | | 1 |
| | | gpmc_a15 | 2 | O | | | | | | | | | | |
| | | vin2a_d14 vin1a_d14 | 4 | I | | | | | | | | | | |
| | | vin2b_d2 vin1b_d2 | 6 | I | | | | | | | | | | |
| | | gpio2_11 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| K6 ⁽⁹⁾ | gpmc_a22 | gpmc_a22 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | mmc2_dat7 | 1 | IO | | | | | | | | | | 1 |
| | | gpmc_a16 | 2 | O | | | | | | | | | | |
| | | vin2a_d15 vin1a_d15 | 4 | I | | | | | | | | | | |
| | | vin2b_d3 vin1b_d3 | 6 | I | | | | | | | | | | |
| | | gpio2_12 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| J7 | gpmc_a23 | gpmc_a23 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | mmc2_clk | 1 | IO | | | | | | | | | | 1 |
| | | gpmc_a17 | 2 | O | | | | | | | | | | |
| | | vin2a_fld0 vin1a_fld0 | 4 | I | | | | | | | | | | |
| | | vin2b_d4 vin1b_d4 | 6 | I | | | | | | | | | | |
| | | gpio2_13 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-------------------|---------------|------------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| J4 ⁽⁹⁾ | gpmc_a24 | gpmc_a24 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | mmc2_dat0 | 1 | IO | | | | | | | | | 1 |
| | | gpmc_a18 | 2 | O | | | | | | | | | |
| | | vin2b_d5 vin1b_d5 | 6 | I | | | | | | | | | |
| | | gpio2_14 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| J6 ⁽⁹⁾ | gpmc_a25 | gpmc_a25 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | mmc2_dat1 | 1 | IO | | | | | | | | | 1 |
| | | gpmc_a19 | 2 | O | | | | | | | | | |
| | | vin2b_d6 vin1b_d6 | 6 | I | | | | | | | | | |
| | | gpio2_15 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| H4 ⁽⁹⁾ | gpmc_a26 | gpmc_a26 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | mmc2_dat2 | 1 | IO | | | | | | | | | 1 |
| | | gpmc_a20 | 2 | O | | | | | | | | | |
| | | vin2b_d7 vin1b_d7 | 6 | I | | | | | | | | | |
| | | gpio2_16 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| H5 ⁽⁹⁾ | gpmc_a27 | gpmc_a27 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | mmc2_dat3 | 1 | IO | | | | | | | | | 1 |
| | | gpmc_a21 | 2 | O | | | | | | | | | |
| | | vin2b_hsync1 vin1b_hsync1 | 6 | I | | | | | | | | | |
| | | gpio2_17 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| M6 | gpmc_ad0 | gpmc_ad0 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d0 | 2 | I | | | | | | | | | 0 |
| | | vout3_d0 | 3 | O | | | | | | | | | |
| | | gpio1_6 | 14 | IO | | | | | | | | | |
| | | sysboot0 | 15 | I | | | | | | | | | |
| M2 | gpmc_ad1 | gpmc_ad1 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d1 | 2 | I | | | | | | | | | 0 |
| | | vout3_d1 | 3 | O | | | | | | | | | |
| | | gpio1_7 | 14 | IO | | | | | | | | | |
| | | sysboot1 | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| L5 | gpmc_ad2 | gpmc_ad2 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d2 | 2 | I | | | | | | | | | 0 |
| | | vout3_d2 | 3 | O | | | | | | | | | |
| | | gpio1_8 | 14 | IO | | | | | | | | | |
| | | sysboot2 | 15 | I | | | | | | | | | |
| M1 | gpmc_ad3 | gpmc_ad3 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d3 | 2 | I | | | | | | | | | 0 |
| | | vout3_d3 | 3 | O | | | | | | | | | |
| | | gpio1_9 | 14 | IO | | | | | | | | | |
| | | sysboot3 | 15 | I | | | | | | | | | |
| L6 | gpmc_ad4 | gpmc_ad4 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d4 | 2 | I | | | | | | | | | 0 |
| | | vout3_d4 | 3 | O | | | | | | | | | |
| | | gpio1_10 | 14 | IO | | | | | | | | | |
| | | sysboot4 | 15 | I | | | | | | | | | |
| L4 | gpmc_ad5 | gpmc_ad5 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d5 | 2 | I | | | | | | | | | 0 |
| | | vout3_d5 | 3 | O | | | | | | | | | |
| | | gpio1_11 | 14 | IO | | | | | | | | | |
| | | sysboot5 | 15 | I | | | | | | | | | |
| L3 | gpmc_ad6 | gpmc_ad6 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d6 | 2 | I | | | | | | | | | 0 |
| | | vout3_d6 | 3 | O | | | | | | | | | |
| | | gpio1_12 | 14 | IO | | | | | | | | | |
| | | sysboot6 | 15 | I | | | | | | | | | |
| L2 | gpmc_ad7 | gpmc_ad7 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d7 | 2 | I | | | | | | | | | 0 |
| | | vout3_d7 | 3 | O | | | | | | | | | |
| | | gpio1_13 | 14 | IO | | | | | | | | | |
| | | sysboot7 | 15 | I | | | | | | | | | |
| L1 | gpmc_ad8 | gpmc_ad8 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d8 | 2 | I | | | | | | | | | 0 |
| | | vout3_d8 | 3 | O | | | | | | | | | |
| | | gpio7_18 | 14 | IO | | | | | | | | | |
| | | sysboot8 | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| K2 | gpmc_ad9 | gpmc_ad9 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d9 | 2 | I | | | | | | | | | 0 |
| | | vout3_d9 | 3 | O | | | | | | | | | |
| | | gpio7_19 | 14 | IO | | | | | | | | | |
| | | sysboot9 | 15 | I | | | | | | | | | |
| J1 | gpmc_ad10 | gpmc_ad10 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d10 | 2 | I | | | | | | | | | 0 |
| | | vout3_d10 | 3 | O | | | | | | | | | |
| | | gpio7_28 | 14 | IO | | | | | | | | | |
| | | sysboot10 | 15 | I | | | | | | | | | |
| J2 | gpmc_ad11 | gpmc_ad11 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d11 | 2 | I | | | | | | | | | 0 |
| | | vout3_d11 | 3 | O | | | | | | | | | |
| | | gpio7_29 | 14 | IO | | | | | | | | | |
| | | sysboot11 | 15 | I | | | | | | | | | |
| H1 | gpmc_ad12 | gpmc_ad12 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d12 | 2 | I | | | | | | | | | 0 |
| | | vout3_d12 | 3 | O | | | | | | | | | |
| | | gpio1_18 | 14 | IO | | | | | | | | | |
| | | sysboot12 | 15 | I | | | | | | | | | |
| J3 | gpmc_ad13 | gpmc_ad13 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d13 | 2 | I | | | | | | | | | 0 |
| | | vout3_d13 | 3 | O | | | | | | | | | |
| | | gpio1_19 | 14 | IO | | | | | | | | | |
| | | sysboot13 | 15 | I | | | | | | | | | |
| H2 | gpmc_ad14 | gpmc_ad14 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d14 | 2 | I | | | | | | | | | 0 |
| | | vout3_d14 | 3 | O | | | | | | | | | |
| | | gpio1_20 | 14 | IO | | | | | | | | | |
| | | sysboot14 | 15 | I | | | | | | | | | |
| H3 | gpmc_ad15 | gpmc_ad15 | 0 | IO | OFF | OFF | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d15 | 2 | I | | | | | | | | | 0 |
| | | vout3_d15 | 3 | O | | | | | | | | | |
| | | gpio1_21 | 14 | IO | | | | | | | | | |
| | | sysboot15 | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-----------------|---------------|------------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|---|
| N1 | gpmc_advn_ale | gpmc_advn_ale | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | gpmc_cs6 | 1 | O | | | | | | | | | | |
| | | clkout2 | 2 | O | | | | | | | | | | |
| | | gpmc_wait1 | 3 | I | | | | | | | | | | |
| | | vin2a_vsync0 vin1a_vsync0 | 4 | I | | | | | | | | | | |
| | | gpmc_a2 | 5 | O | | | | | | | | | | |
| | | gpmc_a23 | 6 | O | | | | | | | | | | |
| | | timer3 | 7 | IO | | | | | | | | | | |
| | | i2c3_sda | 8 | IO | | | | | | | | | | |
| | | dma_evt2 | 9 | I | | | | | | | | | | |
| | | gpio2_23 gpmc_a19 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | | | | | | | | | | | 1 |
| | | | | | | | | | | | | | | 1 |
| | | | | 0 | | | | | | | | | | |
| N6 | gpmc_ben0 | gpmc_ben0 | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | gpmc_cs4 | 1 | O | | | | | | | | | | |
| | | vin2b_de1 vin1b_de1 | 6 | I | | | | | | | | | | |
| | | timer2 | 7 | IO | | | | | | | | | | |
| | | dma_evt3 | 9 | I | | | | | | | | | | |
| | | gpio2_26 gpmc_a21 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | | | | | | | | | | | 0 |
| | | | | | | | | | | | | | | |
| M4 | gpmc_ben1 | gpmc_ben1 | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | gpmc_cs5 | 1 | O | | | | | | | | | | |
| | | vin2b_clk1 vin1b_clk1 | 4 | I | | | | | | | | | | |
| | | gpmc_a3 | 5 | O | | | | | | | | | | |
| | | vin2b_fld1 vin1b_fld1 | 6 | I | | | | | | | | | | |
| | | timer1 | 7 | IO | | | | | | | | | | |
| | | dma_evt4 | 9 | I | | | | | | | | | | |
| | | gpio2_27 gpmc_a22 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | | | | | | | | | | | 0 |
| | | | | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-----------------|---------------|----------------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|---|
| P7 | gpmc_clk | gpmc_clk | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | gpmc_cs7 | 1 | O | | | | | | | | | | |
| | | clkout1 | 2 | O | | | | | | | | | | |
| | | gpmc_wait1 | 3 | I | | | | | | | | | | |
| | | vin2a_hsync0 vin1a_hsync0 | 4 | I | | | | | | | | | | |
| | | vin2a_de0 vin1a_de0 | 5 | I | | | | | | | | | | |
| | | vin2b_clk1 vin1b_clk1 | 6 | I | | | | | | | | | | |
| | | timer4 | 7 | IO | | | | | | | | | | |
| | | i2c3_scl | 8 | IO | | | | | | | | | | |
| | | dma_evt1 | 9 | I | | | | | | | | | | |
| | | gpio2_22 gpmc_a20 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | | | | | | | | | | | 1 |
| | | | | | | | | | | | | | | 0 |
| | | | | | | | | | | | | | | 1 |
| | | | | 0 | | | | | | | | | | |
| T1 | gpmc_cs0 | gpmc_cs0 | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | gpio2_19 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| H6 | gpmc_cs1 | gpmc_cs1 | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv11 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | mmc2_cmd | 1 | IO | | | | | | | | | | |
| | | gpmc_a22 | 2 | O | | | | | | | | | | |
| | | vin2a_de0 vin1a_de0 | 4 | I | | | | | | | | | | |
| | | vin2b_vsync1 vin1b_vsync1 | 6 | I | | | | | | | | | | |
| | | gpio2_18 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | 1 | | | | | | | | | | |
| P2 | gpmc_cs2 | gpmc_cs2 | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | qspi1_cs0 | 1 | IO | | | | | | | | | | |
| | | gpio2_20 gpmc_a23 gpmc_a13 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| | | | | | | | | | | | | | | 1 |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|----------------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|-------------------------|------------------------|-----------|
| P1 | gpmc_cs3 | gpmc_cs3 | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | qspi1_cs1 | 1 | O | | | | | | | | | 1 |
| | | vin1a_clk0 | 2 | I | | | | | | | | | 0 |
| | | vout3_clk | 3 | O | | | | | | | | | |
| | | gpmc_a1 | 5 | O | | | | | | | | | |
| | | gpio2_21 gpmc_a24 gpmc_a14 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| M5 | gpmc_oen_ren | gpmc_oen_ren | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | gpio2_24 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| N2 | gpmc_wait0 | gpmc_wait0 | 0 | I | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | gpio2_28 gpmc_a25 gpmc_a15 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | | | | | | | | | | | | |
| M3 | gpmc_wen | gpmc_wen | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv10 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | gpio2_25 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AG16 | hdmi1_clockx | hdmi1_clockx | 0 | O | | | | 1.8 | vdda_hdmi | | HDMIPHY | Pdy | |
| AH16 | hdmi1_clocky | hdmi1_clocky | 0 | O | | | | 1.8 | vdda_hdmi | | HDMIPHY | Pdy | |
| AG17 | hdmi1_data0x | hdmi1_data0x | 0 | O | | | | 1.8 | vdda_hdmi | | HDMIPHY | Pdy | |
| AH17 | hdmi1_data0y | hdmi1_data0y | 0 | O | | | | 1.8 | vdda_hdmi | | HDMIPHY | Pdy | |
| AG18 | hdmi1_data1x | hdmi1_data1x | 0 | O | | | | 1.8 | vdda_hdmi | | HDMIPHY | Pdy | |
| AH18 | hdmi1_data1y | hdmi1_data1y | 0 | O | | | | 1.8 | vdda_hdmi | | HDMIPHY | Pdy | |
| AG19 | hdmi1_data2x | hdmi1_data2x | 0 | O | | | | 1.8 | vdda_hdmi | | HDMIPHY | Pdy | |
| AH19 | hdmi1_data2y | hdmi1_data2y | 0 | O | | | | 1.8 | vdda_hdmi | | HDMIPHY | Pdy | |
| C20 | i2c1_scl | i2c1_scl | 0 | IO | | | | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS I2C | PU/PD | |
| | | Driver off | 15 | I | | | | | | | | | |
| C21 | i2c1_sda | i2c1_sda | 0 | IO | | | | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS I2C | PU/PD | |
| | | Driver off | 15 | I | | | | | | | | | |
| F17 | i2c2_scl | i2c2_scl | 0 | IO | | | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS I2C | PU/PD | 1 |
| | | hdmi1_ddc_sda | 1 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| C25 | i2c2_sda | i2c2_sda | 0 | IO | | | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS I2C | PU/PD | 1 |
| | | hdmi1_ddc_scl | 1 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AH15 | ljcb_clkn | ljcb_clkn | 0 | IO | | | | 1.8 | vdda_pcie | | LJCB | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|---|
| AG15 | ljcb_clkp | ljcb_clkp | 0 | IO | | | | 1.8 | vdda_pcie | | LJCB | | | |
| B14 | mcasep1_aclkr | mcasep1_aclkr | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | mcasep7_axr2 | 1 | IO | | | | | | | | | 0 | |
| | | vout2_d0 | 6 | O | | | | | | | | | | |
| | | vin2a_d0 | 8 | I | | | | | | | | | | |
| | | vin1a_d0 | | | | | | | | | | | | |
| | | i2c4_sda | 10 | IO | | | | | | | | | | 1 |
| | | gpio5_0 | 14 | IO | | | | | | | | | | |
| | Driver off | 15 | I | | | | | | | | | | | |
| C14 | mcasep1_aclkx | mcasep1_aclkx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | vin1a_fld0 | 7 | I | | | | | | | | | 0 | |
| | | i2c3_sda | 10 | IO | | | | | | | | | 1 | |
| | | gpio7_31 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| G12 | mcasep1_axr0 | mcasep1_axr0 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | uart6_rxd | 3 | I | | | | | | | | | 1 | |
| | | vin1a_vsync0 | 7 | I | | | | | | | | | 0 | |
| | | i2c5_sda | 10 | IO | | | | | | | | | 1 | |
| | | gpio5_2 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| F12 | mcasep1_axr1 | mcasep1_axr1 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | uart6_txd | 3 | O | | | | | | | | | | |
| | | vin1a_hsync0 | 7 | I | | | | | | | | | 0 | |
| | | i2c5_scl | 10 | IO | | | | | | | | | 1 | |
| | | gpio5_3 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| G13 | mcasep1_axr2 | mcasep1_axr2 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | mcasep6_axr2 | 1 | IO | | | | | | | | | 0 | |
| | | uart6_ctsn | 3 | I | | | | | | | | | 1 | |
| | | vout2_d2 | 6 | O | | | | | | | | | | |
| | | vin2a_d2 | 8 | I | | | | | | | | | | |
| | | vin1a_d2 | | | | | | | | | | | | |
| | | gpio5_4 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| J11 | mcasep1_axr3 | mcasep1_axr3 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep6_axr3 | 1 | IO | | | | | | | | | 0 |
| | | uart6_rtsn | 3 | O | | | | | | | | | |
| | | vout2_d3 | 6 | O | | | | | | | | | |
| | | vin2a_d3 | 8 | I | | | | | | | | | |
| | | vin1a_d3 | | | | | | | | | | | |
| | | gpio5_5 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| E12 | mcasep1_axr4 | mcasep1_axr4 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep4_axr2 | 1 | IO | | | | | | | | | 0 |
| | | vout2_d4 | 6 | O | | | | | | | | | |
| | | vin2a_d4 | 8 | I | | | | | | | | | |
| | | vin1a_d4 | | | | | | | | | | | |
| | | gpio5_6 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| F13 | mcasep1_axr5 | mcasep1_axr5 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep4_axr3 | 1 | IO | | | | | | | | | 0 |
| | | vout2_d5 | 6 | O | | | | | | | | | |
| | | vin2a_d5 | 8 | I | | | | | | | | | |
| | | vin1a_d5 | | | | | | | | | | | |
| | | gpio5_7 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| C12 | mcasep1_axr6 | mcasep1_axr6 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep5_axr2 | 1 | IO | | | | | | | | | 0 |
| | | vout2_d6 | 6 | O | | | | | | | | | |
| | | vin2a_d6 | 8 | I | | | | | | | | | |
| | | vin1a_d6 | | | | | | | | | | | |
| | | gpio5_8 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| D12 | mcasep1_axr7 | mcasep1_axr7 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep5_axr3 | 1 | IO | | | | | | | | | 0 |
| | | vout2_d7 | 6 | O | | | | | | | | | |
| | | vin2a_d7 | 8 | I | | | | | | | | | |
| | | vin1a_d7 | | | | | | | | | | | |
| | | timer4 | 10 | IO | | | | | | | | | |
| | | gpio5_9 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| B12 | mcasep1_axr8 | mcasep1_axr8 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep6_axr0 | 1 | IO | | | | | | | | | 0 |
| | | spi3_sclk | 3 | IO | | | | | | | | | 0 |
| | | vin1a_d15 | 7 | I | | | | | | | | | 0 |
| | | timer5 | 10 | IO | | | | | | | | | |
| | | gpio5_10 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A11 | mcasep1_axr9 | mcasep1_axr9 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep6_axr1 | 1 | IO | | | | | | | | | 0 |
| | | spi3_d1 | 3 | IO | | | | | | | | | 0 |
| | | vin1a_d14 | 7 | I | | | | | | | | | 0 |
| | | timer6 | 10 | IO | | | | | | | | | |
| | | gpio5_11 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| B13 | mcasep1_axr10 | mcasep1_axr10 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep6_aclkx | 1 | IO | | | | | | | | | 0 |
| | | mcasep6_aclkr | 2 | IO | | | | | | | | | |
| | | spi3_d0 | 3 | IO | | | | | | | | | 0 |
| | | vin1a_d13 | 7 | I | | | | | | | | | 0 |
| | | timer7 | 10 | IO | | | | | | | | | |
| | | gpio5_12 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| A12 | mcasep1_axr11 | mcasep1_axr11 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep6_fsx | 1 | IO | | | | | | | | | 0 |
| | | mcasep6_fsr | 2 | IO | | | | | | | | | |
| | | spi3_cs0 | 3 | IO | | | | | | | | | 1 |
| | | vin1a_d12 | 7 | I | | | | | | | | | 0 |
| | | timer8 | 10 | IO | | | | | | | | | |
| | | gpio4_17 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| E14 | mcasep1_axr12 | mcasep1_axr12 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep7_axr0 | 1 | IO | | | | | | | | | 0 |
| | | spi3_cs1 | 3 | IO | | | | | | | | | 1 |
| | | vin1a_d11 | 7 | I | | | | | | | | | 0 |
| | | timer9 | 10 | IO | | | | | | | | | |
| | | gpio4_18 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|----------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| A13 | mcasep1_axr13 | mcasep1_axr13 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep7_axr1 | 1 | IO | | | | | | | | | 0 |
| | | vin1a_d10 | 7 | I | | | | | | | | | 0 |
| | | timer10 | 10 | IO | | | | | | | | | |
| | | gpio6_4 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| G14 | mcasep1_axr14 | mcasep1_axr14 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep7_aclkx | 1 | IO | | | | | | | | | 0 |
| | | mcasep7_aclkr | 2 | IO | | | | | | | | | |
| | | vin1a_d9 | 7 | I | | | | | | | | | 0 |
| | | timer11 | 10 | IO | | | | | | | | | |
| | | gpio6_5 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| F14 | mcasep1_axr15 | mcasep1_axr15 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep7_fsx | 1 | IO | | | | | | | | | 0 |
| | | mcasep7_fsr | 2 | IO | | | | | | | | | |
| | | vin1a_d8 | 7 | I | | | | | | | | | 0 |
| | | timer12 | 10 | IO | | | | | | | | | |
| | | gpio6_6 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| J14 | mcasep1_fsr | mcasep1_fsr | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep7_axr3 | 1 | IO | | | | | | | | | 0 |
| | | vout2_d1 | 6 | O | | | | | | | | | |
| | | vin2a_d1 vin1a_d1 | 8 | I | | | | | | | | | |
| | | i2c4_scl | 10 | IO | | | | | | | | | 1 |
| | | gpio5_1 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| D14 | mcasep1_fsx | mcasep1_fsx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_de0 | 7 | I | | | | | | | | | 0 |
| | | i2c3_scl | 10 | IO | | | | | | | | | 1 |
| | | gpio7_30 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| E15 | mcasep2_aclkr | mcasep2_aclkr | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep8_axr2 | 1 | IO | | | | | | | | | 0 |
| | | vout2_d8 | 6 | O | | | | | | | | | |
| | | vin2a_d8 vin1a_d8 | 8 | I | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A19 | mcasep2_aclkx | mcasep2_aclkx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d7 | 7 | I | | | | | | | | | 0 |
| | | Driver off | 15 | I | | | | | | | | | |
| B15 | mcasep2_axr0 | mcasep2_axr0 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vout2_d10 | 6 | O | | | | | | | | | |
| | | vin2a_d10 vin1a_d10 | 8 | I | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A15 | mcasep2_axr1 | mcasep2_axr1 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vout2_d11 | 6 | O | | | | | | | | | |
| | | vin2a_d11 vin1a_d11 | 8 | I | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| C15 | mcasep2_axr2 | mcasep2_axr2 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep3_axr2 | 1 | IO | | | | | | | | | 0 |
| | | vin1a_d5 | 7 | I | | | | | | | | | 0 |
| | | gpio6_8 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A16 | mcasep2_axr3 | mcasep2_axr3 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep3_axr3 | 1 | IO | | | | | | | | | 0 |
| | | vin1a_d4 | 7 | I | | | | | | | | | 0 |
| | | gpio6_9 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| D15 | mcasep2_axr4 | mcasep2_axr4 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep8_axr0 | 1 | IO | | | | | | | | | 0 |
| | | vout2_d12 | 6 | O | | | | | | | | | |
| | | vin2a_d12 vin1a_d12 | 8 | I | | | | | | | | | |
| | | gpio1_4 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| B16 | mcasep2_axr5 | mcasep2_axr5 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep8_axr1 | 1 | IO | | | | | | | | | 0 |
| | | vout2_d13 | 6 | O | | | | | | | | | |
| | | vin2a_d13 vin1a_d13 | 8 | I | | | | | | | | | |
| | | gpio6_7 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | | | | | | | | | | | | |
| B17 | mcasep2_axr6 | mcasep2_axr6 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep8_aclkx | 1 | IO | | | | | | | | | 0 |
| | | mcasep8_aclkr | 2 | IO | | | | | | | | | |
| | | vout2_d14 | 6 | O | | | | | | | | | |
| | | vin2a_d14 vin1a_d14 | 8 | I | | | | | | | | | |
| | | gpio2_29 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | | | | | | | | | | | | |
| A17 | mcasep2_axr7 | mcasep2_axr7 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep8_fsx | 1 | IO | | | | | | | | | 0 |
| | | mcasep8_fsr | 2 | IO | | | | | | | | | |
| | | vout2_d15 | 6 | O | | | | | | | | | |
| | | vin2a_d15 vin1a_d15 | 8 | I | | | | | | | | | |
| | | gpio1_5 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | | | | | | | | | | | | |
| A20 | mcasep2_fsr | mcasep2_fsr | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep8_axr3 | 1 | IO | | | | | | | | | 0 |
| | | vout2_d9 | 6 | O | | | | | | | | | |
| | | vin2a_d9 vin1a_d9 | 8 | I | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | | | | | | | | | | | | |
| A18 | mcasep2_fsx | mcasep2_fsx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin1a_d6 | 7 | I | | | | | | | | | 0 |
| | | Driver off | 15 | I | | | | | | | | | |
| | | | | | | | | | | | | | |
| B18 | mcasep3_aclkx | mcasep3_aclkx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep3_aclkr | 1 | IO | | | | | | | | | 0 |
| | | mcasep2_axr12 | 2 | IO | | | | | | | | | 0 |
| | | uart7_rxd | 3 | I | | | | | | | | | 1 |
| | | vin1a_d3 | 7 | I | | | | | | | | | 0 |
| | | gpio5_13 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| B19 | mcasep3_axr0 | mcasep3_axr0 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep2_axr14 | 2 | IO | | | | | | | | | 0 |
| | | uart7_ctsn | 3 | I | | | | | | | | | 1 |
| | | uart5_rxd | 4 | I | | | | | | | | | 1 |
| | | vin1a_d1 | 7 | I | | | | | | | | | 0 |
| | | Driver off | 15 | I | | | | | | | | | |
| C17 | mcasep3_axr1 | mcasep3_axr1 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep2_axr15 | 2 | IO | | | | | | | | | 0 |
| | | uart7_rtsn | 3 | O | | | | | | | | | |
| | | uart5_txd | 4 | O | | | | | | | | | |
| | | vin1a_d0 | 7 | I | | | | | | | | | 0 |
| | | vin1a_fld0 | 9 | I | | | | | | | | | 0 |
| Driver off | 15 | I | | | | | | | | | | | |
| F15 | mcasep3_fsx | mcasep3_fsx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep3_fsr | 1 | IO | | | | | | | | | |
| | | mcasep2_axr13 | 2 | IO | | | | | | | | | 0 |
| | | uart7_txd | 3 | O | | | | | | | | | |
| | | vin1a_d2 | 7 | I | | | | | | | | | 0 |
| | | gpio5_14 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| C18 | mcasep4_aclkx | mcasep4_aclkx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep4_aclkr | 1 | IO | | | | | | | | | |
| | | spi3_sclk | 2 | IO | | | | | | | | | 0 |
| | | uart8_rxd | 3 | I | | | | | | | | | 1 |
| | | i2c4_sda | 4 | IO | | | | | | | | | 1 |
| | | vout2_d16 | 6 | O | | | | | | | | | |
| | | vin2a_d16 | 8 | I | | | | | | | | | |
| | | vin1a_d16 | | | | | | | | | | | |
| | | vin1a_d15 | 9 | I | | | | | | | | | 0 |
| Driver off | 15 | I | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-----------------|---------------|--------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|---|
| G16 | mcasep4_axr0 | mcasep4_axr0 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | spi3_d0 | 2 | IO | | | | | | | | | 0 | |
| | | uart8_ctsn | 3 | I | | | | | | | | | | 1 |
| | | uart4_rxd | 4 | I | | | | | | | | | | 1 |
| | | vout2_d18 | 6 | O | | | | | | | | | | |
| | | vin2a_d18 | 8 | I | | | | | | | | | | |
| | | vin1a_d18 | | | | | | | | | | | | |
| | | vin1a_d13 | 9 | I | | | | | | | | | | 0 |
| | | i2c6_scl ⁽¹⁰⁾ | 14 | IO | | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | | |
| D17 | mcasep4_axr1 | mcasep4_axr1 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | spi3_cs0 | 2 | IO | | | | | | | | | | 1 |
| | | uart8_rtsn | 3 | O | | | | | | | | | | |
| | | uart4_txd | 4 | O | | | | | | | | | | |
| | | vout2_d19 | 6 | O | | | | | | | | | | |
| | | vin2a_d19 | 8 | I | | | | | | | | | | |
| | | vin1a_d19 | | | | | | | | | | | | |
| | | vin1a_d12 | 9 | I | | | | | | | | | | 0 |
| | | i2c6_sda ⁽¹⁰⁾ | 14 | IO | | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | | |
| A21 | mcasep4_fsx | mcasep4_fsx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | mcasep4_fsr | 1 | IO | | | | | | | | | | |
| | | spi3_d1 | 2 | IO | | | | | | | | | | 0 |
| | | uart8_txd | 3 | O | | | | | | | | | | |
| | | i2c4_scl | 4 | IO | | | | | | | | | | 1 |
| | | vout2_d17 | 6 | O | | | | | | | | | | |
| | | vin2a_d17 | 8 | I | | | | | | | | | | |
| | | vin1a_d17 | | | | | | | | | | | | |
| | | vin1a_d14 | 9 | I | | | | | | | | | | 0 |
| Driver off | 15 | I | | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | | |
|-----------------|---------------|-----------------|--------------|--------------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|-----|---------------------|
| AA3 | mcasep5_aclkx | mcasep5_aclkx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | | |
| | | mcasep5_aclkr | 1 | IO | | | | | | | | | | 0 | |
| | | spi4_sclk | 2 | IO | | | | | | | | | | 1 | |
| | | uart9_rxd | 3 | I | | | | | | | | | | 1 | |
| | | i2c5_sda | 4 | IO | | | | | | | | | | 1 | |
| | | mlb_clk | 5 | I | | | | | | | | | | 1 | |
| | | vout2_d20 | 6 | O | | | | | | | | | | | |
| | | vin2a_d20 | 8 | I | | | | | | | | | | | |
| | | vin1a_d20 | | | | | | | | | | | | | |
| | | vin1a_d11 | 9 | I | | | | | | | | | | | 0 |
| | | Driver off | 15 | I | | | | | | | | | | | |
| AB3 | mcasep5_axr0 | mcasep5_axr0 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | | |
| | | spi4_d0 | 2 | IO | | | | | | | | | | 0 | |
| | | uart9_ctsn | 3 | I | | | | | | | | | | 1 | |
| | | uart3_rxd | 4 | I | | | | | | | | | | 1 | |
| | | mlb_sig | 5 | IO | | | | | | | | | | 1 | |
| | | vout2_d22 | 6 | O | | | | | | | | | | | |
| | | vin2a_d22 | 8 | I | | | | | | | | | | | |
| | | vin1a_d22 | | | | | | | | | | | | | |
| | | vin1a_d9 | 9 | I | | | | | | | | | | | 0 |
| | | Driver off | 15 | I | | | | | | | | | | | |
| | | AA4 | mcasep5_axr1 | mcasep5_axr1 | 0 | IO | PD | PD | 15 | 1.8/3.3 | | | vddshv7 | Yes | Dual Voltage LVCMOS |
| spi4_cs0 | 2 | | | IO | | | | | | | | 1 | | | |
| uart9_rtsn | 3 | | | O | | | | | | | | | | | |
| uart3_txd | 4 | | | O | | | | | | | | | | | |
| mlb_dat | 5 | | | IO | | | | | | | | 1 | | | |
| vout2_d23 | 6 | | | O | | | | | | | | | | | |
| vin2a_d23 | 8 | | | I | | | | | | | | | | | |
| vin1a_d23 | | | | | | | | | | | | | | | |
| vin1a_d8 | 9 | | | I | | | | | | | | | 0 | | |
| Driver off | 15 | | | I | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| AB9 | mcasep5_fsx | mcasep5_fsx | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mcasep5_fsr | 1 | IO | | | | | | | | | 0 |
| | | spi4_d1 | 2 | IO | | | | | | | | | 0 |
| | | uart9_txd | 3 | O | | | | | | | | | 0 |
| | | i2c5_scl | 4 | IO | | | | | | | | | 1 |
| | | vout2_d21 | 6 | O | | | | | | | | | 0 |
| | | vin2a_d21 | 8 | I | | | | | | | | | 0 |
| | | vin1a_d21 | 9 | I | | | | | | | | | 0 |
| | | vin1a_d10 | 9 | I | | | | | | | | | 0 |
| Driver off | 15 | I | 0 | | | | | | | | | | |
| U4 | mdio_d | mdio_d | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart3_ctsn | 1 | I | | | | | | | | | 1 |
| | | mii0_txer | 3 | O | | | | | | | | | 0 |
| | | vin2a_d0 | 4 | I | | | | | | | | | 0 |
| | | vin1b_d0 | 5 | I | | | | | | | | | 0 |
| | | gpio5_16 | 14 | IO | | | | | | | | | 0 |
| | | Driver off | 15 | I | | | | | | | | | 0 |
| V1 | mdio_mclk | mdio_mclk | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart3_rtsn | 1 | O | | | | | | | | | 0 |
| | | mii0_col | 3 | I | | | | | | | | | 0 |
| | | vin2a_clk0 | 4 | I | | | | | | | | | 0 |
| | | vin1b_clk1 | 5 | I | | | | | | | | | 0 |
| | | gpio5_15 | 14 | IO | | | | | | | | | 0 |
| | | Driver off | 15 | I | | | | | | | | | 0 |
| AB2 | mlbp_clk_n | mlbp_clk_n | 0 | I | | | | vdds_mlbp | No | BMLB18 | | | |
| AB1 | mlbp_clk_p | mlbp_clk_p | 0 | I | | | | vdds_mlbp | No | BMLB18 | | | |
| AA2 | mlbp_dat_n | mlbp_dat_n | 0 | IO | OFF | OFF | | vdds_mlbp | No | BMLB18 | | | |
| AA1 | mlbp_dat_p | mlbp_dat_p | 0 | IO | OFF | OFF | | vdds_mlbp | No | BMLB18 | | | |
| AC2 | mlbp_sig_n | mlbp_sig_n | 0 | IO | OFF | OFF | | vdds_mlbp | No | BMLB18 | | | |
| AC1 | mlbp_sig_p | mlbp_sig_p | 0 | IO | OFF | OFF | | vdds_mlbp | No | BMLB18 | | | |
| W6 | mmc1_clk | mmc1_clk | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv8 | Yes | SDIO2KV1833 | Pux/PDy | 1 |
| | | gpio6_21 | 14 | IO | | | | | | | | | 0 |
| | | Driver off | 15 | I | | | | | | | | | 0 |
| Y6 | mmc1_cmd | mmc1_cmd | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv8 | Yes | SDIO2KV1833 | Pux/PDy | 1 |
| | | gpio6_22 | 14 | IO | | | | | | | | | 0 |
| | | Driver off | 15 | I | | | | | | | | | 0 |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| AA6 | mmc1_dat0 | mmc1_dat0 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv8 | Yes | SDIO2KV1833 | Pux/PDy | 1 |
| | | gpio6_23 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| Y4 | mmc1_dat1 | mmc1_dat1 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv8 | Yes | SDIO2KV1833 | Pux/PDy | 1 |
| | | gpio6_24 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AA5 | mmc1_dat2 | mmc1_dat2 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv8 | Yes | SDIO2KV1833 | Pux/PDy | 1 |
| | | gpio6_25 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| Y3 | mmc1_dat3 | mmc1_dat3 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv8 | Yes | SDIO2KV1833 | Pux/PDy | 1 |
| | | gpio6_26 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| W7 | mmc1_sdccl | mmc1_sdccl | 0 | I | PU | PU | 15 | 1.8/3.3 | vddshv8 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart6_rxd | 3 | I | | | | | | | | | 1 |
| | | i2c4_sda | 4 | IO | | | | | | | | | 1 |
| | | gpio6_27 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| Y9 | mmc1_sdwp | mmc1_sdwp | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv8 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | uart6_txd | 3 | O | | | | | | | | | |
| | | i2c4_scl | 4 | IO | | | | | | | | | 1 |
| | | gpio6_28 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AD4 | mmc3_clk | mmc3_clk | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | usb3_ulpi_d5 | 3 | IO | | | | | | | | | 0 |
| | | vin2b_d7 | 4 | I | | | | | | | | | 0 |
| | | vin1a_d7 | 9 | I | | | | | | | | | 0 |
| | | ehrpwm2_tripzone_input | 10 | IO | | | | | | | | | 0 |
| | | gpio6_29 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AC4 | mmc3_cmd | mmc3_cmd | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | spi3_sclk | 1 | IO | | | | | | | | | 0 |
| | | usb3_ulpi_d4 | 3 | IO | | | | | | | | | 0 |
| | | vin2b_d6 | 4 | I | | | | | | | | | 0 |
| | | vin1a_d6 | 9 | I | | | | | | | | | 0 |
| | | eCAP2_in_PWM2_out | 10 | IO | | | | | | | | | 0 |
| | | gpio6_30 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| AC7 | mmc3_dat0 | mmc3_dat0 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | spi3_d1 | 1 | IO | | | | | | | | | 0 |
| | | uart5_rxd | 2 | I | | | | | | | | | 1 |
| | | usb3_ulpi_d3 | 3 | IO | | | | | | | | | 0 |
| | | vin2b_d5 | 4 | I | | | | | | | | | 0 |
| | | vin1a_d5 | 9 | I | | | | | | | | | 0 |
| | | eQEP3A_in | 10 | I | | | | | | | | | 0 |
| | | gpio6_31 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AC6 | mmc3_dat1 | mmc3_dat1 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | spi3_d0 | 1 | IO | | | | | | | | | 0 |
| | | uart5_txd | 2 | O | | | | | | | | | |
| | | usb3_ulpi_d2 | 3 | IO | | | | | | | | | 0 |
| | | vin2b_d4 | 4 | I | | | | | | | | | 0 |
| | | vin1a_d4 | 9 | I | | | | | | | | | 0 |
| | | eQEP3B_in | 10 | I | | | | | | | | | 0 |
| | | gpio7_0 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AC9 | mmc3_dat2 | mmc3_dat2 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | spi3_cs0 | 1 | IO | | | | | | | | | 1 |
| | | uart5_ctsn | 2 | I | | | | | | | | | 1 |
| | | usb3_ulpi_d1 | 3 | IO | | | | | | | | | 0 |
| | | vin2b_d3 | 4 | I | | | | | | | | | 0 |
| | | vin1a_d3 | 9 | I | | | | | | | | | 0 |
| | | eQEP3_index | 10 | IO | | | | | | | | | 0 |
| | | gpio7_1 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AC3 | mmc3_dat3 | mmc3_dat3 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | spi3_cs1 | 1 | IO | | | | | | | | | 1 |
| | | uart5_rtsn | 2 | O | | | | | | | | | |
| | | usb3_ulpi_d0 | 3 | IO | | | | | | | | | 0 |
| | | vin2b_d2 | 4 | I | | | | | | | | | 0 |
| | | vin1a_d2 | 9 | I | | | | | | | | | 0 |
| | | eQEP3_strobe | 10 | IO | | | | | | | | | 0 |
| | | gpio7_2 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| AC8 | mmc3_dat4 | mmc3_dat4 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | spi4_sclk | 1 | IO | | | | | | | | | 0 |
| | | uart10_rxd | 2 | I | | | | | | | | | 1 |
| | | usb3_ulpi_nxt | 3 | I | | | | | | | | | 0 |
| | | vin2b_d1 | 4 | I | | | | | | | | | 0 |
| | | vin1a_d1 | 9 | I | | | | | | | | | 0 |
| | | ehrpwm3A | 10 | O | | | | | | | | | |
| | | gpio1_22 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AD6 | mmc3_dat5 | mmc3_dat5 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | spi4_d1 | 1 | IO | | | | | | | | | 0 |
| | | uart10_txd | 2 | O | | | | | | | | | |
| | | usb3_ulpi_dir | 3 | I | | | | | | | | | 0 |
| | | vin2b_d0 | 4 | I | | | | | | | | | 0 |
| | | vin1a_d0 | 9 | I | | | | | | | | | 0 |
| | | ehrpwm3B | 10 | O | | | | | | | | | |
| | | gpio1_23 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AB8 | mmc3_dat6 | mmc3_dat6 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | spi4_d0 | 1 | IO | | | | | | | | | 0 |
| | | uart10_ctsn | 2 | I | | | | | | | | | 1 |
| | | usb3_ulpi_stp | 3 | O | | | | | | | | | |
| | | vin2b_de1 | 4 | I | | | | | | | | | |
| | | vin1a_hsync0 | 9 | I | | | | | | | | | 0 |
| | | ehrpwm3_tripzone_input | 10 | IO | | | | | | | | | 0 |
| | | gpio1_24 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AB5 | mmc3_dat7 | mmc3_dat7 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv7 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | spi4_cs0 | 1 | IO | | | | | | | | | 1 |
| | | uart10_rtsn | 2 | O | | | | | | | | | |
| | | usb3_ulpi_clk | 3 | I | | | | | | | | | 0 |
| | | vin2b_clk1 | 4 | I | | | | | | | | | |
| | | vin1a_vsync0 | 9 | I | | | | | | | | | 0 |
| | | eCAP3_in_PWM3_out | 10 | IO | | | | | | | | | 0 |
| | | gpio1_25 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| D21 | nmin_dsp | nmin_dsp | 0 | I | PD | PD | | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| Y11 | on_off | on_off | 0 | O | PU | drive 1 (OFF) | | 1.8/3.3 | vddshv5 | Yes | BC1833IHHV | PU/PD | |
| AG13 | pcie_rxn0 | pcie_rxn0 | 0 | I | OFF | OFF | | 1.8 | vdda_pcie0 | | SERDES | | |
| AH13 | pcie_rxp0 | pcie_rxp0 | 0 | I | OFF | OFF | | 1.8 | vdda_pcie0 | | SERDES | | |
| AG14 | pcie_txn0 | pcie_txn0 | 0 | O | | | | 1.8 | vdda_pcie0 | | SERDES | | |
| AH14 | pcie_txp0 | pcie_txp0 | 0 | O | | | | 1.8 | vdda_pcie0 | | SERDES | | |
| F22 | porz | porz | 0 | I | | | | 1.8/3.3 | vddshv3 | Yes | IHHV1833 | PU/PD | |
| E23 | resetrn | resetrn | 0 | I | PU | PU | | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |
| U5 | rgmii0_rxc | rgmii0_rxc | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | rmii1_txen | 2 | O | | | | | | | | | |
| | | mii0_txclk | 3 | I | | | | | | | | | |
| | | vin2a_d5 | 4 | I | | | | | | | | | |
| | | vin1b_d5 | 5 | I | | | | | | | | | |
| | | usb3_ulpi_d2 | 6 | IO | | | | | | | | | |
| | | gpio5_26 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| V5 | rgmii0_rxctl | rgmii0_rxctl | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | rmii1_txd1 | 2 | O | | | | | | | | | |
| | | mii0_txd3 | 3 | O | | | | | | | | | |
| | | vin2a_d6 | 4 | I | | | | | | | | | |
| | | vin1b_d6 | 5 | I | | | | | | | | | |
| | | usb3_ulpi_d3 | 6 | IO | | | | | | | | | |
| | | gpio5_27 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| W2 | rgmii0_rxd0 | rgmii0_rxd0 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | rmii0_txd0 | 1 | O | | | | | | | | | |
| | | mii0_txd0 | 3 | O | | | | | | | | | |
| | | vin2a_fld0 | 4 | I | | | | | | | | | |
| | | vin1b_fld1 | 5 | I | | | | | | | | | |
| | | usb3_ulpi_d7 | 6 | IO | | | | | | | | | |
| | | gpio5_31 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|---|
| Y2 | rgmii0_rxd1 | rgmii0_rxd1 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | rmii0_txd1 | 1 | O | | | | | | | | | | |
| | | mii0_txd1 | 3 | O | | | | | | | | | | |
| | | vin2a_d9 | 4 | I | | | | | | | | | | 0 |
| | | usb3_ulpi_d6 | 6 | IO | | | | | | | | | | 0 |
| | | gpio5_30 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| V3 | rgmii0_rxd2 | rgmii0_rxd2 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | rmii0_txen | 1 | O | | | | | | | | | | |
| | | mii0_txen | 3 | O | | | | | | | | | | |
| | | vin2a_d8 | 4 | I | | | | | | | | | | 0 |
| | | usb3_ulpi_d5 | 6 | IO | | | | | | | | | | 0 |
| | | gpio5_29 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| V4 | rgmii0_rxd3 | rgmii0_rxd3 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | rmii1_txd0 | 2 | O | | | | | | | | | | |
| | | mii0_txd2 | 3 | O | | | | | | | | | | |
| | | vin2a_d7 | 4 | I | | | | | | | | | | 0 |
| | | vin1b_d7 | 5 | I | | | | | | | | | | 0 |
| | | usb3_ulpi_d4 | 6 | IO | | | | | | | | | | 0 |
| | | gpio5_28 | 14 | IO | | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | | |
| W9 | rgmii0_txc | rgmii0_txc | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | uart3_ctsn | 1 | I | | | | | | | | | | 1 |
| | | rmii1_rxd1 | 2 | I | | | | | | | | | | 0 |
| | | mii0_rxd3 | 3 | I | | | | | | | | | | 0 |
| | | vin2a_d3 | 4 | I | | | | | | | | | | 0 |
| | | vin1b_d3 | 5 | I | | | | | | | | | | 0 |
| | | usb3_ulpi_clk | 6 | I | | | | | | | | | | 0 |
| | | spi3_d0 | 7 | IO | | | | | | | | | | 0 |
| | | spi4_cs2 | 8 | IO | | | | | | | | | | 1 |
| | | gpio5_20 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | | | | |
|-----------------|---------------|-----------------|-------------|-------------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|---------------------|-------|---------------------|-------|--|
| V9 | rgmii0_txctl | rgmii0_txctl | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | | | | | |
| | | uart3_rtsn | 1 | O | | | | | | | | | | | | | |
| | | rmii1_rxd0 | 2 | I | | | | | | | | | | 0 | | | |
| | | mii0_rxd2 | 3 | I | | | | | | | | | | 0 | | | |
| | | vin2a_d4 | 4 | I | | | | | | | | | | 0 | | | |
| | | vin1b_d4 | 5 | I | | | | | | | | | | 0 | | | |
| | | usb3_ulpi_stp | 6 | O | | | | | | | | | | | | | |
| | | spi3_cs0 | 7 | IO | | | | | | | | | | | 1 | | |
| | | spi4_cs3 | 8 | IO | | | | | | | | | | | 1 | | |
| | | gpio5_21 | 14 | IO | | | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | | | |
| | | U6 | rgmii0_txd0 | rgmii0_txd0 | 0 | O | PD | PD | 15 | 1.8/3.3 | | | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | | | rmii0_rxd0 | 1 | I | | | | | | | | | | | |
| mii0_rxd0 | 3 | | | I | | | | | | | | 0 | | | | | |
| vin2a_d10 | 4 | | | I | | | | | | | | 0 | | | | | |
| usb3_ulpi_d1 | 6 | | | IO | | | | | | | | 0 | | | | | |
| spi4_cs0 | 7 | | | IO | | | | | | | | 1 | | | | | |
| uart4_rtsn | 8 | | | O | | | | | | | | | | | | | |
| gpio5_25 | 14 | | | IO | | | | | | | | | | | | | |
| Driver off | 15 | | | I | | | | | | | | | | | | | |
| V6 | rgmii0_txd1 | | | rgmii0_txd1 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | | | |
| | | rmii0_rxd1 | 1 | I | | | | | | | | 0 | | | | | |
| | | mii0_rxd1 | 3 | I | | | | | | | | 0 | | | | | |
| | | vin2a_vsync0 | 4 | I | | | | | | | | | | | | | |
| | | vin1b_vsync1 | 5 | I | | | | | | | | 0 | | | | | |
| | | usb3_ulpi_d0 | 6 | IO | | | | | | | | 0 | | | | | |
| | | spi4_d0 | 7 | IO | | | | | | | | 0 | | | | | |
| | | uart4_ctsn | 8 | IO | | | | | | | | 1 | | | | | |
| | | gpio5_24 | 14 | IO | | | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|--------------------|--------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| U7 | rgmii0_txd2 | rgmii0_txd2 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | rmii0_rxer | 1 | I | | | | | | | | | 0 |
| | | mii0_rxer | 3 | I | | | | | | | | | 0 |
| | | vin2a_hsync0 | 4 | I | | | | | | | | | 0 |
| | | vin1b_hsync1 | 5 | I | | | | | | | | | 0 |
| | | usb3_ulpi_nxt | 6 | I | | | | | | | | | 0 |
| | | spi4_d1 | 7 | IO | | | | | | | | | 0 |
| | | uart4_txd | 8 | O | | | | | | | | | |
| | | gpio5_23 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| V7 | rgmii0_txd3 | rgmii0_txd3 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | rmii0_crs | 1 | I | | | | | | | | | 0 |
| | | mii0_crs | 3 | I | | | | | | | | | 0 |
| | | vin2a_de0 | 4 | I | | | | | | | | | 0 |
| | | vin1b_de1 | 5 | I | | | | | | | | | 0 |
| | | usb3_ulpi_dir | 6 | I | | | | | | | | | 0 |
| | | spi4_sclk | 7 | IO | | | | | | | | | 0 |
| | | uart4_rxd | 8 | I | | | | | | | | | 1 |
| | | gpio5_22 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| U3 | RMII_MHZ_50_CLK | RMII_MHZ_50_CLK | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin2a_d11 | 4 | I | | | | | | | | | 0 |
| | | gpio5_17 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| F23 | rstoutn | rstoutn | 0 | O | PD | PD | | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |
| E18 | rtck | rtck | 0 | O | PU | OFF | 0 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | gpio8_29 | 14 | IO | | | | | | | | | |
| AF14 | rtc_iso | rtc_iso | 0 | I | | | | 1.8/3.3 | vddshv5 | Yes | IHHV1833 | PU/PD | |
| AE14 | rtc_osc_xi_clkin32 | rtc_osc_xi_clkin32 | 0 | I | | | | 1.8 | vdda_rtc | No | LVCMOS OSC | | |
| AD14 | rtc_osc_xo | rtc_osc_xo | 0 | O | | | | 1.8 | vdda_rtc | No | LVCMOS OSC | | |
| AB17 | rtc_porz | rtc_porz | 0 | I | | | | 1.8/3.3 | vddshv5 | Yes | IHHV1833 | PU/PD | |
| AH9 | sata1_rxn0 | sata1_rxn0 | 0 | I | OFF | OFF | | 1.8 | vdda_sata | | SATAPHY | | |
| AG9 | sata1_rxp0 | sata1_rxp0 | 0 | I | OFF | OFF | | 1.8 | vdda_sata | | SATAPHY | | |
| AG10 | sata1_txn0 | sata1_txn0 | 0 | O | | | | 1.8 | vdda_sata | | SATAPHY | | |
| AH10 | sata1_txp0 | sata1_txp0 | 0 | O | | | | 1.8 | vdda_sata | | SATAPHY | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| A24 | spi1_cs0 | spi1_cs0 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | gpio7_10 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A22 | spi1_cs1 | spi1_cs1 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | sata1_led | 2 | O | | | | | | | | | |
| | | spi2_cs1 | 3 | IO | | | | | | | | | 1 |
| | | gpio7_11 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| B21 | spi1_cs2 | spi1_cs2 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart4_rxd | 1 | I | | | | | | | | | 1 |
| | | mmc3_sdcd | 2 | I | | | | | | | | | 1 |
| | | spi2_cs2 | 3 | IO | | | | | | | | | 1 |
| | | dcan2_tx | 4 | IO | | | | | | | | | 1 |
| | | mdio_mclk | 5 | O | | | | | | | | | 1 |
| | | hdmi1_hpd | 6 | IO | | | | | | | | | |
| | | gpio7_12 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| B20 | spi1_cs3 | spi1_cs3 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart4_txd | 1 | O | | | | | | | | | |
| | | mmc3_sdwp | 2 | I | | | | | | | | | 0 |
| | | spi2_cs3 | 3 | IO | | | | | | | | | 1 |
| | | dcan2_rx | 4 | IO | | | | | | | | | 1 |
| | | mdio_d | 5 | IO | | | | | | | | | 1 |
| | | hdmi1_cec | 6 | IO | | | | | | | | | |
| | | gpio7_13 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| B25 | spi1_d0 | spi1_d0 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | gpio7_9 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| F16 | spi1_d1 | spi1_d1 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | gpio7_8 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A25 | spi1_sclk | spi1_sclk | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | gpio7_7 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| B24 | spi2_cs0 | spi2_cs0 | 0 | IO | PU | PU | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart3_rtsn | 1 | O | | | | | | | | | |
| | | uart5_txd | 2 | O | | | | | | | | | |
| | | gpio7_17 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| G17 | spi2_d0 | spi2_d0 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | uart3_ctsn | 1 | I | | | | | | | | | 1 |
| | | uart5_rxd | 2 | I | | | | | | | | | 1 |
| | | gpio7_16 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| B22 | spi2_d1 | spi2_d1 | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | uart3_txd | 1 | O | | | | | | | | | |
| | | gpio7_15 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A26 | spi2_sclk | spi2_sclk | 0 | IO | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | uart3_rxd | 1 | I | | | | | | | | | 1 |
| | | gpio7_14 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| E20 | tcclk | tcclk | 0 | I | PU | PU | 0 | 1.8/3.3 | vddshv3 | Yes | IQ1833 | PU/PD | |
| D23 | tdi | tdi | 0 | I | PU | PU | 0 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | gpio8_27 | 14 | I | | | | | | | | | |
| F19 | tdo | tdo | 0 | O | PU | PU | 0 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | gpio8_28 | 14 | IO | | | | | | | | | |
| F18 | tms | tms | 0 | I | PU | PU | 0 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |
| D20 | trstn | trstn | 0 | I | PD | PD | | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | |
| E25 | uart1_ctsn | uart1_ctsn | 0 | I | PU | PU | 15 | 1.8/3.3 | vddshv4 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart9_rxd | 2 | I | | | | | | | | | 1 |
| | | mmc4_clk | 3 | IO | | | | | | | | | 1 |
| | | gpio7_24 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| C27 | uart1_rtsn | uart1_rtsn | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv4 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | uart9_txd | 2 | O | | | | | | | | | |
| | | mmc4_cmd | 3 | IO | | | | | | | | | 1 |
| | | gpio7_25 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| B27 | uart1_rxd | uart1_rxd | 0 | I | PU | PU | 15 | 1.8/3.3 | vddshv4 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | mmc4_sdcd | 3 | I | | | | | | | | | 1 |
| | | gpio7_22 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| C26 | uart1_txd | uart1_txd | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv4 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mmc4_sdpw | 3 | I | | | | | | | | | |
| | | gpio7_23 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| D27 | uart2_ctsn | uart2_ctsn | 0 | I | PU | PU | 15 | 1.8/3.3 | vddshv4 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart3_rxd | 2 | I | | | | | | | | | 1 |
| | | mmc4_dat2 | 3 | IO | | | | | | | | | 1 |
| | | uart10_rxd | 4 | I | | | | | | | | | 1 |
| | | uart1_dtrn | 5 | O | | | | | | | | | |
| | | gpio1_16 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| C28 | uart2_rtsn | uart2_rtsn | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv4 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | uart3_txd | 1 | O | | | | | | | | | |
| | | uart3_irtx | 2 | O | | | | | | | | | |
| | | mmc4_dat3 | 3 | IO | | | | | | | | | 1 |
| | | uart10_txd | 4 | O | | | | | | | | | |
| | | uart1_rin | 5 | I | | | | | | | | | 1 |
| | | gpio1_17 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| D28 | uart2_rxd | uart3_ctsn | 1 | I | PU | PU | 15 | 1.8/3.3 | vddshv4 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | uart3_rctx | 2 | O | | | | | | | | | |
| | | mmc4_dat0 | 3 | IO | | | | | | | | | 1 |
| | | uart2_rxd | 4 | I | | | | | | | | | 1 |
| | | uart1_dcdn | 5 | I | | | | | | | | | 1 |
| | | gpio7_26 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| D26 | uart2_txd | uart2_txd | 0 | O | PU | PU | 15 | 1.8/3.3 | vddshv4 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | uart3_rtsn | 1 | O | | | | | | | | | |
| | | uart3_sd | 2 | O | | | | | | | | | |
| | | mmc4_dat1 | 3 | IO | | | | | | | | | 1 |
| | | uart2_txd | 4 | O | | | | | | | | | |
| | | uart1_dsrn | 5 | I | | | | | | | | | 0 |
| | | gpio7_27 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|--------------|----------|---------------------|------------------------|-----------|
| V2 | uart3_rxd | uart3_rxd | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 1 |
| | | rmii1_crs | 2 | I | | | | | | | | | 0 |
| | | mii0_rxdv | 3 | I | | | | | | | | | 0 |
| | | vin2a_d1 | 4 | I | | | | | | | | | 0 |
| | | vin1b_d1 | 5 | I | | | | | | | | | 0 |
| | | spi3_sclk | 7 | IO | | | | | | | | | 0 |
| | | gpio5_18 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| Y1 | uart3_txd | uart3_txd | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv9 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | rmii1_rxer | 2 | I | | | | | | | | | 0 |
| | | mii0_rxclk | 3 | I | | | | | | | | | 0 |
| | | vin2a_d2 | 4 | I | | | | | | | | | 0 |
| | | vin1b_d2 | 5 | I | | | | | | | | | 0 |
| | | spi3_d1 | 7 | IO | | | | | | | | | 0 |
| | | spi4_cs1 | 8 | IO | | | | | | | | | 1 |
| | | gpio5_19 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| AC12 | usb1_dm | usb1_dm | 0 | IO | OFF | OFF | | 3.3 | vdda33v_usb1 | | USBPHY | | |
| AD12 | usb1_dp | usb1_dp | 0 | IO | OFF | OFF | | 3.3 | vdda33v_usb1 | | USBPHY | | |
| AB10 | usb1_drvvbus | usb1_drvvbus | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv6 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | timer16 | 7 | IO | | | | | | | | | |
| | | gpio6_12 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AF11 | usb2_dm | usb2_dm | 0 | IO | | | | 3.3 | vdda33v_usb2 | No | USBPHY | | |
| AE11 | usb2_dp | usb2_dp | 0 | IO | | | | 3.3 | vdda33v_usb2 | No | USBPHY | | |
| AC10 | usb2_drvvbus | usb2_drvvbus | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv6 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | timer15 | 7 | IO | | | | | | | | | |
| | | gpio6_13 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AF12 | usb_rxn0 | usb_rxn0 | 0 | I | OFF | OFF | | 1.8 | vdda_usb1 | | SERDES | | |
| | | pcie_rxn1 | 1 | I | | | | | | | | | |
| AE12 | usb_rxp0 | usb_rxp0 | 0 | I | OFF | OFF | | 1.8 | vdda_usb1 | | SERDES | | |
| | | pcie_rxp1 | 1 | I | | | | | | | | | |
| AC11 | usb_txn0 | usb_txn0 | 0 | O | | | | 1.8 | vdda_usb1 | | SERDES | | |
| | | pcie_txn1 | 1 | O | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|--|----------------|---------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|------------------|------------------------|-----------|
| AD11 | usb_txp0 | usb_txp0 | 0 | O | | | | 1.8 | vdda_usb1 | | SERDES | | |
| | | pcie_txp1 | 1 | O | | | | | | | | | |
| H13, H14, J17, J18, L7, L8, N10, N13, P11, P12, P13, R11, R16, R19, T13, T16, T19, U13, U16, U8, U9, V16, V8 | vdd | vdd | | PWR | | | | | | | | | |
| K14 | vpp | vpp ⁽¹¹⁾ | | PWR | | | | | | | | | |
| AA12 | vdda33v_usb1 | vdda33v_usb1 | | PWR | | | | | | | | | |
| Y12 | vdda33v_usb2 | vdda33v_usb2 | | PWR | | | | | | | | | |
| P14 | vdda_core_gmac | vdda_core_gmac | | PWR | | | | | | | | | |
| W12 | vdda_csi | vdda_csi | | PWR | | | | | | | | | |
| R17 | vdda_ddr | vdda_ddr | | PWR | | | | | | | | | |
| N11 | vdda_debug | vdda_debug | | PWR | | | | | | | | | |
| N12 | vdda_dsp_iva | vdda_dsp_iva | | PWR | | | | | | | | | |
| R14 | vdda_gpu | vdda_gpu | | PWR | | | | | | | | | |
| Y17 | vdda_hdmi | vdda_hdmi | | PWR | | | | | | | | | |
| N16 | vdda_mpu_abe | vdda_mpu_abe | | PWR | | | | | | | | | |
| AD16, AE16 | vdda_osc | vdda_osc | | PWR | | | | | | | | | |
| AA17 | vdda_pcie | vdda_pcie | | PWR | | | | | | | | | |
| AA16 | vdda_pcie0 | vdda_pcie0 | | PWR | | | | | | | | | |
| M14 | vdda_per | vdda_per | | PWR | | | | | | | | | |
| P15 | vdda_pll_spare | vdda_pll_spare | | PWR | | | | | | | | | |
| AB13 | vdda_rtc | vdda_rtc | | PWR | | | | | | | | | |
| V13 | vdda_sata | vdda_sata | | PWR | | | | | | | | | |
| AA13 | vdda_usb1 | vdda_usb1 | | PWR | | | | | | | | | |
| AB12 | vdda_usb2 | vdda_usb2 | | PWR | | | | | | | | | |
| W14 | vdda_usb3 | vdda_usb3 | | PWR | | | | | | | | | |
| P16 | vdda_video | vdda_video | | PWR | | | | | | | | | |
| G18, H17, M8, M9, N8, P8, R8, T8, V21, V22, W17, W18 | vdds18v | vdds18v | | PWR | | | | | | | | | |
| AA18, AA19, N21, P20, P21, W21, Y21 | vdds18v_ddr1 | vdds18v_ddr1 | | PWR | | | | | | | | | |
| E3, E5, G4, G5, H8, H9 | vddshv1 | vddshv1 | | PWR | | | | | | | | | |
| B6, D10, E10, H10, H11 | vddshv2 | vddshv2 | | PWR | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|--|---------------|----------------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| B23, D16, D22, E16, E22, G15, H15, H16, H18, H19 | vddshv3 | vddshv3 | | PWR | | | | | | | | | |
| C24 | vddshv4 | vddshv4 | | PWR | | | | | | | | | |
| V12 | vddshv5 | vddshv5 | | PWR | | | | | | | | | |
| AD5, AD7, AE7, AF5 | vddshv6 | vddshv6 | | PWR | | | | | | | | | |
| AB6, AB7 | vddshv7 | vddshv7 | | PWR | | | | | | | | | |
| W8, Y8 | vddshv8 | vddshv8 | | PWR | | | | | | | | | |
| U10, W4, W5 | vddshv9 | vddshv9 | | PWR | | | | | | | | | |
| N4, N5, P10, R10, R7, T4, T5 | vddshv10 | vddshv10 | | PWR | | | | | | | | | |
| J8, K8 | vddshv11 | vddshv11 | | PWR | | | | | | | | | |
| AA21, AA22, AB21, AB22, AB24, AB25, AC22, AD26, AG20, AG28, AH27, T24, T25, W16, W27 | vdds_dds1 | vdds_dds1 | | PWR | | | | | | | | | |
| AA7, Y7 | vdds_mlbp | vdds_mlbp | | PWR | | | | | | | | | |
| K10, K11, L10, L11, M10, M11 | vdd_dsp | vdd_dsp | | PWR | | | | | | | | | |
| U11, U12, V10, V11, V14, W10, W11, W13 | vdd_gpu | vdd_gpu | | PWR | | | | | | | | | |
| J13, K12, K13, L12, M12, M13 | vdd_iva | vdd_iva | | PWR | | | | | | | | | |
| K17, K18, L15, L16, L17, L18, L19, M15, M16, M17, M18, N17, N18, P17, P18, R18 | vdd_mpu | vdd_mpu | | PWR | | | | | | | | | |
| AB15 | vdd_rtc | vdd_rtc | | PWR | | | | | | | | | |
| E1 | vin2a_clk0 | vin2a_clk0 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vout2_fld | 4 | O | | | | | | | | | |
| | | emu5 | 5 | O | | | | | | | | | |
| | | kbd_row0 | 9 | I | | | | | | | | | 0 |
| | | eQEP1A_in | 10 | I | | | | | | | | | 0 |
| | | gpio3_28 gpmc_a27 gpmc_a17 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | | |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|-----|---------------------|
| F2 | vin2a_d0 | vin2a_d0 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | | |
| | | vout2_d23 | 4 | O | | | | | | | | | | | |
| | | emu10 | 5 | O | | | | | | | | | | | |
| | | uart9_ctsn | 7 | I | | | | | | | | | | | 1 |
| | | spi4_d0 | 8 | IO | | | | | | | | | | | 0 |
| | | kbd_row4 | 9 | I | | | | | | | | | | | 0 |
| | | ehrpwm1B | 10 | O | | | | | | | | | | | |
| | | gpio4_1 | 14 | IO | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | |
| F3 | vin2a_d1 | vin2a_d1 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | | |
| | | vout2_d22 | 4 | O | | | | | | | | | | | |
| | | emu11 | 5 | O | | | | | | | | | | | |
| | | uart9_rtsn | 7 | O | | | | | | | | | | | |
| | | spi4_cs0 | 8 | IO | | | | | | | | | | | 1 |
| | | kbd_row5 | 9 | I | | | | | | | | | | | 0 |
| | | ehrpwm1_tripzone_input | 10 | IO | | | | | | | | | | | 0 |
| | | gpio4_2 | 14 | IO | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | |
| D1 | vin2a_d2 | vin2a_d2 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | | |
| | | vout2_d21 | 4 | O | | | | | | | | | | | |
| | | emu12 | 5 | O | | | | | | | | | | | |
| | | uart10_rxd | 8 | I | | | | | | | | | | | 1 |
| | | kbd_row6 | 9 | I | | | | | | | | | | | 0 |
| | | eCAP1_in_PWM1_out | 10 | IO | | | | | | | | | | | 0 |
| | | gpio4_3 | 14 | IO | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | |
| | | E2 | vin2a_d3 | vin2a_d3 | 0 | I | PD | PD | 15 | 1.8/3.3 | | | vddshv1 | Yes | Dual Voltage LVCMOS |
| vout2_d20 | 4 | | | O | | | | | | | | | | | |
| emu13 | 5 | | | O | | | | | | | | | | | |
| uart10_txd | 8 | | | O | | | | | | | | | | | |
| kbd_col0 | 9 | | | O | | | | | | | | | | | |
| ehrpwm1_synci | 10 | | | I | | | | | | | | | 0 | | |
| gpio4_4 | 14 | | | IO | | | | | | | | | | | |
| Driver off | 15 | | | I | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|---|
| D2 | vin2a_d4 | vin2a_d4 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | vout2_d19 | 4 | O | | | | | | | | | | |
| | | emu14 | 5 | O | | | | | | | | | | |
| | | uart10_ctsn | 8 | I | | | | | | | | | | 1 |
| | | kbd_col1 | 9 | O | | | | | | | | | | |
| | | ehrpwm1_synco | 10 | O | | | | | | | | | | |
| | | gpio4_5 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| F4 | vin2a_d5 | vin2a_d5 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | vout2_d18 | 4 | O | | | | | | | | | | |
| | | emu15 | 5 | O | | | | | | | | | | |
| | | uart10_rtsn | 8 | O | | | | | | | | | | |
| | | kbd_col2 | 9 | O | | | | | | | | | | |
| | | eQEP2A_in | 10 | I | | | | | | | | | | 0 |
| | | gpio4_6 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| C1 | vin2a_d6 | vin2a_d6 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | vout2_d17 | 4 | O | | | | | | | | | | |
| | | emu16 | 5 | O | | | | | | | | | | |
| | | mii1_rxd1 | 8 | I | | | | | | | | | | 0 |
| | | kbd_col3 | 9 | O | | | | | | | | | | |
| | | eQEP2B_in | 10 | I | | | | | | | | | | 0 |
| | | gpio4_7 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| E4 | vin2a_d7 | vin2a_d7 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 | |
| | | vout2_d16 | 4 | O | | | | | | | | | | |
| | | emu17 | 5 | O | | | | | | | | | | |
| | | mii1_rxd2 | 8 | I | | | | | | | | | | 0 |
| | | kbd_col4 | 9 | O | | | | | | | | | | |
| | | eQEP2_index | 10 | IO | | | | | | | | | | 0 |
| | | gpio4_8 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|------------------------|---------------|----------------------|-------------|-----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|---------------------|
| F5 | vin2a_d8 | vin2a_d8 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vout2_d15 | 4 | O | | | | | | | | | |
| | | emu18 | 5 | O | | | | | | | | | |
| | | mii1_rxd3 | 8 | I | | | | | | | | | 0 |
| | | kbd_col5 | 9 | O | | | | | | | | | |
| | | eQEP2_strobe | 10 | IO | | | | | | | | | 0 |
| | | gpio4_9 gpmc_a26 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| E6 | vin2a_d9 | vin2a_d9 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vout2_d14 | 4 | O | | | | | | | | | |
| | | emu19 | 5 | O | | | | | | | | | |
| | | mii1_rxd0 | 8 | I | | | | | | | | | 0 |
| | | kbd_col6 | 9 | O | | | | | | | | | |
| | | ehrpwm2A | 10 | O | | | | | | | | | |
| | | gpio4_10 gpmc_a25 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| D3 | vin2a_d10 | vin2a_d10 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | mdio_mclk | 3 | O | | | | | | | | | 1 |
| | | vout2_d13 | 4 | O | | | | | | | | | |
| | | kbd_col7 | 9 | O | | | | | | | | | |
| | | ehrpwm2B | 10 | O | | | | | | | | | |
| | | gpio4_11 gpmc_a24 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | F6 | vin2a_d11 | vin2a_d11 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS |
| mdio_d | 3 | | | IO | | | | | | | | | 1 |
| vout2_d12 | 4 | | | O | | | | | | | | | |
| kbd_row7 | 9 | | | I | | | | | | | | | 0 |
| ehrpwm2_tripzone_input | 10 | | | IO | | | | | | | | | 0 |
| gpio4_12 gpmc_a23 | 14 | | | IO | | | | | | | | | |
| Driver off | 15 | | | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| D5 | vin2a_d12 | vin2a_d12 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | rgmii1_txc | 3 | O | | | | | | | | | |
| | | vout2_d11 | 4 | O | | | | | | | | | |
| | | mii1_rxclk | 8 | I | | | | | | | | | 0 |
| | | kbd_col8 | 9 | O | | | | | | | | | |
| | | eCAP2_in_PWM2_out | 10 | IO | | | | | | | | | 0 |
| | | gpio4_13 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| C2 | vin2a_d13 | vin2a_d13 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | rgmii1_txc1 | 3 | O | | | | | | | | | |
| | | vout2_d10 | 4 | O | | | | | | | | | |
| | | mii1_rxdv | 8 | I | | | | | | | | | 0 |
| | | kbd_row8 | 9 | I | | | | | | | | | 0 |
| | | eQEP3A_in | 10 | I | | | | | | | | | 0 |
| | | gpio4_14 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| C3 | vin2a_d14 | vin2a_d14 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | rgmii1_txd3 | 3 | O | | | | | | | | | |
| | | vout2_d9 | 4 | O | | | | | | | | | |
| | | mii1_txclk | 8 | I | | | | | | | | | 0 |
| | | eQEP3B_in | 10 | I | | | | | | | | | 0 |
| | | gpio4_15 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| C4 | vin2a_d15 | vin2a_d15 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | rgmii1_txd2 | 3 | O | | | | | | | | | |
| | | vout2_d8 | 4 | O | | | | | | | | | |
| | | mii1_txd0 | 8 | O | | | | | | | | | |
| | | eQEP3_index | 10 | IO | | | | | | | | | 0 |
| | | gpio4_16 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |
| B2 | vin2a_d16 | vin2a_d16 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin2b_d7 | 2 | I | | | | | | | | | 0 |
| | | rgmii1_txd1 | 3 | O | | | | | | | | | |
| | | vout2_d7 | 4 | O | | | | | | | | | |
| | | mii1_txd1 | 8 | O | | | | | | | | | |
| | | eQEP3_strobe | 10 | IO | | | | | | | | | 0 |
| | | gpio4_24 | 14 | IO | | | | | | | | | |
| Driver off | 15 | I | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| D6 | vin2a_d17 | vin2a_d17 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin2b_d6 | 2 | I | | | | | | | | | 0 |
| | | rgmii1_txd0 | 3 | O | | | | | | | | | |
| | | vout2_d6 | 4 | O | | | | | | | | | |
| | | mii1_txd2 | 8 | O | | | | | | | | | |
| | | ehrpwm3A | 10 | O | | | | | | | | | |
| | | gpio4_25 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| C5 | vin2a_d18 | vin2a_d18 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin2b_d5 | 2 | I | | | | | | | | | 0 |
| | | rgmii1_rxc | 3 | I | | | | | | | | | 0 |
| | | vout2_d5 | 4 | O | | | | | | | | | |
| | | mii1_txd3 | 8 | O | | | | | | | | | |
| | | ehrpwm3B | 10 | O | | | | | | | | | |
| | | gpio4_26 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A3 | vin2a_d19 | vin2a_d19 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin2b_d4 | 2 | I | | | | | | | | | 0 |
| | | rgmii1_rxctl | 3 | I | | | | | | | | | 0 |
| | | vout2_d4 | 4 | O | | | | | | | | | |
| | | mii1_txer | 8 | O | | | | | | | | | 0 |
| | | ehrpwm3_tripzone_input | 10 | IO | | | | | | | | | 0 |
| | | gpio4_27 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| B3 | vin2a_d20 | vin2a_d20 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin2b_d3 | 2 | I | | | | | | | | | 0 |
| | | rgmii1_rxd3 | 3 | I | | | | | | | | | 0 |
| | | vout2_d3 | 4 | O | | | | | | | | | |
| | | mii1_rxer | 8 | I | | | | | | | | | 0 |
| | | eCAP3_in_PWM3_out | 10 | IO | | | | | | | | | 0 |
| | | gpio4_28 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| B4 | vin2a_d21 | vin2a_d21 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin2b_d2 | 2 | I | | | | | | | | | 0 |
| | | rgmii1_rxd2 | 3 | I | | | | | | | | | 0 |
| | | vout2_d2 | 4 | O | | | | | | | | | |
| | | mii1_col | 8 | I | | | | | | | | | 0 |
| | | gpio4_29 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| B5 | vin2a_d22 | vin2a_d22 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin2b_d1 | 2 | I | | | | | | | | | 0 |
| | | rgmii1_rxd1 | 3 | I | | | | | | | | | 0 |
| | | vout2_d1 | 4 | O | | | | | | | | | |
| | | mii1_crs | 8 | I | | | | | | | | | 0 |
| | | gpio4_30 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A4 | vin2a_d23 | vin2a_d23 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | 0 |
| | | vin2b_d0 | 2 | I | | | | | | | | | 0 |
| | | rgmii1_rxd0 | 3 | I | | | | | | | | | 0 |
| | | vout2_d0 | 4 | O | | | | | | | | | |
| | | mii1_txen | 8 | O | | | | | | | | | |
| | | gpio4_31 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| G2 | vin2a_de0 | vin2a_de0 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin2a_fld0 | 1 | I | | | | | | | | | |
| | | vin2b_fld1 | 2 | I | | | | | | | | | |
| | | vin2b_de1 | 3 | I | | | | | | | | | |
| | | vout2_de | 4 | O | | | | | | | | | |
| | | emu6 | 5 | O | | | | | | | | | |
| | | kbd_row1 | 9 | I | | | | | | | | | 0 |
| | | eQEP1B_in | 10 | I | | | | | | | | | 0 |
| | | gpio3_29 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|----------------------------------|--------------|--------------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|---------------------|
| H7 | vin2a_fld0 | vin2a_fld0 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin2b_clk1 | 2 | I | | | | | | | | | |
| | | vout2_clk | 4 | O | | | | | | | | | |
| | | emu7 | 5 | O | | | | | | | | | |
| | | eQEP1_index | 10 | IO | | | | | | | | | 0 |
| | | gpio3_30 gpmc_a27 gpmc_a18 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| G1 | vin2a_hsync0 | vin2a_hsync0 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv1 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin2b_hsync1 | 3 | I | | | | | | | | | |
| | | vout2_hsync | 4 | O | | | | | | | | | |
| | | emu8 | 5 | O | | | | | | | | | |
| | | uart9_rxd | 7 | I | | | | | | | | | 1 |
| | | spi4_sclk | 8 | IO | | | | | | | | | 0 |
| | | kbd_row2 | 9 | I | | | | | | | | | 0 |
| | | eQEP1_strobe | 10 | IO | | | | | | | | | 0 |
| | | gpio3_31 gpmc_a27 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | G6 | vin2a_vsync0 | vin2a_vsync0 | 0 | I | PD | PD | 15 | 1.8/3.3 | | | vddshv1 |
| vin2b_vsync1 | 3 | | | I | | | | | | | | | |
| vout2_vsync | 4 | | | O | | | | | | | | | |
| emu9 | 5 | | | O | | | | | | | | | |
| uart9_txd | 7 | | | O | | | | | | | | | |
| spi4_d1 | 8 | | | IO | | | | | | | 0 | | |
| kbd_row3 | 9 | | | I | | | | | | | 0 | | |
| ehrpwm1A | 10 | | | O | | | | | | | | | |
| gpio4_0 | 14 | | | IO | | | | | | | | | |
| Driver off | 15 | | | I | | | | | | | | | |
| D11 | vout1_clk | | | vout1_clk | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS |
| | | vin2a_fld0 vin1a_fld0 | 3 | I | | | | | | | | | |
| | | vin1a_fld0 | 4 | I | | | | | | | 0 | | |
| | | spi3_cs0 | 8 | IO | | | | | | | 1 | | |
| | | gpio4_19 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| F11 | vout1_d0 | vout1_d0 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | uart5_rxd | 2 | I | | | | | | | | | 1 |
| | | vin2a_d16 vin1a_d16 | 3 | I | | | | | | | | | |
| | | vin1a_d16 | 4 | I | | | | | | | | | 0 |
| | | spi3_cs2 | 8 | IO | | | | | | | | | 1 |
| | | gpio8_0 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| G10 | vout1_d1 | vout1_d1 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | uart5_txd | 2 | O | | | | | | | | | |
| | | vin2a_d17 vin1a_d17 | 3 | I | | | | | | | | | |
| | | vin1a_d17 | 4 | I | | | | | | | | | 0 |
| | | gpio8_1 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| F10 | vout1_d2 | vout1_d2 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | emu2 | 2 | O | | | | | | | | | |
| | | vin2a_d18 vin1a_d18 | 3 | I | | | | | | | | | |
| | | vin1a_d18 | 4 | I | | | | | | | | | 0 |
| | | obs0 | 5 | O | | | | | | | | | |
| | | obs16 | 6 | O | | | | | | | | | |
| | | obs_irq1 | 7 | O | | | | | | | | | |
| | | gpio8_2 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| G11 | vout1_d3 | vout1_d3 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | emu5 | 2 | O | | | | | | | | | |
| | | vin2a_d19 vin1a_d19 | 3 | I | | | | | | | | | |
| | | vin1a_d19 | 4 | I | | | | | | | | | 0 |
| | | obs1 | 5 | O | | | | | | | | | |
| | | obs17 | 6 | O | | | | | | | | | |
| | | obs_dmarq1 | 7 | O | | | | | | | | | |
| | | gpio8_3 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|--|
| E9 | vout1_d4 | vout1_d4 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu6 | 2 | O | | | | | | | | | | |
| | | vin2a_d20 vin1a_d20 | 3 | I | | | | | | | | | | |
| | | vin1a_d20 | 4 | I | | | | | | | | | 0 | |
| | | obs2 | 5 | O | | | | | | | | | | |
| | | obs18 | 6 | O | | | | | | | | | | |
| | | gpio8_4 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| F9 | vout1_d5 | vout1_d5 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu7 | 2 | O | | | | | | | | | | |
| | | vin2a_d21 vin1a_d21 | 3 | I | | | | | | | | | | |
| | | vin1a_d21 | 4 | I | | | | | | | | | 0 | |
| | | obs3 | 5 | O | | | | | | | | | | |
| | | obs19 | 6 | O | | | | | | | | | | |
| | | gpio8_5 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| F8 | vout1_d6 | vout1_d6 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu8 | 2 | O | | | | | | | | | | |
| | | vin2a_d22 vin1a_d22 | 3 | I | | | | | | | | | | |
| | | vin1a_d22 | 4 | I | | | | | | | | | 0 | |
| | | obs4 | 5 | O | | | | | | | | | | |
| | | obs20 | 6 | O | | | | | | | | | | |
| | | gpio8_6 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| E7 | vout1_d7 | vout1_d7 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu9 | 2 | O | | | | | | | | | | |
| | | vin2a_d23 vin1a_d23 | 3 | I | | | | | | | | | | |
| | | vin1a_d23 | 4 | I | | | | | | | | | 0 | |
| | | gpio8_7 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|------------------------|---------------|------------------------|-------------|-----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| E8 | vout1_d8 | vout1_d8 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | uart6_rxd | 2 | I | | | | | | | | | 1 |
| | | vin2a_d8 vin1a_d8 | 3 | I | | | | | | | | | |
| | | vin1a_d8 | 4 | I | | | | | | | | | 0 |
| | | gpio8_8 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| D9 | vout1_d9 | vout1_d9 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | uart6_txd | 2 | O | | | | | | | | | |
| | | vin2a_d9 vin1a_d9 | 3 | I | | | | | | | | | |
| | | vin1a_d9 | 4 | I | | | | | | | | | 0 |
| | | gpio8_9 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| D7 | vout1_d10 | vout1_d10 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | emu3 | 2 | O | | | | | | | | | |
| | | vin2a_d10 vin1a_d10 | 3 | I | | | | | | | | | |
| | | vin1a_d10 | 4 | I | | | | | | | | | 0 |
| | | obs5 | 5 | O | | | | | | | | | |
| | | obs21 | 6 | O | | | | | | | | | |
| | | obs_irq2 | 7 | O | | | | | | | | | |
| | | gpio8_10 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| | | D8 | vout1_d11 | vout1_d11 | 0 | O | PD | PD | 15 | 1.8/3.3 | | | vddshv2 |
| emu10 | 2 | | | O | | | | | | | | | |
| vin2a_d11 vin1a_d11 | 3 | | | I | | | | | | | | | |
| vin1a_d11 | 4 | | | I | | | | | | | 0 | | |
| obs6 | 5 | | | O | | | | | | | | | |
| obs22 | 6 | | | O | | | | | | | | | |
| obs_dmarq2 | 7 | | | O | | | | | | | | | |
| gpio8_11 | 14 | | | IO | | | | | | | | | |
| Driver off | 15 | | | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|--|
| A5 | vout1_d12 | vout1_d12 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu11 | 2 | O | | | | | | | | | | |
| | | vin2a_d12 vin1a_d12 | 3 | I | | | | | | | | | | |
| | | vin1a_d12 | 4 | I | | | | | | | | | 0 | |
| | | obs7 | 5 | O | | | | | | | | | | |
| | | obs23 | 6 | O | | | | | | | | | | |
| | | gpio8_12 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| C6 | vout1_d13 | vout1_d13 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu12 | 2 | O | | | | | | | | | | |
| | | vin2a_d13 vin1a_d13 | 3 | I | | | | | | | | | | |
| | | vin1a_d13 | 4 | I | | | | | | | | | 0 | |
| | | obs8 | 5 | O | | | | | | | | | | |
| | | obs24 | 6 | O | | | | | | | | | | |
| | | gpio8_13 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| C8 | vout1_d14 | vout1_d14 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu13 | 2 | O | | | | | | | | | | |
| | | vin2a_d14 vin1a_d14 | 3 | I | | | | | | | | | | |
| | | vin1a_d14 | 4 | I | | | | | | | | | 0 | |
| | | obs9 | 5 | O | | | | | | | | | | |
| | | obs25 | 6 | O | | | | | | | | | | |
| | | gpio8_14 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| C7 | vout1_d15 | vout1_d15 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu14 | 2 | O | | | | | | | | | | |
| | | vin2a_d15 vin1a_d15 | 3 | I | | | | | | | | | | |
| | | vin1a_d15 | 4 | I | | | | | | | | | 0 | |
| | | obs10 | 5 | O | | | | | | | | | | |
| | | obs26 | 6 | O | | | | | | | | | | |
| | | gpio8_15 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|----------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| B7 | vout1_d16 | vout1_d16 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | uart7_rxd | 2 | I | | | | | | | | | 1 |
| | | vin2a_d0 vin1a_d0 | 3 | I | | | | | | | | | |
| | | vin1a_d0 | 4 | I | | | | | | | | | 0 |
| | | gpio8_16 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| B8 | vout1_d17 | vout1_d17 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | uart7_txd | 2 | O | | | | | | | | | |
| | | vin2a_d1 vin1a_d1 | 3 | I | | | | | | | | | |
| | | vin1a_d1 | 4 | I | | | | | | | | | 0 |
| | | gpio8_17 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A7 | vout1_d18 | vout1_d18 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | emu4 | 2 | O | | | | | | | | | |
| | | vin2a_d2 vin1a_d2 | 3 | I | | | | | | | | | |
| | | vin1a_d2 | 4 | I | | | | | | | | | 0 |
| | | obs11 | 5 | O | | | | | | | | | |
| | | obs27 | 6 | O | | | | | | | | | |
| | | gpio8_18 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| A8 | vout1_d19 | vout1_d19 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | emu15 | 2 | O | | | | | | | | | |
| | | vin2a_d3 vin1a_d3 | 3 | I | | | | | | | | | |
| | | vin1a_d3 | 4 | I | | | | | | | | | 0 |
| | | obs12 | 5 | O | | | | | | | | | |
| | | obs28 | 6 | O | | | | | | | | | |
| | | gpio8_19 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | |
|-----------------|---------------|----------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|--|
| C9 | vout1_d20 | vout1_d20 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu16 | 2 | O | | | | | | | | | | |
| | | vin2a_d4 vin1a_d4 | 3 | I | | | | | | | | | | |
| | | vin1a_d4 | 4 | I | | | | | | | | | 0 | |
| | | obs13 | 5 | O | | | | | | | | | | |
| | | obs29 | 6 | O | | | | | | | | | | |
| | | gpio8_20 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| A9 | vout1_d21 | vout1_d21 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu17 | 2 | O | | | | | | | | | | |
| | | vin2a_d5 vin1a_d5 | 3 | I | | | | | | | | | | |
| | | vin1a_d5 | 4 | I | | | | | | | | | 0 | |
| | | obs14 | 5 | O | | | | | | | | | | |
| | | obs30 | 6 | O | | | | | | | | | | |
| | | gpio8_21 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| B9 | vout1_d22 | vout1_d22 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu18 | 2 | O | | | | | | | | | | |
| | | vin2a_d6 vin1a_d6 | 3 | I | | | | | | | | | | |
| | | vin1a_d6 | 4 | I | | | | | | | | | 0 | |
| | | obs15 | 5 | O | | | | | | | | | | |
| | | obs31 | 6 | O | | | | | | | | | | |
| | | gpio8_22 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |
| A10 | vout1_d23 | vout1_d23 | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | | |
| | | emu19 | 2 | O | | | | | | | | | | |
| | | vin2a_d7 vin1a_d7 | 3 | I | | | | | | | | | | |
| | | vin1a_d7 | 4 | I | | | | | | | | | 0 | |
| | | spi3_cs3 | 8 | IO | | | | | | | | | 1 | |
| | | gpio8_23 | 14 | IO | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|-----------------|---------------|-----------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|
| B10 | vout1_de | vout1_de | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin2a_de0 | 3 | I | | | | | | | | | |
| | | vin1a_de0 | 4 | I | | | | | | | | | 0 |
| | | spi3_d1 | 8 | IO | | | | | | | | | 0 |
| | | gpio4_20 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| B11 | vout1_fld | vout1_fld | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin2a_clk0 | 3 | I | | | | | | | | | |
| | | vin1a_clk0 | 4 | I | | | | | | | | | 0 |
| | | spi3_cs1 | 8 | IO | | | | | | | | | 1 |
| | | gpio4_21 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| C11 | vout1_hsync | vout1_hsync | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin2a_hsync0 | 3 | I | | | | | | | | | |
| | | vin1a_hsync0 | 4 | I | | | | | | | | | 0 |
| | | spi3_d0 | 8 | IO | | | | | | | | | 0 |
| | | gpio4_22 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| E11 | vout1_vsync | vout1_vsync | 0 | O | PD | PD | 15 | 1.8/3.3 | vddshv2 | Yes | Dual Voltage LVCMOS | PU/PD | |
| | | vin2a_vsync0 | 3 | I | | | | | | | | | |
| | | vin1a_vsync0 | 4 | I | | | | | | | | | 0 |
| | | spi3_sclk | 8 | IO | | | | | | | | | 0 |
| | | gpio4_23 | 14 | IO | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] |
|---|---------------|----------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|-------------------|------------------|------------------------|-----------|
| A1, A14, A2, A23, A28, A6, AA14, AA15, AA20, AA8, AA9, AB14, AB20, AD1, AD24, AG1, AH1, AH2, AH20, AH28, B1, D13, D19, E13, E19, F1, F7, G7, G8, G9, H12, J12, J15, J28, K1, K15, K24, K25, K4, K5, L13, L14, M19, N14, N15, N19, N24, N25, P28, R1, R12, R13, R21, T10, T11, T12, T14, T15, T17, T18, T21, U14, U15, U17, U20, U21, V15, V17, W1, W15, W24, W25, W28 | vss | vss | | GND | | | | | | | | | |
| AA10, AH8 | vssa_csi | vssa_csi | | GND | | | | | | | | | |
| AD19, AE19 | vssa_hdmi | vssa_hdmi | | GND | | | | | | | | | |
| AF15 | vssa_osc0 | vssa_osc0 | | GND | | | | | | | | | |
| AC14 | vssa_osc1 | vssa_osc1 | | GND | | | | | | | | | |
| AD13, AE13 | vssa_pcie | vssa_pcie | | GND | | | | | | | | | |
| AE10 | vssa_sata | vssa_sata | | GND | | | | | | | | | |
| AA11, AB11 | vssa_usb | vssa_usb | | GND | | | | | | | | | |
| AD10 | vssa_usb3 | vssa_usb3 | | GND | | | | | | | | | |
| R15 | vssa_video | vssa_video | | GND | | | | | | | | | |
| AD17 | Wakeup0 | Wakeup0 | 0 | I | | | 15 | 1.8/3.3 | vddshv5 | Yes | IHHV1833 | PU/PD | 1 |
| | | dcan1_rx | 1 | I | | | | | | | | | |
| | | gpio1_0 sys_nirq2 | 14 | I | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AC16 | Wakeup3 | Wakeup3 | 0 | I | | | 15 | 1.8/3.3 | vddshv5 | Yes | IHHV1833 | PU/PD | |
| | | sys_nirq1 | 1 | I | | | | | | | | | |
| | | gpio1_3 dcan2_rx | 14 | I | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | |
| AE15 | xi_osc0 | xi_osc0 | 0 | I | | | 1.8 | vdda_osc | No | LVC MOS Analog | | | |
| AC15 | xi_osc1 | xi_osc1 | 0 | I | | | 1.8 | vdda_osc | No | LVC MOS Analog | | | |
| AD15 | xo_osc0 | xo_osc0 | 0 | O | | | 1.8 | vdda_osc | No | LVC MOS Analog | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | | |
|-----------------|---------------|-----------------|-------------|---------------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|----------------------|------------------------|----------------------|-------|---|
| AC13 | xo_osc1 | xo_osc1 | 0 | A | | | | 1.8 | vdda_osc | No | LVC MOS Analog | | | | |
| D18 | xref_clk0 | xref_clk0 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVC MOS | PU/PD | | | |
| | | mcasp2_axr8 | 1 | IO | | | | | | | | | 0 | | |
| | | mcasp1_axr4 | 2 | IO | | | | | | | | | 0 | | |
| | | mcasp1_ahclkx | 3 | O | | | | | | | | | | | |
| | | mcasp5_ahclkx | 4 | O | | | | | | | | | | | |
| | | atl_clk0 | 5 | O | | | | | | | | | | | |
| | | vin1a_d0 | 7 | I | | | | | | | | | 0 | | |
| | | hdq0 | 8 | IO | | | | | | | | | 1 | | |
| | | clkout2 | 9 | O | | | | | | | | | | | |
| | | timer13 | 10 | IO | | | | | | | | | | | |
| | | gpio6_17 | 14 | IO | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | |
| | | E17 | xref_clk1 | xref_clk1 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVC MOS | PU/PD | |
| | | | | mcasp2_axr9 | 1 | IO | | | | | | | | | 0 |
| mcasp1_axr5 | 2 | | | IO | | | | | | | | | 0 | | |
| mcasp2_ahclkx | 3 | | | O | | | | | | | | | | | |
| mcasp6_ahclkx | 4 | | | O | | | | | | | | | | | |
| atl_clk1 | 5 | | | O | | | | | | | | | | | |
| vin1a_clk0 | 7 | | | I | | | | | | | | | 0 | | |
| timer14 | 10 | | | IO | | | | | | | | | | | |
| gpio6_18 | 14 | | | IO | | | | | | | | | | | |
| Driver off | 15 | | | I | | | | | | | | | | | |
| B26 | xref_clk2 | | | xref_clk2 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVC MOS | PU/PD | |
| | | | | mcasp2_axr10 | 1 | IO | | | | | | | | | 0 |
| | | | | mcasp1_axr6 | 2 | IO | | | | | | | | | 0 |
| | | | | mcasp3_ahclkx | 3 | O | | | | | | | | | |
| | | mcasp7_ahclkx | 4 | O | | | | | | | | | | | |
| | | atl_clk2 | 5 | O | | | | | | | | | | | |
| | | vout2_clk | 6 | O | | | | | | | | | | | |
| | | vin2a_clk0 | 8 | I | | | | | | | | | | | |
| | | vin1a_clk0 | | | | | | | | | | | | | |
| | | timer15 | 10 | IO | | | | | | | | | | | |
| | | gpio6_19 | 14 | IO | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | |

Table 4-2. Ball Characteristics⁽¹⁾ (continued)

| BALL NUMBER [1] | BALL NAME [2] | SIGNAL NAME [3] | MUXMODE [4] | TYPE [5] | BALL RESET STATE [6] | BALL RESET REL. STATE [7] | BALL RESET REL. MUXMODE [8] | I/O VOLTAGE VALUE [9] | POWER [10] | HYS [11] | BUFFER TYPE [12] | PULL UP/DOWN TYPE [13] | DSIS [14] | | |
|-----------------|---------------|------------------------|-------------|----------|----------------------|---------------------------|-----------------------------|-----------------------|------------|----------|---------------------|------------------------|-----------|---|---|
| C23 | xref_clk3 | xref_clk3 | 0 | I | PD | PD | 15 | 1.8/3.3 | vddshv3 | Yes | Dual Voltage LVCMOS | PU/PD | | | |
| | | mcasp2_axr11 | 1 | IO | | | | | | | | | | 0 | |
| | | mcasp1_axr7 | 2 | IO | | | | | | | | | | 0 | |
| | | mcasp4_ahclkx | 3 | O | | | | | | | | | | | |
| | | mcasp8_ahclkx | 4 | O | | | | | | | | | | | |
| | | atl_clk3 | 5 | O | | | | | | | | | | | |
| | | vout2_de | 6 | O | | | | | | | | | | | |
| | | hdq0 | 7 | IO | | | | | | | | | | | 1 |
| | | vin2a_de0 vin1a_de0 | 8 | I | | | | | | | | | | | |
| | | clkout3 | 9 | O | | | | | | | | | | | |
| | | timer16 | 10 | IO | | | | | | | | | | | |
| | | gpio6_20 | 14 | IO | | | | | | | | | | | |
| | | Driver off | 15 | I | | | | | | | | | | | |

- (1) N/A stands for Not Applicable.
- (2) For more information on recommended operating conditions, see [Table 5-4, Recommended Operating Conditions](#).
- (3) The pullup or pulldown block strength is equal to: minimum = 50 μ A, typical = 100 μ A, maximum = 250 μ A.
- (4) The output impedance settings of this IO cell are programmable; by default, the value is DS[1:0] = 10, this means 40 Ω . For more information on DS[1:0] register configuration, see the device TRM.
- (5) IO drive strength for usb1_dp, usb1_dm, usb2_dp and usb2_dm: minimum 18.3 mA, maximum 89 mA (for a power supply vdda33v_usb1 and vdda33v_usb2 = 3.46 V).
- (6) Minimum PU = 900 Ω , maximum PU = 3.090 k Ω and minimum PD = 14.25 k Ω , maximum PD = 24.8 k Ω .
For more information, see chapter 7 of the USB2.0 specification, in particular section Signaling / Device Speed Identification.
- (7) This function will not be supported on some pin-compatible roadmap devices. Pin compatibility can be maintained in the future by not using these GPIO signals.
- (8) In PUX / PDy, x and y = 60 to 200 μ A.
The output impedance settings (or drive strengths) of this IO are programmable (34 Ω , 40 Ω , 48 Ω , 60 Ω , 80 Ω) depending on the values of the I[2:0] registers.
- (9) The internal pull resistors for balls K7, M7, J5, K6, J4, J6, H4, H5 are permanently disabled when sysboot15 is set to 0 as described in the section Sysboot Configuration in the device TRM. If internal pull-up/down resistors are desired on these balls then sysboot15 should be set to 1. If gpmc boot mode is used with SYSBOOT15=0 (not recommended) then external pull-downs should be implemented to keep the address bus at logic-1 value during boot since the gpmc ms-address bits are high-z during boot.
- (10) I2C6 is not supported in TI standard software. I2C6 is not recommended for use to due to internal clock/reset dependencies on i2c1-5 and uart7.
- (11) This signal is valid only for High-Security devices. For more details, see [Section 5.8 VPP Specification for One-Time Programmable \(OTP\) eFUSES](#). For General Purpose devices do not connect any signal, test point, or board trace to this signal.

4.3 Multiplexing Characteristics

Table 4-3 describes the device multiplexing (no characteristics are available).

NOTE

This table doesn't take into account subsystem multiplexing signals. Subsystem multiplexing signals are described in Section 4.4, *Signal Descriptions*.

NOTE

For more information, see *Control Module* chapter, *PAD Functional Multiplexing and Configuration* section in the device TRM.

NOTE

Configuring two pins to the same input signal is not supported as it can yield unexpected results. This can be easily prevented with the proper software configuration (Hi-Z mode is not an input signal).

NOTE

When a pad is set into a multiplexing mode which is not defined by pin multiplexing, that pad's behavior is undefined. This should be avoided.

NOTE

In some cases Table 4-3 may present more than one signal per muxmode for the same ball. First signal in the list is the dominant function as selected via CTRL_CORE_PAD_* register.

All other signals are virtual functions that present alternate multiplexing options. This virtual functions are controlled via CTRL_CORE_ALT_SELECT_MUX or CTRL_CORE_VIP_MUX_SELECT register. For more information on how to use these options, see *Pad Configuration Registers* section, *Control Module* chapter in the device TRM.

NOTE

ECC is not available on this device, but signal names are retained for consistency with the DRA7xx family of devices.

CAUTION

The I/O timings provided in Section 7, *Timing Requirements and Switching Characteristics* are valid only if signals within a single IOSET are used. The IOSETs are defined in the corresponding tables.

NOTE

Dual rank support is not available on this device, but signal names are retained for consistency with the DRA7xx family of devices.

Table 4-3. Multiplexing Characteristics

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | |
|---------|---------------|-------------|---|-----------|---|----|----|----|----|---|----|---|----|-----|----|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 |
| | | Y23 | ddr1_d26 | | | | | | | | | | | | |
| | | Y19 | ddr1_d21 | | | | | | | | | | | | |
| | | AE15 | xi_osc0 | | | | | | | | | | | | |
| | | AH24 | ddr1_nck | | | | | | | | | | | | |
| | | AG15 | ljcb_clkp | | | | | | | | | | | | |
| | | AF24 | ddr1_d4 | | | | | | | | | | | | |
| | | V25 | ddr1_ecc_d6 | | | | | | | | | | | | |
| | | AB16 | ddr1_csn1 | | | | | | | | | | | | |
| | | AG19 | hdmi1_data2x | | | | | | | | | | | | |
| | | AF21 | ddr1_a4 | | | | | | | | | | | | |
| | | AG5 | csi2_1_dx0 | | | | | | | | | | | | |
| | | W23 | ddr1_ecc_d3 | | | | | | | | | | | | |
| | | Y27 | ddr1_dqsn3 | | | | | | | | | | | | |
| | | AC24 | ddr1_d14 | | | | | | | | | | | | |
| | | AF28 | ddr1_d11 | | | | | | | | | | | | |
| | | AA23 | ddr1_d24 | | | | | | | | | | | | |
| | | AD18 | ddr1_a15 | | | | | | | | | | | | |
| | | AH16 | hdmi1_clocky | | | | | | | | | | | | |
| | | AH5 | csi2_1_dy0 | | | | | | | | | | | | |
| | | AC20 | ddr1_a2 | | | | | | | | | | | | |
| | | AA24 | ddr1_d27 | | | | | | | | | | | | |
| | | W19 | ddr1_ecc_d2 | | | | | | | | | | | | |
| | | AG21 | ddr1_rst | | | | | | | | | | | | |
| | | AE28 | ddr1_dqsn1 | | | | | | | | | | | | |
| | | AC11 | usb_txn0 | pcie_txn1 | | | | | | | | | | | |
| | | AG25 | ddr1_dqsn0 | | | | | | | | | | | | |
| | | AC17 | ddr1_odt1 | | | | | | | | | | | | |
| | | AG4 | csi2_0_dy3 | | | | | | | | | | | | |
| | | W20 | ddr1_d17 | | | | | | | | | | | | |
| | | AF14 | rtc_iso | | | | | | | | | | | | |
| | | AA27 | ddr1_dqm3 | | | | | | | | | | | | |
| | | AF25 | ddr1_d0 | | | | | | | | | | | | |
| | | AF2 | csi2_0_dx2 | | | | | | | | | | | | |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*(3:0)) | | | | | | | | | | | | | | |
|---------|---------------|-------------|---|-----------|---|----|----|----|----|---|----|---|----|-----|----|--|--|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 | | |
| | | AF23 | ddr1_d6 | | | | | | | | | | | | | | |
| | | AG18 | hdmi1_data1x | | | | | | | | | | | | | | |
| | | AH6 | csi2_1_dy1 | | | | | | | | | | | | | | |
| | | AG10 | sata1_txn0 | | | | | | | | | | | | | | |
| | | AF20 | ddr1_rasn | | | | | | | | | | | | | | |
| | | V26 | ddr1_dqm_etc | | | | | | | | | | | | | | |
| | | V20 | ddr1_d16 | | | | | | | | | | | | | | |
| | | AH13 | pcie_rxp0 | | | | | | | | | | | | | | |
| | | AC18 | ddr1_casn | | | | | | | | | | | | | | |
| | | AG9 | sata1_rxp0 | | | | | | | | | | | | | | |
| | | AH23 | ddr1_csn0 | | | | | | | | | | | | | | |
| | | AE11 | usb2_dp | | | | | | | | | | | | | | |
| | | Y24 | ddr1_d28 | | | | | | | | | | | | | | |
| | | AH15 | ljcb_clkn | | | | | | | | | | | | | | |
| | | AD20 | ddr1_a0 | | | | | | | | | | | | | | |
| | | AA25 | ddr1_d30 | | | | | | | | | | | | | | |
| | | AA1 | mlbp_dat_p | | | | | | | | | | | | | | |
| | | AD14 | rtc_osc_xo | | | | | | | | | | | | | | |
| | | AC25 | ddr1_d13 | | | | | | | | | | | | | | |
| | | AB23 | ddr1_dqm1 | | | | | | | | | | | | | | |
| | | AE1 | csi2_0_dx0 | | | | | | | | | | | | | | |
| | | AH19 | hdmi1_data2y | | | | | | | | | | | | | | |
| | | AB27 | ddr1_d22 | | | | | | | | | | | | | | |
| | | AG14 | pcie_txn0 | | | | | | | | | | | | | | |
| | | Y28 | ddr1_dqs3 | | | | | | | | | | | | | | |
| | | AB19 | ddr1_a3 | | | | | | | | | | | | | | |
| | | AH10 | sata1_txp0 | | | | | | | | | | | | | | |
| | | AG24 | ddr1_ck | | | | | | | | | | | | | | |
| | | AE24 | ddr1_d5 | | | | | | | | | | | | | | |
| | | AC15 | xi_osc1 | | | | | | | | | | | | | | |
| | | AC21 | ddr1_a12 | | | | | | | | | | | | | | |
| | | AB1 | mlbp_clk_p | | | | | | | | | | | | | | |
| | | AF12 | usb_rxn0 | pcie_rxn1 | | | | | | | | | | | | | |
| | | AH9 | sata1_rxn0 | | | | | | | | | | | | | | |
| | | AC26 | ddr1_dqm2 | | | | | | | | | | | | | | |
| | | AA28 | ddr1_d31 | | | | | | | | | | | | | | |
| | | AD23 | ddr1_dqm0 | | | | | | | | | | | | | | |
| | | AE27 | ddr1_dqs1 | | | | | | | | | | | | | | |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | | |
|---------|---------------|-------------|---|-----------|---|----|----|----|----|---|----|---|----|-----|----|--|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 | |
| | | AF27 | ddr1_d9 | | | | | | | | | | | | | |
| | | V24 | ddr1_ecc_d5 | | | | | | | | | | | | | |
| | | AG27 | ddr1_d10 | | | | | | | | | | | | | |
| | | AF22 | ddr1_a8 | | | | | | | | | | | | | |
| | | AA2 | mlbp_dat_n | | | | | | | | | | | | | |
| | | AH21 | ddr1_wen | | | | | | | | | | | | | |
| | | AE21 | ddr1_a7 | | | | | | | | | | | | | |
| | | AC12 | usb1_dm | | | | | | | | | | | | | |
| | | Y20 | ddr1_d23 | | | | | | | | | | | | | |
| | | AC27 | ddr1_d20 | | | | | | | | | | | | | |
| | | AE23 | ddr1_d7 | | | | | | | | | | | | | |
| | | AG22 | ddr1_cke | | | | | | | | | | | | | |
| | | AD27 | ddr1_dqs2 | | | | | | | | | | | | | |
| | | AH14 | pcie_txp0 | | | | | | | | | | | | | |
| | | AH26 | ddr1_d3 | | | | | | | | | | | | | |
| | | AD21 | ddr1_a10 | | | | | | | | | | | | | |
| | | Y25 | ddr1_ecc_d4 | | | | | | | | | | | | | |
| | | AE17 | ddr1_a14 | | | | | | | | | | | | | |
| | | AG7 | csi2_1_dy2 | | | | | | | | | | | | | |
| | | AH18 | hdmi1_data1y | | | | | | | | | | | | | |
| | | AH22 | ddr1_a5 | | | | | | | | | | | | | |
| | | W22 | ddr1_ecc_d0 | | | | | | | | | | | | | |
| | | V23 | ddr1_ecc_d1 | | | | | | | | | | | | | |
| | | AE12 | usb_rxp0 | pcie_rxp1 | | | | | | | | | | | | |
| | | AE14 | rtc_osc_xi_clk n32 | | | | | | | | | | | | | |
| | | AF3 | csi2_0_dy2 | | | | | | | | | | | | | |
| | | AB2 | mlbp_clk_n | | | | | | | | | | | | | |
| | | AG23 | ddr1_a6 | | | | | | | | | | | | | |
| | | AG6 | csi2_1_dx1 | | | | | | | | | | | | | |
| | | AB18 | ddr1_ba2 | | | | | | | | | | | | | |
| | | AG17 | hdmi1_data0x | | | | | | | | | | | | | |
| | | AF26 | ddr1_d1 | | | | | | | | | | | | | |
| | | AD11 | usb_txp0 | pcie_txp1 | | | | | | | | | | | | |
| | | AC1 | mlbp_sig_p | | | | | | | | | | | | | |
| | | V27 | ddr1_dqs_ecc | | | | | | | | | | | | | |
| | | AF17 | ddr1_ba0 | | | | | | | | | | | | | |
| | | AE26 | ddr1_d12 | | | | | | | | | | | | | |
| | | AC19 | ddr1_a1 | | | | | | | | | | | | | |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | | | |
|---------|------------------------|-------------|---|---|----------|----------|----|----|----|---|----|---|----|-----|----|---------|----------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 | | |
| | | AG13 | pcie_rxn0 | | | | | | | | | | | | | | |
| | | AB28 | ddr1_d18 | | | | | | | | | | | | | | |
| | | Y26 | ddr1_ecc_d7 | | | | | | | | | | | | | | |
| | | AH3 | csi2_0_dx4 | | | | | | | | | | | | | | |
| | | AD22 | ddr1_a11 | | | | | | | | | | | | | | |
| | | AD28 | ddr1_dqsn2 | | | | | | | | | | | | | | |
| | | AD2 | csi2_0_dy0 | | | | | | | | | | | | | | |
| | | AE18 | ddr1_ba1 | | | | | | | | | | | | | | |
| | | AE20 | ddr1_odt0 | | | | | | | | | | | | | | |
| | | AF11 | usb2_dm | | | | | | | | | | | | | | |
| | | AD15 | xo_osc0 | | | | | | | | | | | | | | |
| | | AH7 | csi2_1_dx2 | | | | | | | | | | | | | | |
| | | AE22 | ddr1_a9 | | | | | | | | | | | | | | |
| | | Y18 | ddr1_vref0 | | | | | | | | | | | | | | |
| | | AC13 | xo_osc1 | | | | | | | | | | | | | | |
| | | AC2 | mlbp_sig_n | | | | | | | | | | | | | | |
| | | AD12 | usb1_dp | | | | | | | | | | | | | | |
| | | Y22 | ddr1_d25 | | | | | | | | | | | | | | |
| | | AH17 | hdmi1_data0y | | | | | | | | | | | | | | |
| | | AH4 | csi2_0_dx3 | | | | | | | | | | | | | | |
| | | AE2 | csi2_0_dy1 | | | | | | | | | | | | | | |
| | | AG26 | ddr1_d2 | | | | | | | | | | | | | | |
| | | AH25 | ddr1_dqs0 | | | | | | | | | | | | | | |
| | | AF18 | ddr1_a13 | | | | | | | | | | | | | | |
| | | AC28 | ddr1_d19 | | | | | | | | | | | | | | |
| | | AG3 | csi2_0_dy4 | | | | | | | | | | | | | | |
| | | V28 | ddr1_dqsn_ecc | | | | | | | | | | | | | | |
| | | AC23 | ddr1_d8 | | | | | | | | | | | | | | |
| | | F22 | porz | | | | | | | | | | | | | | |
| | | AG16 | hdmi1_clockx | | | | | | | | | | | | | | |
| | | AF1 | csi2_0_dx1 | | | | | | | | | | | | | | |
| | | AA26 | ddr1_d29 | | | | | | | | | | | | | | |
| | | AD25 | ddr1_d15 | | | | | | | | | | | | | | |
| 0x1400 | CTRL_CORE_PAD_GPMC_AD0 | M6 | gpmc_ad0 | | vin1a_d0 | vout3_d0 | | | | | | | | | | gpio1_6 | sysboot0 |
| 0x1404 | CTRL_CORE_PAD_GPMC_AD1 | M2 | gpmc_ad1 | | vin1a_d1 | vout3_d1 | | | | | | | | | | gpio1_7 | sysboot1 |
| 0x1408 | CTRL_CORE_PAD_GPMC_AD2 | L5 | gpmc_ad2 | | vin1a_d2 | vout3_d2 | | | | | | | | | | gpio1_8 | sysboot2 |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | |
|---------|-------------------------|-------------|---|-----------|--------------|-------------|----------------------|----|--------------|-----------|------------|---|----|---------------------------------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 |
| 0x140C | CTRL_CORE_PAD_GPMC_AD3 | M1 | gpmc_ad3 | | vin1a_d3 | vout3_d3 | | | | | | | | gpio1_9 | sysboot3 |
| 0x1410 | CTRL_CORE_PAD_GPMC_AD4 | L6 | gpmc_ad4 | | vin1a_d4 | vout3_d4 | | | | | | | | gpio1_10 | sysboot4 |
| 0x1414 | CTRL_CORE_PAD_GPMC_AD5 | L4 | gpmc_ad5 | | vin1a_d5 | vout3_d5 | | | | | | | | gpio1_11 | sysboot5 |
| 0x1418 | CTRL_CORE_PAD_GPMC_AD6 | L3 | gpmc_ad6 | | vin1a_d6 | vout3_d6 | | | | | | | | gpio1_12 | sysboot6 |
| 0x141C | CTRL_CORE_PAD_GPMC_AD7 | L2 | gpmc_ad7 | | vin1a_d7 | vout3_d7 | | | | | | | | gpio1_13 | sysboot7 |
| 0x1420 | CTRL_CORE_PAD_GPMC_AD8 | L1 | gpmc_ad8 | | vin1a_d8 | vout3_d8 | | | | | | | | gpio7_18 | sysboot8 |
| 0x1424 | CTRL_CORE_PAD_GPMC_AD9 | K2 | gpmc_ad9 | | vin1a_d9 | vout3_d9 | | | | | | | | gpio7_19 | sysboot9 |
| 0x1428 | CTRL_CORE_PAD_GPMC_AD10 | J1 | gpmc_ad10 | | vin1a_d10 | vout3_d10 | | | | | | | | gpio7_28 | sysboot10 |
| 0x142C | CTRL_CORE_PAD_GPMC_AD11 | J2 | gpmc_ad11 | | vin1a_d11 | vout3_d11 | | | | | | | | gpio7_29 | sysboot11 |
| 0x1430 | CTRL_CORE_PAD_GPMC_AD12 | H1 | gpmc_ad12 | | vin1a_d12 | vout3_d12 | | | | | | | | gpio1_18 | sysboot12 |
| 0x1434 | CTRL_CORE_PAD_GPMC_AD13 | J3 | gpmc_ad13 | | vin1a_d13 | vout3_d13 | | | | | | | | gpio1_19 | sysboot13 |
| 0x1438 | CTRL_CORE_PAD_GPMC_AD14 | H2 | gpmc_ad14 | | vin1a_d14 | vout3_d14 | | | | | | | | gpio1_20 | sysboot14 |
| 0x143C | CTRL_CORE_PAD_GPMC_AD15 | H3 | gpmc_ad15 | | vin1a_d15 | vout3_d15 | | | | | | | | gpio1_21 | sysboot15 |
| 0x1440 | CTRL_CORE_PAD_GPMC_A0 | R6 | gpmc_a0 | | vin1a_d16 | vout3_d16 | vin2a_d0 vin1a_d0 | | vin1b_d0 | i2c4_scl | uart5_rxd | | | gpio7_3 gpmc_a26 gpmc_a16 | Driver off |
| 0x1444 | CTRL_CORE_PAD_GPMC_A1 | T9 | gpmc_a1 | | vin1a_d17 | vout3_d17 | vin2a_d1 vin1a_d1 | | vin1b_d1 | i2c4_sda | uart5_txd | | | gpio7_4 | Driver off |
| 0x1448 | CTRL_CORE_PAD_GPMC_A2 | T6 | gpmc_a2 | | vin1a_d18 | vout3_d18 | vin2a_d2 vin1a_d2 | | vin1b_d2 | uart7_rxd | uart5_ctsn | | | gpio7_5 | Driver off |
| 0x144C | CTRL_CORE_PAD_GPMC_A3 | T7 | gpmc_a3 | qspi1_cs2 | vin1a_d19 | vout3_d19 | vin2a_d3 vin1a_d3 | | vin1b_d3 | uart7_txd | uart5_rtsn | | | gpio7_6 | Driver off |
| 0x1450 | CTRL_CORE_PAD_GPMC_A4 | P6 | gpmc_a4 | qspi1_cs3 | vin1a_d20 | vout3_d20 | vin2a_d4 vin1a_d4 | | vin1b_d4 | i2c5_scl | uart6_rxd | | | gpio1_26 | Driver off |
| 0x1454 | CTRL_CORE_PAD_GPMC_A5 | R9 | gpmc_a5 | | vin1a_d21 | vout3_d21 | vin2a_d5 vin1a_d5 | | vin1b_d5 | i2c5_sda | uart6_txd | | | gpio1_27 | Driver off |
| 0x1458 | CTRL_CORE_PAD_GPMC_A6 | R5 | gpmc_a6 | | vin1a_d22 | vout3_d22 | vin2a_d6 vin1a_d6 | | vin1b_d6 | uart8_rxd | uart6_ctsn | | | gpio1_28 | Driver off |
| 0x145C | CTRL_CORE_PAD_GPMC_A7 | P5 | gpmc_a7 | | vin1a_d23 | vout3_d23 | vin2a_d7 vin1a_d7 | | vin1b_d7 | uart8_txd | uart6_rtsn | | | gpio1_29 | Driver off |
| 0x1460 | CTRL_CORE_PAD_GPMC_A8 | N7 | gpmc_a8 | | vin1a_hsync0 | vout3_hsync | | | vin1b_hsync1 | timer12 | spi4_sclk | | | gpio1_30 | Driver off |
| 0x1464 | CTRL_CORE_PAD_GPMC_A9 | R4 | gpmc_a9 | | vin1a_vsync0 | vout3_vsync | | | vin1b_vsync1 | timer11 | spi4_d1 | | | gpio1_31 | Driver off |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | | |
|---------|------------------------|-------------|---|-------------|------------|------------|------------------------------|------------------------|------------------------------|------------|----------|----------|----------|-----|----------------------------------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 | |
| 0x1468 | CTRL_CORE_PAD_GPMC_A10 | N9 | gpmc_a10 | | vin1a_de0 | vout3_de | | | | vin1b_clk1 | timer10 | spi4_d0 | | | gpio2_0 | Driver off |
| 0x146C | CTRL_CORE_PAD_GPMC_A11 | P9 | gpmc_a11 | | vin1a_fld0 | vout3_fld | vin2a_fld0 vin1a_fld0 | | | vin1b_de1 | timer9 | spi4_cs0 | | | gpio2_1 | Driver off |
| 0x1470 | CTRL_CORE_PAD_GPMC_A12 | P4 | gpmc_a12 | | | | vin2a_clk0 vin1a_clk0 | gpmc_a0 | | vin1b_fld1 | timer8 | spi4_cs1 | dma_evt1 | | gpio2_2 | Driver off |
| 0x1474 | CTRL_CORE_PAD_GPMC_A13 | R3 | gpmc_a13 | qspi1_rtclk | | | vin2a_hsync0 vin1a_hsync0 | | | | timer7 | spi4_cs2 | dma_evt2 | | gpio2_3 | Driver off |
| 0x1478 | CTRL_CORE_PAD_GPMC_A14 | T2 | gpmc_a14 | qspi1_d3 | | | vin2a_vsync0 vin1a_vsync0 | | | | timer6 | spi4_cs3 | | | gpio2_4 | Driver off |
| 0x147C | CTRL_CORE_PAD_GPMC_A15 | U2 | gpmc_a15 | qspi1_d2 | | | vin2a_d8 vin1a_d8 | | | | timer5 | | | | gpio2_5 | Driver off |
| 0x1480 | CTRL_CORE_PAD_GPMC_A16 | U1 | gpmc_a16 | qspi1_d0 | | | vin2a_d9 vin1a_d9 | | | | | | | | gpio2_6 | Driver off |
| 0x1484 | CTRL_CORE_PAD_GPMC_A17 | P3 | gpmc_a17 | qspi1_d1 | | | vin2a_d10 vin1a_d10 | | | | | | | | gpio2_7 | Driver off |
| 0x1488 | CTRL_CORE_PAD_GPMC_A18 | R2 | gpmc_a18 | qspi1_sclk | | | vin2a_d11 vin1a_d11 | | | | | | | | gpio2_8 | Driver off |
| 0x148C | CTRL_CORE_PAD_GPMC_A19 | K7 | gpmc_a19 | mmc2_dat4 | gpmc_a13 | | vin2a_d12 vin1a_d12 | | vin2b_d0 vin1b_d0 | | | | | | gpio2_9 | Driver off |
| 0x1490 | CTRL_CORE_PAD_GPMC_A20 | M7 | gpmc_a20 | mmc2_dat5 | gpmc_a14 | | vin2a_d13 vin1a_d13 | | vin2b_d1 vin1b_d1 | | | | | | gpio2_10 | Driver off |
| 0x1494 | CTRL_CORE_PAD_GPMC_A21 | J5 | gpmc_a21 | mmc2_dat6 | gpmc_a15 | | vin2a_d14 vin1a_d14 | | vin2b_d2 vin1b_d2 | | | | | | gpio2_11 | Driver off |
| 0x1498 | CTRL_CORE_PAD_GPMC_A22 | K6 | gpmc_a22 | mmc2_dat7 | gpmc_a16 | | vin2a_d15 vin1a_d15 | | vin2b_d3 vin1b_d3 | | | | | | gpio2_12 | Driver off |
| 0x149C | CTRL_CORE_PAD_GPMC_A23 | J7 | gpmc_a23 | mmc2_clk | gpmc_a17 | | vin2a_fld0 vin1a_fld0 | | vin2b_d4 vin1b_d4 | | | | | | gpio2_13 | Driver off |
| 0x14A0 | CTRL_CORE_PAD_GPMC_A24 | J4 | gpmc_a24 | mmc2_dat0 | gpmc_a18 | | | | vin2b_d5 vin1b_d5 | | | | | | gpio2_14 | Driver off |
| 0x14A4 | CTRL_CORE_PAD_GPMC_A25 | J6 | gpmc_a25 | mmc2_dat1 | gpmc_a19 | | | | vin2b_d6 vin1b_d6 | | | | | | gpio2_15 | Driver off |
| 0x14A8 | CTRL_CORE_PAD_GPMC_A26 | H4 | gpmc_a26 | mmc2_dat2 | gpmc_a20 | | | | vin2b_d7 vin1b_d7 | | | | | | gpio2_16 | Driver off |
| 0x14AC | CTRL_CORE_PAD_GPMC_A27 | H5 | gpmc_a27 | mmc2_dat3 | gpmc_a21 | | | | vin2b_hsync1 vin1b_hsync1 | | | | | | gpio2_17 | Driver off |
| 0x14B0 | CTRL_CORE_PAD_GPMC_CS1 | H6 | gpmc_cs1 | mmc2_cmd | gpmc_a22 | | vin2a_de0 vin1a_de0 | | vin2b_vsync1 vin1b_vsync1 | | | | | | gpio2_18 | Driver off |
| 0x14B4 | CTRL_CORE_PAD_GPMC_CS0 | T1 | gpmc_cs0 | | | | | | | | | | | | gpio2_19 | Driver off |
| 0x14B8 | CTRL_CORE_PAD_GPMC_CS2 | P2 | gpmc_cs2 | qspi1_cs0 | | | | | | | | | | | gpio2_20 gpmc_a23 gpmc_a13 | Driver off |
| 0x14BC | CTRL_CORE_PAD_GPMC_CS3 | P1 | gpmc_cs3 | qspi1_cs1 | vin1a_clk0 | vout3_clk | | gpmc_a1 | | | | | | | gpio2_21 gpmc_a24 gpmc_a14 | Driver off |
| 0x14C0 | CTRL_CORE_PAD_GPMC_CLK | P7 | gpmc_clk | gpmc_cs7 | clkout1 | gpmc_wait1 | vin2a_hsync0 vin1a_hsync0 | vin2a_de0 vin1a_de0 | vin2b_clk1 vin1b_clk1 | timer4 | i2c3_scl | dma_evt1 | | | gpio2_22 gpmc_a20 | Driver off |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | |
|---------|-----------------------------|-------------|---|------------|------------|--------------|------------------------------|---------|--------------------------|------------|-------------|----------|----------------------------|----------------------------------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 |
| 0x14C4 | CTRL_CORE_PAD_GPMC_ADV_NALE | N1 | gpmc_advn_ale | gpmc_cs6 | clkout2 | gpmc_wait1 | vin2a_vsync0 vin1a_vsync0 | gpmc_a2 | gpmc_a23 | timer3 | i2c3_sda | dma_evt2 | | gpio2_23 gpmc_a19 | Driver off |
| 0x14C8 | CTRL_CORE_PAD_GPMC_OEN_REN | M5 | gpmc_oen_ren | | | | | | | | | | | gpio2_24 | Driver off |
| 0x14CC | CTRL_CORE_PAD_GPMC_WEN | M3 | gpmc_wen | | | | | | | | | | | gpio2_25 | Driver off |
| 0x14D0 | CTRL_CORE_PAD_GPMC_BEN0 | N6 | gpmc_ben0 | gpmc_cs4 | | | | | vin2b_de1 vin1b_de1 | timer2 | | dma_evt3 | | gpio2_26 gpmc_a21 | Driver off |
| 0x14D4 | CTRL_CORE_PAD_GPMC_BEN1 | M4 | gpmc_ben1 | gpmc_cs5 | | | vin2b_clk1 vin1b_clk1 | gpmc_a3 | vin2b_fld1 vin1b_fld1 | timer1 | | dma_evt4 | | gpio2_27 gpmc_a22 | Driver off |
| 0x14D8 | CTRL_CORE_PAD_GPMC_WAIT0 | N2 | gpmc_wait0 | | | | | | | | | | | gpio2_28 gpmc_a25 gpmc_a15 | Driver off |
| 0x1554 | CTRL_CORE_PAD_VIN2A_CLK0 | E1 | vin2a_clk0 | | | | vout2_fld | emu5 | | | | kbd_row0 | eQEP1A_in | gpio3_28 gpmc_a27 gpmc_a17 | Driver off |
| 0x1558 | CTRL_CORE_PAD_VIN2A_DE0 | G2 | vin2a_de0 | vin2a_fld0 | vin2b_fld1 | vin2b_de1 | vout2_de | emu6 | | | | kbd_row1 | eQEP1B_in | gpio3_29 | Driver off |
| 0x155C | CTRL_CORE_PAD_VIN2A_FLD0 | H7 | vin2a_fld0 | | vin2b_clk1 | | vout2_clk | emu7 | | | | | eQEP1_index | gpio3_30 gpmc_a27 gpmc_a18 | Driver off |
| 0x1560 | CTRL_CORE_PAD_VIN2A_HSYNC0 | G1 | vin2a_hsync0 | | | vin2b_hsync1 | vout2_hsync | emu8 | | uart9_rxd | spi4_sclk | kbd_row2 | eQEP1_strobe | gpio3_31 gpmc_a27 | Driver off |
| 0x1564 | CTRL_CORE_PAD_VIN2A_VSYNC0 | G6 | vin2a_vsync0 | | | vin2b_vsync1 | vout2_vsync | emu9 | | uart9_txd | spi4_d1 | kbd_row3 | ehrpwm1A | gpio4_0 | Driver off |
| 0x1568 | CTRL_CORE_PAD_VIN2A_D0 | F2 | vin2a_d0 | | | | vout2_d23 | emu10 | | uart9_ctsn | spi4_d0 | kbd_row4 | ehrpwm1B | gpio4_1 | Driver off |
| 0x156C | CTRL_CORE_PAD_VIN2A_D1 | F3 | vin2a_d1 | | | | vout2_d22 | emu11 | | uart9_rtsn | spi4_cs0 | kbd_row5 | ehrpwm1_trip zone_input | gpio4_2 | Driver off |
| 0x1570 | CTRL_CORE_PAD_VIN2A_D2 | D1 | vin2a_d2 | | | | vout2_d21 | emu12 | | | uart10_rxd | kbd_row6 | eCAP1_in_P WM1_out | gpio4_3 | Driver off |
| 0x1574 | CTRL_CORE_PAD_VIN2A_D3 | E2 | vin2a_d3 | | | | vout2_d20 | emu13 | | | uart10_txd | kbd_col0 | ehrpwm1_syn ci | gpio4_4 | Driver off |
| 0x1578 | CTRL_CORE_PAD_VIN2A_D4 | D2 | vin2a_d4 | | | | vout2_d19 | emu14 | | | uart10_ctsn | kbd_col1 | ehrpwm1_syn co | gpio4_5 | Driver off |
| 0x157C | CTRL_CORE_PAD_VIN2A_D5 | F4 | vin2a_d5 | | | | vout2_d18 | emu15 | | | uart10_rtsn | kbd_col2 | eQEP2A_in | gpio4_6 | Driver off |
| 0x1580 | CTRL_CORE_PAD_VIN2A_D6 | C1 | vin2a_d6 | | | | vout2_d17 | emu16 | | | mii1_rxd1 | kbd_col3 | eQEP2B_in | gpio4_7 | Driver off |
| 0x1584 | CTRL_CORE_PAD_VIN2A_D7 | E4 | vin2a_d7 | | | | vout2_d16 | emu17 | | | mii1_rxd2 | kbd_col4 | eQEP2_index | gpio4_8 | Driver off |
| 0x1588 | CTRL_CORE_PAD_VIN2A_D8 | F5 | vin2a_d8 | | | | vout2_d15 | emu18 | | | mii1_rxd3 | kbd_col5 | eQEP2_strobe | gpio4_9 gpmc_a26 | Driver off |
| 0x158C | CTRL_CORE_PAD_VIN2A_D9 | E6 | vin2a_d9 | | | | vout2_d14 | emu19 | | | mii1_rxd0 | kbd_col6 | ehrpwm2A | gpio4_10 gpmc_a25 | Driver off |
| 0x1590 | CTRL_CORE_PAD_VIN2A_D10 | D3 | vin2a_d10 | | | mdio_mclk | vout2_d13 | | | | | kbd_col7 | ehrpwm2B | gpio4_11 gpmc_a24 | Driver off |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*(3:0)) | | | | | | | | | | | | |
|---------|---------------------------|-------------|---|---|-----------|------------------------------|--------------|------|-------|------------|------------|-----------|------------------------|----------------------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 |
| 0x1594 | CTRL_CORE_PAD_VIN2A_D11 | F6 | vin2a_d11 | | | mdio_d | vout2_d12 | | | | | kbd_row7 | ehrpwm2_tripzone_input | gpio4_12 gpmc_a23 | Driver off |
| 0x1598 | CTRL_CORE_PAD_VIN2A_D12 | D5 | vin2a_d12 | | | rgmii1_txc | vout2_d11 | | | | mii1_rxclk | kbd_col8 | eCAP2_in_PWM2_out | gpio4_13 | Driver off |
| 0x159C | CTRL_CORE_PAD_VIN2A_D13 | C2 | vin2a_d13 | | | rgmii1_txctl | vout2_d10 | | | | mii1_rxdv | kbd_row8 | eQEP3A_in | gpio4_14 | Driver off |
| 0x15A0 | CTRL_CORE_PAD_VIN2A_D14 | C3 | vin2a_d14 | | | rgmii1_txd3 | vout2_d9 | | | | mii1_txclk | | eQEP3B_in | gpio4_15 | Driver off |
| 0x15A4 | CTRL_CORE_PAD_VIN2A_D15 | C4 | vin2a_d15 | | | rgmii1_txd2 | vout2_d8 | | | | mii1_txd0 | | eQEP3_index | gpio4_16 | Driver off |
| 0x15A8 | CTRL_CORE_PAD_VIN2A_D16 | B2 | vin2a_d16 | | vin2b_d7 | rgmii1_txd1 | vout2_d7 | | | | mii1_txd1 | | eQEP3_strobe | gpio4_24 | Driver off |
| 0x15AC | CTRL_CORE_PAD_VIN2A_D17 | D6 | vin2a_d17 | | vin2b_d6 | rgmii1_txd0 | vout2_d6 | | | | mii1_txd2 | | ehrpwm3A | gpio4_25 | Driver off |
| 0x15B0 | CTRL_CORE_PAD_VIN2A_D18 | C5 | vin2a_d18 | | vin2b_d5 | rgmii1_rxc | vout2_d5 | | | | mii1_txd3 | | ehrpwm3B | gpio4_26 | Driver off |
| 0x15B4 | CTRL_CORE_PAD_VIN2A_D19 | A3 | vin2a_d19 | | vin2b_d4 | rgmii1_rxctl | vout2_d4 | | | | mii1_txer | | ehrpwm3_tripzone_input | gpio4_27 | Driver off |
| 0x15B8 | CTRL_CORE_PAD_VIN2A_D20 | B3 | vin2a_d20 | | vin2b_d3 | rgmii1_rxd3 | vout2_d3 | | | | mii1_rxer | | eCAP3_in_PWM3_out | gpio4_28 | Driver off |
| 0x15BC | CTRL_CORE_PAD_VIN2A_D21 | B4 | vin2a_d21 | | vin2b_d2 | rgmii1_rxd2 | vout2_d2 | | | | mii1_col | | | gpio4_29 | Driver off |
| 0x15C0 | CTRL_CORE_PAD_VIN2A_D22 | B5 | vin2a_d22 | | vin2b_d1 | rgmii1_rxd1 | vout2_d1 | | | | mii1_crs | | | gpio4_30 | Driver off |
| 0x15C4 | CTRL_CORE_PAD_VIN2A_D23 | A4 | vin2a_d23 | | vin2b_d0 | rgmii1_rxd0 | vout2_d0 | | | | mii1_txen | | | gpio4_31 | Driver off |
| 0x15C8 | CTRL_CORE_PAD_VOUT1_CLK | D11 | vout1_clk | | | vin2a_fld0 vin1a_fld0 | vin1a_fld0 | | | | | spi3_cs0 | | gpio4_19 | Driver off |
| 0x15CC | CTRL_CORE_PAD_VOUT1_DE | B10 | vout1_de | | | vin2a_de0 vin1a_de0 | vin1a_de0 | | | | | spi3_d1 | | gpio4_20 | Driver off |
| 0x15D0 | CTRL_CORE_PAD_VOUT1_FLD | B11 | vout1_fld | | | vin2a_clk0 vin1a_clk0 | vin1a_clk0 | | | | | spi3_cs1 | | gpio4_21 | Driver off |
| 0x15D4 | CTRL_CORE_PAD_VOUT1_HSYNC | C11 | vout1_hsync | | | vin2a_hsync0 vin1a_hsync0 | vin1a_hsync0 | | | | | spi3_d0 | | gpio4_22 | Driver off |
| 0x15D8 | CTRL_CORE_PAD_VOUT1_VSYNC | E11 | vout1_vsync | | | vin2a_vsync0 vin1a_vsync0 | vin1a_vsync0 | | | | | spi3_sclk | | gpio4_23 | Driver off |
| 0x15DC | CTRL_CORE_PAD_VOUT1_D0 | F11 | vout1_d0 | | uart5_rxd | vin2a_d16 vin1a_d16 | vin1a_d16 | | | | | spi3_cs2 | | gpio8_0 | Driver off |
| 0x15E0 | CTRL_CORE_PAD_VOUT1_D1 | G10 | vout1_d1 | | uart5_txd | vin2a_d17 vin1a_d17 | vin1a_d17 | | | | | | | gpio8_1 | Driver off |
| 0x15E4 | CTRL_CORE_PAD_VOUT1_D2 | F10 | vout1_d2 | | emu2 | vin2a_d18 vin1a_d18 | vin1a_d18 | obs0 | obs16 | obs_irq1 | | | | gpio8_2 | Driver off |
| 0x15E8 | CTRL_CORE_PAD_VOUT1_D3 | G11 | vout1_d3 | | emu5 | vin2a_d19 vin1a_d19 | vin1a_d19 | obs1 | obs17 | obs_dmarq1 | | | | gpio8_3 | Driver off |
| 0x15EC | CTRL_CORE_PAD_VOUT1_D4 | E9 | vout1_d4 | | emu6 | vin2a_d20 vin1a_d20 | vin1a_d20 | obs2 | obs18 | | | | | gpio8_4 | Driver off |
| 0x15F0 | CTRL_CORE_PAD_VOUT1_D5 | F9 | vout1_d5 | | emu7 | vin2a_d21 vin1a_d21 | vin1a_d21 | obs3 | obs19 | | | | | gpio8_5 | Driver off |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | |
|---------|-------------------------------|-------------|---|------------|------------|------------------------|------------|------------|---------------|------------|-----------|----------|----|----------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 |
| 0x15F4 | CTRL_CORE_PAD_VOUT1_D6 | F8 | vout1_d6 | | emu8 | vin2a_d22 vin1a_d22 | vin1a_d22 | obs4 | obs20 | | | | | gpio8_6 | Driver off |
| 0x15F8 | CTRL_CORE_PAD_VOUT1_D7 | E7 | vout1_d7 | | emu9 | vin2a_d23 vin1a_d23 | vin1a_d23 | | | | | | | gpio8_7 | Driver off |
| 0x15FC | CTRL_CORE_PAD_VOUT1_D8 | E8 | vout1_d8 | | uart6_rxd | vin2a_d8 vin1a_d8 | vin1a_d8 | | | | | | | gpio8_8 | Driver off |
| 0x1600 | CTRL_CORE_PAD_VOUT1_D9 | D9 | vout1_d9 | | uart6_txd | vin2a_d9 vin1a_d9 | vin1a_d9 | | | | | | | gpio8_9 | Driver off |
| 0x1604 | CTRL_CORE_PAD_VOUT1_D10 | D7 | vout1_d10 | | emu3 | vin2a_d10 vin1a_d10 | vin1a_d10 | obs5 | obs21 | obs_irq2 | | | | gpio8_10 | Driver off |
| 0x1608 | CTRL_CORE_PAD_VOUT1_D11 | D8 | vout1_d11 | | emu10 | vin2a_d11 vin1a_d11 | vin1a_d11 | obs6 | obs22 | obs_dmarq2 | | | | gpio8_11 | Driver off |
| 0x160C | CTRL_CORE_PAD_VOUT1_D12 | A5 | vout1_d12 | | emu11 | vin2a_d12 vin1a_d12 | vin1a_d12 | obs7 | obs23 | | | | | gpio8_12 | Driver off |
| 0x1610 | CTRL_CORE_PAD_VOUT1_D13 | C6 | vout1_d13 | | emu12 | vin2a_d13 vin1a_d13 | vin1a_d13 | obs8 | obs24 | | | | | gpio8_13 | Driver off |
| 0x1614 | CTRL_CORE_PAD_VOUT1_D14 | C8 | vout1_d14 | | emu13 | vin2a_d14 vin1a_d14 | vin1a_d14 | obs9 | obs25 | | | | | gpio8_14 | Driver off |
| 0x1618 | CTRL_CORE_PAD_VOUT1_D15 | C7 | vout1_d15 | | emu14 | vin2a_d15 vin1a_d15 | vin1a_d15 | obs10 | obs26 | | | | | gpio8_15 | Driver off |
| 0x161C | CTRL_CORE_PAD_VOUT1_D16 | B7 | vout1_d16 | | uart7_rxd | vin2a_d0 vin1a_d0 | vin1a_d0 | | | | | | | gpio8_16 | Driver off |
| 0x1620 | CTRL_CORE_PAD_VOUT1_D17 | B8 | vout1_d17 | | uart7_txd | vin2a_d1 vin1a_d1 | vin1a_d1 | | | | | | | gpio8_17 | Driver off |
| 0x1624 | CTRL_CORE_PAD_VOUT1_D18 | A7 | vout1_d18 | | emu4 | vin2a_d2 vin1a_d2 | vin1a_d2 | obs11 | obs27 | | | | | gpio8_18 | Driver off |
| 0x1628 | CTRL_CORE_PAD_VOUT1_D19 | A8 | vout1_d19 | | emu15 | vin2a_d3 vin1a_d3 | vin1a_d3 | obs12 | obs28 | | | | | gpio8_19 | Driver off |
| 0x162C | CTRL_CORE_PAD_VOUT1_D20 | C9 | vout1_d20 | | emu16 | vin2a_d4 vin1a_d4 | vin1a_d4 | obs13 | obs29 | | | | | gpio8_20 | Driver off |
| 0x1630 | CTRL_CORE_PAD_VOUT1_D21 | A9 | vout1_d21 | | emu17 | vin2a_d5 vin1a_d5 | vin1a_d5 | obs14 | obs30 | | | | | gpio8_21 | Driver off |
| 0x1634 | CTRL_CORE_PAD_VOUT1_D22 | B9 | vout1_d22 | | emu18 | vin2a_d6 vin1a_d6 | vin1a_d6 | obs15 | obs31 | | | | | gpio8_22 | Driver off |
| 0x1638 | CTRL_CORE_PAD_VOUT1_D23 | A10 | vout1_d23 | | emu19 | vin2a_d7 vin1a_d7 | vin1a_d7 | | | | | spi3_cs3 | | gpio8_23 | Driver off |
| 0x163C | CTRL_CORE_PAD_MDIO_MCLK | V1 | mdio_mclk | uart3_rtsn | | mii0_col | vin2a_clk0 | vin1b_clk1 | | | | | | gpio5_15 | Driver off |
| 0x1640 | CTRL_CORE_PAD_MDIO_D | U4 | mdio_d | uart3_ctsn | | mii0_txer | vin2a_d0 | vin1b_d0 | | | | | | gpio5_16 | Driver off |
| 0x1644 | CTRL_CORE_PAD_RMII_MHZ_50_CLK | U3 | RMII_MHZ_50_CLK | | | | vin2a_d11 | | | | | | | gpio5_17 | Driver off |
| 0x1648 | CTRL_CORE_PAD_UART3_RXD | V2 | uart3_rxd | | rmii1_crs | mii0_rxdv | vin2a_d1 | vin1b_d1 | | | spi3_sclk | | | gpio5_18 | Driver off |
| 0x164C | CTRL_CORE_PAD_UART3_TXD | Y1 | uart3_txd | | rmii1_rxer | mii0_rxclk | vin2a_d2 | vin1b_d2 | | | spi3_d1 | spi4_cs1 | | gpio5_19 | Driver off |
| 0x1650 | CTRL_CORE_PAD_RGMII0_TXC | W9 | rgmii0_txc | uart3_ctsn | rmii1_rxd1 | mii0_rxd3 | vin2a_d3 | vin1b_d3 | usb3_ulpi_clk | spi3_d0 | spi4_cs2 | | | gpio5_20 | Driver off |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | | |
|---------|-----------------------------|-------------|---|--------------|-------------|---------------|---------------|--------------|---------------|-----------|------------------------------|----------|---------|----------|------------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 | |
| 0x1654 | CTRL_CORE_PAD_R_GMII0_TXCTL | V9 | rgmii0_txctl | uart3_rtsn | rmii1_rxd0 | mii0_rxd2 | vin2a_d4 | vin1b_d4 | usb3_ulpi_stp | spi3_cs0 | spi4_cs3 | | | gpio5_21 | Driver off | |
| 0x1658 | CTRL_CORE_PAD_R_GMII0_TXD3 | V7 | rgmii0_txd3 | rmii0_crs | | mii0_crs | vin2a_de0 | vin1b_de1 | usb3_ulpi_dir | spi4_sclk | uart4_rxd | | | gpio5_22 | Driver off | |
| 0x165C | CTRL_CORE_PAD_R_GMII0_TXD2 | U7 | rgmii0_txd2 | rmii0_rxer | | mii0_rxer | vin2a_hsync0 | vin1b_hsync1 | usb3_ulpi_nxt | spi4_d1 | uart4_txd | | | gpio5_23 | Driver off | |
| 0x1660 | CTRL_CORE_PAD_R_GMII0_TXD1 | V6 | rgmii0_txd1 | rmii0_rxd1 | | mii0_rxd1 | vin2a_vsync0 | vin1b_vsync1 | usb3_ulpi_d0 | spi4_d0 | uart4_ctsn | | | gpio5_24 | Driver off | |
| 0x1664 | CTRL_CORE_PAD_R_GMII0_TXD0 | U6 | rgmii0_txd0 | rmii0_rxd0 | | mii0_rxd0 | vin2a_d10 | | usb3_ulpi_d1 | spi4_cs0 | uart4_rtsn | | | gpio5_25 | Driver off | |
| 0x1668 | CTRL_CORE_PAD_R_GMII0_RXC | U5 | rgmii0_rxc | | rmii1_txen | mii0_txclk | vin2a_d5 | vin1b_d5 | usb3_ulpi_d2 | | | | | gpio5_26 | Driver off | |
| 0x166C | CTRL_CORE_PAD_R_GMII0_RXCTL | V5 | rgmii0_rxctl | | rmii1_txd1 | mii0_txd3 | vin2a_d6 | vin1b_d6 | usb3_ulpi_d3 | | | | | gpio5_27 | Driver off | |
| 0x1670 | CTRL_CORE_PAD_R_GMII0_RXD3 | V4 | rgmii0_rxd3 | | rmii1_txd0 | mii0_txd2 | vin2a_d7 | vin1b_d7 | usb3_ulpi_d4 | | | | | gpio5_28 | Driver off | |
| 0x1674 | CTRL_CORE_PAD_R_GMII0_RXD2 | V3 | rgmii0_rxd2 | rmii0_txen | | mii0_txen | vin2a_d8 | | usb3_ulpi_d5 | | | | | gpio5_29 | Driver off | |
| 0x1678 | CTRL_CORE_PAD_R_GMII0_RXD1 | Y2 | rgmii0_rxd1 | rmii0_txd1 | | mii0_txd1 | vin2a_d9 | | usb3_ulpi_d6 | | | | | gpio5_30 | Driver off | |
| 0x167C | CTRL_CORE_PAD_R_GMII0_RXD0 | W2 | rgmii0_rxd0 | rmii0_txd0 | | mii0_txd0 | vin2a_fld0 | vin1b_fld1 | usb3_ulpi_d7 | | | | | gpio5_31 | Driver off | |
| 0x1680 | CTRL_CORE_PAD_U_SB1_DRVVBUS | AB10 | usb1_drvvbus | | | | | | | | timer16 | | | gpio6_12 | Driver off | |
| 0x1684 | CTRL_CORE_PAD_U_SB2_DRVVBUS | AC10 | usb2_drvvbus | | | | | | | | timer15 | | | gpio6_13 | Driver off | |
| 0x1688 | CTRL_CORE_PAD_GPIO6_14 | E21 | gpio6_14 | mcasp1_axr8 | dcan2_tx | uart10_rxd | | | vout2_hsync | | vin2a_hsync0 vin1a_hsync0 | i2c3_sda | timer1 | gpio6_14 | Driver off | |
| 0x168C | CTRL_CORE_PAD_GPIO6_15 | F20 | gpio6_15 | mcasp1_axr9 | dcan2_rx | uart10_txd | | | vout2_vsync | | vin2a_vsync0 vin1a_vsync0 | i2c3_scl | timer2 | gpio6_15 | Driver off | |
| 0x1690 | CTRL_CORE_PAD_GPIO6_16 | F21 | gpio6_16 | mcasp1_axr10 | | | | | vout2_fld | | vin2a_fld0 vin1a_fld0 | clkout1 | timer3 | gpio6_16 | Driver off | |
| 0x1694 | CTRL_CORE_PAD_X_REF_CLK0 | D18 | xref_clk0 | mcasp2_axr8 | mcasp1_axr4 | mcasp1_ahclkx | mcasp5_ahclkx | atl_clk0 | | | vin1a_d0 | hdq0 | clkout2 | timer13 | gpio6_17 | Driver off |
| 0x1698 | CTRL_CORE_PAD_X_REF_CLK1 | E17 | xref_clk1 | mcasp2_axr9 | mcasp1_axr5 | mcasp2_ahclkx | mcasp6_ahclkx | atl_clk1 | | | vin1a_clk0 | | | timer14 | gpio6_18 | Driver off |
| 0x169C | CTRL_CORE_PAD_X_REF_CLK2 | B26 | xref_clk2 | mcasp2_axr10 | mcasp1_axr6 | mcasp3_ahclkx | mcasp7_ahclkx | atl_clk2 | vout2_clk | | vin2a_clk0 vin1a_clk0 | | | timer15 | gpio6_19 | Driver off |
| 0x16A0 | CTRL_CORE_PAD_X_REF_CLK3 | C23 | xref_clk3 | mcasp2_axr11 | mcasp1_axr7 | mcasp4_ahclkx | mcasp8_ahclkx | atl_clk3 | vout2_de | hdq0 | vin2a_de0 vin1a_de0 | clkout3 | timer16 | gpio6_20 | Driver off | |
| 0x16A4 | CTRL_CORE_PAD_MCASP1_ACLKX | C14 | mcasp1_aclkx | | | | | | | | vin1a_fld0 | | | i2c3_sda | gpio7_31 | Driver off |
| 0x16A8 | CTRL_CORE_PAD_MCASP1_FSX | D14 | mcasp1_fsx | | | | | | | | vin1a_de0 | | | i2c3_scl | gpio7_30 | Driver off |
| 0x16AC | CTRL_CORE_PAD_MCASP1_ACLKR | B14 | mcasp1_aclkr | mcasp7_axr2 | | | | | vout2_d0 | | vin2a_d0 vin1a_d0 | | | i2c4_sda | gpio5_0 | Driver off |
| 0x16B0 | CTRL_CORE_PAD_MCASP1_FSR | J14 | mcasp1_fsr | mcasp7_axr3 | | | | | vout2_d1 | | vin2a_d1 vin1a_d1 | | | i2c4_scl | gpio5_1 | Driver off |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | | |
|---------|----------------------------|-------------|---|--------------|---------------|------------|----|----|-----------|----------|------------------------|----------------------|----|----------|----------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 | |
| 0x16B4 | CTRL_CORE_PAD_MCASP1_AXR0 | G12 | mcasp1_axr0 | | | uart6_rxd | | | | | vin1a_vsync0 | | | i2c5_sda | gpio5_2 | Driver off |
| 0x16B8 | CTRL_CORE_PAD_MCASP1_AXR1 | F12 | mcasp1_axr1 | | | uart6_txd | | | | | vin1a_hsync0 | | | i2c5_scl | gpio5_3 | Driver off |
| 0x16BC | CTRL_CORE_PAD_MCASP1_AXR2 | G13 | mcasp1_axr2 | mcasp6_axr2 | | uart6_ctsn | | | | vout2_d2 | | vin2a_d2 vin1a_d2 | | | gpio5_4 | Driver off |
| 0x16C0 | CTRL_CORE_PAD_MCASP1_AXR3 | J11 | mcasp1_axr3 | mcasp6_axr3 | | uart6_rtsn | | | | vout2_d3 | | vin2a_d3 vin1a_d3 | | | gpio5_5 | Driver off |
| 0x16C4 | CTRL_CORE_PAD_MCASP1_AXR4 | E12 | mcasp1_axr4 | mcasp4_axr2 | | | | | | vout2_d4 | | vin2a_d4 vin1a_d4 | | | gpio5_6 | Driver off |
| 0x16C8 | CTRL_CORE_PAD_MCASP1_AXR5 | F13 | mcasp1_axr5 | mcasp4_axr3 | | | | | | vout2_d5 | | vin2a_d5 vin1a_d5 | | | gpio5_7 | Driver off |
| 0x16CC | CTRL_CORE_PAD_MCASP1_AXR6 | C12 | mcasp1_axr6 | mcasp5_axr2 | | | | | | vout2_d6 | | vin2a_d6 vin1a_d6 | | | gpio5_8 | Driver off |
| 0x16D0 | CTRL_CORE_PAD_MCASP1_AXR7 | D12 | mcasp1_axr7 | mcasp5_axr3 | | | | | | vout2_d7 | | vin2a_d7 vin1a_d7 | | timer4 | gpio5_9 | Driver off |
| 0x16D4 | CTRL_CORE_PAD_MCASP1_AXR8 | B12 | mcasp1_axr8 | mcasp6_axr0 | | spi3_sclk | | | | | vin1a_d15 | | | timer5 | gpio5_10 | Driver off |
| 0x16D8 | CTRL_CORE_PAD_MCASP1_AXR9 | A11 | mcasp1_axr9 | mcasp6_axr1 | | spi3_d1 | | | | | vin1a_d14 | | | timer6 | gpio5_11 | Driver off |
| 0x16DC | CTRL_CORE_PAD_MCASP1_AXR10 | B13 | mcasp1_axr10 | mcasp6_aclck | mcasp6_aclckr | spi3_d0 | | | | | vin1a_d13 | | | timer7 | gpio5_12 | Driver off |
| 0x16E0 | CTRL_CORE_PAD_MCASP1_AXR11 | A12 | mcasp1_axr11 | mcasp6_fsx | mcasp6_fsr | spi3_cs0 | | | | | vin1a_d12 | | | timer8 | gpio4_17 | Driver off |
| 0x16E4 | CTRL_CORE_PAD_MCASP1_AXR12 | E14 | mcasp1_axr12 | mcasp7_axr0 | | spi3_cs1 | | | | | vin1a_d11 | | | timer9 | gpio4_18 | Driver off |
| 0x16E8 | CTRL_CORE_PAD_MCASP1_AXR13 | A13 | mcasp1_axr13 | mcasp7_axr1 | | | | | | | vin1a_d10 | | | timer10 | gpio6_4 | Driver off |
| 0x16EC | CTRL_CORE_PAD_MCASP1_AXR14 | G14 | mcasp1_axr14 | mcasp7_aclck | mcasp7_aclckr | | | | | | vin1a_d9 | | | timer11 | gpio6_5 | Driver off |
| 0x16F0 | CTRL_CORE_PAD_MCASP1_AXR15 | F14 | mcasp1_axr15 | mcasp7_fsx | mcasp7_fsr | | | | | | vin1a_d8 | | | timer12 | gpio6_6 | Driver off |
| 0x16F4 | CTRL_CORE_PAD_MCASP2_ACLKX | A19 | mcasp2_aclckx | | | | | | | | vin1a_d7 | | | | | Driver off |
| 0x16F8 | CTRL_CORE_PAD_MCASP2_FSX | A18 | mcasp2_fsx | | | | | | | | vin1a_d6 | | | | | Driver off |
| 0x16FC | CTRL_CORE_PAD_MCASP2_ACLKR | E15 | mcasp2_aclckr | mcasp8_axr2 | | | | | vout2_d8 | | vin2a_d8 vin1a_d8 | | | | | Driver off |
| 0x1700 | CTRL_CORE_PAD_MCASP2_FSR | A20 | mcasp2_fsr | mcasp8_axr3 | | | | | vout2_d9 | | vin2a_d9 vin1a_d9 | | | | | Driver off |
| 0x1704 | CTRL_CORE_PAD_MCASP2_AXR0 | B15 | mcasp2_axr0 | | | | | | vout2_d10 | | vin2a_d10 vin1a_d10 | | | | | Driver off |
| 0x1708 | CTRL_CORE_PAD_MCASP2_AXR1 | A15 | mcasp2_axr1 | | | | | | vout2_d11 | | vin2a_d11 vin1a_d11 | | | | | Driver off |
| 0x170C | CTRL_CORE_PAD_MCASP2_AXR2 | C15 | mcasp2_axr2 | mcasp3_axr2 | | | | | | vin1a_d5 | | | | | gpio6_8 | Driver off |
| 0x1710 | CTRL_CORE_PAD_MCASP2_AXR3 | A16 | mcasp2_axr3 | mcasp3_axr3 | | | | | | vin1a_d4 | | | | | gpio6_9 | Driver off |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*(3:0)) | | | | | | | | | | | | |
|---------|----------------------------|-------------|---|--------------|------------------|------------|-----------|---------|-----------|----------|------------------------|------------|----------|----------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 |
| 0x1714 | CTRL_CORE_PAD_MCASP2_AXR4 | D15 | mcasp2_axr4 | mcasp8_axr0 | | | | | vout2_d12 | | vin2a_d12 vin1a_d12 | | | gpio1_4 | Driver off |
| 0x1718 | CTRL_CORE_PAD_MCASP2_AXR5 | B16 | mcasp2_axr5 | mcasp8_axr1 | | | | | vout2_d13 | | vin2a_d13 vin1a_d13 | | | gpio6_7 | Driver off |
| 0x171C | CTRL_CORE_PAD_MCASP2_AXR6 | B17 | mcasp2_axr6 | mcasp8_aclkx | mcasp8_aclkr | | | | vout2_d14 | | vin2a_d14 vin1a_d14 | | | gpio2_29 | Driver off |
| 0x1720 | CTRL_CORE_PAD_MCASP2_AXR7 | A17 | mcasp2_axr7 | mcasp8_fsx | mcasp8_fsr | | | | vout2_d15 | | vin2a_d15 vin1a_d15 | | | gpio1_5 | Driver off |
| 0x1724 | CTRL_CORE_PAD_MCASP3_ACLKX | B18 | mcasp3_aclkx | mcasp3_aclkr | mcasp2_axr1 2 | uart7_rxd | | | | vin1a_d3 | | | | gpio5_13 | Driver off |
| 0x1728 | CTRL_CORE_PAD_MCASP3_FSX | F15 | mcasp3_fsx | mcasp3_fsr | mcasp2_axr1 3 | uart7_txd | | | | vin1a_d2 | | | | gpio5_14 | Driver off |
| 0x172C | CTRL_CORE_PAD_MCASP3_AXR0 | B19 | mcasp3_axr0 | | mcasp2_axr1 4 | uart7_ctsn | uart5_rxd | | | vin1a_d1 | | | | | Driver off |
| 0x1730 | CTRL_CORE_PAD_MCASP3_AXR1 | C17 | mcasp3_axr1 | | mcasp2_axr1 5 | uart7_rtsn | uart5_txd | | | vin1a_d0 | | vin1a_fid0 | | | Driver off |
| 0x1734 | CTRL_CORE_PAD_MCASP4_ACLKX | C18 | mcasp4_aclkx | mcasp4_aclkr | spi3_sclk | uart8_rxd | i2c4_sda | | vout2_d16 | | vin2a_d16 vin1a_d16 | vin1a_d15 | | | Driver off |
| 0x1738 | CTRL_CORE_PAD_MCASP4_FSX | A21 | mcasp4_fsx | mcasp4_fsr | spi3_d1 | uart8_txd | i2c4_scl | | vout2_d17 | | vin2a_d17 vin1a_d17 | vin1a_d14 | | | Driver off |
| 0x173C | CTRL_CORE_PAD_MCASP4_AXR0 | G16 | mcasp4_axr0 | | spi3_d0 | uart8_ctsn | uart4_rxd | | vout2_d18 | | vin2a_d18 vin1a_d18 | vin1a_d13 | i2c6_scl | | Driver off |
| 0x1740 | CTRL_CORE_PAD_MCASP4_AXR1 | D17 | mcasp4_axr1 | | spi3_cs0 | uart8_rtsn | uart4_txd | | vout2_d19 | | vin2a_d19 vin1a_d19 | vin1a_d12 | i2c6_sda | | Driver off |
| 0x1744 | CTRL_CORE_PAD_MCASP5_ACLKX | AA3 | mcasp5_aclkx | mcasp5_aclkr | spi4_sclk | uart9_rxd | i2c5_sda | m1b_clk | vout2_d20 | | vin2a_d20 vin1a_d20 | vin1a_d11 | | | Driver off |
| 0x1748 | CTRL_CORE_PAD_MCASP5_FSX | AB9 | mcasp5_fsx | mcasp5_fsr | spi4_d1 | uart9_txd | i2c5_scl | | vout2_d21 | | vin2a_d21 vin1a_d21 | vin1a_d10 | | | Driver off |
| 0x174C | CTRL_CORE_PAD_MCASP5_AXR0 | AB3 | mcasp5_axr0 | | spi4_d0 | uart9_ctsn | uart3_rxd | m1b_sig | vout2_d22 | | vin2a_d22 vin1a_d22 | vin1a_d9 | | | Driver off |
| 0x1750 | CTRL_CORE_PAD_MCASP5_AXR1 | AA4 | mcasp5_axr1 | | spi4_cs0 | uart9_rtsn | uart3_txd | m1b_dat | vout2_d23 | | vin2a_d23 vin1a_d23 | vin1a_d8 | | | Driver off |
| 0x1754 | CTRL_CORE_PAD_MMC1_CLK | W6 | mmc1_clk | | | | | | | | | | | gpio6_21 | Driver off |
| 0x1758 | CTRL_CORE_PAD_MMC1_CMD | Y6 | mmc1_cmd | | | | | | | | | | | gpio6_22 | Driver off |
| 0x175C | CTRL_CORE_PAD_MMC1_DAT0 | AA6 | mmc1_dat0 | | | | | | | | | | | gpio6_23 | Driver off |
| 0x1760 | CTRL_CORE_PAD_MMC1_DAT1 | Y4 | mmc1_dat1 | | | | | | | | | | | gpio6_24 | Driver off |
| 0x1764 | CTRL_CORE_PAD_MMC1_DAT2 | AA5 | mmc1_dat2 | | | | | | | | | | | gpio6_25 | Driver off |
| 0x1768 | CTRL_CORE_PAD_MMC1_DAT3 | Y3 | mmc1_dat3 | | | | | | | | | | | gpio6_26 | Driver off |
| 0x176C | CTRL_CORE_PAD_MMC1_SD CD | W7 | mmc1_sdcd | | | uart6_rxd | i2c4_sda | | | | | | | gpio6_27 | Driver off |
| 0x1770 | CTRL_CORE_PAD_MMC1_SD WP | Y9 | mmc1_sdwp | | | uart6_txd | i2c4_scl | | | | | | | gpio6_28 | Driver off |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | | |
|---------|-------------------------|-------------|---|------------|-------------|---------------|--------------|-----------|-----------|---|----|---|--------------|------------------------|----------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 | |
| 0x1774 | CTRL_CORE_PAD_GPIO6_10 | AC5 | gpio6_10 | mdio_mclk | i2c3_sda | usb3_ulpi_d7 | vin2b_hsync1 | | | | | | vin1a_clk0 | ehrpwm2A | gpio6_10 | Driver off |
| 0x1778 | CTRL_CORE_PAD_GPIO6_11 | AB4 | gpio6_11 | mdio_d | i2c3_scl | usb3_ulpi_d6 | vin2b_vsync1 | | | | | | vin1a_de0 | ehrpwm2B | gpio6_11 | Driver off |
| 0x177C | CTRL_CORE_PAD_MMC3_CLK | AD4 | mmc3_clk | | | usb3_ulpi_d5 | vin2b_d7 | | | | | | vin1a_d7 | ehrpwm2_tripzone_input | gpio6_29 | Driver off |
| 0x1780 | CTRL_CORE_PAD_MMC3_CMD | AC4 | mmc3_cmd | spi3_sclk | | usb3_ulpi_d4 | vin2b_d6 | | | | | | vin1a_d6 | eCAP2_in_PWM2_out | gpio6_30 | Driver off |
| 0x1784 | CTRL_CORE_PAD_MMC3_DAT0 | AC7 | mmc3_dat0 | spi3_d1 | uart5_rxd | usb3_ulpi_d3 | vin2b_d5 | | | | | | vin1a_d5 | eQEP3A_in | gpio6_31 | Driver off |
| 0x1788 | CTRL_CORE_PAD_MMC3_DAT1 | AC6 | mmc3_dat1 | spi3_d0 | uart5_txd | usb3_ulpi_d2 | vin2b_d4 | | | | | | vin1a_d4 | eQEP3B_in | gpio7_0 | Driver off |
| 0x178C | CTRL_CORE_PAD_MMC3_DAT2 | AC9 | mmc3_dat2 | spi3_cs0 | uart5_ctsn | usb3_ulpi_d1 | vin2b_d3 | | | | | | vin1a_d3 | eQEP3_index | gpio7_1 | Driver off |
| 0x1790 | CTRL_CORE_PAD_MMC3_DAT3 | AC3 | mmc3_dat3 | spi3_cs1 | uart5_rtsn | usb3_ulpi_d0 | vin2b_d2 | | | | | | vin1a_d2 | eQEP3_strobe | gpio7_2 | Driver off |
| 0x1794 | CTRL_CORE_PAD_MMC3_DAT4 | AC8 | mmc3_dat4 | spi4_sclk | uart10_rxd | usb3_ulpi_nxt | vin2b_d1 | | | | | | vin1a_d1 | ehrpwm3A | gpio1_22 | Driver off |
| 0x1798 | CTRL_CORE_PAD_MMC3_DAT5 | AD6 | mmc3_dat5 | spi4_d1 | uart10_txd | usb3_ulpi_dir | vin2b_d0 | | | | | | vin1a_d0 | ehrpwm3B | gpio1_23 | Driver off |
| 0x179C | CTRL_CORE_PAD_MMC3_DAT6 | AB8 | mmc3_dat6 | spi4_d0 | uart10_ctsn | usb3_ulpi_stp | vin2b_de1 | | | | | | vin1a_hsync0 | ehrpwm3_tripzone_input | gpio1_24 | Driver off |
| 0x17A0 | CTRL_CORE_PAD_MMC3_DAT7 | AB5 | mmc3_dat7 | spi4_cs0 | uart10_rtsn | usb3_ulpi_clk | vin2b_clk1 | | | | | | vin1a_vsync0 | eCAP3_in_PWM3_out | gpio1_25 | Driver off |
| 0x17A4 | CTRL_CORE_PAD_SPI1_SCLK | A25 | spi1_sclk | | | | | | | | | | | | gpio7_7 | Driver off |
| 0x17A8 | CTRL_CORE_PAD_SPI1_D1 | F16 | spi1_d1 | | | | | | | | | | | | gpio7_8 | Driver off |
| 0x17AC | CTRL_CORE_PAD_SPI1_D0 | B25 | spi1_d0 | | | | | | | | | | | | gpio7_9 | Driver off |
| 0x17B0 | CTRL_CORE_PAD_SPI1_CS0 | A24 | spi1_cs0 | | | | | | | | | | | | gpio7_10 | Driver off |
| 0x17B4 | CTRL_CORE_PAD_SPI1_CS1 | A22 | spi1_cs1 | | sata1_led | spi2_cs1 | | | | | | | | | gpio7_11 | Driver off |
| 0x17B8 | CTRL_CORE_PAD_SPI1_CS2 | B21 | spi1_cs2 | uart4_rxd | mmc3_sdcd | spi2_cs2 | dcan2_tx | mdio_mclk | hdmi1_hpd | | | | | | gpio7_12 | Driver off |
| 0x17BC | CTRL_CORE_PAD_SPI1_CS3 | B20 | spi1_cs3 | uart4_txd | mmc3_sdwp | spi2_cs3 | dcan2_rx | mdio_d | hdmi1_cec | | | | | | gpio7_13 | Driver off |
| 0x17C0 | CTRL_CORE_PAD_SPI2_SCLK | A26 | spi2_sclk | uart3_rxd | | | | | | | | | | | gpio7_14 | Driver off |
| 0x17C4 | CTRL_CORE_PAD_SPI2_D1 | B22 | spi2_d1 | uart3_txd | | | | | | | | | | | gpio7_15 | Driver off |
| 0x17C8 | CTRL_CORE_PAD_SPI2_D0 | G17 | spi2_d0 | uart3_ctsn | uart5_rxd | | | | | | | | | | gpio7_16 | Driver off |
| 0x17CC | CTRL_CORE_PAD_SPI2_CS0 | B24 | spi2_cs0 | uart3_rtsn | uart5_txd | | | | | | | | | | gpio7_17 | Driver off |
| 0x17D0 | CTRL_CORE_PAD_DCAN1_TX | G20 | dcan1_tx | | uart8_rxd | mmc2_sdcd | | | hdmi1_hpd | | | | | | gpio1_14 | Driver off |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | |
|---------|---------------------------|-------------|---|---------------|------------|-----------|------------|------------|-----------|---|----|---|----|----------------------|------------|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 |
| 0x17D4 | CTRL_CORE_PAD_D_CAN1_RX | G19 | dcan1_rx | | uart8_txd | mmc2_sdwp | sata1_led | | hdmi1_cec | | | | | gpio1_15 | Driver off |
| 0x17E0 | CTRL_CORE_PAD_U_ART1_RXD | B27 | uart1_rxd | | | mmc4_sdcd | | | | | | | | gpio7_22 | Driver off |
| 0x17E4 | CTRL_CORE_PAD_U_ART1_TXD | C26 | uart1_txd | | | mmc4_sdwp | | | | | | | | gpio7_23 | Driver off |
| 0x17E8 | CTRL_CORE_PAD_U_ART1_CTSN | E25 | uart1_ctsn | | uart9_rxd | mmc4_clk | | | | | | | | gpio7_24 | Driver off |
| 0x17EC | CTRL_CORE_PAD_U_ART1_RTSN | C27 | uart1_rtsn | | uart9_txd | mmc4_cmd | | | | | | | | gpio7_25 | Driver off |
| 0x17F0 | CTRL_CORE_PAD_U_ART2_RXD | D28 | | uart3_ctsn | uart3_rctx | mmc4_dat0 | uart2_rxd | uart1_dcdn | | | | | | gpio7_26 | Driver off |
| 0x17F4 | CTRL_CORE_PAD_U_ART2_TXD | D26 | uart2_txd | uart3_rtsn | uart3_sd | mmc4_dat1 | uart2_txd | uart1_dsrn | | | | | | gpio7_27 | Driver off |
| 0x17F8 | CTRL_CORE_PAD_U_ART2_CTSN | D27 | uart2_ctsn | | uart3_rxd | mmc4_dat2 | uart10_rxd | uart1_dtrn | | | | | | gpio1_16 | Driver off |
| 0x17FC | CTRL_CORE_PAD_U_ART2_RTSN | C28 | uart2_rtsn | uart3_txd | uart3_irtx | mmc4_dat3 | uart10_txd | uart1_rin | | | | | | gpio1_17 | Driver off |
| 0x1800 | CTRL_CORE_PAD_I_2C1_SDA | C21 | i2c1_sda | | | | | | | | | | | | Driver off |
| 0x1804 | CTRL_CORE_PAD_I_2C1_SCL | C20 | i2c1_scl | | | | | | | | | | | | Driver off |
| 0x1808 | CTRL_CORE_PAD_I_2C2_SDA | C25 | i2c2_sda | hdmi1_ddc_scl | | | | | | | | | | | Driver off |
| 0x180C | CTRL_CORE_PAD_I_2C2_SCL | F17 | i2c2_scl | hdmi1_ddc_sda | | | | | | | | | | | Driver off |
| 0x1818 | CTRL_CORE_PAD_WAKEUP0 | AD17 | Wakeup0 | dcan1_rx | | | | | | | | | | gpio1_0 sys_nirq2 | Driver off |
| 0x1824 | CTRL_CORE_PAD_WAKEUP3 | AC16 | Wakeup3 | sys_nirq1 | | | | | | | | | | gpio1_3 dcan2_rx | Driver off |
| 0x1828 | CTRL_CORE_PAD_ON_OFF | Y11 | on_off | | | | | | | | | | | | |
| 0x182C | CTRL_CORE_PAD_RTC_PORZ | AB17 | rtc_porz | | | | | | | | | | | | |
| 0x1830 | CTRL_CORE_PAD_TMS | F18 | tms | | | | | | | | | | | | |
| 0x1834 | CTRL_CORE_PAD_TDI | D23 | tdi | | | | | | | | | | | gpio8_27 | |
| 0x1838 | CTRL_CORE_PAD_TDO | F19 | tdo | | | | | | | | | | | gpio8_28 | |
| 0x183C | CTRL_CORE_PAD_TCLK | E20 | tcik | | | | | | | | | | | | |
| 0x1840 | CTRL_CORE_PAD_TRSTN | D20 | trstn | | | | | | | | | | | | |
| 0x1844 | CTRL_CORE_PAD_RTCK | E18 | rtck | | | | | | | | | | | gpio8_29 | |
| 0x1848 | CTRL_CORE_PAD_EMU0 | G21 | emu0 | | | | | | | | | | | gpio8_30 | |

Table 4-3. Multiplexing Characteristics (continued)

| ADDRESS | REGISTER NAME | BALL NUMBER | MUXMODE FIELD SETTINGS (CTRL_CORE_PAD_*[3:0]) | | | | | | | | | | | | | |
|---------|------------------------|-------------|---|---|---|----|----|----|----|---|----|---|----|-----|----------|--|
| | | | 0 | 1 | 2 | 3* | 4* | 5* | 6* | 7 | 8* | 9 | 10 | 14* | 15 | |
| 0x184C | CTRL_CORE_PAD_EMU1 | D24 | emu1 | | | | | | | | | | | | gpio8_31 | |
| 0x185C | CTRL_CORE_PAD_RESETN | E23 | resetn | | | | | | | | | | | | | |
| 0x1860 | CTRL_CORE_PAD_NMIN_DSP | D21 | nmin_dsp | | | | | | | | | | | | | |
| 0x1864 | CTRL_CORE_PAD_RSTOUTN | F23 | rstoutn | | | | | | | | | | | | | |

1. N/A stands for Not Applicable.

4.4 Signal Descriptions

Many signals are available on multiple pins, according to the software configuration of the pin multiplexing options.

1. **SIGNAL NAME:** The name of the signal passing through the pin.

NOTE

The subsystem multiplexing signals are not described in [Table 4-2](#) and [Table 4-3](#).

2. **DESCRIPTION:** Description of the signal

3. **TYPE:** Signal direction and type:

- I = Input
- O = Output
- IO = Input or output
- D = Open Drain
- DS = Differential
- A = Analog
- PWR = Power
- GND = Ground

4. **BALL:** Associated ball(s) bottom

NOTE

For more information, see *Control Module* chapter, *Control Module Register Manual* section in the device TRM.

4.4.1 Video Input Ports (VIP)

NOTE

For more information, see *Video Input Port* chapter in the device TRM.

CAUTION

The I/O timings provided in [Section 7, Timing Requirements and Switching Characteristics](#) are valid only for VIN1 and VIN2 if signals within a single IOSET are used. The IOSETs are defined in [Table 7-4](#) and [Table 7-5](#).

Table 4-4. VIP Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|----------------------|--|------|--------------------------------------|
| Video Input 1 | | | |
| vin1a_clk0 | Video Input 1 Port A Clock input. Input clock for 8-bit 16-bit or 24-bit Port A video capture. Input data is sampled on the CLK0 edge. | I | AC5 / B11 / E17 / P1 / P4 / B26 |
| vin1a_d0 | Video Input 1 Port A Data input | I | AD6 / B7 / C17 / D18 / M6 / R6 / B14 |
| vin1a_d1 | Video Input 1 Port A Data input | I | AC8 / B19 / B8 / M2 / T9 / J14 |
| vin1a_d2 | Video Input 1 Port A Data input | I | A7 / AC3 / F15 / L5 / T6 / G13 |
| vin1a_d3 | Video Input 1 Port A Data input | I | A8 / AC9 / B18 / M1 / T7 / J11 |
| vin1a_d4 | Video Input 1 Port A Data input | I | A16 / AC6 / C9 / L6 / P6 / E12 |

Table 4-4. VIP Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|----------------------|--|------|--------------------------------------|
| vin1a_d5 | Video Input 1 Port A Data input | I | A9 / AC7 / C15 / L4 / R9 / F13 |
| vin1a_d6 | Video Input 1 Port A Data input | I | A18 / AC4 / B9 / L3 / R5 / C12 |
| vin1a_d7 | Video Input 1 Port A Data input | I | A10 / A19 / AD4 / L2 / P5 / D12 |
| vin1a_d8 | Video Input 1 Port A Data input | I | AA4 / E8 / F14 / L1 / U2 / E15 |
| vin1a_d9 | Video Input 1 Port A Data input | I | AB3 / D9 / G14 / K2 / U1 / A20 |
| vin1a_d10 | Video Input 1 Port A Data input | I | A13 / AB9 / D7 / J1 / P3 / B15 |
| vin1a_d11 | Video Input 1 Port A Data input | I | AA3 / D8 / E14 / J2 / R2 / A15 |
| vin1a_d12 | Video Input 1 Port A Data input | I | A12 / A5 / D17 / H1 / K7 / D15 |
| vin1a_d13 | Video Input 1 Port A Data input | I | B13 / C6 / G16 / J3 / M7 / B16 |
| vin1a_d14 | Video Input 1 Port A Data input | I | A11 / A21 / C8 / H2 / J5 / B17 |
| vin1a_d15 | Video Input 1 Port A Data input | I | B12 / C18 / C7 / H3 / K6 / A17 |
| vin1a_d16 | Video Input 1 Port A Data input | I | F11 / R6 / C18 |
| vin1a_d17 | Video Input 1 Port A Data input | I | G10 / T9 / A21 |
| vin1a_d18 | Video Input 1 Port A Data input | I | F10 / T6 / G16 |
| vin1a_d19 | Video Input 1 Port A Data input | I | G11 / T7 / D17 |
| vin1a_d20 | Video Input 1 Port A Data input | I | E9 / P6 / AA3 |
| vin1a_d21 | Video Input 1 Port A Data input | I | F9 / R9 / AB9 |
| vin1a_d22 | Video Input 1 Port A Data input | I | F8 / R5 / AB3 |
| vin1a_d23 | Video Input 1 Port A Data input | I | E7 / P5 / AA4 |
| vin1a_de0 | Video Input 1 Port A Field ID input | I | AB4 / B10 / D14 / N9 / H6 / C23 / P7 |
| vin1a_fld0 | Video Input 1 Port A Field ID input | I | C14 / C17 / D11 / P9 / J7 / F21 |
| vin1a_hsync0 | Video Input 1 Port A Horizontal Sync input | I | AB8 / C11 / F12 / N7 / R3 / P7 / E21 |
| vin1a_vsync0 | Video Input 1 Port A Vertical Sync input | I | AB5 / E11 / G12 / R4 / T2 / N1 / F20 |
| vin1b_clk1 | Video Input 1 Port B Clock input | I | N9 / V1 / M4 / P7 |
| vin1b_d0 | Video Input 1 Port B Data input | I | R6 / U4 / K7 |
| vin1b_d1 | Video Input 1 Port B Data input | I | T9 / V2 / M7 |
| vin1b_d2 | Video Input 1 Port B Data input | I | T6 / Y1 / J5 |
| vin1b_d3 | Video Input 1 Port B Data input | I | T7 / W9 / K6 |
| vin1b_d4 | Video Input 1 Port B Data input | I | P6 / V9 / J7 |
| vin1b_d5 | Video Input 1 Port B Data input | I | R9 / U5 / J4 |
| vin1b_d6 | Video Input 1 Port B Data input | I | R5 / V5 / J6 |
| vin1b_d7 | Video Input 1 Port B Data input | I | P5 / V4 / H4 |
| vin1b_de1 | Video Input 1 Port B Field ID input | I | P9 / V7 / N6 |
| vin1b_fld1 | Video Input 1 Port B Field ID input | I | P4 / W2 / M4 |
| vin1b_hsync1 | Video Input 1 Port B Horizontal Sync input | I | N7 / U7 / H5 |
| vin1b_vsync1 | Video Input 1 Port B Vertical Sync input | I | R4 / V6 / H6 |
| Video Input 2 | | | |

Table 4-4. VIP Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--------------|--|------|------------------------------------|
| vin2a_clk0 | Video Input 2 Port A Clock input | I | B11 / B26 / E1 / P4 / V1 |
| vin2a_d0 | Video Input 2 Port A Data input | I | B14 / B7 / F2 / R6 / U4 |
| vin2a_d1 | Video Input 2 Port A Data input | I | B8 / F3 / J14 / T9 / V2 |
| vin2a_d2 | Video Input 2 Port A Data input | I | A7 / D1 / G13 / T6 / Y1 |
| vin2a_d3 | Video Input 2 Port A Data input | I | A8 / E2 / J11 / T7 / W9 |
| vin2a_d4 | Video Input 2 Port A Data input | I | C9 / D2 / E12 / P6 / V9 |
| vin2a_d5 | Video Input 2 Port A Data input | I | A9 / F13 / F4 / R9 / U5 |
| vin2a_d6 | Video Input 2 Port A Data input | I | B9 / C1 / C12 / R5 / V5 |
| vin2a_d7 | Video Input 2 Port A Data input | I | A10 / D12 / E4 / P5 / V4 |
| vin2a_d8 | Video Input 2 Port A Data input | I | E15 / E8 / F5 / U2 / V3 |
| vin2a_d9 | Video Input 2 Port A Data input | I | A20 / D9 / E6 / U1 / Y2 |
| vin2a_d10 | Video Input 2 Port A Data input | IO | B15 / D3 / D7 / P3 / U6 |
| vin2a_d11 | Video Input 2 Port A Data input | IO | A15 / D8 / F6 / R2 / U3 |
| vin2a_d12 | Video Input 2 Port A Data input | I | A5 / D15 / D5 / K7 |
| vin2a_d13 | Video Input 2 Port A Data input | I | B16 / C2 / C6 / M7 |
| vin2a_d14 | Video Input 2 Port A Data input | I | B17 / C3 / C8 / J5 |
| vin2a_d15 | Video Input 2 Port A Data input | I | A17 / C4 / C7 / K6 |
| vin2a_d16 | Video Input 2 Port A Data input | I | B2 / C18 / F11 |
| vin2a_d17 | Video Input 2 Port A Data input | I | A21 / D6 / G10 |
| vin2a_d18 | Video Input 2 Port A Data input | I | C5 / F10 / G16 |
| vin2a_d19 | Video Input 2 Port A Data input | I | A3 / D17 / G11 |
| vin2a_d20 | Video Input 2 Port A Data input | I | AA3 / B3 / E9 |
| vin2a_d21 | Video Input 2 Port A Data input | I | AB9 / B4 / F9 |
| vin2a_d22 | Video Input 2 Port A Data input | I | AB3 / B5 / F8 |
| vin2a_d23 | Video Input 2 Port A Data input | I | A4 / AA4 / E7 |
| vin2a_de0 | Video Input 2 Port A Field ID input | I | B10 / C23 / G2 / H6 / P7 / V7 |
| vin2a_fld0 | Video Input 2 Port A Field ID input | I | D11 / F21 / G2 / H7 / J7 / P9 / W2 |
| vin2a_hsync0 | Video Input 2 Port A Horizontal Sync input | I | C11 / E21 / G1 / P7 / R3 / U7 |
| vin2a_vsync0 | Video Input 2 Port A Vertical Sync input | I | E11 / F20 / G6 / N1 / T2 / V6 |
| vin2b_clk1 | Video Input 2 Port B Clock input | I | AB5 / H7 / M4 / P7 |
| vin2b_d0 | Video Input 2 Port B Data input | I | A4 / AD6 / K7 |
| vin2b_d1 | Video Input 2 Port B Data input | I | AC8 / B5 / M7 |
| vin2b_d2 | Video Input 2 Port B Data input | I | AC3 / B4 / J5 |
| vin2b_d3 | Video Input 2 Port B Data input | I | AC9 / B3 / K6 |
| vin2b_d4 | Video Input 2 Port B Data input | I | A3 / AC6 / J7 |
| vin2b_d5 | Video Input 2 Port B Data input | I | AC7 / C5 / J4 |

Table 4-4. VIP Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--------------|--|------|---------------|
| vin2b_d6 | Video Input 2 Port B Data input | I | AC4 / D6 / J6 |
| vin2b_d7 | Video Input 2 Port B Data input | I | AD4 / B2 / H4 |
| vin2b_de1 | Video Input 2 Port B Field ID input | I | AB8 / G2 / N6 |
| vin2b fld1 | Video Input 2 Port B Field ID input | I | G2 / M4 |
| vin2b_hsync1 | Video Input 2 Port B Horizontal Sync input | I | AC5 / G1 / H5 |
| vin2b_vsync1 | Video Input 2 Port B Vertical Sync input | I | AB4 / G6 / H6 |

4.4.2 Display Subsystem – Video Output Ports

CAUTION

The I/O timings provided in [Section 7, Timing Requirements and Switching Characteristics](#) are valid only if signals within a single IOSET are used. The IOSETs are defined in [Table 7-18](#).

Table 4-5. DSS Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------------------|---|------|------|
| DPI Video Output 1 | | | |
| vout1_clk | Video Output 1 Clock output | O | D11 |
| vout1_de | Video Output 1 Data Enable output | O | B10 |
| vout1_fld | Video Output 1 Field ID output. This signal is not used for embedded sync modes. | O | B11 |
| vout1_hsync | Video Output 1 Horizontal Sync output. This signal is not used for embedded sync modes. | O | C11 |
| vout1_vsync | Video Output 1 Vertical Sync output. This signal is not used for embedded sync modes. | O | E11 |
| vout1_d0 | Video Output 1 Data output | O | F11 |
| vout1_d1 | Video Output 1 Data output | O | G10 |
| vout1_d2 | Video Output 1 Data output | O | F10 |
| vout1_d3 | Video Output 1 Data output | O | G11 |
| vout1_d4 | Video Output 1 Data output | O | E9 |
| vout1_d5 | Video Output 1 Data output | O | F9 |
| vout1_d6 | Video Output 1 Data output | O | F8 |
| vout1_d7 | Video Output 1 Data output | O | E7 |
| vout1_d8 | Video Output 1 Data output | O | E8 |
| vout1_d9 | Video Output 1 Data output | O | D9 |
| vout1_d10 | Video Output 1 Data output | O | D7 |
| vout1_d11 | Video Output 1 Data output | O | D8 |
| vout1_d12 | Video Output 1 Data output | O | A5 |
| vout1_d13 | Video Output 1 Data output | O | C6 |
| vout1_d14 | Video Output 1 Data output | O | C8 |
| vout1_d15 | Video Output 1 Data output | O | C7 |
| vout1_d16 | Video Output 1 Data output | O | B7 |
| vout1_d17 | Video Output 1 Data output | O | B8 |
| vout1_d18 | Video Output 1 Data output | O | A7 |
| vout1_d19 | Video Output 1 Data output | O | A8 |
| vout1_d20 | Video Output 1 Data output | O | C9 |
| vout1_d21 | Video Output 1 Data output | O | A9 |
| vout1_d22 | Video Output 1 Data output | O | B9 |

Table 4-5. DSS Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------------------|---|------|----------|
| vout1_d23 | Video Output 1 Data output | O | A10 |
| DPI Video Output 2 | | | |
| vout2_clk | Video Output 2 Clock output | O | H7 / B26 |
| vout2_de | Video Output 2 Data Enable output | O | G2 / C23 |
| vout2_fid | Video Output 2 Field ID output. This signal is not used for embedded sync modes. | O | E1 / F21 |
| vout2_hsync | Video Output 2 Horizontal Sync output. This signal is not used for embedded sync modes. | O | G1 / E21 |
| vout2_vsync | Video Output 2 Vertical Sync output. This signal is not used for embedded sync modes. | O | G6 / F20 |
| vout2_d0 | Video Output 2 Data output | O | A4 / B14 |
| vout2_d1 | Video Output 2 Data output | O | B5 / J14 |
| vout2_d2 | Video Output 2 Data output | O | B4 / G13 |
| vout2_d3 | Video Output 2 Data output | O | B3 / J11 |
| vout2_d4 | Video Output 2 Data output | O | A3 / E12 |
| vout2_d5 | Video Output 2 Data output | O | C5 / F13 |
| vout2_d6 | Video Output 2 Data output | O | D6 / C12 |
| vout2_d7 | Video Output 2 Data output | O | B2 / D12 |
| vout2_d8 | Video Output 2 Data output | O | C4 / E15 |
| vout2_d9 | Video Output 2 Data output | O | C3 / A20 |
| vout2_d10 | Video Output 2 Data output | O | C2 / B15 |
| vout2_d11 | Video Output 2 Data output | O | D5 / A15 |
| vout2_d12 | Video Output 2 Data output | O | F6 / D15 |
| vout2_d13 | Video Output 2 Data output | O | D3 / B16 |
| vout2_d14 | Video Output 2 Data output | O | E6 / B17 |
| vout2_d15 | Video Output 2 Data output | O | F5 / A17 |
| vout2_d16 | Video Output 2 Data output | O | E4 / C18 |
| vout2_d17 | Video Output 2 Data output | O | C1 / A21 |
| vout2_d18 | Video Output 2 Data output | O | F4 / G16 |
| vout2_d19 | Video Output 2 Data output | O | D2 / D17 |
| vout2_d20 | Video Output 2 Data output | O | E2 / AA3 |
| vout2_d21 | Video Output 2 Data output | O | D1 / AB9 |
| vout2_d22 | Video Output 2 Data output | O | F3 / AB3 |
| vout2_d23 | Video Output 2 Data output | O | F2 / AA4 |
| DPI Video Output 3 | | | |
| vout3_clk | Video Output 3 Clock output | O | P1 |
| vout3_d0 | Video Output 3 Data output | O | M6 |
| vout3_d1 | Video Output 3 Data output | O | M2 |
| vout3_d2 | Video Output 3 Data output | O | L5 |
| vout3_d3 | Video Output 3 Data output | O | M1 |
| vout3_d4 | Video Output 3 Data output | O | L6 |
| vout3_d5 | Video Output 3 Data output | O | L4 |
| vout3_d6 | Video Output 3 Data output | O | L3 |
| vout3_d7 | Video Output 3 Data output | O | L2 |
| vout3_d8 | Video Output 3 Data output | O | L1 |
| vout3_d9 | Video Output 3 Data output | O | K2 |
| vout3_d10 | Video Output 3 Data output | O | J1 |
| vout3_d11 | Video Output 3 Data output | O | J2 |
| vout3_d12 | Video Output 3 Data output | O | H1 |
| vout3_d13 | Video Output 3 Data output | O | J3 |

Table 4-5. DSS Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|------|
| vout3_d14 | Video Output 3 Data output | O | H2 |
| vout3_d15 | Video Output 3 Data output | O | H3 |
| vout3_d16 | Video Output 3 Data output | O | R6 |
| vout3_d17 | Video Output 3 Data output | O | T9 |
| vout3_d18 | Video Output 3 Data output | O | T6 |
| vout3_d19 | Video Output 3 Data output | O | T7 |
| vout3_d20 | Video Output 3 Data output | O | P6 |
| vout3_d21 | Video Output 3 Data output | O | R9 |
| vout3_d22 | Video Output 3 Data output | O | R5 |
| vout3_d23 | Video Output 3 Data output | O | P5 |
| vout3_de | Video Output 3 Data Enable output | O | N9 |
| vout3_fld | Video Output 3 Field ID output. This signal is not used for embedded sync modes. | O | P9 |
| vout3_hsync | Video Output 3 Horizontal Sync output. This signal is not used for embedded sync modes. | O | N7 |
| vout3_vsync | Video Output 3 Vertical Sync output. This signal is not used for embedded sync modes. | O | R4 |

4.4.3 Display Subsystem – High-Definition Multimedia Interface (HDMI)

NOTE

For more information, see *Display Subsystem* chapter in the device TRM.

Table 4-6. HDMI Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------|---|------|----------|
| hdmi1_cec | HDMI consumer electronic control | IOD | B20/ G19 |
| hdmi1_hpd | HDMI display hot plug detect | IO | B21/ G20 |
| hdmi1_ddc_scl | HDMI display data channel clock | IOD | C25 |
| hdmi1_ddc_sda | HDMI display data channel data | IOD | F17 |
| hdmi1_clockx | HDMI clock differential positive or negative | ODS | AG16 |
| hdmi1_clocky | HDMI clock differential positive or negative | ODS | AH16 |
| hdmi1_data2x | HDMI data 2 differential positive or negative | ODS | AG19 |
| hdmi1_data2y | HDMI data 2 differential positive or negative | ODS | AH19 |
| hdmi1_data1x | HDMI data 1 differential positive or negative | ODS | AG18 |
| hdmi1_data1y | HDMI data 1 differential positive or negative | ODS | AH18 |
| hdmi1_data0x | HDMI data 0 differential positive or negative | ODS | AG17 |
| hdmi1_data0y | HDMI data 0 differential positive or negative | ODS | AH17 |

4.4.4 Camera Serial Interface 2 CAL bridge (CSI2)

NOTE

For more information, see *Camera Interface Subsystem* chapter in the device TRM.

Table 4-7. CSI 2 Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|------|
| csi2_0_dx0 | Serial data/clock input - line 0 (position 1) | I | AE1 |
| csi2_0_dy0 | Serial data/clock input - line 0 (position 1) | I | AD2 |
| csi2_0_dx1 | Serial data/clock input - line 1 (position 2) | I | AF1 |

Table 4-7. CSI 2 Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|------|
| csi2_0_dy1 | Serial data/clock input - line 1 (position 2) | I | AE2 |
| csi2_0_dx2 | Serial data/clock input - line 2 (position 3) | I | AF2 |
| csi2_0_dy2 | Serial data/clock input - line 2 (position 3) | I | AF3 |
| csi2_0_dx3 | Serial data/clock input - line 3 (position 4) | I | AH4 |
| csi2_0_dy3 | Serial data/clock input - line 3 (position 4) | I | AG4 |
| csi2_0_dx4 | Serial data input only - line 4 (position 5) ⁽¹⁾ | I | AH3 |
| csi2_0_dy4 | Serial data input only - line 4 (position 5) ⁽¹⁾ | I | AG3 |
| csi2_1_dx0 | Serial data/clock input - line 0 (position 1) | I | AG5 |
| csi2_1_dy0 | Serial data/clock input - line 0 (position 1) | I | AH5 |
| csi2_1_dx1 | Serial data/clock input - line 1 (position 2) | I | AG6 |
| csi2_1_dy1 | Serial data/clock input - line 1 (position 2) | I | AH6 |
| csi2_1_dx2 | Serial data/clock input - line 2 (position 3) | I | AH7 |
| csi2_1_dy2 | Serial data/clock input - line 2 (position 3) | I | AG7 |

(1) Line 4 (position 5) supports only data. For more information, see *Camera Interface Subsystem* chapter in the device TRM.

4.4.5 External Memory Interface (EMIF)

NOTE

For more information, see *Memory Subsystem* chapter, *EMIF Controller* section in the device TRM.

NOTE

Dual rank support is not available on this device, but signal names are retained for consistency with the DRA7xx family of devices.

NOTE

ECC is not available on this device, but signal names are retained for consistency with the DRA7xx family of devices.

NOTE

The index number 1 which is part of the EMIF1 signal prefixes (ddr1_*) listed in [Table 4-8](#), EMIF Signal Descriptions, column "SIGNAL NAME" not to be confused with DDR1 type of SDRAM memories.

Table 4-8. EMIF Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|--|------|------|
| ddr1_csn0 | EMIF1 Chip Select 0 | O | AH23 |
| ddr1_csn1 | EMIF1 Chip Select 1 | O | AB16 |
| ddr1_cke | EMIF1 Clock Enable | O | AG22 |
| ddr1_ck | EMIF1 Clock | O | AG24 |
| ddr1_nck | EMIF1 Negative Clock | O | AH24 |
| ddr1_odt0 | EMIF1 On-Die Termination for Chip Select 0 | O | AE20 |
| ddr1_odt1 | EMIF1 On-Die Termination for Chip Select 1 | O | AC17 |
| ddr1_casn | EMIF1 Column Address Strobe | O | AC18 |
| ddr1_rasn | EMIF1 Row Address Strobe | O | AF20 |

Table 4-8. EMIF Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|--------------------------------------|------|------|
| ddr1_wen | EMIF1 Write Enable | O | AH21 |
| ddr1_rst | EMIF1 Reset output (DDR3-SDRAM only) | O | AG21 |
| ddr1_ba0 | EMIF1 Bank Address | O | AF17 |
| ddr1_ba1 | EMIF1 Bank Address | O | AE18 |
| ddr1_ba2 | EMIF1 Bank Address | O | AB18 |
| ddr1_a0 | EMIF1 Address Bus | O | AD20 |
| ddr1_a1 | EMIF1 Address Bus | O | AC19 |
| ddr1_a2 | EMIF1 Address Bus | O | AC20 |
| ddr1_a3 | EMIF1 Address Bus | O | AB19 |
| ddr1_a4 | EMIF1 Address Bus | O | AF21 |
| ddr1_a5 | EMIF1 Address Bus | O | AH22 |
| ddr1_a6 | EMIF1 Address Bus | O | AG23 |
| ddr1_a7 | EMIF1 Address Bus | O | AE21 |
| ddr1_a8 | EMIF1 Address Bus | O | AF22 |
| ddr1_a9 | EMIF1 Address Bus | O | AE22 |
| ddr1_a10 | EMIF1 Address Bus | O | AD21 |
| ddr1_a11 | EMIF1 Address Bus | O | AD22 |
| ddr1_a12 | EMIF1 Address Bus | O | AC21 |
| ddr1_a13 | EMIF1 Address Bus | O | AF18 |
| ddr1_a14 | EMIF1 Address Bus | O | AE17 |
| ddr1_a15 | EMIF1 Address Bus | O | AD18 |
| ddr1_d0 | EMIF1 Data Bus | IO | AF25 |
| ddr1_d1 | EMIF1 Data Bus | IO | AF26 |
| ddr1_d2 | EMIF1 Data Bus | IO | AG26 |
| ddr1_d3 | EMIF1 Data Bus | IO | AH26 |
| ddr1_d4 | EMIF1 Data Bus | IO | AF24 |
| ddr1_d5 | EMIF1 Data Bus | IO | AE24 |
| ddr1_d6 | EMIF1 Data Bus | IO | AF23 |
| ddr1_d7 | EMIF1 Data Bus | IO | AE23 |
| ddr1_d8 | EMIF1 Data Bus | IO | AC23 |
| ddr1_d9 | EMIF1 Data Bus | IO | AF27 |
| ddr1_d10 | EMIF1 Data Bus | IO | AG27 |
| ddr1_d11 | EMIF1 Data Bus | IO | AF28 |
| ddr1_d12 | EMIF1 Data Bus | IO | AE26 |
| ddr1_d13 | EMIF1 Data Bus | IO | AC25 |
| ddr1_d14 | EMIF1 Data Bus | IO | AC24 |
| ddr1_d15 | EMIF1 Data Bus | IO | AD25 |
| ddr1_d16 | EMIF1 Data Bus | IO | V20 |
| ddr1_d17 | EMIF1 Data Bus | IO | W20 |
| ddr1_d18 | EMIF1 Data Bus | IO | AB28 |
| ddr1_d19 | EMIF1 Data Bus | IO | AC28 |
| ddr1_d20 | EMIF1 Data Bus | IO | AC27 |
| ddr1_d21 | EMIF1 Data Bus | IO | Y19 |
| ddr1_d22 | EMIF1 Data Bus | IO | AB27 |
| ddr1_d23 | EMIF1 Data Bus | IO | Y20 |
| ddr1_d24 | EMIF1 Data Bus | IO | AA23 |
| ddr1_d25 | EMIF1 Data Bus | IO | Y22 |

Table 4-8. EMIF Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------|--|------|------|
| ddr1_d26 | EMIF1 Data Bus | IO | Y23 |
| ddr1_d27 | EMIF1 Data Bus | IO | AA24 |
| ddr1_d28 | EMIF1 Data Bus | IO | Y24 |
| ddr1_d29 | EMIF1 Data Bus | IO | AA26 |
| ddr1_d30 | EMIF1 Data Bus | IO | AA25 |
| ddr1_d31 | EMIF1 Data Bus | IO | AA28 |
| ddr1_ecc_d0 | EMIF1 ECC Data Bus | IO | W22 |
| ddr1_ecc_d1 | EMIF1 ECC Data Bus | IO | V23 |
| ddr1_ecc_d2 | EMIF1 ECC Data Bus | IO | W19 |
| ddr1_ecc_d3 | EMIF1 ECC Data Bus | IO | W23 |
| ddr1_ecc_d4 | EMIF1 ECC Data Bus | IO | Y25 |
| ddr1_ecc_d5 | EMIF1 ECC Data Bus | IO | V24 |
| ddr1_ecc_d6 | EMIF1 ECC Data Bus | IO | V25 |
| ddr1_ecc_d7 | EMIF1 ECC Data Bus | IO | Y26 |
| ddr1_dqm0 | EMIF1 Data Mask | O | AD23 |
| ddr1_dqm1 | EMIF1 Data Mask | O | AB23 |
| ddr1_dqm2 | EMIF1 Data Mask | O | AC26 |
| ddr1_dqm3 | EMIF1 Data Mask | O | AA27 |
| ddr1_dqm_ecc | EMIF1 ECC Data Mask | O | V26 |
| ddr1_dqs0 | Data strobe 0 input/output for byte 0 of the 32-bit data bus. This signal is output to the EMIF1 memory when writing and input when reading. | IO | AH25 |
| ddr1_dqsn0 | Data strobe 0 invert | IO | AG25 |
| ddr1_dqs1 | Data strobe 1 input/output for byte 1 of the 32-bit data bus. This signal is output to the EMIF1 memory when writing and input when reading. | IO | AE27 |
| ddr1_dqsn1 | Data strobe 1 invert | IO | AE28 |
| ddr1_dqs2 | Data strobe 2 input/output for byte 2 of the 32-bit data bus. This signal is output to the EMIF1 memory when writing and input when reading. | IO | AD27 |
| ddr1_dqsn2 | Data strobe 2 invert | IO | AD28 |
| ddr1_dqs3 | Data strobe 3 input/output for byte 3 of the 32-bit data bus. This signal is output to the EMIF1 memory when writing and input when reading. | IO | Y28 |
| ddr1_dqsn3 | Data strobe 3 invert | IO | Y27 |
| ddr1_dqs_ecc | EMIF1 ECC Data strobe input/output. This signal is output to the EMIF1 memory when writing and input when reading. | IO | V27 |
| ddr1_dqsn_ecc | EMIF1 ECC Complementary Data strobe | IO | V28 |
| ddr1_vref0 | Reference Power Supply EMIF1 | A | Y18 |

4.4.6 General-Purpose Memory Controller (GPMC)

NOTE

For more information, see *Memory Subsystem* chapter, *General-Purpose Memory Controller* section in the device TRM.

Table 4-9. GPMC Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|------|
| gpmc_ad0 | GPMC Data 0 in A/D nonmultiplexed mode and additionally Address 1 in A/D multiplexed mode | IO | M6 |
| gpmc_ad1 | GPMC Data 1 in A/D nonmultiplexed mode and additionally Address 2 in A/D multiplexed mode | IO | M2 |

Table 4-9. GPMC Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|--------------|
| gpmc_ad2 | GPMC Data 2 in A/D nonmultiplexed mode and additionally Address 3 in A/D multiplexed mode | IO | L5 |
| gpmc_ad3 | GPMC Data 3 in A/D nonmultiplexed mode and additionally Address 4 in A/D multiplexed mode | IO | M1 |
| gpmc_ad4 | GPMC Data 4 in A/D nonmultiplexed mode and additionally Address 5 in A/D multiplexed mode | IO | L6 |
| gpmc_ad5 | GPMC Data 5 in A/D nonmultiplexed mode and additionally Address 6 in A/D multiplexed mode | IO | L4 |
| gpmc_ad6 | GPMC Data 6 in A/D nonmultiplexed mode and additionally Address 7 in A/D multiplexed mode | IO | L3 |
| gpmc_ad7 | GPMC Data 7 in A/D nonmultiplexed mode and additionally Address 8 in A/D multiplexed mode | IO | L2 |
| gpmc_ad8 | GPMC Data 8 in A/D nonmultiplexed mode and additionally Address 9 in A/D multiplexed mode | IO | L1 |
| gpmc_ad9 | GPMC Data 9 in A/D nonmultiplexed mode and additionally Address 10 in A/D multiplexed mode | IO | K2 |
| gpmc_ad10 | GPMC Data 10 in A/D nonmultiplexed mode and additionally Address 11 in A/D multiplexed mode | IO | J1 |
| gpmc_ad11 | GPMC Data 11 in A/D nonmultiplexed mode and additionally Address 12 in A/D multiplexed mode | IO | J2 |
| gpmc_ad12 | GPMC Data 12 in A/D nonmultiplexed mode and additionally Address 13 in A/D multiplexed mode | IO | H1 |
| gpmc_ad13 | GPMC Data 13 in A/D nonmultiplexed mode and additionally Address 14 in A/D multiplexed mode | IO | J3 |
| gpmc_ad14 | GPMC Data 14 in A/D nonmultiplexed mode and additionally Address 15 in A/D multiplexed mode | IO | H2 |
| gpmc_ad15 | GPMC Data 15 in A/D nonmultiplexed mode and additionally Address 16 in A/D multiplexed mode | IO | H3 |
| gpmc_a0 | GPMC Address 0. Only used to effectively address 8-bit data nonmultiplexed memories | O | R6 / P4 |
| gpmc_a1 | GPMC address 1 in A/D nonmultiplexed mode and Address 17 in A/D multiplexed mode | O | T9 / P1 |
| gpmc_a2 | GPMC address 2 in A/D nonmultiplexed mode and Address 18 in A/D multiplexed mode | O | T6 / N1 |
| gpmc_a3 | GPMC address 3 in A/D nonmultiplexed mode and Address 19 in A/D multiplexed mode | O | T7 / M4 |
| gpmc_a4 | GPMC address 4 in A/D nonmultiplexed mode and Address 20 in A/D multiplexed mode | O | P6 |
| gpmc_a5 | GPMC address 5 in A/D nonmultiplexed mode and Address 21 in A/D multiplexed mode | O | R9 |
| gpmc_a6 | GPMC address 6 in A/D nonmultiplexed mode and Address 22 in A/D multiplexed mode | O | R5 |
| gpmc_a7 | GPMC address 7 in A/D nonmultiplexed mode and Address 23 in A/D multiplexed mode | O | P5 |
| gpmc_a8 | GPMC address 8 in A/D nonmultiplexed mode and Address 24 in A/D multiplexed mode | O | N7 |
| gpmc_a9 | GPMC address 9 in A/D nonmultiplexed mode and Address 25 in A/D multiplexed mode | O | R4 |
| gpmc_a10 | GPMC address 10 in A/D nonmultiplexed mode and Address 26 in A/D multiplexed mode | O | N9 |
| gpmc_a11 | GPMC address 11 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | P9 |
| gpmc_a12 | GPMC address 12 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | P4 |
| gpmc_a13 | GPMC address 13 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | R3 / K7 / P2 |

Table 4-9. GPMC Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|----------------------------|---|------|----------------------------------|
| gpmc_a14 | GPMC address 14 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | T2 / M7 / P1 |
| gpmc_a15 | GPMC address 15 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | U2 / J5 / N2 |
| gpmc_a16 | GPMC address 16 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | U1 / K6 / R6 |
| gpmc_a17 | GPMC address 17 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | P3 / J7 / E1 |
| gpmc_a18 | GPMC address 18 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | R2 / J4 / H7 |
| gpmc_a19 | GPMC address 19 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | K7 ⁽³⁾ / J6 |
| gpmc_a20 | GPMC address 20 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | M7 ⁽³⁾ / H4 |
| gpmc_a21 | GPMC address 21 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | J5 ⁽³⁾ / H5 |
| gpmc_a22 | GPMC address 22 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | K6 ⁽³⁾ / H6 |
| gpmc_a23 | GPMC address 23 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | F6 / J7 / N1 / P2 |
| gpmc_a24 | GPMC address 24 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | D3 / J4 ⁽³⁾ / P1 |
| gpmc_a25 | GPMC address 25 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | E6 / J6 ⁽³⁾ / N2 |
| gpmc_a26 | GPMC address 26 in A/D nonmultiplexed mode and unused in A/D multiplexed mode | O | F5 / H4 ⁽³⁾ / R6 |
| gpmc_a27 | GPMC address 27 in A/D nonmultiplexed mode and Address 27 in A/D multiplexed mode | O | G1 / H5 ⁽³⁾ / E1 / H7 |
| gpmc_cs0 | GPMC Chip Select 0 (active low) | O | T1 |
| gpmc_cs1 | GPMC Chip Select 1 (active low) | O | H6 |
| gpmc_cs2 | GPMC Chip Select 2 (active low) | O | P2 |
| gpmc_cs3 | GPMC Chip Select 3 (active low) | O | P1 |
| gpmc_cs4 | GPMC Chip Select 4 (active low) | O | N6 |
| gpmc_cs5 | GPMC Chip Select 5 (active low) | O | M4 |
| gpmc_cs6 | GPMC Chip Select 6 (active low) | O | N1 |
| gpmc_cs7 | GPMC Chip Select 7 (active low) | O | P7 |
| gpmc_clk ⁽¹⁾⁽²⁾ | GPMC Clock output | IO | P7 |
| gpmc_advn_ale | GPMC address valid active low or address latch enable | O | N1 |
| gpmc_oen_ren | GPMC output enable active low or read enable | O | M5 |
| gpmc_wen | GPMC write enable active low | O | M3 |
| gpmc_ben0 | GPMC lower-byte enable active low | O | N6 |
| gpmc_ben1 | GPMC upper-byte enable active low | O | M4 |
| gpmc_wait0 | GPMC external indication of wait 0 | I | N2 |
| gpmc_wait1 | GPMC external indication of wait 1 | I | P7 / N1 |

- (1) This clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. Series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any nonmonotonicity in voltage that occurs at the pad loopback clock pin between V_{IH} and V_{IL} must be less than V_{HYS} .
- (2) The gpio6_16.clkout1 signal can be used as an "always-on" alternative to gpmc_clk provided that the external device can support the associated timing. See [Table 7-25, GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Default](#) and [Table 7-27, GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Alternate](#) for timing information.
- (3) The internal pull resistors for balls K7, M7, J5, K6, J4, J6, H4, H5 are permanently disabled when sysboot15 is set to 0 as described in the section Sysboot Configuration in the device TRM. If internal pull-up/down resistors are desired on these balls then sysboot15 should be set to 1. If gpmc boot mode is used with SYSBOOT15=0 (not recommended) then external pull-downs should be implemented to keep the address bus at logic-1 value during boot since the gpmc ms-address bits are high-z during boot.

4.4.7 Timers

NOTE

For more information, see *Timers* chapter in the device TRM.

Table 4-10. Timers Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|--------------------------------|------|------------|
| timer1 | PWM output/event trigger input | IO | M4 / E21 |
| timer2 | PWM output/event trigger input | IO | N6 / F20 |
| timer3 | PWM output/event trigger input | IO | N1 / F21 |
| timer4 | PWM output/event trigger input | IO | P7 / D12 |
| timer5 | PWM output/event trigger input | IO | U2 / B12 |
| timer6 | PWM output/event trigger input | IO | T2 / A11 |
| timer7 | PWM output/event trigger input | IO | R3 / B13 |
| timer8 | PWM output/event trigger input | IO | P4 / A12 |
| timer9 | PWM output/event trigger input | IO | P9 / E14 |
| timer10 | PWM output/event trigger input | IO | N9 / A13 |
| timer11 | PWM output/event trigger input | IO | R4 / G14 |
| timer12 | PWM output/event trigger input | IO | N7 / F14 |
| timer13 | PWM output/event trigger input | IO | D18 |
| timer14 | PWM output/event trigger input | IO | E17 |
| timer15 | PWM output/event trigger input | IO | AC10 / B26 |
| timer16 | PWM output/event trigger input | IO | AB10 / C23 |

4.4.8 Inter-Integrated Circuit Interface (I2C)

NOTE

For more information, see *Multimaster High Speed I2C Controller* section in the device TRM.

NOTE

I2C1 and I2C2 do not support HS-mode.

Table 4-11. I2C Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--|-------------|------|-------------------|
| Inter-Integrated Circuit Interface 1 (I2C1) | | | |
| i2c1_scl | I2C1 Clock | IOD | C20 |
| i2c1_sda | I2C1 Data | IOD | C21 |
| Inter-Integrated Circuit Interface 2 (I2C2) | | | |
| i2c2_scl | I2C2 Clock | IOD | F17 |
| i2c2_sda | I2C2 Data | IOD | C25 |
| Inter-Integrated Circuit Interface 3 (I2C3) | | | |
| i2c3_scl | I2C3 Clock | IOD | P7/ D14/ AB4/ F20 |
| i2c3_sda | I2C3 Data | IOD | N1/ C14/ AC5/ E21 |
| Inter-Integrated Circuit Interface 4 (I2C4) | | | |
| i2c4_scl | I2C4 Clock | IOD | R6/ J14/ A21/ Y9 |
| i2c4_sda | I2C4 Data | IOD | T9/ B14/ C18/ W7 |
| Inter-Integrated Circuit Interface 5 (I2C5) | | | |

Table 4-11. I2C Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--|-------------|------|--------------|
| i2c5_scl | I2C5 Clock | IOD | AB9/ P6/ F12 |
| i2c5_sda | I2C5 Data | IOD | AA3/ R9/ G12 |
| Inter-Integrated Circuit Interface 6 (I2C6) | | | |
| i2c6_scl ⁽¹⁾ | I2C6 Clock | IOD | G16 |
| i2c6_sda ⁽¹⁾ | I2C6 Data | IOD | D17 |

(1) I2C6 is not supported in TI standard software. I2C6 is not recommended for use to due to internal clock/reset dependencies on i2c1-5 and uart7.

4.4.9 HDQ / 1-Wire Interface (HDQ1W)

NOTE

For more information, see *HDQ/1-Wire* chapter in the device TRM.

Table 4-12. HDQ / 1-Wire Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|----------|
| hdq0 | HDQ or 1-wire protocol single interface pin | IOD | D18/ C23 |

4.4.10 Universal Asynchronous Receiver Transmitter (UART)

NOTE

For more information about UART booting, see *UART/IrDA/CIR* section in the device TRM.

Table 4-13. UART Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---|---|------|--------------------|
| Universal Asynchronous Receiver/Transmitter 1 (UART1) | | | |
| uart1_dcdn | UART1 Data Carrier Detect active low | I | D28 |
| uart1_dsrn | UART1 Data Set Ready Active Low | I | D26 |
| uart1_dtrn | UART1 Data Terminal Ready Active Low | O | D27 |
| uart1_rin | UART1 Ring Indicator | I | C28 |
| uart1_rxd | UART1 Receive Data | I | B27 |
| uart1_txd | UART1 Transmit Data | O | C26 |
| uart1_ctsn | UART1 Clear to Send Active Low | I | E25 |
| uart1_rtsn | UART1 Request to Send Active Low | O | C27 |
| Universal Asynchronous Receiver/Transmitter 2 (UART2) | | | |
| uart2_rxd | UART2 Receive Data | I | D28 |
| uart2_txd | UART2 Transmit Data | O | D26 |
| uart2_ctsn | UART2 Clear to Send Active Low | I | D27 |
| uart2_rtsn | UART2 Request to Send Active Low | O | C28 |
| Universal Asynchronous Receiver/Transmitter 3 (UART3)/IrDA | | | |
| uart3_rxd | UART3 Receive Data | I | V2/ AB3/ A26 / D27 |
| uart3_txd | UART3 Transmit Data | O | Y1/ AA4/ B22/ C28 |
| uart3_ctsn | UART3 Clear to Send Active Low | I | U4/ W9/ G17/ D28 |
| uart3_rtsn | UART3 Request to Send Active Low | O | V1/ V9/ D26/ B24 |
| uart3_rctx | Remote control data | O | D28 |
| uart3_sd | Infrared transceiver configure/shutdown | O | D26 |

Table 4-13. UART Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--|---|------|---------------------------|
| uart3_irrx | Infrared data input. Also functions as uart3_rxd Receive Data Input when IrDA mode is not used. | I | D27 |
| uart3_irtx | Infrared data output | O | C28 |
| Universal Asynchronous Receiver/Transmitter 4 (UART4) | | | |
| uart4_rxd | UART4 Receive Data | I | V7/ G16/ B21 |
| uart4_txd | UART4 Transmit Data | O | U7/ D17/ B20 |
| uart4_ctsn | UART4 Clear to Send Active Low | I | V6 |
| uart4_rtsn | UART4 Request to Send Active Low | O | U6 |
| Universal Asynchronous Receiver/Transmitter 5 (UART5) | | | |
| uart5_rxd | UART5 Receive Data | I | R6/ F11/ B19/ AC7/ G17 |
| uart5_txd | UART5 Transmit Data | O | T9/ G10/ C17/ AC6/ B24 |
| uart5_ctsn | UART5 Clear to Send Active Low | I | T6 / AC9 |
| uart5_rtsn | UART5 Request to Send Active Low | O | T7 / AC3 |
| Universal Asynchronous Receiver/Transmitter 6 (UART6) | | | |
| uart6_rxd | UART6 Receive Data | I | P6/ E8/ G12/ W7 |
| uart6_txd | UART6 Transmit Data | O | R9/ D9/ F12/ Y9 |
| uart6_ctsn | UART6 Clear to Send Active Low | I | R5 / G13 |
| uart6_rtsn | UART6 Request to Send Active Low | O | P5 / J11 |
| Universal Asynchronous Receiver/Transmitter 7 (UART7) | | | |
| uart7_rxd | UART7 Receive Data | I | B18 / B7 / T6 |
| uart7_txd | UART7 Transmit Data | O | B8 / F15 / T7 |
| uart7_ctsn | UART7 Clear to Send Active Low | I | B19 |
| uart7_rtsn | UART7 Request to Send Active Low | O | C17 |
| Universal Asynchronous Receiver/Transmitter 8 (UART8) | | | |
| uart8_rxd | UART8 Receive Data | I | C18 / G20 / R5 |
| uart8_txd | UART8 Transmit Data | O | A21 / G19 / P5 |
| uart8_ctsn | UART8 Clear to Send Active Low | I | G16 |
| uart8_rtsn | UART8 Request to Send Active Low | O | D17 |
| Universal Asynchronous Receiver/Transmitter 9 (UART9) | | | |
| uart9_rxd | UART9 Receive Data | I | G1/ AA3/ E25 |
| uart9_txd | UART9 Transmit Data | O | G6/ AB9/ C27 |
| uart9_ctsn | UART9 Clear to Send Active Low | I | F2 / AB3 |
| uart9_rtsn | UART9 Request to Send Active Low | O | F3/ AA4 |
| Universal Asynchronous Receiver/Transmitter 10 (UART10) | | | |
| uart10_rxd | UART10 Receive Data | I | D1/ E21/ AC8/ D27 |
| uart10_txd | UART10 Transmit Data | O | E2/ F20/ AD6/ C28 |
| uart10_ctsn | UART10 Clear to Send Active Low | I | D2 / AB8 |
| uart10_rtsn | UART10 Request to Send Active Low | O | F4 / AB5 |

4.4.11 Multichannel Serial Peripheral Interface (McSPI)

CAUTION

The I/O timings provided in [Section 7, Timing Requirements and Switching Characteristics](#) are applicable for all combinations of signals for SPI1 and SPI2. However, the timings are valid only for SPI3 and SPI4 if signals within a single IOSET are used. The IOSETS are defined in [Table 7-44](#).

NOTE

For more information, see *Multichannel Serial Peripheral Interface* section in the device TRM.

Table 4-14. SPI Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--------------------------------------|--|------|----------------------------|
| Serial Peripheral Interface 1 | | | |
| spi1_sclk ⁽¹⁾ | SPI1 Clock | IO | A25 |
| spi1_d1 | SPI1 Data. Can be configured as either MISO or MOSI. | IO | F16 |
| spi1_d0 | SPI1 Data. Can be configured as either MISO or MOSI. | IO | B25 |
| spi1_cs0 | SPI1 Chip Select | IO | A24 |
| spi1_cs1 | SPI1 Chip Select | IO | A22 |
| spi1_cs2 | SPI1 Chip Select | IO | B21 |
| spi1_cs3 | SPI1 Chip Select | IO | B20 |
| Serial Peripheral Interface 2 | | | |
| spi2_sclk ⁽¹⁾ | SPI2 Clock | IO | A26 |
| spi2_d1 | SPI2 Data. Can be configured as either MISO or MOSI. | IO | B22 |
| spi2_d0 | SPI2 Data. Can be configured as either MISO or MOSI. | IO | G17 |
| spi2_cs0 | SPI2 Chip Select | IO | B24 |
| spi2_cs1 | SPI2 Chip Select | IO | A22 |
| spi2_cs2 | SPI2 Chip Select | IO | B21 |
| spi2_cs3 | SPI2 Chip Select | IO | B20 |
| Serial Peripheral Interface 3 | | | |
| spi3_sclk ⁽¹⁾ | SPI3 Clock | IO | AC4 / B12 / C18 / E11 / V2 |
| spi3_d1 | SPI3 Data. Can be configured as either MISO or MOSI. | IO | A11 / A21 / AC7 / B10 / Y1 |
| spi3_d0 | SPI3 Data. Can be configured as either MISO or MOSI. | IO | AC6 / B13 / C11 / G16 / W9 |
| spi3_cs0 | SPI3 Chip Select | IO | A12 / AC9 / D11 / D17 / V9 |
| spi3_cs1 | SPI3 Chip Select | IO | AC3 / B11 / E14 |
| spi3_cs2 | SPI3 Chip Select | IO | F11 |
| spi3_cs3 | SPI3 Chip Select | IO | A10 |
| Serial Peripheral Interface 4 | | | |
| spi4_sclk ⁽¹⁾ | SPI4 Clock | IO | N7/ G1/ AA3/ V7/ AC8 |
| spi4_d1 | SPI4 Data. Can be configured as either MISO or MOSI. | IO | R4/ G6/ AB9/ U7/ AD6 |
| spi4_d0 | SPI4 Data. Can be configured as either MISO or MOSI. | IO | N9/ F2/ AB3/ V6/ AB8 |

Table 4-14. SPI Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|------------------|------|-------------------------|
| spi4_cs0 | SPI4 Chip Select | IO | P9/ F3/ AA4/ U6/ AB5 |
| spi4_cs1 | SPI4 Chip Select | IO | P4 / Y1 |
| spi4_cs2 | SPI4 Chip Select | IO | R3 / W9 |
| spi4_cs3 | SPI4 Chip Select | IO | T2 / V9 |

(1) This clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. Series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any nonmonotonicity in voltage that occurs at the pad loopback clock pin between V_{IH} and V_{IL} must be less than V_{HYS} .

4.4.12 Quad Serial Peripheral Interface (QSPI)

NOTE

For more information, see *Quad Serial Peripheral Interface* section in the device TRM.

Table 4-15. QSPI Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|------|
| qspi1_sclk | QSPI1 Serial Clock | IO | R2 |
| qspi1_rtclk | QSPI1 Return Clock Input. Must be connected from QSPI1_SCLK on PCB. Refer to PCB Guidelines for QSPI1 | I | R3 |
| qspi1_d0 | QSPI1 Data[0]. This pin is output data for all commands/writes and for dual read and quad read modes it becomes input data pin during read phase. | IO | U1 |
| qspi1_d1 | QSPI1 Data[1]. Input read data in all modes. | IO | P3 |
| qspi1_d2 | QSPI1 Data[2]. This pin is used only in quad read mode as input data pin during read phase | IO | U2 |
| qspi1_d3 | QSPI1 Data[3]. This pin is used only in quad read mode as input data pin during read phase | IO | T2 |
| qspi1_cs0 | QSPI1 Chip Select[0]. This pin is Used for QSPI1 boot modes. | IO | P2 |
| qspi1_cs1 | QSPI1 Chip Select[1] | O | P1 |
| qspi1_cs2 | QSPI1 Chip Select[2] | O | T7 |
| qspi1_cs3 | QSPI1 Chip Select[3] | O | P6 |

4.4.13 Multichannel Audio Serial Port (McASP)

NOTE

For more information, see *Multichannel Audio Serial Port* section in the device TRM.

Table 4-16. McASP Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---|------------------------------|------|-----------|
| Multichannel Audio Serial Port 1 | | | |
| mcasp1_axr0 | McASP1 Transmit/Receive Data | IO | G12 |
| mcasp1_axr1 | McASP1 Transmit/Receive Data | IO | F12 |
| mcasp1_axr2 | McASP1 Transmit/Receive Data | IO | G13 |
| mcasp1_axr3 | McASP1 Transmit/Receive Data | IO | J11 |
| mcasp1_axr4 | McASP1 Transmit/Receive Data | IO | D18/ E12 |
| mcasp1_axr5 | McASP1 Transmit/Receive Data | IO | E17 / F13 |
| mcasp1_axr6 | McASP1 Transmit/Receive Data | IO | B26 / C12 |
| mcasp1_axr7 | McASP1 Transmit/Receive Data | IO | C23 / D12 |
| mcasp1_axr8 | McASP1 Transmit/Receive Data | IO | E21 / B12 |

Table 4-16. McASP Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---|---|------|-----------|
| mcasp1_axr9 | McASP1 Transmit/Receive Data | IO | F20/ A11 |
| mcasp1_axr10 | McASP1 Transmit/Receive Data | IO | F21 / B13 |
| mcasp1_axr11 | McASP1 Transmit/Receive Data | IO | A12 |
| mcasp1_axr12 | McASP1 Transmit/Receive Data | IO | E14 |
| mcasp1_axr13 | McASP1 Transmit/Receive Data | IO | A13 |
| mcasp1_axr14 | McASP1 Transmit/Receive Data | IO | G14 |
| mcasp1_axr15 | McASP1 Transmit/Receive Data | IO | F14 |
| mcasp1_fsx | McASP1 Transmit Frame Sync | IO | D14 |
| mcasp1_aclkr ⁽¹⁾ | McASP1 Receive Bit Clock | IO | B14 |
| mcasp1_fsr | McASP1 Receive Frame Sync | IO | J14 |
| mcasp1_ahclkx | McASP1 Transmit High-Frequency Master Clock | O | D18 |
| mcasp1_aclkx ⁽¹⁾ | McASP1 Transmit Bit Clock | IO | C14 |
| Multichannel Audio Serial Port 2 | | | |
| mcasp2_axr0 | McASP2 Transmit/Receive Data | IO | B15 |
| mcasp2_axr1 | McASP2 Transmit/Receive Data | IO | A15 |
| mcasp2_axr2 | McASP2 Transmit/Receive Data | IO | C15 |
| mcasp2_axr3 | McASP2 Transmit/Receive Data | IO | A16 |
| mcasp2_axr4 | McASP2 Transmit/Receive Data | IO | D15 |
| mcasp2_axr5 | McASP2 Transmit/Receive Data | IO | B16 |
| mcasp2_axr6 | McASP2 Transmit/Receive Data | IO | B17 |
| mcasp2_axr7 | McASP2 Transmit/Receive Data | IO | A17 |
| mcasp2_axr8 | McASP2 Transmit/Receive Data | IO | D18 |
| mcasp2_axr9 | McASP2 Transmit/Receive Data | IO | E17 |
| mcasp2_axr10 | McASP2 Transmit/Receive Data | IO | B26 |
| mcasp2_axr11 | McASP2 Transmit/Receive Data | IO | C23 |
| mcasp2_axr12 | McASP2 Transmit/Receive Data | IO | B18 |
| mcasp2_axr13 | McASP2 Transmit/Receive Data | IO | F15 |
| mcasp2_axr14 | McASP2 Transmit/Receive Data | IO | B19 |
| mcasp2_axr15 | McASP2 Transmit/Receive Data | IO | C17 |
| mcasp2_fsx | McASP2 Transmit Frame Sync | IO | A18 |
| mcasp2_aclkr ⁽¹⁾ | McASP2 Receive Bit Clock | IO | E15 |
| mcasp2_fsr | McASP2 Receive Frame Sync | IO | A20 |
| mcasp2_ahclkx | McASP2 Transmit High-Frequency Master Clock | O | E17 |
| mcasp2_aclkx ⁽¹⁾ | McASP2 Transmit Bit Clock | IO | A19 |
| Multichannel Audio Serial Port 3 | | | |
| mcasp3_axr0 | McASP3 Transmit/Receive Data | IO | B19 |
| mcasp3_axr1 | McASP3 Transmit/Receive Data | IO | C17 |
| mcasp3_axr2 | McASP3 Transmit/Receive Data | IO | C15 |
| mcasp3_axr3 | McASP3 Transmit/Receive Data | IO | A16 |
| mcasp3_fsx | McASP3 Transmit Frame Sync | IO | F15 |
| mcasp3_ahclkx | McASP3 Transmit High-Frequency Master Clock | O | B26 |
| mcasp3_aclkx ⁽¹⁾ | McASP3 Transmit Bit Clock | IO | B18 |
| mcasp3_aclkr ⁽¹⁾ | McASP3 Receive Bit Clock | IO | B18 |
| mcasp3_fsr | McASP3 Receive Frame Sync | IO | F15 |
| Multichannel Audio Serial Port 4 | | | |
| mcasp4_axr0 | McASP4 Transmit/Receive Data | IO | G16 |
| mcasp4_axr1 | McASP4 Transmit/Receive Data | IO | D17 |

Table 4-16. McASP Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---|---|------|------|
| mcasp4_axr2 | McASP4 Transmit/Receive Data | IO | E12 |
| mcasp4_axr3 | McASP4 Transmit/Receive Data | IO | F13 |
| mcasp4_fsx | McASP4 Transmit Frame Sync | IO | A21 |
| mcasp4_ahclkx | McASP4 Transmit High-Frequency Master Clock | O | C23 |
| mcasp4_aclkx ⁽¹⁾ | McASP4 Transmit Bit Clock | IO | C18 |
| mcasp4_aclkr ⁽¹⁾ | McASP4 Receive Bit Clock | IO | C18 |
| mcasp4_fsr | McASP4 Receive Frame Sync | IO | A21 |
| Multichannel Audio Serial Port 5 | | | |
| mcasp5_axr0 | McASP5 Transmit/Receive Data | IO | AB3 |
| mcasp5_axr1 | McASP5 Transmit/Receive Data | IO | AA4 |
| mcasp5_axr2 | McASP5 Transmit/Receive Data | IO | C12 |
| mcasp5_axr3 | McASP5 Transmit/Receive Data | IO | D12 |
| mcasp5_fsx | McASP5 Transmit Frame Sync | IO | AB9 |
| mcasp5_ahclkx | McASP5 Transmit High-Frequency Master Clock | O | D18 |
| mcasp5_aclkx ⁽¹⁾ | McASP5 Transmit Bit Clock | IO | AA3 |
| mcasp5_aclkr ⁽¹⁾ | McASP5 Receive Bit Clock | IO | AA3 |
| mcasp5_fsr | McASP5 Receive Frame Sync | IO | AB9 |
| Multichannel Audio Serial Port 6 | | | |
| mcasp6_axr0 | McASP6 Transmit/Receive Data | IO | B12 |
| mcasp6_axr1 | McASP6 Transmit/Receive Data | IO | A11 |
| mcasp6_axr2 | McASP6 Transmit/Receive Data | IO | G13 |
| mcasp6_axr3 | McASP6 Transmit/Receive Data | IO | J11 |
| mcasp6_ahclkx | McASP6 Transmit High-Frequency Master Clock | O | E17 |
| mcasp6_aclkx ⁽¹⁾ | McASP6 Transmit Bit Clock | IO | B13 |
| mcasp6_fsx | McASP6 Transmit Frame Sync | IO | A12 |
| mcasp6_aclkr ⁽¹⁾ | McASP6 Receive Bit Clock | IO | B13 |
| mcasp6_fsr | McASP6 Receive Frame Sync | IO | A12 |
| Multichannel Audio Serial Port 7 | | | |
| mcasp7_axr0 | McASP7 Transmit/Receive Data | IO | E14 |
| mcasp7_axr1 | McASP7 Transmit/Receive Data | IO | A13 |
| mcasp7_axr2 | McASP7 Transmit/Receive Data | IO | B14 |
| mcasp7_axr3 | McASP7 Transmit/Receive Data | IO | J14 |
| mcasp7_ahclkx | McASP7 Transmit High-Frequency Master Clock | O | B26 |
| mcasp7_aclkx ⁽¹⁾ | McASP7 Transmit Bit Clock | IO | G14 |
| mcasp7_fsx | McASP7 Transmit Frame Sync | IO | F14 |
| mcasp7_aclkr ⁽¹⁾ | McASP7 Receive Bit Clock | IO | G14 |
| mcasp7_fsr | McASP7 Receive Frame Sync | IO | F14 |
| Multichannel Audio Serial Port 8 | | | |
| mcasp8_axr0 | McASP8 Transmit/Receive Data | IO | D15 |
| mcasp8_axr1 | McASP8 Transmit/Receive Data | IO | B16 |
| mcasp8_axr2 | McASP8 Transmit/Receive Data | IO | E15 |
| mcasp8_axr3 | McASP8 Transmit/Receive Data | IO | A20 |
| mcasp8_ahclkx | McASP8 Transmit High-Frequency Master Clock | O | C23 |
| mcasp8_aclkx ⁽¹⁾ | McASP8 Transmit Bit Clock | IO | B17 |
| mcasp8_fsx | McASP8 Transmit Frame Sync | IO | A17 |
| mcasp8_aclkr ⁽¹⁾ | McASP8 Receive Bit Clock | IO | B17 |
| mcasp8_fsr | McASP8 Receive Frame Sync | IO | A17 |

- (1) This clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. Series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any nonmonotonicity in voltage that occurs at the pad loopback clock pin between V_{IH} and V_{IL} must be less than V_{HYS} .

4.4.14 Universal Serial Bus (USB)

NOTE

For more information, see *SuperSpeed USB DRD* section in the device TRM.

Table 4-17. Universal Serial Bus Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------------------------|---|------|----------|
| Universal Serial Bus 1 | | | |
| usb1_dp | USB1 USB2.0 differential signal pair (positive) | IODS | AD12 |
| usb1_dm | USB1 USB2.0 differential signal pair (negative) | IODS | AC12 |
| usb1_drvvbus | USB1 Drive VBUS signal | O | AB10 |
| usb_rxn0 ⁽¹⁾ | USB1 USB3.0 receiver negative lane | IDS | AF12 |
| usb_rxp0 ⁽¹⁾ | USB1 USB3.0 receiver positive lane | IDS | AE12 |
| usb_txn0 ⁽¹⁾ | USB1 USB3.0 transmitter negative lane | ODS | AC11 |
| usb_txp0 ⁽¹⁾ | USB1 USB3.0 transmitter positive lane | ODS | AD11 |
| Universal Serial Bus 2 | | | |
| usb2_dp | USB2 USB2.0 differential signal pair (positive) | IO | AE11 |
| usb2_dm | USB2 USB2.0 differential signal pair (negative) | IO | AF11 |
| usb2_drvvbus | USB2 Drive VBUS signal | O | AC10 |
| Universal Serial Bus 3 | | | |
| usb3_ulpi_d0 | USB3 - ULPI 8-bit data bus | IODS | AC3 / V6 |
| usb3_ulpi_d1 | USB3 - ULPI 8-bit data bus | IODS | AC9 / U6 |
| usb3_ulpi_d2 | USB3 - ULPI 8-bit data bus | IO | AC6 / U5 |
| usb3_ulpi_d3 | USB3 - ULPI 8-bit data bus | IO | AC7 / V5 |
| usb3_ulpi_d4 | USB3 - ULPI 8-bit data bus | IO | AC4 / V4 |
| usb3_ulpi_d5 | USB3 - ULPI 8-bit data bus | IO | AD4 / V3 |
| usb3_ulpi_d6 | USB3 - ULPI 8-bit data bus | IO | AB4 / Y2 |
| usb3_ulpi_d7 | USB3 - ULPI 8-bit data bus | IO | AC5 / W2 |
| usb3_ulpi_nxt | USB3 - ULPI next | I | AC8 / U7 |
| usb3_ulpi_dir | USB3 - ULPI bus direction | I | AD6 / V7 |
| usb3_ulpi_stp | USB3 - ULPI stop | O | AB8 / V9 |
| usb3_ulpi_clk | USB3 - ULPI functional clock | I | AB5 / W9 |

- (1) Signals are enabled by selecting the correct field in the PCIE_B1C0_MODE_SEL register. There are no CTRL_CORE_PAD* register involved.

4.4.15 SATA

NOTE

For more information, see *SATA Controller* section in the device TRM.

Table 4-18. SATA Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|------|
| sata1_rxn0 | SATA differential negative receiver lane 0 | IDS | AH9 |
| sata1_rxp0 | SATA differential positive receiver lane 0 | IDS | AG9 |
| sata1_txn0 | SATA differential negative transmitter lane 0 | ODS | AG10 |

Table 4-18. SATA Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|-----------|
| sata1_txp0 | SATA differential positive transmitter lane 0 | ODS | AH10 |
| sata1_led | SATA channel activity indicator | O | A22 / G19 |

4.4.16 Peripheral Component Interconnect Express (PCIe)

NOTE

For more information, see *PCIe Controller* sections in the device TRM.

Table 4-19. PCIe Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|--|------|------|
| pcie_rxn0 | PCIe1_PHY_RX Receive Data Lane 0 (negative) - mapped to PCIe_SS1 only. | IDS | AG13 |
| pcie_rxp0 | PCIe1_PHY_RX Receive Data Lane 0 (positive) - mapped to PCIe_SS1 only. | IDS | AH13 |
| pcie_txn0 | PCIe1_PHY_TX Transmit Data Lane 0 (negative) - mapped to PCIe_SS1 only. | ODS | AG14 |
| pcie_txp0 | PCIe1_PHY_TX Transmit Data Lane 0 (positive) - mapped to PCIe_SS1 only. | ODS | AH14 |
| pcie_rxn1 | PCIe2_PHY_RX Receive Data Lane 1 (negative) - mapped to either PCIe_SS1 (dual lane- mode) or PCIe_SS2 (single lane- mode) | IDS | AF12 |
| pcie_rxp1 | PCIe2_PHY_RX Receive Data Lane 1 (positive) - mapped to either PCIe_SS1 (dual lane- mode) or PCIe_SS2 (single lane- mode) | IDS | AE12 |
| pcie_txn1 | PCIe2_PHY_TX Transmit Data Lane 1 (negative) - mapped to either PCIe_SS1 (dual lane- mode) or PCIe_SS2 (single lane- mode) | ODS | AC11 |
| pcie_txp1 | PCIe2_PHY_TX Transmit Data Lane 1 (positive) - mapped to either PCIe_SS1 (dual lane- mode) or PCIe_SS2 (single lane- mode) | ODS | AD11 |
| ljcb_clkp | PCIe1_PHY / PCIe2_PHY shared Reference Clock Input / Output Differential Pair (positive) | IODS | AG15 |
| ljcb_clkn | PCIe1_PHY / PCIe2_PHY shared Reference Clock Input / Output Differential Pair (negative) | IODS | AH15 |

4.4.17 Controller Area Network Interface (DCAN)

NOTE

For more information, see *DCAN* section in the device TRM.

Table 4-20. DCAN Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------|-------------------------|------|----------------|
| DCAN 1 | | | |
| dcan1_tx | DCAN1 transmit data pin | IO | G20 |
| dcan1_rx | DCAN1 receive data pin | IO | G19 / AD17 |
| DCAN 2 | | | |
| dcan2_tx | DCAN2 transmit data pin | IO | E21/ B21 |
| dcan2_rx | DCAN2 receive data pin | IO | F20/ B20/ AC16 |

4.4.18 Ethernet Interface (GMAC_SW)

CAUTION

The I/O timings provided in [Section 7, Timing Requirements and Switching Characteristics](#) are valid only if signals within a single IOSET are used. The IOSETs are defined in [Table 7-74](#), [Table 7-77](#), [Table 7-82](#) and [Table 7-89](#).

NOTE

For more information, see *Gigabit Ethernet Switch (GMAC_SW)* section in the device TRM.

Table 4-21. GMAC Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--------------|-------------------------|------|------|
| rgmii0_txc | RGMIIO Transmit Clock | O | W9 |
| rgmii0_txctl | RGMIIO Transmit Enable | O | V9 |
| rgmii0_txd3 | RGMIIO Transmit Data | O | V7 |
| rgmii0_txd2 | RGMIIO Transmit Data | O | U7 |
| rgmii0_txd1 | RGMIIO Transmit Data | O | V6 |
| rgmii0_txd0 | RGMIIO Transmit Data | O | U6 |
| rgmii0_rxc | RGMIIO Receive Clock | I | U5 |
| rgmii0_rxctl | RGMIIO Receive Control | I | V5 |
| rgmii0_rxd3 | RGMIIO Receive Data | I | V4 |
| rgmii0_rxd2 | RGMIIO Receive Data | I | V3 |
| rgmii0_rxd1 | RGMIIO Receive Data | I | Y2 |
| rgmii0_rxd0 | RGMIIO Receive Data | I | W2 |
| rgmii1_txc | RGMIIO Transmit Clock | O | D5 |
| rgmii1_txctl | RGMIIO Transmit Enable | O | C2 |
| rgmii1_txd3 | RGMIIO Transmit Data | O | C3 |
| rgmii1_txd2 | RGMIIO Transmit Data | O | C4 |
| rgmii1_txd1 | RGMIIO Transmit Data | O | B2 |
| rgmii1_txd0 | RGMIIO Transmit Data | O | D6 |
| rgmii1_rxc | RGMIIO Receive Clock | I | C5 |
| rgmii1_rxctl | RGMIIO Receive Control | I | A3 |
| rgmii1_rxd3 | RGMIIO Receive Data | I | B3 |
| rgmii1_rxd2 | RGMIIO Receive Data | I | B4 |
| rgmii1_rxd1 | RGMIIO Receive Data | I | B5 |
| rgmii1_rxd0 | RGMIIO Receive Data | I | A4 |
| mii1_rxd1 | MII1 Receive Data | I | C1 |
| mii1_rxd2 | MII1 Receive Data | I | E4 |
| mii1_rxd3 | MII1 Receive Data | I | F5 |
| mii1_rxd0 | MII1 Receive Data | I | E6 |
| mii1_rxclk | MII1 Receive Clock | I | D5 |
| mii1_rxdv | MII1 Receive Data Valid | I | C2 |
| mii1_txclk | MII1 Transmit Clock | I | C3 |
| mii1_txd0 | MII1 Transmit Data | O | C4 |
| mii1_txd1 | MII1 Transmit Data | O | B2 |
| mii1_txd2 | MII1 Transmit Data | O | D6 |
| mii1_txd3 | MII1 Transmit Data | O | C5 |

Table 4-21. GMAC Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|-------------------------------|------|---------------------|
| mii1_txer | MII1 Transmit Error | I | A3 |
| mii1_rxer | MII1 Receive Data Error | I | B3 |
| mii1_col | MII1 Collision Detect (Sense) | I | B4 |
| mii1_crs | MII1 Carrier Sense | I | B5 |
| mii1_txen | MII1 Transmit Data Enable | O | A4 |
| mii0_rxd1 | MII0 Receive Data | I | V6 |
| mii0_rxd2 | MII0 Receive Data | I | V9 |
| mii0_rxd3 | MII0 Receive Data | I | W9 |
| mii0_rxd0 | MII0 Receive Data | I | U6 |
| mii0_rxclk | MII0 Receive Clock | I | Y1 |
| mii0_rxdv | MII0 Receive Data Valid | I | V2 |
| mii0_txclk | MII0 Transmit Clock | I | U5 |
| mii0_txd0 | MII0 Transmit Data | O | W2 |
| mii0_txd1 | MII0 Transmit Data | O | Y2 |
| mii0_txd2 | MII0 Transmit Data | O | V4 |
| mii0_txd3 | MII0 Transmit Data | O | V5 |
| mii0_txer | MII0 Transmit Error | I | U4 |
| mii0_rxer | MII0 Receive Data Error | I | U7 |
| mii0_col | MII0 Collision Detect (Sense) | I | V1 |
| mii0_crs | MII0 Carrier Sense | I | V7 |
| mii0_txen | MII0 Transmit Data Enable | O | V3 |
| rmii1_crs | RMII1 Carrier Sense | I | V2 |
| rmii1_rxer | RMII1 Receive Data Error | I | Y1 |
| rmii1_rxd1 | RMII1 Receive Data | I | W9 |
| rmii1_rxd0 | RMII1 Receive Data | I | V9 |
| rmii1_txen | RMII1 Transmit Data Enable | O | U5 |
| rmii1_txd1 | RMII1 Transmit Data | O | V5 |
| rmii1_txd0 | RMII1 Transmit Data | O | V4 |
| rmii0_crs | RMII0 Carrier Sense | I | V7 |
| rmii0_rxer | RMII0 Receive Data Error | I | U7 |
| rmii0_rxd1 | RMII0 Receive Data | I | V6 |
| rmii0_rxd0 | RMII0 Receive Data | I | U6 |
| rmii0_txen | RMII0 Transmit Data Enable | O | V3 |
| rmii0_txd1 | RMII0 Transmit Data | O | Y2 |
| rmii0_txd0 | RMII0 Transmit Data | O | W2 |
| mdio_mclk | Management Data Serial Clock | O | AC5 / V1 / B21 / D3 |
| mdio_d | Management Data | IO | AB4 / U4 / B20 / F6 |

4.4.19 Media Local Bus (MLB) Interface

NOTE

FMLB in 6-pin mode may require pull ups/ downs on SIG and DAT bus signals.

For additional details, please consult the MLB bus interface specification.

NOTE

For more information, see *Media Local Bus (MLB)* section in the device TRM.

Table 4-22. MLB Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|------|
| mlb_sig | Media Local Bus (MLB) Subsystem signal | IO | AB3 |
| mlb_dat | Media Local Bus (MLB) Subsystem data | IO | AA4 |
| mlb_clk | Media Local Bus (MLB) Subsystem clock | I | AA3 |
| mlbp_sig_p | Media Local Bus (MLB) Subsystem signal differential pair (positive) | IODS | AC1 |
| mlbp_sig_n | Media Local Bus (MLB) Subsystem signal differential pair (negative) | IODS | AC2 |
| mlbp_dat_p | Media Local Bus (MLB) Subsystem data differential pair (positive) | IODS | AA1 |
| mlbp_dat_n | Media Local Bus (MLB) Subsystem data differential pair (negative) | IODS | AA2 |
| mlbp_clk_p | Media Local Bus (MLB) Subsystem clock differential pair (positive) | IDS | AB1 |
| mlbp_clk_n | Media Local Bus (MLB) Subsystem clock differential pair (negative) | IDS | AB2 |

4.4.20 eMMC/SD/SDIO

NOTE

For more information, see eMMC/SD/SDIO chapter of the device TRM.

Table 4-23. eMMC/SD/SDIO Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------------------|--------------------|------|------|
| Multi Media Card 1 | | | |
| mmc1_clk ⁽¹⁾ | MMC1 clock | IO | W6 |
| mmc1_cmd | MMC1 command | IO | Y6 |
| mmc1_sdcd | MMC1 Card Detect | I | W7 |
| mmc1_sdwp | MMC1 Write Protect | I | Y9 |
| mmc1_dat0 | MMC1 data bit 0 | IO | AA6 |
| mmc1_dat1 | MMC1 data bit 1 | IO | Y4 |
| mmc1_dat2 | MMC1 data bit 2 | IO | AA5 |
| mmc1_dat3 | MMC1 data bit 3 | IO | Y3 |
| Multi Media Card 2 | | | |
| mmc2_clk ⁽¹⁾ | MMC2 clock | IO | J7 |
| mmc2_cmd | MMC2 command | IO | H6 |
| mmc2_sdcd | MMC2 Card Detect | I | G20 |
| mmc2_sdwp | MMC2 Write Protect | I | G19 |
| mmc2_dat0 | MMC2 data bit 0 | IO | J4 |
| mmc2_dat1 | MMC2 data bit 1 | IO | J6 |
| mmc2_dat2 | MMC2 data bit 2 | IO | H4 |
| mmc2_dat3 | MMC2 data bit 3 | IO | H5 |
| mmc2_dat4 | MMC2 data bit 4 | IO | K7 |
| mmc2_dat5 | MMC2 data bit 5 | IO | M7 |
| mmc2_dat6 | MMC2 data bit 6 | IO | J5 |
| mmc2_dat7 | MMC2 data bit 7 | IO | K6 |
| Multi Media Card 3 | | | |
| mmc3_clk ⁽¹⁾ | MMC3 clock | IO | AD4 |
| mmc3_cmd | MMC3 command | IO | AC4 |
| mmc3_sdcd | MMC3 Card Detect | I | B21 |
| mmc3_sdwp | MMC3 Write Protect | I | B20 |
| mmc3_dat0 | MMC3 data bit 0 | IO | AC7 |
| mmc3_dat1 | MMC3 data bit 1 | IO | AC6 |

Table 4-23. eMMC/SD/SDIO Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------------------|--------------------|------|------|
| mmc3_dat2 | MMC3 data bit 2 | IO | AC9 |
| mmc3_dat3 | MMC3 data bit 3 | IO | AC3 |
| mmc3_dat4 | MMC3 data bit 4 | IO | AC8 |
| mmc3_dat5 | MMC3 data bit 5 | IO | AD6 |
| mmc3_dat6 | MMC3 data bit 6 | IO | AB8 |
| mmc3_dat7 | MMC3 data bit 7 | IO | AB5 |
| Multi Media Card 4 | | | |
| mmc4_clk ⁽¹⁾ | MMC4 clock | IO | E25 |
| mmc4_cmd | MMC4 command | IO | C27 |
| mmc4_sdc | MMC4 Card Detect | I | B27 |
| mmc4_sdp | MMC4 Write Protect | I | C26 |
| mmc4_dat0 | MMC4 data bit 0 | IO | D28 |
| mmc4_dat1 | MMC4 data bit 1 | IO | D26 |
| mmc4_dat2 | MMC4 data bit 2 | IO | D27 |
| mmc4_dat3 | MMC4 data bit 3 | IO | C28 |

(1) By default, this clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. mmc1_clk and mmc2_clk have an optional software programmable setting to use an 'internal loopback clock' instead of the default 'pad loopback clock'. If the 'pad loopback clock' is used, series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any nonmonotonicity in voltage that occurs at the pad loopback clock pin between V_{IH} and V_{IL} must be less than V_{HYS} .

4.4.21 General-Purpose Interface (GPIO)

NOTE

For more information, see *General-Purpose Interface* chapter in the device TRM.

Table 4-24. GPIOs Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------|------------------------------|------|------|
| GPIO 1 | | | |
| gpio1_0 | General-Purpose Input | I | AD17 |
| gpio1_3 | General-Purpose Input | I | AC16 |
| gpio1_4 | General-Purpose Input/Output | IO | D15 |
| gpio1_5 | General-Purpose Input/Output | IO | A17 |
| gpio1_6 | General-Purpose Input/Output | IO | M6 |
| gpio1_7 | General-Purpose Input/Output | IO | M2 |
| gpio1_8 | General-Purpose Input/Output | IO | L5 |
| gpio1_9 | General-Purpose Input/Output | IO | M1 |
| gpio1_10 | General-Purpose Input/Output | IO | L6 |
| gpio1_11 | General-Purpose Input/Output | IO | L4 |
| gpio1_12 | General-Purpose Input/Output | IO | L3 |
| gpio1_13 | General-Purpose Input/Output | IO | L2 |
| gpio1_14 | General-Purpose Input/Output | IO | G20 |
| gpio1_15 | General-Purpose Input/Output | IO | G19 |
| gpio1_16 | General-Purpose Input/Output | IO | D27 |
| gpio1_17 | General-Purpose Input/Output | IO | C28 |
| gpio1_18 | General-Purpose Input/Output | IO | H1 |
| gpio1_19 | General-Purpose Input/Output | IO | J3 |
| gpio1_20 | General-Purpose Input/Output | IO | H2 |

Table 4-24. GPIOs Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------|------------------------------|------|------|
| gpio1_21 | General-Purpose Input/Output | IO | H3 |
| gpio1_22 | General-Purpose Input/Output | IO | AC8 |
| gpio1_23 | General-Purpose Input/Output | IO | AD6 |
| gpio1_24 | General-Purpose Input/Output | IO | AB8 |
| gpio1_25 | General-Purpose Input/Output | IO | AB5 |
| gpio1_26 | General-Purpose Input/Output | IO | P6 |
| gpio1_27 | General-Purpose Input/Output | IO | R9 |
| gpio1_28 | General-Purpose Input/Output | IO | R5 |
| gpio1_29 | General-Purpose Input/Output | IO | P5 |
| gpio1_30 | General-Purpose Input/Output | IO | N7 |
| gpio1_31 | General-Purpose Input/Output | IO | R4 |
| GPIO 2 | | | |
| gpio2_0 | General-Purpose Input/Output | IO | N9 |
| gpio2_1 | General-Purpose Input/Output | IO | P9 |
| gpio2_2 | General-Purpose Input/Output | IO | P4 |
| gpio2_3 | General-Purpose Input/Output | IO | R3 |
| gpio2_4 | General-Purpose Input/Output | IO | T2 |
| gpio2_5 | General-Purpose Input/Output | IO | U2 |
| gpio2_6 | General-Purpose Input/Output | IO | U1 |
| gpio2_7 | General-Purpose Input/Output | IO | P3 |
| gpio2_8 | General-Purpose Input/Output | IO | R2 |
| gpio2_9 | General-Purpose Input/Output | IO | K7 |
| gpio2_10 | General-Purpose Input/Output | IO | M7 |
| gpio2_11 | General-Purpose Input/Output | IO | J5 |
| gpio2_12 | General-Purpose Input/Output | IO | K6 |
| gpio2_13 | General-Purpose Input/Output | IO | J7 |
| gpio2_14 | General-Purpose Input/Output | IO | J4 |
| gpio2_15 | General-Purpose Input/Output | IO | J6 |
| gpio2_16 | General-Purpose Input/Output | IO | H4 |
| gpio2_17 | General-Purpose Input/Output | IO | H5 |
| gpio2_18 | General-Purpose Input/Output | IO | H6 |
| gpio2_19 | General-Purpose Input/Output | IO | T1 |
| gpio2_20 | General-Purpose Input/Output | IO | P2 |
| gpio2_21 | General-Purpose Input/Output | IO | P1 |
| gpio2_22 | General-Purpose Input/Output | IO | P7 |
| gpio2_23 | General-Purpose Input/Output | IO | N1 |
| gpio2_24 | General-Purpose Input/Output | IO | M5 |
| gpio2_25 | General-Purpose Input/Output | IO | M3 |
| gpio2_26 | General-Purpose Input/Output | IO | N6 |
| gpio2_27 | General-Purpose Input/Output | IO | M4 |
| gpio2_28 | General-Purpose Input/Output | IO | N2 |
| gpio2_29 | General-Purpose Input/Output | IO | B17 |
| GPIO 3 | | | |
| gpio3_28 | General-Purpose Input/Output | IO | E1 |
| gpio3_29 | General-Purpose Input/Output | IO | G2 |
| gpio3_30 | General-Purpose Input/Output | IO | H7 |
| gpio3_31 | General-Purpose Input/Output | IO | G1 |

Table 4-24. GPIOs Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------|------------------------------|------|------|
| GPIO 4 | | | |
| gpio4_0 | General-Purpose Input/Output | IO | G6 |
| gpio4_1 | General-Purpose Input/Output | IO | F2 |
| gpio4_2 | General-Purpose Input/Output | IO | F3 |
| gpio4_3 | General-Purpose Input/Output | IO | D1 |
| gpio4_4 | General-Purpose Input/Output | IO | E2 |
| gpio4_5 | General-Purpose Input/Output | IO | D2 |
| gpio4_6 | General-Purpose Input/Output | IO | F4 |
| gpio4_7 | General-Purpose Input/Output | IO | C1 |
| gpio4_8 | General-Purpose Input/Output | IO | E4 |
| gpio4_9 | General-Purpose Input/Output | IO | F5 |
| gpio4_10 | General-Purpose Input/Output | IO | E6 |
| gpio4_11 | General-Purpose Input/Output | IO | D3 |
| gpio4_12 | General-Purpose Input/Output | IO | F6 |
| gpio4_13 | General-Purpose Input/Output | IO | D5 |
| gpio4_14 | General-Purpose Input/Output | IO | C2 |
| gpio4_15 | General-Purpose Input/Output | IO | C3 |
| gpio4_16 | General-Purpose Input/Output | IO | C4 |
| gpio4_17 | General-Purpose Input/Output | IO | A12 |
| gpio4_18 | General-Purpose Input/Output | IO | E14 |
| gpio4_19 | General-Purpose Input/Output | IO | D11 |
| gpio4_20 | General-Purpose Input/Output | IO | B10 |
| gpio4_21 | General-Purpose Input/Output | IO | B11 |
| gpio4_22 | General-Purpose Input/Output | IO | C11 |
| gpio4_23 | General-Purpose Input/Output | IO | E11 |
| gpio4_24 | General-Purpose Input/Output | IO | B2 |
| gpio4_25 | General-Purpose Input/Output | IO | D6 |
| gpio4_26 | General-Purpose Input/Output | IO | C5 |
| gpio4_27 | General-Purpose Input/Output | IO | A3 |
| gpio4_28 | General-Purpose Input/Output | IO | B3 |
| gpio4_29 | General-Purpose Input/Output | IO | B4 |
| gpio4_30 | General-Purpose Input/Output | IO | B5 |
| gpio4_31 | General-Purpose Input/Output | IO | A4 |
| GPIO 5 | | | |
| gpio5_0 | General-Purpose Input/Output | IO | B14 |
| gpio5_1 | General-Purpose Input/Output | IO | J14 |
| gpio5_2 | General-Purpose Input/Output | IO | G12 |
| gpio5_3 | General-Purpose Input/Output | IO | F12 |
| gpio5_4 | General-Purpose Input/Output | IO | G13 |
| gpio5_5 | General-Purpose Input/Output | IO | J11 |
| gpio5_6 | General-Purpose Input/Output | IO | E12 |
| gpio5_7 | General-Purpose Input/Output | IO | F13 |
| gpio5_8 | General-Purpose Input/Output | IO | C12 |
| gpio5_9 | General-Purpose Input/Output | IO | D12 |
| gpio5_10 | General-Purpose Input/Output | IO | B12 |
| gpio5_11 | General-Purpose Input/Output | IO | A11 |
| gpio5_12 | General-Purpose Input/Output | IO | B13 |

Table 4-24. GPIOs Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------|------------------------------|------|------|
| gpio5_13 | General-Purpose Input/Output | IO | B18 |
| gpio5_14 | General-Purpose Input/Output | IO | F15 |
| gpio5_15 | General-Purpose Input/Output | IO | V1 |
| gpio5_16 | General-Purpose Input/Output | IO | U4 |
| gpio5_17 | General-Purpose Input/Output | IO | U3 |
| gpio5_18 | General-Purpose Input/Output | IO | V2 |
| gpio5_19 | General-Purpose Input/Output | IO | Y1 |
| gpio5_20 | General-Purpose Input/Output | IO | W9 |
| gpio5_21 | General-Purpose Input/Output | IO | V9 |
| gpio5_22 | General-Purpose Input/Output | IO | V7 |
| gpio5_23 | General-Purpose Input/Output | IO | U7 |
| gpio5_24 | General-Purpose Input/Output | IO | V6 |
| gpio5_25 | General-Purpose Input/Output | IO | U6 |
| gpio5_26 | General-Purpose Input/Output | IO | U5 |
| gpio5_27 | General-Purpose Input/Output | IO | V5 |
| gpio5_28 | General-Purpose Input/Output | IO | V4 |
| gpio5_29 | General-Purpose Input/Output | IO | V3 |
| gpio5_30 | General-Purpose Input/Output | IO | Y2 |
| gpio5_31 | General-Purpose Input/Output | IO | W2 |
| GPIO 6 | | | |
| gpio6_4 | General-Purpose Input/Output | IO | A13 |
| gpio6_5 | General-Purpose Input/Output | IO | G14 |
| gpio6_6 | General-Purpose Input/Output | IO | F14 |
| gpio6_7 | General-Purpose Input/Output | IO | B16 |
| gpio6_8 | General-Purpose Input/Output | IO | C15 |
| gpio6_9 | General-Purpose Input/Output | IO | A16 |
| gpio6_10 | General-Purpose Input/Output | IO | AC5 |
| gpio6_11 | General-Purpose Input/Output | IO | AB4 |
| gpio6_12 | General-Purpose Input/Output | IO | AB10 |
| gpio6_13 | General-Purpose Input/Output | IO | AC10 |
| gpio6_14 | General-Purpose Input/Output | IO | E21 |
| gpio6_15 | General-Purpose Input/Output | IO | F20 |
| gpio6_16 | General-Purpose Input/Output | IO | F21 |
| gpio6_17 | General-Purpose Input/Output | IO | D18 |
| gpio6_18 | General-Purpose Input/Output | IO | E17 |
| gpio6_19 | General-Purpose Input/Output | IO | B26 |
| gpio6_20 | General-Purpose Input/Output | IO | C23 |
| gpio6_21 | General-Purpose Input/Output | IO | W6 |
| gpio6_22 | General-Purpose Input/Output | IO | Y6 |
| gpio6_23 | General-Purpose Input/Output | IO | AA6 |
| gpio6_24 | General-Purpose Input/Output | IO | Y4 |
| gpio6_25 | General-Purpose Input/Output | IO | AA5 |
| gpio6_26 | General-Purpose Input/Output | IO | Y3 |
| gpio6_27 | General-Purpose Input/Output | IO | W7 |
| gpio6_28 | General-Purpose Input/Output | IO | Y9 |
| gpio6_29 | General-Purpose Input/Output | IO | AD4 |
| gpio6_30 | General-Purpose Input/Output | IO | AC4 |

Table 4-24. GPIOs Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------|------------------------------|------|------|
| gpio6_31 | General-Purpose Input/Output | IO | AC7 |
| GPIO 7 | | | |
| gpio7_0 | General-Purpose Input/Output | IO | AC6 |
| gpio7_1 | General-Purpose Input/Output | IO | AC9 |
| gpio7_2 | General-Purpose Input/Output | IO | AC3 |
| gpio7_3 | General-Purpose Input/Output | IO | R6 |
| gpio7_4 | General-Purpose Input/Output | IO | T9 |
| gpio7_5 | General-Purpose Input/Output | IO | T6 |
| gpio7_6 | General-Purpose Input/Output | IO | T7 |
| gpio7_7 | General-Purpose Input/Output | IO | A25 |
| gpio7_8 | General-Purpose Input/Output | IO | F16 |
| gpio7_9 | General-Purpose Input/Output | IO | B25 |
| gpio7_10 | General-Purpose Input/Output | IO | A24 |
| gpio7_11 | General-Purpose Input/Output | IO | A22 |
| gpio7_12 | General-Purpose Input/Output | IO | B21 |
| gpio7_13 | General-Purpose Input/Output | IO | B20 |
| gpio7_14 | General-Purpose Input/Output | IO | A26 |
| gpio7_15 | General-Purpose Input/Output | IO | B22 |
| gpio7_16 | General-Purpose Input/Output | IO | G17 |
| gpio7_17 | General-Purpose Input/Output | IO | B24 |
| gpio7_18 | General-Purpose Input/Output | IO | L1 |
| gpio7_19 | General-Purpose Input/Output | IO | K2 |
| gpio7_22 | General-Purpose Input/Output | IO | B27 |
| gpio7_23 | General-Purpose Input/Output | IO | C26 |
| gpio7_24 | General-Purpose Input/Output | IO | E25 |
| gpio7_25 | General-Purpose Input/Output | IO | C27 |
| gpio7_26 | General-Purpose Input/Output | IO | D28 |
| gpio7_27 | General-Purpose Input/Output | IO | D26 |
| gpio7_28 | General-Purpose Input/Output | IO | J1 |
| gpio7_29 | General-Purpose Input/Output | IO | J2 |
| gpio7_30 | General-Purpose Input/Output | IO | D14 |
| gpio7_31 | General-Purpose Input/Output | IO | C14 |
| GPIO 8 | | | |
| gpio8_0 | General-Purpose Input/Output | IO | F11 |
| gpio8_1 | General-Purpose Input/Output | IO | G10 |
| gpio8_2 | General-Purpose Input/Output | IO | F10 |
| gpio8_3 | General-Purpose Input/Output | IO | G11 |
| gpio8_4 | General-Purpose Input/Output | IO | E9 |
| gpio8_5 | General-Purpose Input/Output | IO | F9 |
| gpio8_6 | General-Purpose Input/Output | IO | F8 |
| gpio8_7 | General-Purpose Input/Output | IO | E7 |
| gpio8_8 | General-Purpose Input/Output | IO | E8 |
| gpio8_9 | General-Purpose Input/Output | IO | D9 |
| gpio8_10 | General-Purpose Input/Output | IO | D7 |
| gpio8_11 | General-Purpose Input/Output | IO | D8 |
| gpio8_12 | General-Purpose Input/Output | IO | A5 |
| gpio8_13 | General-Purpose Input/Output | IO | C6 |

Table 4-24. GPIOs Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------------------|------------------------------|------|------|
| gpio8_14 | General-Purpose Input/Output | IO | C8 |
| gpio8_15 | General-Purpose Input/Output | IO | C7 |
| gpio8_16 | General-Purpose Input/Output | IO | B7 |
| gpio8_17 | General-Purpose Input/Output | IO | B8 |
| gpio8_18 | General-Purpose Input/Output | IO | A7 |
| gpio8_19 | General-Purpose Input/Output | IO | A8 |
| gpio8_20 | General-Purpose Input/Output | IO | C9 |
| gpio8_21 | General-Purpose Input/Output | IO | A9 |
| gpio8_22 | General-Purpose Input/Output | IO | B9 |
| gpio8_23 | General-Purpose Input/Output | IO | A10 |
| gpio8_27 | General-Purpose Input | I | D23 |
| gpio8_28 | General-Purpose Input/Output | IO | F19 |
| gpio8_29 | General-Purpose Input/Output | IO | E18 |
| gpio8_30 ⁽¹⁾ | General-Purpose Input/Output | IO | G21 |
| gpio8_31 ⁽¹⁾ | General-Purpose Input/Output | IO | D24 |

(1) gpio8_30 is multiplexed with EMU0 and gpio8_31 is multiplexed with EMU1. These pins will be sampled at reset release by the test and emulation logic. Therefore, if they are used as GPIO pins, they must return to the high state whenever the device enters reset. This can be controlled by logic driven from rstoutn. After the device exits reset (indicated by rstoutn rising), these can return to GPIO mode.

4.4.22 Keyboard controller (KBD)

NOTE

For more information, see *Keyboard Controller* chapter in the device TRM.

Table 4-25. Keyboard Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|-----------------|------|------|
| kbd_row0 | Keypad row 0 | I | E1 |
| kbd_row1 | Keypad row 1 | I | G2 |
| kbd_row2 | Keypad row 2 | I | G1 |
| kbd_row3 | Keypad row 3 | I | G6 |
| kbd_row4 | Keypad row 4 | I | F2 |
| kbd_row5 | Keypad row 5 | I | F3 |
| kbd_row6 | Keypad row 6 | I | D1 |
| kbd_row7 | Keypad row 7 | I | F6 |
| kbd_row8 | Keypad row 8 | I | C2 |
| kbd_col0 | Keypad column 0 | O | E2 |
| kbd_col1 | Keypad column 1 | O | D2 |
| kbd_col2 | Keypad column 2 | O | F4 |
| kbd_col3 | Keypad column 3 | O | C1 |
| kbd_col4 | Keypad column 4 | O | E4 |
| kbd_col5 | Keypad column 5 | O | F5 |
| kbd_col6 | Keypad column 6 | O | E6 |
| kbd_col7 | Keypad column 7 | O | D3 |
| kbd_col8 | Keypad column 8 | O | D5 |

4.4.23 Pulse Width Modulation (PWM) Interface

NOTE

For more information, see *Pulse-Width Modulation Subsystem* chapter in the device TRM.

Table 4-26. PWM Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|----------------------------|----------------------------------|------|----------|
| PWMSS1 | | | |
| eQEP1A_in | EQEP1 Quadrature Input A | I | E1 |
| eQEP1B_in | EQEP1 Quadrature Input B | I | G2 |
| eQEP1_index | EQEP1 Index Input | IO | H7 |
| eQEP1_strobe | EQEP1 Strobe Input | IO | G1 |
| ehrpwm1A | EHRPWM1 Output A | O | G6 |
| ehrpwm1B | EHRPWM1 Output B | O | F2 |
| ehrpwm1_tripzone_in put | EHRPWM1 Trip Zone Input | IO | F3 |
| eCAP1_in_PWM1_out | ECAP1 Capture Input / PWM Output | IO | D1 |
| ehrpwm1_synci | EHRPWM1 Sync Input | I | E2 |
| ehrpwm1_synco | EHRPWM1 Sync Output | O | D2 |
| PWMSS2 | | | |
| eQEP2A_in | EQEP2 Quadrature Input A | I | F4 |
| eQEP2B_in | EQEP2 Quadrature Input B | I | C1 |
| eQEP2_index | EQEP2 Index Input | IO | E4 |
| eQEP2_strobe | EQEP2 Strobe Input | IO | F5 |
| ehrpwm2A | EHRPWM2 Output A | O | AC5 / E6 |
| ehrpwm2B | EHRPWM2 Output B | O | AB4 / D3 |
| ehrpwm2_tripzone_in put | EHRPWM2 Trip Zone Input | IO | AD4 / F6 |
| eCAP2_in_PWM2_out | ECAP2 Capture Input / PWM Output | IO | AC4 / D5 |
| PWMSS3 | | | |
| eQEP3A_in | EQEP3 Quadrature Input A | I | AC7 / C2 |
| eQEP3B_in | EQEP3 Quadrature Input B | I | AC6 / C3 |
| eQEP3_index | EQEP3 Index Input | IO | AC9 / C4 |
| eQEP3_strobe | EQEP3 Strobe Input | IO | AC3 / B2 |
| ehrpwm3A | EHRPWM3 Output A | O | AC8 / D6 |
| ehrpwm3B | EHRPWM3 Output B | O | AD6 / C5 |
| ehrpwm3_tripzone_in put | EHRPWM3 Trip Zone Input | IO | AB8 / A3 |
| eCAP3_in_PWM3_out | ECAP3 Capture Input / PWM Output | IO | AB5 / B3 |

4.4.24 Audio Tracking Logic (ATL)

NOTE

For more information, see *Audio Tracking Logic* chapter in the device TRM.

Table 4-27. ATL Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|------------------------------|------|------|
| atl_clk0 | Audio Tracking Logic Clock 0 | O | D18 |
| atl_clk1 | Audio Tracking Logic Clock 1 | O | E17 |

Table 4-27. ATL Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|------------------------------|------|------|
| atl_clk2 | Audio Tracking Logic Clock 2 | O | B26 |
| atl_clk3 | Audio Tracking Logic Clock 3 | O | C23 |

4.4.25 Test Interfaces

CAUTION

The I/O timings provided in [Section 7, Timing Requirements and Switching Characteristics](#) are valid only if signals within a single IOSET are used. The IOSETs are defined in [Table 7-147](#).

NOTE

For more information, see *On-Chip Debug Support* chapter in the device TRM.

Table 4-28. Debug Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------------|---|------|----------|
| tms | JTAG® test port mode select. An external pullup resistor should be used on this ball. | IO | F18 |
| tdi | JTAG test data | I | D23 |
| tdo | JTAG test port data | O | F19 |
| tclk | JTAG test clock | I | E20 |
| trstn | JTAG test reset | I | D20 |
| rtck | JTAG return clock | O | E18 |
| emu0 ⁽¹⁾ | Emulator pin 0 | IO | G21 |
| emu1 ⁽¹⁾ | Emulator pin 1 | IO | D24 |
| emu2 | Emulator pin 2 | O | F10 |
| emu3 | Emulator pin 3 | O | D7 |
| emu4 | Emulator pin 4 | O | A7 |
| emu5 | Emulator pin 5 | O | E1 / G11 |
| emu6 | Emulator pin 6 | O | G2 / E9 |
| emu7 | Emulator pin 7 | O | H7 / F9 |
| emu8 | Emulator pin 8 | O | G1 / F8 |
| emu9 | Emulator pin 9 | O | G6 / E7 |
| emu10 | Emulator pin 10 | O | F2 / D8 |
| emu11 | Emulator pin 11 | O | F3 / A5 |
| emu12 | Emulator pin 12 | O | D1 / C6 |
| emu13 | Emulator pin 13 | O | E2 / C8 |
| emu14 | Emulator pin 14 | O | D2 / C7 |
| emu15 | Emulator pin 15 | O | F4 / A8 |
| emu16 | Emulator pin 16 | O | C1 / C9 |
| emu17 | Emulator pin 17 | O | E4 / A9 |
| emu18 | Emulator pin 18 | O | F5 / B9 |
| emu19 | Emulator pin 19 | O | E6 / A10 |

- (1) EMU0 and EMU1 are multiplexed with GPIO. These pins will be sampled at reset release by the test and emulation logic. Therefore, if they are used as GPIO pins, they must return to the high state whenever the device enters reset. This can be controlled by logic driven from rstoutn. After the device exits reset (indicated by rstoutn rising), these can return to GPIO mode.

4.4.26 System and Miscellaneous

4.4.26.1 Sysboot

NOTE

For more information, see *Initialization* chapter in the device TRM.

Table 4-29. Sysboot Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|------|
| sysboot0 | Boot Mode Configuration 0. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | M6 |
| sysboot1 | Boot Mode Configuration 1. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | M2 |
| sysboot2 | Boot Mode Configuration 2. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | L5 |
| sysboot3 | Boot Mode Configuration 3. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | M1 |
| sysboot4 | Boot Mode Configuration 4. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | L6 |
| sysboot5 | Boot Mode Configuration 5. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | L4 |
| sysboot6 | Boot Mode Configuration 6. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | L3 |
| sysboot7 | Boot Mode Configuration 7. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | L2 |
| sysboot8 | Boot Mode Configuration 8. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | L1 |
| sysboot9 | Boot Mode Configuration 9. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | K2 |
| sysboot10 | Boot Mode Configuration 10. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | J1 |
| sysboot11 | Boot Mode Configuration 11. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | J2 |
| sysboot12 | Boot Mode Configuration 12. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | H1 |
| sysboot13 | Boot Mode Configuration 13. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | J3 |
| sysboot14 | Boot Mode Configuration 14. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | H2 |
| sysboot15 | Boot Mode Configuration 15. The value latched on this pin upon porz reset release will determine the boot mode configuration of the device. | I | H3 |

4.4.26.2 Power, Reset, and Clock Management (PRCM)

NOTE

For more information, see the *Power, Reset, and Clock Management* chapter in the device TRM.

Table 4-30. PRCM Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--------------------------------|---|------|----------|
| clkout1 | Device Clock output 1. Can be used externally for devices with non-critical timing requirements, or for debug, or as a reference clock on GPMC as described in Table 7-25 GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Default and Table 7-27 GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Alternate . | O | F21 / P7 |
| clkout2 | Device Clock output 2. Can be used externally for devices with non-critical timing requirements, or for debug. | O | D18 / N1 |
| clkout3 | Device Clock output 3. Can be used externally for devices with non-critical timing requirements, or for debug. | O | C23 |
| rstoutn | Reset out (Active low) output is asserted low whenever any global reset condition exists. After a brief delay, it will be set high upon removal of the internal global reset condition (that is, porz, warm reset). It is only functional after its output buffer's reference voltage (vddshv3) is valid. If it is used as a reset for device peripheral components, then it should be AND gated with porz to avoid the possibility of reset signal glitches during a power up sequence. ⁽²⁾ | O | F23 |
| resetn | Reset (active low) input's falling edge can trigger a device warm reset state from an external component. This signal should be high prior to or simultaneous with, porz rising. If the signal is not used in the system, resetn should be pulled high with an external pull-up resistor to vddshv3. | I | E23 |
| porz | Power on Reset (active low) input must be asserted low during a device power up sequence or cold reset state when all supplies are disabled. Typically, an external PMIC is the source and sets porz high after all supplies reach valid operating levels. Asserting porz low puts the entire device in a safe reset state. | I | F22 |
| xref_clk0 | External Reference Clock 0. For Audio and other Peripherals. | I | D18 |
| xref_clk1 | External Reference Clock 1. For Audio and other Peripherals. | I | E17 |
| xref_clk2 | External Reference Clock 2. For Audio and other Peripherals. | I | B26 |
| xref_clk3 | External Reference Clock 3. For Audio and other Peripherals. | I | C23 |
| xi_osc0 | System Oscillator OSC0 Crystal input / LVCMOS clock input. Functions as the input connection to a crystal when the internal oscillator OSC0 is used. Functions as an LVCMOS-compatible input clock when an external oscillator is used. | I | AE15 |
| xo_osc0 | System Oscillator OSC0 Crystal output | O | AD15 |
| xi_osc1 | Auxiliary Oscillator OSC1 Crystal input / LVCMOS clock input. Functions as the input connection to a crystal when the internal oscillator OSC1 is used. Functions as an LVCMOS-compatible input clock when an external oscillator is used | I | AC15 |
| xo_osc1 | Auxiliary Oscillator OSC1 Crystal output | O | AC13 |
| RMII_MHZ_50_CLK ⁽¹⁾ | RMII Reference Clock (50MHz). This pin is an input when external reference is used or output when internal reference is used. | IO | U3 |

(1) This clock signal is implemented as 'pad loopback' inside the device - the output signal is looped back through the input buffer to serve as the internal reference signal. Series termination is recommended (as close to device pin as possible) to improve signal integrity of the clock input. Any nonmonotonicity in voltage that occurs at the pad loopback clock pin between V_{IH} and V_{IL} must be less than V_{HYS} .

(2) Note that rstoutn is only valid after vddshv3 is valid. If the rstoutn signal will be used as a reset into other devices attached to the SOC, it must be AND'ed with porz. This will prevent glitches occurring during supply ramping being propagated.

4.4.26.3 Real-Time Clock (RTC) Interface

NOTE

For more information, see *Real-Time Clock (RTC)* chapter in the device TRM.

Table 4-31. RTC Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|-----------------------------|------|------|
| Wakeup0 | RTC External Wakeup Input 0 | I | AD17 |

Table 4-31. RTC Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|------------------------|---|------|------|
| Wakeup3 | RTC External Wakeup Input 3 | I | AC16 |
| rtc_porz | RTC Power Domain Power-On Reset Input | I | AB17 |
| rtc_osc_xi_clkin32 | RTC Oscillator Input. Crystal connection to internal RTC oscillator. Functions as an RTC clock input when an external oscillator is used. | I | AE14 |
| rtc_osc_xo | RTC Oscillator Output | O | AD14 |
| rtc_iso ⁽¹⁾ | RTC domain Isolation Signal | I | AF14 |
| on_off | RTC Power Enable output pin | O | Y11 |

(1) This signal must be kept 0 if device power supplies are not valid during RTC mode and 1 during normal operation. This can typically be achieved by connecting rtc_iso to the same signal driving porz (not rtc_porz) with appropriate voltage level translation if necessary.

4.4.26.4 System Direct Memory Access (SDMA)

NOTE

For more information, see *DMA Controllers* chapter in the device TRM.

Table 4-32. SDMA Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|--------------------------|------|---------|
| dma_evt1 | System DMA Event Input 1 | I | P7 / P4 |
| dma_evt2 | System DMA Event Input 2 | I | N1 / R3 |
| dma_evt3 | System DMA Event Input 3 | I | N6 |
| dma_evt4 | System DMA Event Input 4 | I | M4 |

4.4.26.5 Interrupt Controllers (INTC)

NOTE

For more information, see *Interrupt Controllers* section in the device TRM.

Table 4-33. INTC Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|--|------|------|
| nmin_dsp | Non maskable interrupt input, active-low. This pin can be optionally routed to the DSP NMI input or as generic input to the Arm cores. Note that by default this pin has an internal pulldown resistor enabled. This internal pulldown should be disabled or countered by a stronger external pullup resistor before routing to the DSP or Arm processors. | I | D21 |
| sys_nirq2 | External interrupt event to any device INTC | I | AD17 |
| sys_nirq1 | External interrupt event to any device INTC | I | AC16 |

4.4.26.6 Observability

NOTE

For more information, see *Control Module* chapter in the device TRM.

Table 4-34. Observability Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|----------------------|------|------|
| obs0 | Observation Output 0 | O | F10 |
| obs1 | Observation Output 1 | O | G11 |
| obs2 | Observation Output 2 | O | E9 |

Table 4-34. Observability Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|------|
| obs3 | Observation Output 3 | O | F9 |
| obs4 | Observation Output 4 | O | F8 |
| obs5 | Observation Output 5 | O | D7 |
| obs6 | Observation Output 6 | O | D8 |
| obs7 | Observation Output 7 | O | A5 |
| obs8 | Observation Output 8 | O | C6 |
| obs9 | Observation Output 9 | O | C8 |
| obs10 | Observation Output 10 | O | C7 |
| obs11 | Observation Output 11 | O | A7 |
| obs12 | Observation Output 12 | O | A8 |
| obs13 | Observation Output 13 | O | C9 |
| obs14 | Observation Output 14 | O | A9 |
| obs15 | Observation Output 15 | O | B9 |
| obs16 | Observation Output 16 | O | F10 |
| obs17 | Observation Output 17 | O | G11 |
| obs18 | Observation Output 18 | O | E9 |
| obs19 | Observation Output 19 | O | F9 |
| obs20 | Observation Output 20 | O | F8 |
| obs21 | Observation Output 21 | O | D7 |
| obs22 | Observation Output 22 | O | D8 |
| obs23 | Observation Output 23 | O | A5 |
| obs24 | Observation Output 24 | O | C6 |
| obs25 | Observation Output 25 | O | C8 |
| obs26 | Observation Output 26 | O | C7 |
| obs27 | Observation Output 27 | O | A7 |
| obs28 | Observation Output 28 | O | A8 |
| obs29 | Observation Output 29 | O | C9 |
| obs30 | Observation Output 30 | O | A9 |
| obs31 | Observation Output 31 | O | B9 |
| obs_dmarq1 | DMA Request External Observation Output 1 | O | G11 |
| obs_dmarq2 | DMA Request External Observation Output 2 | O | D8 |
| obs_irq1 | IRQ External Observation Output 1 | O | F10 |
| obs_irq2 | IRQ External Observation Output 2 | O | D7 |

4.4.27 Power Supplies

NOTE

For more information, see *Power, Reset, and Clock Management* chapter in the device TRM.

Table 4-35. Power Supply Signal Descriptions

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--------------------|----------------------------|------|--|
| vdd | Core voltage domain supply | PWR | H13 / H14 / J17 / J18 / L7 / L8 / N10 / N13 / P11 / P12 / P13 / R11 / R16 / R19 / T13 / T16 / T19 / U13 / U16 / U8 / U9 / V16 / V8 |
| vpp ⁽²⁾ | eFuse power supply | PWR | K14 |

Table 4-35. Power Supply Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|---------------------------------|--|------|---|
| vss | Ground | GND | A1 / A14 / A2 / A23 / A28 / A6 / AA14 / AA15 / AA20 / AA8 / AA9 / AB14 / AB20 / AD1 / AD24 / AG1 / AH1 / AH2 / AH20 / AH28 / B1 / D13 / D19 / E13 / E19 / F1 / F7 / G7 / G8 / G9 / H12 / J12 / J15 / J28 / K1 / K15 / K24 / K25 / K4 / K5 / L13 / L14 / M19 / N14 / N15 / N19 / N24 / N25 / P28 / R1 / R12 / R13 / R21 / T10 / T11 / T12 / T14 / T15 / T17 / T18 / T21 / U14 / U15 / U17 / U20 / U21 / V15 / V17 / W1 / W15 / W24 / W25 / W28 |
| cap_vbbldo_gpu ⁽¹⁾ | External capacitor connection for the GPU vbb ldo output | CAP | Y14 |
| cap_vbbldo_iva ⁽¹⁾ | External capacitor connection for the IVA vbb ldo output | CAP | J10 |
| cap_vbbldo_mpu ⁽¹⁾ | External capacitor connection for the MPU vbb ldo output | CAP | J16 |
| cap_vbbldo_dsp ⁽¹⁾ | External capacitor connection for the DSP vbb ldo output | CAP | K9 |
| cap_vddram_core1 ⁽¹⁾ | External capacitor connection for the Core SRAM array ldo1 output | CAP | T20 |
| cap_vddram_core3 ⁽¹⁾ | External capacitor connection for the Core SRAM array ldo3 output | CAP | L9 |
| cap_vddram_core4 ⁽¹⁾ | External capacitor connection for the Core SRAM array ldo4 output | CAP | J19 |
| cap_vddram_mpu ⁽¹⁾ | External capacitor connection for the MPU SRAM array ldo output | CAP | K19 |
| cap_vddram_gpu ⁽¹⁾ | External capacitor connection for the GPU SRAM array ldo output | CAP | Y13 |
| cap_vddram_iva ⁽¹⁾ | External capacitor connection for the IVA SRAM array ldo output | CAP | K16 |
| cap_vddram_dsp ⁽¹⁾ | External capacitor connection for the DSP | CAP | J9 |
| vdda_dsp_iva | DSP PLL and IVA PLL analog power supply | PWR | N12 |
| vdda_core_gmac | DPLL_CORE and CORE HSDIVIDER analog power supply | PWR | P14 |
| vdda_pll_spare | DPLL_SPARE analog power supply | PWR | P15 |
| vdda_per | DPLL_ABE, DPLL_PER, and PER HSDIVIDER analog power supply | PWR | M14 |
| vdda_mpu_abe | MPU_ABE PLL analog power supply | PWR | N16 |
| vdda33v_usb1 | HS USB1 3.3V analog power supply. If USB1 is not used, this pin can alternatively be connected to VSS if the following requirements are met: - The usb1_dm/usb1_dp pins are left unconnected - The USB1 PHY is kept powered down | PWR | AA12 |
| vdda33v_usb2 | HS USB2 3.3V analog power supply. If USB2 is not used, this pin can alternatively be connected to VSS if the following requirements are met: - The usb2_dm/usb2_dp pins are left unconnected - The USB2 PHY is kept powered down | PWR | Y12 |
| vdda_ddr | DPLL_DDR and DDR HSDIVIDER analog power supply | PWR | R17 |
| vdda_debug | DPLL_DEBUG analog power supply | PWR | N11 |
| vdda_gpu | DPLL_GPU analog power supply | PWR | R14 |
| vdda_hdmi | PLL_HDMI and HDMI analog power supply | PWR | Y17 |
| vdda_osc | HFOSC analog power supply | PWR | AD16 / AE16 |
| vdda_pcie | DPLL_PCIE_REF and PCIe analog power supply | PWR | AA17 |
| vdda_pcie0 | PCIe ch0 RX/TX analog power supply | PWR | AA16 |
| vdda_rtc | RTC bias and RTC LFOSC analog power supply | PWR | AB13 |
| vdda_sata | DPLL_SATA and SATA RX/TX analog power supply | PWR | V13 |
| vdda_usb1 | DPLL_USB and HS USB1 1.8V analog power supply | PWR | AA13 |

Table 4-35. Power Supply Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|--------------|---|------|--|
| vdda_usb2 | HS USB2 1.8V analog power supply | PWR | AB12 |
| vdda_usb3 | DPLL_USB_OTG_SS and USB3.0 RX/TX analog power supply | PWR | W14 |
| vdda_csi | CSI Interface 1.8v Supply | PWR | W12 |
| vdda_video | VIDEO1 and VIDEO2 PLL analog power supply | PWR | P16 |
| vdds18v | 1.8V power supply | PWR | G18 / H17 / M8 / M9 / N8 / P8 / R8 / T8 / V21 / V22 / W17 / W18 |
| vdds18v_dds1 | EMIF1 bias power supply | PWR | AA18 / AA19 / N21 / P20 / P21 / W21 / Y21 |
| vddshv1 | Dual Voltage (1.8V or 3.3V) power supply for the VIN2 Power Group pins | PWR | E3 / E5 / G4 / G5 / H8 / H9 |
| vddshv2 | Dual Voltage (1.8V or 3.3V) power supply for the VOUT Power Group pins | PWR | B6 / D10 / E10 / H10 / H11 |
| vddshv3 | Dual Voltage (1.8V or 3.3V) power supply for the GENERAL Power Group pins | PWR | B23 / D16 / D22 / E16 / E22 / G15 / H15 / H16 / H18 / H19 |
| vddshv4 | Dual Voltage (1.8V or 3.3V) power supply for the MMC4 Power Group pins | PWR | C24 |
| vddshv5 | Dual Voltage (1.8V or 3.3V) power supply for the RTC Power Group pins | PWR | V12 |
| vddshv6 | Dual Voltage (1.8V or 3.3V) power supply for the VIN1 Power Group pins | PWR | AD5 / AD7 / AE7 / AF5 |
| vddshv7 | Dual Voltage (1.8V or 3.3V) power supply for the WIFI Power Group pins | PWR | AB6 / AB7 |
| vddshv8 | Dual Voltage (1.8V or 3.3V) power supply for the MMC1 Power Group pins | PWR | W8 / Y8 |
| vddshv9 | Dual Voltage (1.8V or 3.3V) power supply for the RGMII Power Group pins | PWR | U10 / W4 / W5 |
| vddshv10 | Dual Voltage (1.8V or 3.3V) power supply for the GPMC Power Group pins | PWR | N4 / N5 / P10 / R10 / R7 / T4 / T5 |
| vddshv11 | Dual Voltage (1.8V or 3.3V) power supply for the MMC2 Power Group pins | PWR | J8 / K8 |
| vdds_dds1 | EMIF1 power supply (1.5V for DDR3 mode / 1.35V DDR3L mode) | PWR | AA21 / AA22 / AB21 / AB22 / AB24 / AB25 / AC22 / AD26 / AG20 / AG28 / AH27 / T24 / T25 / W16 / W27 |
| vdds_milbp | MLBP IO power supply | PWR | AA7 / Y7 |
| vdd_dsp | DSP voltage domain supply | PWR | K10 / K11 / L10 / L11 / M10 / M11 |
| vdd_gpu | GPU voltage domain supply | PWR | U11 / U12 / V10 / V11 / V14 / W10 / W11 / W13 |
| vdd_iva | IVA voltage domain supply | PWR | J13 / K12 / K13 / L12 / M12 / M13 |
| vdd_mpu | MPU voltage domain supply | PWR | K17 / K18 / L15 / L16 / L17 / L18 / L19 / M15 / M16 / M17 / M18 / N17 / N18 / P17 / P18 / R18 |
| vdd_rtc | RTC voltage domain supply | PWR | AB15 |
| vssa_hdmi | DPLL_HDMI and HDMI PHY analog ground | GND | AD19 / AE19 |
| vssa_osc0 | OSC0 analog ground | GND | AF15 |
| vssa_osc1 | OSC1 analog ground | GND | AC14 |

Table 4-35. Power Supply Signal Descriptions (continued)

| SIGNAL NAME | DESCRIPTION | TYPE | BALL |
|-------------|---|------|-------------|
| vssa_pcie | PCIe analog ground | GND | AD13 / AE13 |
| vssa_sata | SATA analog ground | GND | AE10 |
| vssa_usb | HS USB1 and HS USB2 analog ground | GND | AA11 / AB11 |
| vssa_usb3 | DPLL_USB and USB3.0 RX/TX analog ground | GND | AD10 |
| vssa_csi | CSI Interface 0v Supply | GND | AA10 / AH8 |
| vssa_video | DPLL_VIDEO1 analog ground | GND | R15 |

- (1) This pin must always be connected via a 1- μ F capacitor to vss.
- (2) This signal is valid only for High-Security devices. For more details, see [Section 5.8 VPP Specification for One-Time Programmable \(OTP\) eFUSES](#). For General Purpose devices do not connect any signal, test point, or board trace to this signal.

5 Specifications

NOTE

For more information, see *Power, Reset, and Clock Management* section in the device TRM.

NOTE

The index numbers 1 and 2 which is part of the EMIF1 signal prefixes (ddr1_*) listed in [Table 4-8, EMIF Signal Descriptions](#), column "SIGNAL NAME" not to be confused with DDR1 type of SDRAM memories.

NOTE

Audio Back End (ABE) module is not supported for this family of devices, but "ABE" name is still present in some clock or DPLL names.

CAUTION

All IO Cells are NOT Fail-safe compliant and should not be externally driven in absence of their IO supply.

5.1 Absolute Maximum Ratings

Stresses beyond those listed as 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 listed under [Section 5.4, Recommended Operating Conditions](#), is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

Table 5-1. Absolute Maximum Rating Over Junction Temperature Range

| PARAMETER ⁽¹⁾ | | MIN | MAX | UNIT | |
|------------------------------------|---|---|------|------|---|
| V _{SUPPLY} (Steady-State) | Supply Voltage Ranges (Steady-State) | Core (vdd, vdd_mpu, vdd_gpu, vdd_dsp, vdd_iva, vdd_rtc) | -0.3 | 1.5 | V |
| | Analog (vdda_usb1, vdda_usb2, vdda_per, vdda_ddr, vdda_debug, vdda_mpu_abe, vdda_usb3, vdda_csi, vdda_core_gmac, vdda_pll_spare, vdda_dsp_iva, vdda_gpu, vdda_hdmi, vdda_pcie, vdda_pcie0, vdda_sata, vdda_video, vdda_osc, vdda_rtc) | -0.3 | 2.0 | V | |
| | Analog 3.3V (vdda33v_usb1, vdda33v_usb2) | -0.3 | 3.8 | V | |
| | vdds18v, vdds18v_ddr1, vdds_mlbp, vdds_ddr1 | -0.3 | 2.1 | V | |
| | vddshv1-11 (1.8V mode) | -0.3 | 2.1 | V | |
| | vddshv1-7 (3.3V mode), vddshv9-11 (3.3V mode) | -0.3 | 3.8 | V | |
| | vddshv8 (3.3V mode) | -0.3 | 3.6 | V | |

Table 5-1. Absolute Maximum Rating Over Junction Temperature Range (continued)

| PARAMETER ⁽¹⁾ | | MIN | MAX | UNIT | |
|--|---|---|-------------------------------|------|----|
| V _{IO} (Steady-State) | Input and Output Voltage Ranges (Steady-State) | Core I/Os | -0.3 | 1.5 | V |
| | | Analog I/Os (except HDMI) | -0.3 | 2.0 | V |
| | | HDMI I/Os | -0.3 | 3.5 | V |
| | | I/O 1.35V | -0.3 | 1.65 | V |
| | | I/O 1.5V | -0.3 | 1.8 | V |
| | | 1.8V I/Os | -0.3 | 2.1 | V |
| | | 3.3V I/Os (except those powered by vddshv8) | -0.3 | 3.8 | V |
| | | 3.3V I/Os (powered by vddshv8) | -0.3 | 3.6 | V |
| SR | Maximum slew rate, all supplies | | 10 ⁵ | V/s | |
| V _{IO} (Transient Overshoot / Undershoot) | Input and Output Voltage Ranges (Transient Overshoot/Undershoot) Note: valid for up to 20% of the signal period. See Figure 5-1, IO Transient Voltage Ranges . | | 0.2 × VDD ⁽²⁾ | V | |
| T _J | Operating junction temperature range | Automotive | -40 | +125 | °C |
| T _{STG} | Storage temperature range after soldered onto PC Board | | -55 | +150 | °C |
| Latch-up I-Test | I-test ⁽³⁾ , All I/Os (if different levels then one line per level) | -100 | 100 | mA | |
| Latch-up OV-Test | Over-voltage Test ⁽⁴⁾ , All supplies (if different levels then one line per level) | N/A | 1.5 × V _{supply max} | V | |

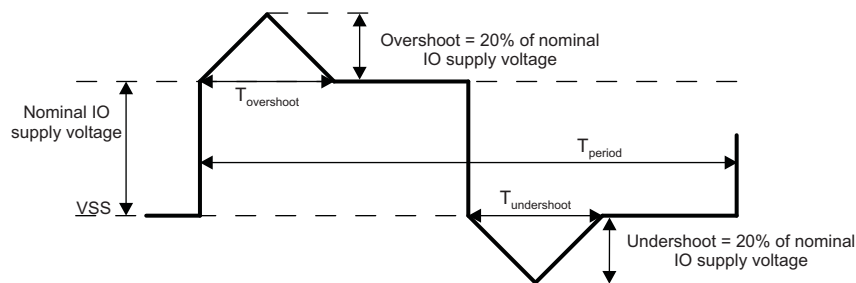
(1) See I/Os supplied by this power pin in [Table 4-2 Ball Characteristics](#)

(2) VDD is the voltage on the corresponding power-supply pin(s) for the IO.

(3) Per JEDEC JESD78 at 125°C with specified I/O pin injection current and clamp voltage of 1.5 times maximum recommended I/O voltage and negative 0.5 times maximum recommended I/O voltage.

(4) Per JEDEC JESD78 at 125°C.

(5) The maximum valid input voltage on an IO pin cannot exceed 0.3 volts when the supply powering the IO is turned off. This requirement applies to all the IO pins which are not fail-safe and for all values of IO supply voltage. 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.



osus_sprs851

(1) $T_{overshoot} + T_{undershoot} < 20\%$ of T_{period}

Figure 5-1. IO Transient Voltage Ranges

5.2 ESD Ratings

Table 5-2. ESD Ratings

| | | VALUE | UNIT | |
|--|---|---|------|------|
| V _{ESD} Electrostatic discharge | Human-Body model (HBM), per AEC Q100-002 ⁽¹⁾ | ±1000 | V | |
| | Charged-device model (CDM), per AEC Q100-011 | HDMIPHY pins (AG16, AH16, AG19, AH19, AG18, AH18, AG17, AH17) | | ±200 |
| | | All pins (other than HDMIPHY) | | ±250 |
| | | Corner pins (A1, AH1, A28, AH28) | | ±750 |

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

5.3 Power-On-Hour (POH) Limits

The information in the section below 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.

NOTE

POH is a functional of voltage, temperature and time. Usage at higher voltages and temperatures will result in a reduction in POH to achieve the same reliability performance. For assessment of alternate use cases, contact your local TI representative.

Table 5-3. Power on Hour (POH) Limits

| IP | DUTY CYCLE | VOLTAGE DOMAIN | VOLTAGE (V) (MAX) | FREQUENCY (MHz) (MAX) | T _J (°C) | POH |
|-----------------------|------------|----------------|-------------------|-----------------------|-----------------------------------|-------|
| Arm | 70% | vdd_mpu | OPP_HIGH | 1500 | Automotive Profile ⁽¹⁾ | 20000 |
| | 30% | vdd_mpu | Retention | 0 | | |
| | 40% | vdd_mpu | OPP_HIGH | 1500 | Automotive Profile ⁽¹⁾ | 20000 |
| | 60% | vdd_mpu | OPP_HIGH | 1000 | Automotive Profile ⁽¹⁾ | 20000 |
| | 55% | vdd_mpu | OPP_HIGH | 1500 | | |
| | 45% | vdd_mpu | OPP_NOM | 1000 | Automotive Profile ⁽¹⁾ | 20000 |
| | 100% | vdd_mpu | OPP_HIGH | 1176 | Automotive Profile ⁽¹⁾ | 20000 |
| | 100% | vdd_mpu | OPP_NOM | 1000 | Automotive Profile ⁽¹⁾ | 20000 |
| Others ⁽²⁾ | 100% | All | All Support OPPs | | Automotive Profile ⁽¹⁾ | 20000 |

(1) Automotive profile is defined as 20000 power on hours with junction temperature as follows: 5%@-40°C, 65%@70°C, 20%@110°C, 10%@125°C.

(2) Others covers all other IP's voltage and temperature combinations that are not specified in the table, and are constrained by other sections of this data manual.

5.4 Recommended Operating Conditions

The device is used under the recommended operating conditions described in [Table 5-4](#).

NOTE

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

Table 5-4. Recommended Operating Conditions

| PARAMETER | DESCRIPTION | MIN ⁽²⁾ | NOM | MAX DC ⁽³⁾ | MAX ⁽²⁾ | UNIT |
|---|-------------|--------------------|-----|-----------------------|--------------------|------|
| Input Power Supply Voltage Range | | | | | | |

Table 5-4. Recommended Operating Conditions (continued)

| PARAMETER | DESCRIPTION | MIN ⁽²⁾ | NOM | MAX DC ⁽³⁾ | MAX ⁽²⁾ | UNIT |
|----------------|---|--------------------|-----------------|-----------------------|--------------------|---------------------|
| vdd | Core voltage domain supply | | See Section 5.5 | | | V |
| vdd_mpu | Supply voltage range for MPU domain | | See Section 5.5 | | | V |
| vdd_gpu | GPU voltage domain supply | | See Section 5.5 | | | V |
| vdd_dsp | DSP voltage domain supply | | See Section 5.5 | | | V |
| vdd_iva | IVA voltage domain supply | | See Section 5.5 | | | V |
| vdd_rtc | RTC voltage domain supply | | See Section 5.5 | | | V |
| vdda_usb1 | DPLL_USB and HS USB1 1.8 V analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_usb2 | HS USB2 1.8 V analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda33v_usb1 | HS USB1 3.3 V analog power supply. If USB1 is not used, this pin can alternatively be connected to VSS if the following requirements are met: - The usb1_dm/usb1_dp pins are left unconnected - The USB1 PHY is kept powered down | 3.135 | 3.3 | 3.366 | 3.465 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda33v_usb2 | HS USB2 3.3 V analog power supply. If USB2 is not used, this pin can alternatively be connected to VSS if the following requirements are met: - The usb2_dm/usb2_dp pins are left unconnected - The USB2 PHY is kept powered down | 3.135 | 3.3 | 3.366 | 3.465 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_per | PER PLL and PER HSDIVIDER analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_ddr | DPLL_DDR and DDR HSDIVIDER analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_debug | DPLL_DEBUG analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_dsp_iva | DPLL_DSP and DPLL_IVA analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_core_gmac | DPLL_CORE and CORE HSDIVIDER analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_pll_spare | DPLL_SPARE analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_gpu | DPLL_GPU analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_hdmi | PLL_HDMI and HDMI analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |
| vdda_pcie | DPLL_PCIE_REF and PCIe analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} |

Table 5-4. Recommended Operating Conditions (continued)

| PARAMETER | DESCRIPTION | MIN ⁽²⁾ | NOM | MAX DC ⁽³⁾ | MAX ⁽²⁾ | UNIT | |
|--------------|--|--------------------|-------|-----------------------|--------------------|---------------------|---------------------|
| vdda_pcie0 | PCIe ch0 RX/TX analog power supply | 1.71 | 1.80 | | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdda_sata | DPLL_SATA and SATA RX/TX analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdda_usb3 | DPLL_USB_OTG_SS and USB3.0 RX/TX analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdda_video | DPLL_VIDEO1 analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdds_mlbp | MLBP IO power supply | 1.71 | 1.80 | | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdda_mpu_abe | DPLL_MPU analog power supply | 1.71 | 1.80 | 1.836 | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdda_osc | HFOSC analog power supply | 1.71 | 1.80 | | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdda_rtc | RTC bias and RTC LFOSC analog power supply | 1.71 | 1.80 | | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdda_csi | CSI Interface 1.8 V Supply | 1.71 | 1.80 | 1.836 | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdds18v | 1.8 V power supply | 1.71 | 1.80 | 1.836 | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdds18v_dds1 | EMIF1 bias power supply | 1.71 | 1.80 | 1.836 | 1.89 | V | |
| | Maximum noise (peak-peak) | | 50 | | | mV _{PPmax} | |
| vdds_dds1 | EMIF1 power supply (1.5 V for DDR3 mode / 1.35 V DDR3L mode) | 1.35-V Mode | 1.28 | 1.35 | 1.377 | 1.42 | V |
| | | 1.5-V Mode | 1.43 | 1.50 | 1.53 | 1.57 | |
| | Maximum noise (peak-peak) | 1.35-V Mode | | 50 | | | mV _{PPmax} |
| | | 1.5-V Mode | | | | | |
| vddshv5 | Dual Voltage (1.8 V or 3.3 V) power supply for the RTC Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | | 50 | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vddshv1 | Dual Voltage (1.8 V or 3.3 V) power supply for the VIN2 Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | | 50 | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vddshv10 | Dual Voltage (1.8 V or 3.3 V) power supply for the GPMC Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | | 50 | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |

Table 5-4. Recommended Operating Conditions (continued)

| PARAMETER | DESCRIPTION | | MIN ⁽²⁾ | NOM | MAX DC ⁽³⁾ | MAX ⁽²⁾ | UNIT |
|-----------|---|------------|--------------------|------|-----------------------|--------------------|---------------------|
| vddshv11 | Dual Voltage (1.8 V or 3.3 V) power supply for the MMC2 Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | 50 | | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vddshv2 | Dual Voltage (1.8 V or 3.3 V) power supply for the VOUT Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | 50 | | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vddshv3 | Dual Voltage (1.8 V or 3.3 V) power supply for the GENERAL Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | 50 | | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vddshv4 | Dual Voltage (1.8 V or 3.3 V) power supply for the MMC4 Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | 50 | | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vddshv6 | Dual Voltage (1.8 V or 3.3 V) power supply for the VIN1 Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | 50 | | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vddshv7 | Dual Voltage (1.8 V or 3.3 V) power supply for the WIFI Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | 50 | | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vddshv8 | Dual Voltage (1.8 V or 3.3 V) power supply for the MMC1 Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | 50 | | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vddshv9 | Dual Voltage (1.8 V or 3.3 V) power supply for the RGMII Power Group pins | 1.8-V Mode | 1.71 | 1.80 | 1.836 | 1.89 | V |
| | | 3.3-V Mode | 3.135 | 3.30 | 3.366 | 3.465 | |
| | Maximum noise (peak-peak) | 1.8-V Mode | 50 | | | | mV _{PPmax} |
| | | 3.3-V Mode | | | | | |
| vss | Ground supply | | | 0 | | | V |
| vssa_hdmi | DPLL_HDMI and HDMI PHY analog ground | | | 0 | | | V |
| vssa_pcie | PCIe analog ground | | | 0 | | | V |
| vssa_usb | HS USB1 and HS USB2 analog ground | | | 0 | | | V |
| vssa_usb3 | DPLL_USB and USB3.0 RX/TX analog ground | | | 0 | | | V |

Table 5-4. Recommended Operating Conditions (continued)

| PARAMETER | DESCRIPTION | | MIN ⁽²⁾ | NOM | MAX DC ⁽³⁾ | MAX ⁽²⁾ | UNIT |
|-------------------------------|--------------------------------------|------------|--------------------|-----------------|-----------------------|---------------------|------|
| vssa_csi | CSI Interface 0v Supply | | | 0 | | | V |
| vssa_sata | SATA TX ground | | | 0 | | | V |
| vssa_video | DPLL_VIDEO1 analog ground | | | 0 | | | V |
| vssa_osc0 | OSC0 analog ground | | | 0 | | | V |
| vssa_osc1 | OSC1 analog ground | | | 0 | | | V |
| T _J ⁽¹⁾ | Operating junction temperature range | Automotive | -40 | | | +125 ⁽⁴⁾ | °C |
| ddr1_vref0 | Reference Power Supply EMIF1 | | | 0.5 × vdds_ddr1 | | | V |

(1) Refer to Power-On-Hours table [Table 5-3](#) for limitations.

(2) The voltage at the device ball should never be below the MIN voltage or above the MAX voltage for any amount of time. This requirement includes dynamic voltage events such as AC ripple, voltage transients, voltage dips, etc.

(3) The DC voltage at the device ball should never be above the MAX DC voltage to avoid impact on device reliability and lifetime POH (Power-On-Hours). The MAX DC voltage is defined as the highest allowed DC regulated voltage, without transients, seen at the ball.

(4) The TSHUT feature of the SoC resets the device by default when one of the on-die temp sensors reports 123°C. This is intended to protect the device from exceeding 125°C. Though not recommended, the TSHUT temperature threshold can be modified in software if other mechanisms are in place to avoid exceeding 125°C. Refer to the device TRM for details on the TSHUT feature.

5.5 Operating Performance Points

This section describes the operating conditions of the device. This section also contains the description of each Operating Performance Point (OPP) for processor clocks and device core clocks.

[Table 5-5](#) describes the maximum supported frequency per speed grade for DRA72x devices.

Table 5-5. Speed Grade Maximum Frequency

| DEVICE | MAXIMUM FREQUENCY (MHz) | | | | | | |
|----------|-------------------------|-----|-----|-----|-------|-----|-----------------|
| | MPU | DSP | IVA | GPU | IPU | L3 | DDR3/DDR3L |
| DRA72xxP | 1500 | 750 | 532 | 532 | 212.8 | 266 | 667 (DDR3-1333) |
| DRA72xxL | 1176 | 750 | 532 | 532 | 212.8 | 266 | 667 (DDR3-1333) |
| DRA72xxJ | 1000 | 750 | 532 | 532 | 212.8 | 266 | 667 (DDR3-1333) |
| DRA72xxH | 800 | 750 | 532 | 532 | 212.8 | 266 | 667 (DDR3-1333) |

(1) N/A stands for Not Applicable.

5.5.1 AVS and ABB Requirements

Adaptive Voltage Scaling (AVS) and Adaptive Body Biasing (ABB) are required on most of the vdd_* supplies as defined in [Table 5-6](#).

Table 5-6. AVS and ABB Requirements per vdd_* Supply

| Supply | AVS Required? | ABB Required? |
|----------|-------------------|-------------------|
| vdd_core | Yes, for all OPPs | No |
| vdd_mpu | Yes, for all OPPs | Yes, for all OPPs |
| vdd_iva | Yes, for all OPPs | Yes, for all OPPs |
| vdd_dsp | Yes, for all OPPs | Yes, for all OPPs |
| vdd_gpu | Yes, for all OPPs | Yes, for all OPPs |
| vdd_rtc | No | No |

5.5.2 Voltage And Core Clock Specifications

Table 5-7 shows the recommended OPP per voltage domain.

Table 5-7. Voltage Domains Operating Performance Points ⁽¹⁾

| DOMAIN | CONDITION | OPP_NOM | | | OPP_OD | | | OPP_HIGH | | | |
|---------------------------|---|-----------------------------------|----------------------------|--------------------|-----------------------------------|----------------------------|---------------------------------|-----------------------------------|----------------------------|---------------------------------|---------------------------------|
| | | MIN ⁽³⁾ | NOM ⁽²⁾ | MAX ⁽³⁾ | MIN ⁽³⁾ | NOM ⁽²⁾ | MAX ⁽³⁾ | MIN ⁽³⁾ | NOM ⁽²⁾ | MAX DC ⁽⁴⁾ | MAX ⁽³⁾ |
| VD_CORE (V) | BOOT (Before AVS is enabled) ⁽⁵⁾ | 1.11 | 1.15 | 1.2 | Not Applicable | | | Not Applicable | | | |
| | After AVS is enabled ⁽⁵⁾ | AVS Voltage ⁽⁶⁾ – 3.5% | AVS Voltage ⁽⁶⁾ | 1.16 | Not Applicable | | | Not Applicable | | | |
| VD_MPU (V) | BOOT (Before AVS is enabled) ⁽⁵⁾ | 1.11 | 1.15 | 1.2 | Not Applicable | | | Not Applicable | | | |
| | After AVS is enabled ⁽⁵⁾ | AVS Voltage ⁽⁶⁾ – 3.5% | AVS Voltage ⁽⁶⁾ | 1.16 | AVS Voltage ⁽⁶⁾ – 3.5% | AVS Voltage ⁽⁶⁾ | AVS Voltage ⁽⁶⁾ + 5% | AVS Voltage ⁽⁶⁾ – 3.5% | AVS Voltage ⁽⁶⁾ | AVS Voltage ⁽⁶⁾ + 2% | AVS Voltage ⁽⁶⁾ + 5% |
| VD_RTC (V) ⁽⁷⁾ | - | 0.84 | 0.88 to 1.06 | 1.16 | Not Applicable | | | Not Applicable | | | |
| Others (V) | BOOT (Before AVS is enabled) ⁽⁵⁾ | 1.02 | 1.06 | 1.16 | Not Applicable | | | Not Applicable | | | |
| | After AVS is enabled ⁽⁵⁾ | AVS Voltage ⁽⁶⁾ – 3.5% | AVS Voltage ⁽⁶⁾ | 1.16 | AVS Voltage ⁽⁶⁾ – 3.5% | AVS Voltage ⁽⁶⁾ | AVS Voltage ⁽⁶⁾ + 5% | AVS Voltage ⁽⁶⁾ – 3.5% | AVS Voltage ⁽⁶⁾ | AVS Voltage ⁽⁶⁾ + 2% | AVS Voltage ⁽⁶⁾ + 5% |

(1) The voltage ranges in this table are preliminary, and final voltage ranges may be different than shown. Systems should be designed with the ability to modify the voltage to comply with future recommendations.

(2) In a typical implementation, the power supply should target the NOM voltage.

(3) The voltage at the device ball should never be below the MIN voltage or above the MAX voltage for any amount of time. This requirement includes dynamic voltage events such as AC ripple, voltage transients, voltage dips, etc.

(4) The DC voltage at the device ball should never be above the MAX DC voltage to avoid impact on device reliability and lifetime POH (Power-On-Hour). The MAX DC voltage is defined as the highest allowed DC regulated voltage, without transients, seen at the ball.

(5) For all OPPs, AVS must be enabled to avoid impact on device reliability, lifetime POH (Power-On-Hour), and device power.

(6) The AVS voltages are device-dependent, voltage domain-dependent, and OPP-dependent. They must be read from the STD_FUSE_OPP Registers. For information about STD_FUSE_OPP Registers address, refer to the *Control Module* chapter in the device TRM. The power supply should be adjustable over the following ranges for each required OPP:

- OPP_NOM for MPU: 0.85 V – 1.15 V
- OPP_NOM for CORE and Others: 0.85 V - 1.15 V
- OPP_OD: 0.94 V - 1.15 V
- OPP_HIGH: 1.01 V - 1.25 V

The AVS voltages will be within the above specified ranges.

(7) VD_RTC can optionally be tied to VD_CORE and operate at the VD_CORE AVS voltages.

(8) The power supply must be programmed with the AVS voltages for the MPU and the CORE voltage domain, either just after the ROM boot or at the earliest possible time in the secondary boot loader before there is significant activity seen on these domains.

Table 5-8 describes the standard processor clocks speed characteristics vs OPP of the device.

Table 5-8. Supported OPP vs Max Frequency ⁽²⁾

| CLOCK | OPP_NOM | OPP_OD | OPP_HIGH |
|---------------|-------------------------|-------------------------|-------------------------|
| | MAXIMUM FREQUENCY (MHz) | MAXIMUM FREQUENCY (MHz) | MAXIMUM FREQUENCY (MHz) |
| VD_MPU | | | |
| MPU_CLK | 1000 | 1176 | 1500 |
| VD_DSP | | | |
| DSP_CLK | 600 | 700 | 750 |
| VD_IVA | | | |

Table 5-8. Supported OPP vs Max Frequency ⁽²⁾ (continued)

| CLOCK | OPP_NOM | OPP_OD | OPP_HIGH |
|----------------|-------------------------|-------------------------|-------------------------|
| | MAXIMUM FREQUENCY (MHz) | MAXIMUM FREQUENCY (MHz) | MAXIMUM FREQUENCY (MHz) |
| IVA_GCLK | 388.3 | 430 | 532 |
| VD_GPU | | | |
| GPU_CLK | 425.6 | 500 | 532 |
| VD_CORE | | | |
| CORE_IPUx_CLK | 212.8 | N/A | N/A |
| L3_CLK | 266 | N/A | N/A |
| DDR3 / DDR3L | 667 (DDR3-1333) | N/A | N/A |
| VD_RTC | | | |
| RTC_FCLK | 0.034 | N/A | N/A |

(1) N/A stands for Not Applicable.

(2) Maximum supported frequency is limited to the device speed grade (see [Table 5-5, Speed Grade Maximum Frequency](#)).

5.5.3 Maximum Supported Frequency

Device modules either receive their clock directly from an external clock input, directly from a PLL, or from a PRCM. [Table 5-9](#) lists the clock source options for each module on this device, along with the maximum frequency that module can accept. To ensure proper module functionality, the device PLLs and dividers must be programmed not to exceed the maximum frequencies listed in this table.

Table 5-9. Maximum Supported Frequency

| MODULE | | | | CLOCK SOURCES | | |
|---------------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| AES1 | AES1_L3_CLK | Int | 266 | L4SEC_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| AES2 | AES2_L3_CLK | Int | 266 | L4SEC_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| ATL | ATL_ICLK_L3 | Int | 266 | ATL_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | ATLPCLK | Func | 266 | ATL_GFCLK | CORE_X2_CLK | DPLL_CORE |
| | | | | | PER_ABE_X1_GFCLK | DPLL_ABE |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | HDMI_CLK | DPLL_HDMI |
| | | | | | VIDEO1_CLK | DPLL_VIDEO1 |
| BB2D | BB2D_FCLK | Func | 354.6 | BB2D_GFCLK | BB2D_GFCLK | DPLL_CORE |
| | BB2D_ICLK | Int | 266 | DSS_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| COUNTER_32K | COUNTER_32K_FCLK | Func | 0.032 | FUNC_32K_CLK | SYS_CLK1/610 | OSC0 |
| | COUNTER_32K_ICLK | Int | 38.4 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| CTRL_MODULE_BANDGAP | L3INSTR_TS_GCLK | Int | 4.8 | L3INSTR_TS_GCLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| CTRL_MODULE_CORE | L4CFG_L4_GICLK | Int | 133 | L4CFG_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| CTRL_MODULE_WKUP | WKUPAON_GICLK | Int | 38.4 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|------------------|---------------------|---------------|--------------------------|------------------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| DCAN1 | DCAN1_FCLK | Func | 38.4 | DCAN1_SYS_CLK | SYS_CLK1 | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | DCAN1_ICLK | Int | 266 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| DCAN2 | DCAN2_FCLK | Func | 38.4 | DCAN2_SYS_CLK | SYS_CLK1 | OSC0 |
| | DCAN2_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| DES3DES | DES_CLK_L3 | Int | 266 | L4SEC_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| DLL | EMIF_DLL_FCLK | Func | EMIF_DLL_FC LK | EMIF_DLL_GCLK | EMIF_DLL_GCLK | DPLL_DDR |
| DLL_AGING | FCLK | Int | 38.4 | L3INSTR_DLL_AGING_GCLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| DMA_CRYPT0 | DMA_CRYPT0_FC LK | Int & Func | 266 | L4SEC_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | DMA_CRYPT0_IC LK | Int | 133 | L4SEC_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| DMM | DMM_CLK | Int | 266 | EMIF_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| DPLL_DEBUG | SYSCLK | Int | 38.4 | EMU_SYS_CLK | SYS_CLK1 | OSC0 |
| DSP1 | DSP1_FICLK | Int & Func | DSP_CLK | DSP1_GFCLK | DSP_GFCLK | DPLL_DSP |
| DSS | DSS_HDMI_CEC_CLK | Func | 0.032 | HDMI_CEC_GFCLK | SYS_CLK1/610 | OSC0 |
| | DSS_HDMI_PHY_CLK | Func | 48 | HDMI_PHY_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | DSS_CLK | Func | 192 | DSS_GFCLK | DSS_CLK | DPLL_PER |
| | HDMI_CLKINP | Func | 38.4 | HDMI_DPLL_CLK | SYS_CLK1 | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | DSS_L3_ICLK | Int | 266 | DSS_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | VIDEO1_CLKINP | Func | 38.4 | VIDEO1_DPLL_CLK | SYS_CLK1 | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | VIDEO2_CLKINP | Func | 38.4 | VIDEO2_DPLL_CLK | SYS_CLK1 | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | DPLL_DS11_A_CLK1 | Func | 209.3 | N/A | HDMI_CLK | DPLL_HDMI |
| | | | | | VIDEO1_CLKOUT1 | DPLL_VIDEO1 |
| | DPLL_DS11_B_CLK1 | Func | 209.3 | N/A | VIDEO1_CLKOUT3 | DPLL_VIDEO1 |
| | | | | | HDMI_CLK | DPLL_HDMI |
| DPLL_ABE_X2_CLK | | | | | DPLL_ABE | |
| DPLL_DS11_C_CLK1 | Func | 209.3 | N/A | HDMI_CLK | DPLL_HDMI | |
| | | | | VIDEO1_CLKOUT3 | DPLL_VIDEO1 | |
| DPLL_HDMI_CLK1 | Func | 185.6 | N/A | HDMI_CLK | DPLL_HDMI | |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|------------------|------------------|------------|--------------------------|---------------------|-------------------------------|--------------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| DSS DISPC | LCD1_CLK | Func | 209.3 | N/A | DPLL_DSI1_A_CLK1 | See DSS data in the rows above |
| | | | | | DSS_CLK | |
| | LCD2_CLK | Func | 209.3 | N/A | DPLL_DSI1_B_CLK1 | |
| | | | | | DSS_CLK | |
| | LCD3_CLK | Func | 209.3 | N/A | DPLL_DSI1_C_CLK1 | |
| | | | | | DSS_CLK | |
| | F_CLK | Func | 209.3 | N/A | DPLL_DSI1_A_CLK1 | |
| | | | | | DPLL_DSI1_B_CLK1 | |
| DPLL_DSI1_C_CLK1 | | | | | | |
| DSS_CLK | | | | | | |
| EFUSE_CTRL_CUST | ocp_clk | Int | 133 | CUSTEFUSE_L4_GICK | CORE_X2_CLK | DPLL_CORE |
| | sys_clk | Func | 38.4 | CUSTEFUSE_SYS_GFCLK | SYS_CLK1 | OSC0 |
| ELM | ELM_ICLK | Int | 266 | L4PER_L3_GICK | CORE_X2_CLK | DPLL_CORE |
| EMIF_OCP_FW | L3_CLK | Int | 266 | EMIF_L3_GICK | CORE_X2_CLK | DPLL_CORE |
| EMIF_PHY1 | EMIF_PHY1_FCLK | Func | DDR | EMIF_PHY_GCLK | EMIF_PHY_GCLK | DPLL_DDR |
| EMIF1 | EMIF1_ICLK | Int | 266 | EMIF_L3_GICK | CORE_X2_CLK | DPLL_CORE |
| FPKA | PKA_CLK | Int & Func | 266 | L4SEC_L3_GICK | CORE_X2_CLK | DPLL_CORE |
| GMAC_SW | CPTS_RFT_CLK | Func | 266 | GMAC_RFT_CLK | PER_ABE_X1_GFCLK | DPLL_ABE |
| | | | | | VIDEO1_CLK | DPLL_VIDEO1 |
| | | | | | HDMI_CLK | DPLL_HDMI |
| | | | | | CORE_X2_CLK | DPLL_CORE |
| | MAIN_CLK | Int | 125 | GMAC_MAIN_CLK | GMAC_250M_CLK | DPLL_GMAC |
| | MHZ_250_CLK | Func | 250 | GMII_250MHZ_CLK | GMII_250MHZ_CLK | DPLL_GMAC |
| | MHZ_5_CLK | Func | 5 | RGMII_5MHZ_CLK | GMAC_RMII_HS_CLK | DPLL_GMAC |
| | MHZ_50_CLK | Func | 50 | RMII_50MHZ_CLK | GMAC_RMII_HS_CLK | DPLL_GMAC |
| RMII1_MHZ_50_CLK | Func | 50 | RMII_50MHZ_CLK | GMAC_RMII_HS_CLK | DPLL_GMAC | |
| RMII2_MHZ_50_CLK | Func | 50 | RMII_50MHZ_CLK | GMAC_RMII_HS_CLK | DPLL_GMAC | |
| GPIO1 | GPIO1_ICLK | Int | 38.4 | WKUPAON_GICK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| | GPIO1_DBCLK | Func | 0.032 | WKUPAON_SYS_GFC | FUNC_32K_CLK | OSC0 |
| GPIO2 | GPIO2_ICLK | Int | 266 | L4PER_L3_GICK | CORE_X2_CLK | DPLL_CORE |
| | GPIO2_DBCLK | Func | 0.032 | GPIO_GFCLK | FUNC_32K_CLK | OSC0 |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|----------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| GPIO3 | GPIO3_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | GPIO3_DBCLK | Func | 0.032 | GPIO_GFCLK | FUNC_32K_CLK | OSC0 |
| GPIO4 | GPIO4_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | GPIO4_DBCLK | Func | 0.032 | GPIO_GFCLK | FUNC_32K_CLK | OSC0 |
| | PIDBCLK | Func | 0.032 | GPIO_GFCLK | | |
| GPIO5 | GPIO5_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | GPIO5_DBCLK | Func | 0.032 | GPIO_GFCLK | FUNC_32K_CLK | OSC0 |
| | PIDBCLK | Func | 0.032 | GPIO_GFCLK | | |
| GPIO6 | GPIO6_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | GPIO6_DBCLK | Func | 0.032 | GPIO_GFCLK | FUNC_32K_CLK | OSC0 |
| | PIDBCLK | Func | 0.032 | GPIO_GFCLK | | |
| GPIO7 | GPIO7_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | GPIO7_DBCLK | Func | 0.032 | GPIO_GFCLK | FUNC_32K_CLK | OSC0 |
| | PIDBCLK | Func | 0.032 | GPIO_GFCLK | | |
| GPIO8 | GPIO8_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | GPIO8_DBCLK | Func | 0.032 | GPIO_GFCLK | FUNC_32K_CLK | OSC0 |
| | PIDBCLK | Func | 0.032 | GPIO_GFCLK | | |
| GPMC | GPMC_FCLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| GPU | GPU_FCLK1 | Func | GPU_CLK | GPU_CORE_GCLK | CORE_GPU_CLK | DPLL_CORE |
| | | | | | PER_GPU_CLK | DPLL_PER |
| | | | | | GPU_GCLK | DPLL_GPU |
| | GPU_FCLK2 | Func | GPU_CLK | GPU_HYD_GCLK | CORE_GPU_CLK | DPLL_CORE |
| | | | | | PER_GPU_CLK | DPLL_PER |
| | | | | | GPU_GCLK | DPLL_GPU |
| GPU_ICLK | Int | 266 | GPU_L3_GICLK | CORE_X2_CLK | DPLL_CORE | |
| HDMI PHY | DSS_HDMI_PHY_CLK | Func | 38.4 | HDMI_PHY_GFCLK | FUNC_192M_CLK | DPLL_PER |
| HDQ1W | HDQ1W_ICLK | Int & Func | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | HDQ1W_FCLK | Func | 12 | PER_12M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| I2C1 | I2C1_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | I2C1_FCLK | Func | 96 | PER_96M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| I2C2 | I2C2_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | I2C2_FCLK | Func | 96 | PER_96M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| I2C3 | I2C3_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | I2C3_FCLK | Func | 96 | PER_96M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| I2C4 | I2C4_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | I2C4_FCLK | Func | 96 | PER_96M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| I2C5 | I2C5_ICLK | Int | 266 | IPU_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | I2C5_FCLK | Func | 96 | IPU_96M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| I2C6 | I2C6_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | I2C6_FCLK | Func | 96 | IPU_96M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| IEEE1500_2_OCP | PI_L3CLK | Int & Func | 266 | L3INIT_L3_GICLK | CORE_X2_CLK | DPLL_CORE |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|------------------|------------|--------------------------|--------------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| IPU1 | IPU1_GFCLK | Int & Func | 425.6 | IPU1_GFCLK | DPLL_ABE_X2_CLK | DPLL_ABE |
| | | | | | CORE_IPU_ISS_B_OOST_CLK | DPLL_CORE |
| IPU2 | IPU2_GFCLK | Int & Func | 425.6 | IPU2_GFCLK | CORE_IPU_ISS_B_OOST_CLK | DPLL_CORE |
| IVA | IVA_GCLK | Int | IVA_GCLK | IVA_GCLK | IVA_GFCLK | DPLL_IVA |
| KBD | KBD_FCLK | Func | 0.032 | WKUPAON_SYS_GFC LK | FUNC_32K_CLK | OSC0 |
| | PICLKKB | Func | 0.032 | WKUPAON_SYS_GFC LK | | |
| | KBD_ICLK | Int | 38.4 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| | PICLKOC | Int | 38.4 | WKUPAON_GICLK | DPLL_ABE_X2_CLK | DPLL_ABE |
| L3_INSTR | L3_CLK | Int | L3_CLK | L3INSTR_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| L3_MAIN | L3_CLK1 | Int | L3_CLK | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | L3_CLK2 | Int | L3_CLK | L3INSTR_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| L4_CFG | L4_CFG_CLK | Int | 133 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| L4_PER1 | L4_PER1_CLK | Int | 133 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| L4_PER2 | L4_PER2_CLK | Int | 133 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| L4_PER3 | L4_PER3_CLK | Int | 133 | L4PER3_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| L4_WKUP | L4_WKUP_CLK | Int | 38.4 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| MAILBOX1 | MAILBOX1_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX2 | MAILBOX2_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX3 | MAILBOX3_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX4 | MAILBOX4_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX5 | MAILBOX5_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX6 | MAILBOX6_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX7 | MAILBOX7_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX8 | MAILBOX8_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX9 | MAILBOX9_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX10 | MAILBOX10_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX11 | MAILBOX11_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX12 | MAILBOX12_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MAILBOX13 | MAILBOX13_FLCK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|----------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| McASP1 | MCASP1_AHCLKR | Func | 100 | MCASP1_AHCLKR | ABE_24M_GFCLK | DPLL_ABE |
| | | | | | ABE_SYS_CLK | OSC0 |
| | | | | | FUNC_24M_GFCLK | DPLL_PER |
| | | | | | ATL_CLK0 | Module ATL |
| | | | | | ATL_CLK1 | Module ATL |
| | | | | | ATL_CLK2 | Module ATL |
| | | | | | ATL_CLK3 | Module ATL |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | MLB_CLK | Module MLB |
| | | | | | MLBP_CLK | Module MLB |
| | | | | | McASP1 | MCASP1_AHCLKX |
| ABE_SYS_CLK | OSC0 | | | | | |
| FUNC_24M_GFCLK | DPLL_PER | | | | | |
| ATL_CLK0 | Module ATL | | | | | |
| ATL_CLK1 | Module ATL | | | | | |
| ATL_CLK2 | Module ATL | | | | | |
| ATL_CLK3 | Module ATL | | | | | |
| SYS_CLK2 | OSC1 | | | | | |
| XREF_CLK0 | XREF_CLK0 | | | | | |
| XREF_CLK1 | XREF_CLK1 | | | | | |
| XREF_CLK2 | XREF_CLK2 | | | | | |
| XREF_CLK3 | XREF_CLK3 | | | | | |
| MLB_CLK | Module MLB | | | | | |
| MLBP_CLK | Module MLB | | | | | |
| McASP1 | MCASP1_FCLK | Func | 192 | MCASP1_AUX_GFCLK | | |
| | | | | | VIDEO1_CLK | DPLL_VIDEO1 |
| | | | | | HDMI_CLK | DPLL_HDMI |
| | | | | | MCASP1_ICLK | Int |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| McASP2 | MCASP2_AHCLKR | Func | 100 | MCASP2_AHCLKR | ABE_24M_GFCLK | DPLL_ABE |
| | | | | | ABE_SYS_CLK | OSC0 |
| | | | | | FUNC_24M_GFCLK | DPLL_PER |
| | | | | | ATL_CLK3 | Module ATL |
| | | | | | ATL_CLK2 | Module ATL |
| | | | | | ATL_CLK1 | Module ATL |
| | | | | | ATL_CLK0 | Module ATL |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | MLB_CLK | Module MLB |
| | | | | | MLBP_CLK | Module MLB |
| McASP2 | MCASP2_AHCLKX | Func | 100 | MCASP2_AHCLKX | ABE_24M_GFCLK | DPLL_ABE |
| | | | | | ABE_SYS_CLK | OSC0 |
| | | | | | FUNC_24M_GFCLK | DPLL_PER |
| | | | | | ATL_CLK3 | Module ATL |
| | | | | | ATL_CLK2 | Module ATL |
| | | | | | ATL_CLK1 | Module ATL |
| | | | | | ATL_CLK0 | Module ATL |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | MLB_CLK | Module MLB |
| | | | | | MLBP_CLK | Module MLB |
| McASP2 | MCASP2_FCLK | Func | 192 | MCASP2_AUX_GFCLK | PER_ABE_X1_GFCLK | DPLL_ABE |
| | | | | | VIDEO1_CLK | DPLL_VIDEO1 |
| | | | | | HDMI_CLK | DPLL_HDMI |
| | | | | | MCASP2_ICLK | Int |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| McASP3 | MCASP3_AHCLKX | Func | 100 | MCASP3_AHCLKX | ABE_24M_GFCLK | DPLL_ABE |
| | | | | | ABE_SYS_CLK | OSC0 |
| | | | | | FUNC_24M_GFCLK | DPLL_PER |
| | | | | | ATL_CLK3 | Module ATL |
| | | | | | ATL_CLK2 | Module ATL |
| | | | | | ATL_CLK1 | Module ATL |
| | | | | | ATL_CLK0 | Module ATL |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | MLB_CLK | Module MLB |
| | | | | | MLBP_CLK | Module MLB |
| | | | | | McASP3 | MCASP3_FCLK |
| VIDEO1_CLK | DPLL_ABE | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| McASP3 | MCASP3_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| McASP4 | MCASP4_AHCLKX | Func | 100 | MCASP4_AHCLKX | ABE_24M_GFCLK | DPLL_ABE |
| | | | | | ABE_SYS_CLK | OSC0 |
| | | | | | FUNC_24M_GFCLK | DPLL_PER |
| | | | | | ATL_CLK3 | Module ATL |
| | | | | | ATL_CLK2 | Module ATL |
| | | | | | ATL_CLK1 | Module ATL |
| | | | | | ATL_CLK0 | Module ATL |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | MLB_CLK | Module MLB |
| | | | | | MLBP_CLK | Module MLB |
| | | | | | McASP4 | MCASP4_FCLK |
| VIDEO1_CLK | DPLL_ABE | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| McASP4 | MCASP4_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| McASP5 | MCASP5_AHCLKX | Func | 100 | MCASP5_AHCLKX | ABE_24M_GFCLK | DPLL_ABE |
| | | | | | ABE_SYS_CLK | OSC0 |
| | | | | | FUNC_24M_GFCLK | DPLL_PER |
| | | | | | ATL_CLK3 | Module ATL |
| | | | | | ATL_CLK2 | Module ATL |
| | | | | | ATL_CLK1 | Module ATL |
| | | | | | ATL_CLK0 | Module ATL |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | MLB_CLK | Module MLB |
| | | | | | MLBP_CLK | Module MLB |
| | | | | | McASP5 | MCASP5_FCLK |
| VIDEO1_CLK | DPLL_ABE | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| McASP5 | MCASP5_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| McASP6 | MCASP6_AHCLKX | Func | 100 | MCASP6_AHCLKX | ABE_24M_GFCLK | DPLL_ABE |
| | | | | | FUNC_24M_GFCLK | DPLL_PER |
| | | | | | ATL_CLK3 | Module ATL |
| | | | | | ATL_CLK2 | Module ATL |
| | | | | | ATL_CLK1 | Module ATL |
| | | | | | ATL_CLK0 | Module ATL |
| | | | | | MLB_CLK | Module MLB |
| | | | | | MLBP_CLK | Module MLB |
| | | | | | ABE_SYS_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | McASP6 | MCASP6_FCLK |
| VIDEO1_CLK | DPLL_ABE | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| McASP6 | MCASP6_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| McASP7 | MCASP7_AHCLKX | Func | 100 | MCASP7_AHCLKX | ABE_24M_GFCLK | DPLL_ABE |
| | | | | | ABE_SYS_CLK | OSC0 |
| | | | | | FUNC_24M_GFCLK | DPLL_PER |
| | | | | | ATL_CLK3 | Module ATL |
| | | | | | ATL_CLK2 | Module ATL |
| | | | | | ATL_CLK1 | Module ATL |
| | | | | | ATL_CLK0 | Module ATL |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | MLB_CLK | Module MLB |
| | | | | | MLBP_CLK | Module MLB |
| | | | | | McASP7 | MCASP7_FCLK |
| VIDEO1_CLK | DPLL_ABE | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| McASP7 | MCASP7_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| McASP8 | MCASP8_AHCLKX | Func | 100 | MCASP8_AHCLKX | ABE_24M_GFCLK | DPLL_ABE |
| | | | | | ABE_SYS_CLK | OSC0 |
| | | | | | FUNC_24M_GFCLK | DPLL_PER |
| | | | | | ATL_CLK3 | Module ATL |
| | | | | | ATL_CLK2 | Module ATL |
| | | | | | ATL_CLK1 | Module ATL |
| | | | | | ATL_CLK0 | Module ATL |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | MLB_CLK | Module MLB |
| | | | | | MLBP_CLK | Module MLB |
| | | | | | McASP8 | MCASP8_FCLK |
| VIDEO1_CLK | DPLL_ABE | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| McASP8 | MCASP8_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| McSPI1 | SPI1_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SPI1_FCLK | Func | 48 | PER_48M_GFCLK | PER_48M_GFCLK | DPLL_PER |
| McSPI2 | SPI2_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SPI2_FCLK | Func | 48 | PER_48M_GFCLK | PER_48M_GFCLK | DPLL_PER |
| McSPI3 | SPI3_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SPI3_FCLK | Func | 48 | PER_48M_GFCLK | PER_48M_GFCLK | DPLL_PER |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|-----------------------|------------|--------------------------|------------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| McSPI4 | SPI4_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SPI4_FCLK | Func | 48 | PER_48M_GFCLK | PER_48M_GFCLK | DPLL_PER |
| MLB_SS | MLB_L3_ICLK | Int | 266 | MLB_SHB_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | MLB_L4_ICLK | Int | 133 | MLB_SPB_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| | MLB_FCLK | Func | 266 | MLB_SYS_L3_GFCLK | CORE_X2_CLK | DPLL_CORE |
| CSI2_0 | CTRLCLK | Int & Func | 96 | LVDSRX_96M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | CAL_FCLK | Int & Func | 266 | CAL_GICLK | CORE_ISS_MAIN_CLK | DPLL_CORE |
| | | | | | L3_ICLK | CM_CORE_AON |
| CSI2_1 | CTRLCLK | Int & Func | 96 | LVDSRX_96M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | CAL_FCLK | Int & Func | 266 | CAL_GICLK | CORE_ISS_MAIN_CLK | DPLL_CORE |
| | | | | | L3_ICLK | CM_CORE_AON |
| MMC1 | MMC1_CLK_32K | Func | 0.032 | L3INIT_32K_GFCLK | FUNC_32K_CLK | OSC0 |
| | MMC1_FCLK | Func | 192 | MMC1_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | | | 128 | | FUNC_256M_CLK | DPLL_PER |
| | MMC1_ICLK1 | Int | 266 | L3INIT_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | MMC1_ICLK2 | Int | 133 | L3INIT_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| MMC2 | MMC2_CLK_32K | Func | 0.032 | L3INIT_32K_GFCLK | FUNC_32K_CLK | OSC0 |
| | MMC2_FCLK | Func | 192 | MMC2_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | | | 128 | | FUNC_256M_CLK | DPLL_PER |
| | MMC2_ICLK1 | Int | 266 | L3INIT_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | MMC2_ICLK2 | Int | 133 | L3INIT_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| MMC3 | MMC3_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | MMC3_CLK_32K | Func | 0.032 | L4PER_32K_GFCLK | FUNC_32K_CLK | OSC0 |
| | MMC3_FCLK | Func | 48 | MMC3_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | | | 192 | | | |
| MMC4 | MMC4_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | MMC4_CLK_32K | Func | 0.032 | L4PER_32K_GFCLK | FUNC_32K_CLK | OSC0 |
| | MMC4_FCLK | Func | 48 | MMC4_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | | | 192 | | | |
| MMU_EDMA | MMU1_CLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MMU_PCIESS | MMU2_CLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| MPU | MPU_CLK | Int & Func | MPU_CLK | MPU_GCLK | MPU_GCLK | DPLL_MPU |
| MPU_EMU_DBG | FCLK | Int | 38.4 | EMU_SYS_CLK | SYS_CLK1 | OSC0 |
| | | | | | MPU_GCLK | DPLL_MPU |
| OCMC_RAM1 | OCMC1_L3_CLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| OCMC_ROM | OCMC_L3_CLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| OCP_WP_NOC | PICLKOCPL3 | Int | 266 | L3INSTR_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| OCP2SCP1 | L4CFG1_ADAPTE R_CLKIN | Int | 133 | L3INIT_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| OCP2SCP2 | L4CFG2_ADAPTE R_CLKIN | Int | 133 | L4CFG_L4_GICLK | CORE_X2_CLK | DPLL_CORE |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|--------------------------|---------------|--------------------------|-----------------------------|----------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| OCP2SCP3 | L4CFG3_ADAPTE R_CLKIN | Int | 133 | L3INIT_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| PCISS1 | PCIE1_PHY_WKU P_CLK | Func | 0.032 | PCIE_32K_GFCLK | FUNC_32K_CLK | OSC0 |
| | PCle_SS1_FICLK | Int & Func | 266 | PCIE_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | PCIEPHY_CLK | Func | 2500 | PCIE_PHY_GCLK | PCIE_PHY_GCLK | APLL_PCIE |
| | PCIEPHY_CLK_DI V | Func | 1250 | PCIE_PHY_DIV_GCLK | PCIE_PHY_DIV_G CLK | APLL_PCIE |
| | PCIE1_REF_CLKI N | Func | 34.3 | PCIE_REF_GFCLK | CORE_USB_OTG_ SS_LFPS_TX_CLK | DPLL_CORE |
| | PCIE1_PWR_CLK | Func | 38.4 | PCIE_SYS_GFCLK | SYS_CLK1 | OSC0 |
| PCISS2 | PCIE2_PHY_WKU P_CLK | Func | 0.032 | PCIE_32K_GFCLK | FUNC_32K_CLK | OSC0 |
| | PCle_SS2_FICLK | Int & Func | 266 | PCIE_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | PCIEPHY_CLK | Func | 2500 | PCIE_PHY_GCLK | PCIE_PHY_GCLK | APLL_PCIE |
| | PCIEPHY_CLK_DI V | Func | 1250 | PCIE_PHY_DIV_GCLK | PCIE_PHY_DIV_G CLK | APLL_PCIE |
| | PCIE2_REF_CLKI N | Func | 34.3 | PCIE_REF_GFCLK | CORE_USB_OTG_ SS_LFPS_TX_CLK | DPLL_CORE |
| | PCIE2_PWR_CLK | Func | 38.4 | PCIE_SYS_GFCLK | SYS_CLK1 | OSC0 |
| PRCM_MPU | 32K_CLK | Func | 0.032 | FUNC_32K_CLK | SYS_CLK1/610 | OSC0 |
| | SYS_CLK | Func | 38.4 | WKUPAON_ICLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CL K | DPLL_ABE |
| PWMSS1 | PWMSS1_GICLK | Int & Func | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| PWMSS2 | PWMSS2_GICLK | Int & Func | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| PWMSS3 | PWMSS3_GICLK | Int & Func | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| QSPI | QSPI_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | QSPI_FCLK | Func | 128 | QSPI_GFCLK | FUNC_256M_CLK PER_QSPI_CLK | DPLL_PER DPLL_PER |
| RNG | RNG_ICLK | Int | 266 | L4SEC_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| RTC_SS | RTC_ICLK | Int | 133 | RTC_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| | RTC_FCLK | Func | RTC_FCLK | RTC_AUX_CLK FUNC_32K_CLK | rtc_osc_xi_clk32 SYS_CLK1/610 | RTC Oscillator OSC0 |
| SAR_ROM | PRCM_ROM_CLO CK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| SATA | SATA_FICLK | Int | 266 | L3INIT_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SATA_PMALIVE_F CLK | Func | 48 | L3INIT_48M_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | REF_CLK | Func | 38 | SATA_REF_GFCLK | SYS_CLK1 | OSC0 |
| SDMA | SDMA_FCLK | Int & Func | 266 | DMA_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| SHA2MD51 | SHAM_1_CLK | Int | 266 | L4SEC_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| SHA2MD52 | SHAM_2_CLK | Int | 266 | L4SEC_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| SL2 | IVA_GCLK | Int | IVA_GCLK | IVA_GCLK | IVA_GFCLK | DPLL_IVA |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|-------------------|------------------|-------------|--------------------------|------------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| SMARTREFLEX_CORE | MCLK | Int | 133 | COREAON_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SYSCLK | Func | 38.4 | WKUPAON_ICLK | SYS_CLK1 DPLL_ABE_X2_CLK | OSC0 DPLL_ABE |
| SMARTREFLEX_DSP | MCLK | Int | 133 | COREAON_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SYSCLK | Func | 38.4 | WKUPAON_ICLK | SYS_CLK1 DPLL_ABE_X2_CLK | OSC0 DPLL_ABE |
| SMARTREFLEX_GPU | MCLK | Int | 133 | COREAON_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SYSCLK | Func | 38.4 | WKUPAON_ICLK | SYS_CLK1 DPLL_ABE_X2_CLK | OSC0 DPLL_ABE |
| SMARTREFLEX_IVAHD | MCLK | Int | 133 | COREAON_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SYSCLK | Func | 38.4 | WKUPAON_ICLK | SYS_CLK1 DPLL_ABE_X2_CLK | OSC0 DPLL_ABE |
| SMARTREFLEX_MPU | MCLK | Int | 133 | COREAON_L4_GICLK | CORE_X2_CLK | DPLL_CORE |
| | SYSCLK | Func | 38.4 | WKUPAON_ICLK | SYS_CLK1 DPLL_ABE_X2_CLK | OSC0 DPLL_ABE |
| SPINLOCK | SPINLOCK_ICLK | Int | 266 | L4CFG_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| TIMER1 | TIMER1_ICLK | Int | 38.4 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| | TIMER1_FCLK | Func | 100 | TIMER1_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| TIMER2 | TIMER2_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER2_FCLK | Func | 100 | TIMER2_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| | VIDEO1_CLK | DPLL_VIDEO1 | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| TIMER3 | TIMER3_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER3_FCLK | Func | 100 | TIMER3_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| TIMER4 | TIMER4_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER4_FCLK | Func | 100 | TIMER4_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| TIMER5 | TIMER5_ICLK | Int | 266 | IPU_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER5_FCLK | Func | 100 | TIMER5_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| CLKOUTMUX[0] | CLKOUTMUX[0] | | | | | |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| TIMER6 | TIMER6_ICLK | Int | 266 | IPU_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER6_FCLK | Func | 100 | TIMER6_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| | | | | | VIDEO1_CLK | DPLL_VIDEO1 |
| HDMI_CLK | DPLL_HDMI | | | | | |
| CLKOUTMUX[0] | CLKOUTMUX[0] | | | | | |
| TIMER7 | TIMER7_ICLK | Int | 266 | IPU_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER7_FCLK | Func | 100 | TIMER7_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| | | | | | VIDEO1_CLK | DPLL_VIDEO1 |
| HDMI_CLK | DPLL_HDMI | | | | | |
| CLKOUTMUX[0] | CLKOUTMUX[0] | | | | | |
| TIMER8 | TIMER8_ICLK | Int | 266 | IPU_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER8_FCLK | Func | 100 | TIMER8_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| | | | | | VIDEO1_CLK | DPLL_VIDEO1 |
| HDMI_CLK | DPLL_HDMI | | | | | |
| CLKOUTMUX[0] | CLKOUTMUX[0] | | | | | |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| TIMER9 | TIMER9_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER9_FCLK | Func | 100 | TIMER9_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| TIMER10 | TIMER10_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER10_FCLK | Func | 100 | TIMER10_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| TIMER11 | TIMER11_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER11_FCLK | Func | 100 | TIMER11_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| TIMER12 | TIMER12_ICLK | Int | 38.4 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| | TIMER12_FCLK | Func | 0.032 | OSC_32K_CLK | DPLL_ABE_X2_CLK | DPLL_ABE |
| | | | | | RC_CLK | RC oscillator |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|------------------|------------|--------------------------|-----------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| TIMER13 | TIMER13_ICLK | Int | 266 | L4PER3_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER13_FCLK | Func | 100 | TIMER13_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| TIMER14 | TIMER14_ICLK | Int | 266 | L4PER3_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER14_FCLK | Func | 100 | TIMER14_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| TIMER15 | TIMER15_ICLK | Int | 266 | L4PER3_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER15_FCLK | Func | 100 | TIMER15_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|-------------------|------------|--------------------------|--------------------|-------------------------------|-----------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| TIMER16 | TIMER16_ICLK | Int | 266 | L4PER3_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | TIMER16_FCLK | Func | 100 | TIMER16_GFCLK | SYS_CLK1 | OSC0 |
| | | | | | FUNC_32K_CLK | OSC0 |
| | | | | | SYS_CLK2 | OSC1 |
| | | | | | XREF_CLK0 | XREF_CLK0 |
| | | | | | XREF_CLK1 | XREF_CLK1 |
| | | | | | XREF_CLK2 | XREF_CLK2 |
| | | | | | XREF_CLK3 | XREF_CLK3 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| VIDEO1_CLK | DPLL_VIDEO1 | | | | | |
| HDMI_CLK | DPLL_HDMI | | | | | |
| TPCC | TPCC_GCLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| TPTC1 | TPTC0_GCLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| TPTC2 | TPTC1_GCLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART1 | UART1_FCLK | Func | 48 | UART1_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART1_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART2 | UART2_FCLK | Func | 48 | UART2_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART2_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART3 | UART3_FCLK | Func | 48 | UART3_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART3_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART4 | UART4_FCLK | Func | 48 | UART4_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART4_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART5 | UART5_FCLK | Func | 48 | UART5_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART5_ICLK | Int | 266 | L4PER_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART6 | UART6_FCLK | Func | 48 | UART6_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART6_ICLK | Int | 266 | IPU_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART7 | UART7_FCLK | Func | 48 | UART7_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART7_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART8 | UART8_FCLK | Func | 48 | UART8_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART8_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART9 | UART9_FCLK | Func | 48 | UART9_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART9_ICLK | Int | 266 | L4PER2_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| UART10 | UART10_FCLK | Func | 48 | UART10_GFCLK | FUNC_192M_CLK | DPLL_PER |
| | UART10_ICLK | Int | 38.4 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| USB1 | USB1_MICLK | Int | 266 | L3INIT_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | | | | | USB_LFPS_TX_GFCLK | CORE_USB_OTG_SS_LFPS_TX_CLK |
| | USB2PHY1_TREF_CLK | Func | 38.4 | USB_OTG_SS_REF_CLK | SYS_CLK1 | OSC0 |
| | USB2PHY1_REF_CLK | Func | 960 | L3INIT_960M_GFCLK | L3INIT_960_GFCLK | DPLL_USB |

Table 5-9. Maximum Supported Frequency (continued)

| MODULE | | | | CLOCK SOURCES | | |
|---------------|-------------------|------------|--------------------------|--------------------|-------------------------------|-------------------------|
| INSTANCE NAME | INPUT CLOCK NAME | CLOCK TYPE | MAX. CLOCK ALLOWED (MHz) | PRCM CLOCK NAME | PLL / OSC / SOURCE CLOCK NAME | PLL / OSC / SOURCE NAME |
| USB2 | USB2_MICLK | Int | 266 | L3INIT_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | USB2PHY2_TREF_CLK | Func | 38.4 | USB_OTG_SS_REF_CLK | SYS_CLK1 | OSC0 |
| | USB2PHY2_REF_CLK | Func | 960 | L3INIT_960M_GFCLK | L3INIT_960_GFCLK | DPLL_USB |
| USB3 | USB3_MICLK | Int | 266 | L3INIT_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| | USB3PHY_PWRS_CLK | Func | 38.4 | USB_OTG_SS_REF_CLK | SYS_CLK1 | OSC0 |
| USB_PHY1_CORE | USB2PHY1_WKUP_CLK | Func | 0.032 | COREAON_32K_GFCLK | SYS_CLK1/610 | OSC0 |
| USB_PHY2_CORE | USB2PHY2_WKUP_CLK | Func | 0.032 | COREAON_32K_GFCLK | SYS_CLK1/610 | OSC0 |
| USB_PHY3_CORE | USB3PHY_WKUP_CLK | Func | 0.032 | COREAON_32K_GFCLK | SYS_CLK1/610 | OSC0 |
| VCP1 | VCP1_CLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| VCP2 | VCP2_CLK | Int | 266 | L3MAIN1_L3_GICLK | CORE_X2_CLK | DPLL_CORE |
| VIP1 | L3_CLK_PROC_CLK | Int & Func | 266 | VIP1_GICLK | CORE_X2_CLK | DPLL_CORE |
| | | | | | CORE_ISS_MAIN_CLK | DPLL_CORE |
| VPE | L3_CLK_PROC_CLK | Int & Func | 300 | VPE_GICLK | CORE_ISS_MAIN_CLK | DPLL_CORE |
| | | | | | VIDEO1_CLKOUT4 | DPLL_VIDEO1 |
| WD_TIMER1 | PIOCPCLK | Int | 38.4 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| | PITIMERCLK | Func | 0.032 | OSC_32K_CLK | RC_CLK | RC oscillator |
| WD_TIMER2 | WD_TIMER2_ICLK | Int | 38.4 | WKUPAON_GICLK | SYS_CLK1 | OSC0 |
| | | | | | DPLL_ABE_X2_CLK | DPLL_ABE |
| | WD_TIMER2_FCLK | Func | 0.032 | WKUPAON_SYS_GFCLK | FUNC_32K_CLK | OSC0 |

5.6 Power Consumption Summary

NOTE

Maximum power consumption for this SoC depends on the specific use conditions for the end system. Contact your TI representative for assistance in estimating maximum power consumption for the end system use case.

5.7 Electrical Characteristics

NOTE

The data specified in [Section 5.7.1](#) through [Section 5.7.14](#) are subject to change.

NOTE

The interfaces or signals described in [Section 5.7.1](#) through [Section 5.7.14](#) correspond to the interfaces or signals available in multiplexing mode 0 (Function 1).

All interfaces or signals multiplexed on the balls described in these tables have the same DC electrical characteristics, unless multiplexing involves a PHY/GPIO combination in which case different DC electrical characteristics are specified for the different multiplexing modes (Functions).

5.7.1 LVC MOS DDR DC Electrical Characteristics

Table 5-10 summarizes the DC electrical characteristics for LVC MOS DDR Buffers.

NOTE

For more information on the I/O cell configurations (i[2:0], sr[1:0]), see *Control Module* chapter in the device TRM.

Table 5-10. LVC MOS DDR DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|--|--|------------------------|----------------------------|----------------------------|------|
| Signal Names in MUXMODE 0 (Single-Ended Signals): ddr1_d[31:0] / ddr1_a[15:0] / ddr1_dqm[3:0] / ddr1_ba[2:0] / ddr1_csn[1:0] / ddr1_cke / ddr1_odt[1:0] / ddr1_casn / ddr1_rasn / ddr1_wen / ddr1_rst / ddr1_ecc_d[7:0] / ddr1_dqm_ecc | | | | | |
| Balls: AH23 / AB16 / AG22 / AE20 / AC17 / AC18 / AF20 / AH21 / AG21 / AF17 / AE18 / AB18 / AD20 / AC19 / AC20 / AB19 / AF21 / AH22 / AG23 / AE21 / AF22 / AE22 / AD21 / AD22 / AC21 / AF18 / AE17 / AD18 / AF25 / AF26 / AG26 / AH26 / AF24 / AE24 / AF23 / AE23 / AC23 / AF27 / AG27 / AF28 / AE26 / AC25 / AC24 / AD25 / V20 / W20 / AB28 / AC28 / AC27 / Y19 / AB27 / Y20 / AA23 / Y22 / Y23 / AA24 / Y24 / AA26 / AA25 / AA28 / W22 / V23 / W19 / W23 / Y25 / V24 / V25 / Y26 / AD23 / AB23 / AC26 / AA27 / V26 | | | | | |
| Driver Mode | | | | | |
| V _{OH} | High-level output threshold (I _{OH} = 0.1 mA) | 0.9 × V _{DD5} | | | V |
| V _{OL} | Low-level output threshold (I _{OL} = 0.1 mA) | | | 0.1 × V _{DD5} | V |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 3 | pF |
| Z _O | Output impedance (drive strength) | I[2:0] = 000 (Imp80) | 80 | | Ω |
| | | I[2:0] = 001 (Imp60) | 60 | | |
| | | I[2:0] = 010 (Imp48) | 48 | | |
| | | I[2:0] = 011 (Imp40) | 40 | | |
| | | I[2:0] = 100 (Imp34) | 34 | | |
| Single-Ended Receiver Mode | | | | | |
| V _{IH} | High-level input threshold | DDR3/DDR3L | VREF + 0.1 | V _{DD5} + 0.2 | V |
| V _{IL} | Low-level input threshold | DDR3/DDR3L | -0.2 | VREF - 0.1 | V |
| V _{CM} | Input common-mode voltage | | VREF - 10%v _{dd5} | VREF + 10%v _{dd5} | V |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 3 | pF |
| Signal Names in MUXMODE 0 (Differential Signals): ddr1_dqs[3:0] / ddr1_dqsn[3:0] / ddr1_ck / ddr1_nck / ddr1_dqs_ecc / ddr1_dqsn_ecc | | | | | |
| Bottom Balls: AH25 / AG25 / AE27 / AE28 / AD27 / AD28 / Y28 / Y27 / V27 / V28 / AG24 / AH24 | | | | | |
| Driver Mode | | | | | |
| V _{OH} | High-level output threshold (I _{OH} = 0.1 mA) | 0.9 × V _{DD5} | | | V |
| V _{OL} | Low-level output threshold (I _{OL} = 0.1 mA) | | | 0.1 × V _{DD5} | V |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 3 | pF |

Table 5-10. LVCMOS DDR DC Electrical Characteristics (continued)

| PARAMETER | | | MIN | NOM | MAX | UNIT |
|-----------------------------------|---|----------------------|----------------------------|-----|----------------------------|------|
| Z _O | Output impedance (drive strength) | I[2:0] = 000 (Imp80) | | 80 | | Ω |
| | | I[2:0] = 001 (Imp60) | | 60 | | |
| | | I[2:0] = 010 (Imp48) | | 48 | | |
| | | I[2:0] = 011 (Imp40) | | 40 | | |
| | | I[2:0] = 100 (Imp34) | | 34 | | |
| Single-Ended Receiver Mode | | | | | | |
| V _{IH} | High-level input threshold | DDR3/DDR3L | VREF + 0.1 | | VDD _S + 0.2 | V |
| V _{IL} | Low-level input threshold | DDR3/DDR3L | -0.2 | | VREF - 0.1 | V |
| V _{CM} | Input common-mode voltage | | VREF - 10%v _{dds} | | VREF + 10%v _{dds} | V |
| C _{PAD} | Pad capacitance (including package capacitance) | | | | 3 | pF |
| Differential Receiver Mode | | | | | | |
| V _{SWING} | Input voltage swing | DDR3/DDR3L | 0.2 | | v _{dds} + 0.4 | V |
| V _{CM} | Input common-mode voltage | | VREF - 10%v _{dds} | | VREF + 10%v _{dds} | V |
| C _{PAD} | Pad capacitance (including package capacitance) | | | | 3 | pF |

- (1) VDD_S stands for corresponding power supply (that is, v_{dds}_ddr1). For more information on the power supply name and the corresponding ball, see [Table 4-2](#), POWER [10] column.
- (2) VREF stands for corresponding Reference Power Supply (that is, ddr1_vref0). For more information on the power supply name and the corresponding ball, see [Table 4-2](#), POWER [10] column.
- (3) For more information on the I/O cell configurations (i[2:0], sr[1:0]), see the *Control Module* chapter in the device TRM.

5.7.2 HDMIPHY DC Electrical Characteristics

The HDMIPHY DC Electrical Characteristics are compliant with the HDMI 1.4a specification and are not reproduced here.

5.7.3 Dual Voltage LVCMOS I2C DC Electrical Characteristics

[Table 5-11](#) summarizes the DC electrical characteristics for Dual Voltage LVCMOS I2C Buffers.

NOTE

For more information on the IO cell configurations, see *Control Module* section in the device TRM.

Table 5-11. Dual Voltage LVCMOS I2C DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|---|--|------------------------|------------------------|-----|------|
| Signal Names in MUXMODE 0: i2c2_scl / i2c1_scl / i2c1_sda / i2c2_sda | | | | | |
| Balls: F17 / C20 / C21 / C25 | | | | | |
| I2C Standard Mode – 1.8 V | | | | | |
| V _{IH} | Input high-level threshold | 0.7 × VDD _S | | | V |
| V _{IL} | Input low-level threshold | | 0.3 × VDD _S | | V |
| V _{hys} | Hysteresis | 0.1 × VDD _S | | | V |
| I _{IN} | Input current at each I/O pin with an input voltage between 0.1 × VDD _S to 0.9 × VDD _S | | | 12 | μA |

Table 5-11. Dual Voltage LVC MOS I2C DC Electrical Characteristics (continued)

| PARAMETER | | MIN | NOM | MAX | UNIT |
|----------------------------------|---|-----------------------|-----|-------------------|---------|
| I_{OZ} | $I_{OZ}(I_{PAD}$ Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDD5 and the $Max(I_{PAD})$ is measured and is reported as I_{OZ} | | | 12 | μA |
| C_{IN} | Input capacitance | | | 10 | pF |
| V_{OL3} | Output low-level threshold open-drain at 3-mA sink current | | | $0.2 \times VDD5$ | V |
| I_{OLmin} | Low-level output current @ $V_{OL}=0.2 \times VDD5$ | 3 | | | mA |
| t_{OF} | Output fall time from V_{IHmin} to V_{ILmax} with a bus capacitance CB from 5 pF to 400 pF | | | 250 | ns |
| I2C Fast Mode – 1.8 V | | | | | |
| V_{IH} | Input high-level threshold | $0.7 \times VDD5$ | | | V |
| V_{IL} | Input low-level threshold | | | $0.3 \times VDD5$ | V |
| V_{hys} | Hysteresis | $0.1 \times VDD5$ | | | V |
| I_{IN} | Input current at each I/O pin with an input voltage between $0.1 \times VDD5$ to $0.9 \times VDD5$ | | | 12 | μA |
| I_{OZ} | $I_{OZ}(I_{PAD}$ Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDD5 and the $Max(I_{PAD})$ is measured and is reported as I_{OZ} | | | 12 | μA |
| C_{IN} | Input capacitance | | | 10 | pF |
| V_{OL3} | Output low-level threshold open-drain at 3-mA sink current | | | $0.2 \times VDD5$ | V |
| I_{OLmin} | Low-level output current @ $V_{OL}=0.2 \times VDD5$ | 3 | | | mA |
| t_{OF} | Output fall time from V_{IHmin} to V_{ILmax} with a bus capacitance CB from 10 pF to 400 pF | $20 + 0.1 \times C_b$ | | 250 | ns |
| I2C Standard Mode – 3.3 V | | | | | |
| V_{IH} | Input high-level threshold | $0.7 \times VDD5$ | | | V |
| V_{IL} | Input low-level threshold | | | $0.3 \times VDD5$ | V |
| V_{hys} | Hysteresis | $0.05 \times VDD5$ | | | V |
| I_{IN} | Input current at each I/O pin with an input voltage between $0.1 \times VDD5$ to $0.9 \times VDD5$ | 31 | | 80 | μA |
| I_{OZ} | $I_{OZ}(I_{PAD}$ Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDD5 and the $Max(I_{PAD})$ is measured and is reported as I_{OZ} | 31 | | 80 | μA |
| C_{IN} | Input capacitance | | | 10 | pF |
| V_{OL3} | Output low-level threshold open-drain at 3-mA sink current | | | 0.4 | V |
| I_{OLmin} | Low-level output current @ $V_{OL}=0.4V$ | 3 | | | mA |
| I_{OLmin} | Low-level output current @ $V_{OL}=0.6V$ for full drive load (400pF/400KHz) | 6 | | | mA |
| t_{OF} | Output fall time from V_{IHmin} to V_{ILmax} with a bus capacitance CB from 5 pF to 400 pF | | | 250 | ns |
| I2C Fast Mode – 3.3 V | | | | | |
| V_{IH} | Input high-level threshold | $0.7 \times VDD5$ | | | V |
| V_{IL} | Input low-level threshold | | | $0.3 \times VDD5$ | V |
| V_{hys} | Hysteresis | $0.05 \times VDD5$ | | | V |
| I_{IN} | Input current at each I/O pin with an input voltage between $0.1 \times VDD5$ to $0.9 \times VDD5$ | 31 | | 80 | μA |

Table 5-11. Dual Voltage LVCMOS I2C DC Electrical Characteristics (continued)

| PARAMETER | | MIN | NOM | MAX | UNIT |
|--------------------|---|---------------------------|-----|-----|------|
| I _{OZ} | I _{OZ} (I _{PAD} Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V _{DDS} and the Max(I _{PAD}) is measured and is reported as I _{OZ} | 31 | | 80 | μA |
| C _{IN} | Input capacitance | | | 10 | pF |
| V _{OL3} | Output low-level threshold open-drain at 3-mA sink current | | | 0.4 | V |
| I _{OLmin} | Low-level output current @V _{OL} =0.4V | 3 | | | mA |
| I _{OLmin} | Low-level output current @V _{OL} =0.6V for full drive load (400pF/400KHz) | 6 | | | mA |
| t _{OF} | Output fall time from V _{IHmin} to V _{ILmax} with a bus capacitance CB from 10 pF to 200 pF (Proper External Resistor Value should be used as per I2C spec) | 20 + 0.1 × C _b | | 250 | ns |
| | Output fall time from V _{IHmin} to V _{ILmax} with a bus capacitance CB from 300 pF to 400 pF (Proper External Resistor Value should be used as per I2C spec) | 40 | | 290 | |

(1) V_{DDS} stands for corresponding power supply (that is, vddshv3). For more information on the power supply name and the corresponding ball, see [Table 4-2, POWER \[10\]](#) column.

5.7.4 IQ1833 Buffers DC Electrical Characteristics

[Table 5-12](#) summarizes the DC electrical characteristics for IQ1833 Buffers.

Table 5-12. IQ1833 Buffers DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|--|---|-------------------------|-----|-------------------------|------|
| Signal Names in MUXMODE 0: tclk | | | | | |
| Balls: E20 | | | | | |
| 1.8-V Mode | | | | | |
| V _{IH} | Input high-level threshold (Does not meet JEDEC V _{IH}) | 0.75 × V _{DDS} | | | V |
| V _{IL} | Input low-level threshold (Does not meet JEDEC V _{IL}) | | | 0.25 × V _{DDS} | V |
| V _{HYS} | Input hysteresis voltage | 100 | | | mV |
| I _{IN} | Input current at each I/O pin | 2 | | 11 | μA |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 1 | pF |
| 3.3-V Mode | | | | | |
| V _{IH} | Input high-level threshold (Does not meet JEDEC V _{IH}) | 2.0 | | | V |
| V _{IL} | Input low-level threshold (Does not meet JEDEC V _{IL}) | | | 0.6 | V |
| V _{HYS} | Input hysteresis voltage | 400 | | | mV |
| I _{IN} | Input current at each I/O pin | 5 | | 11 | μA |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 1 | pF |

(1) V_{DDS} stands for corresponding power supply (that is, vddshv3). For more information on the power supply name and the corresponding ball, see [Table 4-2, POWER \[10\]](#) column.

5.7.5 IHHV1833 Buffers DC Electrical Characteristics

[Table 5-13](#) summarizes the DC electrical characteristics for IHHV1833 Buffers.

Table 5-13. IHHV1833 Buffers DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|---|---|------|-----|-----|------|
| Signal Names in MUXMODE 0: porz / rtc_porz / wakeup3 / wakeup0 | | | | | |
| Balls: F22 / AB17 / AD17 / AC16 | | | | | |
| 1.8-V Mode | | | | | |
| V _{IH} | Input high-level threshold | 1.2 | | | V |
| V _{IL} | Input low-level threshold | | | 0.4 | V |
| V _{HYS} | Input hysteresis voltage | 40 | | | mV |
| I _{IN} | Input current at each I/O pin | 0.02 | | 1 | μA |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 1 | pF |
| 3.3-V Mode | | | | | |
| V _{IH} | Input high-level threshold | 1.2 | | | V |
| V _{IL} | Input low-level threshold | | | 0.4 | V |
| V _{HYS} | Input hysteresis voltage | 40 | | | mV |
| I _{IN} | Input current at each I/O pin | 5 | | 8 | μA |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 1 | pF |

5.7.6 LVCMOS OSC Buffers DC Electrical Characteristics

Table 5-14 summarizes the DC electrical characteristics for LVCMOS OSC Buffers.

Table 5-14. LVCMOS OSC Buffers DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|---|---|-------------------------|-----|-------------------------|------|
| Signal Names in MUXMODE 0: rtc_osc_xi_clkln32 / rtc_osc_xo | | | | | |
| Balls: AE14 / AD14 | | | | | |
| 1.8-V Mode | | | | | |
| V _{IH} | Input high-level threshold | 0.65 × V _{DD5} | | | V |
| V _{IL} | Input low-level threshold | | | 0.35 × V _{DD5} | V |
| V _{HYS} | Input hysteresis voltage | 150 | | | mV |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 3 | pF |

(1) V_{DD5} stands for corresponding power supply (that is, vdda_rtc). For more information on the power supply name and the corresponding ball, see Table 4-2, POWER [10] column.

5.7.7 LVCMOS CSI2 DC Electrical Characteristics

Table 5-15 summarizes the DC electrical characteristics for LVCMOS CSI2 Buffers.

Table 5-15. LVCMOS CSI2 DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|--|---|-----|-----|------|------|
| Signals MUXMODE0 : csi2_0_dx[4:0] / csi2_0_dy[4:0] / csi2_1_dx[2:0] / csi2_1_dy[2:0] | | | | | |
| Bottom Balls: AE1 / AD2 / AF1 / AE2 / AF2 / AF3 / AH4 / AG4 / AH3 / AG3 / AG5 / AH5 / AG6 / AH6 / AH7 / AG7 | | | | | |
| MIPI D-PHY Mode Low-Power Receiver (LP-RX) | | | | | |
| V _{IH} | Input high-level voltage | 880 | | 1350 | mV |
| V _{IL} | Input low-level voltage | | | 550 | mV |
| V _{ITH} | Input high-level threshold ⁽¹⁾ | | | 880 | mV |
| V _{ITL} | Input low-level threshold ⁽²⁾ | 550 | | | mV |
| V _{HYS} | Input hysteresis ⁽³⁾ | 25 | | | mV |
| MIPI D-PHY Mode Ultralow Power Receiver (ULP-RX) | | | | | |

Table 5-15. LVCMOS CSI2 DC Electrical Characteristics (continued)

| PARAMETER | | MIN | NOM | MAX | UNIT |
|--|--|-----|-----|-----|------|
| V _{IL} | Input low-level voltage | | | 300 | mV |
| V _{ITL} | Input low-level threshold ⁽⁴⁾ | 300 | | | mV |
| V _{HYS} | Input hysteresis ⁽³⁾ | 25 | | | mV |
| MIPI D-PHY Mode High Speed Receiver (HS-RX) | | | | | |
| V _{IDTH} | Differential input high-level threshold | 70 | | | mV |
| V _{IDTL} | Differential input low-level threshold | | | -70 | mV |
| V _{IDMAX} | Maximum differential input voltage ⁽⁷⁾ | | | 270 | mV |
| V _{IHHS} | Single-ended input high voltage ⁽⁵⁾ | | | 460 | mV |
| V _{ILHS} | Single-ended input low voltage ⁽⁵⁾ | -40 | | | mV |
| V _{CMRXDC} | Differential input common-mode voltage ⁽⁵⁾⁽⁶⁾ | 70 | | 330 | mV |
| Z _{ID} | Differential input impedance | 80 | 100 | 125 | Ω |

- (1) V_{ITH} is the voltage at which the receiver is required to detect a high state in the input signal.
- (2) V_{ITL} is the voltage at which the receiver is required to detect a low state in the input signal. V_{ITL} is larger than the maximum single-ended line high voltage during HS transmission. Therefore, both low-power (LP) receivers will detect low during HS signaling.
- (3) To reduce noise sensitivity on the received signal, the LP receiver is required to incorporate a hysteresis, V_{HYST}. V_{HYST} is the difference between the V_{ITH} threshold and the V_{ITL} threshold.
- (4) V_{ITL} is the voltage at which the receiver is required to detect a low state in the input signal. Specification is relaxed for detecting 0 during ultralow power (ULP) state. The LP receiver is not required to detect HS single-ended voltage as 0 in this state.
- (5) Excluding possible additional RF interference of 200 mV_{PP} beyond 450 MHz.
- (6) This value includes a ground difference of 50 mV between the transmitter and the receiver, the static common-mode level tolerance and variations below 450 MHz.
- (7) This number corresponds to the VOD_{MAX} transmitter.
- (8) Common mode is defined as the average voltage level of X and Y: V_{CMRX} = (V_X + V_Y) / 2.
- (9) Common mode ripple may be due to t_R or t_F and transmission line impairments in the PCB.
- (10) For more information regarding the pin name (or ball name) and corresponding signal name, see [Table 4-7 CSI 2 Signal Descriptions](#).

5.7.8 BMLB18 Buffers DC Electrical Characteristics

[Table 5-16](#) summarizes the DC electrical characteristics for BMLB18 Buffers.

Table 5-16. BMLB18 Buffers DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|---|--|------------------------|------|-----|------|
| Signal Names in MUXMODE 0: mlbp_dat_n / mlbp_dat_p / mlbp_sig_n / mlbp_sig_p / mlbp_clk_n / mlbp_clk_p | | | | | |
| Balls: AA2 / AA1 / AC2 / AC1 / AB2 / AB1 | | | | | |
| 1.8-V Mode | | | | | |
| V _{IH} /V _{IL} | Input high-level threshold | V _{CM} ± 50mV | | | V |
| V _{HYS} | Input hysteresis voltage | | NONE | | mV |
| V _{OD} | Differential output voltage (measured with 50 Ω resistor between PAD and PADN) | 300 | | 500 | mV |
| V _{CM} | Common mode output voltage | 1 | | 1.5 | V |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 4 | pF |

5.7.9 BC1833IHHV Buffers DC Electrical Characteristics

[Table 5-17](#) summarizes the DC electrical characteristics for BC1833IHHV Buffers.

Table 5-17. BC1833IHHV Buffers DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|--|---|-------------|-----|------|---------------|
| Signal Names in MUXMODE 0: on_off | | | | | |
| Balls: Y11 | | | | | |
| 1.8-V Mode | | | | | |
| V_{OH} | Output high-level threshold ($I_{OH} = 2\text{ mA}$) | VDDS - 0.45 | | | V |
| V_{OL} | Output low-level threshold ($I_{OL} = 2\text{ mA}$) | | | 0.45 | V |
| I_{DRIVE} | Pin Drive strength at PAD Voltage = 0.45V or VDDS-0.45V | 6 | | | mA |
| I_{IN} | Input current at each I/O pin | 6 | | 12 | μA |
| I_{OZ} | $I_{OZ}(I_{PAD}\text{ Current})$ for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDDS and the $\text{Max}(I_{PAD})$ is measured and is reported as I_{OZ} | | | 6 | μA |
| C_{PAD} | Pad capacitance (including package capacitance) | | | 4 | pF |
| 3.3-V Mode | | | | | |
| V_{OH} | Output high-level threshold ($I_{OH} = 100\ \mu\text{A}$) | VDDS - 0.2 | | | V |
| V_{OL} | Output low-level threshold ($I_{OL} = 100\ \mu\text{A}$) | | | 0.2 | V |
| I_{DRIVE} | Pin Drive strength at PAD Voltage = 0.45V or VDDS-0.45V | 6 | | | mA |
| I_{IN} | Input current at each I/O pin | | | 60 | μA |
| I_{OZ} | $I_{OZ}(I_{PAD}\text{ Current})$ for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDDS and the $\text{Max}(I_{PAD})$ is measured and is reported as I_{OZ} | | | 60 | μA |
| C_{PAD} | Pad capacitance (including package capacitance) | | | 4 | pF |

(1) VDDS stands for corresponding power supply (that is, vddshv5). For more information on the power supply name and the corresponding ball, see [Table 4-2](#), POWER [10] column.

5.7.10 USBPHY DC Electrical Characteristics

NOTE

USB1 instance is compliant with the USB3.0 SuperSpeed Transmitter and Receiver Normative Electrical Parameters as defined in the USB3.0 Specification Rev 1.0 dated Jun 6, 2011.

NOTE

USB1 and USB2 Electrical Characteristics are compliant with USB2.0 Specification Rev 2.0 dated April 27, 2000 including ECNs and Errata as applicable.

5.7.11 Dual Voltage SDIO1833 DC Electrical Characteristics

Table 5-18 summarizes the DC electrical characteristics for Dual Voltage SDIO1833 Buffers.

Table 5-18. Dual Voltage SDIO1833 DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|---|--|-------------------|-----|--------------|------|
| Signal Names in Mode 0: mmc1_clk / mmc1_cmd / mmc1_data[3:0] | | | | | |
| Bottom Balls: W6 / Y6 / AA6 / Y4 / AA5 / Y3 | | | | | |
| 1.8-V Mode | | | | | |
| V _{IH} | Input high-level threshold | 1.27 | | | V |
| V _{IL} | Input low-level threshold | | | 0.58 | V |
| V _{HYS} | Input hysteresis voltage | 50 ⁽²⁾ | | | mV |
| I _{IN} | Input current at each I/O pin | | | 30 | μA |
| I _{OZ} | I _{OZ} (I _{PAD} Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDD5 and the Max(I(PAD)) is measured and is reported as I _{OZ} | | | 30 | μA |
| I _{IN} with pulldown enabled | Input current at each I/O pin with weak pulldown enabled measured when PAD = VDD5 | 50 | 120 | 210 | μA |
| I _{IN} with pullup enabled | Input current at each I/O pin with weak pullup enabled measured when PAD = 0 | 60 | 120 | 200 | μA |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 5 | pF |
| V _{OH} | Output high-level threshold (I _{OH} = 2 mA) | 1.4 | | | V |
| V _{OL} | Output low-level threshold (I _{OL} = 2 mA) | | | 0.45 | V |
| 3.3-V Mode | | | | | |
| V _{IH} | Input high-level threshold | 0.625 × VDD5 | | | V |
| V _{IL} | Input low-level threshold | | | 0.25 × VDD5 | V |
| V _{HYS} | Input hysteresis voltage | 40 ⁽²⁾ | | | mV |
| I _{IN} | Input current at each I/O pin | | | 110 | μA |
| I _{OZ} | I _{OZ} (I _{PAD} Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to VDD5 and the Max(I(PAD)) is measured and is reported as I _{OZ} | | | 110 | μA |
| I _{IN} with pulldown enabled | Input current at each I/O pin with weak pulldown enabled measured when PAD = VDD5 | 40 | 100 | 290 | μA |
| I _{IN} with pullup enabled | Input current at each I/O pin with weak pullup enabled measured when PAD = 0 | 10 | 100 | 290 | μA |
| C _{PAD} | Pad capacitance (including package capacitance) | | | 5 | pF |
| V _{OH} | Output high-level threshold (I _{OH} = 2 mA) | 0.75 × VDD5 | | | V |
| V _{OL} | Output low-level threshold (I _{OL} = 2 mA) | | | 0.125 × VDD5 | V |

(1) VDD5 stands for corresponding power supply (i.e. vddshv8). For more information on the power supply name and the corresponding ball, see Table 4-2, POWER [10] column.

(2) Hysteresis is enabled/disabled with CTRL_CORE_CONTROL_HYST_1.SDCARD_HYST register.

5.7.12 Dual Voltage LVCMOS DC Electrical Characteristics

Table 5-19 summarizes the DC electrical characteristics for Dual Voltage LVCMOS Buffers.

Table 5-19. Dual Voltage LVC MOS DC Electrical Characteristics

| PARAMETER | | MIN | NOM | MAX | UNIT |
|---------------------------------------|---|-------------------------|-----|-----|------|
| 1.8-V Mode | | | | | |
| V _{IH} | Input high-level threshold | 0.65 × V _{DD5} | | | V |
| V _{IL} | Input low-level threshold | 0.35 × V _{DD5} | | | V |
| V _{HYS} | Input hysteresis voltage | 100 | | | mV |
| V _{OH} | Output high-level threshold (I _{OH} = 2 mA) | V _{DD5} - 0.45 | | | V |
| V _{OL} | Output low-level threshold (I _{OL} = 2 mA) | 0.45 | | | V |
| I _{DRIVE} | Pin Drive strength at PAD Voltage = 0.45V or V _{DD5} -0.45V | 6 | | | mA |
| I _{IN} | Input current at each I/O pin | 16 | | | μA |
| I _{OZ} | I _{OZ} (I _{PAD} Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V _{DD5} and the Max(I _{PAD}) is measured and is reported as I _{OZ} | 16 | | | μA |
| I _{IN} with pulldown enabled | Input current at each I/O pin with weak pulldown enabled measured when PAD = V _{DD5} | 50 | 120 | 210 | μA |
| I _{IN} with pullup enabled | Input current at each I/O pin with weak pullup enabled measured when PAD = 0 | 60 | 120 | 200 | μA |
| C _{PAD} | Pad capacitance (including package capacitance) | 4 | | | pF |
| Z _O | Output impedance (drive strength) | 40 | | | Ω |
| 3.3-V Mode | | | | | |
| V _{IH} | Input high-level threshold | 2 | | | V |
| V _{IL} | Input low-level threshold | 0.8 | | | V |
| V _{HYS} | Input hysteresis voltage | 200 | | | mV |
| V _{OH} | Output high-level threshold (I _{OH} = 100 μA) | V _{DD5} - 0.2 | | | V |
| V _{OL} | Output low-level threshold (I _{OL} = 100 μA) | 0.2 | | | V |
| I _{DRIVE} | Pin Drive strength at PAD Voltage = 0.45V or V _{DD5} -0.45V | 6 | | | mA |
| I _{IN} | Input current at each I/O pin | 65 | | | μA |
| I _{OZ} | I _{OZ} (I _{PAD} Current) for BIDI cell. This current is contributed by the tristated driver leakage + input current of the Rx + weak pullup/pulldown leakage. PAD is swept from 0 to V _{DD5} and the Max(I _{PAD}) is measured and is reported as I _{OZ} | 65 | | | μA |
| I _{IN} with pulldown enabled | Input current at each I/O pin with weak pulldown enabled measured when PAD = V _{DD5} | 40 | 100 | 200 | μA |
| I _{IN} with pullup enabled | Input current at each I/O pin with weak pullup enabled measured when PAD = 0 | 10 | 100 | 290 | μA |
| C _{PAD} | Pad capacitance (including package capacitance) | 4 | | | pF |
| Z _O | Output impedance (drive strength) | 40 | | | Ω |

(1) V_{DD5} stands for corresponding power supply. For more information on the power supply name and the corresponding ball, see [Table 4-2, POWER \[10\]](#) column.

5.7.13 SATAPHY DC Electrical Characteristics

NOTE

The SATA module is compliant with the electrical parameters specified in the *SATA-IO SATA Specification*, Revision 3.2, August 7, 2013.

5.7.14 PCIEPHY DC Electrical Characteristics

NOTE

The PCIe interfaces are compliant with the electrical parameters specified in PCI-Express® Base Specification Revision 3.0.

5.8 VPP Specifications for One-Time Programmable (OTP) eFuses

NOTE

This functionality is available only for Silicon Revision 2.1.

This section specifies the operating conditions required for programming the OTP eFuses and is applicable only for High-Security Devices.

Table 5-20. Recommended Operating Conditions for OTP eFuse Programming

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

| PARAMETER | DESCRIPTION | MIN | NOM | MAX | UNIT |
|------------------------|--|------|------|-----|------|
| vdd | Supply voltage range for the core domain during OTP operation | 1.11 | 1.15 | 1.2 | V |
| vpp | Supply voltage range for the eFuse ROM domain during normal operation | NC | | | V |
| | Supply voltage range for the eFuse ROM domain during OTP programming ⁽¹⁾⁽²⁾ | 1.8 | | | V |
| I(vpp) | | | | 100 | mA |
| Temperature (junction) | | 0 | 25 | 85 | °C |

(1) Supply voltage range includes DC errors and peak-to-peak noise. TI power management solutions [TLV70718](#) from the TLV707x family meet the supply voltage range needed for vpp.

(2) During normal operation, no voltage should be applied to vpp. This can be typically achieved by disabling the regulator attached to the vpp terminal. For more details, see [TLV707](#), [TLV707P 200-mA, Low-I_Q, Low-Noise, Low-Dropout Regulator for Portable Devices](#).

5.8.1 Hardware Requirements

The following hardware requirements must be met when programming keys in the OTP eFuses:

- The vpp power supply must be disabled when not programming OTP registers.
- The vpp power supply must be ramped up after the proper device power-up sequence (for more details, see [Section 5.10](#)).

5.8.2 Programming Sequence

Programming sequence for OTP eFuses:

1. Power on the board per the power-up sequencing. No voltage should be applied on the vpp terminal during power up and normal operation.
2. Load the OTP write software required to program the eFuse (contact your local TI representative for the OTP software package).
3. Apply the voltage on the vpp terminal according to the specification in [Table 5-20](#).
4. Run the software that programs the OTP registers.
5. After validating the content of the OTP registers, remove the voltage from the vpp terminal.

5.8.3 Impact to Your Hardware Warranty

You accept that e-Fusing the TI Devices with security keys permanently alters them. You acknowledge that the e-Fuse can fail, for example, due to incorrect or aborted program sequence or if you omit a sequence step. Further the TI Device may fail to secure boot if the error code correction check fails for the Production Keys or if the image is not signed and optionally encrypted with the current active Production Keys. These types of situations will render the TI Device inoperable and TI will be unable to confirm whether the TI Devices conformed to their specifications prior to the attempted e-Fuse. CONSEQUENTLY, TI WILL HAVE NO LIABILITY (WARRANTY OR OTHERWISE) FOR ANY TI DEVICES THAT HAVE BEEN e-FUSED WITH SECURITY KEYS.

5.9 Thermal Characteristics

For reliability and operability concerns, the maximum junction temperature of the device has to be at or below the T_J value identified in [Table 5-4, Recommended Operating Conditions](#).

A BCI compact thermal model for this device is available and recommended for use when modeling thermal performance in a system.

Therefore, it is recommended to perform thermal simulations at the system level with the worst case device power consumption.

5.9.1 Package Thermal Characteristics

[Table 5-21](#) provides the thermal resistance characteristics for the package used on this device.

NOTE

Power dissipation of 1.5 W and an ambient temperature of 85°C is assumed for ABC package.

Table 5-21. Thermal Resistance Characteristics

| NO. | PARAMETER | DESCRIPTION | °C/W ⁽¹⁾ | AIR FLOW (m/s) ⁽²⁾ |
|-----|-------------------|-------------------------|---------------------|-------------------------------|
| T1 | $R_{\theta_{JC}}$ | Junction-to-case | 0.41 | N/A |
| T2 | $R_{\theta_{JB}}$ | Junction-to-board | 4.74 | N/A |
| T3 | $R_{\theta_{JA}}$ | Junction-to-free air | 11.9 | 0 |
| T4 | | Junction-to-moving air | 8.9 | 1 |
| T5 | | | 8.0 | 2 |
| T6 | | | 7.4 | 3 |
| T7 | Ψ_{JT} | Junction-to-package top | 0.22 | 0 |
| T8 | | | 0.22 | 1 |
| T9 | | | 0.22 | 2 |
| T10 | | | 0.23 | 3 |
| T11 | Ψ_{JB} | Junction-to-board | 4.12 | 0 |
| T12 | | | 3.73 | 1 |
| T13 | | | 3.59 | 2 |
| T14 | | | 3.48 | 3 |

(1) These measurements were conducted in a JEDEC defined 2S2P system (with the exception of the Theta JC [$R_{\theta_{JC}}$] measurement, which was conducted in a JEDEC defined 1S0P system) and will change based on environment as well as application. For more information, see these EIA/JEDEC standards:

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

(2) m/s = meters per second

5.10 Power Supply Sequences

This section describes the power-up and power-down sequence required to ensure proper device operation. The power supply names described in this section comprise a superset of a family of compatible devices. Some members of this family will not include a subset of these power supplies and their associated device modules. Refer to the [Section 4.2, Ball Characteristics](#) of the [Section 4, Terminal Configuration and Functions](#) to determine which power supplies are applicable.

[Figure 5-2](#) and [Figure 5-3](#) describe the device Power Sequencing.

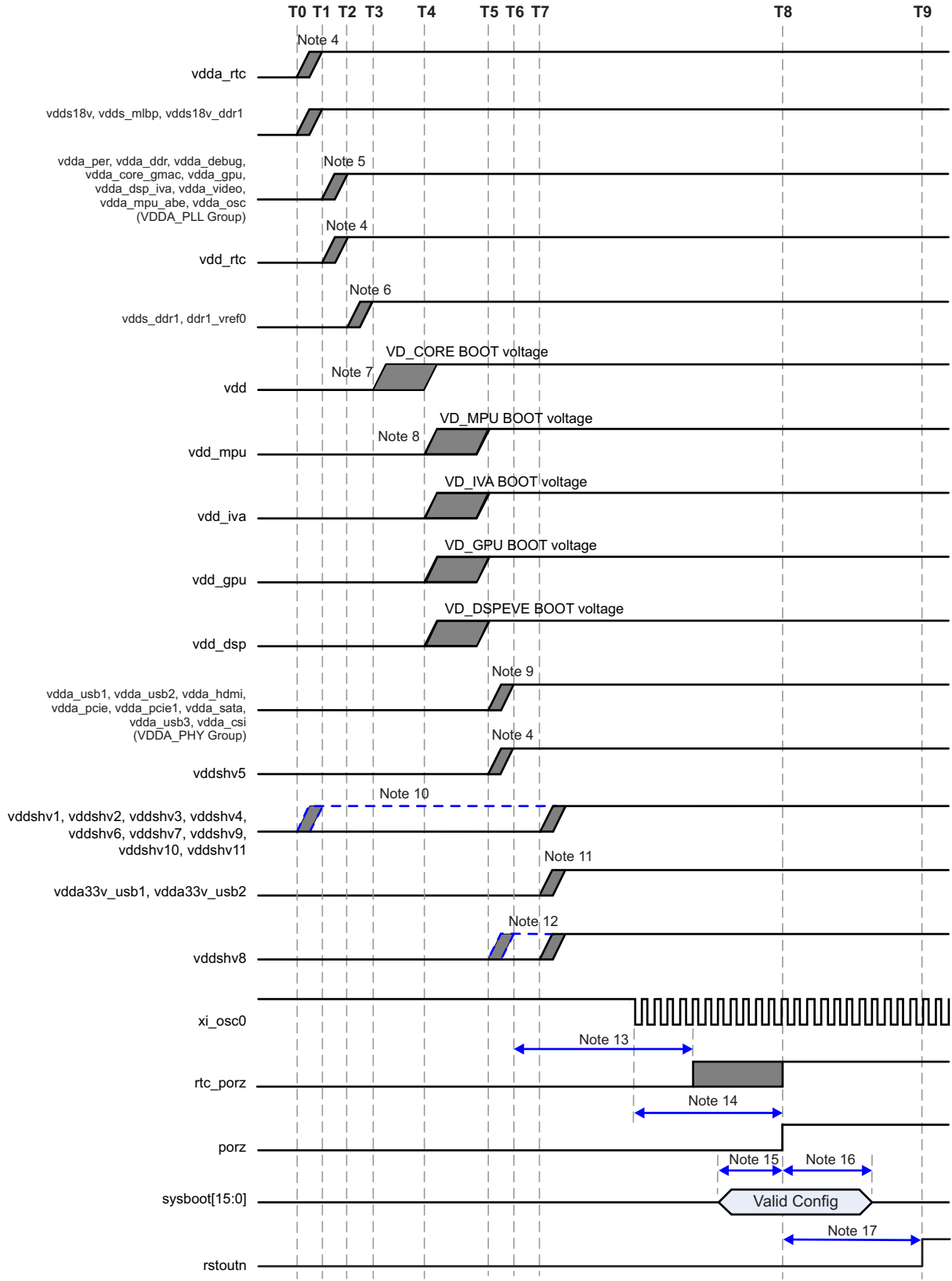


Figure 5-2. Recommended Power-Up Sequencing

(1) Time stamps:

- T0 = 0 ms; T1 = 0.55 ms; T2 = 1.1 ms; T3 = 1.65 ms; T4 = 2.2 ms; T5 = 2.75 ms; T6 = 3.3 ms; T7 = 5.85 ms; T8 = 6.4 ms; T9 = 8.4

ms. All “Tn” markers show total elapsed time from T0.

(2) Terminology:

- $V_{OPR\ MIN}$ = Minimum Operational Voltage level that ensures device functionality and specified performance per [Section 5.4, Recommended Operating Conditions](#).
- Ramp Up = transition time from V_{OFF} to $V_{OPR\ MIN}$.

(3) General timing diagram items:

- Grey shaded areas show valid transition times for supplies between $V_{OPR\ MIN}$ and V_{OFF} .
- Dashed horizontal lines are not valid ramp times but show alternate transition times based upon common sources and clarified in associated note.
- Dashed vertical lines show approximate elapse times based upon TI recommended PMIC power sequencer circuit performance.

(4) vddshv5, vdd_rtc, and vdda_rtc domains:

- If RTC mode is used, then vdda_rtc, vdd_rtc and vddshv5 must be individually powered with separate power supplies and cannot be combined with other rails.
 - If RTC-mode is not supported then the following combinations are approved:
 - vdda_rtc can be combined with vdds18v
 - vdd_rtc can be combined with vdd
 - vddshv5 can be combined with other 1.8 V or 3.3 V vddshv rails
- If combinations listed above are not followed then sequencing for these 3 voltage rails should follow the RTC mode timing requirements.

(5) vdda_* rails should not be combined with vdds18v_* for best performance to avoid transient switching noise impacts on analog domains. vdda_* should not ramp-up before vdds18v_* but could ramp concurrently if design ensures final operational voltage will not be reached until after vdds18v. The preferred sequence is to follow all vdds18v_* to ensure circuit components and PCB design do not cause an inadvertent violation.

(6) vdds_dds_* should not ramp-up before vdds18v_*. The preferred sequence has vdds_dds1 following vdds18v_* to ensure circuit components and PCB design do not cause an inadvertent violation. vdds_dds1 can ramp-up before, concurrently or after vdda_*, there are no dependencies between vdds_dds1 and vdda_* domains.

(7) vdd should not ramp-up before vdds18v_* or vdds_dds_* domains have reached $V_{OPR\ MIN}$.

(8) vdd_mpu, vdd_iva, vdd_gpu, vdd_dsp domains should follow vdd core supply as preferred sequence. If vdd_mpu, vdd_iva, vdd_gpu, vdd_dsp domains ramp concurrently or quicker than vdd core, then vdd core must remain at least 150 mV greater than vdd_mpu, vdd_iva, vdd_gpu, vdd_dsp domains during ramp. Circuit design (components and PCB) must ensure vdd reaches final operational voltage before any of the vdd_mpu, vdd_iva, vdd_gpu, vdd_dsp domains.

(9) VDDA_PHY group should not be combined with VDDA_PLL group to avoid transient switching noise impacts.

(10) vddshv[1-7, 9-11] domains:

- If 1.8 V I/O signaling is needed, then 1.8 V must be sourced from common vdds18v supply and ramp up concurrently with vdds18v.
- If 3.3 V I/O signaling is needed, then 3.3 V vddshvx rails must ramp up after vdd_mpu, vdd_iva, vdd_gpu, vdd_dsp, and VDDA_PHY group domains.

(11) vdda33v_usb[1-2] domain:

- If USB1 and USB2 interfaces are used, should be supplied from independent analog supply.
- If USB1/USB2 interface is not used, could be connected to VSS/GND if both conditions are met:
 - USB1/USB2 diff pair (usb1_dm/usb1_dp; usb2_dm/usb2_dp) pins are left unconnected
 - vdda_usb1 and/or vdda_usb2 PHY is not energized

(12) vddshv8 shows two ramp up options for 1.8 V I/O or 3.3 V I/O or SD Card operation:

- If 1.8 V I/O signaling is needed, then vddshv8 must ramp up after vdd and before or concurrently with 3.3 V vddshv* rails.
- If 3.3 V I/O signaling is needed, then vddshv8 must be combined with other 3.3 V vddshv* rails.
- If SD Card operation is needed, then vddshv8 must be sourced from a dual voltage (3.3 V / 1.8 V) power source per SDIO specifications and ramp up concurrently with 3.3 V vddshv* rails.

(13) Pulse duration: rtc_porz must remain low 1 ms after vdda_rtc, vddshv5, and vdd_rtc are ramped and stable or can be de-asserted before but no later than porz. The FUNK_32K_CLK source must be stable and at a valid frequency 1 ms prior to de-asserting rtc_porz high.

(14) porz must remain asserted low until both of the following conditions are met:

- Minimum of 12P, where $P = 1 / (\text{SYS_CLK1} / 610)$, units in ns.
- All device supply rails reach stable operational levels.

(15) Setup time: sysboot[15:0] pins must be valid 2P⁽¹⁴⁾ before porz is de-asserted high.

(16) Hold time: sysboot[15:0] pins must be valid 15P⁽¹⁴⁾ after porz is de-asserted high.

(17) rstoutn will be set high after global reset, due to porz, is de-asserted following an internal 2 ms delay. rstoutn is only valid after vddshv3 reaches an operational level. If used as a peripheral component reset, it should be AND gated with porz to avoid possible reset glitches during power up.

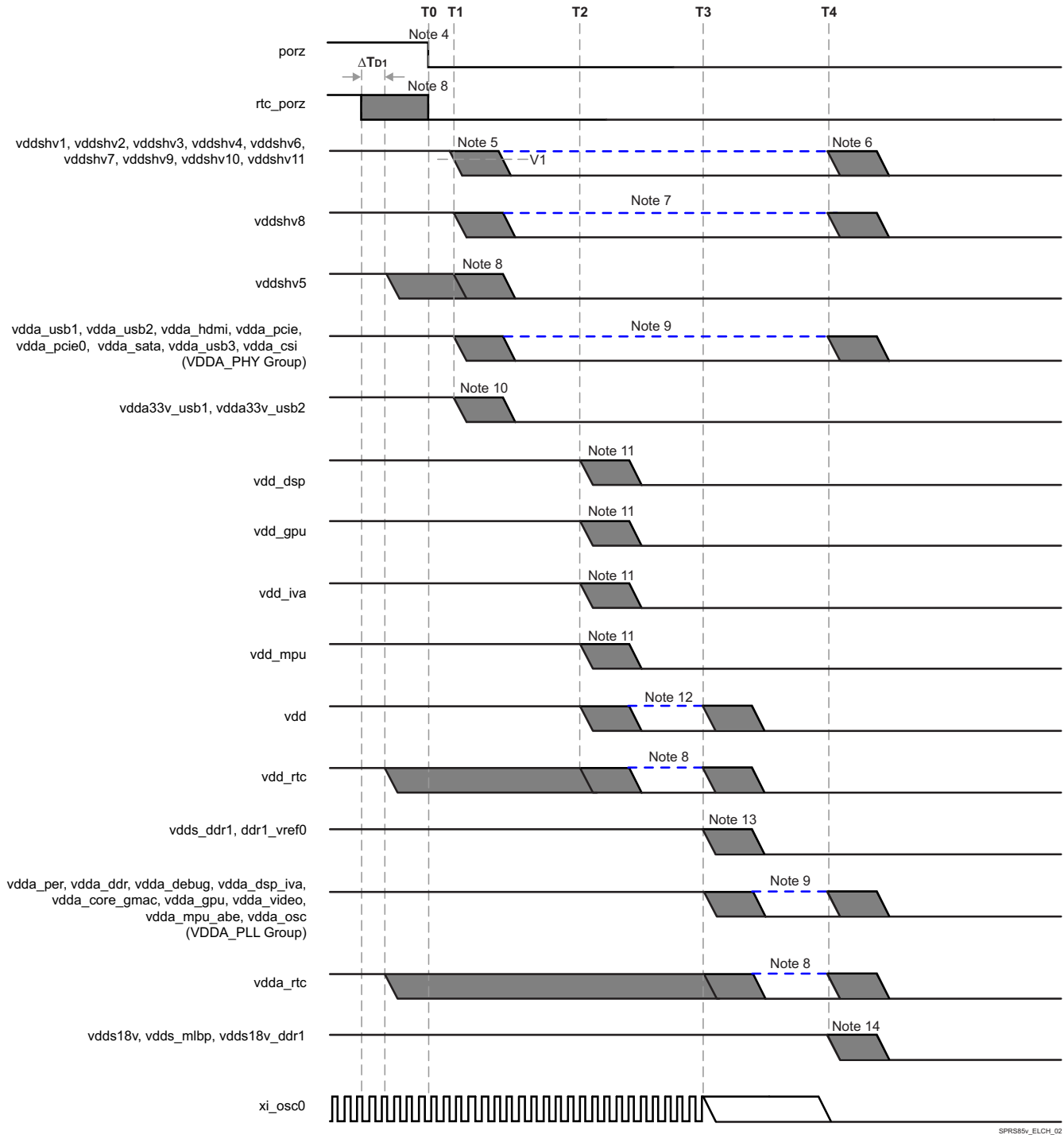
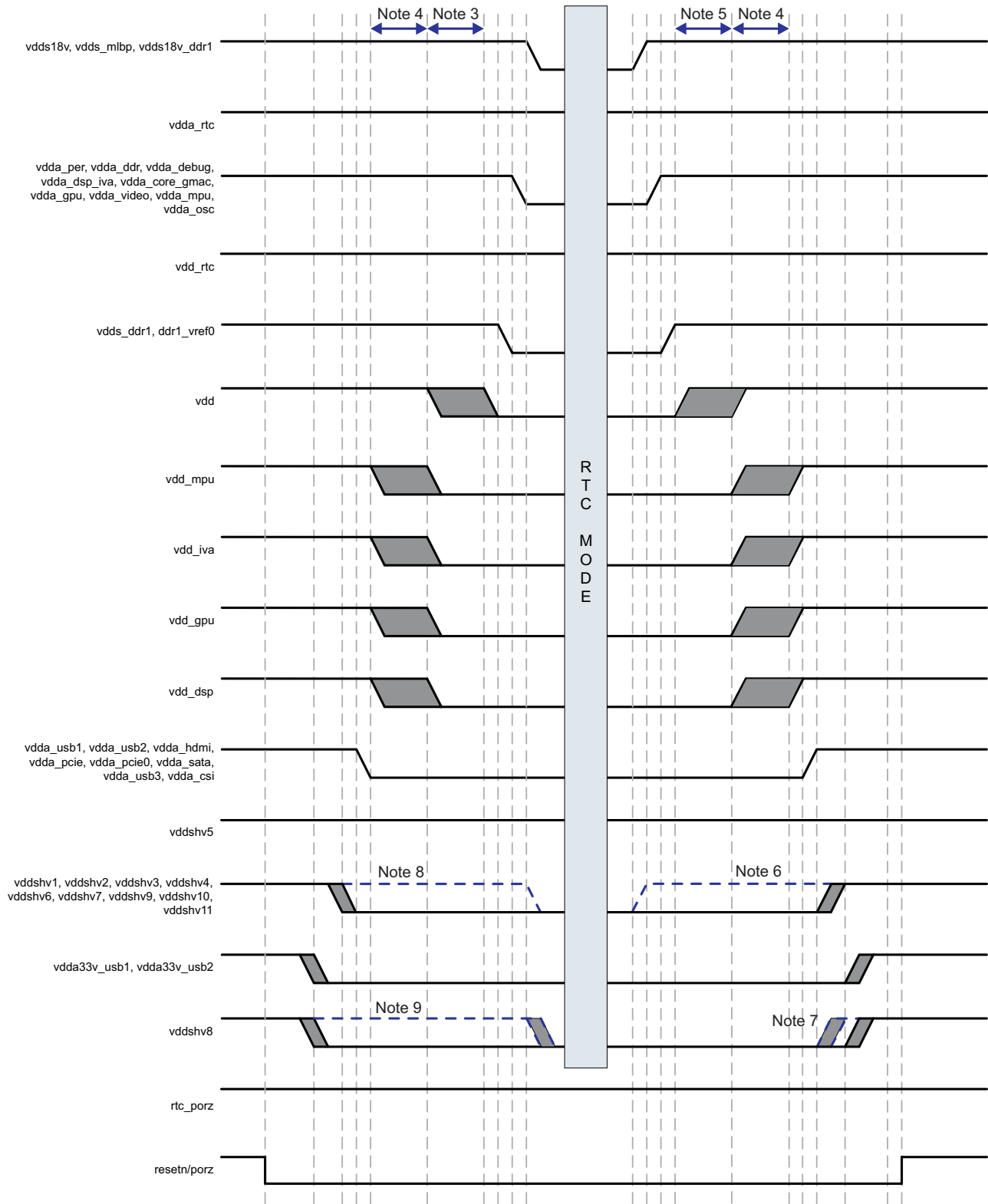


Figure 5-3. Recommended Power-Down Sequencing

- (1) Time stamps:
 - T0 = 0 ms, T1 > 100 μ s, T2 = 0.5 ms, T3 = 1.0 ms, T4 = 1.5 ms; V1 = 2.7 V. All “Tn” markers are intended to show elapsed times from T0. Delta time: ΔT_{D1} > 100 μ s.
- (2) Terminology:
 - V_{OPR MIN} = Minimum Operational Voltage level that ensures device functionality and specified performance per Section 5.4, Recommended Operating Conditions.
 - V_{OFF} = OFF Voltage level is defined to be less than 0.6 V where any current draw has no impact to POH.
 - Ramp Down = transition time from V_{OPR MIN} to V_{OFF} and is slew rate independent.
- (3) General timing diagram items:

- Grey shaded areas show valid transition times for supplies between V_{OPR_MIN} and V_{OFF} .
 - Dashed horizontal lines are not valid ramp times but show alternate transition times based upon common sources and clarified in associated note.
 - Dashed vertical lines show approximate elapse times based upon TI recommended PMIC power-down sequencer circuit performance.
- (4) porz signals must be asserted low for 100 μ s min to ensure SoC is set to a safe functional state before any voltage begins to ramp down.
 - (5) vddshv* domains supplied by 3.3 V:
 - must remain greater than 2.7 V to enable Dual Voltage GPIO selector circuit operation for 100 μ s min after porz is asserted low.
 - must be in first group of supplies ramping down after porz has been asserted low for 100 μ s min.
 - must not exceed vdds18v by more than 2 V during ramp down, see [Figure 5-7](#) “vdds18v and vdda_* Discharge Relationship”.
 - (6) vddshv* domains supplied by 1.8 V:
 - must ramp down concurrently with vdds18v and be sourced from the same vdds18v supply.
 - (7) vddshv8 domain:
 - must be in first group of supplies to ramp down after porz has been asserted low for 100 μ s min.
 - if SDIO operation is needed, must be sourced from independent power resource that can provide dual voltage (3.3 V / 1.8 V) operation as required to be compliant to SDIO specification
 - if SDIO operation is not needed, must be grouped and ramped down with other vddshv* domains as noted above.
 - (8) RTC domains (vddshv5, vdd_rtc, and vdda_rtc):
 - If RTC mode is used:
 - rtc_porz can be asserted low before porz and RTC domains can be ramped down after 100 μ s elapsed time.
 - must be sourced from independent supplies and must not be combined with other rails.
 - timing diagram shows this mode of operation.
 - If RTC mode is not used, then:
 - rtc_porz must be connected to porz signal.
 - vddshv5 must be grouped and ramped down with other vddshv* domains as noted above.
 - vdd_rtc must be grouped and ramped down with vdd.
 - vdda_rtc must be grouped and ramped down with either VDDA_PHY group or vdds18v.
 - (9) vdda_* domains:
 - should not be combined with vdds18v for best performance to avoid transient switching noise impacts on analog domains.
 - can ramp down before or concurrently with vdds18v.
 - must satisfy the vdds18v and vdda_* Discharge Relationship (see [Figure 5-7](#)) if vdda_* disable point is later or discharge rate is slower than vdds18v.
 - can ramp down before, concurrently or after vdds_dds*, there is no dependency between these supplies.
 - (10) vdda33v_usb* domains:
 - can start ramping down 100 μ s after low assertion of porz
 - can ramp down concurrently or before VDDA_PHY group
 - (11) vdd_dsp, vdd_gpu, vdd_iva, vdd_mpu domains can ramp down before or concurrently with vdd.
 - (12) vdd can ramp down concurrently or after with vdd_dsp, vdd_gpu, vdd_iva, vdd_mpu domains.
 - (13) vdds_dds* domains:
 - should ramp down after vdd begins ramping down.
 - (14) vdds18v domain:
 - should maintain V_{OPR_MIN} ($V_{NOM} - 5\% = 1.71$ V) until all other supplies start to ramp down.
 - must satisfy the vdds18v versus vddshv[1-7, 9-11] Discharge Relationship (see [Figure 5-5](#)) if vddshv* is operating at 3.3 V
 - must satisfy the vdds18v and vdds_dds* Discharge Relationship (see [Figure 5-6](#)) if vdds_dds* discharge rate is slower than vdds18v.

Figure 5-4 describes the RTC-mode Power Sequencing.



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Figure 5-4. RTC Mode Sequencing

(1) Grey shaded areas are windows where it is valid to ramp the voltage rail.

- (2) Blue dashed lines are not valid windows but show alternate ramp possibilities based on the associated note.
- (3) vdd must ramp down after or at the same time as vdd_mpu, vdd_gpu, vdd_dsp and vdd_iva.
- (4) vdd_mpu, vdd_gpu, vdd_dsp, vdd_iva can be ramped at the same time or can be staggered.
- (5) vdd must ramp up before or at the same time as vdd_mpu, vdd_gpu, vdd_dsp and vdd_iva.
- (6) If any of the vddshv[1-7,9-11] rails (not including vddshv8) are used as 1.8V only, then these rails can be combined with vdds18v.
- (7) vddshv8 is separated out to show support for dual voltage. If single voltage is used then vddshv8 can be combined with other vddshvn rails but vddshv8 must ramp down before vdd and must ramp up after vdd.
- (8) If any of the vddshv[1-7,9-11] rails (not including vddshv8) are used as 1.8V only, then these rails can be combined with vdds18v. vddshv[1-7,9-11] is allowed to ramp down at either of the two points shown in the timing diagram in either 1.8V mode or in 3.3V mode. If vddshv[1-7,9-11] ramps down at the later time in the diagram then the board design must ensure that the vddshvn rail is never higher than 2.0 V above the vdds18v rail.
- (9) vddshv8 is separated out to show support for dual voltage. If a dedicated LDO/supply source is used for vddshv8, then vddshv8 ramp down should occur at one of the two earliest points in the timing diagram. If vddshv8 is powered by the same supply source as the other vddshvn rails, then it is allowed to ramp down at either of the last two points in the timing diagram.

Figure 5-5 describes vddshv[1-7,9-11] Supplies Falling Before vdds18v Supplies Delta.

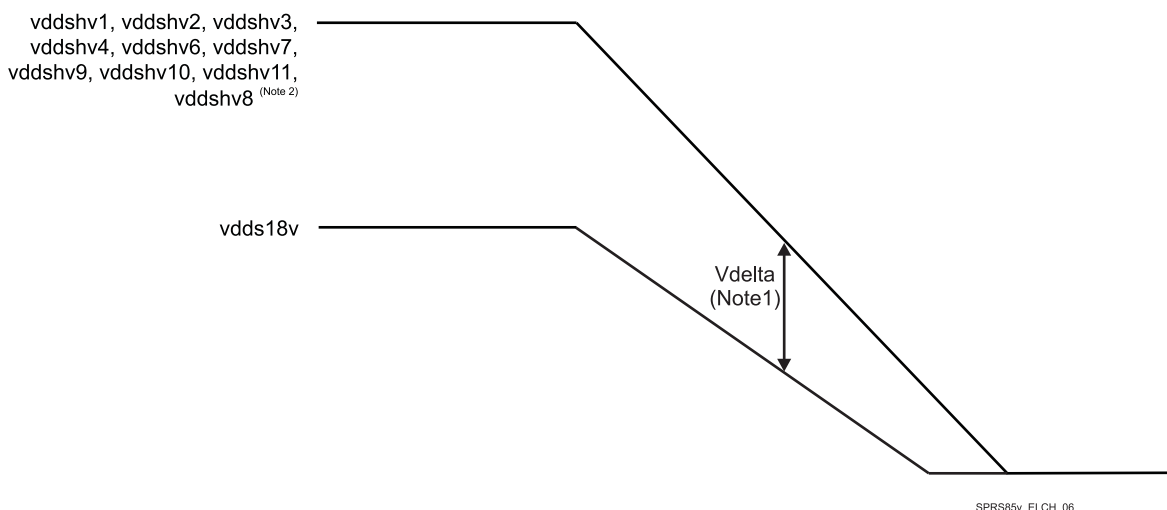


Figure 5-5. vdds18v versus vddshv[1-7, 9-11] Discharge Relationship

- (1) Vdelta MAX = 2 V
- (2) If vddshv8 is powered by the same supply source as the other vddshv[1-7,9-11] rails.

If vdds18v and vdds_dds* are disabled at the same time due to a loss of input power event or if vdds_dds* discharges more slowly than vdds18v, analysis has shown no reliability impacts when the elapsed time period beginning with vdds18v dropping below 1.0 V and ending with vdds_dds* dropping below 0.6 V is less than 10 ms (Figure 5-6).

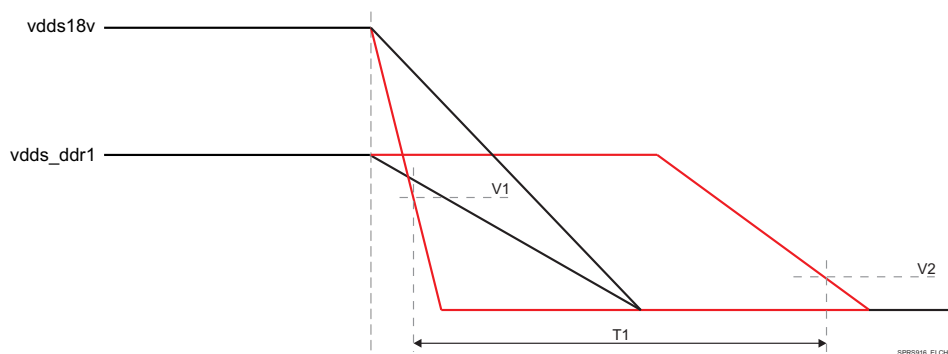


Figure 5-6. vdds18v and vdds_dds* Discharge Relationship⁽¹⁾

- (1) V1 > 1.0 V; V2 < 0.6V; T1 < 10 ms.

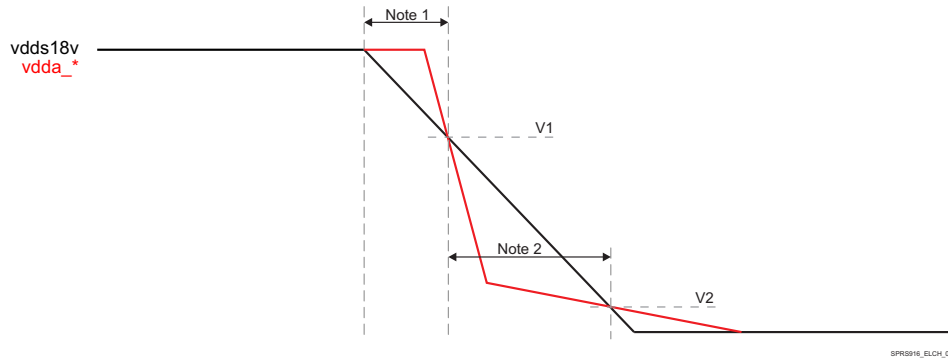


Figure 5-7. vdds18v and vdda_* Discharge Relationship⁽³⁾

- (1) vdda_* can be \geq vdds18v, until vdds18v drops below 1.62 V.
- (2) vdds18v must be \geq vdda_*, until vdds18v reaches 0.6 V.
- (3) V1 = 1.62 V; V2 < 0.6 V.

Figure 5-5 through Figure 5-8 and associated notes described the device abrupt power down sequence.

A "loss of input power event" occurs when the system's input power is unexpectedly removed. Normally, the recommended power-down sequence should be followed and can be accomplished within 1.5-2 ms of elapsed time. This is the typical range of elapsed time available following a loss of power event, see Section 8.3.7 for design recommendations. If sufficient elapse time is not provided, then an "abrupt" power down sequence can be supported without impacting POH reliability if all of the following conditions are met (Figure 5-8).

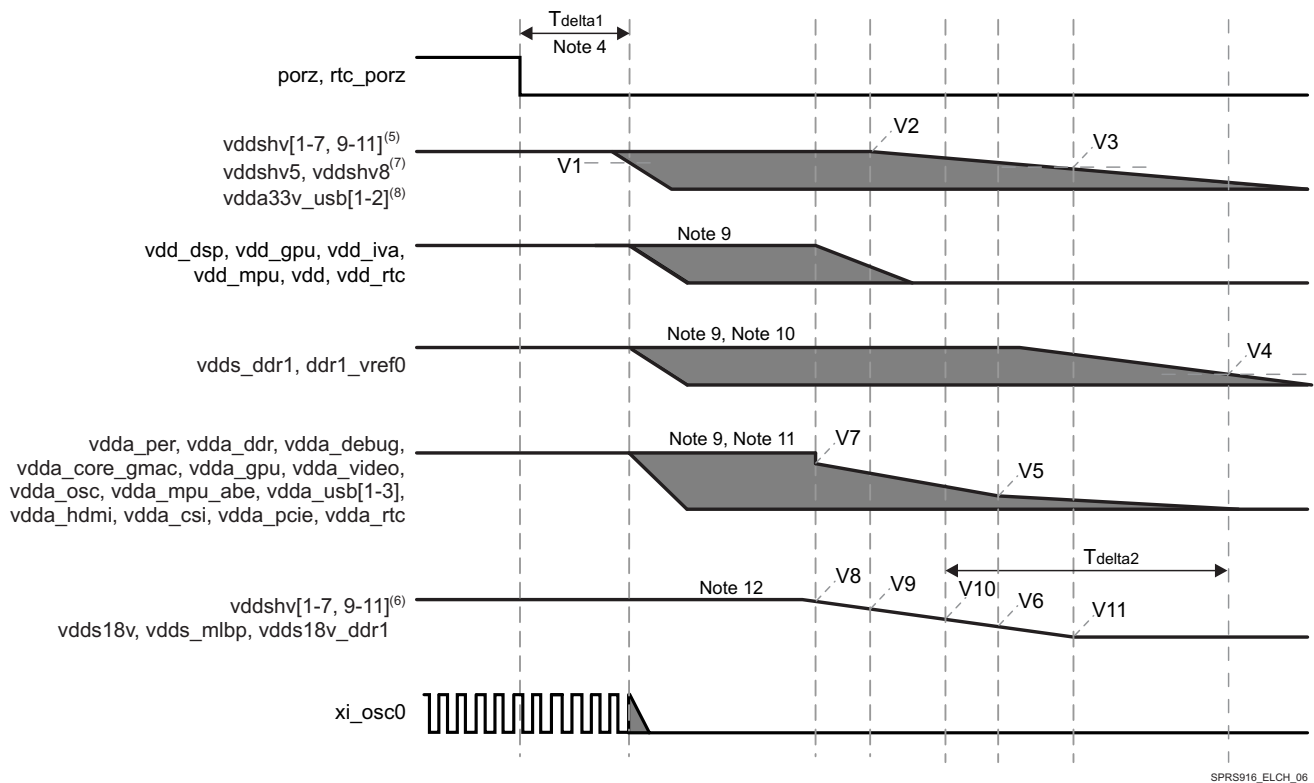


Figure 5-8. Abrupt Power-Down Sequencing⁽¹⁾

- (1) Time stamps:
 - V1 = 2.7 V; V2 = 3.3 V; V3 = 2.0 V; V4 = V5 = V6 = 0.6 V; V7 = V8 = 1.62 V; V9 = 1.3 V; V10 = 1.0 V; V11 = 0.0 V; T_{delta1} > 100 μ s; T_{delta2} < 10 ms.

- (2) Terminology:
- $V_{OPR\ MIN}$ = Minimum Operational Voltage level that ensures device functionality and specified performance in [Section 5.4, Recommended Operating Conditions table](#).
 - V_{OFF} = OFF Voltage level is defined to be less than 0.6 V, where any current draw has no impact to POH.
 - Ramp Down = transition time from $V_{OPR\ MIN}$ to V_{OFF} and is slew rate independent.
- (3) General timing diagram items:
- Grey shaded areas show valid transition times for supplies between $V_{OPR\ MIN}$ and V_{OFF} .
 - Dashed vertical lines show approximate elapse times based upon TI recommended PMIC power-down sequencer circuit performance.
- (4) porz and rtc_porz must be asserted low for 100 μ s min to ensure SoC is set to a safe functional state before any voltage begins to ramp down.
- Only if using RTC-mode with an independent RTC input power source, then rtc_porz can remain high and RTC-domains (vdd_rtc, vdda_rtc, and vddshv5) can remain energized while all other domains sourced from the system input power are powered down.
- (5) vddshv[1-7, 9-11] domains supplied by 3.3 V:
- must remain greater than 2.7 V to enable Dual Voltage GPIO selector circuit operation for 100 μ s min, after porz is asserted low.
 - must not exceed vdds18v voltage level by more than 2 V during ramp down, until vdds18v drops below V_{OFF} (0.6 V).
- (6) vddshv[1-7, 9-11] domains supplied by 1.8 V must ramp down concurrently with vdds18v and be sourced from common vdds18v supply.
- (7) vddshv8 supporting SD Card:
- must be in first group of supplies to ramp down after porz has been asserted low for 100 μ s min.
 - must be sourced from independent power resource that can provide dual voltage (3.3 V / 1.8 V) operation as required to be compliant to SDIO specification.
 - if SDIO operation is not needed, must be grouped with other vddshv[1-7, 9-11] domains.
- (8) vdda33v_usb[1-2] domains must be in first group of supplies to ramp down after porz has been asserted low for 100 μ s min.
- (9) vdd_dsp, vdd_gpu, vdd_iva, vdd_mpu, vdd, vdd_rtc, vdds_dds1, vdda_* domains can all start to ramp down in any order after 100 μ s low assertion of porz.
- (10) vdds_dds1 domains:
- can remain at $V_{OPR\ MIN}$ or a level greater than vdds18v during ramp down.
 - elapsed time from vdds18v dropping below 1.0 V to vdds_dds1[1-3] dropping below 0.6 V must not exceed 10 ms.
- (11) vdda_* domains:
- can start to ramp down before or concurrently with vdds18v.
 - must not exceed vdds18v voltage level after vdds18v drops below 1.62 V until vdds18v drops below V_{OFF} (0.6 V).
- (12) vdds18v domain should maintain a minimum level of 1.62 V ($V_{NOM} - 10\%$) until vdd_dsp and vdd start to ramp down.

6 Clock Specifications

NOTE

For more information, see *Power, Reset, and Clock Management* chapter in the device TRM.

NOTE

Audio Back End (ABE) module is not supported for this family of devices, but “ABE” name is still present in some clock or DPLL names.

The device operation requires the following clocks:

- The 32 kHz frequency is used for low frequency operation. It supplies the wake-up domain for operation in lowest power mode. This is an optional clock and will be supplied by on chip divider + mux (FUNC_32K_CLK) incase it is not available on external pin.
- The system clocks, SYS_CLK1 (Mandatory) and SYS_CLK2 (Optional) are the main clock sources of the device. They supply the reference clock to the DPLLs as well as functional clock to several modules.

The device also embeds an internal free-running 32-kHz oscillator that is always active as long as the the wake-up (WKUP) domain is supplied.

Figure 6-1 shows the external input clock sources and the output clocks to peripherals.

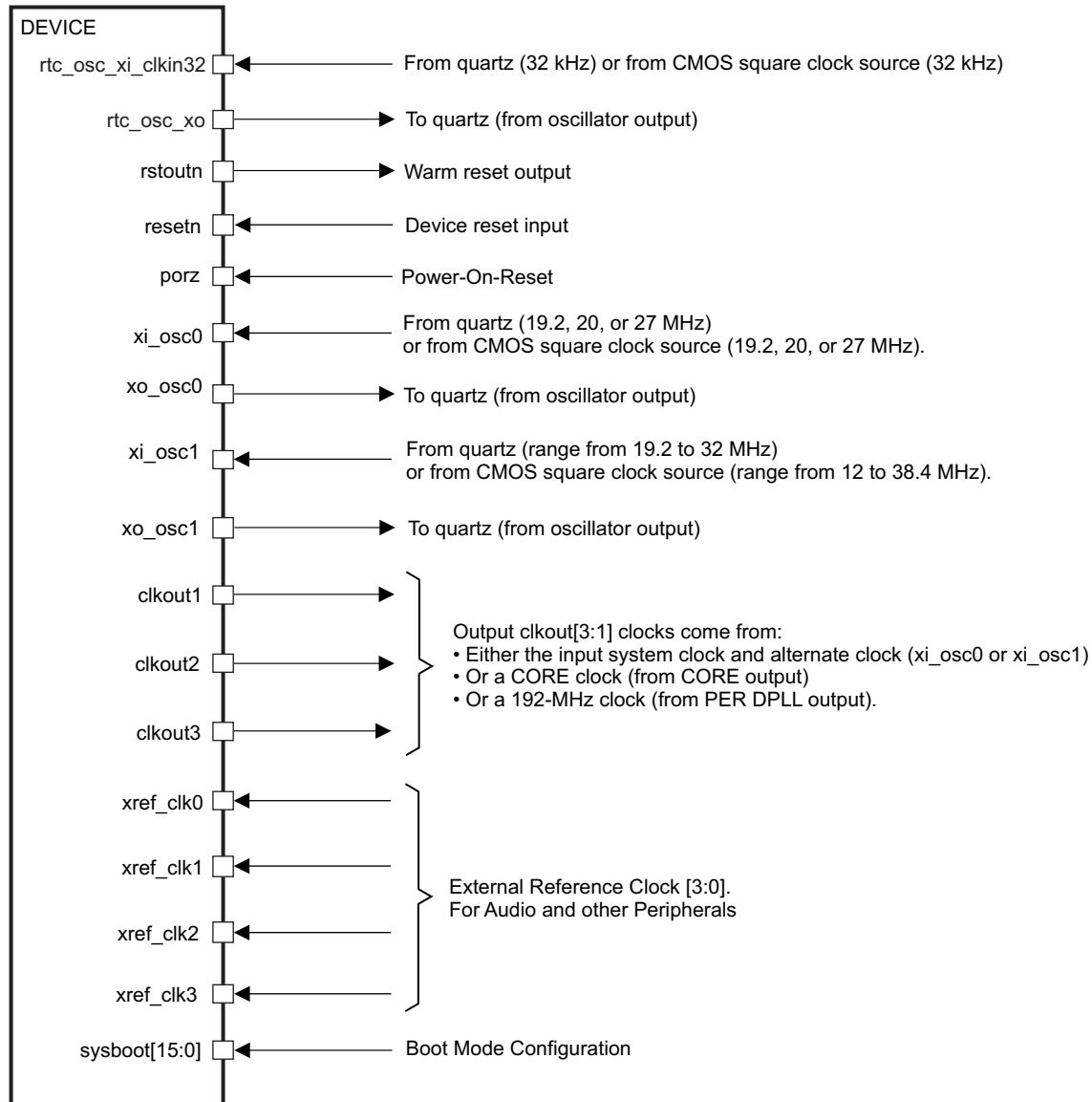


Figure 6-1. Clock Interface

6.1 Input Clock Specifications

6.1.1 Input Clock Requirements

- The source of the internal system clock (SYS_CLK1) could be either:
 - A CMOS clock that enters on the xi_osc0 ball (with xo_osc0 left unconnected on the CMOS clock case).
 - A crystal oscillator clock managed by xi_osc0 and xo_osc0.
- The source of the internal system clock (SYS_CLK2) could be either:
 - A CMOS clock that enters on the xi_osc1 ball (with xo_osc1 left unconnected on the CMOS clock case).
 - A crystal oscillator clock managed by xi_osc1 and xo_osc1.
- The source of the internal system clock (FUNC_32K_CLK) could be either:
 - A CMOS clock that enters on the rtc_osc_xi_clkin32 ball and supports external LVCMOS clock generators
 - A crystal oscillator clock managed by rtc_osc_xi_clkin32 and rtc_osc_xo.

6.1.2 System Oscillator OSC0 Input Clock

SYS_CLK1 is received directly from oscillator OSC0. For more information about SYS_CLK1, see *Power, Reset, and Clock Management* chapter in the device TRM.

6.1.2.1 OSC0 External Crystal

An external crystal is connected to the device pins. [Figure 6-2](#) describes the crystal implementation.

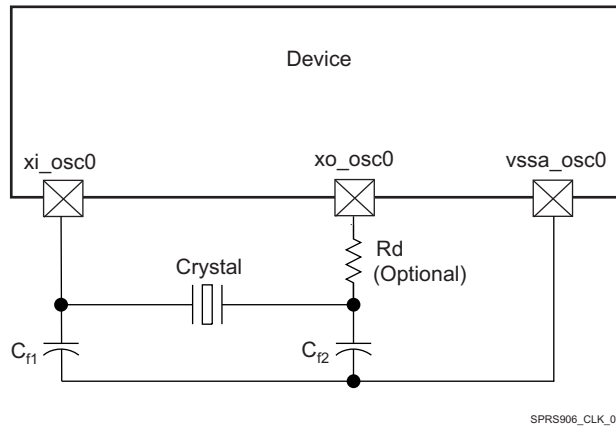


Figure 6-2. OSC0 Crystal Implementation

NOTE

The load capacitors, C_{f1} and C_{f2} in [Figure 6-2](#), should be chosen such that the below equation is satisfied. C_L in the equation is the load specified by the crystal manufacturer. All discrete components used to implement the oscillator circuit should be placed as close as possible to the associated oscillator xi_osc0 , xo_osc0 , and $vssa_osc0$ pins.

$$C_L = \frac{C_{f1} C_{f2}}{(C_{f1} + C_{f2})}$$

Figure 6-3. Load Capacitance Equation

The crystal must be in the fundamental mode of operation and parallel resonant. [Table 6-1](#) summarizes the required electrical constraints. and [Table 6-5](#)

Table 6-1. OSC0 Crystal Electrical Characteristics

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|-----------------------|---|--------------|-----|-----|----------|
| f_p | Parallel resonance crystal frequency | 19.2, 20, 27 | | | MHz |
| C_{f1} | C_{f1} load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ | 12 | | 24 | pF |
| C_{f2} | C_{f2} load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ | 12 | | 24 | pF |
| $ESR(C_{f1}, C_{f2})$ | Crystal ESR | | | 100 | Ω |

Table 6-1. OSC0 Crystal Electrical Characteristics (continued)

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT | | |
|-------------------------|---|---|----------------------------|---------------|--------|-----|----|
| C _O | Crystal shunt capacitance | ESR = 30 Ω ESR = 40 Ω | 19.2 MHz, 20 MHz, 27 MHz | | 7 | pF | |
| | | ESR = 50 Ω | 19.2 MHz, 20 MHz 27 MHz | | 7 5 | pF | |
| | | ESR = 60 Ω | 19.2 MHz, 20 MHz 27 MHz | Not Supported | | - | pF |
| | | ESR = 80 Ω | 19.2 MHz, 20 MHz 27 MHz | Not Supported | | 5 | pF |
| | | ESR = 100 Ω | 19.2 MHz, 20 MHz 27 MHz | Not Supported | | 3 | pF |
| | | | | | | | |
| L _M | Crystal motional inductance for f _p = 20 MHz | | 10.16 | | mH | | |
| C _M | Crystal motional capacitance | | 3.42 | | fF | | |
| t _{j(xi_osc0)} | Frequency accuracy ⁽¹⁾ , xi_osc0 | Ethernet and MLB not used | | | ±200 | ppm | |
| | | Ethernet RGMII and RMII using derived clock | | | ±50 | | |
| | | Ethernet MII using derived clock | | | ±100 | | |
| | | MLB using derived clock | | | ±50 | | |

(1) Crystal characteristics should account for tolerance+stability+aging.

When selecting a crystal, the system design must take into account the temperature and aging characteristics of a crystal versus the user environment and expected lifetime of the system.

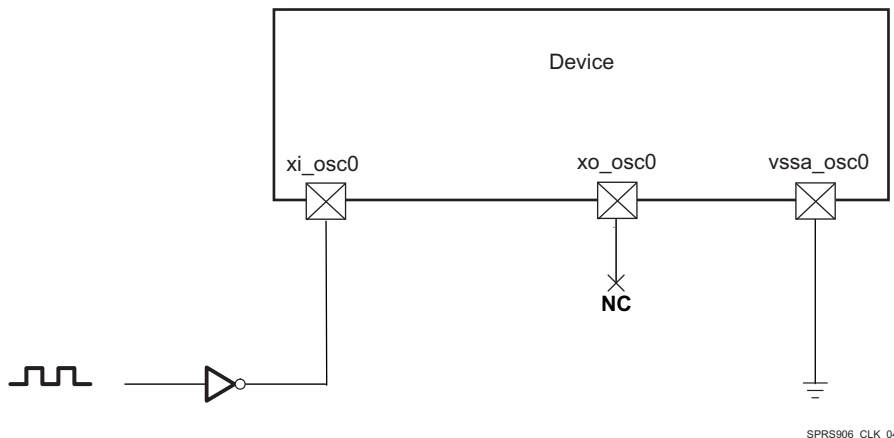
Table 6-2 details the switching characteristics of the oscillator and the requirements of the input clock.

Table 6-2. Oscillator Switching Characteristics—Crystal Mode

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|-----------------|-----------------------|-----|------------------|-----|------|
| f _p | Oscillation frequency | | 19.2, 20, 27 MHz | | MHz |
| t _{sX} | Start-up time | | | 4 | ms |

6.1.2.2 OSC0 Input Clock

A 1.8-V LVCMOS-Compatible Clock Input can be used instead of the internal oscillator to provide the SYS_CLK1 clock input to the system. The external connections to support this are shown in Figure 6-4. The xi_osc0 pin is connected to the 1.8-V LVCMOS-Compatible clock source. The xi_osc0 pin is left unconnected. The vssa_osc0 pin is connected to board ground (VSS).



SPRS906_CLK_04

Figure 6-4. 1.8-V LVCMOS-Compatible Clock Input

Table 6-3 summarizes the OSC0 input clock electrical characteristics.

Table 6-3. OSC0 Input Clock Electrical Characteristics—Bypass Mode

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|-----------------|---------------------------|--------------|-------|-------|------|
| f | Frequency | 19.2, 20, 27 | | | MHz |
| C _{IN} | Input capacitance | 2.184 | 2.384 | 2.584 | pF |
| I _{IN} | Input current (3.3V mode) | 4 | 6 | 10 | μA |

Table 6-4 details the OSC0 input clock timing requirements.

Table 6-4. OSC0 Input Clock Timing Requirements

| NAME | DESCRIPTION | | MIN | TYP | MAX | UNIT |
|------|-----------------------------|---|---|-----|--------------------------------|------|
| CK0 | 1 / t _{c(xi_osc0)} | Frequency, xi_osc0 | 19.2, 20, 27 | | | MHz |
| CK1 | t _{w(xi_osc0)} | Pulse duration, xi_osc0 low or high | 0.45 × t _{c(xi_osc0)} | | 0.55 × t _{c(xi_osc0)} | ns |
| | t _{j(xi_osc0)} | Period jitter ⁽¹⁾ , xi_osc0 | | | 0.01 × t _{c(xi_osc0)} | ns |
| | t _{R(xi_osc0)} | Rise time, xi_osc0 | | | 5 | ns |
| | t _{F(xi_osc0)} | Fall time, xi_osc0 | | | 5 | ns |
| | t _{j(xi_osc0)} | Frequency accuracy ⁽²⁾ , xi_osc0 | Ethernet and MLB not used | | ±200 | ppm |
| | | | Ethernet RGMII and RMII using derived clock | | ±50 | |
| | | | Ethernet MII using derived clock | | ±100 | |
| | | | MLB using derived clock | | ±50 | |

(1) Period jitter is meant here as follows:

- The maximum value is the difference between the longest measured clock period and the expected clock period
- The minimum value is the difference between the shortest measured clock period and the expected clock period

(2) Crystal characteristics should account for tolerance+stability+aging.

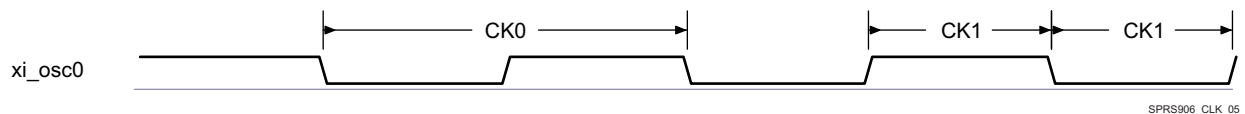


Figure 6-5. xi_osc0 Input Clock

6.1.3 Auxiliary Oscillator OSC1 Input Clock

SYS_CLK2 is received directly from oscillator OSC1. For more information about SYS_CLK2, see *Power, Reset, and Clock Management* chapter in the device TRM.

6.1.3.1 OSC1 External Crystal

An external crystal is connected to the device pins. Figure 6-6 describes the crystal implementation.

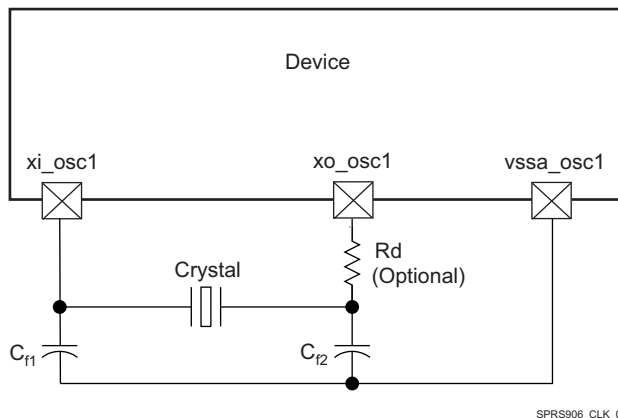


Figure 6-6. Crystal Implementation

NOTE

The load capacitors, C_{f1} and C_{f2} in Figure 6-6, should be chosen such that the below equation is satisfied. C_L in the equation is the load specified by the crystal manufacturer. All discrete components used to implement the oscillator circuit should be placed as close as possible to the associated oscillator xi_osc1, xo_osc1, and vssa_osc1 pins.

$$C_L = \frac{C_{f1} C_{f2}}{(C_{f1} + C_{f2})}$$

Figure 6-7. Load Capacitance Equation

The crystal must be in the fundamental mode of operation and parallel resonant. Table 6-5 summarizes the required electrical constraints.

Table 6-5. OSC1 Crystal Electrical Characteristics

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT | | |
|----------------------------|---|-----------------------|---------------------------------|-----|---------------|----|---|
| f_p | Parallel resonance crystal frequency | Range from 19.2 to 32 | | | MHz | | |
| C_{f1} | C_{f1} load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ | 12 | | 24 | pF | | |
| C_{f2} | C_{f2} load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ | 12 | | 24 | pF | | |
| $ESR(C_{f1}, C_{f2})$ | Crystal ESR | | | 100 | Ω | | |
| C_O | Crystal shunt capacitance | ESR = 30 Ω | 19.2 MHz $\leq f_p \leq$ 32 MHz | | 7 | pF | |
| | | ESR = 40 Ω | 19.2 MHz $\leq f_p \leq$ 32 MHz | | 5 | pF | |
| | | ESR = 50 Ω | 19.2 MHz $\leq f_p \leq$ 25 MHz | | 7 | pF | |
| | | | 25 MHz $< f_p \leq$ 27 MHz | | 5 | pF | |
| | | ESR = 60 Ω | 27 MHz $< f_p \leq$ 32 MHz | | Not Supported | | - |
| | | | 19.2 MHz $\leq f_p \leq$ 23 MHz | | 7 | pF | |
| | | | 23 MHz $< f_p \leq$ 25 MHz | | 5 | pF | |
| | | ESR = 80 Ω | 25 MHz $< f_p \leq$ 32 MHz | | Not Supported | | - |
| | | | 19.2 MHz $\leq f_p \leq$ 23 MHz | | 5 | pF | |
| | | | 23 MHz $\leq f_p \leq$ 25 MHz | | 3 | pF | |
| 25 MHz $< f_p \leq$ 32 MHz | | | Not Supported | | - | | |
| ESR = 100 Ω | 19.2 MHz $\leq f_p \leq$ 20 MHz | | 3 | pF | | | |
| | 20 MHz $< f_p \leq$ 32 MHz | | Not Supported | | - | | |
| L_M | Crystal motional inductance for $f_p = 20$ MHz | | 10.16 | | mH | | |
| C_M | Crystal motional capacitance | | 3.42 | | fF | | |

Table 6-5. OSC1 Crystal Electrical Characteristics (continued)

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|-----------------|---|---|-----|------|------|
| $t_{j(xiosc1)}$ | Frequency accuracy ⁽¹⁾ , xi_osc1 | Ethernet and MLB not used | | ±200 | ppm |
| | | Ethernet RGMII and RMII using derived clock | | ±50 | |
| | | Ethernet MII using derived clock | | ±100 | |
| | | MLB using derived clock | | ±50 | |

(1) Crystal characteristics should account for tolerance+stability+aging.

When selecting a crystal, the system design must take into account the temperature and aging characteristics of a crystal versus the user environment and expected lifetime of the system.

Table 6-6 details the switching characteristics of the oscillator and the requirements of the input clock.

Table 6-6. Oscillator Switching Characteristics—Crystal Mode

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|----------|-----------------------|-----------------------|-----|-----|------|
| f_p | Oscillation frequency | Range from 19.2 to 32 | | | MHz |
| t_{sX} | Start-up time | | | 4 | ms |

6.1.3.2 OSC1 Input Clock

A 1.8-V LVCMOS-Compatible Clock Input can be used instead of the internal oscillator to provide the SYS_CLK2 clock input to the system. The external connections to support this are shown in, Figure 6-8. The xi_osc1 pin is connected to the 1.8-V LVCMOS-Compatible clock sources. The xo_osc1 pin is left unconnected. The vssa_osc1 pin is connected to board ground (vss).

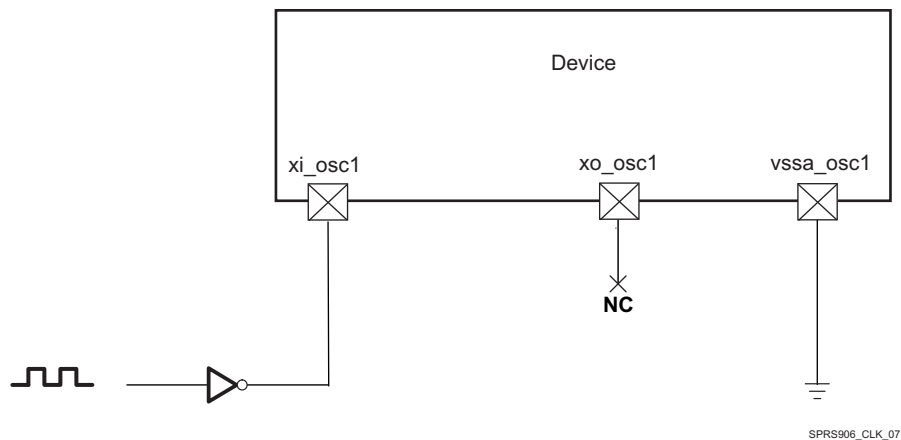


Figure 6-8. 1.8-V LVCMOS-Compatible Clock Input

Table 6-7 summarizes the OSC1 input clock electrical characteristics.

Table 6-7. OSC1 Input Clock Electrical Characteristics—Bypass Mode

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|----------|------------------------------|-----------------------|-------|-------|------|
| f | Frequency | Range from 12 to 38.4 | | | MHz |
| C_{IN} | Input capacitance | 2.819 | 3.019 | 3.219 | pF |
| I_{IN} | Input current (3.3V mode) | 4 | 6 | 10 | μA |
| t_{sX} | Start-up time ⁽¹⁾ | See ⁽²⁾ | | | ms |

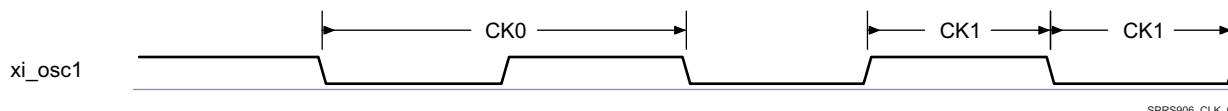
- (1) To switch from bypass mode to crystal or from crystal mode to bypass mode, there is a waiting time about 100 μ s; however, if the chip comes from bypass mode to crystal mode the crystal will start-up after time mentioned in Table 6-6, t_{SX} parameter.
- (2) Before the processor boots up and the oscillator is set to bypass mode, there is a waiting time when the internal oscillator is in application mode and receives a wave. The switching time in this case is about 100 μ s.

Table 6-8 details the OSC1 input clock timing requirements.

Table 6-8. OSC1 Input Clock Timing Requirements

| NAME | DESCRIPTION | | MIN | TYP | MAX | UNIT |
|---|---------------------|---|----------------------------------|-----------|---|------|
| CK0 | 1 / $t_{c(xiosc1)}$ | Frequency, xi_osc1 | Range from 12 to 38.4 | | | MHz |
| CK1 | $t_{w(xiosc1)}$ | Pulse duration, xi_osc1 low or high | 0.45 \times $t_{c(xiosc1)}$ | | 0.55 \times $t_{c(xiosc1)}$ | ns |
| | $t_{j(xiosc1)}$ | Period jitter ⁽¹⁾ , xi_osc1 | | | 0.01 \times $t_{c(xiosc1)}$ (3) | ns |
| | $t_{R(xiosc1)}$ | Rise time, xi_osc1 | | | 5 | ns |
| | $t_{F(xiosc1)}$ | Fall time, xi_osc1 | | | 5 | ns |
| | $t_{f(xiosc1)}$ | Frequency accuracy ⁽²⁾ , xi_osc1 | Ethernet and MLB not used | | \pm 200 | ppm |
| Ethernet RGMII and RMII using derived clock | | | | \pm 50 | | |
| Ethernet MII using derived clock | | | | \pm 100 | | |
| MLB using derived clock | | | | \pm 50 | | |

- (1) Period jitter is meant here as follows:
 - The maximum value is the difference between the longest measured clock period and the expected clock period
 - The minimum value is the difference between the shortest measured clock period and the expected clock period
- (2) Crystal characteristics should account for tolerance+stability+aging.
- (3) The Period jitter requirement for osc1 can be relaxed to $0.02 \times t_{c(xiosc1)}$ under the following constraints:
 - a. The osc1/SYS_CLK2 clock bypasses all device PLLs
 - b. The osc1/SYS_CLK2 clock is only used to source the DSS pixel clock outputs



SPRS906_CLK_08

Figure 6-9. xi_osc1 Input Clock

6.1.4 RTC Oscillator Input Clock

FUNC_32K_CLK is received directly from RTC oscillator. For more information about FUNC_32K_CLK, see *Power, Reset, and Clock Management* chapter in the device TRM.

6.1.4.1 RTC Oscillator External Crystal

An external crystal is connected to the device pins. Figure 6-10 describes the crystal implementation.

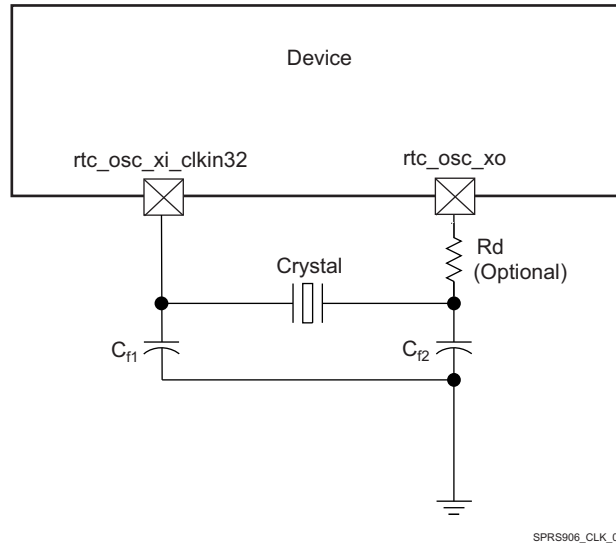


Figure 6-10. Crystal Implementation

NOTE

The load capacitors, C_{f1} and C_{f2} in Figure 6-10, should be chosen such that the below equation is satisfied. C_L in the equation is the load specified by the crystal manufacturer. All discrete components used to implement the oscillator circuit should be placed as close as possible to the associated oscillator rtc_osc_xi_clkin32 and rtc_osc_xo pins.

$$C_L = \frac{C_{f1} C_{f2}}{(C_{f1} + C_{f2})}$$

Figure 6-11. Load Capacitance Equation

The crystal must be in the fundamental mode of operation and parallel resonant. Table 6-9 summarizes the required electrical constraints.

Table 6-9. RTC Crystal Electrical Characteristics

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|---------------------------------------|---|-----|--------|-----------|------------|
| f_p | Parallel resonance crystal frequency | | 32.768 | | kHz |
| C_{f1} | C_{f1} load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ | 12 | | 24 | pF |
| C_{f2} | C_{f2} load capacitance for crystal parallel resonance with $C_{f1} = C_{f2}$ | 12 | | 24 | pF |
| ESR(C_{f1}, C_{f2}) | Crystal ESR | | | 80 | k Ω |
| C_O | Crystal shunt capacitance | | | 5 | pF |
| L_M | Crystal motional inductance for $f_p = 32,768$ kHz | | 10.7 | | mH |
| C_M | Crystal motional capacitance | | 2.2 | | fF |
| $t_{j}(\text{rtc_osc_xi_clkin32})$ | Frequency accuracy, rtc_osc_xi_clkin32 | | | ± 200 | ppm |

When selecting a crystal, the system design must take into account the temperature and aging characteristics of a crystal versus the user environment and expected lifetime of the system.

Table 6-10 details the switching characteristics of the oscillator and the requirements of the input clock.

Table 6-10. Oscillator Switching Characteristics—Crystal Mode

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|-------|-----------------------|-----|--------|-----|------|
| f_p | Oscillation frequency | | 32.768 | | kHz |

Table 6-10. Oscillator Switching Characteristics—Crystal Mode (continued)

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|----------|---------------|-----|-----|-----|------|
| t_{sX} | Start-up time | | | 4 | ms |

6.1.4.2 RTC Oscillator Input Clock

A 1.8-V LVCMOS-Compatible Clock Input can be used instead of the internal oscillator to provide the FUNC_32K_CLK clock input to the system. The external connections to support this are shown in Figure 6-12. The rtc_osc_xi_clkin32 pin is connected to the 1.8-V LVCMOS-Compatible clock sources. The rtc_osc_xo pin is left unconnected.

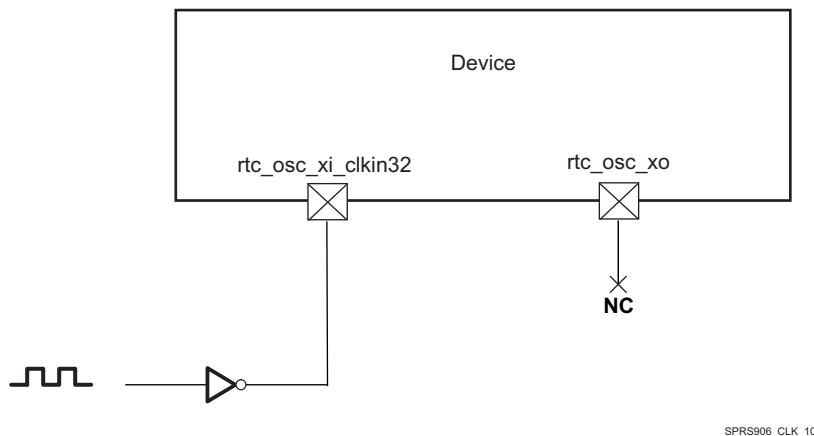


Figure 6-12. LVCMOS-Compatible Clock Input

Table 6-11 summarizes the RTC Oscillator input clock electrical characteristics.

Table 6-11. RTC Oscillator Input Clock Electrical Characteristics—Bypass Mode

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|------|---|---|---------|---|---------------|
| CK0 | $1/t_c(\text{rtc_osc_xi_clkin32})$ Frequency, rtc_osc_xi_clkin32 | | 32.768 | | kHz |
| CK1 | $t_w(\text{rtc_osc_xi_clkin32})$ Pulse duration, rtc_osc_xi_clkin32 low or high | $0.45 \times t_c(\text{rtc_osc_xi_clkin32})$ | | $0.55 \times t_c(\text{rtc_osc_xi_clkin32})$ | ns |
| | C_{IN} Input capacitance | 2.178 | 2.378 | 2.578 | pF |
| | I_{IN} Input current (3.3V mode) | 4 | 6 | 10 | μA |
| | t_{sX} Start-up time | | See (1) | | ms |

(1) Before the processor boots up and the oscillator is set to bypass mode, there is a waiting time when the internal oscillator is inapplication mode and receives a wave. The switching time in this case is about 100 μs .

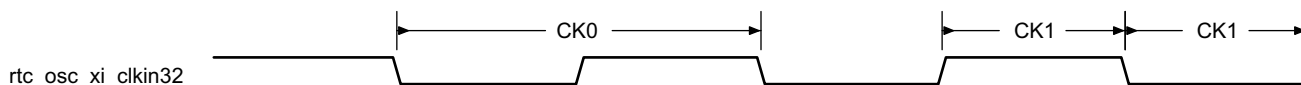


Figure 6-13. rtc_osc_xi_clkin32 Input Clock

6.1.4.3 RC On-die Oscillator Clock

NOTE

The OSC_32K_CLK clock, provided by the On-die 32K RC oscillator, inside of the SoC, is not accurate 32kHz clock.

The frequency may significantly vary with temperature and silicon characteristics.

For more information about OSC_32K_CLK, see *Power, Reset, and Clock Management* chapter in the device TRM.

6.2 DPLLs, DLLs Specifications

NOTE

For more information, see *Power, Reset, and Clock Management* and *Display Subsystem* chapters in the device TRM.

To generate high-frequency clocks, the device supports multiple on-chip DPLLs controlled directly by the PRCM module. They are of two types: type A and type B DPLLs.

- They have their own independent power domain (each one embeds its own switch and can be controlled as an independent functional power domain)
- They are fed with ALWAYS ON system clock, with independent control per DPLL.

The different DPLLs managed by the PRCM are listed below:

- DPLL_MPU: It supplies the MPU subsystem clocking internally.
- DPLL_IVA: It feeds the IVA subsystem clocking.
- DPLL_CORE: It supplies all interface clocks and also few module functional clocks.
- DPLL_PER: It supplies several clock sources: a 192-MHz clock for the display functional clock, a 96-MHz functional clock to subsystems and peripherals.
- DPLL_ABE: It provides clocks to various modules within the device.
- DPLL_USB: It provides 960M clock for USB modules (USB1/2/3/4).
- DPLL_GMAC: It supplies several clocks for the Gigabit Ethernet Switch (GMAC_SW).
- DPLL_DSP: It feeds the DSP Subsystem clocking.
- DPLL_GPU: It supplies clock for the GPU Subsystem.
- DPLL_DDR: It generates clocks for the two External Memory Interface (EMIF) controllers and their associated EMIF PHYs.
- DPLL_PCIE_REF: It provides reference clock for the APLL_PCIE in PCIE Subsystem.
- APLL_PCIE: It feeds clocks for the device Peripheral Component Interconnect Express (PCIe) controllers.

NOTE

The following DPLLs are controlled by the clock manager located in the always-on Core power domain (CM_CORE_AON):

- DPLL_MPU, DPLL_IVA, DPLL_CORE, DPLL_ABE, DPLL_DDR, DPLL_GMAC, DPLL_PCIE_REF, DPLL_PER, DPLL_USB, DPLL_DSP, DPLL_GPU, APLL_PCIE_REF.
-

For more information on CM_CORE_AON and CM_CORE or PRCM DPLLs, see *Power, Reset, and Clock Management* chapter in the device TRM.

The following DPLLs are not managed by the PRCM:

- DPLL_VIDEO1; (It is controlled from DSS)
- DPLL_HDMI; (It is controlled from DSS)
- DPLL_SATA; (It is controlled from SATA)
- DPLL_DEBUG; (It is controlled from DEBUGSS)
- DPLL_USB_OTG_SS; (It is controlled from OCP2SCP1)

NOTE

For more information for not controlled from PRCM DPLL's see the related chapters in TRM.

6.2.1 DPLL Characteristics

The DPLL has three relevant input clocks. One of them is the reference clock (CLKINP) used to generated the synthesized clock but can also be used as the bypass clock whenever the DPLL enters a bypass mode. It is therefore mandatory. The second one is a fast bypass clock (CLKINPULOW) used when selected as the bypass clock and is optional. The third clock (CLKINPHIF) is explained in the next paragraph.

The DPLL has three output clocks (namely CLKOUT, CLKOUTX2, and CLKOUTHIF). CLKOUT and CLKOUTX2 run at the bypass frequency whenever the DPLL enters a bypass mode. Both of them are generated from the lock frequency divided by a post-divider (namely M2 post-divider). The third clock, CLKOUTHIF, has no automatic bypass capability. It is an output of a post-divider (M3 post-divider) with the input clock selectable between the internal lock clock (Fdpll) and CLKINPHIF input of the PLL through an asynchronous multiplexing.

For more information, see *Power, Reset, and Clock Management* chapter in the device TRM.

Table 6-12 summarizes DPLL type described in Section 6.2, *DPLLs, DLLs Specifications* introduction.

Table 6-12. DPLL Control Type

| DPLL NAME | TYPE | CONTROLLED BY PRCM |
|-----------------|---------------------|--------------------|
| DPLL_ABE | Table 6-13 (Type A) | Yes ⁽¹⁾ |
| DPLL_CORE | Table 6-13 (Type A) | Yes ⁽¹⁾ |
| DPLL_DEBUGSS | Table 6-13 (Type A) | No |
| DPLL_DSP | Table 6-13 (Type A) | Yes ⁽¹⁾ |
| DPLL_GMAC | Table 6-13 (Type A) | Yes ⁽¹⁾ |
| DPLL_HDMI | Table 6-14 (Type B) | No |
| DPLL_IVA | Table 6-13 (Type A) | Yes ⁽¹⁾ |
| DPLL_MPU | Table 6-13 (Type A) | Yes ⁽¹⁾ |
| DPLL_PER | Table 6-13 (Type A) | Yes ⁽¹⁾ |
| APLL_PCIE | Table 6-13 (Type A) | Yes ⁽¹⁾ |
| DPLL_PCIE_REF | Table 6-14 (Type B) | Yes ⁽¹⁾ |
| DPLL_SATA | Table 6-14 (Type B) | No |
| DPLL_USB | Table 6-14 (Type B) | Yes ⁽¹⁾ |
| DPLL_USB_OTG_SS | Table 6-14 (Type B) | No |
| DPLL_VIDEO1 | Table 6-13 (Type A) | No |
| DPLL_DDR | Table 6-13 (Type A) | Yes ⁽¹⁾ |
| DPLL_GPU | Table 6-13 (Type A) | Yes ⁽¹⁾ |

(1) DPLL is in the always-on domain.

Table 6-13 and Table 6-14 summarize the DPLL characteristics and assume testing over recommended operating conditions.

Table 6-13. DPLL Type A Characteristics

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT | COMMENTS |
|------------------------|------------------------------|-------|-----|------|------|---------------------|
| f _{input} | CLKINP input frequency | 0.032 | | 52 | MHz | F _{INP} |
| f _{internal} | Internal reference frequency | 0.15 | | 52 | MHz | REFCLK |
| f _{CLKINPHIF} | CLKINPHIF input frequency | 10 | | 1400 | MHz | F _{INPHIF} |

Table 6-13. DPLL Type A Characteristics (continued)

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT | COMMENTS |
|-------------------------|--|-------------------|-----|---------------------|------|---|
| f _{CLKINPULOW} | CLKINPULOW input frequency | 0.001 | | 600 | MHz | Bypass mode: f _{CLKOUT} = f _{CLKINPULOW} / (M1 + 1) if ulowclken = 1 ⁽⁶⁾ |
| f _{CLKOUT} | CLKOUT output frequency | 20 ⁽¹⁾ | | 1800 ⁽²⁾ | MHz | [M / (N + 1)] × F _{INP} × [1 / M2] (in locked condition) |
| f _{CLKOUTx2} | CLKOUTx2 output frequency | 40 ⁽¹⁾ | | 2200 ⁽²⁾ | MHz | 2 × [M / (N + 1)] × F _{INP} × [1 / M2] (in locked condition) |
| f _{CLKOUTHIF} | CLKOUTHIF output frequency | 20 ⁽³⁾ | | 1400 ⁽⁴⁾ | MHz | F _{INPHIF} / M3 if clkinphifsel = 1 |
| | | 40 ⁽³⁾ | | 2200 ⁽⁴⁾ | MHz | 2 × [M / (N + 1)] × F _{INP} × [1 / M3] if clkinphifsel = 0 |
| f _{CLKDCOLDO} | DCOCLKLDO output frequency | 40 | | 2800 | MHz | 2 × [M / (N + 1)] × F _{INP} (in locked condition) |
| t _{lock} | Frequency lock time | | | 6 + 350 × REFCLK | μs | |
| p _{lock} | Phase lock time | | | 6 + 500 × REFCLK | μs | |
| t _{relock-L} | Relock time—Frequency lock ⁽⁵⁾ (LP relock time from bypass) | | | 6 + 70 × REFCLK | μs | DPLL in LP relock time: lowcurrstbby = 1 |
| p _{relock-L} | Relock time—Phase lock ⁽⁵⁾ (LP relock time from bypass) | | | 6 + 120 × REFCLK | μs | DPLL in LP relock time: lowcurrstbby = 1 |
| t _{relock-F} | Relock time—Frequency lock ⁽⁵⁾ (fast relock time from bypass) | | | 3.55 + 70 × REFCLK | μs | DPLL in fast relock time: lowcurrstbby = 0 |
| p _{relock-F} | Relock time—Phase lock ⁽⁵⁾ (fast relock time from bypass) | | | 3.55 + 120 × REFCLK | μs | DPLL in fast relock time: lowcurrstbby = 0 |

(1) The minimum frequencies on CLKOUT and CLKOUTX2 are assuming M2 = 1.

For M2 > 1, the minimum frequency on these clocks will further scale down by factor of M2.

(2) The maximum frequencies on CLKOUT and CLKOUTX2 are assuming M2 = 1.

(3) The minimum frequency on CLKOUTHIF is assuming M3 = 1. For M3 > 1, the minimum frequency on this clock will further scale down by factor of M3.

(4) The maximum frequency on CLKOUTHIF is assuming M3 = 1.

(5) Relock time assumes typical operating conditions, 10°C maximum temperature drift.

(6) Bypass mode: f_{CLKOUT} = F_{INP} if ulowclken = 0. For more information, see the device TRM.

Table 6-14. DPLL Type B Characteristics

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT | COMMENTS |
|-------------------------|--|----------------------|-----|------------------------|------|---|
| f _{input} | CLKINP input clock frequency | 0.62 | | 60 | MHz | F _{INP} |
| f _{internal} | REFCLK internal reference clock frequency | 0.62 | | 2.5 | MHz | [1 / (N + 1)] × F _{INP} |
| f _{CLKINPULOW} | CLKINPULOW bypass input clock frequency | 0.001 | | 600 | MHz | Bypass mode: f _{CLKOUT} = f _{CLKINPULOW} / (M1 + 1) if ulowclken = 1 ⁽⁴⁾ |
| f _{CLKLDOOUT} | CLKOUTLDO output clock frequency | 20 ⁽¹⁾⁽⁵⁾ | | 2500 ⁽²⁾⁽⁵⁾ | MHz | M / (N + 1) × F _{INP} × [1 / M2] (in locked condition) |
| f _{CLKOUT} | CLKOUT output clock frequency | 20 ⁽¹⁾⁽⁵⁾ | | 1450 ⁽²⁾⁽⁵⁾ | MHz | [M / (N + 1)] × F _{INP} × [1 / M2] (in locked condition) |
| f _{CLKDCOLDO} | Internal oscillator (DCO) output clock frequency | 750 ⁽⁵⁾ | | 1500 ⁽⁵⁾ | MHz | [M / (N + 1)] × F _{INP} (in locked condition) |
| | | 1250 ⁽⁵⁾ | | 2500 ⁽⁵⁾ | MHz | |
| t _j | CLKOUTLDO period jitter | –2.5% | | 2.5% | | The period jitter at the output clocks is ± 2.5% peak to peak |
| | CLKOUT period jitter | | | | | |
| | CLKDCOLDO period jitter | | | | | |
| t _{lock} | Frequency lock time | | | 350 × REFCLKs | μs | |

Table 6-14. DPLL Type B Characteristics (continued)

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT | COMMENTS |
|------------------------|--|-----|-----|-------------------|------|----------|
| t_{Plock} | Phase lock time | | | 500 × REFCLKs | μs | |
| $t_{\text{relock-L}}$ | Relock time—Frequency lock ⁽³⁾ (LP relock time from bypass) | | | 9 + 30 × REFCLKs | μs | |
| $t_{\text{Prelock-L}}$ | Relock time—Phase lock ⁽³⁾ (LP relock time from bypass) | | | 9 + 125 × REFCLKs | μs | |

(1) The minimum frequency on CLKOUT is assuming M2 = 1.

For M2 > 1, the minimum frequency on this clock will further scale down by factor of M2.

(2) The maximum frequency on CLKOUT is assuming M2 = 1.

(3) Relock time assumes typical operating conditions, 10°C maximum temperature drift.

(4) Bypass mode: $f_{\text{CLKOUT}} = F_{\text{INP}}$ if ULOWCLKEN = 0. For more information, see the device TRM.

(5) For output clocks, there are two frequency ranges according to the SELFREQDCO setting. For more information, see the device TRM.

6.2.2 DLL Characteristics

Table 6-15 summarizes the DLL characteristics and assumes testing over recommended operating conditions.

Table 6-15. DLL Characteristics

| NAME | DESCRIPTION | MIN | TYP | MAX | UNIT |
|---------------------|--|-----|-----|-----|--------|
| f_{input} | Input clock frequency (EMIF_DLL_FCLK) | | | 333 | MHz |
| t_{lock} | Lock time | | | 50k | cycles |
| t_{relock} | Relock time (a change of the DLL frequency implies that DLL must relock) | | | 50k | cycles |

6.2.3 DPLL and DLL Noise Isolation

NOTE

For more information on DPLL and DLL decoupling capacitor requirements, see *Core Power Domains* section.

7 Timing Requirements and Switching Characteristics

7.1 Timing Test Conditions

All timing requirements and switching characteristics are valid over the recommended operating conditions unless otherwise specified.

7.2 Interface Clock Specifications

7.2.1 Interface Clock Terminology

The interface clock is used at the system level to sequence the data and/or to control transfers accordingly with the interface protocol.

7.2.2 Interface Clock Frequency

The two interface clock characteristics are:

- The maximum clock frequency
- The maximum operating frequency

The interface clock frequency documented in this document is the maximum clock frequency, which corresponds to the maximum frequency programmable on this output clock. This frequency defines the maximum limit supported by the Device IC and does not take into account any system consideration (PCB, peripherals).

The system designer will have to consider these system considerations and the Device IC timing characteristics as well to define properly the maximum operating frequency that corresponds to the maximum frequency supported to transfer the data on this interface.

7.3 Timing Parameters and Information

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

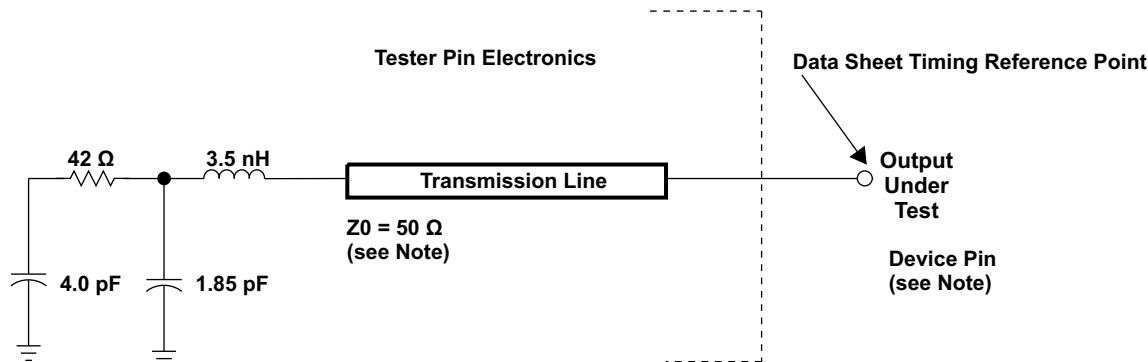
Table 7-1. Timing Parameters

| SUBSCRIPTS | |
|------------|--|
| SYMBOL | PARAMETER |
| c | Cycle time (period) |
| d | Delay time |
| dis | Disable time |
| en | Enable time |
| h | Hold time |
| su | Setup time |
| START | Start bit |
| t | Transition time |
| v | Valid time |
| w | Pulse duration (width) |
| X | Unknown, changing, or don't care level |
| F | Fall time |
| H | High |
| L | Low |
| R | Rise time |
| V | Valid |
| IV | Invalid |

Table 7-1. Timing Parameters (continued)

| SUBSCRIPTS | |
|------------|----------------|
| SYMBOL | PARAMETER |
| AE | Active Edge |
| FE | First Edge |
| LE | Last Edge |
| Z | High impedance |

7.3.1 Parameter Information



NOTE: The data sheet provides timing at the device pin. For output timing analysis, the tester pin electronics and its transmission line effects must be taken into account. A transmission line with a delay of 2 ns can be used to produce the desired transmission line effect. The transmission line is intended as a load only. It is not necessary to add or subtract the transmission line delay (2 ns) from the data sheet timings.

Input requirements in this data sheet are tested with an input slew rate of < 4 Volts per nanosecond (4 V/ns) at the device pin.

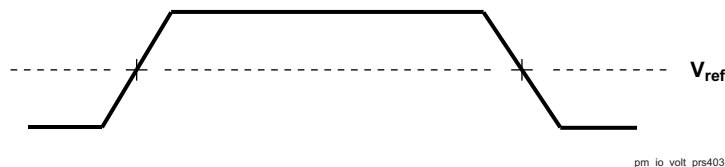
pm_tstcirc_prs403

Figure 7-1. Test Load Circuit for AC Timing Measurements

The load capacitance value stated is only for characterization and measurement of AC timing signals. This load capacitance value does not indicate the maximum load the device is capable of driving.

7.3.1.1 1.8V and 3.3V Signal Transition Levels

All input and output timing parameters are referenced to V_{ref} for both "0" and "1" logic levels. $V_{ref} = (V_{DD} I/O)/2$.



pm_io_volt_prs403

Figure 7-2. Input and Output Voltage Reference Levels for AC Timing Measurements

All rise and fall transition timing parameters are referenced to $V_{IL} MAX$ and $V_{IH} MIN$ for input clocks, $V_{OL} MAX$ and $V_{OH} MIN$ for output clocks.

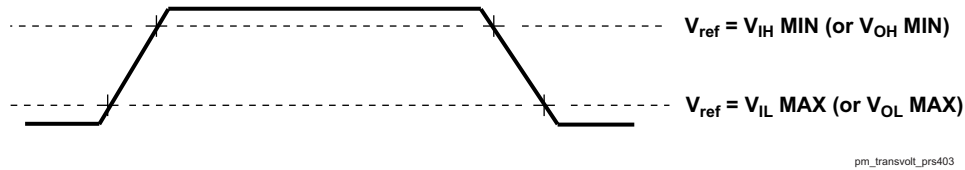


Figure 7-3. Rise and Fall Transition Time Voltage Reference Levels

7.3.1.2 1.8V and 3.3V Signal Transition Rates

The default SLEWCONTROL settings in each pad configuration register must be used to ensure timings, unless specific instructions otherwise are given in the individual timing sub-sections of the datasheet.

All timings are tested with an input edge rate of 4 volts per nanosecond (4 V/ns).

7.3.1.3 Timing Parameters and Board Routing Analysis

The timing parameter values specified in this data manual do not include delays by board routes. As a good board design practice, such delays must *always* be taken into account. Timing values may be adjusted by increasing/decreasing such delays. TI recommends using the available I/O buffer information specification (IBIS) models to analyze the timing characteristics correctly. To properly use IBIS models to attain accurate timing analysis for a given system, see the [Using IBIS Models for timing Analysis](#). If needed, external logic hardware such as buffers may be used to compensate any timing differences.

7.4 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. Monotonic transitions are more easily ensured with faster switching signals. Slower input transitions are more susceptible to glitches due to noise and special care should be taken for slow input clocks.

7.5 Virtual and Manual I/O Timing Modes

Some of the timings described in the following sections require the use of Virtual or Manual I/O Timing Modes. [Table 7-2](#) provides a summary of the Virtual and Manual I/O Timing Modes across all device interfaces. The individual interface timing sections found later in this document provide the full description of each applicable Virtual and Manual I/O Timing Mode. Refer to the "Pad Configuration" section of the TRM for the procedure on implementing the Virtual and Manual Timing Modes in a system.

Table 7-2. Modes Summary

| VIRTUAL OR MANUAL IO MODE NAME | DATA MANUAL TIMING MODE |
|--|---|
| DPI VIDEO OUTPUT | |
| No Virtual or Manual IO Timing Mode Required | DPI1/3 Video Output Default Timings - Rising-edge Clock Reference |
| DSS_VIRTUAL1 | DPI1/3 Video Output Default Timings - Falling-edge Clock Reference |
| VOUT1_MANUAL1 | DPI1 Video Output Alternate Timings |
| VOUT1_MANUAL4 | DPI1 Video Output MANUAL4 Timings |
| VOUT1_MANUAL5 | DPI1 Video Output MANUAL5 Timings |
| VOUT2_IOSET1_MANUAL1 | DPI2 Video Output IOSET1 Alternate Timings |
| VOUT2_IOSET1_MANUAL2 | DPI2 Video Output IOSET1 Default Timings - Rising-edge Clock Reference |
| VOUT2_IOSET1_MANUAL3 | DPI2 Video Output IOSET1 Default Timings - Falling-edge Clock Reference |
| VOUT2_IOSET1_MANUAL4 | DPI2 Video Output IOSET1 MANUAL4 Timings |
| VOUT2_IOSET1_MANUAL5 | DPI2 Video Output IOSET1 MANUAL5 Timings |
| VOUT2_IOSET2_MANUAL1 | DPI2 Video Output IOSET2 Alternate Timings |
| VOUT2_IOSET2_MANUAL2 | DPI2 Video Output IOSET2 Default Timings - Rising-edge Clock Reference |
| VOUT2_IOSET2_MANUAL3 | DPI2 Video Output IOSET2 Default Timings - Falling-edge Clock Reference |
| VOUT2_IOSET2_MANUAL4 | DPI2 Video Output IOSET2 MANUAL4 Timings |

Table 7-2. Modes Summary (continued)

| VIRTUAL OR MANUAL IO MODE NAME | DATA MANUAL TIMING MODE |
|--|---|
| VOUT2_IOSET2_MANUAL5 | DPI2 Video Output IOSET2 MANUAL5 Timings |
| VOUT3_MANUAL1 | DPI3 Video Output Alternate Timings |
| VOUT3_MANUAL4 | DPI3 Video Output MANUAL4 Timings |
| VOUT3_MANUAL5 | DPI3 Video Output MANUAL5 Timings |
| GPMC | |
| No Virtual or Manual IO Timing Mode Required | GPMC Asynchronous Mode Timings and Synchronous Mode - Default Timings |
| GPMC_VIRTUAL1 | GPMC Synchronous Mode - Alternate Timings |
| McASP | |
| No Virtual or Manual IO Timing Mode Required | McASP1 Asynchronous and Synchronous Transmit Timings |
| MCASP1_VIRTUAL1_SYNC_RX | See Table 7-54 |
| MCASP1_VIRTUAL2_ASYNC_RX | See Table 7-54 |
| No Virtual or Manual IO Timing Mode Required | McASP2 Asynchronous and Synchronous Transmit Timings |
| MCASP2_VIRTUAL1_SYNC_RX_80M | See Table 7-55 |
| MCASP2_VIRTUAL2_ASYNC_RX | See Table 7-55 |
| MCASP2_VIRTUAL3_SYNC_RX | See Table 7-55 |
| MCASP2_VIRTUAL4_ASYNC_RX_80M | See Table 7-55 |
| No Virtual or Manual IO Timing Mode Required | McASP3 Synchronous Transmit Timings |
| MCASP3_VIRTUAL2_SYNC_RX | See Table 7-56 |
| No Virtual or Manual IO Timing Mode Required | McASP4 Synchronous Transmit Timings |
| MCASP4_VIRTUAL1_SYNC_RX | See Table 7-57 |
| No Virtual or Manual IO Timing Mode Required | McASP5 Synchronous Transmit Timings |
| MCASP5_VIRTUAL1_SYNC_RX | See Table 7-58 |
| No Virtual or Manual IO Timing Mode Required | McASP6 Synchronous Transmit Timings |
| MCASP6_VIRTUAL1_SYNC_RX | See Table 7-59 |
| No Virtual or Manual IO Timing Mode Required | McASP7 Synchronous Transmit Timings |
| MCASP7_VIRTUAL2_SYNC_RX | See Table 7-60 |
| No Virtual or Manual IO Timing Mode Required | McASP8 Synchronous Transmit Timings |
| MCASP8_VIRTUAL1_SYNC_RX | See Table 7-61 |
| eMMC/SD/SDIO | |
| No Virtual or Manual IO Timing Mode Required | MMC1 DS (Pad Loopback), HS (Internal Loopback and Pad Loopback), SDR12 (Internal Loopback and Pad Loopback), and SDR25 Timings (Internal Loopback and Pad Loopback) Timings |
| MMC1_VIRTUAL1 | MMC1 SDR50 (Pad Loopback) Timings |
| MMC1_VIRTUAL4 | MMC1 DS (Internal Loopback) Timings |
| MMC1_VIRTUAL5 | MMC1 SDR50 (Internal Loopback) Timings |
| MMC1_VIRTUAL6 | MMC1 DDR50 (Internal Loopback) Timings |
| MMC1_MANUAL1 | MMC1 DDR50 (Pad Loopback) Timings |
| MMC1_MANUAL2 | MMC1 SDR104 Timings |
| No Virtual or Manual IO Timing Mode Required | MMC2 Standard (Pad Loopback), High Speed (Pad Loopback) Timings |
| MMC2_VIRTUAL2 | MMC2 Standard (Internal Loopback), High Speed (Internal Loopback) Timings |
| MMC2_MANUAL1 | MMC2 DDR (Pad Loopback) Timings |
| MMC2_MANUAL2 | MMC2 DDR (Internal Loopback Manual) Timings |
| MMC2_MANUAL3 | MMC2 HS200 Timings |
| No Virtual or Manual IO Timing Mode Required | MMC3 DS, SDR12, HS, SDR25 Timings |
| MMC3_MANUAL1 | MMC3 SDR50 Timings |
| No Virtual or Manual IO Timing Mode Required | MMC4 DS, SDR12, HS, SDR25 Timings |
| QSPI | |
| No Virtual or Manual IO Timing Mode Required | QSPI Mode 3 Timings |

Table 7-2. Modes Summary (continued)

| VIRTUAL OR MANUAL IO MODE NAME | DATA MANUAL TIMING MODE |
|---|--|
| QSPI1_MANUAL1 | QSPI Mode 0 Timings |
| GMAC | |
| No Virtual or Manual IO Timing Mode Required | GMAC MII0/1 Timings |
| GMAC_RGMII0_MANUAL1 | GMAC RGMII0 with Transmit Clock Internal Delay Enabled |
| GMAC_RGMII1_MANUAL1 | GMAC RGMII1 with Transmit Clock Internal Delay Enabled |
| GMAC_RMII0_MANUAL1 | GMAC RMII0 Timings |
| GMAC_RMII1_MANUAL1 | GMAC RMII1 Timings |
| VIP | |
| VIP_MANUAL1 | VIN1A (IOSET7) and VIN2A (IOSET10) Rise-Edge Capture Mode Timings |
| VIP_MANUAL2 | VIN1A (IOSET7) and VIN2A (IOSET10) Fall-Edge Capture Mode Timings |
| VIP_MANUAL3 | VIN2A (IOSET4/5/6) Rise-Edge Capture Mode Timings |
| VIP_MANUAL4 | VIN2B (IOSET7/8/9) Rise-Edge Capture Mode Timings |
| VIP_MANUAL5 | VIN2A (IOSET4/5/6) Fall-Edge Capture Mode Timings |
| VIP_MANUAL6 | VIN2B (IOSET7/8/9) Fall-Edge Capture Mode Timings |
| VIP_MANUAL7 | VIN1A (IOSET2/3/4) and VIN1B (IOSET4/7) and VIN2B (IOSET1/10) Rise-Edge Capture Mode Timings |
| VIP_MANUAL8 | VIN1A (IOSET5/6) and VIN2A (IOSET7/8/9) Rise-Edge Capture Mode Timings |
| VIP_MANUAL9 | VIN1B (IOSET6/7) Rise-Edge Capture Mode Timings |
| VIP_MANUAL10 | VIN1B (IOSET5) and VIN2B (IOSET2/11) Rise-Edge Capture Mode Timings |
| VIP_MANUAL11 | VIN1B (IOSET5) and VIN2B (IOSET2/11) Fall-Edge Capture Mode Timings |
| VIP_MANUAL12 | VIN1A (IOSET2/3/4) and VIN1B (IOSET4/7) and VIN2B (IOSET1/10) Fall-Edge Capture Mode Timings |
| VIP_MANUAL13 | VIN1A (IOSET5/6) and VIN2A (IOSET7/8/9) Fall-Edge Capture Mode Timings |
| VIP_MANUAL14 | VIN1B (IOSET6/7) Fall-Edge Capture Mode Timings |
| VIP_MANUAL15 | VIN1A (IOSET8/9/10) Rise-Edge Capture Mode Timings |
| VIP_MANUAL16 | VIN1A (IOSET8/9/10) Fall-Edge Capture Mode Timings |
| HDMI, EMIF, Timers, I2C, HDQ/1-Wire, UART, McSPI, USB, SATA, PCIe, DCAN, GPIO, KBD, PWM, ATL, JTAG, TPIU, RTC, SDMA, INTC, MLB | |
| No Virtual or Manual IO Timing Mode Required | All Modes |

7.6 Video Input Ports (VIP)

The Device includes 1 Video Input Ports (VIP).

[Table 7-3](#), [Figure 7-4](#) and [Figure 7-5](#) present timings and switching characteristics of the VIPs.

CAUTION

The I/O timings provided in this section are valid only for VIN1 and VIN2 if signals within a single IOSET are used. The IOSETs are defined in [Table 7-4](#) and [Table 7-5](#).

Table 7-3. Timing Requirements for VIP ⁽³⁾⁽⁴⁾⁽⁵⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|---------------|---|-------------------------|-----|------|
| V1 | $t_{c(CLK)}$ | Cycle time, vinx_clki ^{(3) (5)} | 6.06 ⁽²⁾ | | ns |
| V2 | $t_{w(CLKH)}$ | Pulse duration, vinx_clki high ^{(3) (5)} | 0.45 × P ⁽²⁾ | | ns |
| V3 | $t_{w(CLKL)}$ | Pulse duration, vinx_clki low ^{(3) (5)} | 0.45 × P ⁽²⁾ | | ns |

Table 7-3. Timing Requirements for VIP (3)(4)(5) (continued)

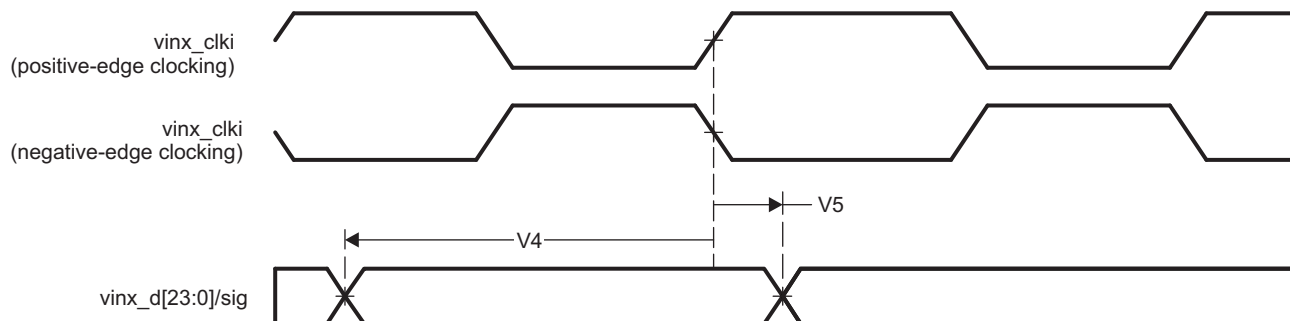
| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|------------------------|---|-----------|-----|------|
| V4 | $t_{su(CTL/DATA-CLK)}$ | Input setup time, Control (vinx_dei, vinx_vsynci, vinx_fldi, vinx_hsynci) and Data (vinx_dn) valid to vinx_clki transition (3) (4) (5) | 3.11 (2) | | ns |
| V6 | $t_{h(CLK-CTL/DATA)}$ | Input hold time, Control (vinx_dei, vinx_vsynci, vinx_fldi, vinx_hsynci) and Data (vinx_dn) valid from vinx_clki transition (3) (4) (5) | -0.05 (2) | | ns |

- (1) For maximum frequency of 165 MHz.
- (2) P = vinx_clki period.
- (3) x in vinx = 1a, 1b, 2a, 2b.
- (4) n in dn = 0 to 7 when x = 1b, 2b.
n = 0 to 23 when x = 1a, 2a.
- (5) i in clki, dei, vsynci, hsynci and fldi = 0 or 1.



SPRS906_TIMING_VIP_01

Figure 7-4. Video Input Ports clock signal



SPRS8xx_VIP_02

Figure 7-5. Video Input Ports timings

In [Table 7-4](#) and [Table 7-5](#) are presented the specific groupings of signals (IOSET) for use with vin1 and vin2.

Table 7-4. VIN1 IOSETs

| SIGNALS | IOSET2 | | IOSET3 | | IOSET4 ⁽¹⁾ | | IOSET5 ⁽¹⁾ | | IOSET6 ⁽¹⁾ | | IOSET7 ⁽¹⁾ | | IOSET8 | | IOSET9 | | IOSET10 | |
|--------------|--------|-----|--------|-----|-----------------------|-----|-----------------------|-----|-----------------------|-----|-----------------------|-----|--------|-----|--------|-----|---------|-----|
| | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX |
| vin1a | | | | | | | | | | | | | | | | | | |
| vin1a_clk0 | P1 | 2 | B11 | 4 | B11 | 3 | P4 | 4 | P4 | 4 | B26 | 8 | AC5 | 9 | E17 | 7 | E17 | 7 |
| vin1a_hsync0 | N7 | 2 | C11 | 4 | C11 | 3 | R3 | 4 | P7 | 4 | E21 | 8 | AB8 | 9 | F12 | 7 | F12 | 7 |
| vin1a_vsync0 | R4 | 2 | E11 | 4 | E11 | 3 | T2 | 4 | N1 | 4 | F20 | 8 | AB5 | 9 | G12 | 7 | G12 | 7 |
| vin1a_fld0 | P9 | 2 | D11 | 4 | D11 | 3 | P9 | 4 | J7 | 4 | F21 | 8 | C17 | 9 | C14 | 7 | C14 | 7 |
| vin1a_de0 | N9 | 2 | B10 | 4 | B10 | 3 | P7 | 5 | H6 | 4 | C23 | 8 | AB4 | 9 | D14 | 7 | D14 | 7 |
| vin1a_d0 | M6 | 2 | B7 | 4 | B7 | 3 | R6 | 4 | R6 | 4 | B14 | 8 | AD6 | 9 | D18 | 7 | C17 | 7 |
| vin1a_d1 | M2 | 2 | B8 | 4 | B8 | 3 | T9 | 4 | T9 | 4 | J14 | 8 | AC8 | 9 | B19 | 7 | B19 | 7 |
| vin1a_d2 | L5 | 2 | A7 | 4 | A7 | 3 | T6 | 4 | T6 | 4 | G13 | 8 | AC3 | 9 | F15 | 7 | F15 | 7 |
| vin1a_d3 | M1 | 2 | A8 | 4 | A8 | 3 | T7 | 4 | T7 | 4 | J11 | 8 | AC9 | 9 | B18 | 7 | B18 | 7 |
| vin1a_d4 | L6 | 2 | C9 | 4 | C9 | 3 | P6 | 4 | P6 | 4 | E12 | 8 | AC6 | 9 | A16 | 7 | A16 | 7 |
| vin1a_d5 | L4 | 2 | A9 | 4 | A9 | 3 | R9 | 4 | R9 | 4 | F13 | 8 | AC7 | 9 | C15 | 7 | C15 | 7 |
| vin1a_d6 | L3 | 2 | B9 | 4 | B9 | 3 | R5 | 4 | R5 | 4 | C12 | 8 | AC4 | 9 | A18 | 7 | A18 | 7 |
| vin1a_d7 | L2 | 2 | A10 | 4 | A10 | 3 | P5 | 4 | P5 | 4 | D12 | 8 | AD4 | 9 | A19 | 7 | A19 | 7 |
| vin1a_d8 | L1 | 2 | E8 | 4 | E8 | 3 | U2 | 4 | U2 | 4 | E15 | 8 | AA4 | 9 | F14 | 7 | F14 | 7 |
| vin1a_d9 | K2 | 2 | D9 | 4 | D9 | 3 | U1 | 4 | U1 | 4 | A20 | 8 | AB3 | 9 | G14 | 7 | G14 | 7 |
| vin1a_d10 | J1 | 2 | D7 | 4 | D7 | 3 | P3 | 4 | P3 | 4 | B15 | 8 | AB9 | 9 | A13 | 7 | A13 | 7 |
| vin1a_d11 | J2 | 2 | D8 | 4 | D8 | 3 | R2 | 4 | R2 | 4 | A15 | 8 | AA3 | 9 | E14 | 7 | E14 | 7 |
| vin1a_d12 | H1 | 2 | A5 | 4 | A5 | 3 | K7 | 4 | K7 | 4 | D15 | 8 | D17 | 9 | A12 | 7 | A12 | 7 |
| vin1a_d13 | J3 | 2 | C6 | 4 | C6 | 3 | M7 | 4 | M7 | 4 | B16 | 8 | G16 | 9 | B13 | 7 | B13 | 7 |
| vin1a_d14 | H2 | 2 | C8 | 4 | C8 | 3 | J5 | 4 | J5 | 4 | B17 | 8 | A21 | 9 | A11 | 7 | A11 | 7 |
| vin1a_d15 | H3 | 2 | C7 | 4 | C7 | 3 | K6 | 4 | K6 | 4 | A17 | 8 | C18 | 9 | B12 | 7 | B12 | 7 |
| vin1a_d16 | R6 | 2 | F11 | 4 | F11 | 3 | | | | | C18 | 8 | | | | | | |
| vin1a_d17 | T9 | 2 | G10 | 4 | G10 | 3 | | | | | A21 | 8 | | | | | | |
| vin1a_d18 | T6 | 2 | F10 | 4 | F10 | 3 | | | | | G16 | 8 | | | | | | |
| vin1a_d19 | T7 | 2 | G11 | 4 | G11 | 3 | | | | | D17 | 8 | | | | | | |
| vin1a_d20 | P6 | 2 | E9 | 4 | E9 | 3 | | | | | AA3 | 8 | | | | | | |
| vin1a_d21 | R9 | 2 | F9 | 4 | F9 | 3 | | | | | AB9 | 8 | | | | | | |
| vin1a_d22 | R5 | 2 | F8 | 4 | F8 | 3 | | | | | AB3 | 8 | | | | | | |
| vin1a_d23 | P5 | 2 | E7 | 4 | E7 | 3 | | | | | AA4 | 8 | | | | | | |

Table 7-4. VIN1 IOSETs (continued)

| SIGNALS | IOSET2 | | IOSET3 | | IOSET4 ⁽¹⁾ | | IOSET5 ⁽¹⁾ | | IOSET6 ⁽¹⁾ | | IOSET7 ⁽¹⁾ | | IOSET8 | | IOSET9 | | IOSET10 | |
|--------------|--------|-----|--------|-----|-----------------------|-----|-----------------------|-----|-----------------------|-----|-----------------------|-----|--------|-----|--------|-----|---------|-----|
| | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX |
| vin1b | | | | | | | | | | | | | | | | | | |
| vin1b_clk1 | | | | | P7 | 6 | M4 | 4 | V1 | 5 | N9 | 6 | | | | | | |
| vin1b_hsync1 | | | | | H5 | 6 | H5 | 6 | U7 | 5 | N7 | 6 | | | | | | |
| vin1b_vsync1 | | | | | H6 | 6 | H6 | 6 | V6 | 5 | R4 | 6 | | | | | | |
| vin1b_fld1 | | | | | M4 | 6 | | | W2 | 5 | P4 | 6 | | | | | | |
| vin1b_de1 | | | | | N6 | 6 | N6 | 6 | V7 | 5 | P9 | 6 | | | | | | |
| vin1b_d0 | | | | | K7 | 6 | K7 | 6 | U4 | 5 | R6 | 6 | | | | | | |
| vin1b_d1 | | | | | M7 | 6 | M7 | 6 | V2 | 5 | T9 | 6 | | | | | | |
| vin1b_d2 | | | | | J5 | 6 | J5 | 6 | Y1 | 5 | T6 | 6 | | | | | | |
| vin1b_d3 | | | | | K6 | 6 | K6 | 6 | W9 | 5 | T7 | 6 | | | | | | |
| vin1b_d4 | | | | | J7 | 6 | J7 | 6 | V9 | 5 | P6 | 6 | | | | | | |
| vin1b_d5 | | | | | J4 | 6 | J4 | 6 | U5 | 5 | R9 | 6 | | | | | | |
| vin1b_d6 | | | | | J6 | 6 | J6 | 6 | V5 | 5 | R5 | 6 | | | | | | |
| vin1b_d7 | | | | | H4 | 6 | H4 | 6 | V4 | 5 | P5 | 6 | | | | | | |

(1) The IOSET under this column is only applicable for pins with alternate functionality which allows either VIN1 or VIN2 signals to be mapped to the pins. These alternate functions are controlled via CTRL_CORE_VIP_MUX_SELECT register. For more information on how to use these options, see *Pad Configuration Registers* section, *Control Module* chapter in the device TRM.

Table 7-5. VIN2 IOSETs

| SIGNALS | IOSET1 | | IOSET2 | | IOSET4 | | IOSET5 | | IOSET6 | | IOSET7 ⁽¹⁾ | | IOSET8 ⁽¹⁾ | | IOSET9 ⁽¹⁾ | | IOSET10 ⁽¹⁾ | |
|--------------|--------|-----|--------|-----|--------|-----|--------|-----|--------|-----|-----------------------|-----|-----------------------|-----|-----------------------|-----|------------------------|-----|
| | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX |
| vin2a | | | | | | | | | | | | | | | | | | |
| vin2a_clk0 | | | | | E1 | 0 | E1 | 0 | V1 | 4 | B11 | 3 | P4 | 4 | P4 | 4 | B26 | 8 |
| vin2a_hsync0 | | | | | G1 | 0 | G1 | 0 | U7 | 4 | C11 | 3 | R3 | 4 | P7 | 4 | E21 | 8 |
| vin2a_vsync0 | | | | | G6 | 0 | G6 | 0 | V6 | 4 | E11 | 3 | T2 | 4 | N1 | 4 | F20 | 8 |
| vin2a_fld0 | | | | | H7 | 0 | G2 | 1 | W2 | 4 | D11 | 3 | P9 | 4 | J7 | 4 | F21 | 8 |
| vin2a_de0 | | | | | G2 | 0 | | | V7 | 4 | B10 | 3 | P7 | 5 | H6 | 4 | C23 | 8 |
| vin2a_d0 | | | | | F2 | 0 | F2 | 0 | U4 | 4 | B7 | 3 | R6 | 4 | R6 | 4 | B14 | 8 |
| vin2a_d1 | | | | | F3 | 0 | F3 | 0 | V2 | 4 | B8 | 3 | T9 | 4 | T9 | 4 | J14 | 8 |
| vin2a_d2 | | | | | D1 | 0 | D1 | 0 | Y1 | 4 | A7 | 3 | T6 | 4 | T6 | 4 | G13 | 8 |
| vin2a_d3 | | | | | E2 | 0 | E2 | 0 | W9 | 4 | A8 | 3 | T7 | 4 | T7 | 4 | J11 | 8 |
| vin2a_d4 | | | | | D2 | 0 | D2 | 0 | V9 | 4 | C9 | 3 | P6 | 4 | P6 | 4 | E12 | 8 |

Table 7-5. VIN2 IOSETs (continued)

| SIGNALS | IOSET1 | | IOSET2 | | IOSET4 | | IOSET5 | | IOSET6 | | IOSET7 ⁽¹⁾ | | IOSET8 ⁽¹⁾ | | IOSET9 ⁽¹⁾ | | IOSET10 ⁽¹⁾ | |
|--------------|--------|-----|--------|-----|--------|-----|--------|-----|--------|-----|-----------------------|-----|-----------------------|-----|-----------------------|-----|------------------------|-----|
| | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX |
| vin2a_d5 | | | | | F4 | 0 | F4 | 0 | U5 | 4 | A9 | 3 | R9 | 4 | R9 | 4 | F13 | 8 |
| vin2a_d6 | | | | | C1 | 0 | C1 | 0 | V5 | 4 | B9 | 3 | R5 | 4 | R5 | 4 | C12 | 8 |
| vin2a_d7 | | | | | E4 | 0 | E4 | 0 | V4 | 4 | A10 | 3 | P5 | 4 | P5 | 4 | D12 | 8 |
| vin2a_d8 | | | | | F5 | 0 | F5 | 0 | V3 | 4 | E8 | 3 | U2 | 4 | U2 | 4 | E15 | 8 |
| vin2a_d9 | | | | | E6 | 0 | E6 | 0 | Y2 | 4 | D9 | 3 | U1 | 4 | U1 | 4 | A20 | 8 |
| vin2a_d10 | | | | | D3 | 0 | D3 | 0 | U6 | 4 | D7 | 3 | P3 | 4 | P3 | 4 | B15 | 8 |
| vin2a_d11 | | | | | F6 | 0 | F6 | 0 | U3 | 4 | D8 | 3 | R2 | 4 | R2 | 4 | A15 | 8 |
| vin2a_d12 | | | | | D5 | 0 | D5 | 0 | | | A5 | 3 | K7 | 4 | K7 | 4 | D15 | 8 |
| vin2a_d13 | | | | | C2 | 0 | C2 | 0 | | | C6 | 3 | M7 | 4 | M7 | 4 | B16 | 8 |
| vin2a_d14 | | | | | C3 | 0 | C3 | 0 | | | C8 | 3 | J5 | 4 | J5 | 4 | B17 | 8 |
| vin2a_d15 | | | | | C4 | 0 | C4 | 0 | | | C7 | 3 | K6 | 4 | K6 | 4 | A17 | 8 |
| vin2a_d16 | | | | | B2 | 0 | B2 | 0 | | | F11 | 3 | | | | | C18 | 8 |
| vin2a_d17 | | | | | D6 | 0 | D6 | 0 | | | G10 | 3 | | | | | A21 | 8 |
| vin2a_d18 | | | | | C5 | 0 | C5 | 0 | | | F10 | 3 | | | | | G16 | 8 |
| vin2a_d19 | | | | | A3 | 0 | A3 | 0 | | | G11 | 3 | | | | | D17 | 8 |
| vin2a_d20 | | | | | B3 | 0 | B3 | 0 | | | E9 | 3 | | | | | AA3 | 8 |
| vin2a_d21 | | | | | B4 | 0 | B4 | 0 | | | F9 | 3 | | | | | AB9 | 8 |
| vin2a_d22 | | | | | B5 | 0 | B5 | 0 | | | F8 | 3 | | | | | AB3 | 8 |
| vin2a_d23 | | | | | A4 | 0 | A4 | 0 | | | E7 | 3 | | | | | AA4 | 8 |
| vin2b | | | | | | | | | | | | | | | | | | |
| vin2b_clk1 | P7 | 6 | M4 | 4 | | | | | | | H7 | 2 | H7 | 2 | AB5 | 4 | | |
| vin2b_hsync1 | H5 | 6 | H5 | 6 | | | | | | | G1 | 3 | G1 | 3 | AC5 | 4 | | |
| vin2b_vsync1 | H6 | 6 | H6 | 6 | | | | | | | G6 | 3 | G6 | 3 | AB4 | 4 | | |
| vin2b fld1 | M4 | 6 | | | | | | | | | | | G2 | 2 | | | | |
| vin2b_de1 | N6 | 6 | N6 | 6 | | | | | | | G2 | 3 | | | AB8 | 4 | | |
| vin2b_d0 | K7 | 6 | K7 | 6 | | | | | | | A4 | 2 | A4 | 2 | AD6 | 4 | | |
| vin2b_d1 | M7 | 6 | M7 | 6 | | | | | | | B5 | 2 | B5 | 2 | AC8 | 4 | | |
| vin2b_d2 | J5 | 6 | J5 | 6 | | | | | | | B4 | 2 | B4 | 2 | AC3 | 4 | | |
| vin2b_d3 | K6 | 6 | K6 | 6 | | | | | | | B3 | 2 | B3 | 2 | AC9 | 4 | | |
| vin2b_d4 | J7 | 6 | J7 | 6 | | | | | | | A3 | 2 | A3 | 2 | AC6 | 4 | | |
| vin2b_d5 | J4 | 6 | J4 | 6 | | | | | | | C5 | 2 | C5 | 2 | AC7 | 4 | | |
| vin2b_d6 | J6 | 6 | J6 | 6 | | | | | | | D6 | 2 | D6 | 2 | AC4 | 4 | | |

Table 7-5. VIN2 IOSETs (continued)

| SIGNALS | IOSET1 | | IOSET2 | | IOSET4 | | IOSET5 | | IOSET6 | | IOSET7 ⁽¹⁾ | | IOSET8 ⁽¹⁾ | | IOSET9 ⁽¹⁾ | | IOSET10 ⁽¹⁾ | |
|----------|--------|-----|--------|-----|--------|-----|--------|-----|--------|-----|-----------------------|-----|-----------------------|-----|-----------------------|-----|------------------------|-----|
| | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX |
| vin2b_d7 | H4 | 6 | H4 | 6 | | | | | | | B2 | 2 | B2 | 2 | AD4 | 4 | | |

(1) The IOSET under this column is only applicable for pins with alternate functionality which allows either VIN1 or VIN2 signals to be mapped to the pins. These alternate functions are controlled via CTRL_CORE_VIP_MUX_SELECT register. For more information on how to use these options, see *Pad Configuration Registers* section, *Control Module* chapter in the device TRM.

NOTE

To configure the desired Manual IO Timing Mode the user must follow the steps described in section "*Manual IO Timing Modes*" in the device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information, see *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for VIP1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See *Manual Functions Mapping for VIP1 1A IOSET7 and 2A IOSET10* for a definition of the Manual modes.

[Table 7-6](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-6. Manual Functions Mapping for VIP1 1A IOSET7 and 2A IOSET10

| BALL | BALL NAME | VIP_MANUAL1 | | VIP_MANUAL2 | | CFG REGISTER | MUXMODE | |
|------|--------------|--------------|--------------|--------------|--------------|---------------------|--------------|------------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 8 | g ⁽¹⁾ |
| E21 | gpio6_14 | 1400 | 240 | 1767 | 0 | CFG_GPIO6_14_IN | vin2a_hsync0 | vin1a_hsync0 |
| F20 | gpio6_15 | 1170 | 240 | 1522 | 0 | CFG_GPIO6_15_IN | vin2a_vsync0 | vin1a_vsync0 |
| F21 | gpio6_16 | 1470 | 0 | 1600 | 0 | CFG_GPIO6_16_IN | vin2a_fld0 | vin1a_fld0 |
| B14 | mcasp1_aclkr | 2145 | 200 | 2509 | 0 | CFG_MCASP1_ACLKR_IN | vin2a_d0 | vin1a_d0 |
| G13 | mcasp1_axr2 | 2740 | 900 | 2680 | 1180 | CFG_MCASP1_AXR2_IN | vin2a_d2 | vin1a_d2 |
| J11 | mcasp1_axr3 | 2933 | 200 | 2700 | 600 | CFG_MCASP1_AXR3_IN | vin2a_d3 | vin1a_d3 |
| E12 | mcasp1_axr4 | 2901 | 240 | 2660 | 700 | CFG_MCASP1_AXR4_IN | vin2a_d4 | vin1a_d4 |
| F13 | mcasp1_axr5 | 2600 | 840 | 2640 | 920 | CFG_MCASP1_AXR5_IN | vin2a_d5 | vin1a_d5 |
| C12 | mcasp1_axr6 | 2718 | 240 | 3081 | 0 | CFG_MCASP1_AXR6_IN | vin2a_d6 | vin1a_d6 |
| D12 | mcasp1_axr7 | 2983 | 240 | 2540 | 800 | CFG_MCASP1_AXR7_IN | vin2a_d7 | vin1a_d7 |
| J14 | mcasp1_fsr | 2203 | 240 | 2566 | 0 | CFG_MCASP1_FSR_IN | vin2a_d1 | vin1a_d1 |
| E15 | mcasp2_aclkr | 2143 | 240 | 2492 | 0 | CFG_MCASP2_ACLKR_IN | vin2a_d8 | vin1a_d8 |
| B15 | mcasp2_axr0 | 2543 | 240 | 2905 | 0 | CFG_MCASP2_AXR0_IN | vin2a_d10 | vin1a_d10 |
| A15 | mcasp2_axr1 | 2664 | 240 | 2730 | 400 | CFG_MCASP2_AXR1_IN | vin2a_d11 | vin1a_d11 |

Table 7-6. Manual Functions Mapping for VIP1 1A IOSET7 and 2A IOSET10 (continued)

| BALL | BALL NAME | VIP_MANUAL1 | | VIP_MANUAL2 | | CFG REGISTER | MUXMODE | |
|------|--------------|--------------|--------------|--------------|--------------|---------------------|------------|------------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 8 | 8 ⁽¹⁾ |
| D15 | mcasp2_axr4 | 2792 | 240 | 2750 | 400 | CFG_MCASP2_AXR4_IN | vin2a_d12 | vin1a_d12 |
| B16 | mcasp2_axr5 | 2621 | 300 | 2983 | 0 | CFG_MCASP2_AXR5_IN | vin2a_d13 | vin1a_d13 |
| B17 | mcasp2_axr6 | 1903 | 100 | 2086 | 0 | CFG_MCASP2_AXR6_IN | vin2a_d14 | vin1a_d14 |
| A17 | mcasp2_axr7 | 2928 | 200 | 2670 | 700 | CFG_MCASP2_AXR7_IN | vin2a_d15 | vin1a_d15 |
| A20 | mcasp2_fsr | 2291 | 200 | 2654 | 0 | CFG_MCASP2_FSR_IN | vin2a_d9 | vin1a_d9 |
| C18 | mcasp4_aclkx | 1433 | 0 | 1540 | 0 | CFG_MCASP4_ACLKX_IN | vin2a_d16 | vin1a_d16 |
| G16 | mcasp4_axr0 | 2500 | 0 | 2560 | 0 | CFG_MCASP4_AXR0_IN | vin2a_d18 | vin1a_d18 |
| D17 | mcasp4_axr1 | 2379 | 100 | 2599 | 0 | CFG_MCASP4_AXR1_IN | vin2a_d19 | vin1a_d19 |
| A21 | mcasp4_fsx | 1500 | 1400 | 1900 | 1040 | CFG_MCASP4_FSX_IN | vin2a_d17 | vin1a_d17 |
| AA3 | mcasp5_aclkx | 3740 | 1850 | 3900 | 1700 | CFG_MCASP5_ACLKX_IN | vin2a_d20 | vin1a_d20 |
| AB3 | mcasp5_axr0 | 3800 | 2760 | 3800 | 2800 | CFG_MCASP5_AXR0_IN | vin2a_d22 | vin1a_d22 |
| AA4 | mcasp5_axr1 | 4099 | 2500 | 3900 | 2870 | CFG_MCASP5_AXR1_IN | vin2a_d23 | vin1a_d23 |
| AB9 | mcasp5_fsx | 3740 | 2100 | 3860 | 2060 | CFG_MCASP5_FSX_IN | vin2a_d21 | vin1a_d21 |
| B26 | xref_clk2 | 0 | 0 | 0 | 0 | CFG_XREF_CLK2_IN | vin2a_clk0 | vin1a_clk0 |
| C23 | xref_clk3 | 1440 | 0 | 1623 | 0 | CFG_XREF_CLK3_IN | vin2a_de0 | vin1a_de0 |

(1) Some signals listed are manual functions that present alternate multiplexing options. These manual functions are controlled via CTRL_CORE_ALT_SELECT_MUX or CTRL_CORE_VIP_MUX_SELECT registers. For more information on how to use these options, see *Pad Configuration Registers* section, *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for VIP1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-7 Manual Functions Mapping for VIN2A \(IOSET4/5/6\)](#) for a definition of the Manual modes.

[Table 7-7](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-7. Manual Functions Mapping for VIN2A (IOSET4/5/6)

| BALL | BALL NAME | VIP_MANUAL3 | | VIP_MANUAL5 | | CFG REGISTER | MUXMODE | | | | |
|------|-----------------|--------------|--------------|--------------|--------------|------------------------|---------|---|---|---|------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 0 | 1 | 2 | 3 | 4 |
| U3 | RMII_MHZ_50_CLK | 2616 | 1379 | 2798 | 1294 | CFG_RMII_MHZ_50_CLK_IN | - | - | - | - | vin2a_d11 |
| U4 | mdio_d | 2558 | 1105 | 2790 | 954 | CFG_MDIO_D_IN | - | - | - | - | vin2a_d0 |
| V1 | mdio_mclk | 998 | 463 | 1029 | 431 | CFG_MDIO_MCLK_IN | - | - | - | - | vin2a_clk0 |
| U5 | rgmii0_rxc | 2658 | 862 | 2896 | 651 | CFG_RGMII0_RXC_IN | - | - | - | - | vin2a_d5 |
| V5 | rgmii0_rxctl | 2658 | 1628 | 2844 | 1518 | CFG_RGMII0_RXCTL_IN | - | - | - | - | vin2a_d6 |
| W2 | rgmii0_rxd0 | 2638 | 1123 | 2856 | 888 | CFG_RGMII0_RXD0_IN | - | - | - | - | vin2a_fld0 |
| Y2 | rgmii0_rxd1 | 2641 | 1737 | 2804 | 1702 | CFG_RGMII0_RXD1_IN | - | - | - | - | vin2a_d9 |

Table 7-7. Manual Functions Mapping for VIN2A (IOSET4/5/6) (continued)

| BALL | BALL NAME | VIP_MANUAL3 | | VIP_MANUAL5 | | CFG REGISTER | MUXMODE | | | | |
|------|--------------|--------------|--------------|--------------|--------------|---------------------|------------|---|----------|---|--------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 0 | 1 | 2 | 3 | 4 |
| V3 | rgmii0_rxd2 | 2641 | 1676 | 2801 | 1652 | CFG_RGMII0_RXD2_IN | - | - | - | - | vin2a_d8 |
| V4 | rgmii0_rxd3 | 2644 | 1828 | 2807 | 1790 | CFG_RGMII0_RXD3_IN | - | - | - | - | vin2a_d7 |
| W9 | rgmii0_txc | 2638 | 1454 | 2835 | 1396 | CFG_RGMII0_TXC_IN | - | - | - | - | vin2a_d3 |
| V9 | rgmii0_txctl | 2672 | 1663 | 2831 | 1640 | CFG_RGMII0_TXCTL_IN | - | - | - | - | vin2a_d4 |
| U6 | rgmii0_txd0 | 2604 | 1442 | 2764 | 1417 | CFG_RGMII0_TXD0_IN | - | - | - | - | vin2a_d10 |
| V6 | rgmii0_txd1 | 2683 | 1598 | 2843 | 1600 | CFG_RGMII0_TXD1_IN | - | - | - | - | vin2a_vsync0 |
| U7 | rgmii0_txd2 | 2563 | 1483 | 2816 | 1344 | CFG_RGMII0_TXD2_IN | - | - | - | - | vin2a_hsync0 |
| V7 | rgmii0_txd3 | 2717 | 1461 | 2913 | 1310 | CFG_RGMII0_TXD3_IN | - | - | - | - | vin2a_de0 |
| V2 | uart3_rxd | 2445 | 1145 | 2743 | 923 | CFG_UART3_RXD_IN | - | - | - | - | vin2a_d1 |
| Y1 | uart3_txd | 2650 | 1197 | 2842 | 1080 | CFG_UART3_TXD_IN | - | - | - | - | vin2a_d2 |
| E1 | vin2a_clk0 | 0 | 0 | 0 | 0 | CFG_VIN2A_CLK0_IN | vin2a_clk0 | - | - | - | - |
| F2 | vin2a_d0 | 1812 | 102 | 1936 | 0 | CFG_VIN2A_D0_IN | vin2a_d0 | - | - | - | - |
| F3 | vin2a_d1 | 1701 | 439 | 2229 | 10 | CFG_VIN2A_D1_IN | vin2a_d1 | - | - | - | - |
| D3 | vin2a_d10 | 1720 | 215 | 2031 | 0 | CFG_VIN2A_D10_IN | vin2a_d10 | - | - | - | - |
| F6 | vin2a_d11 | 1622 | 0 | 1702 | 0 | CFG_VIN2A_D11_IN | vin2a_d11 | - | - | - | - |
| D5 | vin2a_d12 | 1350 | 412 | 1819 | 0 | CFG_VIN2A_D12_IN | vin2a_d12 | - | - | - | - |
| C2 | vin2a_d13 | 1613 | 147 | 1476 | 260 | CFG_VIN2A_D13_IN | vin2a_d13 | - | - | - | - |
| C3 | vin2a_d14 | 1149 | 516 | 1701 | 0 | CFG_VIN2A_D14_IN | vin2a_d14 | - | - | - | - |
| C4 | vin2a_d15 | 1530 | 450 | 2021 | 0 | CFG_VIN2A_D15_IN | vin2a_d15 | - | - | - | - |
| B2 | vin2a_d16 | 1512 | 449 | 2044 | 11 | CFG_VIN2A_D16_IN | vin2a_d16 | - | vin2b_d7 | - | - |
| D6 | vin2a_d17 | 1293 | 488 | 1839 | 5 | CFG_VIN2A_D17_IN | vin2a_d17 | - | vin2b_d6 | - | - |
| C5 | vin2a_d18 | 2140 | 371 | 2494 | 0 | CFG_VIN2A_D18_IN | vin2a_d18 | - | vin2b_d5 | - | - |
| A3 | vin2a_d19 | 2041 | 275 | 1699 | 611 | CFG_VIN2A_D19_IN | vin2a_d19 | - | vin2b_d4 | - | - |
| D1 | vin2a_d2 | 1675 | 35 | 1736 | 0 | CFG_VIN2A_D2_IN | vin2a_d2 | - | - | - | - |
| B3 | vin2a_d20 | 1972 | 441 | 2412 | 88 | CFG_VIN2A_D20_IN | vin2a_d20 | - | vin2b_d3 | - | - |
| B4 | vin2a_d21 | 1957 | 556 | 2391 | 161 | CFG_VIN2A_D21_IN | vin2a_d21 | - | vin2b_d2 | - | - |
| B5 | vin2a_d22 | 2011 | 433 | 2446 | 102 | CFG_VIN2A_D22_IN | vin2a_d22 | - | vin2b_d1 | - | - |
| A4 | vin2a_d23 | 1962 | 523 | 2395 | 145 | CFG_VIN2A_D23_IN | vin2a_d23 | - | vin2b_d0 | - | - |
| E2 | vin2a_d3 | 1457 | 361 | 1943 | 0 | CFG_VIN2A_D3_IN | vin2a_d3 | - | - | - | - |
| D2 | vin2a_d4 | 1535 | 0 | 1601 | 0 | CFG_VIN2A_D4_IN | vin2a_d4 | - | - | - | - |

Table 7-7. Manual Functions Mapping for VIN2A (IOSET4/5/6) (continued)

| BALL | BALL NAME | VIP_MANUAL3 | | VIP_MANUAL5 | | CFG REGISTER | MUXMODE | | | | |
|------|--------------|--------------|--------------|--------------|--------------|---------------------|--------------|------------|------------|--------------|---|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 0 | 1 | 2 | 3 | 4 |
| F4 | vin2a_d5 | 1676 | 271 | 2052 | 0 | CFG_VIN2A_D5_IN | vin2a_d5 | - | - | - | - |
| C1 | vin2a_d6 | 1513 | 0 | 1571 | 0 | CFG_VIN2A_D6_IN | vin2a_d6 | - | - | - | - |
| E4 | vin2a_d7 | 1616 | 141 | 1855 | 0 | CFG_VIN2A_D7_IN | vin2a_d7 | - | - | - | - |
| F5 | vin2a_d8 | 1286 | 437 | 1224 | 618 | CFG_VIN2A_D8_IN | vin2a_d8 | - | - | - | - |
| E6 | vin2a_d9 | 1544 | 265 | 1373 | 509 | CFG_VIN2A_D9_IN | vin2a_d9 | - | - | - | - |
| G2 | vin2a_de0 | 1732 | 208 | 1949 | 0 | CFG_VIN2A_DE0_IN | vin2a_de0 | vin2a_fld0 | vin2b_fld1 | vin2b_de1 | - |
| H7 | vin2a_fld0 | 1461 | 562 | 1983 | 151 | CFG_VIN2A_FLD0_IN | vin2a_fld0 | - | vin2b_clk1 | - | - |
| G1 | vin2a_hsync0 | 1877 | 0 | 1943 | 0 | CFG_VIN2A_HSYNC0_IN | vin2a_hsync0 | - | - | vin2b_hsync1 | - |
| G6 | vin2a_vsync0 | 1566 | 0 | 1612 | 0 | CFG_VIN2A_VSYNC0_IN | vin2a_vsync0 | - | - | vin2b_vsync1 | - |

Manual IO Timings Modes must be used to ensure some IO timings for VIP1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-8 Manual Functions Mapping for VIN2B \(IOSET7/8/9\)](#) for a definition of the Manual modes.

[Table 7-8](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-8. Manual Functions Mapping for VIN2B (IOSET7/8/9)

| BALL | BALL NAME | VIP_MANUAL4 | | VIP_MANUAL6 | | CFG REGISTER | MUXMODE | | |
|------|-----------|--------------|--------------|--------------|--------------|------------------|----------|---|--------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 2 | 3 | 4 |
| AC5 | gpio6_10 | 2829 | 884 | 3009 | 892 | CFG_GPIO6_10_IN | - | - | vin2b_hsync1 |
| AB4 | gpio6_11 | 2648 | 1033 | 2890 | 1096 | CFG_GPIO6_11_IN | - | - | vin2b_vsync1 |
| AD4 | mmc3_clk | 2794 | 1074 | 2997 | 1089 | CFG_MMC3_CLK_IN | - | - | vin2b_d7 |
| AC4 | mmc3_cmd | 2789 | 1162 | 2959 | 1210 | CFG_MMC3_CMD_IN | - | - | vin2b_d6 |
| AC7 | mmc3_dat0 | 2689 | 1180 | 2897 | 1269 | CFG_MMC3_DAT0_IN | - | - | vin2b_d5 |
| AC6 | mmc3_dat1 | 2605 | 1219 | 2891 | 1219 | CFG_MMC3_DAT1_IN | - | - | vin2b_d4 |
| AC9 | mmc3_dat2 | 2616 | 703 | 2947 | 590 | CFG_MMC3_DAT2_IN | - | - | vin2b_d3 |
| AC3 | mmc3_dat3 | 2760 | 1235 | 2931 | 1342 | CFG_MMC3_DAT3_IN | - | - | vin2b_d2 |
| AC8 | mmc3_dat4 | 2757 | 880 | 2979 | 891 | CFG_MMC3_DAT4_IN | - | - | vin2b_d1 |
| AD6 | mmc3_dat5 | 2688 | 1177 | 2894 | 1262 | CFG_MMC3_DAT5_IN | - | - | vin2b_d0 |
| AB8 | mmc3_dat6 | 2638 | 1165 | 2894 | 1187 | CFG_MMC3_DAT6_IN | - | - | vin2b_de1 |
| AB5 | mmc3_dat7 | 995 | 182 | 1202 | 107 | CFG_MMC3_DAT7_IN | - | - | vin2b_clk1 |
| B2 | vin2a_d16 | 1423 | 0 | 1739 | 0 | CFG_VIN2A_D16_IN | vin2b_d7 | - | - |

Table 7-8. Manual Functions Mapping for VIN2B (IOSET7/8/9) (continued)

| BALL | BALL NAME | VIP_MANUAL4 | | VIP_MANUAL6 | | CFG REGISTER | MUXMODE | | |
|------|--------------|--------------|--------------|--------------|--------------|---------------------|------------|--------------|---|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 2 | 3 | 4 |
| D6 | vin2a_d17 | 1253 | 0 | 1568 | 0 | CFG_VIN2A_D17_IN | vin2b_d6 | - | - |
| C5 | vin2a_d18 | 2080 | 0 | 2217 | 0 | CFG_VIN2A_D18_IN | vin2b_d5 | - | - |
| A3 | vin2a_d19 | 1849 | 0 | 2029 | 0 | CFG_VIN2A_D19_IN | vin2b_d4 | - | - |
| B3 | vin2a_d20 | 1881 | 50 | 2202 | 0 | CFG_VIN2A_D20_IN | vin2b_d3 | - | - |
| B4 | vin2a_d21 | 1917 | 167 | 2313 | 0 | CFG_VIN2A_D21_IN | vin2b_d2 | - | - |
| B5 | vin2a_d22 | 1955 | 79 | 2334 | 0 | CFG_VIN2A_D22_IN | vin2b_d1 | - | - |
| A4 | vin2a_d23 | 1899 | 145 | 2288 | 0 | CFG_VIN2A_D23_IN | vin2b_d0 | - | - |
| G2 | vin2a_de0 | 1568 | 261 | 2048 | 0 | CFG_VIN2A_DE0_IN | vin2b_fld1 | vin2b_de1 | - |
| H7 | vin2a_fld0 | 0 | 0 | 0 | 0 | CFG_VIN2A_FLD0_IN | vin2b_clk1 | - | - |
| G1 | vin2a_hsync0 | 1793 | 0 | 2011 | 0 | CFG_VIN2A_HSYNC0_IN | - | vin2b_hsync1 | - |
| G6 | vin2a_vsync0 | 1382 | 0 | 1632 | 0 | CFG_VIN2A_VSYNC0_IN | - | vin2b_vsync1 | - |

Manual IO Timings Modes must be used to ensure some IO timings for VIP1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-9 Manual Functions Mapping for VIN1A \(IOSET2/3/4\) and VIN1B \(IOSET4/7\) and VIN2B \(IOSET1/10\)](#) for a definition of the Manual modes.

[Table 7-9](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-9. Manual Functions Mapping for VIN1A (IOSET2/3/4) and VIN1B (IOSET4/7) and VIN2B (IOSET1/10)

| BALL | BALL NAME | VIP_MANUAL7 | | VIP_MANUAL12 | | CFG REGISTER | MUXMODE | | | | | | | |
|------|-----------|--------------|--------------|--------------|--------------|-----------------|------------|------------------|------------------|------------------|------------------|---|------------------|------------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 2 | 3 ⁽¹⁾ | 3 ⁽¹⁾ | 4 ⁽¹⁾ | 4 ⁽¹⁾ | 5 | 6 ⁽¹⁾ | 6 ⁽¹⁾ |
| R6 | gpmc_a0 | 3080 | 1792 | 3376 | 1632 | CFG_GPMC_A0_IN | vin1a_d16 | - | - | vin2a_d0 | - | - | vin1b_d0 | - |
| T9 | gpmc_a1 | 2958 | 1890 | 3249 | 1749 | CFG_GPMC_A1_IN | vin1a_d17 | - | - | vin2a_d1 | - | - | vin1b_d1 | - |
| N9 | gpmc_a10 | 3073 | 1653 | 3388 | 1433 | CFG_GPMC_A10_IN | vin1a_de0 | - | - | - | - | - | vin1b_clk1 | - |
| P9 | gpmc_a11 | 3014 | 1784 | 3290 | 1693 | CFG_GPMC_A11_IN | vin1a_fld0 | - | - | vin2a_fld0 | vin1a_fld0 | - | vin1b_de1 | - |
| K7 | gpmc_a19 | 1385 | 0 | 1246 | 0 | CFG_GPMC_A19_IN | - | - | - | vin2a_d12 | - | - | vin2b_d0 | vin1b_d0 |
| T6 | gpmc_a2 | 3041 | 1960 | 3322 | 1850 | CFG_GPMC_A2_IN | vin1a_d18 | - | - | vin2a_d2 | - | - | vin1b_d2 | - |
| M7 | gpmc_a20 | 859 | 0 | 720 | 0 | CFG_GPMC_A20_IN | - | - | - | vin2a_d13 | - | - | vin2b_d1 | vin1b_d1 |

Table 7-9. Manual Functions Mapping for VIN1A (IOSET2/3/4) and VIN1B (IOSET4/7) and VIN2B (IOSET1/10) (continued)

| BALL | BALL NAME | VIP_MANUAL7 | | VIP_MANUAL12 | | CFG REGISTER | MUXMODE | | | | | | | |
|------|-----------|------------------|------------------|------------------|------------------|------------------|-------------------|------------------|------------------|------------------|------------------|---|-------------------|------------------|
| | | A_DELA Y (ps) | G_DELA Y (ps) | A_DELA Y (ps) | G_DELA Y (ps) | | 2 | 3 ⁽¹⁾ | 3 ⁽¹⁾ | 4 ⁽¹⁾ | 4 ⁽¹⁾ | 5 | 6 ⁽¹⁾ | 6 ⁽¹⁾ |
| J5 | gpmc_a21 | 1465 | 0 | 1334 | 0 | CFG_GPMC_A21_IN | - | - | - | vin2a_d1 4 | - | - | vin2b_d2 | vin1b_d2 |
| K6 | gpmc_a22 | 1210 | 0 | 1064 | 0 | CFG_GPMC_A22_IN | - | - | - | vin2a_d1 5 | - | - | vin2b_d3 | vin1b_d3 |
| J7 | gpmc_a23 | 1111 | 0 | 954 | 0 | CFG_GPMC_A23_IN | - | - | - | vin2a_fld 0 | - | - | vin2b_d4 | vin1b_d4 |
| J4 | gpmc_a24 | 1137 | 0 | 1051 | 0 | CFG_GPMC_A24_IN | - | - | - | - | - | - | vin2b_d5 | vin1b_d5 |
| J6 | gpmc_a25 | 1402 | 0 | 1283 | 0 | CFG_GPMC_A25_IN | - | - | - | - | - | - | vin2b_d6 | vin1b_d6 |
| H4 | gpmc_a26 | 1298 | 0 | 1153 | 0 | CFG_GPMC_A26_IN | - | - | - | - | - | - | vin2b_d7 | vin1b_d7 |
| H5 | gpmc_a27 | 934 | 0 | 870 | 0 | CFG_GPMC_A27_IN | - | - | - | - | - | - | vin2b_hsyn nc1 | vin1b_hsyn c1 |
| T7 | gpmc_a3 | 3019 | 2145 | 3296 | 2050 | CFG_GPMC_A3_IN | vin1a_d1 9 | - | - | vin2a_d3 | - | - | vin1b_d3 | - |
| P6 | gpmc_a4 | 3063 | 1981 | 3357 | 1829 | CFG_GPMC_A4_IN | vin1a_d2 0 | - | - | vin2a_d4 | - | - | vin1b_d4 | - |
| R9 | gpmc_a5 | 3021 | 1954 | 3304 | 1840 | CFG_GPMC_A5_IN | vin1a_d2 1 | - | - | vin2a_d5 | - | - | vin1b_d5 | - |
| R5 | gpmc_a6 | 3062 | 1716 | 3348 | 1592 | CFG_GPMC_A6_IN | vin1a_d2 2 | - | - | vin2a_d6 | - | - | vin1b_d6 | - |
| P5 | gpmc_a7 | 3260 | 1889 | 3583 | 1631 | CFG_GPMC_A7_IN | vin1a_d2 3 | - | - | vin2a_d7 | - | - | vin1b_d7 | - |
| N7 | gpmc_a8 | 3033 | 1702 | 3328 | 1547 | CFG_GPMC_A8_IN | vin1a_hsyn nc0 | - | - | - | - | - | vin1b_hsyn nc1 | - |
| R4 | gpmc_a9 | 2991 | 1905 | 3281 | 1766 | CFG_GPMC_A9_IN | vin1a_vsyn nc0 | - | - | - | - | - | vin1b_vsyn nc1 | - |
| M6 | gpmc_ad0 | 2907 | 1342 | 3181 | 1255 | CFG_GPMC_AD0_IN | vin1a_d0 | - | - | - | - | - | - | - |
| M2 | gpmc_ad1 | 2858 | 1321 | 3132 | 1234 | CFG_GPMC_AD1_IN | vin1a_d1 | - | - | - | - | - | - | - |
| J1 | gpmc_ad10 | 2920 | 1384 | 3223 | 1204 | CFG_GPMC_AD10_IN | vin1a_d1 0 | - | - | - | - | - | - | - |
| J2 | gpmc_ad11 | 2719 | 1310 | 3019 | 1198 | CFG_GPMC_AD11_IN | vin1a_d1 1 | - | - | - | - | - | - | - |
| H1 | gpmc_ad12 | 2845 | 1135 | 3160 | 917 | CFG_GPMC_AD12_IN | vin1a_d1 2 | - | - | - | - | - | - | - |
| J3 | gpmc_ad13 | 2765 | 1225 | 3045 | 1119 | CFG_GPMC_AD13_IN | vin1a_d1 3 | - | - | - | - | - | - | - |
| H2 | gpmc_ad14 | 2845 | 1150 | 3153 | 952 | CFG_GPMC_AD14_IN | vin1a_d1 4 | - | - | - | - | - | - | - |

Table 7-9. Manual Functions Mapping for VIN1A (IOSET2/3/4) and VIN1B (IOSET4/7) and VIN2B (IOSET1/10) (continued)

| BALL | BALL NAME | VIP_MANUAL7 | | VIP_MANUAL12 | | CFG REGISTER | MUXMODE | | | | | | | | |
|------|-----------|------------------|------------------|------------------|------------------|------------------|------------|------------------|------------------|------------------|------------------|-----------|------------------|------------------|---|
| | | A_DELA Y (ps) | G_DELA Y (ps) | A_DELA Y (ps) | G_DELA Y (ps) | | 2 | 3 ⁽¹⁾ | 3 ⁽¹⁾ | 4 ⁽¹⁾ | 4 ⁽¹⁾ | 5 | 6 ⁽¹⁾ | 6 ⁽¹⁾ | |
| H3 | gpmc_ad15 | 2766 | 1453 | 3044 | 1355 | CFG_GPMC_AD15_IN | vin1a_d15 | - | - | - | - | - | - | - | - |
| L5 | gpmc_ad2 | 2951 | 1296 | 3226 | 1209 | CFG_GPMC_AD2_IN | vin1a_d2 | - | - | - | - | - | - | - | - |
| M1 | gpmc_ad3 | 2825 | 1154 | 3121 | 997 | CFG_GPMC_AD3_IN | vin1a_d3 | - | - | - | - | - | - | - | - |
| L6 | gpmc_ad4 | 2927 | 1245 | 3246 | 1014 | CFG_GPMC_AD4_IN | vin1a_d4 | - | - | - | - | - | - | - | - |
| L4 | gpmc_ad5 | 2923 | 1251 | 3217 | 1098 | CFG_GPMC_AD5_IN | vin1a_d5 | - | - | - | - | - | - | - | - |
| L3 | gpmc_ad6 | 2958 | 1342 | 3238 | 1239 | CFG_GPMC_AD6_IN | vin1a_d6 | - | - | - | - | - | - | - | - |
| L2 | gpmc_ad7 | 2900 | 1244 | 3174 | 1157 | CFG_GPMC_AD7_IN | vin1a_d7 | - | - | - | - | - | - | - | - |
| L1 | gpmc_ad8 | 2845 | 1585 | 3125 | 1482 | CFG_GPMC_AD8_IN | vin1a_d8 | - | - | - | - | - | - | - | - |
| K2 | gpmc_ad9 | 2779 | 1343 | 3086 | 1223 | CFG_GPMC_AD9_IN | vin1a_d9 | - | - | - | - | - | - | - | - |
| N6 | gpmc_ben0 | 1555 | 0 | 1425 | 0 | CFG_GPMC_BEN0_IN | - | - | - | - | - | - | vin2b_de1 | vin1b_de1 | |
| M4 | gpmc_ben1 | 1501 | 0 | 1397 | 0 | CFG_GPMC_BEN1_IN | - | - | - | vin2b_clk1 | - | - | vin2b_fld1 | vin1b_fld1 | |
| P7 | gpmc_clk | 0 | 0 | 0 | 0 | CFG_GPMC_CLK_IN | - | - | - | vin2a_hsync0 | - | vin2a_de0 | vin2b_clk1 | vin1b_clk1 | |
| H6 | gpmc_cs1 | 1192 | 0 | 1102 | 0 | CFG_GPMC_CS1_IN | - | - | - | vin2a_de0 | - | - | vin2b_vsync1 | vin1b_vsync1 | |
| P1 | gpmc_cs3 | 1324 | 374 | 1466 | 353 | CFG_GPMC_CS3_IN | vin1a_clk0 | - | - | - | - | - | - | - | |
| D11 | vout1_clk | 1648 | 885 | 1762 | 928 | CFG_VOUT1_CLK_IN | - | vin2a_fld0 | vin1a_fld0 | vin1a_fld0 | - | - | - | - | |
| F11 | vout1_d0 | 2197 | 565 | 2734 | 215 | CFG_VOUT1_D0_IN | - | vin2a_d16 | vin1a_d16 | vin1a_d16 | - | - | - | - | |
| G10 | vout1_d1 | 2221 | 576 | 2750 | 230 | CFG_VOUT1_D1_IN | - | vin2a_d17 | vin1a_d17 | vin1a_d17 | - | - | - | - | |
| D7 | vout1_d10 | 1800 | 863 | 1910 | 916 | CFG_VOUT1_D10_IN | - | vin2a_d10 | vin1a_d10 | vin1a_d10 | - | - | - | - | |
| D8 | vout1_d11 | 1656 | 931 | 1780 | 945 | CFG_VOUT1_D11_IN | - | vin2a_d11 | vin1a_d11 | vin1a_d11 | - | - | - | - | |
| A5 | vout1_d12 | 1719 | 1086 | 1866 | 1041 | CFG_VOUT1_D12_IN | - | vin2a_d12 | vin1a_d12 | vin1a_d12 | - | - | - | - | |
| C6 | vout1_d13 | 1757 | 928 | 1851 | 1022 | CFG_VOUT1_D13_IN | - | vin2a_d13 | vin1a_d13 | vin1a_d13 | - | - | - | - | |
| C8 | vout1_d14 | 2279 | 345 | 2788 | 0 | CFG_VOUT1_D14_IN | - | vin2a_d14 | vin1a_d14 | vin1a_d14 | - | - | - | - | |

Table 7-9. Manual Functions Mapping for VIN1A (IOSET2/3/4) and VIN1B (IOSET4/7) and VIN2B (IOSET1/10) (continued)

| BALL | BALL NAME | VIP_MANUAL7 | | VIP_MANUAL12 | | CFG REGISTER | MUXMODE | | | | | | | |
|------|-------------|------------------|------------------|------------------|------------------|--------------------|---------|------------------|------------------|------------------|------------------|---|------------------|------------------|
| | | A_DELA Y (ps) | G_DELA Y (ps) | A_DELA Y (ps) | G_DELA Y (ps) | | 2 | 3 ⁽¹⁾ | 3 ⁽¹⁾ | 4 ⁽¹⁾ | 4 ⁽¹⁾ | 5 | 6 ⁽¹⁾ | 6 ⁽¹⁾ |
| C7 | vout1_d15 | 1810 | 874 | 2786 | 69 | CFG_VOUT1_D15_IN | - | vin2a_d1 5 | vin1a_d1 5 | vin1a_d1 5 | - | - | - | - |
| B7 | vout1_d16 | 1763 | 774 | 1880 | 807 | CFG_VOUT1_D16_IN | - | vin2a_d0 | vin1a_d0 | vin1a_d0 | - | - | - | - |
| B8 | vout1_d17 | 1695 | 788 | 1805 | 838 | CFG_VOUT1_D17_IN | - | vin2a_d1 | vin1a_d1 | vin1a_d1 | - | - | - | - |
| A7 | vout1_d18 | 1777 | 590 | 1871 | 684 | CFG_VOUT1_D18_IN | - | vin2a_d2 | vin1a_d2 | vin1a_d2 | - | - | - | - |
| A8 | vout1_d19 | 2047 | 22 | 2196 | 0 | CFG_VOUT1_D19_IN | - | vin2a_d3 | vin1a_d3 | vin1a_d3 | - | - | - | - |
| F10 | vout1_d2 | 1809 | 941 | 2759 | 178 | CFG_VOUT1_D2_IN | - | vin2a_d1 8 | vin1a_d1 8 | vin1a_d1 8 | - | - | - | - |
| C9 | vout1_d20 | 1676 | 944 | 1795 | 973 | CFG_VOUT1_D20_IN | - | vin2a_d4 | vin1a_d4 | vin1a_d4 | - | - | - | - |
| A9 | vout1_d21 | 1712 | 688 | 1848 | 670 | CFG_VOUT1_D21_IN | - | vin2a_d5 | vin1a_d5 | vin1a_d5 | - | - | - | - |
| B9 | vout1_d22 | 1698 | 557 | 2443 | 0 | CFG_VOUT1_D22_IN | - | vin2a_d6 | vin1a_d6 | vin1a_d6 | - | - | - | - |
| A10 | vout1_d23 | 1627 | 1035 | 1726 | 1116 | CFG_VOUT1_D23_IN | - | vin2a_d7 | vin1a_d7 | vin1a_d7 | - | - | - | - |
| G11 | vout1_d3 | 2427 | 429 | 2853 | 167 | CFG_VOUT1_D3_IN | - | vin2a_d1 9 | vin1a_d1 9 | vin1a_d1 9 | - | - | - | - |
| E9 | vout1_d4 | 2351 | 412 | 2845 | 85 | CFG_VOUT1_D4_IN | - | vin2a_d2 0 | vin1a_d2 0 | vin1a_d2 0 | - | - | - | - |
| F9 | vout1_d5 | 1634 | 983 | 1729 | 1076 | CFG_VOUT1_D5_IN | - | vin2a_d2 1 | vin1a_d2 1 | vin1a_d2 1 | - | - | - | - |
| F8 | vout1_d6 | 1776 | 880 | 2736 | 107 | CFG_VOUT1_D6_IN | - | vin2a_d2 2 | vin1a_d2 2 | vin1a_d2 2 | - | - | - | - |
| E7 | vout1_d7 | 2272 | 351 | 2757 | 53 | CFG_VOUT1_D7_IN | - | vin2a_d2 3 | vin1a_d2 3 | vin1a_d2 3 | - | - | - | - |
| E8 | vout1_d8 | 1724 | 898 | 1819 | 990 | CFG_VOUT1_D8_IN | - | vin2a_d8 | vin1a_d8 | vin1a_d8 | - | - | - | - |
| D9 | vout1_d9 | 2281 | 566 | 2804 | 195 | CFG_VOUT1_D9_IN | - | vin2a_d9 | vin1a_d9 | vin1a_d9 | - | - | - | - |
| B10 | vout1_de | 1734 | 749 | 1828 | 842 | CFG_VOUT1_DE_IN | - | vin2a_de 0 | vin1a_de 0 | vin1a_de 0 | - | - | - | - |
| B11 | vout1_fld | 0 | 0 | 0 | 0 | CFG_VOUT1_FLD_IN | - | vin2a_clk 0 | vin1a_clk 0 | vin1a_clk 0 | - | - | - | - |
| C11 | vout1_hsync | 1634 | 606 | 2399 | 0 | CFG_VOUT1_HSYNC_IN | - | vin2a_hsy nc0 | vin1a_hsy nc0 | vin1a_hsy nc0 | - | - | - | - |
| E11 | vout1_vsync | 1887 | 0 | 2068 | 0 | CFG_VOUT1_VSYNC_IN | - | vin2a_vsy nc0 | vin1a_vsy nc0 | vin1a_vsy nc0 | - | - | - | - |

(1) Some signals listed are manual functions that present alternate multiplexing options. These manual functions are controlled via CTRL_CORE_ALT_SELECT_MUX or CTRL_CORE_VIP_MUX_SELECT registers. For more information on how to use these options, see *Pad Configuration Registers* section, *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for VIP1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-10 Manual Functions Mapping for VIN1A \(IOSET5/6\) and VIN2A \(IOSET7/8/9\)](#) for a definition of the Manual modes.

[Table 7-10](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-10. Manual Functions Mapping for VIN1A (IOSET5/6) and VIN2A (IOSET7/8/9)

| BALL | BALL NAME | VIP_MANUAL8 | | VIP_MANUAL13 | | CFG REGISTER | MUXMODE | | | | |
|------|-------------------|--------------|--------------|--------------|--------------|--------------------------|---------|------------------|------------------|------------------|------------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 3 | 4 ⁽¹⁾ | 4 ⁽¹⁾ | 5 ⁽¹⁾ | 5 ⁽¹⁾ |
| R6 | gpmc_a0 | 1891 | 427 | 2176 | 0 | CFG_GPMC_A0_IN | - | vin2a_d0 | vin1a_d0 | - | - |
| T9 | gpmc_a1 | 1713 | 513 | 2109 | 0 | CFG_GPMC_A1_IN | - | vin2a_d1 | vin1a_d1 | - | - |
| P9 | gpmc_a11 | 1797 | 317 | 2036 | 0 | CFG_GPMC_A11_IN | - | vin2a_fld0 | vin1a_fld0 | - | - |
| P4 | gpmc_a12 | 0 | 0 | 0 | 0 | CFG_GPMC_A12_IN | - | vin2a_clk0 | vin1a_clk0 | - | - |
| R3 | gpmc_a13 | 1876 | 391 | 2144 | 0 | CFG_GPMC_A13_IN | - | vin2a_hsync0 | vin1a_hsync0 | - | - |
| T2 | gpmc_a14 | 1720 | 756 | 2384 | 38 | CFG_GPMC_A14_IN | - | vin2a_vsync0 | vin1a_vsync0 | - | - |
| U2 | gpmc_a15 | 1502 | 368 | 1804 | 0 | CFG_GPMC_A15_IN | - | vin2a_d8 | vin1a_d8 | - | - |
| U1 | gpmc_a16 | 1651 | 355 | 1902 | 0 | CFG_GPMC_A16_IN | - | vin2a_d9 | vin1a_d9 | - | - |
| P3 | gpmc_a17 | 1642 | 338 | 1862 | 0 | CFG_GPMC_A17_IN | - | vin2a_d10 | vin1a_d10 | - | - |
| R2 | gpmc_a18 | 1612 | 0 | 1406 | 0 | CFG_GPMC_A18_IN | - | vin2a_d11 | vin1a_d11 | - | - |
| K7 | gpmc_a19 | 1463 | 152 | 1418 | 0 | CFG_GPMC_A19_IN | - | vin2a_d12 | vin1a_d12 | - | - |
| T6 | gpmc_a2 | 1789 | 646 | 2310 | 0 | CFG_GPMC_A2_IN | - | vin2a_d2 | vin1a_d2 | - | - |
| M7 | gpmc_a20 | 1124 | 0 | 933 | 0 | CFG_GPMC_A20_IN | - | vin2a_d13 | vin1a_d13 | - | - |
| J5 | gpmc_a21 | 1491 | 206 | 1483 | 0 | CFG_GPMC_A21_IN | - | vin2a_d14 | vin1a_d14 | - | - |
| K6 | gpmc_a22 | 1218 | 245 | 1254 | 0 | CFG_GPMC_A22_IN | - | vin2a_d15 | vin1a_d15 | - | - |
| J7 | gpmc_a23 | 1216 | 0 | 1021 | 0 | CFG_GPMC_A23_IN | - | vin2a_fld0 | vin1a_fld0 | - | - |
| T7 | gpmc_a3 | 1789 | 766 | 2451 | 8 | CFG_GPMC_A3_IN | - | vin2a_d3 | vin1a_d3 | - | - |
| P6 | gpmc_a4 | 1842 | 646 | 2329 | 0 | CFG_GPMC_A4_IN | - | vin2a_d4 | vin1a_d4 | - | - |
| R9 | gpmc_a5 | 1778 | 556 | 2215 | 0 | CFG_GPMC_A5_IN | - | vin2a_d5 | vin1a_d5 | - | - |
| R5 | gpmc_a6 | 1783 | 443 | 2088 | 0 | CFG_GPMC_A6_IN | - | vin2a_d6 | vin1a_d6 | - | - |
| P5 | gpmc_a7 | 2207 | 370 | 2393 | 0 | CFG_GPMC_A7_IN | - | vin2a_d7 | vin1a_d7 | - | - |
| N1 | gpmc_advn_al e | 1755 | 116 | 1745 | 0 | CFG_GPMC_ADVN_ALE_I N | - | vin2a_vsync0 | vin1a_vsync0 | - | - |

Table 7-10. Manual Functions Mapping for VIN1A (IOSET5/6) and VIN2A (IOSET7/8/9) (continued)

| BAL L | BALL NAME | VIP_MANUAL8 | | VIP_MANUAL13 | | CFG REGISTER | MUXMODE | | | | |
|----------|-------------|-----------------|-----------------|-----------------|-----------------|--------------------|------------------|------------------|------------------|------------------|------------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 3 | 4 ⁽¹⁾ | 4 ⁽¹⁾ | 5 ⁽¹⁾ | 5 ⁽¹⁾ |
| P7 | gpmc_clk | 1896 | 351 | 2152 | 0 | CFG_GPMC_CLK_IN | - | vin2a_hsync 0 | vin1a_hsync 0 | vin2a_de0 | vin1a_de0 |
| H6 | gpmc_cs1 | 1337 | 74 | 1288 | 0 | CFG_GPMC_CS1_IN | - | vin2a_de0 | vin1a_de0 | - | - |
| D11 | vout1_clk | 1939 | 332 | 2486 | 0 | CFG_VOUT1_CLK_IN | vin2a_fld0 | - | - | - | - |
| F11 | vout1_d0 | 2140 | 647 | 2617 | 386 | CFG_VOUT1_D0_IN | vin2a_d16 | - | - | - | - |
| G10 | vout1_d1 | 2104 | 615 | 2620 | 314 | CFG_VOUT1_D1_IN | vin2a_d17 | - | - | - | - |
| D7 | vout1_d10 | 2139 | 406 | 2675 | 85 | CFG_VOUT1_D10_IN | vin2a_d10 | - | - | - | - |
| D8 | vout1_d11 | 1944 | 534 | 2569 | 125 | CFG_VOUT1_D11_IN | vin2a_d11 | - | - | - | - |
| A5 | vout1_d12 | 1966 | 659 | 2646 | 154 | CFG_VOUT1_D12_IN | vin2a_d12 | - | - | - | - |
| C6 | vout1_d13 | 2048 | 447 | 2624 | 87 | CFG_VOUT1_D13_IN | vin2a_d13 | - | - | - | - |
| C8 | vout1_d14 | 2222 | 548 | 2700 | 286 | CFG_VOUT1_D14_IN | vin2a_d14 | - | - | - | - |
| C7 | vout1_d15 | 2072 | 443 | 2664 | 67 | CFG_VOUT1_D15_IN | vin2a_d15 | - | - | - | - |
| B7 | vout1_d16 | 2044 | 455 | 2634 | 82 | CFG_VOUT1_D16_IN | vin2a_d0 | - | - | - | - |
| B8 | vout1_d17 | 1971 | 246 | 2433 | 0 | CFG_VOUT1_D17_IN | vin2a_d1 | - | - | - | - |
| A7 | vout1_d18 | 2104 | 120 | 2440 | 0 | CFG_VOUT1_D18_IN | vin2a_d2 | - | - | - | - |
| A8 | vout1_d19 | 1888 | 0 | 2105 | 0 | CFG_VOUT1_D19_IN | vin2a_d3 | - | - | - | - |
| F10 | vout1_d2 | 2170 | 237 | 2624 | 0 | CFG_VOUT1_D2_IN | vin2a_d18 | - | - | - | - |
| C9 | vout1_d20 | 1942 | 512 | 2579 | 91 | CFG_VOUT1_D20_IN | vin2a_d4 | - | - | - | - |
| A9 | vout1_d21 | 1997 | 141 | 2324 | 0 | CFG_VOUT1_D21_IN | vin2a_d5 | - | - | - | - |
| B9 | vout1_d22 | 1949 | 0 | 2165 | 0 | CFG_VOUT1_D22_IN | vin2a_d6 | - | - | - | - |
| A10 | vout1_d23 | 1871 | 704 | 2522 | 269 | CFG_VOUT1_D23_IN | vin2a_d7 | - | - | - | - |
| G11 | vout1_d3 | 2319 | 417 | 2740 | 191 | CFG_VOUT1_D3_IN | vin2a_d19 | - | - | - | - |
| E9 | vout1_d4 | 2300 | 369 | 2739 | 137 | CFG_VOUT1_D4_IN | vin2a_d20 | - | - | - | - |
| F9 | vout1_d5 | 1923 | 579 | 2527 | 191 | CFG_VOUT1_D5_IN | vin2a_d21 | - | - | - | - |
| F8 | vout1_d6 | 2148 | 396 | 2622 | 138 | CFG_VOUT1_D6_IN | vin2a_d22 | - | - | - | - |
| E7 | vout1_d7 | 2212 | 335 | 2653 | 110 | CFG_VOUT1_D7_IN | vin2a_d23 | - | - | - | - |
| E8 | vout1_d8 | 1962 | 573 | 2573 | 178 | CFG_VOUT1_D8_IN | vin2a_d8 | - | - | - | - |
| D9 | vout1_d9 | 2312 | 335 | 2725 | 138 | CFG_VOUT1_D9_IN | vin2a_d9 | - | - | - | - |
| B10 | vout1_de | 1973 | 414 | 2551 | 52 | CFG_VOUT1_DE_IN | vin2a_de0 | - | - | - | - |
| B11 | vout1_fld | 0 | 0 | 0 | 0 | CFG_VOUT1_FLD_IN | vin2a_clk0 | - | - | - | - |
| C11 | vout1_hsync | 1813 | 261 | 2277 | 0 | CFG_VOUT1_HSYNC_IN | vin2a_hsync 0 | - | - | - | - |

Table 7-10. Manual Functions Mapping for VIN1A (IOSET5/6) and VIN2A (IOSET7/8/9) (continued)

| BALL | BALL NAME | VIP_MANUAL8 | | VIP_MANUAL13 | | CFG REGISTER | MUXMODE | | | | |
|------|-------------|--------------|--------------|--------------|--------------|--------------------|------------------|------------------|------------------|------------------|------------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 3 | 4 ⁽¹⁾ | 4 ⁽¹⁾ | 5 ⁽¹⁾ | 5 ⁽¹⁾ |
| E11 | vout1_vsync | 1665 | 0 | 1881 | 0 | CFG_VOUT1_VSYNC_IN | vin2a_vsync 0 | - | - | - | - |

(1) Some signals listed are manual functions that present alternate multiplexing options. These manual functions are controlled via CTRL_CORE_ALT_SELECT_MUX or CTRL_CORE_VIP_MUX_SELECT registers. For more information on how to use these options, see *Pad Configuration Registers* section, *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for VIP1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-11 Manual Functions Mapping for VIN1B \(IOSET6/7\)](#) for a definition of the Manual modes.

[Table 7-11](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-11. Manual Functions Mapping for VIN1B (IOSET6/7)

| BALL | BALL NAME | VIP_MANUAL9 | | VIP_MANUAL14 | | CFG REGISTER | MUXMODE | |
|------|--------------|--------------|--------------|--------------|--------------|---------------------|------------|--------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 5 | 6 |
| R6 | gpmc_a0 | 1873 | 702 | 2202 | 441 | CFG_GPMC_A0_IN | - | vin1b_d0 |
| T9 | gpmc_a1 | 1629 | 772 | 2057 | 413 | CFG_GPMC_A1_IN | - | vin1b_d1 |
| N9 | gpmc_a10 | 0 | 0 | 0 | 0 | CFG_GPMC_A10_IN | - | vin1b_clk1 |
| P9 | gpmc_a11 | 1851 | 1011 | 2126 | 856 | CFG_GPMC_A11_IN | - | vin1b_de1 |
| P4 | gpmc_a12 | 2009 | 601 | 2289 | 327 | CFG_GPMC_A12_IN | - | vin1b_fld1 |
| T6 | gpmc_a2 | 1734 | 898 | 2131 | 573 | CFG_GPMC_A2_IN | - | vin1b_d2 |
| T7 | gpmc_a3 | 1757 | 1076 | 2106 | 812 | CFG_GPMC_A3_IN | - | vin1b_d3 |
| P6 | gpmc_a4 | 1794 | 893 | 2164 | 559 | CFG_GPMC_A4_IN | - | vin1b_d4 |
| R9 | gpmc_a5 | 1726 | 853 | 2120 | 523 | CFG_GPMC_A5_IN | - | vin1b_d5 |
| R5 | gpmc_a6 | 1792 | 612 | 2153 | 338 | CFG_GPMC_A6_IN | - | vin1b_d6 |
| P5 | gpmc_a7 | 2117 | 610 | 2389 | 304 | CFG_GPMC_A7_IN | - | vin1b_d7 |
| N7 | gpmc_a8 | 1758 | 653 | 2140 | 308 | CFG_GPMC_A8_IN | - | vin1b_hsync1 |
| R4 | gpmc_a9 | 1705 | 899 | 2067 | 646 | CFG_GPMC_A9_IN | - | vin1b_vsync1 |
| U4 | mdio_d | 1945 | 671 | 2265 | 414 | CFG_MDIO_D_IN | vin1b_d0 | - |
| V1 | mdio_mclk | 255 | 119 | 337 | 0 | CFG_MDIO_MCLK_IN | vin1b_clk1 | - |
| U5 | rgmii0_rxc | 2057 | 909 | 2341 | 646 | CFG_RGMII0_RXC_IN | vin1b_d5 | - |
| V5 | rgmii0_rxctl | 2121 | 1139 | 2323 | 988 | CFG_RGMII0_RXCTL_IN | vin1b_d6 | - |
| W2 | rgmii0_rxd0 | 2070 | 655 | 2336 | 340 | CFG_RGMII0_RXD0_IN | vin1b_fld1 | - |
| V4 | rgmii0_rxd3 | 2092 | 1357 | 2306 | 1216 | CFG_RGMII0_RXD3_IN | vin1b_d7 | - |
| W9 | rgmii0_txc | 2088 | 1205 | 2328 | 1079 | CFG_RGMII0_TXC_IN | vin1b_d3 | - |
| V9 | rgmii0_txctl | 2143 | 1383 | 2312 | 1311 | CFG_RGMII0_TXCTL_IN | vin1b_d4 | - |

Table 7-11. Manual Functions Mapping for VIN1B (IOSET6/7) (continued)

| BALL | BALL NAME | VIP_MANUAL9 | | VIP_MANUAL14 | | CFG REGISTER | MUXMODE | |
|------|-------------|--------------|--------------|--------------|--------------|--------------------|--------------|---|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 5 | 6 |
| V6 | rgmii0_txd1 | 2078 | 1189 | 2324 | 1065 | CFG_RGMII0_TXD1_IN | vin1b_vsync1 | - |
| U7 | rgmii0_txd2 | 1928 | 1125 | 2306 | 763 | CFG_RGMII0_TXD2_IN | vin1b_hsync1 | - |
| V7 | rgmii0_txd3 | 2255 | 971 | 2401 | 846 | CFG_RGMII0_TXD3_IN | vin1b_de1 | - |
| V2 | uart3_rxd | 1829 | 747 | 2220 | 400 | CFG_UART3_RXD_IN | vin1b_d1 | - |
| Y1 | uart3_txd | 2030 | 837 | 2324 | 568 | CFG_UART3_TXD_IN | vin1b_d2 | - |

Manual IO Timings Modes must be used to ensure some IO timings for VIP1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-12 Manual Functions Mapping for VIN1B \(IOSET5\) and VIN2B \(IOSET2/11\)](#) for a definition of the Manual modes.

[Table 7-12](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-12. Manual Functions Mapping for VIN1B (IOSET5) and VIN2B (IOSET2/11)

| BALL | BALL NAME | VIP_MANUAL10 | | VIP_MANUAL11 | | CFG REGISTER | MUXMODE | | | |
|------|-----------|--------------|--------------|--------------|--------------|------------------|------------------|------------------|------------------|------------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 4 ⁽¹⁾ | 4 ⁽¹⁾ | 6 ⁽¹⁾ | 6 ⁽¹⁾ |
| K7 | gpmc_a19 | 1600 | 943 | 2023 | 477 | CFG_GPMC_A19_IN | - | - | vin2b_d0 | vin1b_d0 |
| M7 | gpmc_a20 | 1440 | 621 | 1875 | 136 | CFG_GPMC_A20_IN | - | - | vin2b_d1 | vin1b_d1 |
| J5 | gpmc_a21 | 1602 | 1066 | 2021 | 604 | CFG_GPMC_A21_IN | - | - | vin2b_d2 | vin1b_d2 |
| K6 | gpmc_a22 | 1395 | 983 | 1822 | 519 | CFG_GPMC_A22_IN | - | - | vin2b_d3 | vin1b_d3 |
| J7 | gpmc_a23 | 1571 | 716 | 2045 | 200 | CFG_GPMC_A23_IN | - | - | vin2b_d4 | vin1b_d4 |
| J4 | gpmc_a24 | 1463 | 832 | 1893 | 396 | CFG_GPMC_A24_IN | - | - | vin2b_d5 | vin1b_d5 |
| J6 | gpmc_a25 | 1426 | 1166 | 1842 | 732 | CFG_GPMC_A25_IN | - | - | vin2b_d6 | vin1b_d6 |
| H4 | gpmc_a26 | 1362 | 1094 | 1797 | 584 | CFG_GPMC_A26_IN | - | - | vin2b_d7 | vin1b_d7 |
| H5 | gpmc_a27 | 1283 | 809 | 1760 | 338 | CFG_GPMC_A27_IN | - | - | vin2b_hsync1 | vin1b_hsync1 |
| N6 | gpmc_ben0 | 1978 | 780 | 2327 | 389 | CFG_GPMC_BEN0_IN | - | - | vin2b_de1 | vin1b_de1 |
| M4 | gpmc_ben1 | 0 | 0 | 0 | 0 | CFG_GPMC_BEN1_IN | vin2b_clk1 | vin1b_clk1 | vin2b_fld1 | vin1b_fld1 |
| H6 | gpmc_cs1 | 1411 | 982 | 1857 | 536 | CFG_GPMC_CS1_IN | - | - | vin2b_vsync1 | vin1b_vsync1 |

(1) Some signals listed are manual functions that present alternate multiplexing options. These manual functions are controlled via CTRL_CORE_ALT_SELECT_MUX or CTRL_CORE_VIP_MUX_SELECT registers. For more information on how to use these options, see *Pad Configuration Registers* section, *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for VIP1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-13 Manual Functions Mapping for VIN1A \(IOSET8/9/10\)](#) for a definition of the Manual modes.

[Table 7-13](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-13. Manual Functions Mapping for VIN1A (IOSET8/9/10)

| BALL | BALL NAME | VIP_MANUAL15 | | VIP_MANUAL16 | | CFG REGISTER | MUXMODE | |
|------|--------------|--------------|--------------|--------------|--------------|---------------------|--------------|------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 7 | 9 |
| AC5 | gpio6_10 | 2131 | 2198 | 2170 | 2180 | CFG_GPIO6_10_IN | - | vin1a_clk0 |
| AB4 | gpio6_11 | 3720 | 2732 | 4106 | 2448 | CFG_GPIO6_11_IN | - | vin1a_de0 |
| C14 | mcasp1_aclkx | 2447 | 0 | 3042 | 0 | CFG_MCASP1_ACLKX_IN | vin1a_fld0 | - |
| G12 | mcasp1_axr0 | 3061 | 0 | 3380 | 292 | CFG_MCASP1_AXR0_IN | vin1a_vsync0 | - |
| F12 | mcasp1_axr1 | 3113 | 0 | 3396 | 304 | CFG_MCASP1_AXR1_IN | vin1a_hsync0 | - |
| B13 | mcasp1_axr10 | 2803 | 0 | 3362 | 0 | CFG_MCASP1_AXR10_IN | vin1a_d13 | - |
| A12 | mcasp1_axr11 | 3292 | 0 | 3357 | 546 | CFG_MCASP1_AXR11_IN | vin1a_d12 | - |
| E14 | mcasp1_axr12 | 2854 | 0 | 3145 | 320 | CFG_MCASP1_AXR12_IN | vin1a_d11 | - |
| A13 | mcasp1_axr13 | 2813 | 0 | 3229 | 196 | CFG_MCASP1_AXR13_IN | vin1a_d10 | - |
| G14 | mcasp1_axr14 | 2471 | 0 | 3053 | 0 | CFG_MCASP1_AXR14_IN | vin1a_d9 | - |
| F14 | mcasp1_axr15 | 2815 | 0 | 3225 | 201 | CFG_MCASP1_AXR15_IN | vin1a_d8 | - |
| B12 | mcasp1_axr8 | 2965 | 0 | 3427 | 83 | CFG_MCASP1_AXR8_IN | vin1a_d15 | - |
| A11 | mcasp1_axr9 | 3082 | 0 | 3253 | 440 | CFG_MCASP1_AXR9_IN | vin1a_d14 | - |
| D14 | mcasp1_fsx | 2898 | 0 | 3368 | 139 | CFG_MCASP1_FSX_IN | vin1a_de0 | - |
| A19 | mcasp2_aclkx | 2413 | 0 | 2972 | 0 | CFG_MCASP2_ACLKX_IN | vin1a_d7 | - |
| C15 | mcasp2_axr2 | 2478 | 0 | 3062 | 0 | CFG_MCASP2_AXR2_IN | vin1a_d5 | - |
| A16 | mcasp2_axr3 | 2806 | 0 | 3175 | 242 | CFG_MCASP2_AXR3_IN | vin1a_d4 | - |
| A18 | mcasp2_fsx | 2861 | 78 | 2936 | 599 | CFG_MCASP2_FSX_IN | vin1a_d6 | - |
| B18 | mcasp3_aclkx | 1583 | 0 | 1878 | 0 | CFG_MCASP3_ACLKX_IN | vin1a_d3 | - |
| B19 | mcasp3_axr0 | 2873 | 0 | 3109 | 375 | CFG_MCASP3_AXR0_IN | vin1a_d1 | - |
| C17 | mcasp3_axr1 | 1625 | 1400 | 2072 | 1023 | CFG_MCASP3_AXR1_IN | vin1a_d0 | vin1a_fld0 |
| F15 | mcasp3_fsx | 2792 | 0 | 3146 | 257 | CFG_MCASP3_FSX_IN | vin1a_d2 | - |
| C18 | mcasp4_aclkx | 1547 | 268 | 1776 | 0 | CFG_MCASP4_ACLKX_IN | - | vin1a_d15 |
| G16 | mcasp4_axr0 | 2362 | 587 | 2815 | 193 | CFG_MCASP4_AXR0_IN | - | vin1a_d13 |
| D17 | mcasp4_axr1 | 2326 | 667 | 2769 | 304 | CFG_MCASP4_AXR1_IN | - | vin1a_d12 |
| A21 | mcasp4_fsx | 924 | 2573 | 1338 | 2219 | CFG_MCASP4_FSX_IN | - | vin1a_d14 |
| AA3 | mcasp5_aclkx | 3731 | 2106 | 4130 | 1708 | CFG_MCASP5_ACLKX_IN | - | vin1a_d11 |
| AB3 | mcasp5_axr0 | 3800 | 3013 | 4159 | 2776 | CFG_MCASP5_AXR0_IN | - | vin1a_d9 |
| AA4 | mcasp5_axr1 | 3828 | 2951 | 4179 | 2733 | CFG_MCASP5_AXR1_IN | - | vin1a_d8 |
| AB9 | mcasp5_fsx | 3675 | 2447 | 4074 | 2142 | CFG_MCASP5_FSX_IN | - | vin1a_d10 |
| AD4 | mmc3_clk | 3907 | 2744 | 4260 | 2450 | CFG_MMC3_CLK_IN | - | vin1a_d7 |
| AC4 | mmc3_cmd | 3892 | 2768 | 4242 | 2470 | CFG_MMC3_CMD_IN | - | vin1a_d6 |

Table 7-13. Manual Functions Mapping for VIN1A (IOSET8/9/10) (continued)

| BALL | BALL NAME | VIP_MANUAL15 | | VIP_MANUAL16 | | CFG REGISTER | MUXMODE | |
|------|-----------|--------------|--------------|--------------|--------------|------------------|------------|--------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 7 | 9 |
| AC7 | mmc3_dat0 | 3786 | 2765 | 4156 | 2522 | CFG_MMC3_DAT0_IN | - | vin1a_d5 |
| AC6 | mmc3_dat1 | 3673 | 2961 | 4053 | 2667 | CFG_MMC3_DAT1_IN | - | vin1a_d4 |
| AC9 | mmc3_dat2 | 3818 | 2447 | 4209 | 2096 | CFG_MMC3_DAT2_IN | - | vin1a_d3 |
| AC3 | mmc3_dat3 | 3902 | 2903 | 4259 | 2672 | CFG_MMC3_DAT3_IN | - | vin1a_d2 |
| AC8 | mmc3_dat4 | 3905 | 2622 | 4259 | 2342 | CFG_MMC3_DAT4_IN | - | vin1a_d1 |
| AD6 | mmc3_dat5 | 3807 | 2824 | 4167 | 2595 | CFG_MMC3_DAT5_IN | - | vin1a_d0 |
| AB8 | mmc3_dat6 | 3724 | 2818 | 4123 | 2491 | CFG_MMC3_DAT6_IN | - | vin1a_hsync0 |
| AB5 | mmc3_dat7 | 3775 | 2481 | 4159 | 2161 | CFG_MMC3_DAT7_IN | - | vin1a_vsync0 |
| D18 | xref_clk0 | 1971 | 0 | 2472 | 0 | CFG_XREF_CLK0_IN | vin1a_d0 | - |
| E17 | xref_clk1 | 0 | 192 | 0 | 603 | CFG_XREF_CLK1_IN | vin1a_clk0 | - |

7.7 Display Subsystem - Video Output Ports

Three Display Parallel Interfaces (DPI) channels are available in DSS named DPI Video Output 1, DPI Video Output 2 and DPI Video Output 3.

NOTE

The DPI Video Output i ($i = 1$ to 3) interface is also referred to as VOUT i .

Every VOUT interface consists of:

- 24-bit data bus (data[23:0])
- Horizontal synchronization signal (HSYNC)
- Vertical synchronization signal (VSYNC)
- Data enable (DE)
- Field ID (FID)
- Pixel clock (CLK)

NOTE

For more information, see *Display Subsystem* chapter in the device TRM.

CAUTION

The I/O timings provided in this section are valid only if signals within a single IOSET are used. The IOSETs are defined in [Table 7-18](#).

CAUTION

The I/O Timings provided in this section are valid only for some DSS usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

CAUTION

All pads/balls configured as vout i _* signals must be programmed to use slow slew rate by setting the corresponding CTRL_CORE_PAD_*[SLEWCONTROL] register field to SLOW (0b1).

[Table 7-14](#) through [Table 7-17](#), and [Figure 7-6](#) assume testing over the recommended operating conditions and electrical characteristic conditions.

Table 7-14. DPI Video Output i ($i = 1..3$) Default Switching Characteristics⁽¹⁾⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|----------------------|---|--|-----------------------|-----|------|
| D1 | $t_{c(\text{clk})}$ | Cycle time, output pixel clock vout i _clk | DPI1/2/3 in 1.8V mode DPI2 in 3.3V mode | 11.76 ⁽³⁾ | | ns |
| | | | DPI1/3 in 3.3V mode | 13.33 ⁽³⁾ | | ns |
| D2 | $t_{w(\text{clkL})}$ | Pulse duration, output pixel clock vout i _clk low | | $P \times 0.5$ - 1 | | ns |
| D3 | $t_{w(\text{clkH})}$ | Pulse duration, output pixel clock vout i _clk high | | $P \times 0.5$ - 1 | | ns |

Table 7-14. DPI Video Output i (i = 1..3) Default Switching Characteristics⁽¹⁾⁽²⁾ (continued)

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|--------------------------|--|-----------------------------------|------|-----|------|
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI1 | -2.5 | 2.5 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI1 | -2.5 | 2.5 | ns |
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI2 (vin2a_fld0 clock reference) | -2.5 | 2.5 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI2 (vin2a_fld0 clock reference) | -2.5 | 2.5 | ns |
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI2 (xref_clk2 clock reference) | -2.5 | 2.5 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI2 (xref_clk2 clock reference) | -2.5 | 2.5 | ns |
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI3 | -2.5 | 2.5 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI3 | -2.5 | 2.5 | ns |

(1) P = output vout_i_clk period in ns.

(2) All pads/balls configured as vout_i_* signals must be programmed to use slow slew rate by setting the corresponding CTRL_CORE_PAD_*[SLEWCONTROL] register field to SLOW (0b1).

(3) SERDES transceivers may be sensitive to the jitter profile of vout_i_clk. See Application Note [SPRAC62](#) for additional guidance.

Table 7-15. DPI Video Output i (i = 1..3) Alternate Switching Characteristics⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|--------------------------|--|-----------------------------------|-----------------------------------|------|------|
| D1 | $t_{c(\text{clk})}$ | Cycle time, output pixel clock vout _i _clk | DPI1/2/3 in 1.8V mode | 6.06 ⁽³⁾ | | ns |
| | | | DPI2 in 3.3V mode | | | |
| | | | DPI1/3 in 3.3V mode | 13.33 ⁽³⁾ | | ns |
| D2 | $t_{w(\text{clkL})}$ | Pulse duration, output pixel clock vout _i _clk low | | $P \times 0.5 - 1$ ⁽¹⁾ | | ns |
| D3 | $t_{w(\text{clkH})}$ | Pulse duration, output pixel clock vout _i _clk high | | $P \times 0.5 - 1$ ⁽¹⁾ | | ns |
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI1 | 1.51 | 4.55 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI1 | 1.51 | 4.55 | ns |
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI2 (vin2a_fld0 clock reference) | 1.51 | 4.55 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI2 (vin2a_fld0 clock reference) | 1.51 | 4.55 | ns |
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI2 (xref_clk2 clock reference) | 1.51 | 4.55 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI2 (xref_clk2 clock reference) | 1.51 | 4.55 | ns |
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI3 | 1.51 | 4.55 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI3 | 1.51 | 4.55 | ns |

- (1) P = output vout_i_clk period in ns.
- (2) All pads/balls configured as vout_i* signals must be programmed to use slow slew rate by setting the corresponding CTRL_CORE_PAD_*[SLEWCONTROL] register field to SLOW (0b1).
- (3) SERDES transceivers may be sensitive to the jitter profile of vout_i_clk. See Application Note [SPRAC62](#) for additional guidance.

Table 7-16. DPI Video Output i (i = 1..3) MANUAL4 Switching Characteristics ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|---------------------------|--|--|-----------------------|------|------|
| D1 | t _c (clk) | Cycle time, output pixel clock vout _i _clk | DPI1/2/3 in 1.8V mode DPI2 in 3.3V mode | 6.06 (3) | | ns |
| | | | DPI1/3 in 3.3V mode | 13.33 (3) | | ns |
| D2 | t _w (clkL) | Pulse duration, output pixel clock vout _i _clk low | | P × 0.5 - 1 (1) | | ns |
| D3 | t _w (clkH) | Pulse duration, output pixel clock vout _i _clk high | | P × 0.5 - 1 (1) | | ns |
| D5 | t _d (clk-ctIV) | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI1 | 2.85 | 5.56 | ns |
| D6 | t _d (clk-dV) | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI1 | 2.85 | 5.56 | ns |
| D5 | t _d (clk-ctIV) | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI2 (vin2a_fld0 clock reference) | 2.85 | 5.56 | ns |
| D6 | t _d (clk-dV) | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI2 (vin2a_fld0 clock reference) | 2.85 | 5.56 | ns |
| D5 | t _d (clk-ctIV) | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI2 (xref_clk2 clock reference) | 2.85 | 5.56 | ns |
| D6 | t _d (clk-dV) | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI2 (xref_clk2 clock reference) | 2.85 | 5.56 | ns |
| D5 | t _d (clk-ctIV) | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI3 | 2.85 | 5.56 | ns |
| D6 | t _d (clk-dV) | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI3 | 2.85 | 5.56 | ns |

- (1) P = output vout_i_clk period in ns.
- (2) All pads/balls configured as vout_i* signals must be programmed to use slow slew rate by setting the corresponding CTRL_CORE_PAD_*[SLEWCONTROL] register field to SLOW (0b1).
- (3) SERDES transceivers may be sensitive to the jitter profile of vout_i_clk. See Application Note [SPRAC62](#) for additional guidance.

Table 7-17. DPI Video Output i (i = 1..3) MANUAL5 Switching Characteristics ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|---------------------------|--|--|-----------------------|------|------|
| D1 | t _c (clk) | Cycle time, output pixel clock vout _i _clk | DPI1/2/3 in 1.8V mode DPI2 in 3.3V mode | 6.06 (3) | | ns |
| | | | DPI1/3 in 3.3V mode | 13.33 (3) | | ns |
| D2 | t _w (clkL) | Pulse duration, output pixel clock vout _i _clk low | | P × 0.5 - 1 (1) | | ns |
| D3 | t _w (clkH) | Pulse duration, output pixel clock vout _i _clk high | | P × 0.5 - 1 (1) | | ns |
| D5 | t _d (clk-ctIV) | Delay time, output pixel clock vout _i _clk transition to output data vout _i _d[23:0] valid | DPI1 | 3.55 | 6.61 | ns |
| D6 | t _d (clk-dV) | Delay time, output pixel clock vout _i _clk transition to output control signals vout _i _vsync, vout _i _hsync, vout _i _de, and vout _i _fld valid | DPI1 | 3.55 | 6.61 | ns |

Table 7-17. DPI Video Output i (i = 1..3) MANUAL5 Switching Characteristics ⁽²⁾ (continued)

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|--------------------------|---|-----------------------------------|------|------|------|
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vouti_clk transition to output data vouti_d[23:0] valid | DPI2 (vin2a_fld0 clock reference) | 3.55 | 6.61 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vouti_clk transition to output control signals vouti_vsync, vouti_hsync, vouti_de, and vouti_fld valid | DPI2 (vin2a_fld0 clock reference) | 3.55 | 6.61 | ns |
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vouti_clk transition to output data vouti_d[23:0] valid | DPI2 (xref_clk2 clock reference) | 3.55 | 6.61 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vouti_clk transition to output control signals vouti_vsync, vouti_hsync, vouti_de, and vouti_fld valid | DPI2 (xref_clk2 clock reference) | 3.55 | 6.61 | ns |
| D5 | $t_{d(\text{clk-ctIV})}$ | Delay time, output pixel clock vouti_clk transition to output data vouti_d[23:0] valid | DPI3 | 3.55 | 6.61 | ns |
| D6 | $t_{d(\text{clk-dV})}$ | Delay time, output pixel clock vouti_clk transition to output control signals vouti_vsync, vouti_hsync, vouti_de, and vouti_fld valid | DPI3 | 3.55 | 6.61 | ns |

- (1) P = output vouti_clk period in ns.
- (2) All pads/balls configured as vouti_* signals must be programmed to use slow slew rate by setting the corresponding CTRL_CORE_PAD_*[SLEWCONTROL] register field to SLOW (0b1).
- (3) SERDES transceivers may be sensitive to the jitter profile of vouti_clk. See Application Note [SPRAC62](#) for additional guidance.

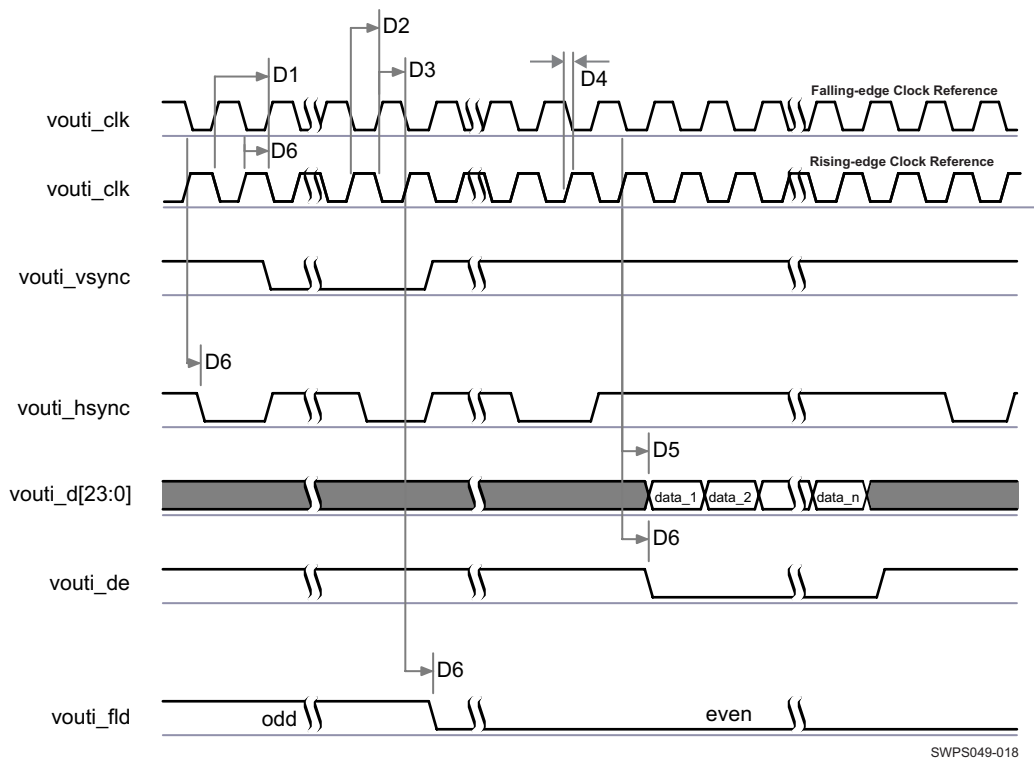


Figure 7-6. DPI Video Output⁽¹⁾⁽²⁾⁽³⁾

- (1) The configuration of assertion of the data can be programmed on the falling or rising edge of the pixel clock.
- (2) The polarity and the pulse width of vouti_hsync and vouti_vsync are programmable, refer to the DSS section of the device TRM.
- (3) The vouti_clk frequency can be configured, refer to the DSS section of the device TRM.

In [Table 7-18](#) are presented the specific groupings of signals (IOSET) for use with VOUT2.

Table 7-18. VOUT2 IOSETs

| SIGNALS | IOSET1 | | IOSET2 | |
|-------------|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX |
| vout2_d23 | F2 | 4 | AA4 | 6 |
| vout2_d22 | F3 | 4 | AB3 | 6 |
| vout2_d21 | D1 | 4 | AB9 | 6 |
| vout2_d20 | E2 | 4 | AA3 | 6 |
| vout2_d19 | D2 | 4 | D17 | 6 |
| vout2_d18 | F4 | 4 | G16 | 6 |
| vout2_d17 | C1 | 4 | A21 | 6 |
| vout2_d16 | E4 | 4 | C18 | 6 |
| vout2_d15 | F5 | 4 | A17 | 6 |
| vout2_d14 | E6 | 4 | B17 | 6 |
| vout2_d13 | D3 | 4 | B16 | 6 |
| vout2_d12 | F6 | 4 | D15 | 6 |
| vout2_d11 | D5 | 4 | A15 | 6 |
| vout2_d10 | C2 | 4 | B15 | 6 |
| vout2_d9 | C3 | 4 | A20 | 6 |
| vout2_d8 | C4 | 4 | E15 | 6 |
| vout2_d7 | B2 | 4 | D12 | 6 |
| vout2_d6 | D6 | 4 | C12 | 6 |
| vout2_d5 | C5 | 4 | F13 | 6 |
| vout2_d4 | A3 | 4 | E12 | 6 |
| vout2_d3 | B3 | 4 | J11 | 6 |
| vout2_d2 | B4 | 4 | G13 | 6 |
| vout2_d1 | B5 | 4 | J14 | 6 |
| vout2_d0 | A4 | 4 | B14 | 6 |
| vout2_vsync | G6 | 4 | F20 | 6 |
| vout2_hsync | G1 | 4 | E21 | 6 |
| vout2_clk | H7 | 4 | B26 | 6 |
| vout2_fld | E1 | 4 | F21 | 6 |
| vout2_de | G2 | 4 | C23 | 6 |

NOTE

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bit field for each corresponding pad control register.

The pad control registers are presented in [Table 4-3](#) and described in Device TRM, *Control Module Chapter*.

Virtual IO Timings Modes must be used to ensure some IO timings for VOUT1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 7-19 Virtual Functions Mapping for VOUT1](#) for a definition of the Virtual modes.

[Table 7-19](#) presents the values for DELAYMODE bit field.

Table 7-19. Virtual Functions Mapping for DSS VOUT1

| BALL | BALL NAME | Delay Mode Value | MUXMODE | |
|------|-----------|------------------|----------|-----------|
| | | DSS_VIRTUAL1 | 0 | 3 |
| H3 | gpmc_ad15 | 14 | | vout3_d15 |
| D9 | vout1_d9 | 15 | vout1_d9 | |

Table 7-19. Virtual Functions Mapping for DSS VOUT1 (continued)

| BALL | BALL NAME | Delay Mode Value | MUXMODE | |
|------|-------------|------------------|-------------|-------------|
| | | DSS_VIRTUAL1 | 0 | 3 |
| N7 | gpmc_a8 | 15 | | vout3_hsync |
| L6 | gpmc_ad4 | 14 | | vout3_d4 |
| E8 | vout1_d8 | 15 | vout1_d8 | |
| M6 | gpmc_ad0 | 14 | | vout3_d0 |
| F9 | vout1_d5 | 15 | vout1_d5 | |
| J3 | gpmc_ad13 | 14 | | vout3_d13 |
| T6 | gpmc_a2 | 15 | | vout3_d18 |
| M2 | gpmc_ad1 | 14 | | vout3_d1 |
| P6 | gpmc_a4 | 15 | | vout3_d20 |
| B10 | vout1_de | 15 | vout1_de | |
| B7 | vout1_d16 | 15 | vout1_d16 | |
| R5 | gpmc_a6 | 15 | | vout3_d22 |
| A9 | vout1_d21 | 15 | vout1_d21 | |
| H2 | gpmc_ad14 | 14 | | vout3_d14 |
| T9 | gpmc_a1 | 15 | | vout3_d17 |
| E7 | vout1_d7 | 15 | vout1_d7 | |
| C11 | vout1_hsync | 15 | vout1_hsync | |
| D11 | vout1_clk | 15 | vout1_clk | |
| P1 | gpmc_cs3 | 15 | | vout3_clk |
| B9 | vout1_d22 | 15 | vout1_d22 | |
| G11 | vout1_d3 | 15 | vout1_d3 | |
| R4 | gpmc_a9 | 15 | | vout3_vsync |
| D8 | vout1_d11 | 15 | vout1_d11 | |
| J2 | gpmc_ad11 | 14 | | vout3_d11 |
| L3 | gpmc_ad6 | 14 | | vout3_d6 |
| D7 | vout1_d10 | 15 | vout1_d10 | |
| L5 | gpmc_ad2 | 14 | | vout3_d2 |
| F10 | vout1_d2 | 15 | vout1_d2 | |
| M1 | gpmc_ad3 | 14 | | vout3_d3 |
| P5 | gpmc_a7 | 15 | | vout3_d23 |
| T7 | gpmc_a3 | 15 | | vout3_d19 |
| A7 | vout1_d18 | 15 | vout1_d18 | |
| C7 | vout1_d15 | 15 | vout1_d15 | |
| J1 | gpmc_ad10 | 14 | | vout3_d10 |
| L2 | gpmc_ad7 | 14 | | vout3_d7 |
| N9 | gpmc_a10 | 15 | | vout3_de |
| F11 | vout1_d0 | 15 | vout1_d0 | |
| G10 | vout1_d1 | 15 | vout1_d1 | |
| R9 | gpmc_a5 | 15 | | vout3_d21 |
| L1 | gpmc_ad8 | 14 | | vout3_d8 |
| F8 | vout1_d6 | 15 | vout1_d6 | |
| L4 | gpmc_ad5 | 14 | | vout3_d5 |
| A10 | vout1_d23 | 15 | vout1_d23 | |
| E11 | vout1_vsync | 15 | vout1_vsync | |
| C9 | vout1_d20 | 15 | vout1_d20 | |
| R6 | gpmc_a0 | 15 | | vout3_d16 |

Table 7-19. Virtual Functions Mapping for DSS VOUT1 (continued)

| BALL | BALL NAME | Delay Mode Value | MUXMODE | |
|------|-----------|------------------|-----------|-----------|
| | | DSS_VIRTUAL1 | 0 | 3 |
| A8 | vout1_d19 | 15 | vout1_d19 | |
| E9 | vout1_d4 | 15 | vout1_d4 | |
| H1 | gpmc_ad12 | 14 | | vout3_d12 |
| B11 | vout1_fld | 15 | vout1_fld | |
| P9 | gpmc_a11 | 15 | | vout3_fld |
| K2 | gpmc_ad9 | 14 | | vout3_d9 |
| C6 | vout1_d13 | 15 | vout1_d13 | |
| B8 | vout1_d17 | 15 | vout1_d17 | |
| A5 | vout1_d12 | 15 | vout1_d12 | |
| C8 | vout1_d14 | 15 | vout1_d14 | |

NOTE

To configure the desired Manual IO Timing Mode the user must follow the steps described in section "Manual IO Timing Modes" in the device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information, see *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for VOUT1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-20 Manual Functions Mapping for DSS VOUT1](#) for a definition of the Manual modes.

[Table 7-20](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-20. Manual Functions Mapping for DSS VOUT1

| BALL | BALL NAME | VOUT1_MANUAL1 | | VOUT1_MANUAL4 | | VOUT1_MANUAL5 | | CFG REGISTER | MUXMODE |
|------|-----------|---------------|--------------|---------------|--------------|---------------|--------------|-------------------|-----------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 0 |
| D11 | vout1_clk | 0 | 212 | 0 | 249 | 0 | 249 | CFG_VOUT1_CLK_OUT | vout1_clk |
| F11 | vout1_d0 | 2502 | 0 | 3778 | 0 | 4648 | 0 | CFG_VOUT1_D0_OUT | vout1_d0 |
| G10 | vout1_d1 | 2402 | 0 | 3650 | 0 | 4520 | 0 | CFG_VOUT1_D1_OUT | vout1_d1 |
| D7 | vout1_d10 | 2147 | 0 | 3353 | 0 | 4223 | 0 | CFG_VOUT1_D10_OUT | vout1_d10 |
| D8 | vout1_d11 | 2249 | 0 | 3588 | 0 | 4458 | 0 | CFG_VOUT1_D11_OUT | vout1_d11 |
| A5 | vout1_d12 | 2410 | 0 | 3733 | 0 | 4603 | 0 | CFG_VOUT1_D12_OUT | vout1_d12 |
| C6 | vout1_d13 | 2129 | 0 | 3427 | 0 | 4297 | 0 | CFG_VOUT1_D13_OUT | vout1_d13 |
| C8 | vout1_d14 | 2279 | 0 | 3485 | 0 | 4355 | 0 | CFG_VOUT1_D14_OUT | vout1_d14 |
| C7 | vout1_d15 | 2266 | 23 | 3573 | 0 | 4443 | 0 | CFG_VOUT1_D15_OUT | vout1_d15 |
| B7 | vout1_d16 | 1798 | 0 | 3069 | 0 | 3939 | 0 | CFG_VOUT1_D16_OUT | vout1_d16 |
| B8 | vout1_d17 | 2243 | 0 | 3492 | 0 | 4362 | 0 | CFG_VOUT1_D17_OUT | vout1_d17 |
| A7 | vout1_d18 | 2127 | 0 | 3319 | 0 | 4189 | 0 | CFG_VOUT1_D18_OUT | vout1_d18 |
| A8 | vout1_d19 | 2096 | 0 | 3455 | 0 | 4225 | 0 | CFG_VOUT1_D19_OUT | vout1_d19 |
| F10 | vout1_d2 | 2375 | 0 | 3788 | 0 | 4658 | 0 | CFG_VOUT1_D2_OUT | vout1_d2 |
| C9 | vout1_d20 | 2105 | 0 | 3402 | 0 | 4272 | 0 | CFG_VOUT1_D20_OUT | vout1_d20 |
| A9 | vout1_d21 | 2120 | 0 | 3477 | 0 | 4347 | 0 | CFG_VOUT1_D21_OUT | vout1_d21 |
| B9 | vout1_d22 | 2013 | 65 | 3395 | 0 | 4265 | 0 | CFG_VOUT1_D22_OUT | vout1_d22 |
| A10 | vout1_d23 | 1887 | 0 | 3213 | 0 | 3983 | 0 | CFG_VOUT1_D23_OUT | vout1_d23 |
| G11 | vout1_d3 | 2429 | 0 | 3753 | 0 | 4623 | 0 | CFG_VOUT1_D3_OUT | vout1_d3 |
| E9 | vout1_d4 | 2639 | 0 | 3728 | 0 | 4598 | 0 | CFG_VOUT1_D4_OUT | vout1_d4 |

Table 7-20. Manual Functions Mapping for DSS VOUT1 (continued)

| BALL | BALL NAME | VOUT1_MANUAL1 | | VOUT1_MANUAL4 | | VOUT1_MANUAL5 | | CFG REGISTER | MUXMODE |
|------|-------------|---------------|--------------|---------------|--------------|---------------|--------------|---------------------|-------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 0 |
| F9 | vout1_d5 | 2319 | 0 | 3643 | 0 | 4363 | 0 | CFG_VOUT1_D5_OUT | vout1_d5 |
| F8 | vout1_d6 | 2227 | 0 | 3544 | 0 | 4264 | 0 | CFG_VOUT1_D6_OUT | vout1_d6 |
| E7 | vout1_d7 | 2309 | 0 | 3707 | 0 | 4427 | 0 | CFG_VOUT1_D7_OUT | vout1_d7 |
| E8 | vout1_d8 | 1999 | 0 | 3315 | 0 | 4185 | 0 | CFG_VOUT1_D8_OUT | vout1_d8 |
| D9 | vout1_d9 | 2276 | 0 | 3539 | 0 | 4409 | 0 | CFG_VOUT1_D9_OUT | vout1_d9 |
| B10 | vout1_de | 1933 | 0 | 3507 | 0 | 4177 | 0 | CFG_VOUT1_DE_OUT | vout1_de |
| B11 | vout1_fld | 1825 | 0 | 3382 | 0 | 4052 | 0 | CFG_VOUT1_FLD_OUT | vout1_fld |
| C11 | vout1_hsync | 1741 | 13 | 3408 | 0 | 4278 | 0 | CFG_VOUT1_HSYNC_OUT | vout1_hsync |
| E11 | vout1_vsync | 2338 | 0 | 3718 | 0 | 4588 | 0 | CFG_VOUT1_VSYNC_OUT | vout1_vsync |

Manual IO Timings Modes must be used to ensure some IO timings for VOUT2. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-21 Manual Functions Mapping for DSS VOUT2 IOSET1](#) for a definition of the Manual modes.

[Table 7-21](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-21. Manual Functions Mapping for DSS VOUT2 IOSET1

| BALL | BALL NAME | VOUT2_IOSET1_MANUAL1 | | VOUT2_IOSET1_MANUAL2 | | VOUT2_IOSET1_MANUAL3 | | VOUT2_IOSET1_MANUAL4 | | VOUT2_IOSET1_MANUAL5 | | CFG REGISTER | MUXMODE |
|------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|--------------|----------------------|-------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 4 |
| E1 | vin2a_clk0 | 2571 | 0 | 1059 | 0 | 1025 | 0 | 4110 | 0 | 4980 | 0 | CFG_VIN2A_CLK0_OUT | vout2_fld |
| F2 | vin2a_d0 | 2124 | 0 | 589 | 0 | 577 | 0 | 3613 | 0 | 4483 | 0 | CFG_VIN2A_D0_OUT | vout2_d23 |
| F3 | vin2a_d1 | 2103 | 0 | 568 | 0 | 557 | 0 | 3442 | 0 | 4312 | 0 | CFG_VIN2A_D1_OUT | vout2_d22 |
| D3 | vin2a_d10 | 2091 | 0 | 557 | 0 | 545 | 0 | 3430 | 0 | 4200 | 0 | CFG_VIN2A_D10_OUT | vout2_d13 |
| F6 | vin2a_d11 | 2142 | 0 | 608 | 0 | 596 | 0 | 3481 | 0 | 4251 | 0 | CFG_VIN2A_D11_OUT | vout2_d12 |
| D5 | vin2a_d12 | 2920 | 385 | 1816 | 255 | 1783 | 276 | 3943 | 601 | 4713 | 601 | CFG_VIN2A_D12_OUT | vout2_d11 |
| C2 | vin2a_d13 | 2776 | 322 | 1872 | 192 | 1838 | 213 | 3799 | 538 | 4669 | 538 | CFG_VIN2A_D13_OUT | vout2_d10 |
| C3 | vin2a_d14 | 2904 | 0 | 1769 | 0 | 1757 | 0 | 3869 | 174 | 4739 | 174 | CFG_VIN2A_D14_OUT | vout2_d9 |
| C4 | vin2a_d15 | 2670 | 257 | 1665 | 127 | 1632 | 148 | 3792 | 473 | 4662 | 473 | CFG_VIN2A_D15_OUT | vout2_d8 |
| B2 | vin2a_d16 | 2814 | 155 | 1908 | 31 | 1878 | 43 | 3837 | 371 | 4707 | 371 | CFG_VIN2A_D16_OUT | vout2_d7 |
| D6 | vin2a_d17 | 3002 | 199 | 1897 | 69 | 1865 | 89 | 4024 | 415 | 4894 | 415 | CFG_VIN2A_D17_OUT | vout2_d6 |
| C5 | vin2a_d18 | 1893 | 0 | 358 | 0 | 347 | 0 | 3432 | 0 | 4302 | 0 | CFG_VIN2A_D18_OUT | vout2_d5 |
| A3 | vin2a_d19 | 1698 | 0 | 163 | 0 | 151 | 0 | 3237 | 0 | 4007 | 0 | CFG_VIN2A_D19_OUT | vout2_d4 |
| D1 | vin2a_d2 | 2193 | 0 | 658 | 0 | 646 | 0 | 3531 | 0 | 4401 | 0 | CFG_VIN2A_D2_OUT | vout2_d21 |
| B3 | vin2a_d20 | 1736 | 0 | 202 | 0 | 190 | 0 | 3075 | 0 | 3945 | 0 | CFG_VIN2A_D20_OUT | vout2_d3 |
| B4 | vin2a_d21 | 1636 | 0 | 101 | 0 | 89 | 0 | 3074 | 0 | 3944 | 0 | CFG_VIN2A_D21_OUT | vout2_d2 |
| B5 | vin2a_d22 | 1628 | 0 | 93 | 0 | 81 | 0 | 3266 | 0 | 4036 | 0 | CFG_VIN2A_D22_OUT | vout2_d1 |
| A4 | vin2a_d23 | 1538 | 0 | 0 | 0 | 0 | 0 | 2968 | 0 | 3838 | 0 | CFG_VIN2A_D23_OUT | vout2_d0 |
| E2 | vin2a_d3 | 1997 | 0 | 462 | 0 | 450 | 0 | 3335 | 0 | 4205 | 0 | CFG_VIN2A_D3_OUT | vout2_d20 |
| D2 | vin2a_d4 | 2528 | 0 | 993 | 0 | 982 | 0 | 3867 | 0 | 4537 | 0 | CFG_VIN2A_D4_OUT | vout2_d19 |
| F4 | vin2a_d5 | 2038 | 0 | 503 | 0 | 492 | 0 | 3577 | 0 | 4347 | 0 | CFG_VIN2A_D5_OUT | vout2_d18 |
| C1 | vin2a_d6 | 1746 | 0 | 211 | 0 | 200 | 0 | 3285 | 0 | 4055 | 0 | CFG_VIN2A_D6_OUT | vout2_d17 |
| E4 | vin2a_d7 | 2213 | 0 | 678 | 0 | 666 | 0 | 3552 | 0 | 4272 | 0 | CFG_VIN2A_D7_OUT | vout2_d16 |
| F5 | vin2a_d8 | 2268 | 0 | 733 | 0 | 721 | 0 | 3607 | 0 | 4277 | 0 | CFG_VIN2A_D8_OUT | vout2_d15 |
| E6 | vin2a_d9 | 2170 | 0 | 635 | 0 | 623 | 0 | 3509 | 0 | 4379 | 0 | CFG_VIN2A_D9_OUT | vout2_d14 |
| G2 | vin2a_de0 | 2102 | 0 | 568 | 0 | 556 | 0 | 3841 | 0 | 4611 | 0 | CFG_VIN2A_DE0_OUT | vout2_de |
| H7 | vin2a_fld0 | 0 | 983 | 1398 | 1185 | 1385 | 1202 | 0 | 994 | 0 | 994 | CFG_VIN2A_FLD0_OUT | vout2_clk |
| G1 | vin2a_hsync0 | 2482 | 0 | 974 | 0 | 936 | 0 | 4021 | 0 | 4891 | 0 | CFG_VIN2A_HSYNC0_OUT | vout2_hsync |

Table 7-21. Manual Functions Mapping for DSS VOUT2 IOSET1 (continued)

| BALL | BALL NAME | VOUT2_IOSET1_ MANUAL1 | | VOUT2_IOSET1_ MANUAL2 | | VOUT2_IOSET1_ MANUAL3 | | VOUT2_IOSET1_ MANUAL4 | | VOUT2_IOSET1_ MANUAL5 | | CFG REGISTER | MUXMODE |
|------|---------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|----------------------|-------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 4 |
| G6 | vin2a_vsync_0 | 2296 | 0 | 784 | 0 | 750 | 0 | 3935 | 0 | 4805 | 0 | CFG_VIN2A_VSYNC0_OUT | vout2_vsync |

Manual IO Timings Modes must be used to ensure some IO timings for VOUT2. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-22 Manual Functions Mapping for DSS VOUT2 IOSET2](#) for a definition of the Manual modes.

[Table 7-22](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-22. Manual Functions Mapping for DSS VOUT2 IOSET2

| BALL | BALL NAME | VOUT2_IOSET2_ MANUAL1 | | VOUT2_IOSET2_ MANUAL2 | | VOUT2_IOSET2_ MANUAL3 | | VOUT2_IOSET2_ MANUAL4 | | VOUT2_IOSET2_ MANUAL5 | | CFG REGISTER | MUXMODE |
|------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|-------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 6 |
| E21 | gpio6_14 | 1983 | 0 | 79 | 0 | 68 | 0 | 3513 | 0 | 4383 | 0 | CFG_GPIO6_14_OUT | vout2_hsync |
| F20 | gpio6_15 | 2159 | 0 | 158 | 0 | 148 | 0 | 3689 | 0 | 4559 | 0 | CFG_GPIO6_15_OUT | vout2_vsync |
| F21 | gpio6_16 | 1864 | 0 | 0 | 0 | 0 | 0 | 3394 | 0 | 4264 | 0 | CFG_GPIO6_16_OUT | vout2_fld |
| B14 | mcasp1_aclkr | 2614 | 0 | 1255 | 0 | 1270 | 0 | 4353 | 0 | 5223 | 0 | CFG_MCASP1_ACLK_R_OUT | vout2_d0 |
| G13 | mcasp1_axr2 | 2705 | 0 | 1350 | 0 | 1360 | 0 | 4444 | 0 | 5314 | 0 | CFG_MCASP1_AXR2_OUT | vout2_d2 |
| J11 | mcasp1_axr3 | 2865 | 0 | 1210 | 0 | 1219 | 0 | 4504 | 0 | 5374 | 0 | CFG_MCASP1_AXR3_OUT | vout2_d3 |
| E12 | mcasp1_axr4 | 2759 | 0 | 1404 | 0 | 1413 | 0 | 4498 | 0 | 5368 | 0 | CFG_MCASP1_AXR4_OUT | vout2_d4 |
| F13 | mcasp1_axr5 | 2980 | 0 | 1325 | 0 | 1335 | 0 | 4419 | 0 | 5289 | 0 | CFG_MCASP1_AXR5_OUT | vout2_d5 |
| C12 | mcasp1_axr6 | 2634 | 0 | 1275 | 0 | 1289 | 0 | 4373 | 0 | 5243 | 0 | CFG_MCASP1_AXR6_OUT | vout2_d6 |
| D12 | mcasp1_axr7 | 2658 | 0 | 1302 | 0 | 1311 | 0 | 4396 | 0 | 5266 | 0 | CFG_MCASP1_AXR7_OUT | vout2_d7 |
| J14 | mcasp1_fsr | 2818 | 0 | 1163 | 0 | 1172 | 0 | 4456 | 0 | 5326 | 0 | CFG_MCASP1_FSR_OUT | vout2_d1 |
| E15 | mcasp2_aclkr | 2728 | 0 | 1373 | 0 | 1382 | 0 | 4367 | 0 | 5237 | 0 | CFG_MCASP2_ACLK_R_OUT | vout2_d8 |
| B15 | mcasp2_axr0 | 2513 | 0 | 319 | 534 | 308 | 560 | 4151 | 0 | 5021 | 0 | CFG_MCASP2_AXR0_OUT | vout2_d10 |

Table 7-22. Manual Functions Mapping for DSS VOUT2 IOSET2 (continued)

| BALL | BALL NAME | VOUT2_IOSET2_ MANUAL1 | | VOUT2_IOSET2_ MANUAL2 | | VOUT2_IOSET2_ MANUAL3 | | VOUT2_IOSET2_ MANUAL4 | | VOUT2_IOSET2_ MANUAL5 | | CFG REGISTER | MUXMODE |
|------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|----------------------|-----------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 6 |
| A15 | mcasp2_axr1 | 2712 | 0 | 1357 | 0 | 1366 | 0 | 4351 | 0 | 5221 | 0 | CFG_MCASP2_AXR1_OUT | vout2_d11 |
| D15 | mcasp2_axr4 | 2529 | 0 | 1169 | 0 | 1184 | 0 | 4267 | 0 | 5137 | 0 | CFG_MCASP2_AXR4_OUT | vout2_d12 |
| B16 | mcasp2_axr5 | 2376 | 0 | 543 | 478 | 1029 | 0 | 4114 | 0 | 4984 | 0 | CFG_MCASP2_AXR5_OUT | vout2_d13 |
| B17 | mcasp2_axr6 | 2620 | 0 | 1265 | 0 | 1274 | 0 | 4359 | 0 | 5229 | 0 | CFG_MCASP2_AXR6_OUT | vout2_d14 |
| A17 | mcasp2_axr7 | 2492 | 0 | 354 | 483 | 845 | 0 | 4130 | 0 | 5000 | 0 | CFG_MCASP2_AXR7_OUT | vout2_d15 |
| A20 | mcasp2_fsr | 2358 | 0 | 12 | 487 | 513 | 0 | 3797 | 0 | 4667 | 0 | CFG_MCASP2_FSR_OUT | vout2_d9 |
| C18 | mcasp4_aclkx | 2524 | 0 | 1165 | 0 | 1179 | 0 | 3863 | 0 | 4733 | 0 | CFG_MCASP4_ACLKX_OUT | vout2_d16 |
| G16 | mcasp4_axr0 | 2578 | 0 | 797 | 0 | 806 | 0 | 4208 | 0 | 5078 | 0 | CFG_MCASP4_AXR0_OUT | vout2_d18 |
| D17 | mcasp4_axr1 | 2253 | 0 | 750 | 0 | 759 | 0 | 3983 | 0 | 4853 | 0 | CFG_MCASP4_AXR1_OUT | vout2_d19 |
| A21 | mcasp4_fsx | 2478 | 0 | 823 | 0 | 832 | 0 | 4117 | 0 | 4987 | 0 | CFG_MCASP4_FSX_OUT | vout2_d17 |
| AA3 | mcasp5_aclkx | 4672 | 1737 | 3256 | 1798 | 3226 | 1837 | 5900 | 1949 | 6770 | 1949 | CFG_MCASP5_ACLKX_OUT | vout2_d20 |
| AB3 | mcasp5_axr0 | 4642 | 1286 | 3226 | 1347 | 3196 | 1386 | 5870 | 1497 | 6740 | 1497 | CFG_MCASP5_AXR0_OUT | vout2_d22 |
| AA4 | mcasp5_axr1 | 4625 | 725 | 3209 | 786 | 3179 | 825 | 6153 | 935 | 7023 | 935 | CFG_MCASP5_AXR1_OUT | vout2_d23 |
| AB9 | mcasp5_fsx | 4565 | 1062 | 3149 | 1123 | 3119 | 1162 | 6093 | 1273 | 6963 | 1273 | CFG_MCASP5_FSX_OUT | vout2_d21 |
| B26 | xref_clk2 | 0 | 49 | 1359 | 466 | 1341 | 512 | 0 | 60 | 0 | 60 | CFG_XREF_CLK2_OUT | vout2_clk |
| C23 | xref_clk3 | 1947 | 0 | 36 | 0 | 45 | 0 | 3378 | 0 | 4248 | 0 | CFG_XREF_CLK3_OUT | vout2_de |

Manual IO Timings Modes must be used to ensure some IO timings for VOUT3. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-23 Manual Functions Mapping for DSS VOUT3](#) for a definition of the Manual modes.

[Table 7-23](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-23. Manual Functions Mapping for DSS VOUT3

| BALL | BALL NAME | VOUT3_MANUAL1 | | VOUT3_MANUAL4 | | VOUT3_MANUAL5 | | CFG REGISTER | MUXMODE 3 |
|------|-----------|---------------|--------------|---------------|--------------|---------------|--------------|-------------------|-----------------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | |
| R6 | gpmc_a0 | 2395 | 0 | 3909 | 0 | 4779 | 0 | CFG_GPMC_A0_OUT | vout3_d16 |
| T9 | gpmc_a1 | 2412 | 0 | 3957 | 0 | 4827 | 0 | CFG_GPMC_A1_OUT | vout3_d17 |
| N9 | gpmc_a10 | 2473 | 0 | 3980 | 0 | 4850 | 0 | CFG_GPMC_A10_OUT | vout3_de |
| P9 | gpmc_a11 | 2906 | 0 | 4253 | 0 | 5123 | 0 | CFG_GPMC_A11_OUT | vout3_fld |
| T6 | gpmc_a2 | 2360 | 0 | 3873 | 0 | 4743 | 0 | CFG_GPMC_A2_OUT | vout3_d18 |
| T7 | gpmc_a3 | 2391 | 0 | 4112 | 0 | 4982 | 0 | CFG_GPMC_A3_OUT | vout3_d19 |
| P6 | gpmc_a4 | 2626 | 0 | 4336 | 0 | 5206 | 0 | CFG_GPMC_A4_OUT | vout3_d20 |
| R9 | gpmc_a5 | 2338 | 0 | 3840 | 0 | 4710 | 0 | CFG_GPMC_A5_OUT | vout3_d21 |
| R5 | gpmc_a6 | 2374 | 0 | 3913 | 0 | 4783 | 0 | CFG_GPMC_A6_OUT | vout3_d22 |
| P5 | gpmc_a7 | 2432 | 0 | 3947 | 0 | 4817 | 0 | CFG_GPMC_A7_OUT | vout3_d23 |
| N7 | gpmc_a8 | 3155 | 0 | 4309 | 105 | 5179 | 105 | CFG_GPMC_A8_OUT | vout3_hsyn c |
| R4 | gpmc_a9 | 2309 | 0 | 3842 | 0 | 4712 | 0 | CFG_GPMC_A9_OUT | vout3_vsyn c |
| M6 | gpmc_ad0 | 2360 | 0 | 3652 | 0 | 4522 | 0 | CFG_GPMC_AD0_OUT | vout3_d0 |
| M2 | gpmc_ad1 | 2420 | 0 | 3762 | 0 | 4632 | 0 | CFG_GPMC_AD1_OUT | vout3_d1 |
| J1 | gpmc_ad10 | 2235 | 0 | 3456 | 0 | 4326 | 0 | CFG_GPMC_AD10_OUT | vout3_d10 |
| J2 | gpmc_ad11 | 2253 | 0 | 3584 | 0 | 4454 | 0 | CFG_GPMC_AD11_OUT | vout3_d11 |
| H1 | gpmc_ad12 | 1949 | 427 | 3589 | 0 | 4459 | 0 | CFG_GPMC_AD12_OUT | vout3_d12 |
| J3 | gpmc_ad13 | 2318 | 0 | 3547 | 0 | 4417 | 0 | CFG_GPMC_AD13_OUT | vout3_d13 |
| H2 | gpmc_ad14 | 2123 | 0 | 3302 | 0 | 4172 | 0 | CFG_GPMC_AD14_OUT | vout3_d14 |
| H3 | gpmc_ad15 | 2195 | 29 | 3532 | 0 | 4402 | 0 | CFG_GPMC_AD15_OUT | vout3_d15 |
| L5 | gpmc_ad2 | 2617 | 0 | 3859 | 0 | 4729 | 0 | CFG_GPMC_AD2_OUT | vout3_d2 |
| M1 | gpmc_ad3 | 2350 | 0 | 3590 | 0 | 4460 | 0 | CFG_GPMC_AD3_OUT | vout3_d3 |
| L6 | gpmc_ad4 | 2324 | 0 | 3534 | 0 | 4404 | 0 | CFG_GPMC_AD4_OUT | vout3_d4 |
| L4 | gpmc_ad5 | 2371 | 0 | 3609 | 0 | 4479 | 0 | CFG_GPMC_AD5_OUT | vout3_d5 |
| L3 | gpmc_ad6 | 2231 | 0 | 3416 | 0 | 4286 | 0 | CFG_GPMC_AD6_OUT | vout3_d6 |
| L2 | gpmc_ad7 | 2440 | 0 | 3661 | 0 | 4531 | 0 | CFG_GPMC_AD7_OUT | vout3_d7 |
| L1 | gpmc_ad8 | 2479 | 0 | 3714 | 0 | 4584 | 0 | CFG_GPMC_AD8_OUT | vout3_d8 |
| K2 | gpmc_ad9 | 2355 | 0 | 3593 | 0 | 4463 | 0 | CFG_GPMC_AD9_OUT | vout3_d9 |
| P1 | gpmc_cs3 | 0 | 641 | 0 | 905 | 0 | 905 | CFG_GPMC_CS3_OUT | vout3_clk |

7.8 Display Subsystem - High-Definition Multimedia Interface (HDMI)

The High-Definition Multimedia Interface is provided for transmitting digital television audiovisual signals from DVD players, set-top boxes and other audiovisual sources to television sets, projectors and other video displays. The HDMI interface is aligned with the HDMI TMDS single stream standard v1.4a (720p @60Hz to 1080p @24Hz) and the HDMI v1.3 (1080p @60Hz): 3 data channels, plus 1 clock channel is supported (differential).

NOTE

For more information, see *High-Definition Multimedia Interface* section in the device TRM

7.9 Camera Serial Interface 2 CAL bridge (CSI2)

NOTE

For more information, see *Camera Interface Subsystem* chapter in the device TRM

The camera adaptation layer (CAL) deals with the processing of the pixel data coming from an external image sensor, data from memory. The CAL is a key component for the following multimedia applications: camera viewfinder, video record, and still image capture. The CAL has two serial camera interfaces (primary and secondary):

- The primary serial interface (CSI2 Port A) is compliant with MIPI CSI-2 protocol with four data lanes.
- The secondary serial interface (CSI2 Port B) is compliant with MIPI CSI-2 protocol with two data lanes.

7.9.1 CSI-2 MIPI D-PHY

The CSI-2 port A is compliant with the MIPI D-PHY RX specification v1.00.00 and the MIPI CSI-2 specification v1.00, with 4 data differential lanes plus 1 clock differential lane in synchronous mode, double data rate:

- 1.5 Gbps (750 MHz) @OPP_NOM for each lane.

The CSI-2 port B is compliant with the MIPI D-PHY RX specification v1.00.00 and the MIPI CSI-2 specification v1.00, with 2 data lanes plus 1 clock lane (differential) in synchronous mode, double data rate:

- 1.5 Gbps (750 MHz) @OPP_NOM for each lane, in synchronous mode.

7.10 External Memory Interface (EMIF)

The device has a dedicated interface to DDR3 and DDR3L SDRAM. It supports JEDEC standard compliant DDR3 and DDR3L SDRAM devices with the following features:

- 16-bit or 32-bit data path to external SDRAM memory
- Memory device capacity: 128Mb, 256Mb, 512Mb, 1Gb, 2Gb, 4Gb and 8Gb devices
- One interface with associated DDR3/DDR3L PHYs

NOTE

For more information, see *EMIF Controller* section in the device TRM.

7.11 General-Purpose Memory Controller (GPMC)

The GPMC is the unified memory controller that interfaces external memory devices such as:

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

NOTE

For more information, see *General-Purpose Memory Controller* section in the device TRM.

7.11.1 GPMC/NOR Flash Interface Synchronous Timing

CAUTION

The I/O Timings provided in this section are valid only for some GPMC usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

Table 7-24 and Table 7-25 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 7-7, Figure 7-8, Figure 7-9, Figure 7-10, Figure 7-11 and Figure 7-12).

Table 7-24. GPMC/NOR Flash Interface Timing Requirements - Synchronous Mode - Default

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|----------------------|---|-----|-----|------|
| F12 | $t_{su(dV-clkH)}$ | Setup time, read gpmc_ad[15:0] valid before gpmc_clk high | 3 | | ns |
| F13 | $t_{h(clkH-dV)}$ | Hold time, read gpmc_ad[15:0] valid after gpmc_clk high | 1.1 | | ns |
| F21 | $t_{su(waitV-clkH)}$ | Setup time, gpmc_wait[1:0] valid before gpmc_clk high | 2.5 | | ns |
| F22 | $t_{h(clkH-waitV)}$ | Hold Time, gpmc_wait[1:0] valid after gpmc_clk high | 1.3 | | ns |

NOTE

Wait monitoring support is limited to a WaitMonitoringTime value > 0. For a full description of wait monitoring feature, see the Device TRM.

Table 7-25. GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Default

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|----------------------|---|-------------------------|-------------------------|------|
| F0 | $t_{c(clk)}$ | Cycle time, output clock gpmc_clk period | 11.3 | | ns |
| F2 | $t_{d(clkH-nCSV)}$ | Delay time, gpmc_clk rising edge to gpmc_cs[7:0] transition | F - 1.7 ⁽⁷⁾ | F + 4.3 ⁽⁷⁾ | ns |
| F3 | $t_{d(clkH-nCSIV)}$ | Delay time, gpmc_clk rising edge to gpmc_cs[7:0] invalid | E - 1.7 ⁽⁶⁾ | E + 4.2 ⁽⁶⁾ | ns |
| F4 | $t_{d(ADDV-clk)}$ | Delay time, gpmc_a[27:0] address bus valid to gpmc_clk first edge | B - 1.8 ⁽³⁾ | B + 4.3 ⁽³⁾ | ns |
| F5 | $t_{d(clkH-ADDIV)}$ | Delay time, gpmc_clk rising edge to gpmc_a[27:0] gpmc address bus invalid | -1.8 | | ns |
| F6 | $t_{d(nBEV-clk)}$ | Delay time, gpmc_ben[1:0] valid to gpmc_clk rising edge | B - 4.3 ⁽³⁾ | B + 1.5 ⁽³⁾ | ns |
| F7 | $t_{d(clkH-nBEIV)}$ | Delay time, gpmc_clk rising edge to gpmc_ben[1:0] invalid | D - 1.5 ⁽⁵⁾ | D + 4.3 ⁽⁵⁾ | ns |
| F8 | $t_{d(clkH-nADV)}$ | Delay time, gpmc_clk rising edge to gpmc_advn_ale transition | G - 1.3 ⁽⁸⁾ | G + 4.2 ⁽⁸⁾ | ns |
| F9 | $t_{d(clkH-nADVIV)}$ | Delay time, gpmc_clk rising edge to gpmc_advn_ale invalid | D - 1.3 ⁽⁵⁾ | G + 4.2 ⁽⁵⁾ | ns |
| F10 | $t_{d(clkH-nOE)}$ | Delay time, gpmc_clk rising edge to gpmc_oen_ren transition | H - 1.0 ⁽⁹⁾ | H + 3.2 ⁽⁹⁾ | ns |
| F11 | $t_{d(clkH-nOEIV)}$ | Delay time, gpmc_clk rising edge to gpmc_oen_ren invalid | E - 1.0 ⁽⁶⁾ | E + 3.2 ⁽⁶⁾ | ns |
| F14 | $t_{d(clkH-nWE)}$ | Delay time, gpmc_clk rising edge to gpmc_wen transition | I - 0.9 ⁽¹⁰⁾ | I + 4.2 ⁽¹⁰⁾ | ns |
| F15 | $t_{d(clkH-Data)}$ | Delay time, gpmc_clk rising edge to gpmc_ad[15:0] data bus transition | J - 2.1 ⁽¹¹⁾ | J + 4.6 ⁽¹¹⁾ | ns |
| F17 | $t_{d(clkH-nBE)}$ | Delay time, gpmc_clk rising edge to gpmc_ben[1:0] transition | J - 1.5 ⁽¹¹⁾ | J + 4.3 ⁽¹¹⁾ | ns |
| F18 | $t_{w(nCSV)}$ | Pulse duration, gpmc_cs[7:0] low | A ⁽²⁾ | | ns |
| F19 | $t_{w(nBEV)}$ | Pulse duration, gpmc_ben[1:0] low | C ⁽⁴⁾ | | ns |

Table 7-25. GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Default (continued)

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|-------------------|--|-------------------|-----|------|
| F20 | $t_{w(nADV)}$ | Pulse duration, gpmc_advn_ale low | K ⁽¹²⁾ | | ns |
| F23 | $t_{d(CLK-GPIO)}$ | Delay time, gpmc_clk transition to gpio6_16 transition ⁽¹⁴⁾ | 0.5 | 7.5 | ns |

Table 7-26. GPMC/NOR Flash Interface Timing Requirements - Synchronous Mode - Alternate

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|----------------------|---|-----|-----|------|
| F12 | $t_{su(dV-clkH)}$ | Setup time, read gpmc_ad[15:0] valid before gpmc_clk high | 2.9 | | ns |
| F13 | $t_{h(clkH-dV)}$ | Hold time, read gpmc_ad[15:0] valid after gpmc_clk high | 2 | | ns |
| F21 | $t_{su(waitV-clkH)}$ | Setup time, gpmc_wait[1:0] valid before gpmc_clk high | 2.5 | | ns |
| F22 | $t_{h(clkH-waitV)}$ | Hold Time, gpmc_wait[1:0] valid after gpmc_clk high | 2.1 | | ns |

Table 7-27. GPMC/NOR Flash Interface Switching Characteristics - Synchronous Mode - Alternate

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|----------------------|--|-------------------------|-------------------------|------|
| F0 | $t_{c(clk)}$ | Cycle time, output clock gpmc_clk period ⁽¹³⁾ | 15.04 | | ns |
| F2 | $t_{d(clkH-nCSV)}$ | Delay time, gpmc_clk rising edge to gpmc_cs[7:0] transition | F + 0.6 ⁽⁷⁾ | F + 7.0 ⁽⁷⁾ | ns |
| F3 | $t_{d(clkH-nCSIV)}$ | Delay time, gpmc_clk rising edge to gpmc_cs[7:0] invalid | E + 0.6 ⁽⁶⁾ | E + 7.0 ⁽⁶⁾ | ns |
| F4 | $t_{d(ADDV-clk)}$ | Delay time, gpmc_a[27:0] address bus valid to gpmc_clk first edge | B - 0.7 ⁽³⁾ | B + 7.0 ⁽³⁾ | ns |
| F5 | $t_{d(clkH-ADDIV)}$ | Delay time, gpmc_clk rising edge to gpmc_a[27:0] gpmc address bus invalid | -0.7 | | ns |
| F6 | $t_{d(nBEV-clk)}$ | Delay time, gpmc_ben[1:0] valid to gpmc_clk rising edge | B - 7.0 | B + 0.4 | ns |
| F7 | $t_{d(clkH-nBEIV)}$ | Delay time, gpmc_clk rising edge to gpmc_ben[1:0] invalid | D - 0.4 | D + 7.0 | ns |
| F8 | $t_{d(clkH-nADV)}$ | Delay time, gpmc_clk rising edge to gpmc_advn_ale transition | G + 0.7 ⁽⁸⁾ | G + 6.1 ⁽⁸⁾ | ns |
| F9 | $t_{d(clkH-nADVIV)}$ | Delay time, gpmc_clk rising edge to gpmc_advn_ale invalid | D + 0.7 ⁽⁵⁾ | D + 6.1 ⁽⁵⁾ | ns |
| F10 | $t_{d(clkH-nOE)}$ | Delay time, gpmc_clk rising edge to gpmc_oen_ren transition | H + 0.7 ⁽⁹⁾ | H + 5.1 ⁽⁹⁾ | ns |
| F11 | $t_{d(clkH-nOEIV)}$ | Delay time, gpmc_clk rising edge to gpmc_oen_ren invalid | E + 0.7 ⁽⁶⁾ | E + 5.1 ⁽⁶⁾ | ns |
| F14 | $t_{d(clkH-nWE)}$ | Delay time, gpmc_clk rising edge to gpmc_wen transition | I + 0.7 ⁽¹⁰⁾ | I + 6.1 ⁽¹⁰⁾ | ns |
| F15 | $t_{d(clkH-Data)}$ | Delay time, gpmc_clk rising edge to gpmc_ad[15:0] data bus transition | J - 0.4 ⁽¹¹⁾ | J + 4.9 ⁽¹¹⁾ | ns |
| F17 | $t_{d(clkH-nBE)}$ | Delay time, gpmc_clk rising edge to gpmc_ben[1:0] transition | J - 0.4 ⁽¹¹⁾ | J + 4.9 ⁽¹¹⁾ | ns |
| F18 | $t_{w(nCSV)}$ | Pulse duration, gpmc_cs[7:0] low | A ⁽²⁾ | | ns |
| F19 | $t_{w(nBEV)}$ | Pulse duration, gpmc_ben[1:0] low | C ⁽⁴⁾ | | ns |
| F20 | $t_{w(nADV)}$ | Pulse duration, gpmc_advn_ale low | K ⁽¹²⁾ | | ns |
| F23 | $t_{d(CLK-GPIO)}$ | Delay time, gpmc_clk transition to gpio6_16.clkout1 transition ⁽¹⁴⁾ | 0.5 | 7.5 | ns |

(1) Total GPMC load on any signal at 3.3V must not exceed 10pF.

(2) For single read: $A = (CSRdOffTime - CSOnTime) \times (TimeParaGranularity + 1) \times GPMC_FCLK$ period
 For burst read: $A = (CSRdOffTime - CSOnTime + (n - 1) \times PageBurstAccessTime) \times (TimeParaGranularity + 1) \times GPMC_FCLK$ period
 For burst write: $A = (CSWrOffTime - CSOnTime + (n - 1) \times PageBurstAccessTime) \times (TimeParaGranularity + 1) \times GPMC_FCLK$ period
 with n the page burst access number.

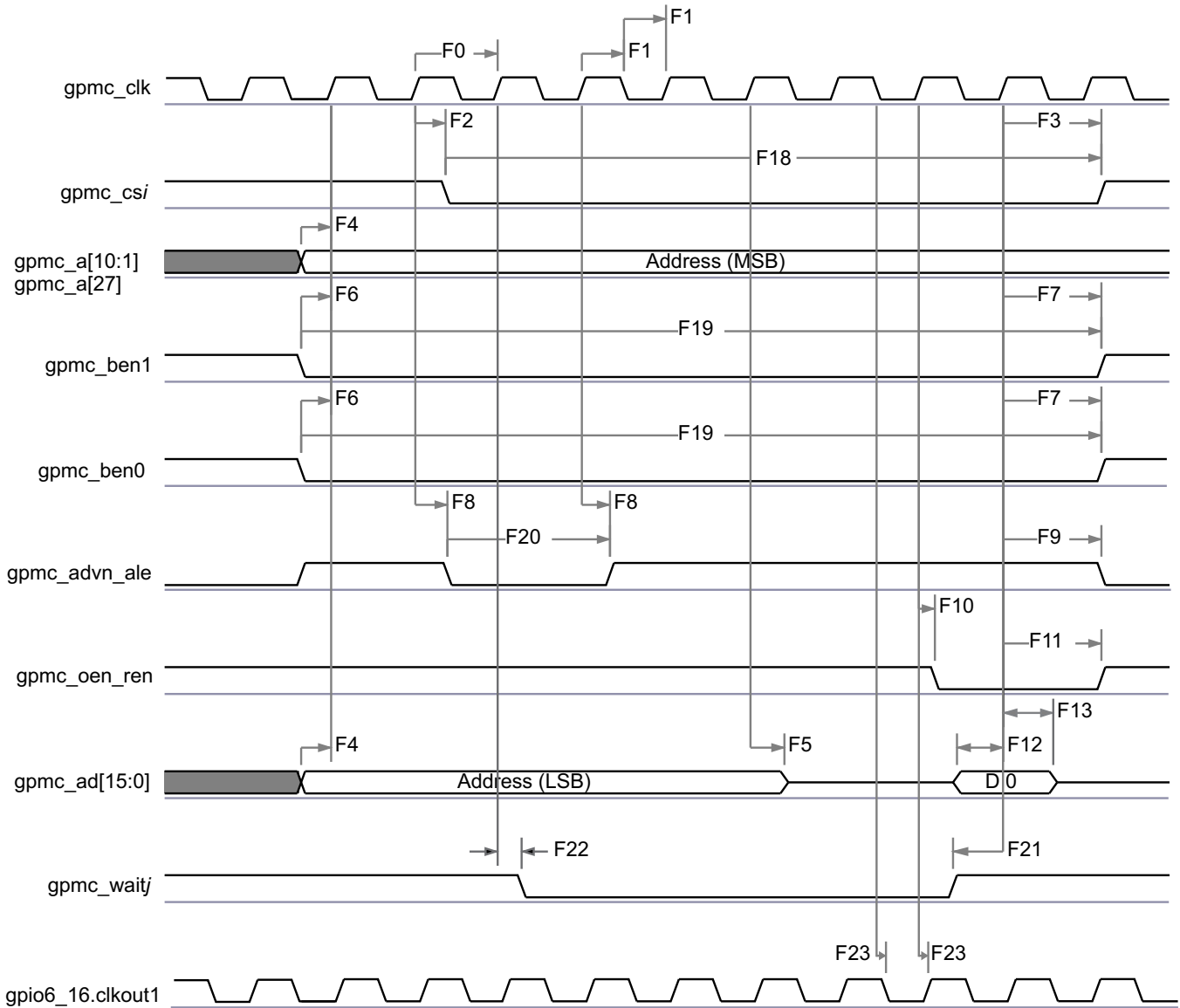
(3) $B = ClkActivationTime \times GPMC_FCLK$

(4) For single read: $C = RdCycleTime \times (TimeParaGranularity + 1) \times GPMC_FCLK$
 For burst read: $C = (RdCycleTime + (n - 1) \times PageBurstAccessTime) \times (TimeParaGranularity + 1) \times GPMC_FCLK$
 For Burst write: $C = (WrCycleTime + (n - 1) \times PageBurstAccessTime) \times (TimeParaGranularity + 1) \times GPMC_FCLK$ with n the page burst

access number.

- (5) For single read: $D = (\text{RdCycleTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC_FCLK}$
For burst read: $D = (\text{RdCycleTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC_FCLK}$
For burst write: $D = (\text{WrCycleTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC_FCLK}$
- (6) For single read: $E = (\text{CSRdOffTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC_FCLK}$
For burst read: $E = (\text{CSRdOffTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC_FCLK}$
For burst write: $E = (\text{CSWrOffTime} - \text{AccessTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC_FCLK}$
- (7) For nCS falling edge (CS activated):
Case GpmcFCLKDivider = 0 :
 $F = 0.5 \times \text{CSExtraDelay} \times \text{GPMC_FCLK}$
Case GpmcFCLKDivider = 1:
 $F = 0.5 \times \text{CSExtraDelay} \times \text{GPMC_FCLK}$ if (ClkActivationTime and CSOnTime are odd) or (ClkActivationTime and CSOnTime are even)
 $F = (1 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC_FCLK}$ otherwise
Case GpmcFCLKDivider = 2:
 $F = 0.5 \times \text{CSExtraDelay} \times \text{GPMC_FCLK}$ if ((CSOnTime - ClkActivationTime) is a multiple of 3)
 $F = (1 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC_FCLK}$ if ((CSOnTime - ClkActivationTime - 1) is a multiple of 3)
 $F = (2 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC_FCLK}$ if ((CSOnTime - ClkActivationTime - 2) is a multiple of 3)
Case GpmcFCLKDivider = 3:
 $F = 0.5 \times \text{CSExtraDelay} \times \text{GPMC_FCLK}$ if ((CSOnTime - ClkActivationTime) is a multiple of 4)
 $F = (1 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC_FCLK}$ if ((CSOnTime - ClkActivationTime - 1) is a multiple of 4)
 $F = (2 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC_FCLK}$ if ((CSOnTime - ClkActivationTime - 2) is a multiple of 4)
 $F = (3 + 0.5 \times \text{CSExtraDelay}) \times \text{GPMC_FCLK}$ if ((CSOnTime - ClkActivationTime - 3) is a multiple of 4)
- (8) For ADV falling edge (ADV activated):
Case GpmcFCLKDivider = 0 :
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$
Case GpmcFCLKDivider = 1:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$ if (ClkActivationTime and ADVOnTime are odd) or (ClkActivationTime and ADVOnTime are even)
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ otherwise
Case GpmcFCLKDivider = 2:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$ if ((ADVOnTime - ClkActivationTime) is a multiple of 3)
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVOnTime - ClkActivationTime - 1) is a multiple of 3)
 $G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVOnTime - ClkActivationTime - 2) is a multiple of 3)
For ADV rising edge (ADV deactivated) in Reading mode:
Case GpmcFCLKDivider = 0:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$
Case GpmcFCLKDivider = 1:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$ if (ClkActivationTime and ADVRdOffTime are odd) or (ClkActivationTime and ADVRdOffTime are even)
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ otherwise
Case GpmcFCLKDivider = 2:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$ if ((ADVRdOffTime - ClkActivationTime) is a multiple of 3)
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVRdOffTime - ClkActivationTime - 1) is a multiple of 3)
 $G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVRdOffTime - ClkActivationTime - 2) is a multiple of 3)
Case GpmcFCLKDivider = 3:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$ if ((ADVRdOffTime - ClkActivationTime) is a multiple of 4)
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVRdOffTime - ClkActivationTime - 1) is a multiple of 4)
 $G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVRdOffTime - ClkActivationTime - 2) is a multiple of 4)
 $G = (3 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVRdOffTime - ClkActivationTime - 3) is a multiple of 4)
For ADV rising edge (ADV deactivated) in Writing mode:
Case GpmcFCLKDivider = 0:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$
Case GpmcFCLKDivider = 1:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$ if (ClkActivationTime and ADVWrOffTime are odd) or (ClkActivationTime and ADVWrOffTime are even)
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ otherwise
Case GpmcFCLKDivider = 2:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$ if ((ADVWrOffTime - ClkActivationTime) is a multiple of 3)
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVWrOffTime - ClkActivationTime - 1) is a multiple of 3)
 $G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVWrOffTime - ClkActivationTime - 2) is a multiple of 3)
Case GpmcFCLKDivider = 3:
 $G = 0.5 \times \text{ADVExtraDelay} \times \text{GPMC_FCLK}$ if ((ADVWrOffTime - ClkActivationTime) is a multiple of 4)
 $G = (1 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVWrOffTime - ClkActivationTime - 1) is a multiple of 4)
 $G = (2 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVWrOffTime - ClkActivationTime - 2) is a multiple of 4)
 $G = (3 + 0.5 \times \text{ADVExtraDelay}) \times \text{GPMC_FCLK}$ if ((ADVWrOffTime - ClkActivationTime - 3) is a multiple of 4)
- (9) For OE falling edge (OE activated):
Case GpmcFCLKDivider = 0:
- $H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC_FCLK}$
Case GpmcFCLKDivider = 1:
- $H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC_FCLK}$ if (ClkActivationTime and OEOnTime are odd) or (ClkActivationTime and OEOnTime are even)

- $H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ otherwise
Case GpmcFCLKDivider = 2:
- $H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC_FCLK}$ if $((\text{OEOnTime} - \text{ClkActivationTime})$ is a multiple of 3)
- $H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOnTime} - \text{ClkActivationTime} - 1)$ is a multiple of 3)
- $H = (2 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOnTime} - \text{ClkActivationTime} - 2)$ is a multiple of 3)
Case GpmcFCLKDivider = 3:
- $H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC_FCLK}$ if $((\text{OEOnTime} - \text{ClkActivationTime})$ is a multiple of 4)
- $H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOnTime} - \text{ClkActivationTime} - 1)$ is a multiple of 4)
- $H = (2 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOnTime} - \text{ClkActivationTime} - 2)$ is a multiple of 4)
- $H = (3 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOnTime} - \text{ClkActivationTime} - 3)$ is a multiple of 4)
For OE rising edge (OE desactivated):
Case GpmcFCLKDivider = 0:
- $H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC_FCLK}$
Case GpmcFCLKDivider = 1:
- $H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC_FCLK}$ if (ClkActivationTime and OEOffTime are odd) or (ClkActivationTime and OEOffTime are even)
- $H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ otherwise
Case GpmcFCLKDivider = 2:
- $H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC_FCLK}$ if $((\text{OEOffTime} - \text{ClkActivationTime})$ is a multiple of 3)
- $H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOffTime} - \text{ClkActivationTime} - 1)$ is a multiple of 3)
- $H = (2 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOffTime} - \text{ClkActivationTime} - 2)$ is a multiple of 3)
Case GpmcFCLKDivider = 3:
- $H = 0.5 \times \text{OEEExtraDelay} \times \text{GPMC_FCLK}$ if $((\text{OEOffTime} - \text{ClkActivationTime})$ is a multiple of 4)
- $H = (1 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOffTime} - \text{ClkActivationTime} - 1)$ is a multiple of 4)
- $H = (2 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOffTime} - \text{ClkActivationTime} - 2)$ is a multiple of 4)
- $H = (3 + 0.5 \times \text{OEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{OEOffTime} - \text{ClkActivationTime} - 3)$ is a multiple of 4)
- (10) For WE falling edge (WE activated):
Case GpmcFCLKDivider = 0:
- $I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC_FCLK}$
Case GpmcFCLKDivider = 1:
- $I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC_FCLK}$ if (ClkActivationTime and WEOnTime are odd) or (ClkActivationTime and WEOnTime are even)
- $I = (1 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ otherwise
Case GpmcFCLKDivider = 2:
- $I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC_FCLK}$ if $((\text{WEOnTime} - \text{ClkActivationTime})$ is a multiple of 3)
- $I = (1 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOnTime} - \text{ClkActivationTime} - 1)$ is a multiple of 3)
- $I = (2 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOnTime} - \text{ClkActivationTime} - 2)$ is a multiple of 3)
Case GpmcFCLKDivider = 3:
- $I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC_FCLK}$ if $((\text{WEOnTime} - \text{ClkActivationTime})$ is a multiple of 4)
- $I = (1 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOnTime} - \text{ClkActivationTime} - 1)$ is a multiple of 4)
- $I = (2 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOnTime} - \text{ClkActivationTime} - 2)$ is a multiple of 4)
- $I = (3 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOnTime} - \text{ClkActivationTime} - 3)$ is a multiple of 4)
For WE rising edge (WE desactivated):
Case GpmcFCLKDivider = 0:
- $I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC_FCLK}$
Case GpmcFCLKDivider = 1:
- $I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC_FCLK}$ if (ClkActivationTime and WEOffTime are odd) or (ClkActivationTime and WEOffTime are even)
- $I = (1 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ otherwise
Case GpmcFCLKDivider = 2:
- $I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC_FCLK}$ if $((\text{WEOffTime} - \text{ClkActivationTime})$ is a multiple of 3)
- $I = (1 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOffTime} - \text{ClkActivationTime} - 1)$ is a multiple of 3)
- $I = (2 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOffTime} - \text{ClkActivationTime} - 2)$ is a multiple of 3)
Case GpmcFCLKDivider = 3:
- $I = 0.5 \times \text{WEEExtraDelay} \times \text{GPMC_FCLK}$ if $((\text{WEOffTime} - \text{ClkActivationTime})$ is a multiple of 4)
- $I = (1 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOffTime} - \text{ClkActivationTime} - 1)$ is a multiple of 4)
- $I = (2 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOffTime} - \text{ClkActivationTime} - 2)$ is a multiple of 4)
- $I = (3 + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$ if $((\text{WEOffTime} - \text{ClkActivationTime} - 3)$ is a multiple of 4)
- (11) $J = \text{GPMC_FCLK}$ period, where GPMC_FCLK is the General Purpose Memory Controller internal functional clock
- (12) For read:
 $K = (\text{ADVRdOffTime} - \text{ADVOnTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC_FCLK}$
For write: $K = (\text{ADVWOffTime} - \text{ADVOnTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC_FCLK}$
- (13) The gpmc_clk output clock maximum and minimum frequency is programmable in the I/F module by setting the GPMC_CONFIG1_CSx configuration register bit fields GpmcFCLKDivider
- (14) gpio6_16 programmed to MUXMODE=9 (clkout1), CM_CLKSEL_CLKOUTMUX1 programmed to 7 (CORE_DPLL_OUT_DCLK), CM_CLKSEL_CORE_DPLL_OUT_CLK_CLKOUTMUX programmed to 1.
- (15) CSEXTRADelay = 0, ADVEXTRADelay = 0, WEEXTRADelay = 0, OEEXTRADelay = 0. Extra half-GPMC_FCLK cycle delay mode is not timed.

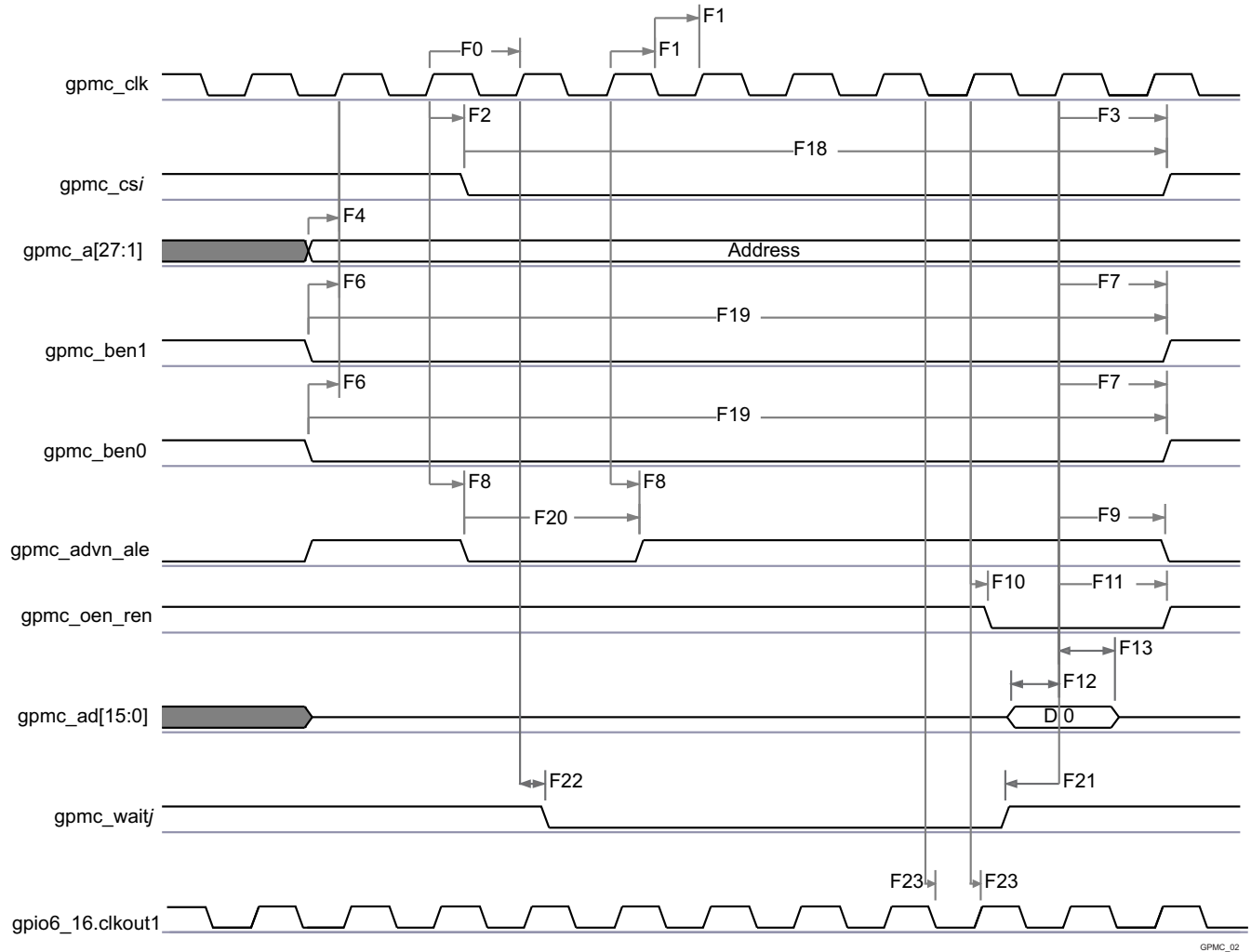


GPMC_01

Figure 7-7. GPMC / Multiplexed 16bits NOR Flash - Synchronous Single Read - (GpmcFCLKDivider = 0)⁽¹⁾⁽²⁾

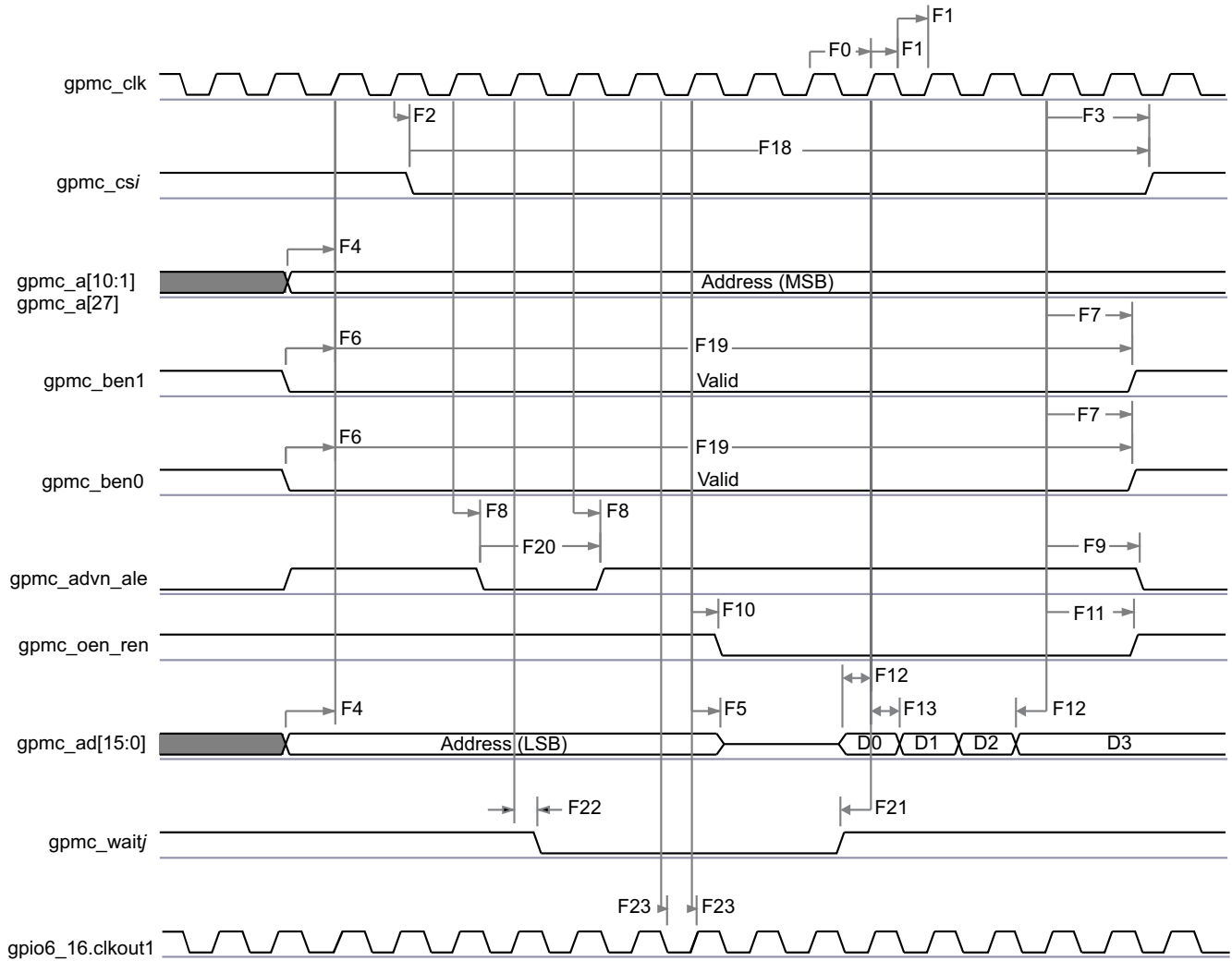
(1) In gpmc_csi, i = 0 to 7.

(2) In gpmc_waitj, j = 0 to 1.



**Figure 7-8. GPMC / Nonmultiplexed 16bits NOR Flash - Synchronous Single Read -
(GpmcFCLKDivider = 0)⁽¹⁾⁽²⁾**

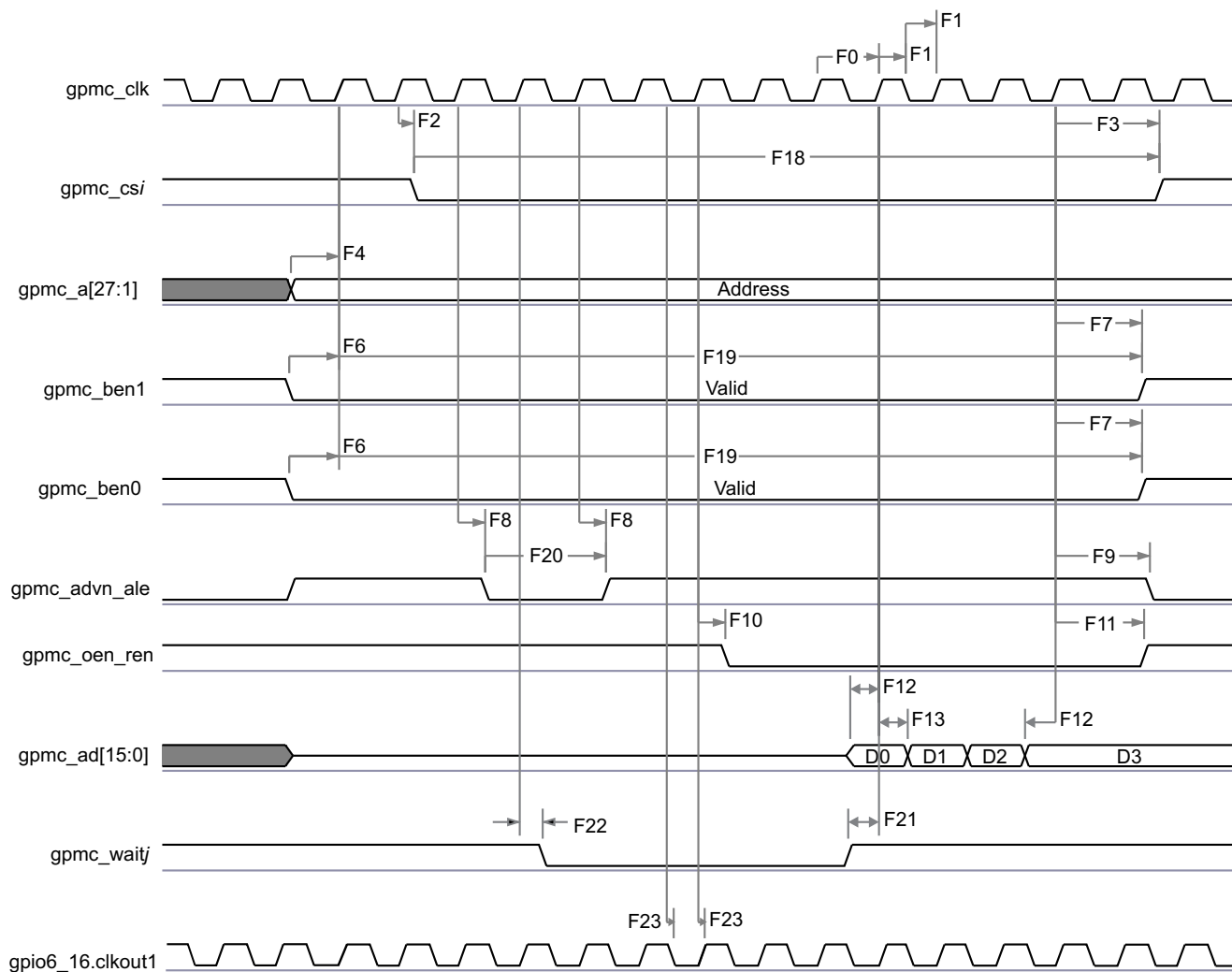
- (1) In gpmc_csi, i = 0 to 7.
- (2) In gpmc_waitj, j = 0 to 1.



GPMC_03

Figure 7-9. GPMC / Multiplexed 16bits NOR Flash - Synchronous Burst Read 4x16 bits - (GpmcFCLKDivider = 0)⁽¹⁾⁽²⁾

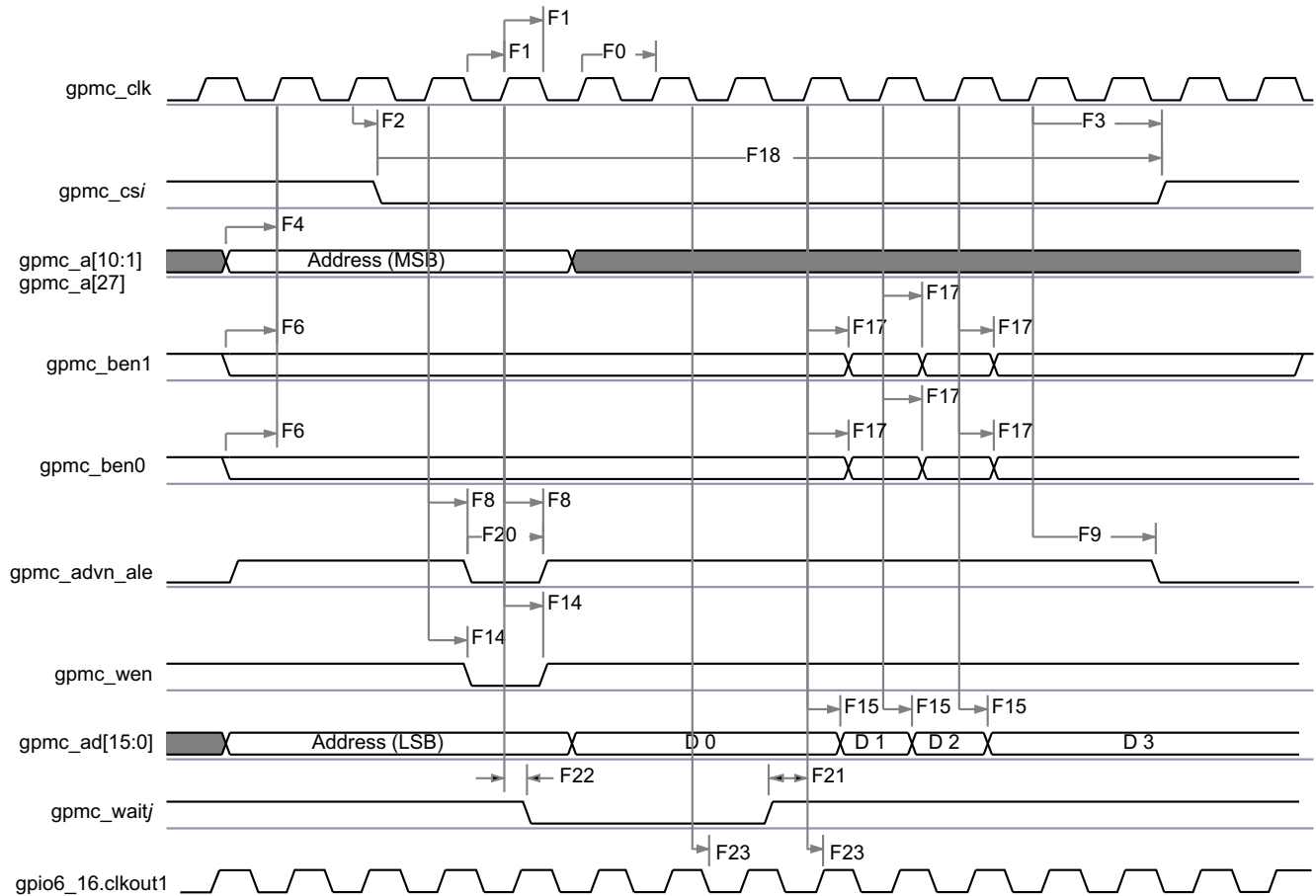
- (1) In gpmc_csi, i= 0 to 7.
- (2) In gpmc_waitj, j = 0 to 1.



GPMC_04

Figure 7-10. GPMC / Nonmultiplexed 16bits NOR Flash - Synchronous Burst Read 4x16 bits - (GpmcFCLKDivider = 0)⁽¹⁾⁽²⁾

- (1) In gpmc_csi, i = 0 to 7.
- (2) In gpmc_waitj, j = 0 to 1.



GPMC_05

Figure 7-11. GPMC / Multiplexed 16bits NOR Flash - Synchronous Burst Write 4x16bits - (GpmcFCLKDivider = 0)⁽¹⁾⁽²⁾

- (1) In “gpmc_csi”, i = 0 to 7.
- (2) In “gpmc_waitj”, j = 0 to 1.

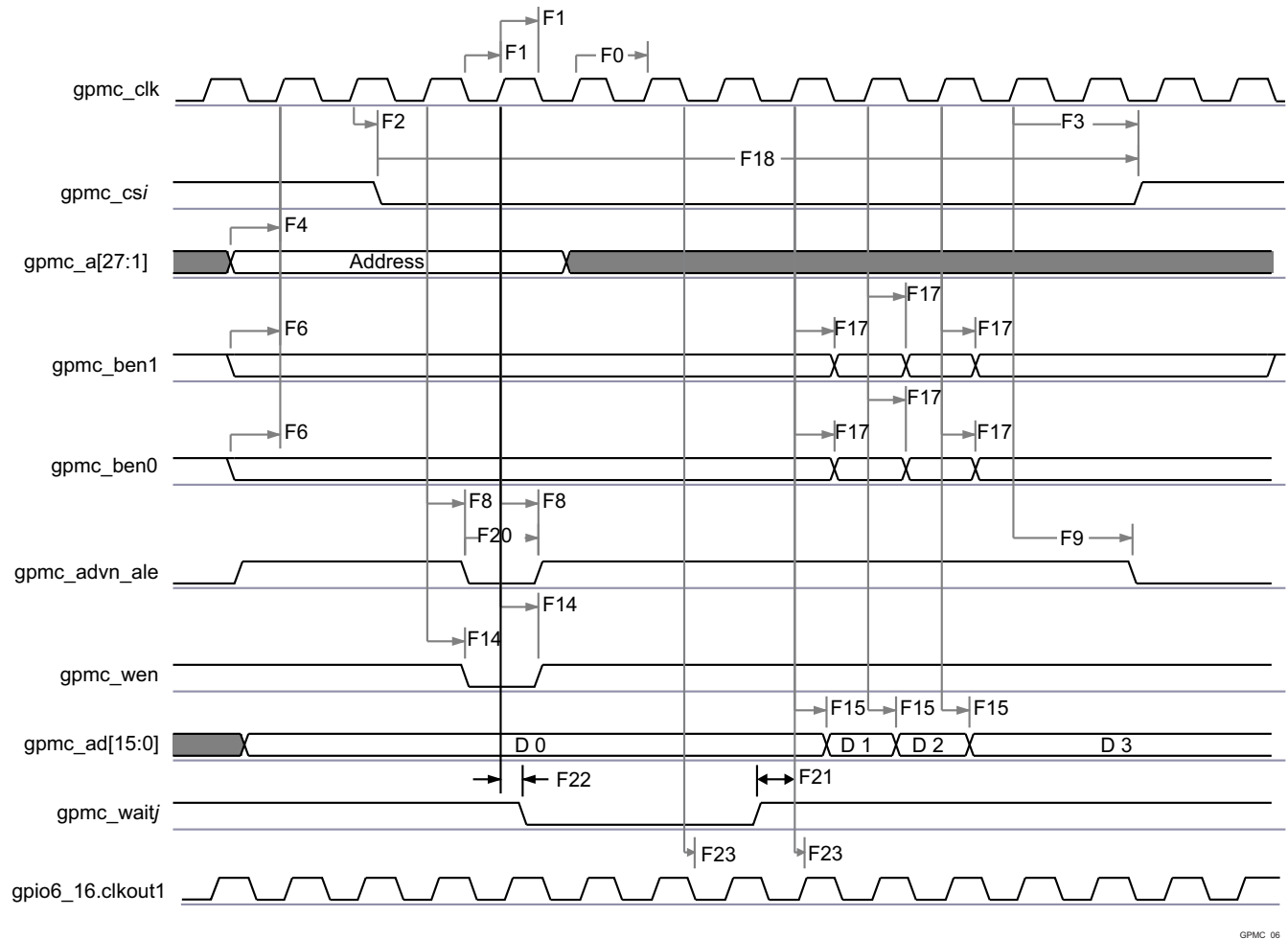


Figure 7-12. GPMC / Nonmultiplexed 16bits NOR Flash - Synchronous Burst Write 4x16bits - (GpmcFCLKDivider = 0)⁽¹⁾⁽²⁾

- (1) In “gpmc_csi”, i = 1 to 7.
- (2) In “gpmc_waitj”, j = 0 to 1.

7.11.2 GPMC/NOR Flash Interface Asynchronous Timing

CAUTION

The I/O Timings provided in this section are valid only for some GPMC usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

Table 7-28 and Table 7-29 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 7-13, Figure 7-14, Figure 7-15, Figure 7-16, Figure 7-17 and Figure 7-18).

Table 7-28. GPMC/NOR Flash Interface Timing Requirements - Asynchronous Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|-----------------------|---|-----|------------------|--------|
| FA5 | t _{acc(DAT)} | Data Maximum Access Time (GPMC_FCLK cycles) | | H ⁽¹⁾ | cycles |

Table 7-28. GPMC/NOR Flash Interface Timing Requirements - Asynchronous Mode (continued)

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|------|------------------------|--|-----|------------------|--------|
| FA20 | $t_{acc1-pgmode}(DAT)$ | Page Mode Successive Data Maximum Access Time (GPMC_FCLK cycles) | | P ⁽²⁾ | cycles |
| FA21 | $t_{acc2-pgmode}(DAT)$ | Page Mode First Data Maximum Access Time (GPMC_FCLK cycles) | | H ⁽¹⁾ | cycles |
| - | $t_{su}(DV-OEH)$ | Setup time, read gpmc_ad[15:0] valid before gpmc_oen_ren high | 1.9 | | ns |
| - | $t_h(OEH-DV)$ | Hold time, read gpmc_ad[15:0] valid after gpmc_oen_ren high | 1 | | ns |

(1) H = Access Time × (TimeParaGranularity + 1)

(2) P = PageBurstAccessTime × (TimeParaGranularity + 1)

Table 7-29. GPMC/NOR Flash Interface Switching Characteristics - Asynchronous Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|------|--------------------|---|-----------------------|-----------------------|------|
| - | $t_r(DO)$ | Rising time, gpmc_ad[15:0] output data | 0.447 | 4.067 | ns |
| - | $t_f(DO)$ | Falling time, gpmc_ad[15:0] output data | 0.43 | 4.463 | ns |
| FA0 | $t_w(nBEV)$ | Pulse duration, gpmc_ben[1:0] valid time | | N ⁽¹⁾ | ns |
| FA1 | $t_w(nCSV)$ | Pulse duration, gpmc_cs[7:0] low | | A ⁽²⁾ | ns |
| FA3 | $t_d(nCSV-nADVIV)$ | Delay time, gpmc_cs[7:0] valid to gpmc_advn_ale invalid | B - 2 ⁽³⁾ | B + 4 ⁽³⁾ | ns |
| FA4 | $t_d(nCSV-nOEIV)$ | Delay time, gpmc_cs[7:0] valid to gpmc_oen_ren invalid (Single read) | C - 2 ⁽⁴⁾ | C + 4 ⁽⁴⁾ | ns |
| FA9 | $t_d(AV-nCSV)$ | Delay time, address bus valid to gpmc_cs[7:0] valid | J - 2 ⁽⁵⁾ | J + 4 ⁽⁵⁾ | ns |
| FA10 | $t_d(nBEV-nCSV)$ | Delay time, gpmc_ben[1:0] valid to gpmc_cs[7:0] valid | J - 2 ⁽⁵⁾ | J + 4 ⁽⁵⁾ | ns |
| FA12 | $t_d(nCSV-nADVIV)$ | Delay time, gpmc_cs[7:0] valid to gpmc_advn_ale valid | K - 2 ⁽⁶⁾ | K + 4 ⁽⁶⁾ | ns |
| FA13 | $t_d(nCSV-nOEIV)$ | Delay time, gpmc_cs[7:0] valid to gpmc_oen_ren valid | L - 2 ⁽⁷⁾ | L + 4 ⁽⁷⁾ | ns |
| FA16 | $t_w(AIV)$ | Pulse duration, address invalid between 2 successive R/W accesses | G ⁽⁸⁾ | | ns |
| FA18 | $t_d(nCSV-nOEIV)$ | Delay time, gpmc_cs[7:0] valid to gpmc_oen_ren invalid (Burst read) | I - 2 ⁽⁹⁾ | I + 4 ⁽⁹⁾ | ns |
| FA20 | $t_w(AV)$ | Pulse duration, address valid : 2nd, 3rd and 4th accesses | D ⁽¹⁰⁾ | | ns |
| FA25 | $t_d(nCSV-nWEV)$ | Delay time, gpmc_cs[7:0] valid to gpmc_wen valid | E - 2 ⁽¹¹⁾ | E + 4 ⁽¹¹⁾ | ns |
| FA27 | $t_d(nCSV-nWEIV)$ | Delay time, gpmc_cs[7:0] valid to gpmc_wen invalid | F - 2 ⁽¹²⁾ | F + 4 ⁽¹²⁾ | ns |
| FA28 | $t_d(nWEV-DV)$ | Delay time, gpmc_wen valid to data bus valid | | 2 | ns |
| FA29 | $t_d(DV-nCSV)$ | Delay time, data bus valid to gpmc_cs[7:0] valid | J - 2 ⁽⁵⁾ | J + 4 ⁽⁵⁾ | ns |
| FA37 | $t_d(nOEIV-AIV)$ | Delay time, gpmc_oen_ren valid to gpmc_ad[15:0] multiplexed address bus phase end | | 2 | ns |

(1) For single read: N = RdCycleTime × (TimeParaGranularity + 1) × GPMC_FCLK
For single write: N = WrCycleTime × (TimeParaGranularity + 1) × GPMC_FCLK
For burst read: N = (RdCycleTime + (n - 1) × PageBurstAccessTime) × (TimeParaGranularity + 1) × GPMC_FCLK
For burst write: N = (WrCycleTime + (n - 1) × PageBurstAccessTime) × (TimeParaGranularity + 1) × GPMC_FCLK

(2) For single read: A = (CSRdOffTime - CSOnTime) × (TimeParaGranularity + 1) × GPMC_FCLK
For single write: A = (CSWrOffTime - CSOnTime) × (TimeParaGranularity + 1) × GPMC_FCLK
For burst read: A = (CSRdOffTime - CSOnTime + (n - 1) × PageBurstAccessTime) × (TimeParaGranularity + 1) × GPMC_FCLK
For burst write: A = (CSWrOffTime - CSOnTime + (n - 1) × PageBurstAccessTime) × (TimeParaGranularity + 1) × GPMC_FCLK

(3) For reading: B = ((ADVrOffTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (ADVExtraDelay - CSEExtraDelay)) × GPMC_FCLK
For writing: B = ((ADVWrOffTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (ADVExtraDelay - CSEExtraDelay)) × GPMC_FCLK

(4) C = ((OEOffTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (OEExtraDelay - CSEExtraDelay)) × GPMC_FCLK

(5) J = (CSOnTime × (TimeParaGranularity + 1) + 0.5 × CSEExtraDelay) × GPMC_FCLK

(6) K = ((ADVOnTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (ADVExtraDelay - CSEExtraDelay)) × GPMC_FCLK

(7) L = ((OEOnTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (OEExtraDelay - CSEExtraDelay)) × GPMC_FCLK

(8) G = Cycle2CycleDelay × GPMC_FCLK × (TimeParaGranularity + 1)

(9) I = ((OEOffTime + (n - 1) × PageBurstAccessTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (OEExtraDelay - CSEExtraDelay)) × GPMC_FCLK

(10) D = PageBurstAccessTime × (TimeParaGranularity + 1) × GPMC_FCLK

(11) E = ((WEOnTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (WEExtraDelay - CSEExtraDelay)) × GPMC_FCLK

(12) F = ((WEOffTime - CSOnTime) × (TimeParaGranularity + 1) + 0.5 × (WEExtraDelay - CSEExtraDelay)) × GPMC_FCLK

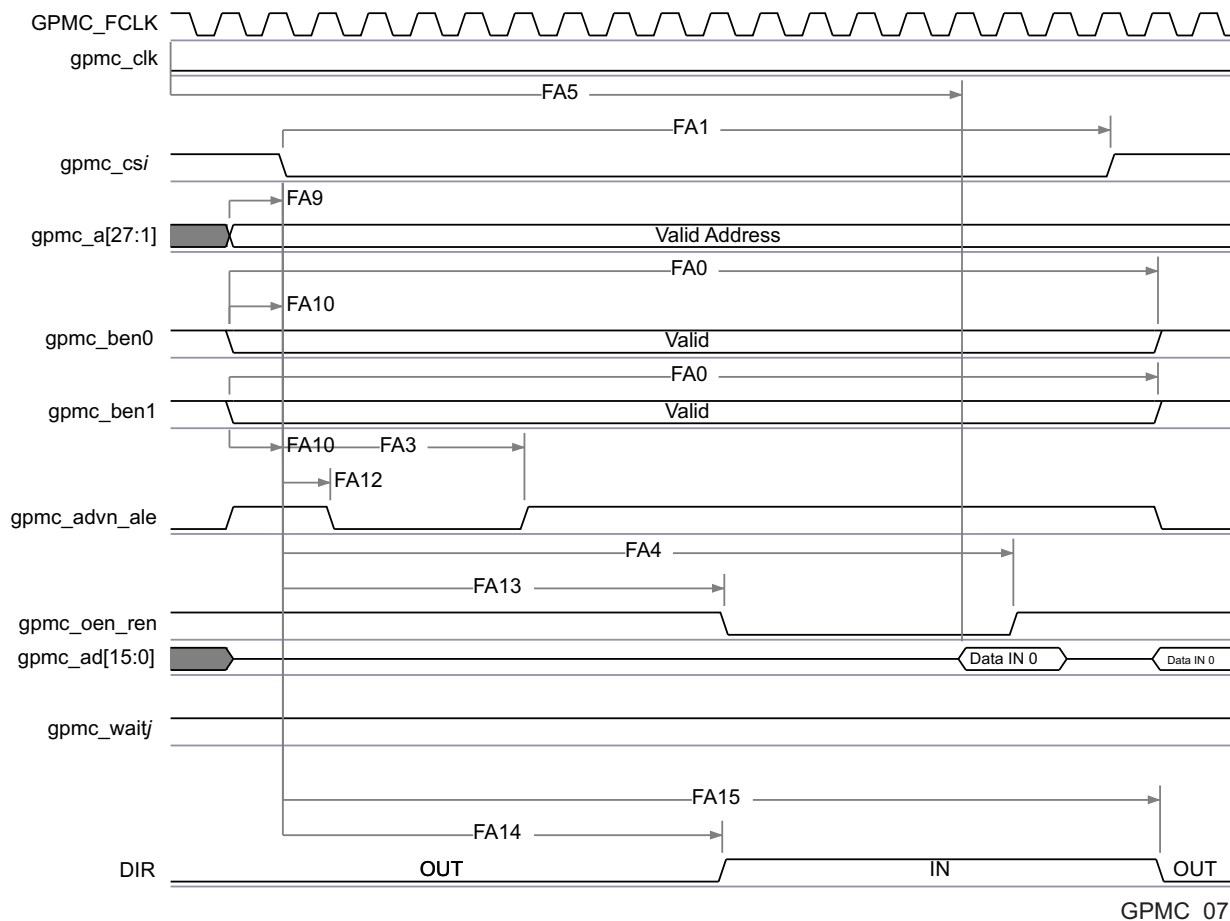


Figure 7-13. GPMC / NOR Flash - Asynchronous Read - Single Word Timing⁽¹⁾⁽²⁾⁽³⁾

- (1) In $gpmc_csi$, $i = 0$ to 7. In $gpmc_waitj$, $j = 0$ to 1.
- (2) 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.
- (3) GPMC_FCLK is an internal clock (GPMC functional clock) not provided externally.
- (4) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.

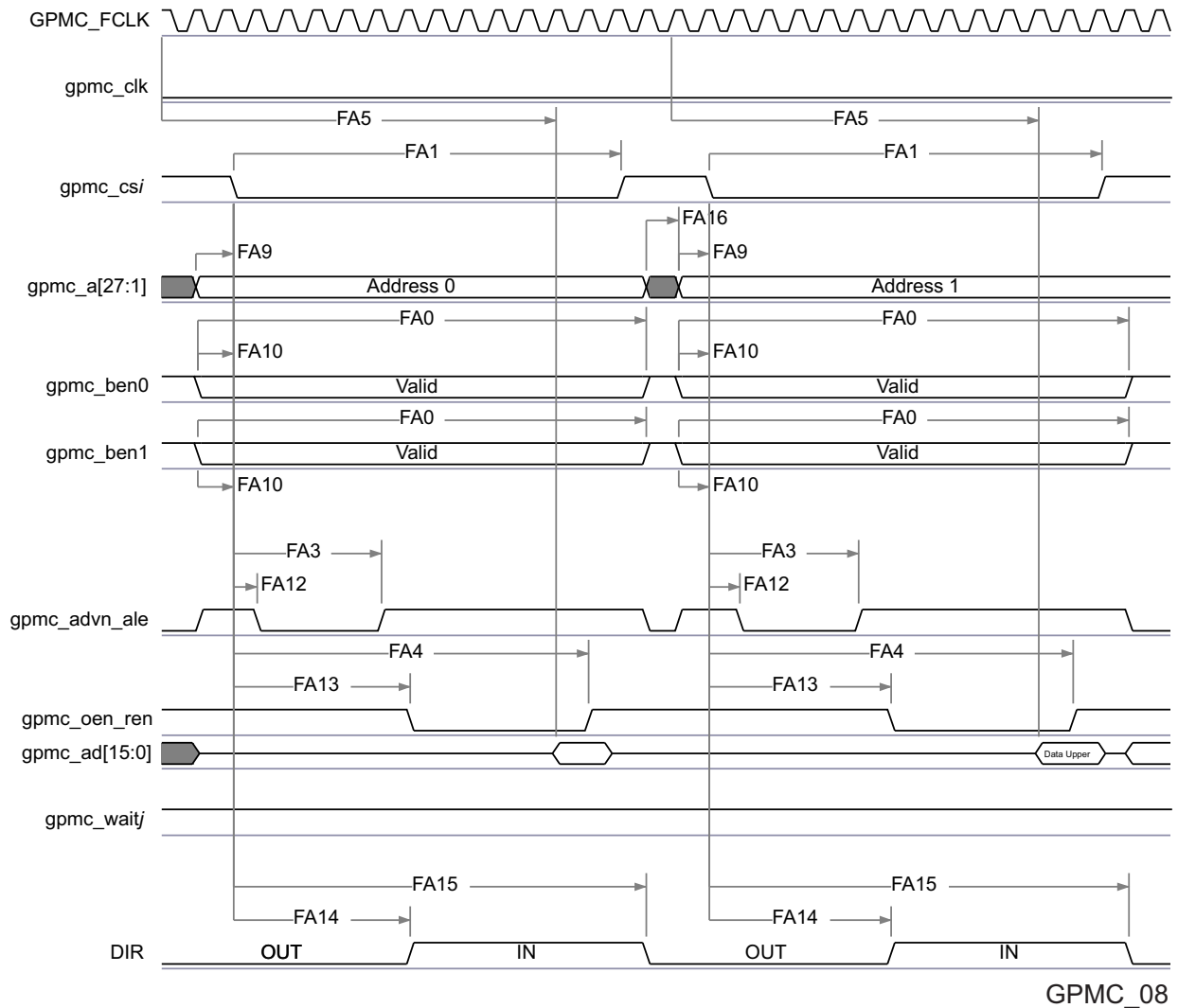
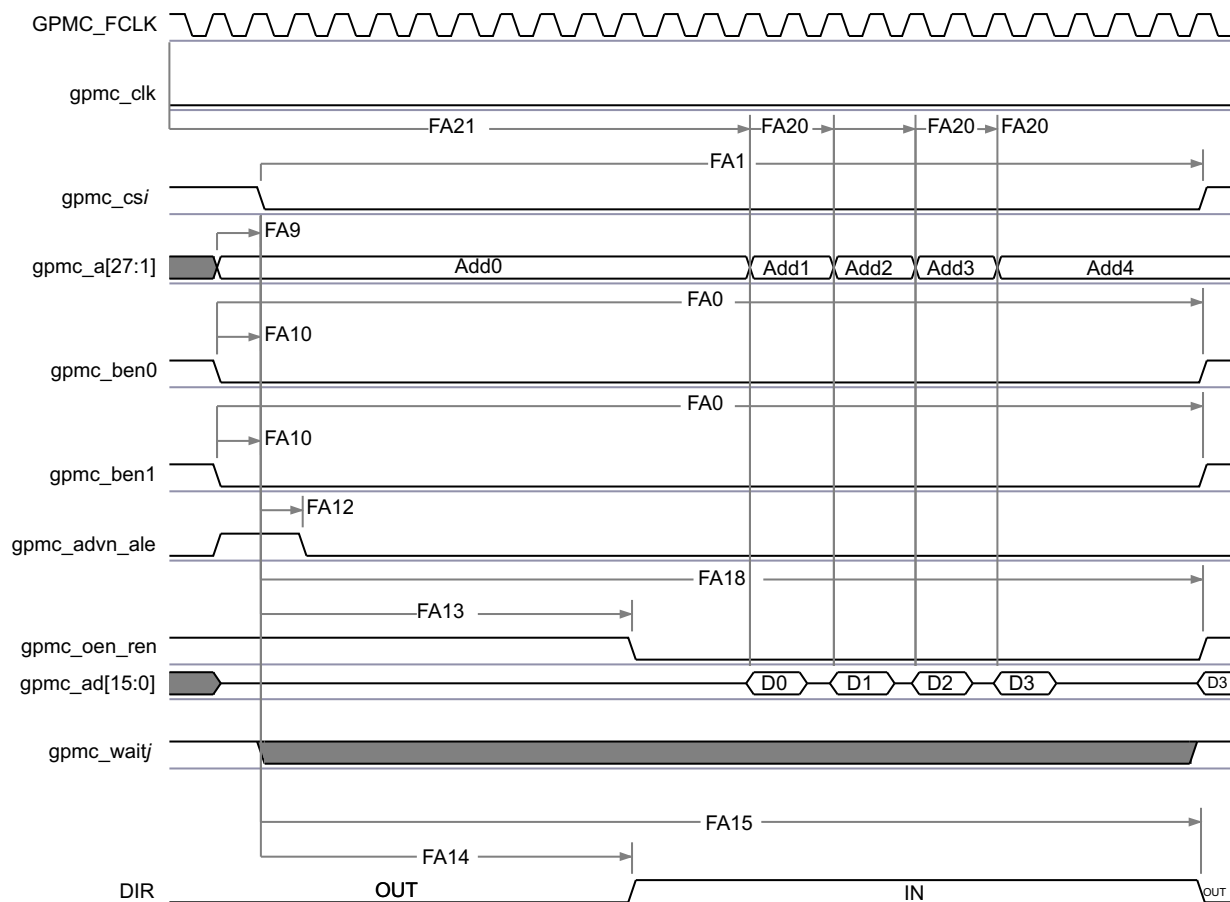


Figure 7-14. GPMC / NOR Flash - Asynchronous Read - 32-bit Timing⁽¹⁾⁽²⁾⁽³⁾

- (1) In "gpmc_csi", i = 0 to 7. In "gpmc_waitj", j = 0 to 1.
- (2) 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 should be stored inside AccessTime register bits field
- (3) GPMC_FCLK is an internal clock (GPMC functional clock) not provided externally
- (4) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.



SPRS91v_GPMC_09

Figure 7-15. GPMC / NOR Flash - Asynchronous Read - Page Mode 4x16-bit Timing⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾

- (1) In "gpmc_csi", i = 0 to 7. In "gpmc_waitj", j = 0 to 1
- (2) 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 is detailed in a separated application note and should be stored inside AccessTime register bits field.
- (3) 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 should be stored in PageBurstAccessTime register bits field.
- (4) GPMC_FCLK is an internal clock (GPMC functional clock) not provided externally
- (5) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.

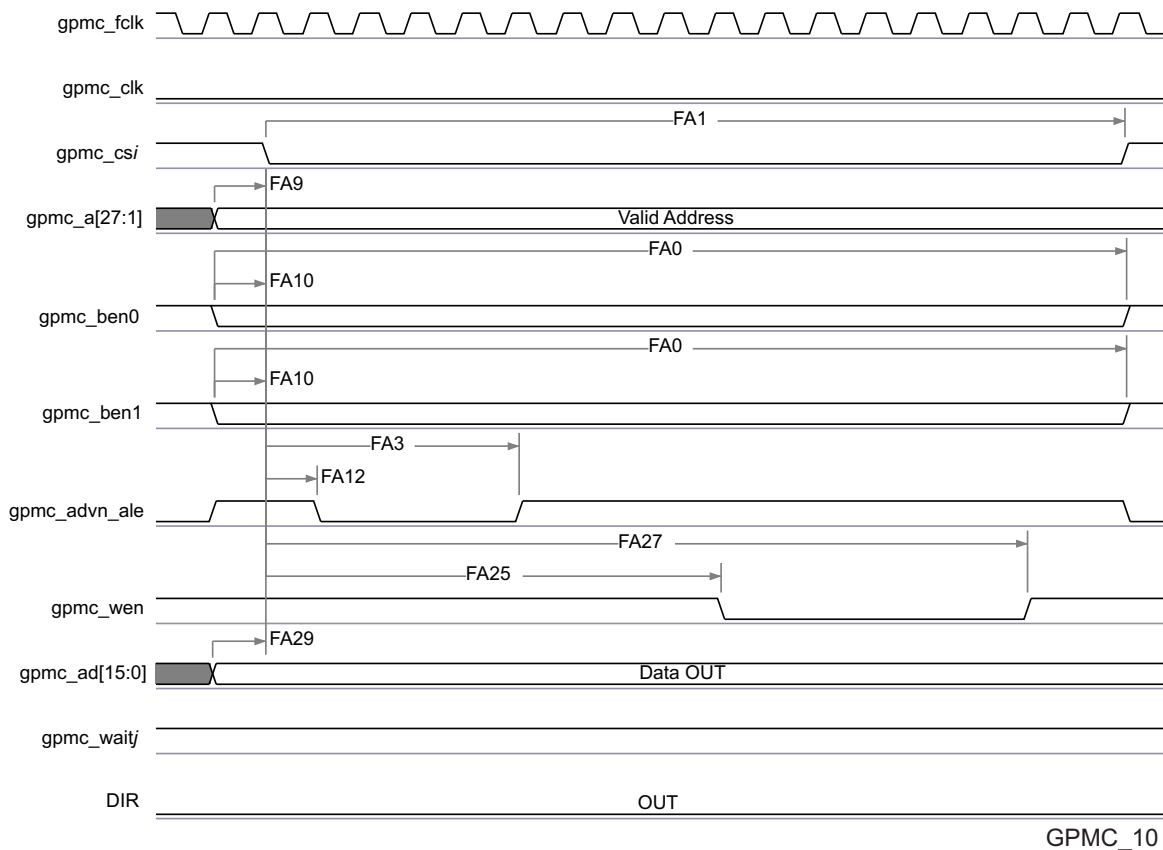
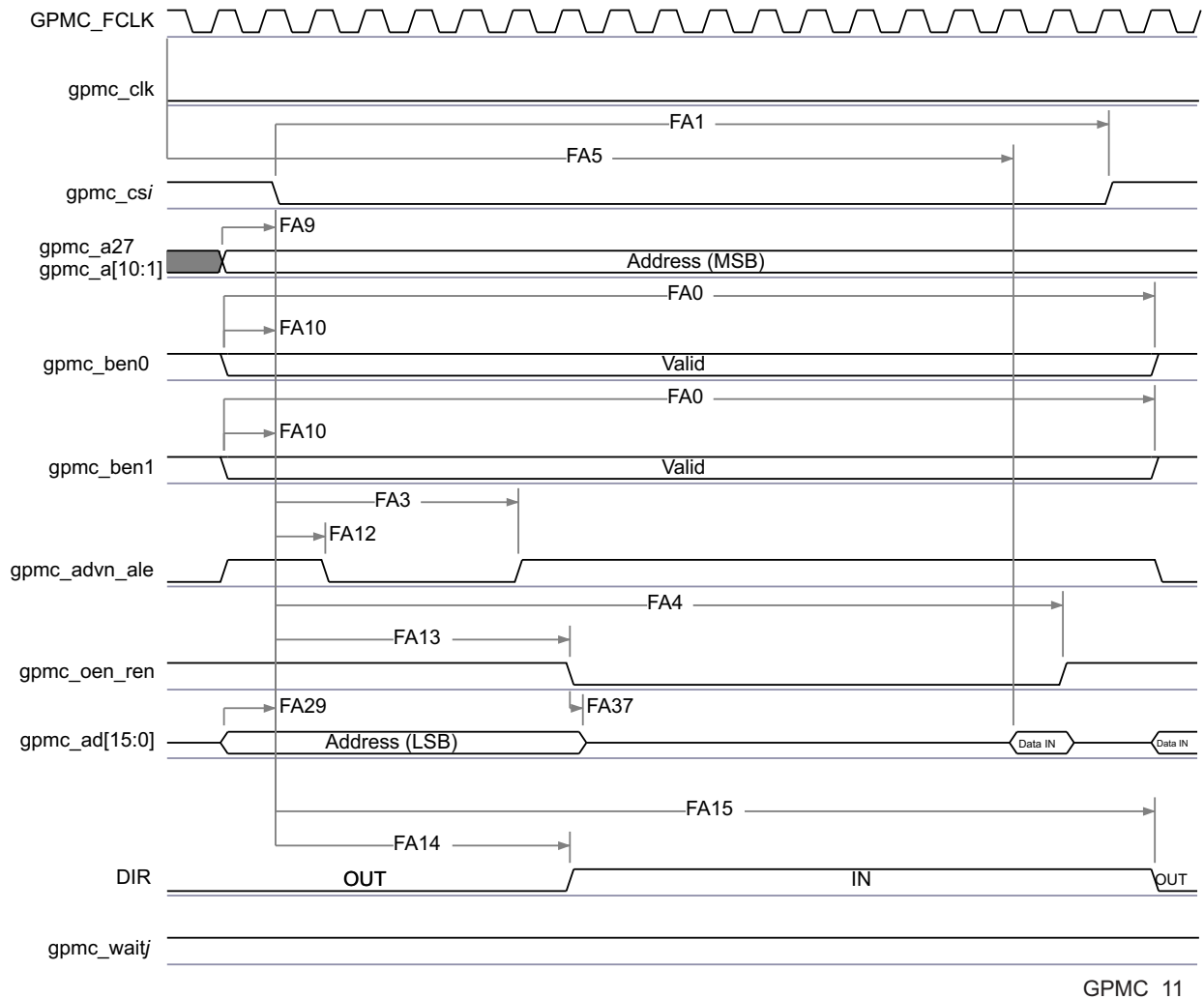


Figure 7-16. GPMC / NOR Flash - Asynchronous Write - Single Word Timing⁽¹⁾

- (1) In "gpmc_csi", i = 0 to 7. In "gpmc_waitj", j = 0 to 1.
- (2) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.



GPMC_11

Figure 7-17. GPMC / Multiplexed NOR Flash - Asynchronous Read - Single Word Timing⁽¹⁾⁽²⁾⁽³⁾

- (1) In "gpmc_csi", i = 0 to 7. In "gpmc_waitj", j = 0 to 1
- (2) 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 should be stored inside AccessTime register bits field.
- (3) GPMC_FCLK is an internal clock (GPMC functional clock) not provided externally
- (4) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.

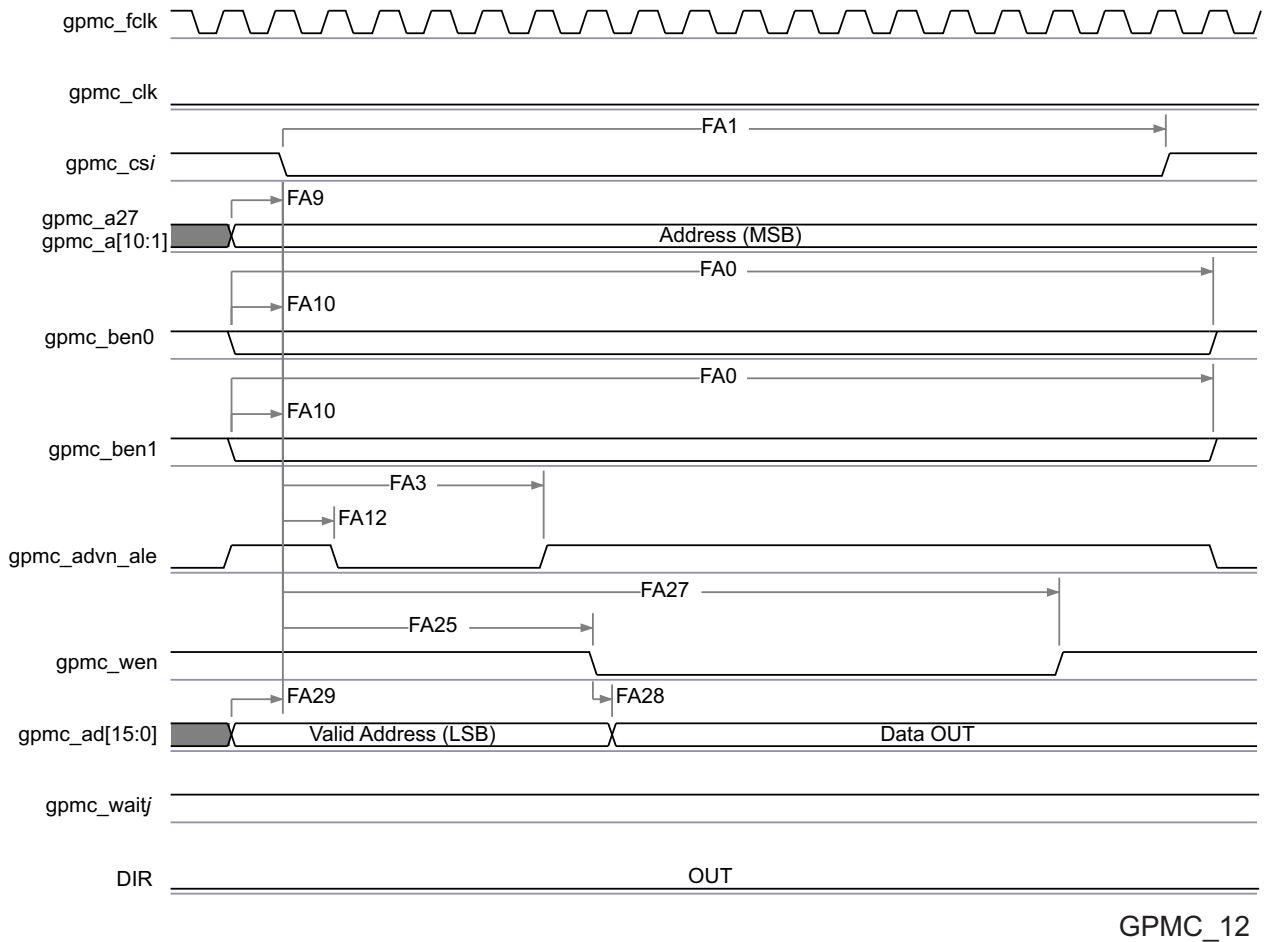


Figure 7-18. GPMC / Multiplexed NOR Flash - Asynchronous Write - Single Word Timing⁽¹⁾

- (1) In "gpmc_csi", i = 0 to 7. In "gpmc_waitj", j = 0 to 1.
- (2) The "DIR" (direction control) output signal is NOT pinned out on any of the device pads. It is an internal signal only representing a signal direction on the GPMC data bus.

7.11.3 GPMC/NAND Flash Interface Asynchronous Timing

CAUTION

The I/O Timings provided in this section are valid only for some GPMC usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

Table 7-30 and Table 7-31 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 7-19, Figure 7-20, Figure 7-21 and Figure 7-22).

Table 7-30. GPMC/NAND Flash Interface Timing Requirements

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|------------------|---|-----|------------------|--------|
| GNF12 | $t_{acc}(DAT)$ | Data maximum access time (GPMC_FCLK Cycles) | | J ⁽¹⁾ | cycles |
| - | $t_{su}(DV-OEH)$ | Setup time, read gpmc_ad[15:0] valid before gpmc_oen_ren high | 1.9 | | ns |
| - | $t_h(OEH-DV)$ | Hold time, read gpmc_ad[15:0] valid after gpmc_oen_ren high | 1 | | ns |

(1) $J = \text{AccessTime} \times (\text{TimeParaGranularity} + 1)$

Table 7-31. GPMC/NAND Flash Interface Switching Characteristics

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|-----------------------------|--|-----------------------|-----------------------|------|
| - | $t_{r(\text{DO})}$ | Rising time, gpmc_ad[15:0] output data | 0.447 | 4.067 | ns |
| - | $t_{f(\text{DO})}$ | Falling time, gpmc_ad[15:0] output data | 0.43 | 4.463 | ns |
| GNF0 | $t_{w(\text{nWEV})}$ | Pulse duration, gpmc_wen valid time | | A ⁽¹⁾ | ns |
| GNF1 | $t_{d(\text{nCSV-nWEV})}$ | Delay time, gpmc_cs[7:0] valid to gpmc_wen valid | B - 2 ⁽²⁾ | B + 4 ⁽²⁾ | ns |
| GNF2 | $t_{d(\text{CLEH-nWEV})}$ | Delay time, gpmc_ben[1:0] high to gpmc_wen valid | C - 2 ⁽³⁾ | C + 4 ⁽³⁾ | ns |
| GNF3 | $t_{d(\text{nWEV-DV})}$ | Delay time, gpmc_ad[15:0] valid to gpmc_wen valid | D - 2 ⁽⁴⁾ | D + 4 ⁽⁴⁾ | ns |
| GNF4 | $t_{d(\text{nWEIV-DIV})}$ | Delay time, gpmc_wen invalid to gpmc_ad[15:0] invalid | E - 2 ⁽⁵⁾ | E + 4 ⁽⁵⁾ | ns |
| GNF5 | $t_{d(\text{nWEIV-CLEIV})}$ | Delay time, gpmc_wen invalid to gpmc_ben[1:0] invalid | F - 2 ⁽⁶⁾ | F + 4 ⁽⁶⁾ | ns |
| GNF6 | $t_{d(\text{nWEIV-nCSIV})}$ | Delay time, gpmc_wen invalid to gpmc_cs[7:0] invalid | G - 2 ⁽⁷⁾ | G + 4 ⁽⁷⁾ | ns |
| GNF7 | $t_{d(\text{ALEH-nWEV})}$ | Delay time, gpmc_advn_ale high to gpmc_wen valid | C - 2 ⁽³⁾ | C + 4 ⁽³⁾ | ns |
| GNF8 | $t_{d(\text{nWEIV-ALEIV})}$ | Delay time, gpmc_wen invalid to gpmc_advn_ale invalid | F - 2 ⁽⁶⁾ | F + 4 ⁽⁶⁾ | ns |
| GNF9 | $t_{c(\text{nWE})}$ | Cycle time, write cycle time | | H ⁽⁸⁾ | ns |
| GNF10 | $t_{d(\text{nCSV-nOEV})}$ | Delay time, gpmc_cs[7:0] valid to gpmc_oen_ren valid | I - 2 ⁽⁹⁾ | I + 4 ⁽⁹⁾ | ns |
| GNF13 | $t_{w(\text{nOEV})}$ | Pulse duration, gpmc_oen_ren valid time | | K ⁽¹⁰⁾ | ns |
| GNF14 | $t_{c(\text{nOE})}$ | Cycle time, read cycle time | | L ⁽¹¹⁾ | ns |
| GNF15 | $t_{d(\text{nOEIV-nCSIV})}$ | Delay time, gpmc_oen_ren invalid to gpmc_cs[7:0] invalid | M - 2 ⁽¹²⁾ | M + 4 ⁽¹²⁾ | ns |

- (1) $A = (\text{WEOffTime} - \text{WEOnTime}) \times (\text{TimeParaGranularity} + 1) \times \text{GPMC_FCLK}$
- (2) $B = ((\text{WEOnTime} - \text{CSONTime}) \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{WEEExtraDelay} - \text{CSEExtraDelay})) \times \text{GPMC_FCLK}$
- (3) $C = ((\text{WEOnTime} - \text{ADVOnTime}) \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{WEEExtraDelay} - \text{ADVEExtraDelay})) \times \text{GPMC_FCLK}$
- (4) $D = (\text{WEOnTime} \times (\text{TimeParaGranularity} + 1) + 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$
- (5) $E = (\text{WrCycleTime} - \text{WEOffTime} \times (\text{TimeParaGranularity} + 1) - 0.5 \times \text{WEEExtraDelay}) \times \text{GPMC_FCLK}$
- (6) $F = (\text{ADVWrOffTime} - \text{WEOffTime} \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{ADVEExtraDelay} - \text{WEEExtraDelay})) \times \text{GPMC_FCLK}$
- (7) $G = (\text{CSWrOffTime} - \text{WEOffTime} \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{CSEExtraDelay} - \text{WEEExtraDelay})) \times \text{GPMC_FCLK}$
- (8) $H = \text{WrCycleTime} \times (1 + \text{TimeParaGranularity}) \times \text{GPMC_FCLK}$
- (9) $I = ((\text{OEOffTime} + (\text{n} - 1) \times \text{PageBurstAccessTime} - \text{CSONTime}) \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{OEEExtraDelay} - \text{CSEExtraDelay})) \times \text{GPMC_FCLK}$
- (10) $K = (\text{OEOffTime} - \text{OEOnTime}) \times (1 + \text{TimeParaGranularity}) \times \text{GPMC_FCLK}$
- (11) $L = \text{RdCycleTime} \times (1 + \text{TimeParaGranularity}) \times \text{GPMC_FCLK}$
- (12) $M = (\text{CSRdOffTime} - \text{OEOffTime} \times (\text{TimeParaGranularity} + 1) + 0.5 \times (\text{CSEExtraDelay} - \text{OEEExtraDelay})) \times \text{GPMC_FCLK}$

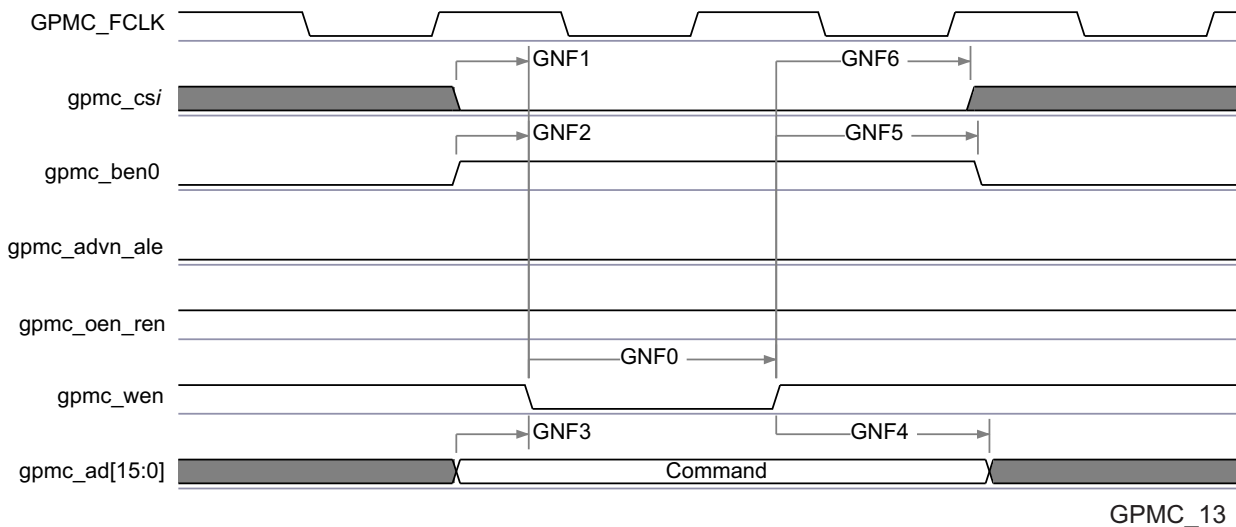


Figure 7-19. GPMC / NAND Flash - Command Latch Cycle Timing⁽¹⁾

(1) In gpmc_csi, i = 0 to 7.

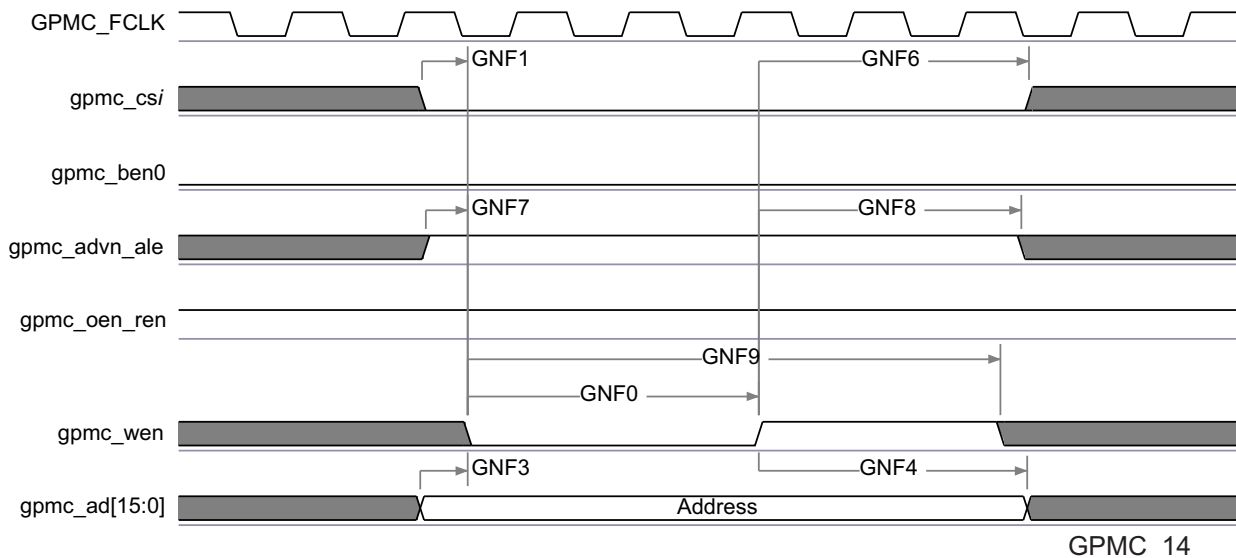


Figure 7-20. GPMC / NAND Flash - Address Latch Cycle Timing⁽¹⁾

(1) In gpmc_csi, i = 0 to 7.

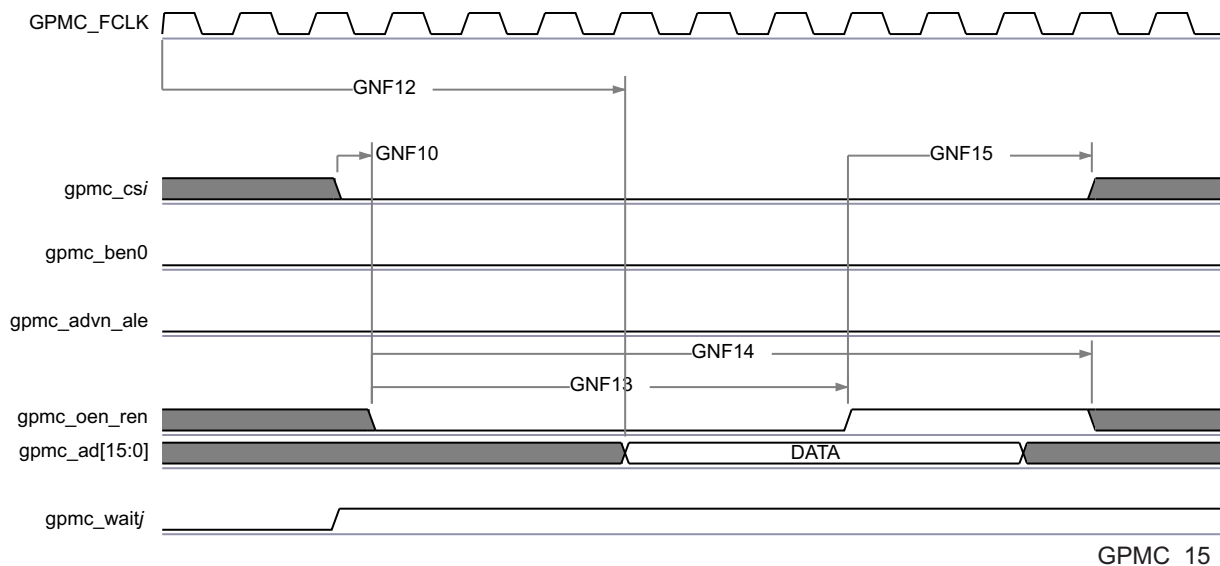


Figure 7-21. GPMC / NAND Flash - Data Read Cycle Timing⁽¹⁾⁽²⁾⁽³⁾

- (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_csi, i = 0 to 7. In gpmc_waitj, j = 0 to 1.

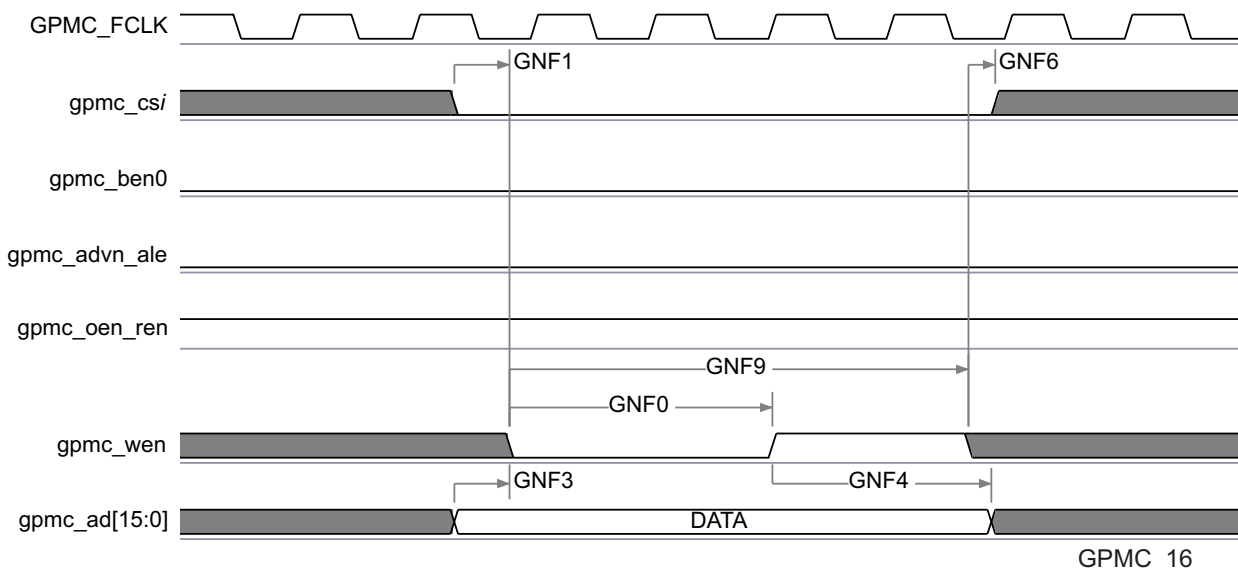


Figure 7-22. GPMC / NAND Flash - Data Write Cycle Timing⁽¹⁾

- (1) In gpmc_csi, i = 0 to 7.

NOTE

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bit field for each corresponding pad control register.

The pad control registers are presented in [Table 4-3](#) and described in Device TRM, *Control Module Chapter*.

Virtual IO Timings Modes must be used to ensure some IO timings for GPMC. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 7-32 Virtual Functions Mapping for GPMC](#) for a definition of the Virtual modes.

[Table 7-32](#) presents the values for DELAYMODE bit field.

Table 7-32. Virtual Functions Mapping for GPMC

| BALL | BALL NAME | Delay Mode Value | MUXMODE | | | | | | | | |
|------|-------------------|------------------|-------------------|----------|---|----------|------------|---------|----------|-------------------|-------------------|
| | | | GPMC_VIRTUAL1 | 0 | 1 | 2 | 3 | 5 | 6 | 14 ⁽¹⁾ | 14 ⁽¹⁾ |
| N1 | gpmc_advn_al e | 15 | gpmc_advn_al e | gpmc_cs6 | | | gpmc_wait1 | gpmc_a2 | gpmc_a23 | | |
| H3 | gpmc_ad15 | 13 | gpmc_ad15 | | | | | | | | |
| L3 | gpmc_ad6 | 13 | gpmc_ad6 | | | | | | | | |
| L5 | gpmc_ad2 | 13 | gpmc_ad2 | | | | | | | | |
| E6 | vin2a_d9 | 9 | | | | | | | | gpmc_a25 | |
| M3 | gpmc_wen | 15 | gpmc_wen | | | | | | | | |
| H2 | gpmc_ad14 | 13 | gpmc_ad14 | | | | | | | | |
| R3 | gpmc_a13 | 15 | gpmc_a13 | | | | | | | | |
| N7 | gpmc_a8 | 14 | gpmc_a8 | | | | | | | | |
| T2 | gpmc_a14 | 15 | gpmc_a14 | | | | | | | | |
| L6 | gpmc_ad4 | 13 | gpmc_ad4 | | | | | | | | |
| H4 | gpmc_a26 | 15 | gpmc_a26 | | | gpmc_a20 | | | | | |
| M6 | gpmc_ad0 | 13 | gpmc_ad0 | | | | | | | | |
| N2 | gpmc_wait0 | 15 | gpmc_wait0 | | | | | | | | |
| F6 | vin2a_d11 | 9 | | | | | | | | gpmc_a23 | |
| M2 | gpmc_ad1 | 13 | gpmc_ad1 | | | | | | | | |
| J3 | gpmc_ad13 | 13 | gpmc_ad13 | | | | | | | | |
| T6 | gpmc_a2 | 14 | gpmc_a2 | | | | | | | | |
| L4 | gpmc_ad5 | 13 | gpmc_ad5 | | | | | | | | |
| F5 | vin2a_d8 | 9 | | | | | | | | gpmc_a26 | |
| T1 | gpmc_cs0 | 15 | gpmc_cs0 | | | | | | | | |
| G1 | vin2a_hsync0 | 9 | | | | | | | | gpmc_a27 | |
| P6 | gpmc_a4 | 14 | gpmc_a4 | | | | | | | | |
| N6 | gpmc_ben0 | 15 | gpmc_ben0 | gpmc_cs4 | | | | | | | |
| R5 | gpmc_a6 | 14 | gpmc_a6 | | | | | | | | |
| U2 | gpmc_a15 | 15 | gpmc_a15 | | | | | | | | |
| J2 | gpmc_ad11 | 13 | gpmc_ad11 | | | | | | | | |

Table 7-32. Virtual Functions Mapping for GPMC (continued)

| BALL | BALL NAME | Delay Mode Value | MUXMODE | | | | | | | | | |
|------|--------------|------------------|---------------|----------|---|----------|------------|---------|---|-------------------|-------------------|--|
| | | | GPMC_VIRTUAL1 | 0 | 1 | 2 | 3 | 5 | 6 | 14 ⁽¹⁾ | 14 ⁽¹⁾ | |
| U1 | gpmc_a16 | 15 | gpmc_a16 | | | | | | | | | |
| T9 | gpmc_a1 | 14 | gpmc_a1 | | | | | | | | | |
| J4 | gpmc_a24 | 15 | gpmc_a24 | | | gpmc_a18 | | | | | | |
| J7 | gpmc_a23 | 15 | gpmc_a23 | | | gpmc_a17 | | | | | | |
| L1 | gpmc_ad8 | 13 | gpmc_ad8 | | | | | | | | | |
| J1 | gpmc_ad10 | 13 | gpmc_ad10 | | | | | | | | | |
| H1 | gpmc_ad12 | 13 | gpmc_ad12 | | | | | | | | | |
| M7 | gpmc_a20 | 15 | gpmc_a20 | | | gpmc_a14 | | | | | | |
| D3 | vin2a_d10 | 9 | | | | | | | | gpmc_a24 | | |
| P1 | gpmc_cs3 | 14 | gpmc_cs3 | | | | | gpmc_a1 | | | | |
| M5 | gpmc_oen_ren | 15 | gpmc_oen_ren | | | | | | | | | |
| R4 | gpmc_a9 | 14 | gpmc_a9 | | | | | | | | | |
| H6 | gpmc_cs1 | 15 | gpmc_cs1 | | | gpmc_a22 | | | | | | |
| M1 | gpmc_ad3 | 13 | gpmc_ad3 | | | | | | | | | |
| L2 | gpmc_ad7 | 13 | gpmc_ad7 | | | | | | | | | |
| P5 | gpmc_a7 | 14 | gpmc_a7 | | | | | | | | | |
| T7 | gpmc_a3 | 14 | gpmc_a3 | | | | | | | | | |
| M4 | gpmc_ben1 | 15 | gpmc_ben1 | gpmc_cs5 | | | | gpmc_a3 | | | | |
| P7 | gpmc_clk | 15 | gpmc_clk | gpmc_cs7 | | | gpmc_wait1 | | | | | |
| K6 | gpmc_a22 | 15 | gpmc_a22 | | | gpmc_a16 | | | | | | |
| P2 | gpmc_cs2 | 15 | gpmc_cs2 | | | | | | | | | |
| H7 | vin2a_fld0 | 11 | | | | | | | | gpmc_a27 | gpmc_a18 | |
| N9 | gpmc_a10 | 14 | gpmc_a10 | | | | | | | | | |
| P4 | gpmc_a12 | 15 | gpmc_a12 | | | | | gpmc_a0 | | | | |
| P3 | gpmc_a17 | 15 | gpmc_a17 | | | | | | | | | |
| R9 | gpmc_a5 | 14 | gpmc_a5 | | | | | | | | | |
| J5 | gpmc_a21 | 15 | gpmc_a21 | | | gpmc_a15 | | | | | | |
| H5 | gpmc_a27 | 15 | gpmc_a27 | | | gpmc_a21 | | | | | | |
| K2 | gpmc_ad9 | 13 | gpmc_ad9 | | | | | | | | | |
| K7 | gpmc_a19 | 15 | gpmc_a19 | | | gpmc_a13 | | | | | | |
| J6 | gpmc_a25 | 15 | gpmc_a25 | | | gpmc_a19 | | | | | | |
| R6 | gpmc_a0 | 14 | gpmc_a0 | | | | | | | | | |

Table 7-32. Virtual Functions Mapping for GPMC (continued)

| BALL | BALL NAME | Delay Mode Value GPMC_VIRTUAL1 | MUXMODE | | | | | | | | |
|------|------------|-----------------------------------|----------|---|---|---|---|---|-------------------|-------------------|----------|
| | | | 0 | 1 | 2 | 3 | 5 | 6 | 14 ⁽¹⁾ | 14 ⁽¹⁾ | |
| E1 | vin2a_clk0 | 11 | | | | | | | | gpmc_a27 | gpmc_a17 |
| R2 | gpmc_a18 | 15 | gpmc_a18 | | | | | | | | |
| P9 | gpmc_a11 | 14 | gpmc_a11 | | | | | | | | |

- (1) Some signals listed are virtual functions that present alternate multiplexing options. These virtual functions are controlled via CTRL_CORE_ALT_SELECT_MUX or CTRL_CORE_VIP_MUX_SELECT registers. For more information on how to use these options, see *Pad Configuration Registers* section, *Control Module* chapter in the device TRM..

7.12 Timers

The device has 16 general-purpose (GP) timers (TIMER1 - TIMER16), two watchdog timers, and a 32-kHz synchronized timer (COUNTER_32K) that have the following features:

- Dedicated input trigger for capture mode and dedicated output trigger/pulse width modulation (PWM) signal
- Interrupts generated on overflow, compare, and capture
- Free-running 32-bit upward counter
- Supported modes:
 - Compare and capture modes
 - Auto-reload mode
 - Start-stop mode
- On-the-fly read/write register (while counting)

The device has two system watchdog timer (WD_TIMER1 and WD_TIMER2) that have the following features:

- Free-running 32-bit upward counter
- On-the-fly read/write register (while counting)
- Reset upon occurrence of a timer overflow condition

WD_TIMER2 is available in all devices as a system watchdog timer. WD_TIMER1 is only supported in security enabled devices.

The watchdog timer is used to provide a recovery mechanism for the device in the event of a fault condition, such as a non-exiting code loop.

NOTE

For additional information on the Timer Module, see the Device TRM.

7.13 Inter-Integrated Circuit Interface (I2C)

The device includes 6 inter-integrated circuit (I2C) modules which provide an interface to other devices compliant with Philips Semiconductors Inter-IC bus (I2C) specification version 2.1. External components attached to this 2-wire serial bus can transmit/receive 8-bit data to/from the device through the I2C module.

NOTE

Note that, on I2C1 and I2C2, due to characteristics of the open drain IO cells, HS mode is not supported.

NOTE

Inter-integrated circuit *i* (*i*=1 to 6) module is also referred to as I2Ci.

NOTE

For more information, see *Multimaster High Speed I2C Controller* section in the device TRM.

Table 7-33, Table 7-34 and Figure 7-23 assume testing over the recommended operating conditions and electrical characteristic conditions below.

Table 7-33. Timing Requirements for I2C Input Timings⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | STANDARD MODE | | FAST MODE | | UNIT |
|-----|----------------------|---|------------------|---------------------|------------------------------|--------------------|---------------|
| | | | MIN | MAX | MIN | MAX | |
| 1 | $t_{c(SCL)}$ | Cycle time, SCL | 10 | | 2.5 | | μs |
| 2 | $t_{su(SCLH-SDAL)}$ | Setup time, SCL high before SDA low (for a repeated START condition) | 4.7 | | 0.6 | | μs |
| 3 | $t_{h(SDAL-SCLL)}$ | Hold time, SCL low after SDA low (for a START and a repeated START condition) | 4 | | 0.6 | | μs |
| 4 | $t_{w(SCLL)}$ | Pulse duration, SCL low | 4.7 | | 1.3 | | μs |
| 5 | $t_{w(SCLH)}$ | Pulse duration, SCL high | 4 | | 0.6 | | μs |
| 6 | $t_{su(SDAV-SCLH)}$ | Setup time, SDA valid before SCL high | 250 | | 100 ⁽²⁾ | | ns |
| 7 | $t_{h(SCLL-SDAV)}$ | Hold time, SDA valid after SCL low | 0 ⁽³⁾ | 3.45 ⁽⁴⁾ | 0 ⁽³⁾ | 0.9 ⁽⁴⁾ | μs |
| 8 | $t_{w(SDAH)}$ | Pulse duration, SDA high between STOP and START conditions | 4.7 | | 1.3 | | μs |
| 9 | $t_{r(SDA)}$ | Rise time, SDA | | 1000 | $20 + 0.1C_b$ ⁽⁵⁾ | 300 ⁽³⁾ | ns |
| 10 | $t_{r(SCL)}$ | Rise time, SCL | | 1000 | $20 + 0.1C_b$ ⁽⁵⁾ | 300 ⁽³⁾ | ns |
| 11 | $t_{f(SDA)}$ | Fall time, SDA | | 300 | $20 + 0.1C_b$ ⁽⁵⁾ | 300 ⁽³⁾ | ns |
| 12 | $t_{f(SCL)}$ | Fall time, SCL | | 300 | $20 + 0.1C_b$ ⁽⁵⁾ | 300 ⁽³⁾ | ns |
| 13 | $t_{su(SCLH-SDAH)}$ | Setup time, SCL high before SDA high (for STOP condition) | 4 | | 0.6 | | μs |
| 14 | $t_{w(SP)}$ | Pulse duration, spike (must be suppressed) | | | 0 | 50 | ns |
| 15 | C_b ⁽⁵⁾ | Capacitive load for each bus line | | 400 | | 400 | pF |

- (1) The I2C pins SDA and SCL do not feature fail-safe I/O buffers. These pins could potentially draw current when the device is powered down.
- (2) A Fast-mode I2C device can be used in a Standard-mode I2C system, but the requirement $t_{su(SDA-SCLH)} \geq 250$ ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line $t_r \text{ max} + t_{su(SDA-SCLH)} = 1000 + 250 = 1250$ ns (according to the Standard-mode I2C Specification) before the SCL line is released.
- (3) 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.
- (4) 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.
- (5) C_b = total capacitance of one bus line in pF. If mixed with HS-mode devices, faster fall-times are allowed.

Table 7-34. Timing Requirements for I2C HS-Mode (I2C3/4/5/6 Only)⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | $C_b = 100$ pF MAX | | $C_b = 400$ pF ⁽²⁾ | | UNIT |
|-----|---------------------|---|--------------------|-----|-------------------------------|-----|---------------|
| | | | MIN | MAX | MIN | MAX | |
| 1 | $t_{c(SCL)}$ | Cycle time, SCL | 0.294 | | 0.588 | | μs |
| 2 | $t_{su(SCLH-SDAL)}$ | Set-up time, SCL high before SDA low (for a repeated START condition) | 160 | | 160 | | ns |
| 3 | $t_{h(SDAL-SCLL)}$ | Hold time, SCL low after SDA low (for a repeated START condition) | 160 | | 160 | | ns |
| 4 | $t_{w(SCLL)}$ | LOW period of the SCLH clock | 160 | | 320 | | ns |
| 5 | $t_{w(SCLH)}$ | HIGH period of the SCLH clock | 60 | | 120 | | ns |
| 6 | $t_{su(SDAV-SCLH)}$ | Setup time, SDA valid before SCL high | 10 | | 10 | | ns |

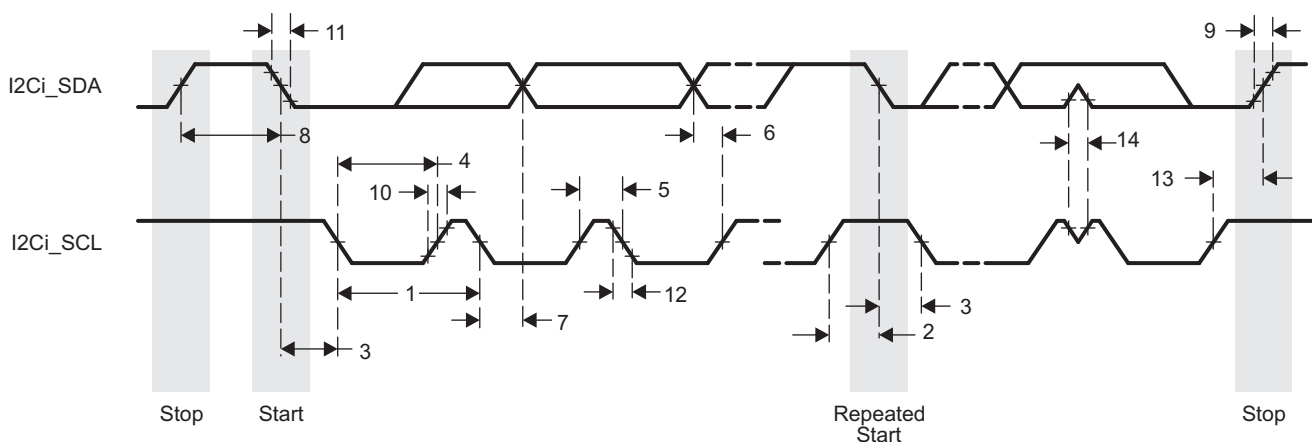
Table 7-34. Timing Requirements for I2C HS-Mode (I2C3/4/5/6 Only)⁽¹⁾ (continued)

| NO. | PARAMETER | DESCRIPTION | C _b = 100 pF MAX | | C _b = 400 pF ⁽²⁾ | | UNIT |
|-----|-------------------------------|---|-----------------------------|-----|--|-----|------|
| | | | MIN | MAX | MIN | MAX | |
| 7 | t _{h(SCLL-SDAV)} | Hold time, SDA valid after SCL low | 0 ⁽³⁾ | 70 | 0 ⁽³⁾ | 150 | ns |
| 13 | t _{su(SCLH-SDAH)} | Setup time, SCL high before SDA high (for a STOP condition) | 160 | | 160 | | ns |
| 14 | t _{w(SP)} | Pulse duration, spike (must be suppressed) | 0 | 10 | 0 | 10 | ns |
| 15 | C _b ⁽²⁾ | Capacitive load for SDAH and SCLH lines | | 100 | | 400 | pF |
| 16 | C _b | Capacitive load for SDAH + SDA line and SCLH + SCL line | | 400 | | 400 | pF |

(1) I2C HS-Mode is only supported on I2C3/4/5/6. I2C HS-Mode is not supported on I2C1/2.

(2) For bus line loads C_b between 100 and 400 pF the timing parameters must be linearly interpolated.

(3) A device must internally provide a Data hold time to bridge the undefined part between V_{IH} and V_{IL} of the falling edge of the SCLH signal. An input circuit with a threshold as low as possible for the falling edge of the SCLH signal minimizes this hold time.



SPRS906_TIMING_I2C_01

Figure 7-23. I2C Receive Timing

Table 7-35 and Figure 7-24 assume testing over the recommended operating conditions and electrical characteristic conditions below.

Table 7-35. Switching Characteristics Over Recommended Operating Conditions for I2C Output Timings⁽²⁾

| NO. | PARAMETER | DESCRIPTION | STANDARD MODE | | FAST MODE | | UNIT |
|-----|----------------------------|---|---------------|------|-----------|-----|------|
| | | | MIN | MAX | MIN | MAX | |
| 16 | t _{c(SCL)} | Cycle time, SCL | 10 | | 2.5 | | μs |
| 17 | t _{su(SCLH-SDAL)} | Setup time, SCL high before SDA low (for a repeated START condition) | 4.7 | | 0.6 | | μs |
| 18 | t _{h(SDAL-SCLL)} | Hold time, SCL low after SDA low (for a START and a repeated START condition) | 4 | | 0.6 | | μs |
| 19 | t _{w(SCLL)} | Pulse duration, SCL low | 4.7 | | 1.3 | | μs |
| 20 | t _{w(SCLH)} | Pulse duration, SCL high | 4 | | 0.6 | | μs |
| 21 | t _{su(SDAV-SCLH)} | Setup time, SDA valid before SCL high | 250 | | 100 | | ns |
| 22 | t _{h(SCLL-SDAV)} | Hold time, SDA valid after SCL low (for I2C bus devices) | 0 | 3.45 | 0 | 0.9 | μs |
| 23 | t _{w(SDAH)} | Pulse duration, SDA high between STOP and START conditions | 4.7 | | 1.3 | | μs |

Table 7-35. Switching Characteristics Over Recommended Operating Conditions for I2C Output Timings⁽²⁾ (continued)

| NO. | PARAMETER | DESCRIPTION | STANDARD MODE | | FAST MODE | | UNIT |
|-----|---------------------|---|---------------|------|--------------------------|--------------------|---------|
| | | | MIN | MAX | MIN | MAX | |
| 24 | $t_{r(SDA)}$ | Rise time, SDA | | 1000 | $20 + 0.1C_b$ (1) (3) | 300 ⁽³⁾ | ns |
| 25 | $t_{r(SCL)}$ | Rise time, SCL | | 1000 | $20 + 0.1C_b$ (1) (3) | 300 ⁽³⁾ | ns |
| 26 | $t_{f(SDA)}$ | Fall time, SDA | | 300 | $20 + 0.1C_b$ (1) (3) | 300 ⁽³⁾ | ns |
| 27 | $t_{f(SCL)}$ | Fall time, SCL | | 300 | $20 + 0.1C_b$ (1) (3) | 300 ⁽³⁾ | ns |
| 28 | $t_{su(SCLH-SDAH)}$ | Setup time, SCL high before SDA high (for STOP condition) | 4 | | 0.6 | | μ s |
| 29 | C_p | Capacitance for each I2C pin | | 10 | | 10 | pF |

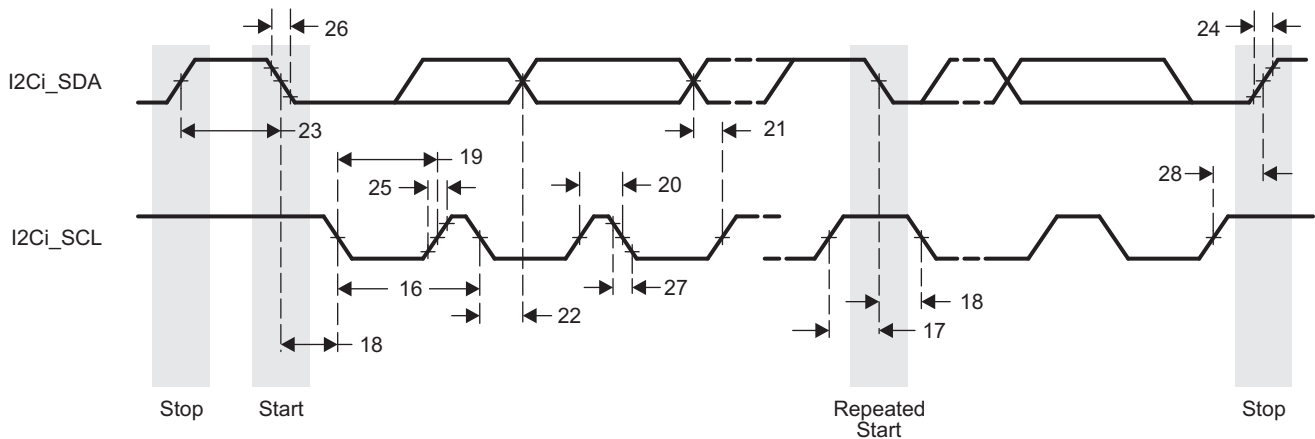
(1) C_b = total capacitance of one bus line in pF. If mixed with HS-mode devices, faster fall-times are allowed.

(2) Software must properly configure the I2C module registers to achieve the required timing parameters. For more information, see *Multimaster High Speed I2C Controller* section in the device TRM.

(3) These timings apply only to I2C1 and I2C2. I2C3, I2C4, I2C5 and I2C6 use standard LVCMOS buffers to emulate open-drain buffers and their rise/fall times should be referenced in the device IBIS model.

NOTE

I2C emulation is achieved by configuring the LVCMOS buffers to output Hi-Z instead of driving high when transmitting logic-1.



SPRS906_TIMING_I2C_02

Figure 7-24. I2C Transmit Timing

7.14 HDQ / 1-Wire Interface (HDQ1W)

The module is intended to work with both HDQ and 1-Wire protocols. The protocols use a single wire to communicate between the master and the slave. The protocols employ an asynchronous return to one mechanism where, after any command, the line is pulled high.

NOTE

For more information, see *HDQ/1-Wire* section in the device TRM.

7.14.1 HDQ / 1-Wire - HDQ Mode

Table 7-36 and Table 7-37 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 7-25, Figure 7-26, Figure 7-27 and Figure 7-28).

Table 7-36. HDQ/1-Wire Timing Requirements-HDQ Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|------------|--|-------------------|--------------------|---------|
| 1 | t_{CYCH} | Read bit window timing | 190 | 250 | μs |
| 2 | t_{HW1} | Read one data valid after HDQ low | 32 ⁽²⁾ | 66 ⁽²⁾ | μs |
| 3 | t_{HW0} | Read zero data hold after HDQ low | 70 ⁽²⁾ | 145 ⁽²⁾ | μs |
| 4 | t_{RSPS} | Response time from HDQ slave device ⁽¹⁾ | 190 | 320 | μs |

(1) Defined by software.

(2) If the HDQ slave device drives a logic-low state after t_{HW0} maximum, it can be interpreted as a break pulse. For more information, see "HDQ / 1-Wire Switching Characteristics - HDQ Mode" and HDQ/1-Wire section in the device TRM.

Table 7-37. HDQ / 1-Wire Switching Characteristics - HDQ Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|------------|------------------------------------|-----|-----|---------|
| 5 | t_B | Break timing | 190 | | μs |
| 6 | t_{BR} | Break recovery time | 40 | | μs |
| 7 | t_{CYCD} | Write bit windows timing | 190 | | μs |
| 8 | t_{DW1} | Write one data valid after HDQ low | 0.5 | 50 | μs |
| 9 | t_{DW0} | Write zero data hold after HDQ low | 86 | 145 | μs |

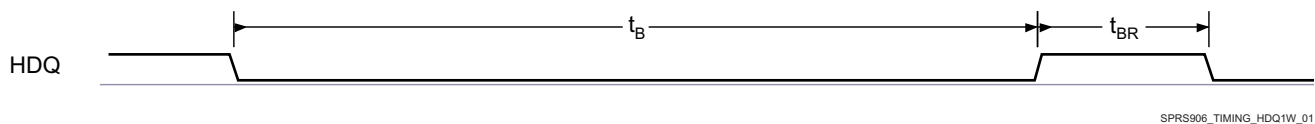


Figure 7-25. HDQ Break and Break Recovery Timing - HDQ Interface Writing to Slave

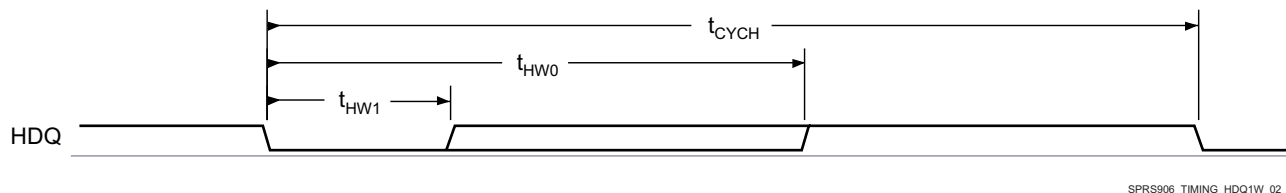


Figure 7-26. Device HDQ Interface Bit Read Timing (Data)

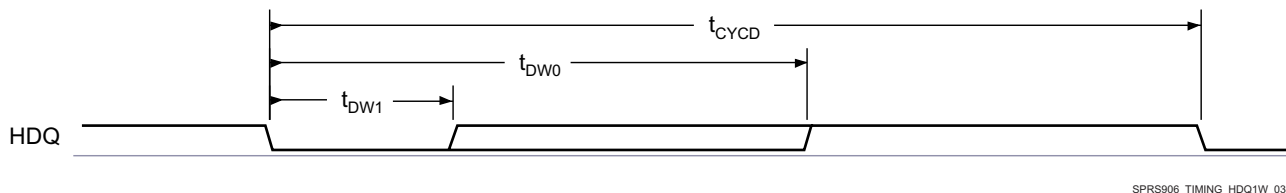


Figure 7-27. Device HDQ Interface Bit Write Timing (Command / Address or Data)

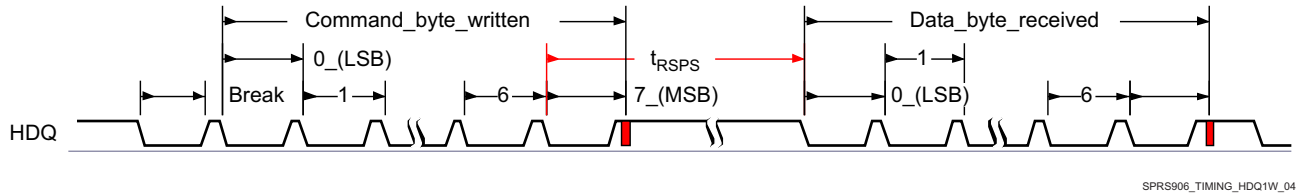


Figure 7-28. HDQ Communication Timing

7.14.2 HDQ/1-Wire-1-Wire Mode

Table 7-38 and Table 7-39 assume testing over the recommended operating conditions and electrical characteristic conditions below (see Figure 7-29, Figure 7-30 and Figure 7-31).

Table 7-38. HDQ / 1-Wire Timing Requirements - 1-Wire Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|-----------|---------------------------|------------|-----|---------|
| 10 | t_{PDH} | Presence pulse delay high | 15 | 60 | μs |
| 11 | t_{PDL} | Presence pulse delay low | 60 | 240 | μs |
| 12 | t_{RDV} | Read data valid time | t_{LOWR} | 15 | μs |
| 13 | t_{REL} | Read data release time | 0 | 45 | μs |

Table 7-39. HDQ / 1-Wire Switching Characteristics - 1-Wire Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|------------|-------------------------------------|-----|-----|---------|
| 14 | t_{RSTL} | Reset time low | 480 | 960 | μs |
| 15 | t_{RSTH} | Reset time high | 480 | | μs |
| 16 | t_{SLOT} | Bit cycle time | 60 | 120 | μs |
| 17 | t_{LOW1} | Write bit-one time | 1 | 15 | μs |
| 18 | t_{LOW0} | Write bit-zero time ⁽²⁾ | 60 | 120 | μs |
| 19 | t_{REC} | Recovery time | 1 | | μs |
| 20 | t_{LOWR} | Read bit strobe time ⁽¹⁾ | 1 | 15 | μs |

(1) t_{LOWR} (low pulse sent by the master) must be short as possible to maximize the master sampling window.

(2) t_{LOWR} must be less than t_{SLOT} .

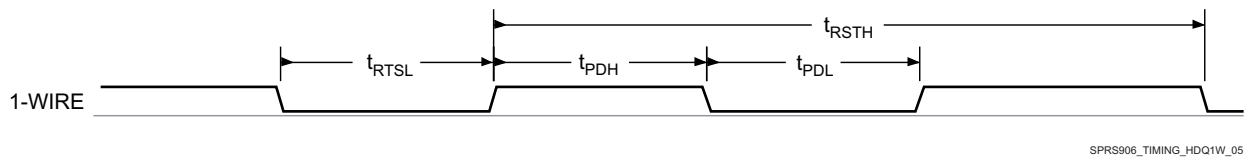


Figure 7-29. 1-Wire-Break (Reset)

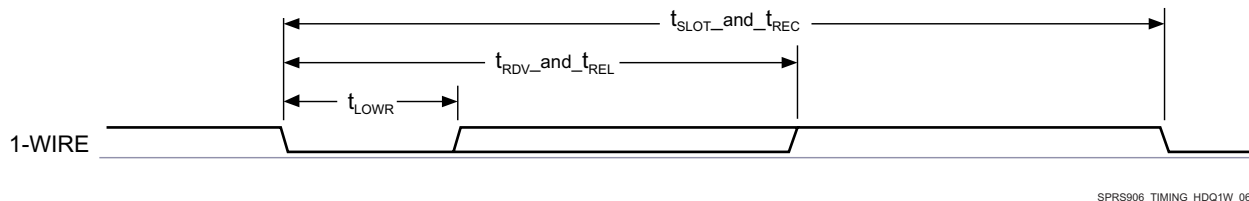
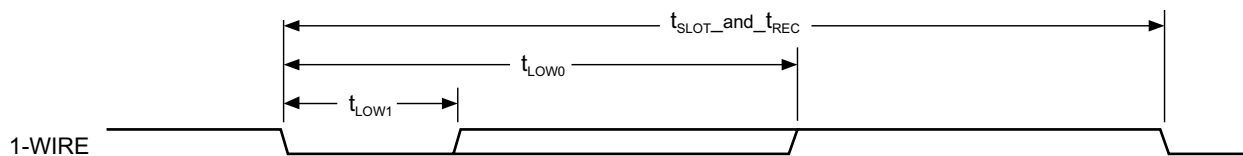


Figure 7-30. 1-Wire-Read Bit (Data)



SPRS906_TIMING_HDQ1W_07

Figure 7-31. 1-Wire-Write Bit-One Timing (Command / Address or Data)

7.15 Universal Asynchronous Receiver Transmitter (UART)

The UART performs serial-to-parallel conversions on data received from a peripheral device and parallel-to-serial conversion on data received from the CPU. There are 10 UART modules in the device. Only one UART supports IrDA features. Each UART can be used for configuration and data exchange with a number of external peripheral devices or interprocessor communication between devices

The UART_i (where *i* = 1 to 10) include the following features:

- 16C750 compatibility
- 64-byte FIFO buffer for receiver and 64-byte FIFO for transmitter
- Baud generation based on programmable divisors *N* (where *N* = 1...16 384) operating from a fixed functional clock of 48 MHz or 192 MHz
- Break character detection and generation
- Configurable data format:
 - Data bit: 5, 6, 7, or 8 bits
 - Parity bit: Even, odd, none
 - Stop-bit: 1, 1.5, 2 bit(s)
- Flow control: Hardware (RTS/CTS) or software (XON/XOFF)
- Only UART1 module has extended modem control signals (CD, RI, DTR, DSR)
- Only UART3 supports IrDA

NOTE

For more information, see *UART/IrDA/CIR* section in the device TRM.

Table 7-40, Table 7-41 and Figure 7-32 assume testing over the recommended operating conditions and electrical characteristic conditions below.

Table 7-40. Timing Requirements for UART

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|---------------|---|----------------------|----------------------|------|
| 4 | $t_{w(RX)}$ | Pulse width, receive data bit, 15/30/100pF high or low | 0.96U ⁽¹⁾ | 1.05U ⁽¹⁾ | ns |
| 5 | $t_{w(CTS)}$ | Pulse width, receive start bit, 15/30/100pF high or low | 0.96U ⁽¹⁾ | 1.05U ⁽¹⁾ | ns |
| | $t_d(RTS-TX)$ | Delay time, transmit start bit to transmit data | P ⁽²⁾ | | ns |
| | $t_d(CTS-TX)$ | Delay time, receive start bit to transmit data | P ⁽²⁾ | | ns |

(1) U = UART baud time = 1/programmed baud rate

(2) P = Clock period of the reference clock (FCLK, usually 48 MHz or 192MHz).

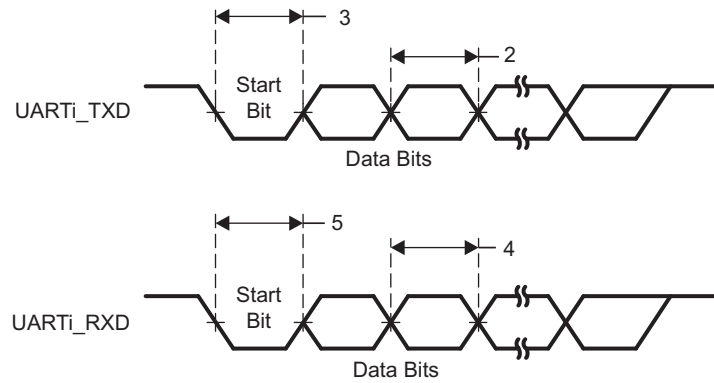
Table 7-41. Switching Characteristics Over Recommended Operating Conditions for UART

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|--------------|--|----------------------|----------------------|------|
| | $f_{(baud)}$ | Maximum programmable baud rate | | 12 | MHz |
| | | | 15 pF | 0.23 | |
| | | | 30 pF | 0.115 | |
| 2 | $t_{w(TX)}$ | Pulse width, transmit data bit, 15/30/100 pF high or low | U - 2 ⁽¹⁾ | U + 2 ⁽¹⁾ | ns |

Table 7-41. Switching Characteristics Over Recommended Operating Conditions for UART (continued)

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|--------------|---|---------------|---------------|------|
| 3 | $t_{w(RTS)}$ | Pulse width, transmit start bit, 15/30/100 pF high or low | $U - 2^{(1)}$ | $U + 2^{(1)}$ | ns |

(1) $U = \text{UART baud time} = 1/\text{programmed baud rate}$



SPRS906_TIMING_UART_01

Figure 7-32. UART Timing

7.16 Multichannel Serial Peripheral Interface (McSPI)

The McSPI is a master/slave synchronous serial bus. There are four separate McSPI modules (SPI1, SPI2, SPI3, and SPI4) in the device. All these four modules support up to four external devices (four chip selects) and are able to work as both master and slave.

The McSPI modules include the following main features:

- Serial clock with programmable frequency, polarity, and phase for each channel
- Wide selection of SPI word lengths, ranging from 4 to 32 bits
- Up to four master channels, or single channel in slave mode
- Master multichannel mode:
 - Full duplex/half duplex
 - Transmit-only/receive-only/transmit-and-receive modes
 - Flexible input/output (I/O) port controls per channel
 - Programmable clock granularity
 - SPI configuration per channel. This means, clock definition, polarity enabling and word width
- Power management through wake-up capabilities
- Programmable timing control between chip select and external clock generation
- Built-in FIFO available for a single channel.
- Each SPI module supports multiple chip select pins $\text{spim_cs}[i]$, where $i = 1$ to 4.

NOTE

For more information, see *Multichannel Serial Peripheral Interface* section in the device TRM.

NOTE

The McSPI m module ($m = 1$ to 4) is also referred to as SPI m .

CAUTION

The I/O timings provided in this section are applicable for all combinations of signals for SPI1 and SPI2. However, the timings are valid only for SPI3 and SPI4 if signals within a single IOSET are used. The IOSETS are defined in Table 7-44.

Table 7-42, Figure 7-33 and Figure 7-34 present Timing Requirements for McSPI - Master Mode.

Table 7-42. Timing Requirements for SPI - Master Mode ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|------------------------------|--|----------------------------|-----------------------------------|-----|------|
| SM1 | $t_c(\text{SPICLK})$ | Cycle time, spi_sclk ⁽¹⁾ ⁽²⁾ | SPI1/2/3/4 | 20.8 ⁽³⁾ | | ns |
| SM2 | $t_w(\text{SPICLK}_L)$ | Typical Pulse duration, spi_sclk low ⁽¹⁾ | | $0.5 \times P - 1$ ⁽⁴⁾ | | ns |
| SM3 | $t_w(\text{SPICLK}_H)$ | Typical Pulse duration, spi_sclk high ⁽¹⁾ | | $0.5 \times P - 1$ ⁽⁴⁾ | | ns |
| SM4 | $t_{su}(\text{MISO-SPICLK})$ | Setup time, spi_d[x] valid before spi_sclk active edge ⁽¹⁾ | | 3.5 | | ns |
| SM5 | $t_h(\text{SPICLK-MISO})$ | Hold time, spi_d[x] valid after spi_sclk active edge ⁽¹⁾ | | 3.7 | | ns |
| SM6 | $t_d(\text{SPICLK-SIMO})$ | Delay time, spi_sclk active edge to spi_d[x] transition ⁽¹⁾ | SPI1 | -3.57 | 4.1 | ns |
| | | | SPI2 | -3.9 | 3.6 | ns |
| | | | SPI3 | -4.9 | 4.7 | ns |
| | | | SPI4 | -4.3 | 4.5 | ns |
| SM7 | $t_d(\text{CS-SIMO})$ | Delay time, spi_cs[x] active edge to spi_d[x] transition | | | 5 | ns |
| SM8 | $t_d(\text{CS-SPICLK})$ | Delay time, spi_cs[x] active to spi_sclk first edge ⁽¹⁾ | MASTER_PHA0 ⁽⁵⁾ | B - 4.2 ⁽⁶⁾ | | ns |
| | | | MASTER_PHA1 ⁽⁵⁾ | A - 4.2 ⁽⁷⁾ | | ns |
| SM9 | $t_d(\text{SPICLK-CS})$ | Delay time, spi_sclk last edge to spi_cs[x] inactive ⁽¹⁾ | MASTER_PHA0 ⁽⁵⁾ | A - 4.2 ⁽⁷⁾ | | ns |
| | | | MASTER_PHA1 ⁽⁵⁾ | B - 4.2 ⁽⁶⁾ | | ns |

(1) This timing applies to all configurations regardless of SPI_CLK polarity and which clock edges are used to drive output data and capture input data.

(2) Related to the SPI_CLK maximum frequency.

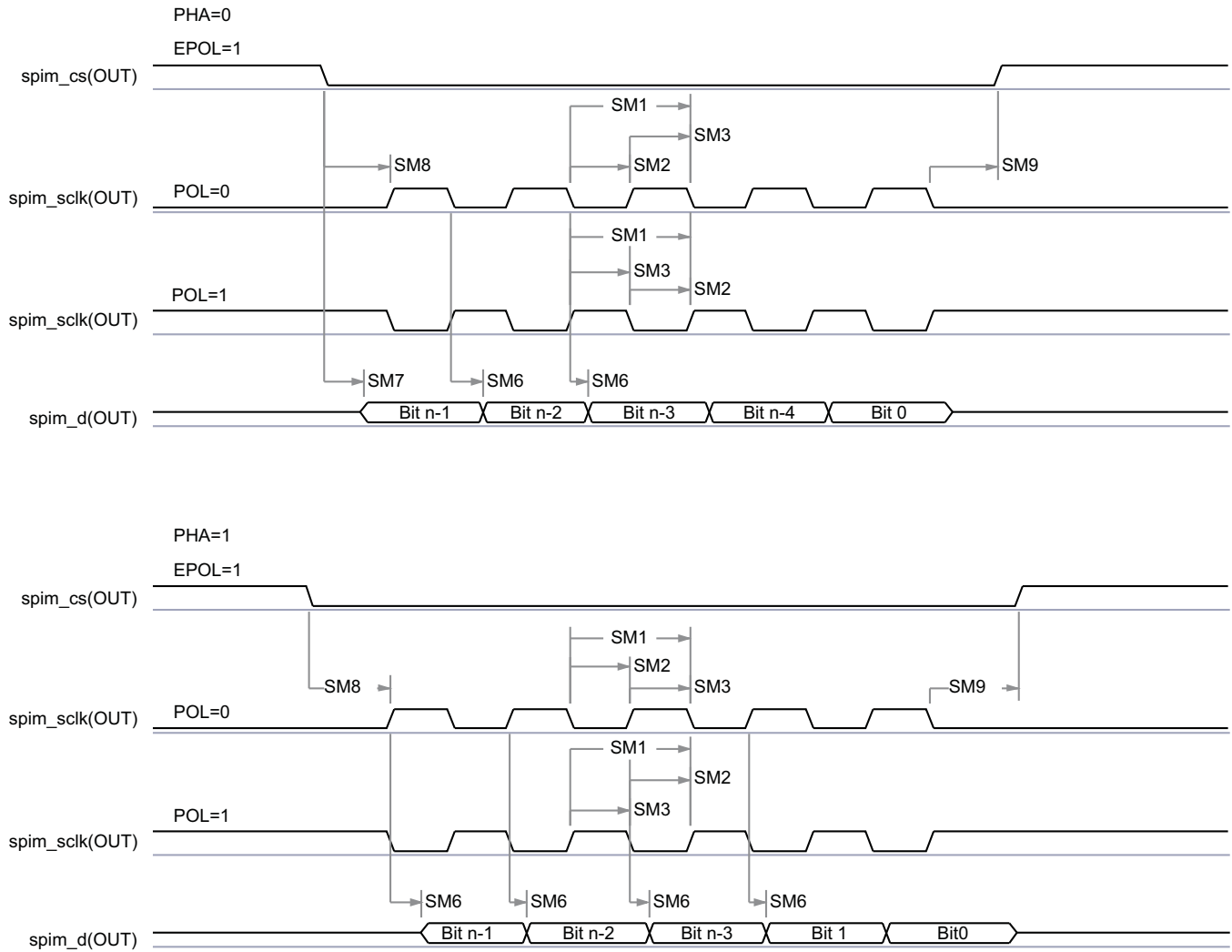
(3) 20.8ns cycle time = 48MHz

(4) P = SPICLK period.

(5) SPI_CLK phase is programmable with the PHA bit of the SPI_CH(i)CONF register.

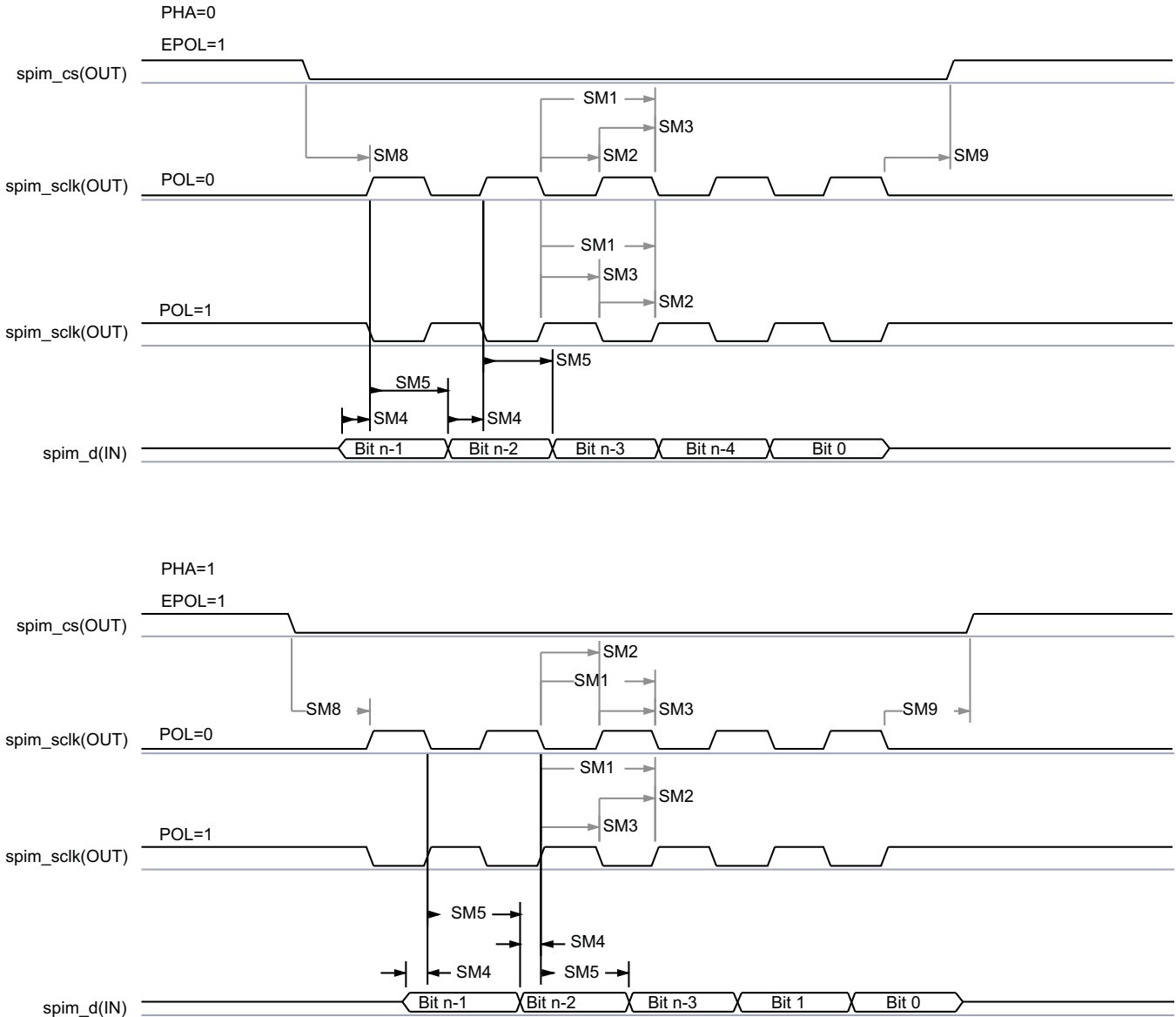
(6) $B = (TCS + 0.5) \times \text{TSPICLKREF} \times \text{Fratio}$, where TCS is a bit field of the SPI_CH(i)CONF register and Fratio = Even ≥ 2 .

(7) When P = 20.8 ns, $A = (TCS + 1) \times \text{TSPICLKREF}$, where TCS is a bit field of the SPI_CH(i)CONF register. When P > 20.8 ns, $A = (TCS + 0.5) \times \text{Fratio} \times \text{TSPICLKREF}$, where TCS is a bit field of the SPI_CH(i)CONF register.



SPRS906_TIMING_McSPI_01

Figure 7-33. McSPI - Master Mode Transmit



SPRS906_TIMING_McSPI_02

Figure 7-34. McSPI - Master Mode Receive

Table 7-43, Figure 7-35 and Figure 7-36 present Timing Requirements for McSPI - Slave Mode.

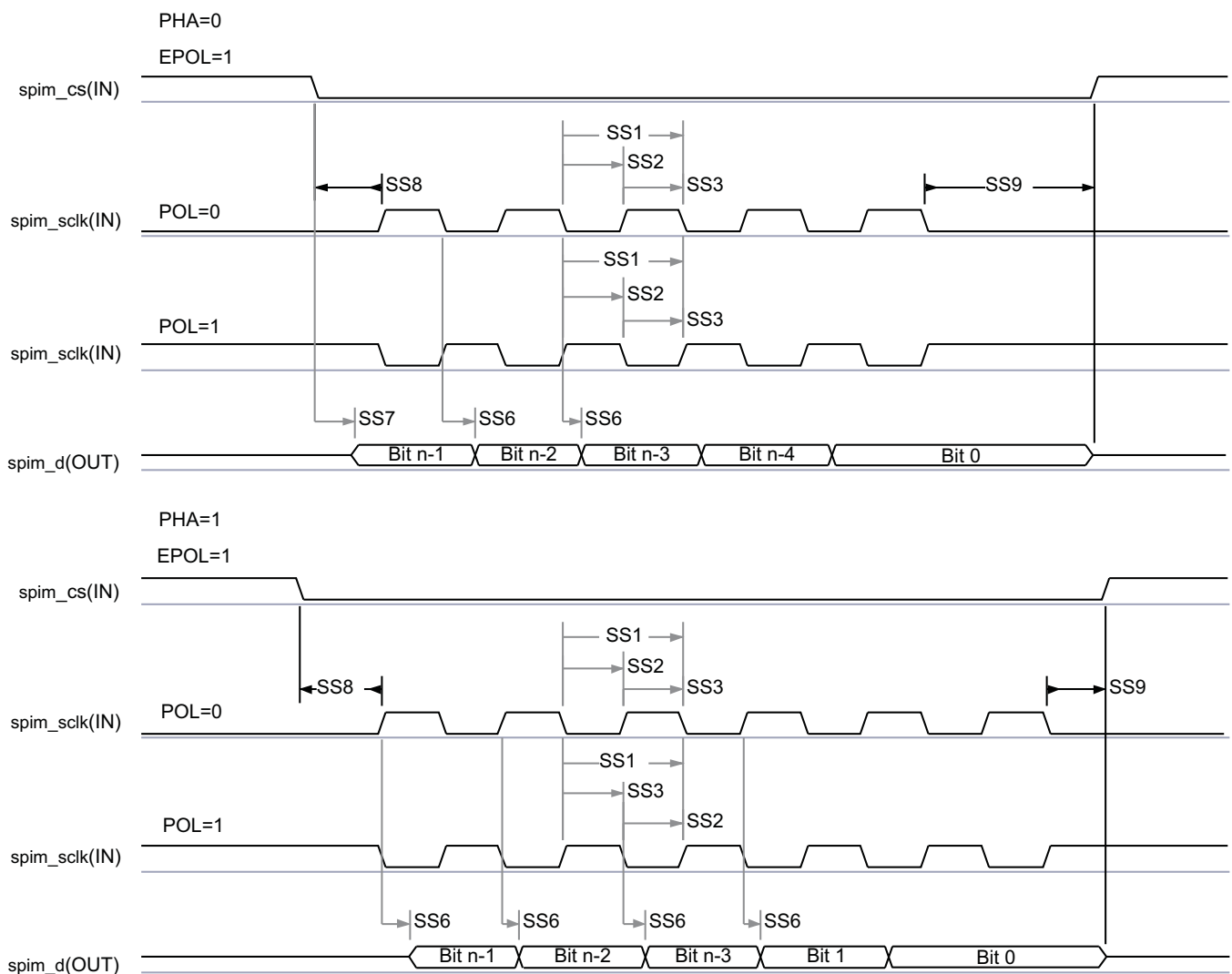
Table 7-43. Timing Requirements for SPI - Slave Mode

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|--------------------|------------------------------|---|----------|---------------------------------------|------|------|
| SS1 ⁽¹⁾ | $t_c(\text{SPICLK})$ | Cycle time, spi_sclk | | 62.5 ⁽²⁾ ⁽³⁾ | | ns |
| SS2 ⁽¹⁾ | $t_w(\text{SPICLK}_L)$ | Typical Pulse duration, spi_sclk low | | $0.45 \times P$ ⁽⁴⁾ | | ns |
| SS3 ⁽¹⁾ | $t_w(\text{SPICLK}_H)$ | Typical Pulse duration, spi_sclk high | | $0.45 \times P$ ⁽⁴⁾ | | ns |
| SS4 ⁽¹⁾ | $t_{su}(\text{SIMO-SPICLK})$ | Setup time, spi_d[x] valid before spi_sclk active edge | | 5 | | ns |
| SS5 ⁽¹⁾ | $t_h(\text{SPICLK-SIMO})$ | Hold time, spi_d[x] valid after spi_sclk active edge | | 5 | | ns |
| SS6 ⁽¹⁾ | $t_d(\text{SPICLK-SOMI})$ | Delay time, spi_sclk active edge to mcspi_somi transition | SPI1/2/3 | 2 | 26.6 | ns |
| | | | SPI4 | 2 | 20.1 | ns |

Table 7-43. Timing Requirements for SPI - Slave Mode (continued)

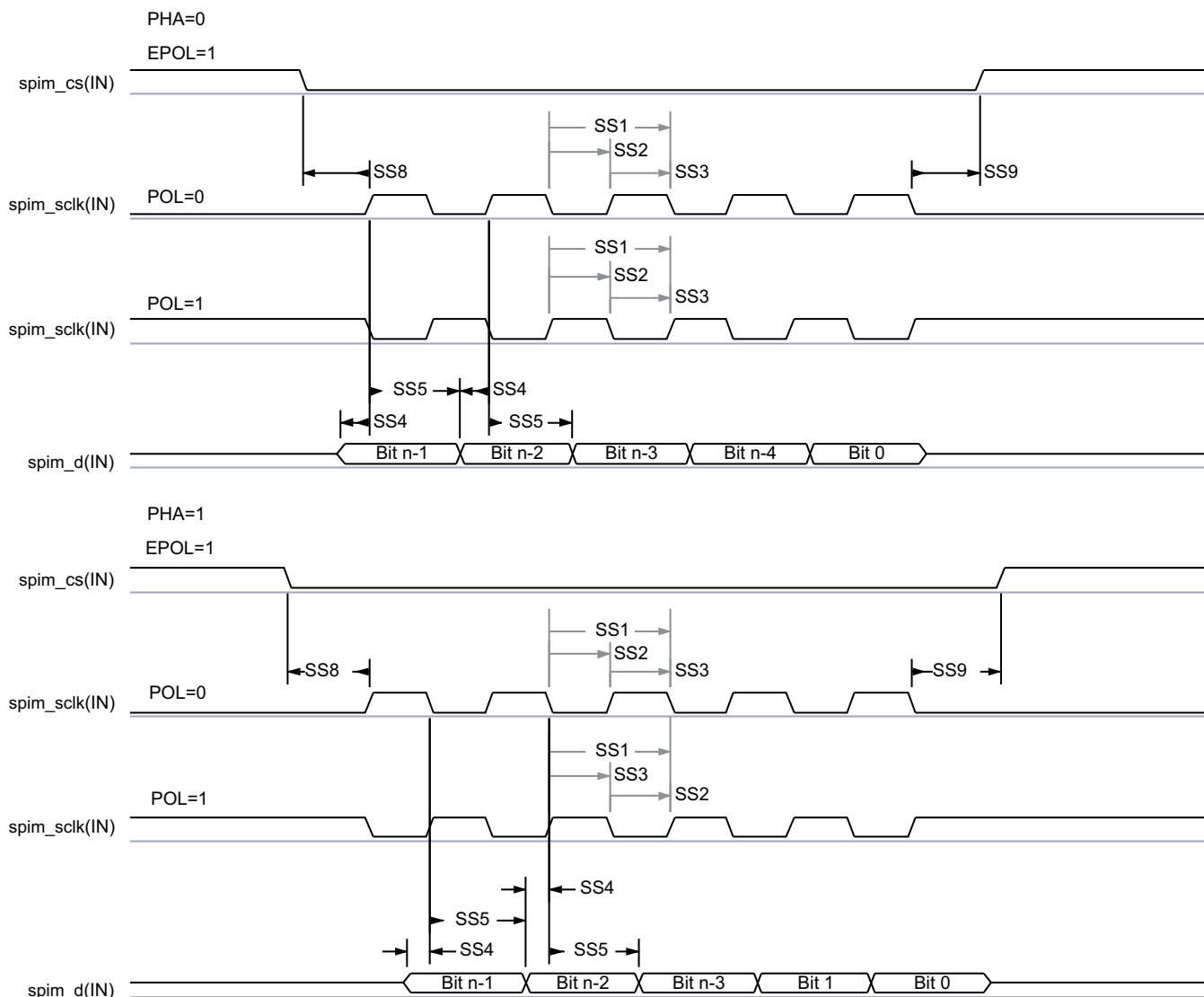
| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|--------------------|---------------------|--|--------|-----|-------|------|
| SS7 ⁽⁵⁾ | $t_{d(CS-SOMI)}$ | Delay time, spi_cs[x] active edge to mcspi_somi transition | | | 20.95 | ns |
| SS8 ⁽¹⁾ | $t_{su(CS-SPICLK)}$ | Setup time, spi_cs[x] valid before spi_sclk first edge | | 5 | | ns |
| SS9 ⁽¹⁾ | $t_{h(SPICLK-CS)}$ | Hold time, spi_cs[x] valid after spi_sclk last edge | SPI1/2 | 5 | | ns |
| | | | SPI3 | 7.5 | | ns |
| | | | SPI4 | 6 | | ns |

- (1) This timing applies to all configurations regardless of SPI_CLK polarity and which clock edges are used to drive output data and capture input data.
- (2) When operating the SPI interface in RX-only mode, the minimum Cycle time is 26ns (38.4MHz)
- (3) 62.5ns Cycle time = 16 MHz
- (4) P = SPICLK period.
- (5) PHA = 0; SPI_CLK phase is programmable with the PHA bit of the SPI_CH(i)CONF register.



SPRS906_TIMING_McSPI_03

Figure 7-35. McSPI - Slave Mode Transmit



SPRS906_TIMING_McSPI_04

Figure 7-36. McSPI - Slave Mode Receive

In Table 7-44 are presented the specific groupings of signals (IOSET) for use with SPI3 and SPI4.

Table 7-44. McSPI3/4 IOSETs

| SIGNALS | IOSET1 | | IOSET2 | | IOSET3 | | IOSET4 | | IOSET5 | |
|---------------|--------|-----|--------|-----|--------|-----|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX |
| McSPI3 | | | | | | | | | | |
| spi3_cs0 | D11 | 8 | V9 | 7 | A12 | 3 | D17 | 2 | AC9 | 1 |
| spi3_cs1 | B11 | 8 | AC3 | 1 | E14 | 3 | B11 | 8 | AC3 | 1 |
| spi3_cs2 | F11 | 8 | | | F11 | 8 | F11 | 8 | | |
| spi3_cs3 | A10 | 8 | | | A10 | 8 | A10 | 8 | | |
| spi3_d0 | C11 | 8 | W9 | 7 | B13 | 3 | G16 | 2 | AC6 | 1 |
| spi3_d1 | B10 | 8 | Y1 | 7 | A11 | 3 | A21 | 2 | AC7 | 1 |
| spi3_sclk | E11 | 8 | V2 | 7 | B12 | 3 | C18 | 2 | AC4 | 1 |
| McSPI4 | | | | | | | | | | |
| spi4_cs0 | P9 | 8 | F3 | 8 | U6 | 7 | AA4 | 2 | AB5 | 1 |

Table 7-44. McSPI3/4 IOSETs (continued)

| SIGNALS | IOSET1 | | IOSET2 | | IOSET3 | | IOSET4 | | IOSET5 | |
|-----------|--------|-----|--------|-----|--------|-----|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX |
| spi4_cs1 | P4 | 8 | P4 | 8 | Y1 | 8 | Y1 | 8 | Y1 | 8 |
| spi4_cs2 | R3 | 8 | R3 | 8 | W9 | 8 | W9 | 8 | W9 | 8 |
| spi4_cs3 | T2 | 8 | T2 | 8 | V9 | 8 | V9 | 8 | V9 | 8 |
| spi4_d0 | N9 | 8 | F2 | 8 | V6 | 7 | AB3 | 2 | AB8 | 1 |
| spi4_d1 | R4 | 8 | G6 | 8 | U7 | 7 | AB9 | 2 | AD6 | 1 |
| spi4_sclk | N7 | 8 | G1 | 8 | V7 | 7 | AA3 | 2 | AC8 | 1 |

7.17 Quad Serial Peripheral Interface (QSPI)

The Quad SPI (QSPI) module is a type of SPI module that allows single, dual or quad read access to external SPI devices. This module has a memory mapped register interface, which provides a direct interface for accessing data from external SPI devices and thus simplifying software requirements. It works as a master only. There is one QSPI module in the device and it is primary intended for fast booting from quad-SPI flash memories.

General SPI features:

- Programmable clock divider
- Six pin interface (DCLK, CS_N, DOUT, DIN, QDIN1, QDIN2)
- 4 external chip select signals
- Support for 3-, 4- or 6-pin SPI interface
- Programmable CS_N to DOUT delay from 0 to 3 DCLKs
- Programmable signal polarities
- Programmable active clock edge
- Software controllable interface allowing for any type of SPI transfer

NOTE

For more information, see *Quad Serial Peripheral Interface* section in the device TRM.

CAUTION

The I/O Timings provided in this section are only valid when all QSPI Chip Selects used in a system are configured to use the same Clock Mode (either Clock Mode 0 or Clock Mode 3).

CAUTION

The I/O Timings provided in this section are valid only for some QSPI usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

Table 7-45 and Table 7-46 Present Timing and Switching Characteristics for Quad SPI Interface.

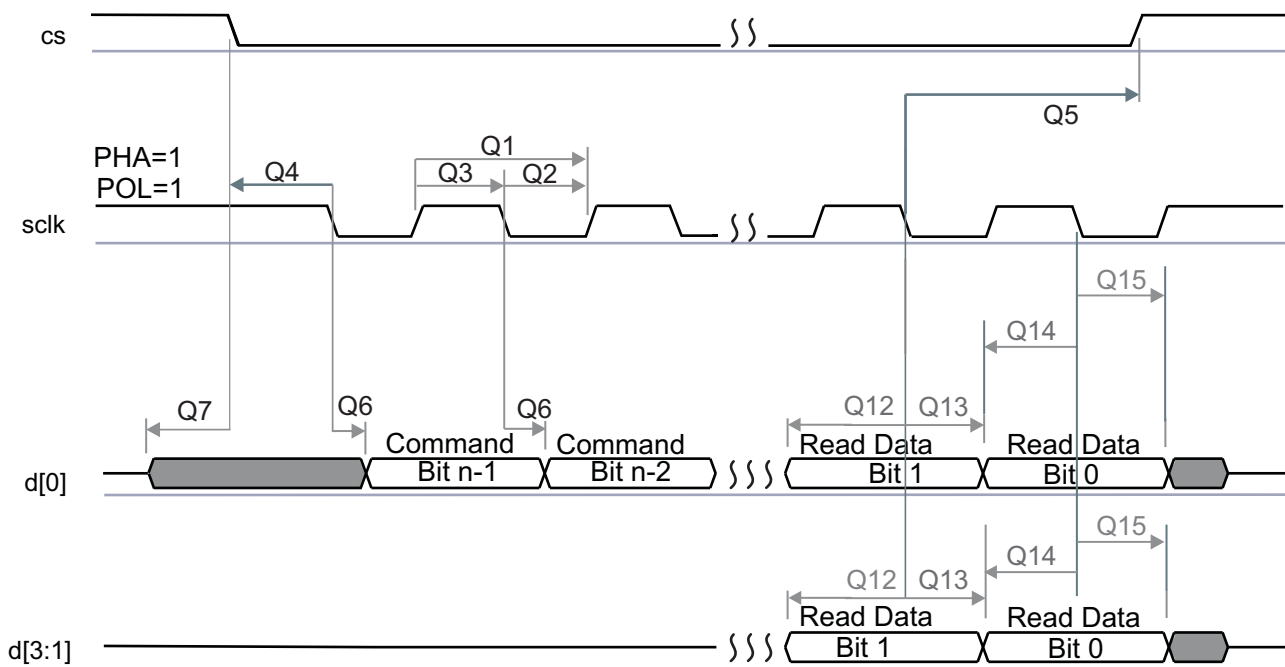
Table 7-45. Switching Characteristics for QSPI

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|----------------------------------|--|-----------------------------------|---|---|------|
| Q1 | $t_c(\text{SCLK})$ | Cycle time, sclk | Default Timing Mode, Clock Mode 0 | 11.71 | | ns |
| | | | Default Timing Mode, Clock Mode 3 | 20.8 | | ns |
| Q2 | $t_w(\text{SCLKL})$ | Pulse duration, sclk low | | $Y \times P - 1^{(1)}$ | | ns |
| Q3 | $t_w(\text{SCLKH})$ | Pulse duration, sclk high | | $Y \times P - 1^{(1)}$ | | ns |
| Q4 | $t_d(\text{CS-SCLK})$ | Delay time, sclk falling edge to cs active edge, CS3:0 | Default Timing Mode | $-M \times P - 1.6^{(2)}$ ₍₃₎ | $-M \times P + 2.6^{(2)}$ ₍₃₎ | ns |
| Q5 | $t_d(\text{SCLK-CS})$ | Delay time, sclk falling edge to cs inactive edge, CS3:0 | Default Timing Mode | $N \times P - 1.6^{(2)}$ ₍₃₎ | $N \times P + 2.6^{(2)}$ ₍₃₎ | ns |
| Q6 | $t_d(\text{SCLK-D0})$ | Delay time, sclk falling edge to d[0] transition | Default Timing Mode | -1.6 | 2.6 | ns |
| Q7 | $t_{\text{ena}}(\text{CS-D0LZ})$ | Enable time, cs active edge to d[0] driven (lo-z) | | -P - 3.5 | -P + 2.5 | ns |
| Q8 | $t_{\text{dis}}(\text{CS-D0Z})$ | Disable time, cs active edge to d[0] tri-stated (hi-z) | | -P - 2.5 | -P + 2.0 | ns |
| Q9 | $t_d(\text{SCLK-D0})$ | Delay time, sclk first falling edge to first d[0] transition | PHA=0 Only, Default Timing Mode | $-1.6 - P^{(2)}$ | $2.6 - P^{(2)}$ | ns |

(1) The Y parameter is defined as follows:
 If DCLK_DIV is 0 or ODD then, Y equals 0.5.
 If DCLK_DIV is EVEN then, Y equals (DCLK_DIV/2) / (DCLK_DIV+1).
 For best performance, it is recommended to use a DCLK_DIV of 0 or ODD to minimize the duty cycle distortion. The HSDIVIDER on CLKOUTX2_H13 output of DPLL_PER can be used to achieve the desired clock divider ratio. All required details about clock division factor DCLK_DIV can be found in the device-specific Technical Reference Manual.

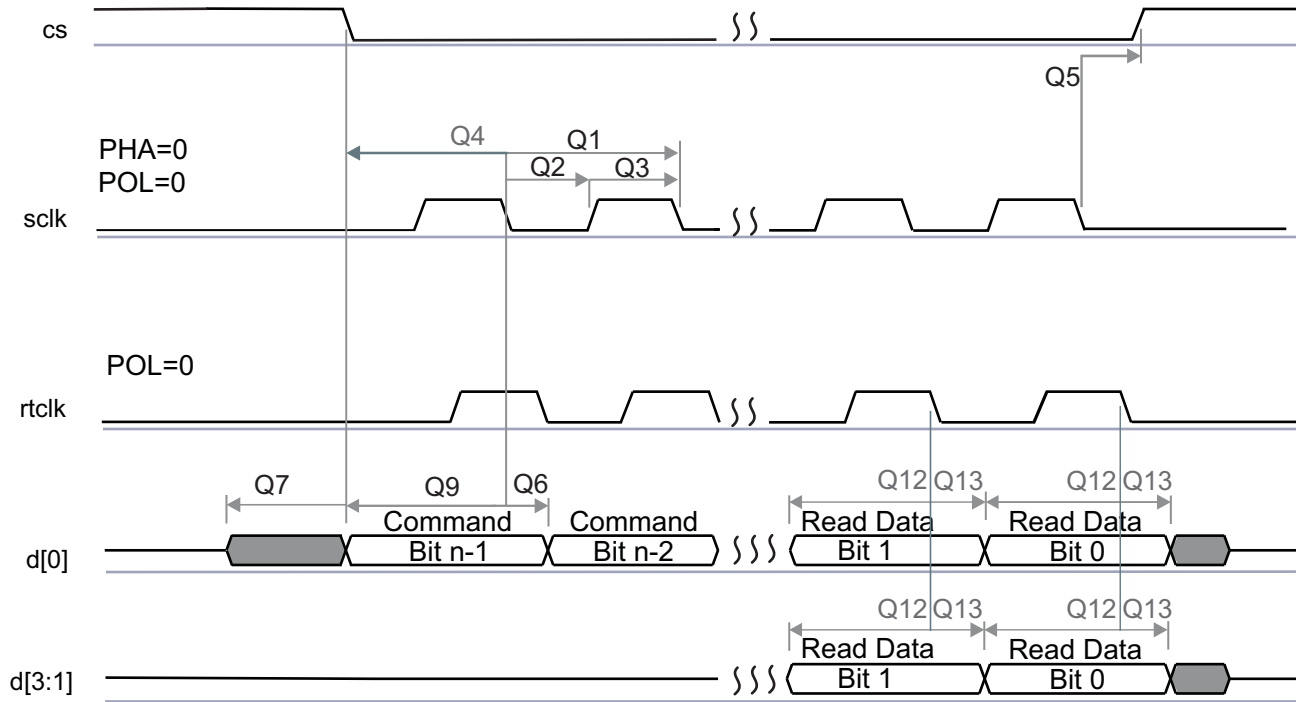
(2) P = SCLK period.

(3) M=QSPI_SPI_DC_REG.DDx + 1 when Clock Mode 0.
 M=QSPI_SPI_DC_REG.DDx when Clock Mode 3.
 N = 2 when Clock Mode 0.
 N = 3 when Clock Mode 3.



SPRS85v_TIMING_OSP1_01

Figure 7-37. QSPI Read (Clock Mode 3)



SPRS85v_TIMING_OSP1_02

Figure 7-38. QSPI Read (Clock Mode 0)

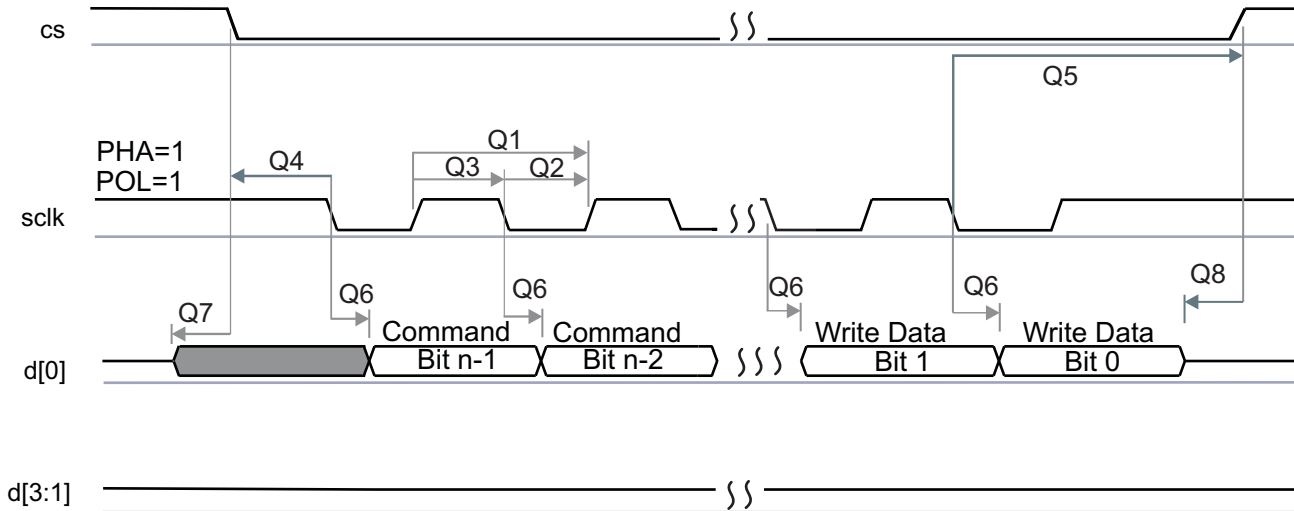
CAUTION

The I/O Timings provided in this section are valid only for some QSPI usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

Table 7-46. Timing Requirements for QSPI⁽³⁾⁽²⁾

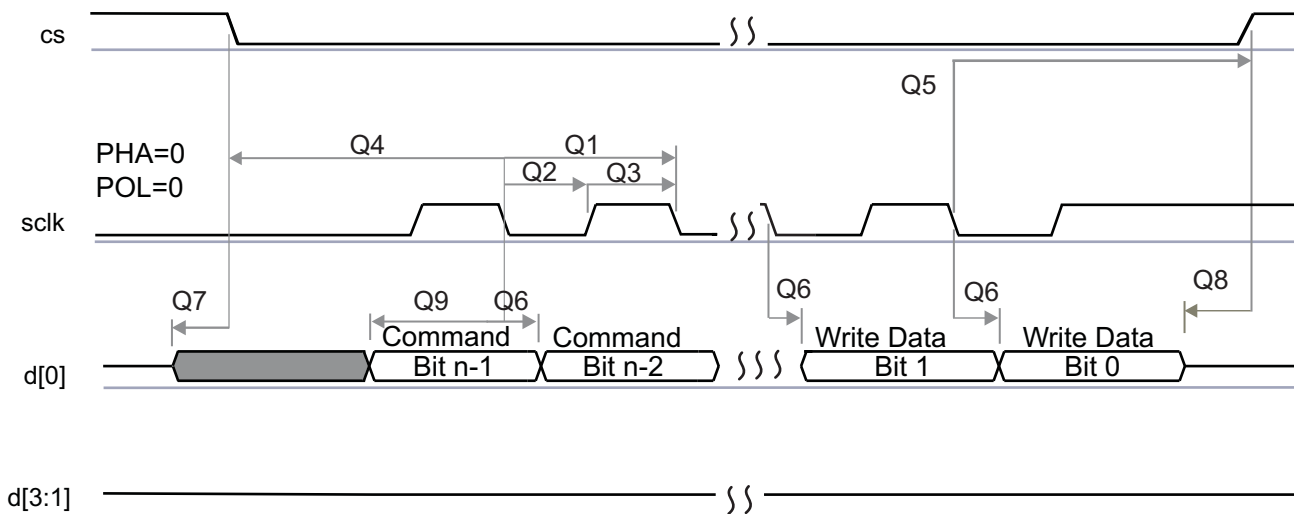
| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|-------------------|---|-----------------------------------|-------------------------|-----|------|
| Q12 | $t_{su}(D-RTCLK)$ | Setup time, d[3:0] valid before falling rtclk edge | Default Timing Mode, Clock Mode 0 | 4.6 | | ns |
| | $t_{su}(D-SCLK)$ | Setup time, d[3:0] valid before falling sclk edge | Default Timing Mode, Clock Mode 3 | 12.3 | | ns |
| Q13 | $t_h(RTCLK-D)$ | Hold time, d[3:0] valid after falling rtclk edge | Default Timing Mode, Clock Mode 0 | -0.1 | | ns |
| | $t_h(SCLK-D)$ | Hold time, d[3:0] valid after falling sclk edge | Default Timing Mode, Clock Mode 3 | 0.1 | | ns |
| Q14 | $t_{su}(D-SCLK)$ | Setup time, final d[3:0] bit valid before final falling sclk edge | Default Timing Mode, Clock Mode 3 | 12.3 - P ⁽¹⁾ | | ns |
| Q15 | $t_h(SCLK-D)$ | Hold time, final d[3:0] bit valid after final falling sclk edge | Default Timing Mode, Clock Mode 3 | 0.1 + P ⁽¹⁾ | | ns |

- (1) P = SCLK period.
- (2) Clock Modes 1 and 2 are not supported.
- (3) The Device captures data on the falling clock edge in Clock Mode 0 and 3, as opposed to the traditional rising clock edge. Although non-standard, the falling-edge-based setup and hold time timings have been designed to be compatible with standard SPI devices that launch data on the falling edge in Clock Modes 0 and 3.



SPRS85v_TIMING_OSP11_03

Figure 7-39. QSPI Write (Clock Mode 3)



SPRS85v_TIMING_OSP11_04

Figure 7-40. QSPI Write (Clock Mode 0)

CAUTION

The I/O Timings provided in this section are valid only for some QSPI usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

NOTE

To configure the desired Manual IO Timing Mode the user must follow the steps described in section Manual IO Timing Modes of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information see *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for QSPI. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-47 Manual Functions Mapping for QSPI](#) for a definition of the Manual modes.

[Table 7-47](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-47. Manual Functions Mapping for QSPI

| BALL | BALL NAME | QSPI1_MANUAL1 | | CFG REGISTER | MUXMODE |
|------|-----------|---------------|--------------|------------------|-------------|
| | | A_DELAY (ps) | G_DELAY (ps) | | 1 |
| T7 | gpmc_a3 | 0 | 0 | CFG_GPMC_A3_OUT | qspi1_cs2 |
| P6 | gpmc_a4 | 0 | 0 | CFG_GPMC_A4_OUT | qspi1_cs3 |
| R3 | gpmc_a13 | 0 | 0 | CFG_GPMC_A13_IN | qspi1_rtclk |
| T2 | gpmc_a14 | 2247 | 1186 | CFG_GPMC_A14_IN | qspi1_d3 |
| U2 | gpmc_a15 | 2176 | 1197 | CFG_GPMC_A15_IN | qspi1_d2 |
| U1 | gpmc_a16 | 2229 | 1268 | CFG_GPMC_A16_IN | qspi1_d0 |
| U1 | gpmc_a16 | 0 | 0 | CFG_GPMC_A16_OUT | qspi1_d0 |
| P3 | gpmc_a17 | 2251 | 1217 | CFG_GPMC_A17_IN | qspi1_d1 |
| R2 | gpmc_a18 | 0 | 0 | CFG_GPMC_A18_OUT | qspi1_sclk |
| P2 | gpmc_cs2 | 0 | 0 | CFG_GPMC_CS2_OUT | qspi1_cs0 |
| P1 | gpmc_cs3 | 0 | 0 | CFG_GPMC_CS3_OUT | qspi1_cs1 |

7.18 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 intercomponent digital audio interface transmission (DIT).

The device have integrated 8 McASP modules (McASP1-McASP8) with:

- McASP1 and McASP2 modules supporting 16 channels with independent TX/RX clock/sync domain
- McASP3 through McASP8 modules supporting 4 channels with independent TX/RX clock/sync domain

NOTE

For more information, see *Multichannel Audio Serial Port* section in the device TRM.

CAUTION

The I/O Timings provided in this section are valid only for some McASP usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

[Table 7-48](#), [Table 7-49](#), [Table 7-50](#) and [Figure 7-41](#) present Timing Requirements for McASP1 to McASP8

Table 7-48. Timing Requirements for McASP1⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|----------------------|--|-----------------------------------|-------------------------|-----|------|
| 1 | $t_{c(AHCLKX)}$ | Cycle time, AHCLKX | | 20 | | ns |
| 2 | $t_{w(AHCLKX)}$ | Pulse duration, AHCLKX high or low | | 0.35P ⁽²⁾ | | ns |
| 3 | $t_{c(ACLKRX)}$ | Cycle time, ACLKR/X | | 20 | | ns |
| 4 | $t_{w(ACLKRX)}$ | Pulse duration, ACLKR/X high or low | | 0.5R - 3 ⁽³⁾ | | ns |
| 5 | $t_{su(AFSRX-ACLK)}$ | Setup time, AFSRX input valid before ACLKR/X | ACLKR/X int | 20.5 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 4 | | ns |
| 6 | $t_h(ACLK-AFSRX)$ | Hold time, AFSRX input valid after ACLKR/X | ACLKR/X int | -1 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 1.7 | | ns |
| 7 | $t_{su(AXR-ACLK)}$ | Setup time, AXR input valid before ACLKR/X | ACLKR/X int | 21.6 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 11.5 | | ns |
| 8 | $t_h(ACLK-AXR)$ | Hold time, AXR input valid after ACLKR/X | ACLKR/X int | -1 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 1.8 | | ns |

(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 = AHCLKX period in ns.

(3) R = ACLKR/X period in ns.

Table 7-49. Timing Requirements for McASP2⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|----------------------|---|--|-------------------------|-----|------|
| 1 | $t_{c(AHCLKX)}$ | Cycle time, AHCLKX | | 20 | | ns |
| 2 | $t_{w(AHCLKX)}$ | Pulse duration, AHCLKX high or low | | 0.35P ⁽²⁾ | | ns |
| 3 | $t_{c(ACLKRX)}$ | Cycle time, ACLKR/X | Any Other Conditions | 20 | | ns |
| | | | ACLKX/AFSX (In Sync Mode), ACLKR/AFSR (In Async Mode), and AXR are all inputs "80M" Virtual IO Timing Modes | 12.5 | | ns |
| 4 | $t_{w(ACLKRX)}$ | Pulse duration, ACLKR/X high or low | Any Other Conditions | 0.5R - 3 ⁽³⁾ | | ns |
| | | | ACLKX/AFSX (In Sync Mode), ACLKR/AFSR (In Async Mode), and AXR are all inputs "80M" Virtual IO Timing Modes | 0.38R ⁽³⁾ | | ns |
| 5 | $t_{su(AFSRX-ACLK)}$ | Setup time, AFSRX input valid before ACLKR/X | ACLKR/X int | 20.3 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 4.5 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out "80M" Virtual IO Timing Modes | 3 | | ns |

Table 7-49. Timing Requirements for McASP2⁽¹⁾ (continued)

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|---------------------|--|--|------|-----|------|
| 6 | $t_{h(ACLK-AFSRX)}$ | Hold time, AFSRX input valid after ACLKR/X | ACLKR/X int | -1 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 1.8 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out "80M" Virtual IO Timing Modes | 3 | | ns |
| 7 | $t_{su}(AXR-ACLK)$ | Setup time, AXR input valid before ACLKR/X | ACLKR/X int | 21.1 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 4.5 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out "80M" Virtual IO Timing Modes | 3 | | ns |
| 8 | $t_{h}(ACLK-AXR)$ | Hold time, AXR input valid after ACLKR/X | ACLKR/X int | -1 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 1.8 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out "80M" Virtual IO Timing Modes | 3 | | ns |

(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 = AHCLKX period in ns.

(3) R = ACLKR/X period in ns.

Table 7-50. Timing Requirements for McASP3/4/5/6/7/8⁽¹⁾

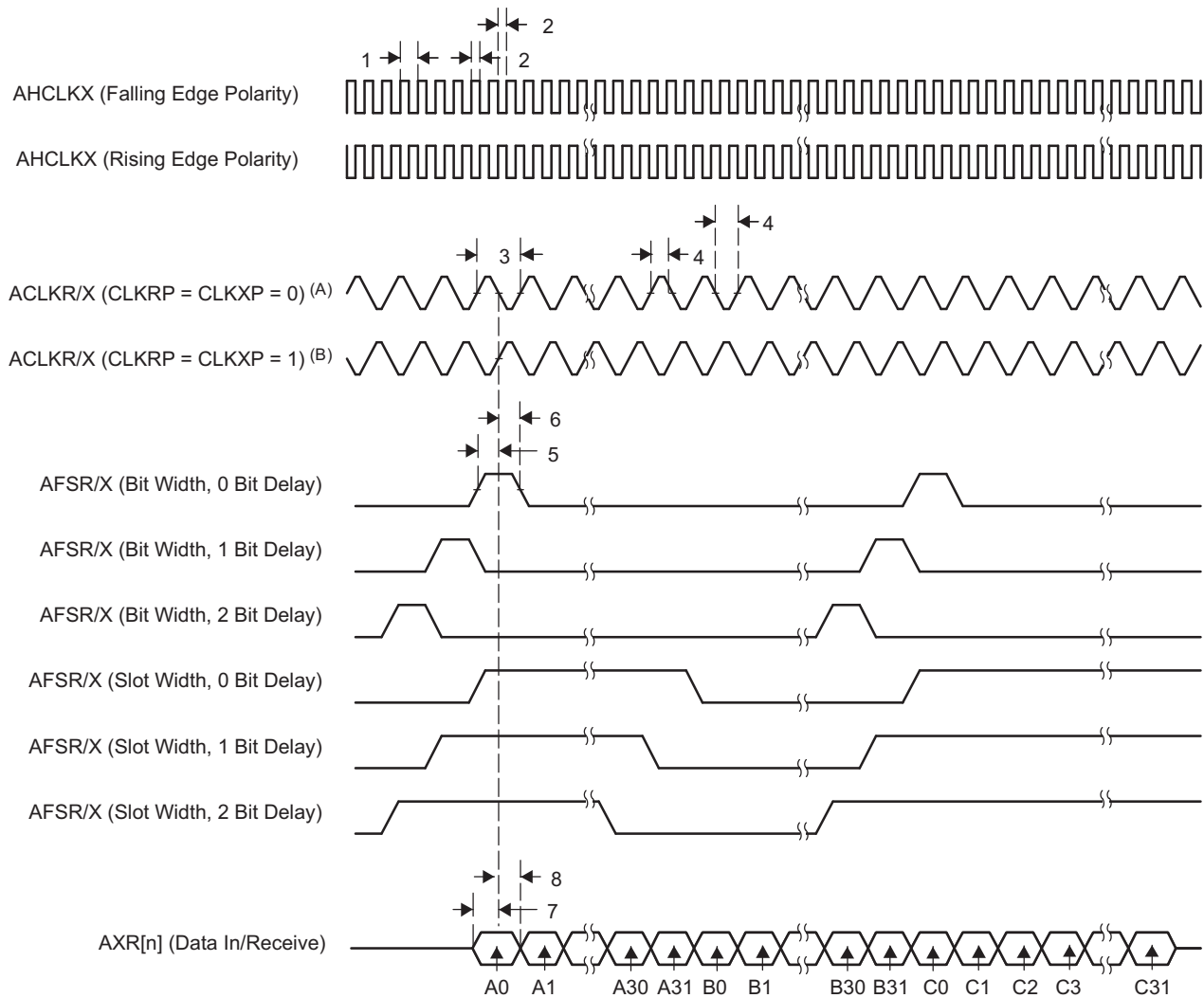
| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|----------------------|--|-----------------------------------|-----------------|-----|------|
| 1 | $t_{c}(AHCLKX)$ | Cycle time, AHCLKX | | 20 | | ns |
| 2 | $t_{w}(AHCLKX)$ | Pulse duration, AHCLKX high or low | | 0.35P (2) | | ns |
| 3 | $t_{c}(ACLKR/X)$ | Cycle time, ACLKR/X | | 20 | | ns |
| 4 | $t_{w}(ACLKR/X)$ | Pulse duration, ACLKR/X high or low | | 0.5R - 3 (3) | | ns |
| 5 | $t_{su}(AFSRX-ACLK)$ | Setup time, AFSRX input valid before ACLKR/X | ACLKR/X int | 19.7 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 5.6 | | ns |
| 6 | $t_{h}(ACLK-AFSRX)$ | Hold time, AFSRX input valid after ACLKR/X | ACLKR/X int | -1.1 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 2.5 | | ns |
| | $t_{su}(AXR-ACLK)$ | Setup time, AXR input valid before ACLKX | ACLKX int (ASYNC=0) | 20.3 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 5.1 | | ns |
| 8 | $t_{h}(ACLK-AXR)$ | Hold time, AXR input valid after ACLKX | ACLKX int (ASYNC=0) | -0.8 | | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 2.5 | | ns |

(1) ACLKR internal: ACLKRCTL.CLKRM=1, PDIR.ACLKR = 1 (NOT SUPPORTED)

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 = AHCLKX period in ns.

(3) R = ACLKR/X period in ns.



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- 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 7-41. McASP Input Timing

Table 7-51, Table 7-52, Table 7-53 and Figure 7-42 present Switching Characteristics Over Recommended Operating Conditions for McASP1 to McASP8.

Table 7-51. Switching Characteristics Over Recommended Operating Conditions for McASP1⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|-----------------|------------------------------------|------|---------------------------|-----|------|
| 9 | $t_{c(AHCLKX)}$ | Cycle time, AHCLKX | | 20 | | ns |
| 10 | $t_{w(AHCLKX)}$ | Pulse duration, AHCLKX high or low | | 0.5P - 2.5 ⁽²⁾ | | ns |
| 11 | $t_{c(ACLKRX)}$ | Cycle time, ACLKR/X | | 20 | | ns |

Table 7-51. Switching Characteristics Over Recommended Operating Conditions for McASP1⁽¹⁾ (continued)

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|---------------------|--|-----------------------------------|---------------------------|------|------|
| 12 | $t_{w(ACLKRX)}$ | Pulse duration, ACLKR/X high or low | | 0.5P - 2.5 ⁽³⁾ | | ns |
| 13 | $t_{d(ACLK-AFSXR)}$ | Delay time, ACLKR/X transmit edge to AFSX/R output valid | ACLKR/X int | -0.9 | 6 | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 2 | 23.1 | ns |
| 14 | $t_{d(ACLK-AXR)}$ | Delay time, ACLKR/X transmit edge to AXR output valid | ACLKR/X int | -1.4 | 6 | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 2 | 24.2 | ns |

(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 = AHCLKX period in ns.

(3) R = ACLKR/X period in ns.

Table 7-52. Switching Characteristics Over Recommended Operating Conditions for McASP2⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|---------------------|--|-----------------------------------|---------------------------|------|------|
| 9 | $t_{c(AHCLKX)}$ | Cycle time, AHCLKX | | 20 | | ns |
| 10 | $t_{w(AHCLKX)}$ | Pulse duration, AHCLKX high or low | | 0.5P - 2.5 ⁽²⁾ | | ns |
| 11 | $t_{c(ACLKRX)}$ | Cycle time, ACLKR/X | | 20 | | ns |
| 12 | $t_{w(ACLKRX)}$ | Pulse duration, ACLKR/X high or low | | 0.5P - 2.5 ⁽³⁾ | | ns |
| 13 | $t_{d(ACLK-AFSXR)}$ | Delay time, ACLKR/X transmit edge to AFSX/R output valid | ACLKR/X int | -1 | 6 | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 2 | 23.2 | ns |
| 14 | $t_{d(ACLK-AXR)}$ | Delay time, ACLKR/X transmit edge to AXR output valid | ACLKR/X int | -1.3 | 6 | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 2 | 23.7 | ns |

(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 = AHCLKX period in ns.

(3) R = ACLKR/X period in ns.

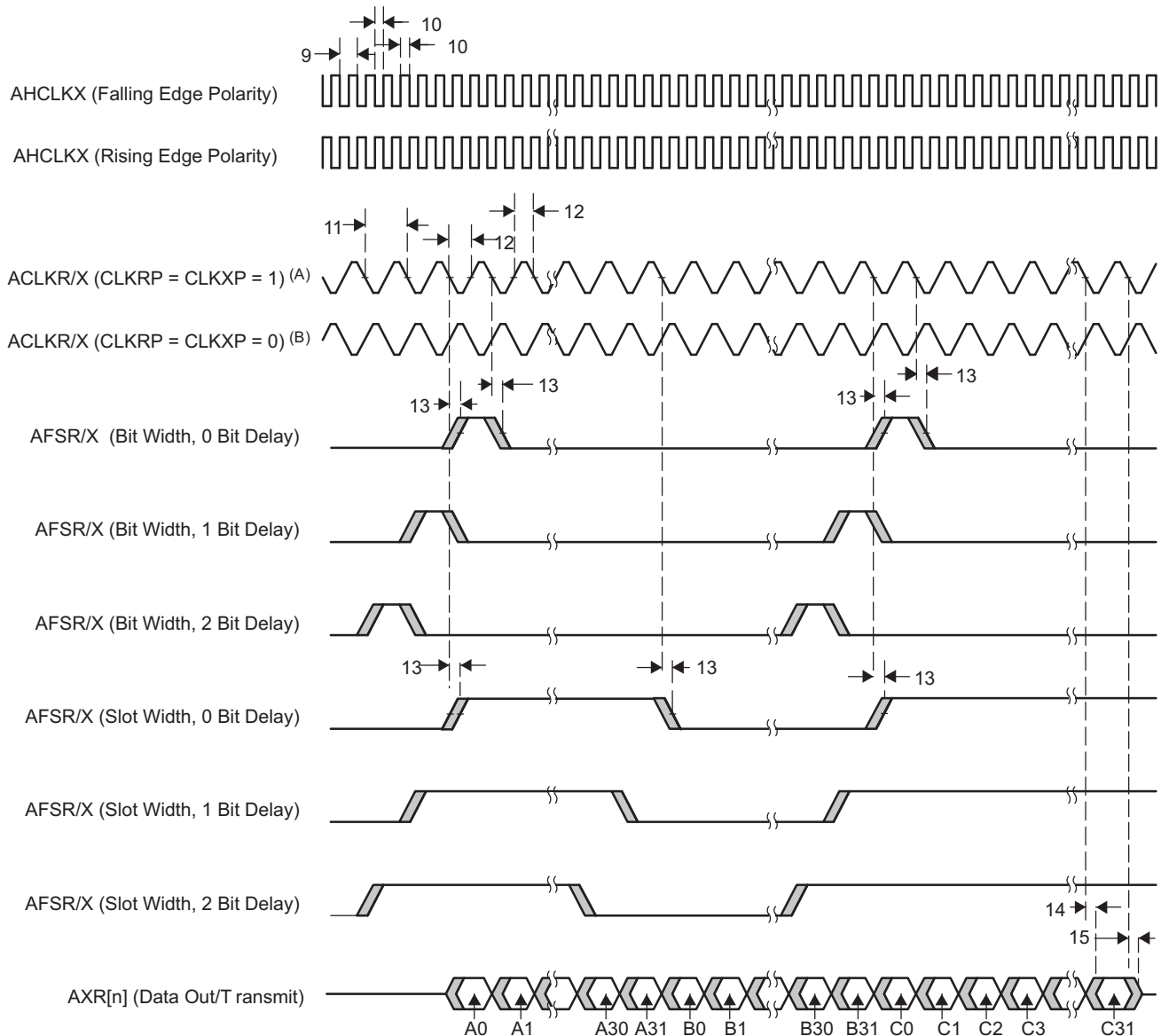
Table 7-53. Switching Characteristics Over Recommended Operating Conditions for McASP3/4/5/6/7/8⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|-----------------|-------------------------------------|------|---------------------------|-----|------|
| 9 | $t_{c(AHCLKX)}$ | Cycle time, AHCLKX | | 20 | | ns |
| 10 | $t_{w(AHCLKX)}$ | Pulse duration, AHCLKX high or low | | 0.5P - 2.5 ⁽²⁾ | | ns |
| 11 | $t_{c(ACLKRX)}$ | Cycle time, ACLKR/X | | 20 | | ns |
| 12 | $t_{w(ACLKRX)}$ | Pulse duration, ACLKR/X high or low | | 0.5P - 2.5 ⁽³⁾ | | ns |

Table 7-53. Switching Characteristics Over Recommended Operating Conditions for McASP3/4/5/6/7/8⁽¹⁾ (continued)

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|---------------------|--|-----------------------------------|------|------|------|
| 13 | $t_{d(ACLK-AFSXR)}$ | Delay time, ACLKR/X transmit edge to AFSX/R output valid | ACLKR/X int | -0.5 | 6 | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 1.9 | 24.5 | ns |
| 14 | $t_{d(ACLK-AXR)}$ | Delay time, ACLKR/X transmit edge to AXR output valid | ACLKR/X int | -1.4 | 7.1 | ns |
| | | | ACLKR/X ext in ACLKR/X ext out | 1.1 | 24.2 | ns |

- (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 = AHCLKX period in ns.
- (3) R = ACLKR/X period in ns.



SPRS906_TIMING_McASP_02

- A. 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).
- B. 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).

Figure 7-42. McASP Output Timing

Table 7-54 through Table 7-61 explain all cases with Virtual Mode Details for McASP1/2/3/4/5/6/7/8 (see Figure 7-43 through Figure 7-50).

Table 7-54. Virtual Mode Case Details for McASP1

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|-----------------|--------|---|-----------------------|---------------------------|-----------------|
| | | | Signals | Virtual Mode Value | |
| IP Mode : ASYNC | | | | | |
| 1 | COIFOI | CLKX / FSX: Output CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-43 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP1_VIRTUAL2_ASYNC_RX | |

Table 7-54. Virtual Mode Case Details for McASP1 (continued)

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|---|--------|---|-----------------------|---------------------------|-----------------|
| | | | Signals | Virtual Mode Value | |
| 2 | COIFIO | CLKX / FSR: Output CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-44 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP1_VIRTUAL2_ASYNC_RX | |
| 3 | CIOFIO | CLKR / FSR: Output CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP1_VIRTUAL2_ASYNC_RX | See Figure 7-45 |
| | | | AXR(Inputs)/CLKR/FSR | Default (No Virtual Mode) | |
| 4 | CIOFOI | CLKR / FSX: Output CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP1_VIRTUAL2_ASYNC_RX | See Figure 7-46 |
| | | | AXR(Inputs)/CLKR/FSR | Default (No Virtual Mode) | |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) | | | | | |
| 5 | CO-FO- | CLKX / FSX: Output | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-47 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |
| 6 | CI-FO- | FSX: Output CLKX: Input | AXR(Outputs)/CLKX/FSX | MCASP1_VIRTUAL1_SYNC_RX | See Figure 7-48 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP1_VIRTUAL1_SYNC_RX | |
| 7 | CI-FI- | CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP1_VIRTUAL1_SYNC_RX | See Figure 7-49 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP1_VIRTUAL1_SYNC_RX | |
| 8 | CO-FI- | CLKX: Output FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-50 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |

Table 7-55. Virtual Mode Case Details for McASP2

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|---|--------|---|-----------------------|---|-----------------|
| | | | Signals | Virtual Mode Value | |
| IP Mode : ASYNC | | | | | |
| 1 | COIFOI | CLKX / FSX: Output CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) ⁽¹⁾ | See Figure 7-43 |
| | | | AXR(Inputs)/CLKR/FSR | Default (No Virtual Mode) ⁽¹⁾ | |
| | | | AXR(Inputs)/CLKR/FSR | MCASP2_VIRTUAL4_ASYNC_RX_80M ⁽²⁾ | |
| 2 | COIFIO | CLKX / FSR: Output CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-44 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP2_VIRTUAL2_ASYNC_RX | |
| 3 | CIOFIO | CLKR / FSR: Output CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP2_VIRTUAL2_ASYNC_RX | See Figure 7-45 |
| | | | AXR(Inputs)/CLKR/FSR | Default (No Virtual Mode) | |
| 4 | CIOFOI | CLKR / FSX: Output CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP2_VIRTUAL2_ASYNC_RX | See Figure 7-46 |
| | | | AXR(Inputs)/CLKR/FSR | Default (No Virtual Mode) | |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) | | | | | |
| 5 | CO-FO- | CLKX / FSX: Output | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-47 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |
| 6 | CI-FO- | FSX: Output CLKX: Input | AXR(Outputs)/CLKX/FSX | MCASP2_VIRTUAL3_SYNC_RX | See Figure 7-48 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP2_VIRTUAL3_SYNC_RX | |
| 7 | CI-FI- | CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP2_VIRTUAL3_SYNC_RX ⁽¹⁾ | See Figure 7-49 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP2_VIRTUAL3_SYNC_RX ⁽¹⁾ | |
| | | | AXR(Inputs)/CLKX/FSX | MCASP2_VIRTUAL1_SYNC_RX_80M ⁽²⁾ | |
| 8 | CO-FI- | CLKX: Output FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-50 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |

(1) Used up to 50MHz. Should also be used in a CI-FI- mixed case where AXR operate as both inputs and outputs (that is, AXR are bidirectional).

(2) Used in 80MHz input only mode when AXR, CLKX and FSX are all inputs.

Table 7-56. Virtual Mode Case Details for McASP3

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|---|--------|---|-----------------------|---------------------------|---------------------------------|
| | | | Signals | Virtual Mode Value | |
| IP Mode : ASYNC | | | | | |
| 1 | COIFOI | CLKX / FSX: Output CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-43 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP3_VIRTUAL2_SYNC_RX | |
| 2 | COIFIO | CLKX / FSR: Output CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-44 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP3_VIRTUAL2_SYNC_RX | |
| 3 | CIOFIO | CLKR / FSR: Output CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX | See Figure 7-45 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP3_VIRTUAL2_SYNC_RX | |
| 4 | CIOFOI | CLKR / FSX: Output CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX | See Figure 7-46 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP3_VIRTUAL2_SYNC_RX | |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) | | | | | |
| 5 | CO-FO- | CLKX / FSX: Output | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-47 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |
| 6 | CI-FO- | FSX: Output CLKX: Input | AXR(Outputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX | See Figure 7-48 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX | |
| 7 | CI-FI- | CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX | See Figure 7-49 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP3_VIRTUAL2_SYNC_RX | |
| 8 | CO-FI- | CLKX: Output FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-50 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |

Table 7-57. Virtual Mode Case Details for McASP4

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|---|--------|---|-----------------------|---------------------------|---------------------------------|
| | | | Signals | Virtual Mode Value | |
| IP Mode : ASYNC | | | | | |
| 1 | COIFOI | CLKX / FSX: Output CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-43 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP4_VIRTUAL1_SYNC_RX | |
| 2 | COIFIO | CLKX / FSR: Output CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-44 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP4_VIRTUAL1_SYNC_RX | |
| 3 | CIOFIO | CLKR / FSR: Output CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX | See Figure 7-45 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP4_VIRTUAL1_SYNC_RX | |
| 4 | CIOFOI | CLKR / FSX: Output CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX | See Figure 7-46 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP4_VIRTUAL1_SYNC_RX | |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) | | | | | |
| 5 | CO-FO- | CLKX / FSX: Output | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-47 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |
| 6 | CI-FO- | FSX: Output CLKX: Input | AXR(Outputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX | See Figure 7-48 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX | |
| 7 | CI-FI- | CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX | See Figure 7-49 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP4_VIRTUAL1_SYNC_RX | |

Table 7-57. Virtual Mode Case Details for McASP4 (continued)

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|-----|--------|----------------------------|-----------------------|---------------------------|---------------------------------|
| | | | Signals | Virtual Mode Value | |
| 8 | CO-FI- | CLKX: Output FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-50 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |

Table 7-58. Virtual Mode Case Details for McASP5

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|---|--------|--|-----------------------|---------------------------|---------------------------------|
| | | | Signals | Virtual Mode Value | |
| IP Mode : ASYNC | | | | | |
| 1 | COIFOI | CLKX / FSX: Output CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-43 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP5_VIRTUAL1_SYNC_RX | |
| 2 | COIFIO | CLKX / FSR: Output CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-44 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP5_VIRTUAL1_SYNC_RX | |
| 3 | CIOFIO | CLKR / FSR: Output CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX | See Figure 7-45 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP5_VIRTUAL1_SYNC_RX | |
| 4 | CIOFOI | CLKR / FSX: Output CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX | See Figure 7-46 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP5_VIRTUAL1_SYNC_RX | |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) | | | | | |
| 5 | CO-FO- | CLKX / FSX: Output | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-47 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |
| 6 | CI-FO- | FSX: Output CLKX: Input | AXR(Outputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX | See Figure 7-48 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX | |
| 7 | CI-FI- | CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX | See Figure 7-49 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP5_VIRTUAL1_SYNC_RX | |
| 8 | CO-FI- | CLKX: Output FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-50 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |

Table 7-59. Virtual Mode Case Details for McASP6

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|---|--------|--|-----------------------|---------------------------|---------------------------------|
| | | | Signals | Virtual Mode Value | |
| IP Mode : ASYNC | | | | | |
| 1 | COIFOI | CLKX / FSX: Output CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-43 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP6_VIRTUAL1_SYNC_RX | |
| 2 | COIFIO | CLKX / FSR: Output CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-44 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP6_VIRTUAL1_SYNC_RX | |
| 3 | CIOFIO | CLKR / FSR: Output CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX | See Figure 7-45 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP6_VIRTUAL1_SYNC_RX | |
| 4 | CIOFOI | CLKR / FSX: Output CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX | See Figure 7-46 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP6_VIRTUAL1_SYNC_RX | |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) | | | | | |
| 5 | CO-FO- | CLKX / FSX: Output | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-47 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |

Table 7-59. Virtual Mode Case Details for McASP6 (continued)

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|-----|--------|-------------------------------|-----------------------|---------------------------|---------------------------------|
| | | | Signals | Virtual Mode Value | |
| 6 | CI-FO- | FSX: Output CLKX: Input | AXR(Outputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX | See Figure 7-48 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX | |
| 7 | CI-FI- | CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX | See Figure 7-49 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP6_VIRTUAL1_SYNC_RX | |
| 8 | CO-FI- | CLKX: Output FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-50 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |

Table 7-60. Virtual Mode Case Details for McASP7

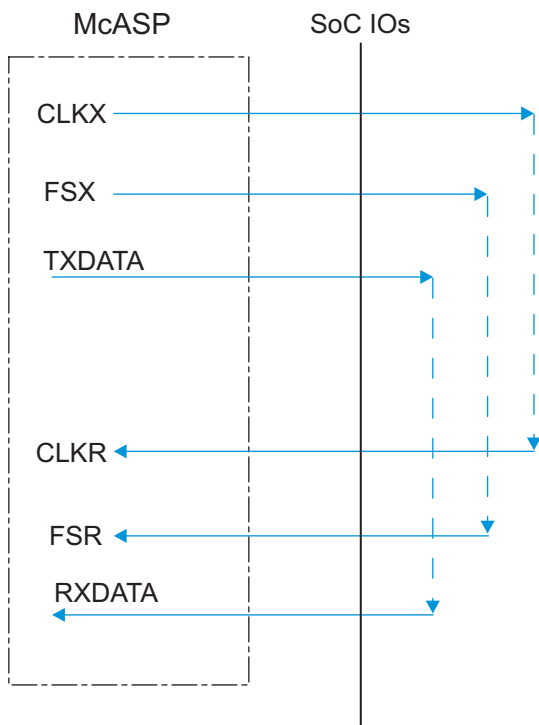
| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|---|--------|--|-----------------------|---------------------------|---------------------------------|
| | | | Signals | Virtual Mode Value | |
| IP Mode : ASYNC | | | | | |
| 1 | COIFOI | CLKX / FSX: Output CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-43 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP7_VIRTUAL2_SYNC_RX | |
| 2 | COIFIO | CLKX / FSR: Output CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-44 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP7_VIRTUAL2_SYNC_RX | |
| 3 | CIOFIO | CLKR / FSR: Output CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX | See Figure 7-45 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP7_VIRTUAL2_SYNC_RX | |
| 4 | CIOFOI | CLKR / FSX: Output CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX | See Figure 7-46 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP7_VIRTUAL2_SYNC_RX | |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) | | | | | |
| 5 | CO-FO- | CLKX / FSX: Output | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-47 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |
| 6 | CI-FO- | FSX: Output CLKX: Input | AXR(Outputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX | See Figure 7-48 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX | |
| 7 | CI-FI- | CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX | See Figure 7-49 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP7_VIRTUAL2_SYNC_RX | |
| 8 | CO-FI- | CLKX: Output FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-50 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |

Table 7-61. Virtual Mode Case Details for McASP8

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|------------------------|--------|--|-----------------------|---------------------------|---------------------------------|
| | | | Signals | Virtual Mode Value | |
| IP Mode : ASYNC | | | | | |
| 1 | COIFOI | CLKX / FSX: Output CLKR / FSR: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-43 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP8_VIRTUAL1_SYNC_RX | |
| 2 | COIFIO | CLKX / FSR: Output CLKR / FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-44 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP8_VIRTUAL1_SYNC_RX | |
| 3 | CIOFIO | CLKR / FSR: Output CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX | See Figure 7-45 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP8_VIRTUAL1_SYNC_RX | |

Table 7-61. Virtual Mode Case Details for McASP8 (continued)

| No. | CASE | CASE Description | Virtual Mode Settings | | Notes |
|---|--------|---|-----------------------|---------------------------|---------------------------------|
| | | | Signals | Virtual Mode Value | |
| 4 | CIOFOI | CLKR / FSX: Output CLKX / FSR: Input | AXR(Outputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX | See Figure 7-46 |
| | | | AXR(Inputs)/CLKR/FSR | MCASP8_VIRTUAL1_SYNC_RX | |
| IP Mode : SYNC (CLKR / FSR internally generated from CLKX / FSX) | | | | | |
| 5 | CO-FO- | CLKX / FSX: Output | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-47 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |
| 6 | CI-FO- | FSX: Output CLKX: Input | AXR(Outputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX | See Figure 7-48 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX | |
| 7 | CI-FI- | CLKX / FSX: Input | AXR(Outputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX | See Figure 7-49 |
| | | | AXR(Inputs)/CLKX/FSX | MCASP8_VIRTUAL1_SYNC_RX | |
| 8 | CO-FI- | CLKX: Output FSX: Input | AXR(Outputs)/CLKX/FSX | Default (No Virtual Mode) | See Figure 7-50 |
| | | | AXR(Inputs)/CLKX/FSX | Default (No Virtual Mode) | |



SPRS906_MCASP_uc_01

Figure 7-43. McASP1-8 COIFOI - ASYNC Mode

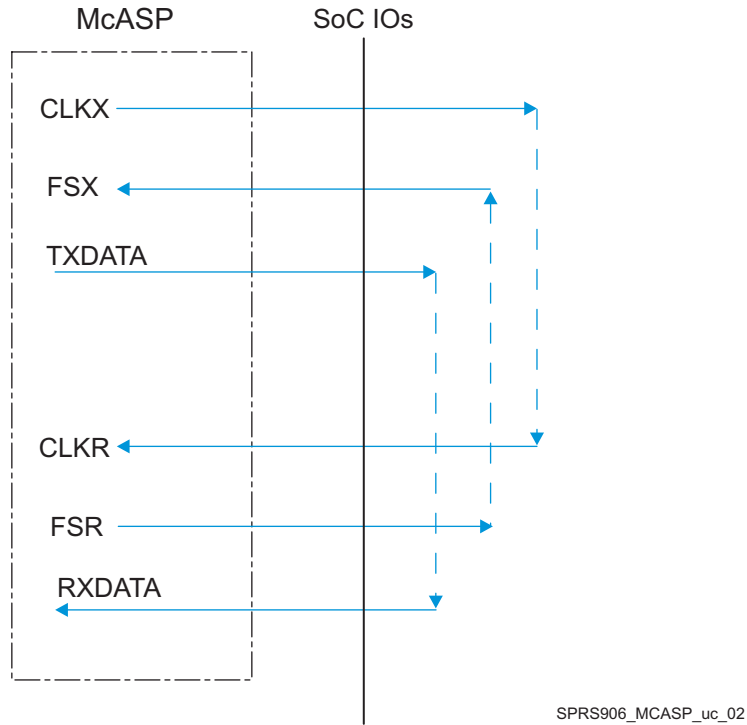


Figure 7-44. McASP1-8 COIFIO - ASYNC Mode

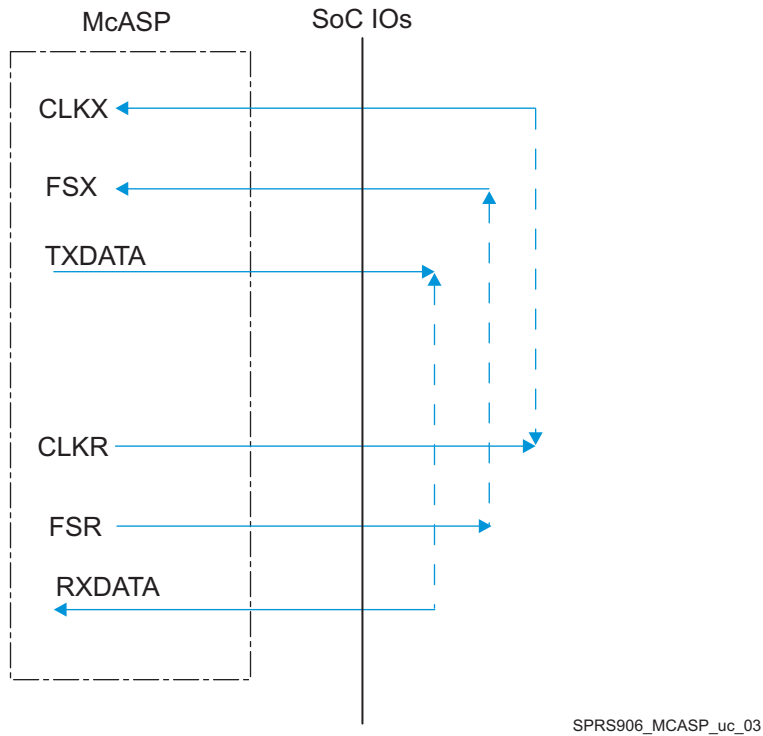
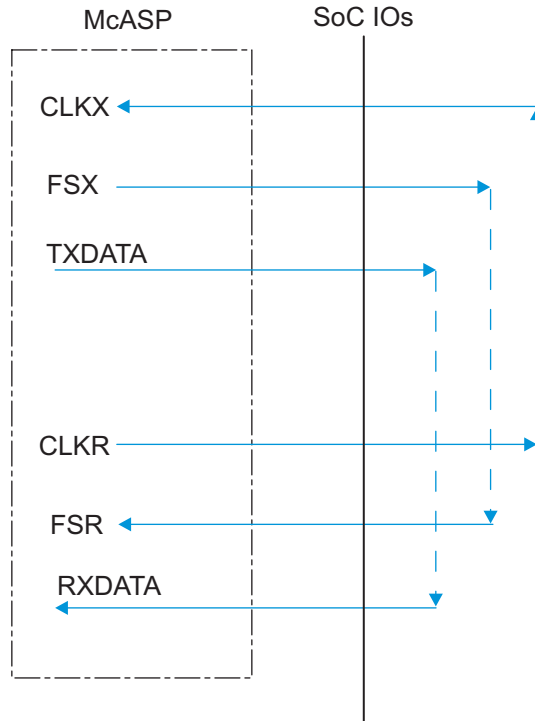
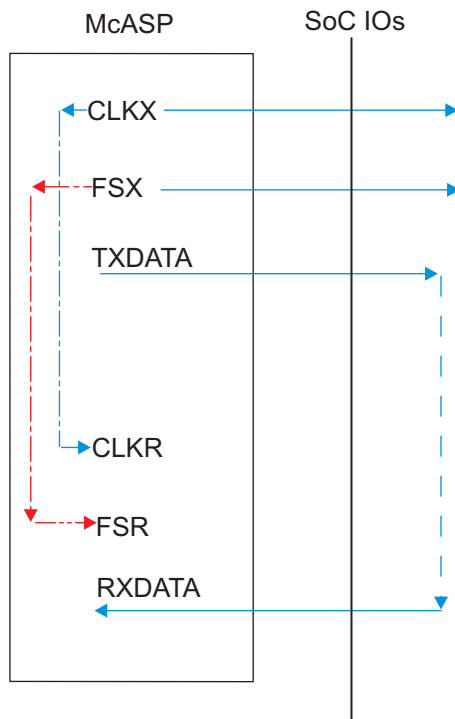


Figure 7-45. McASP1-8 CIOFIO - ASYNC Mode



SPRS906_MCASP_uc_04

Figure 7-46. McASP1-8 CIOFOI - ASYNC Mode



SPRS906_MCASP_uc_05

Figure 7-47. McASP1-8 CO-FO- - SYNC Mode

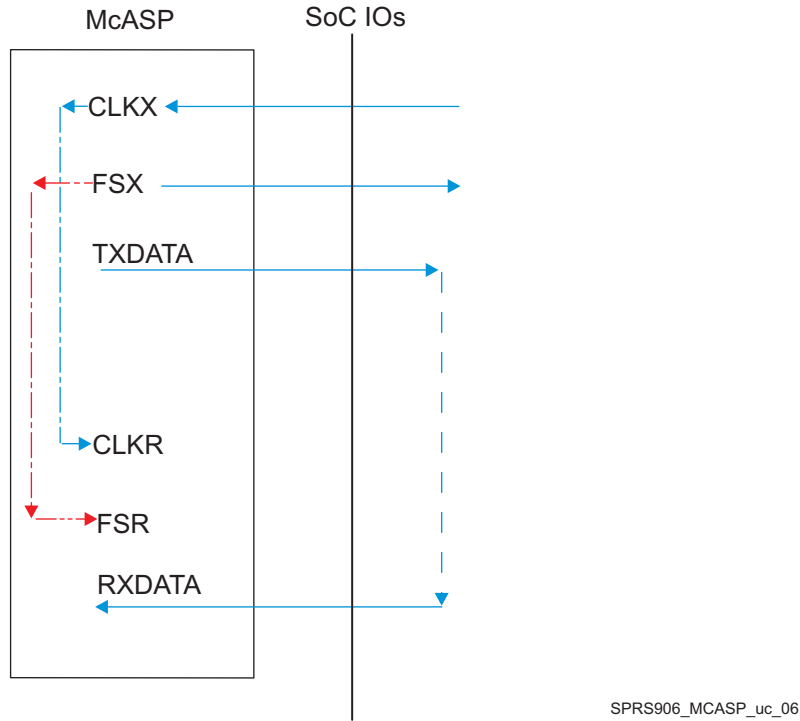


Figure 7-48. McASP1-8 CI-FO- - SYNC Mode

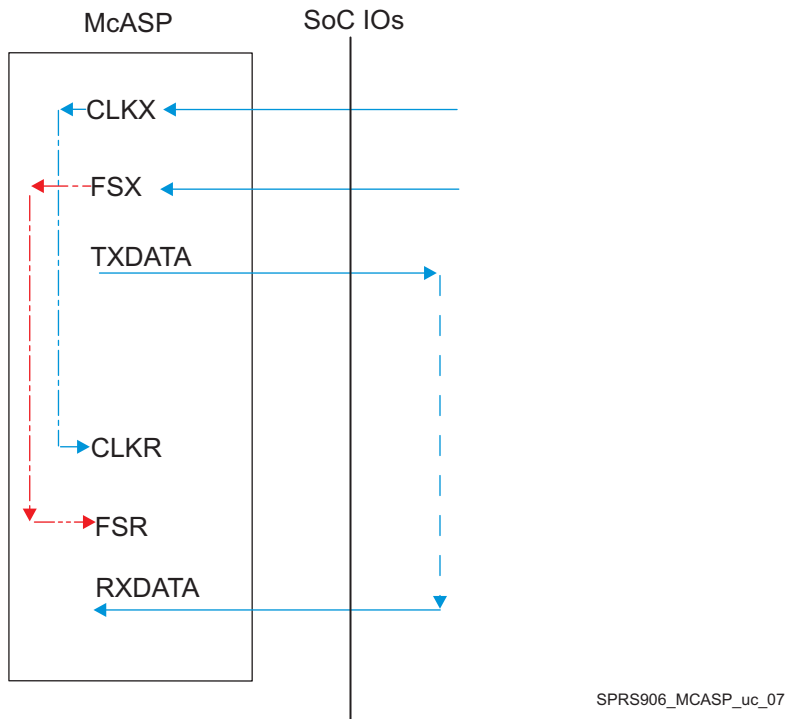
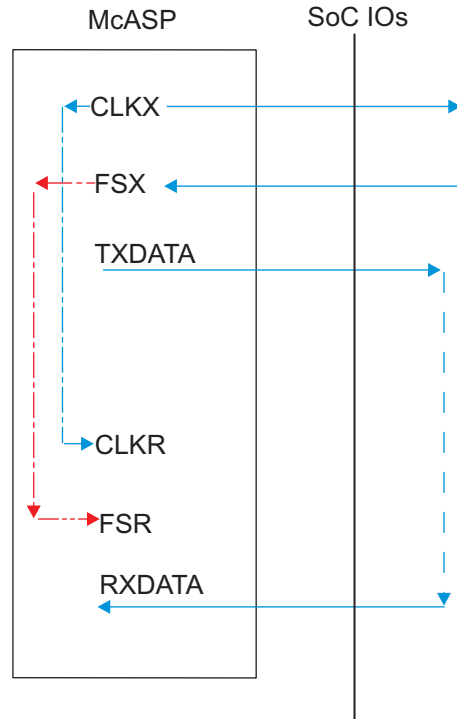


Figure 7-49. McASP1-8 CI-FI- - SYNC Mode



SPRS906_MCASP_uc_08

Figure 7-50. McASP1-8 CO-FI - SYNC Mode

NOTE

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bit field for each corresponding pad control register.

The pad control registers are presented in [Table 4-3](#) and described in Device TRM, *Control Module Chapter*.

CAUTION

The I/O Timings provided in this section are valid only for some McASP usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

Virtual IO Timings Modes must be used to ensure some IO timings for McASP1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 7-62 Virtual Functions Mapping for McASP1](#) for a definition of the Virtual modes.

[Table 7-62](#) presents the values for DELAYMODE bit field.

Table 7-62. Virtual Functions Mapping for McASP1

| BALL | BALL NAME | Delay Mode Value | | MUXMODE | | |
|------|--------------|-------------------------|--------------------------|--------------|--------------|-------------|
| | | MCASP1_VIRTUAL1_SYNC_RX | MCASP1_VIRTUAL2_ASYNC_RX | 0 | 1 | 2 |
| C14 | mcasp1_aclkx | 15 | 14 | mcasp1_aclkx | | |
| E21 | gpio6_14 | 14 | 13 | | mcasp1_axr8 | |
| A13 | mcasp1_axr13 | 15 | 14 | mcasp1_axr13 | | |
| E12 | mcasp1_axr4 | 14 | 13 | mcasp1_axr4 | | |
| B26 | xref_clk2 | 14 | 13 | | | mcasp1_axr6 |
| A11 | mcasp1_axr9 | 15 | 14 | mcasp1_axr9 | | |
| D12 | mcasp1_axr7 | 14 | 13 | mcasp1_axr7 | | |
| E14 | mcasp1_axr12 | 15 | 14 | mcasp1_axr12 | | |
| F21 | gpio6_16 | 14 | 13 | | mcasp1_axr10 | |
| F20 | gpio6_15 | 14 | 13 | | mcasp1_axr9 | |
| C23 | xref_clk3 | 14 | 13 | | | mcasp1_axr7 |
| C12 | mcasp1_axr6 | 14 | 13 | mcasp1_axr6 | | |
| B13 | mcasp1_axr10 | 15 | 14 | mcasp1_axr10 | | |
| J14 | mcasp1_fsr | N/A | 14 | mcasp1_fsr | | |
| B12 | mcasp1_axr8 | 15 | 14 | mcasp1_axr8 | | |
| A12 | mcasp1_axr11 | 15 | 14 | mcasp1_axr11 | | |
| G13 | mcasp1_axr2 | 14 | 13 | mcasp1_axr2 | | |
| D14 | mcasp1_fsx | 15 | 14 | mcasp1_fsx | | |
| G14 | mcasp1_axr14 | 15 | 14 | mcasp1_axr14 | | |
| F14 | mcasp1_axr15 | 15 | 14 | mcasp1_axr15 | | |
| F12 | mcasp1_axr1 | 15 | 14 | mcasp1_axr1 | | |
| B14 | mcasp1_aclkr | N/A | 14 | mcasp1_aclkr | | |
| F13 | mcasp1_axr5 | 14 | 13 | mcasp1_axr5 | | |
| E17 | xref_clk1 | 15 | 14 | | | mcasp1_axr5 |
| G12 | mcasp1_axr0 | 15 | 14 | mcasp1_axr0 | | |
| J11 | mcasp1_axr3 | 14 | 13 | mcasp1_axr3 | | |
| D18 | xref_clk0 | 15 | 14 | | | mcasp1_axr4 |

Virtual IO Timings Modes must be used to ensure some IO timings for McASP2. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 7-63 Virtual Functions Mapping for McASP2](#) for a definition of the Virtual modes.

[Table 7-63](#) presents the values for DELAYMODE bit field.

Table 7-63. Virtual Functions Mapping for McASP2

| BALL | BALL NAME | Delay Mode Value | | | | MUXMODE | | |
|------|--------------|-----------------------------|--------------------------|-------------------------|------------------------------|--------------|--------------|--------------|
| | | MCASP2_VIRTUAL1_SYNC_RX_80M | MCASP2_VIRTUAL2_ASYNC_RX | MCASP2_VIRTUAL3_SYNC_RX | MCASP2_VIRTUAL4_ASYNC_RX_80M | 0 | 1 | 2 |
| B19 | mcasp3_axr0 | 15 | 14 | 10 | 9 | | | mcasp2_axr14 |
| B17 | mcasp2_axr6 | 14 | 13 | 12 | 11 | mcasp2_axr6 | | |
| B16 | mcasp2_axr5 | 14 | 13 | 12 | 11 | mcasp2_axr5 | | |
| A18 | mcasp2_fsx | 15 | 14 | 10 | 9 | mcasp2_fsx | | |
| B26 | xref_clk2 | 12 | 11 | 10 | 9 | | mcasp2_axr10 | |
| A16 | mcasp2_axr3 | 15 | 14 | 10 | 9 | mcasp2_axr3 | | |
| E15 | mcasp2_aclkr | N/A | 14 | N/A | 13 | mcasp2_aclkr | | |
| B18 | mcasp3_aclkx | 15 | 14 | 10 | 9 | | | mcasp2_axr12 |
| A19 | mcasp2_aclkx | 15 | 14 | 10 | 9 | mcasp2_aclkx | | |
| A17 | mcasp2_axr7 | 14 | 13 | 12 | 11 | mcasp2_axr7 | | |
| C23 | xref_clk3 | 12 | 11 | 10 | 9 | | mcasp2_axr11 | |
| C17 | mcasp3_axr1 | 15 | 14 | 10 | 8 | | | mcasp2_axr15 |
| F15 | mcasp3_fsx | 15 | 14 | 10 | 9 | | | mcasp2_axr13 |
| C15 | mcasp2_axr2 | 15 | 14 | 10 | 9 | mcasp2_axr2 | | |
| D15 | mcasp2_axr4 | 14 | 13 | 12 | 11 | mcasp2_axr4 | | |
| A20 | mcasp2_fsr | N/A | 14 | N/A | 13 | mcasp2_fsr | | |
| E17 | xref_clk1 | 10 | 9 | 8 | 6 | | mcasp2_axr9 | |
| A15 | mcasp2_axr1 | 14 | 13 | 12 | 11 | mcasp2_axr1 | | |
| B15 | mcasp2_axr0 | 14 | 13 | 12 | 11 | mcasp2_axr0 | | |
| D18 | xref_clk0 | 10 | 9 | 8 | 6 | | mcasp2_axr8 | |

Virtual IO Timings Modes must be used to ensure some IO timings for McASP3/4/5/6/7/8. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 7-64 Virtual Functions Mapping for McASP3/4/5/6/7/8](#) for a definition of the Virtual modes.

[Table 7-64](#) presents the values for DELAYMODE bit field.

Table 7-64. Virtual Functions Mapping for McASP3/4/5/6/7/8

| BALL | BALL NAME | Delay Mode Value | MUXMODE | | |
|--------------------------------|--------------|------------------|--------------|--------------|--------------|
| | | | 0 | 1 | 2 |
| MCASP3_VIRTUAL2_SYNC_RX | | | | | |
| A16 | mcasp2_axr3 | 8 | | mcasp3_axr3 | |
| B18 | mcasp3_aclkx | 8 | mcasp3_aclkx | mcasp3_aclkr | |
| B19 | mcasp3_axr0 | 8 | mcasp3_axr0 | | |
| C17 | mcasp3_axr1 | 6 | mcasp3_axr1 | | |
| F15 | mcasp3_fsx | 8 | mcasp3_fsx | mcasp3_fsr | |
| C15 | mcasp2_axr2 | 8 | | mcasp3_axr2 | |
| MCASP4_VIRTUAL1_SYNC_RX | | | | | |
| A21 | mcasp4_fsx | 14 | mcasp4_fsx | mcasp4_fsr | |
| C18 | mcasp4_aclkx | 14 | mcasp4_aclkx | mcasp4_aclkr | |
| G16 | mcasp4_axr0 | 14 | mcasp4_axr0 | | |
| D17 | mcasp4_axr1 | 14 | mcasp4_axr1 | | |
| F13 | mcasp1_axr5 | 12 | | mcasp4_axr3 | |
| E12 | mcasp1_axr4 | 12 | | mcasp4_axr2 | |
| MCASP5_VIRTUAL1_SYNC_RX | | | | | |
| AA3 | mcasp5_aclkx | 14 | mcasp5_aclkx | mcasp5_aclkr | |
| AB9 | mcasp5_fsx | 14 | mcasp5_fsx | mcasp5_fsr | |
| AA4 | mcasp5_axr1 | 14 | mcasp5_axr1 | | |
| C12 | mcasp1_axr6 | 12 | | mcasp5_axr2 | |
| AB3 | mcasp5_axr0 | 14 | mcasp5_axr0 | | |
| D12 | mcasp1_axr7 | 12 | | mcasp5_axr3 | |
| MCASP6_VIRTUAL1_SYNC_RX | | | | | |
| G13 | mcasp1_axr2 | 12 | | mcasp6_axr2 | |
| J11 | mcasp1_axr3 | 12 | | mcasp6_axr3 | |
| B13 | mcasp1_axr10 | 10 | | mcasp6_aclkx | mcasp6_aclkr |
| A11 | mcasp1_axr9 | 10 | | mcasp6_axr1 | |
| B12 | mcasp1_axr8 | 10 | | mcasp6_axr0 | |
| A12 | mcasp1_axr11 | 10 | | mcasp6_fsx | mcasp6_fsr |
| MCASP7_VIRTUAL2_SYNC_RX | | | | | |
| E14 | mcasp1_axr12 | 10 | | mcasp7_axr0 | |
| F14 | mcasp1_axr15 | 10 | | mcasp7_fsx | mcasp7_fsr |
| G14 | mcasp1_axr14 | 10 | | mcasp7_aclkx | mcasp7_aclkr |

Table 7-64. Virtual Functions Mapping for McASP3/4/5/6/7/8 (continued)

| BALL | BALL NAME | Delay Mode Value | MUXMODE | | |
|--------------------------------|--------------|------------------|---------|--------------|--------------|
| | | | 0 | 1 | 2 |
| A13 | mcasp1_axr13 | 10 | | mcasp7_axr1 | |
| B14 | mcasp1_aclkr | 13 | | mcasp7_axr2 | |
| J14 | mcasp1_fsr | 13 | | mcasp7_axr3 | |
| MCASP8_VIRTUAL1_SYNC_RX | | | | | |
| D15 | mcasp2_axr4 | 10 | | mcasp8_axr0 | |
| A17 | mcasp2_axr7 | 10 | | mcasp8_fsx | mcasp8_fsr |
| B17 | mcasp2_axr6 | 10 | | mcasp8_aclkx | mcasp8_aclkr |
| A20 | mcasp2_fsr | 12 | | mcasp8_axr3 | |
| B16 | mcasp2_axr5 | 10 | | mcasp8_axr1 | |
| E15 | mcasp2_aclkr | 12 | | mcasp8_axr2 | |

7.19 Universal Serial Bus (USB)

SuperSpeed USB DRD Subsystem has four instances in the device providing the following functions:

- USB1: SuperSpeed (SS) USB 3.0 Dual-Role-Device (DRD) subsystem with integrated SS (USB3.0) PHY and HS/FS (USB2.0) PHY.
- USB2: High Speed (HS) USB 2.0 Dual-Role-Device (DRD) subsystem with integrated HS/FS PHY.
- USB3: HS USB 2.0 Dual-Role-Device (DRD) subsystem with ULPI (SDR) interface to external HS/FS PHYs.

NOTE

For more information, see *SuperSpeed USB DRD* section in the device TRM.

7.19.1 USB1 DRD PHY

The USB1 DRD interface supports the following applications:

- USB2.0 High Speed PHY port (1.8 V and 3.3 V): this asynchronous high speed interface is compliant with the USB2.0 PHY standard with an internal transceiver (USB2.0 standard v2.0), for a maximum data rate of 480 Mbps.
- USB3.0 SuperSpeed PHY port (1.8 V): this asynchronous differential super speed interface is compliant with the USB3.0 RX/TX PHY standard (USB3.0 standard v1.0) for a maximum data bit rate of 5Gbps.

7.19.2 USB2 PHY

The USB2 interface supports the following applications:

- USB2.0 High Speed PHY port (1.8 V and 3.3 V): this asynchronous high speed interface is compliant with the USB2.0 PHY standard with an internal transceiver (USB2.0 standard v2.0), for a maximum data rate of 480 Mbps.

7.19.3 USB3 DRD ULPI-SDR-Slave Mode-12-pin Mode

The USB3 DRD interfaces support the following application:

- USB ULPI port: this synchronous interface is compliant with the USB2.0 ULPI SDR standard (UTMI+ v1.22), for alternative off-chip USB2.0 PHY interface; that is, with external transceiver with a maximum frequency of 60 MHz (synchronous slave mode, SDR, 12-pin, 8-data-bit).

NOTE

The Universal Serial Bus k ULPI modules are also referred as USBk where k = 3, 4.

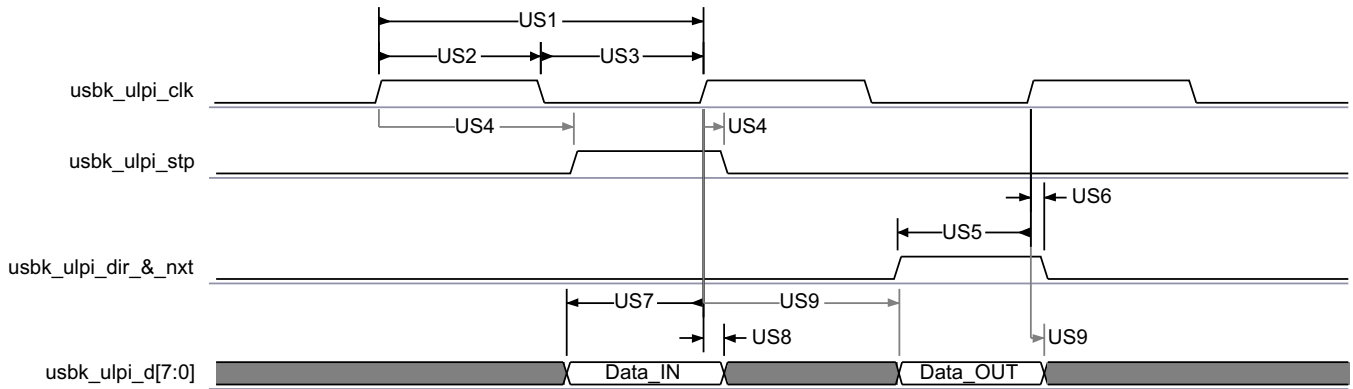
Table 7-65, Table 7-66 and Figure 7-51 assume testing over the recommended operating conditions and electrical characteristic conditions.

Table 7-65. Timing Requirements for ULPI SDR Slave Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|-----------------------------|--|-------|-----|------|
| US1 | $t_{c(\text{clk})}$ | Cycle time, usb_ulpi_clk period | 16.66 | | ns |
| US5 | $t_{su(\text{ctrlV-clkH})}$ | Setup time, usb_ulpi_dir/usb_ulpi_next valid before usb_ulpi_clk rising edge | 6.73 | | ns |
| US6 | $t_{h(\text{clkH-ctrlV})}$ | Hold time, usb_ulpi_dir/usb_ulpi_next valid after usb_ulpi_clk rising edge | -0.41 | | ns |
| US7 | $t_{su(\text{dV-clkH})}$ | Setup time, usb_ulpi_d[7:0] valid before usb_ulpi_clk rising edge | 6.73 | | ns |
| US8 | $t_{h(\text{clkH-dV})}$ | Hold time, usb_ulpi_d[7:0] valid after usb_ulpi_clk rising edge | -0.41 | | ns |

Table 7-66. Switching Characteristics for ULPI SDR Slave Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|---------------------------|---|------|------|------|
| US4 | $t_{d(\text{clkH-stpV})}$ | Delay time, usb_ulpi_clk rising edge high to output usb_ulpi_stp valid | 0.44 | 8.35 | ns |
| US9 | $t_{d(\text{clkL-dov})}$ | Delay time, usb_ulpi_clk rising edge high to output usb_ulpi_d[7:0] valid | 0.44 | 8.35 | ns |



SPRS956_TIMING_USB_01

Figure 7-51. HS USB3 ULPI -SDR-Slave Mode-12-pin Mode

In [Table 7-67](#) are presented the specific groupings of signals (IOSET) for use with USB3 signals.

Table 7-67. USB3 IOSETs

| SIGNALS | IOSET2 | | IOSET3 | |
|---------------|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX |
| usb3_ulpi_d7 | AC5 | 3 | W2 | 6 |
| usb3_ulpi_d6 | AB4 | 3 | Y2 | 6 |
| usb3_ulpi_d5 | AD4 | 3 | V3 | 6 |
| usb3_ulpi_d4 | AC4 | 3 | V4 | 6 |
| usb3_ulpi_d3 | AC7 | 3 | V5 | 6 |
| usb3_ulpi_d2 | AC6 | 3 | U5 | 6 |
| usb3_ulpi_d1 | AC9 | 3 | U6 | 6 |
| usb3_ulpi_d0 | AC3 | 3 | V6 | 6 |
| usb3_ulpi_nxt | AC8 | 3 | U7 | 6 |
| usb3_ulpi_dir | AD6 | 3 | V7 | 6 |
| usb3_ulpi_stp | AB8 | 3 | V9 | 6 |
| usb3_ulpi_clk | AB5 | 3 | W9 | 6 |

7.20 Serial Advanced Technology Attachment (SATA)

The SATA RX/TX PHY interface is compliant with the SATA standard v2.6 for a maximum data rate:

- Gen2i, Gen2m, Gen2x: 3Gbps.
- Gen1i, Gen1m, Gen1x: 1.5Gbps.

NOTE

For more information, see *SATA Controller* section in the device TRM.

7.21 Peripheral Component Interconnect Express (PCIe)

The device supports connections to PCIe-compliant devices via the integrated PCIe master/slave bus interface. The PCIe module is comprised of a dual-mode PCIe core and a SerDes PHY. Each PCIe subsystem controller has support for PCIe Gen-II mode (5.0 Gbps /lane) and Gen-I mode (2.5 Gbps/lane) (Single Lane and Flexible dual lane configuration).

The device PCIe supports the following features:

- 16-bit operation @250 MHz on PIPE interface (per 16-bit lane)
- Supports 2 ports x 1 lane or 1 port x 2 lanes configuration
- Single virtual channel (VC0), single traffic class (TC0)
- Single function in end-point mode
- Automatic width and speed negotiation
- Max payload: 128 byte outbound, 256 byte inbound
- Automatic credit management
- ECRC generation and checking
- Configurable BAR filtering
- Legacy interrupt reception (RC) and generation (EP)
- MSI generation and reception
- PCI-Express Active State Power Management (ASPM) state L0s and L1 (with exceptions)
- All PCI Device Power Management D-states with the exception of D3_{cold} / L2 state

The PCIe controller on this device conforms to the PCI-Express Base 3.0 Specification, revision 1.0 and the PCI Local Bus Specification, revision 3.0

NOTE

For more information, see *PCIe Controller* section in the device TRM.

7.22 Controller Area Network Interface (DCAN)

The device provides two DCAN interfaces for supporting distributed realtime control with a high level of security. The DCAN interfaces implement the following features:

- Supports CAN protocol version 2.0 part A, B
- Bit rates up to 1 MBit/s
- 64 message objects
- Individual identifier mask for each message object
- Programmable FIFO mode for message objects
- Programmable loop-back modes for self-test operation
- Suspend mode for debug support
- Software module reset
- Automatic bus on after Bus-Off state by a programmable 32-bit timer
- Direct access to Message RAM during test mode
- CAN Rx/Tx pins are configurable as general-purpose IO pins
- Two interrupt lines (plus additional parity-error interrupts line)
- RAM initialization
- DMA support

NOTE

For more information, see *DCAN* section in the device TRM.

NOTE

The Controller Area Network Interface x (x = 1 to 2) is also referred to as DCANx.

NOTE

Refer to the CAN Specification for calculations necessary to validate timing compliance. Jitter tolerance calculations must be performed to validate the implementation.

Table 7-68 and Table 7-69 present timing and switching characteristics for DCANx Interface.

Table 7-68. Timing Requirements for DCANx Receive

| NO. | PARAMETER | DESCRIPTION | MIN | NOM | MAX | UNIT |
|-----|------------------------|--|-----|-----|-----|------|
| - | f _(baud) | Maximum programmable baud rate | | | 1 | Mbps |
| - | t _{d(DCANRX)} | Delay time, DCANx_RX pin to receive shift register | | | 15 | ns |

Table 7-69. Switching Characteristics Over Recommended Operating Conditions for DCANx Transmit

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|------------------------|--|-----|-----|------|
| - | f _(baud) | Maximum programmable baud rate | | 1 | Mbps |
| - | t _{d(DCANTX)} | Delay time, Transmit shift register to DCANx_TX pin ⁽¹⁾ | | 23 | ns |

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

7.23 Ethernet Interface (GMAC_SW)

The three-port gigabit ethernet switch subsystem (GMAC_SW) provides ethernet packet communication and can be configured as an ethernet switch. It provides the Gigabit Media Independent Interface (G/MII) in MII mode, Reduced Gigabit Media Independent Interface (RGMII), Reduced Media Independent Interface (RMII), and the Management Data Input/Output (MDIO) for physical layer device (PHY) management.

NOTE

For more information, see *Gigabit Ethernet Switch (GMAC_SW)* section in the device TRM.

NOTE

The Gigabit, Reduced and Media Independent Interface n (n = 0 to 1) are also referred to as MII_n, RMIIn and RGMII_n.

CAUTION

The I/O timings provided in this section are valid only if signals within a single IOSET are used. The IOSETs are defined in Table 7-74, Table 7-77, Table 7-82 and Table 7-89.

CAUTION

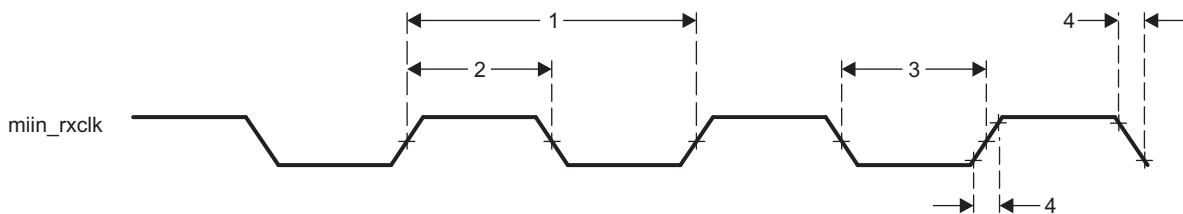
The I/O Timings provided in this section are valid only for some GMAC usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

Table 7-70 and Figure 7-52 present timing requirements for MII_n in receive operation.

7.23.1 GMAC MII Timings

Table 7-70. Timing Requirements for miin_rxclk - MII Operation

| NO. | PARAMETER | DESCRIPTION | SPEED | MIN | MAX | UNIT |
|-----|-------------------|---------------------------------|----------|-----|-----|------|
| 1 | $t_{c(RX_CLK)}$ | Cycle time, miin_rxclk | 10 Mbps | 400 | | ns |
| | | | 100 Mbps | 40 | | ns |
| 2 | $t_{w(RX_CLKH)}$ | Pulse duration, miin_rxclk high | 10 Mbps | 140 | 260 | ns |
| | | | 100 Mbps | 14 | 26 | ns |
| 3 | $t_{w(RX_CLKL)}$ | Pulse duration, miin_rxclk low | 10 Mbps | 140 | 260 | ns |
| | | | 100 Mbps | 14 | 26 | ns |
| 4 | $t_{t(RX_CLK)}$ | Transition time, miin_rxclk | 10 Mbps | | 3 | ns |
| | | | 100 Mbps | | 3 | ns |



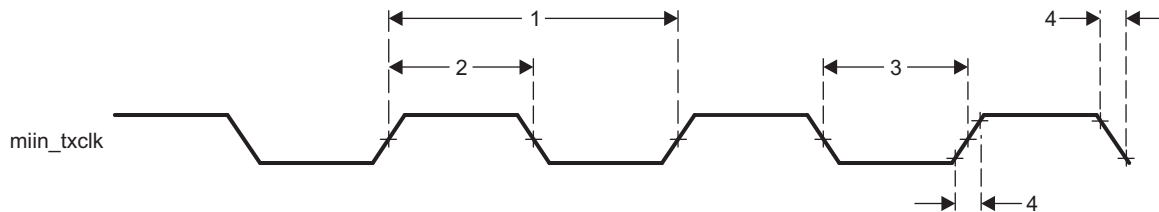
SPRS906_TIMING_GMAC_MIIRXCLK_01

Figure 7-52. Clock Timing (GMAC Receive) - MII operation

Table 7-71 and Figure 7-53 present timing requirements for MII in transmit operation.

Table 7-71. Timing Requirements for miin_txclk - MII Operation

| NO. | PARAMETER | DESCRIPTION | SPEED | MIN | MAX | UNIT |
|-----|-------------------|---------------------------------|----------|-----|-----|------|
| 1 | $t_{c(TX_CLK)}$ | Cycle time, miin_txclk | 10 Mbps | 400 | | ns |
| | | | 100 Mbps | 40 | | ns |
| 2 | $t_{w(TX_CLKH)}$ | Pulse duration, miin_txclk high | 10 Mbps | 140 | 260 | ns |
| | | | 100 Mbps | 14 | 26 | ns |
| 3 | $t_{w(TX_CLKL)}$ | Pulse duration, miin_txclk low | 10 Mbps | 140 | 260 | ns |
| | | | 100 Mbps | 14 | 26 | ns |
| 4 | $t_{t(TX_CLK)}$ | Transition time, miin_txclk | 10 Mbps | | 3 | ns |
| | | | 100 Mbps | | 3 | ns |



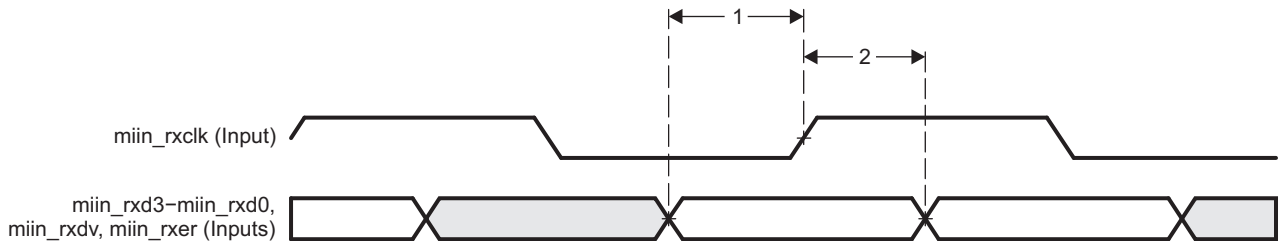
SPRS906_TIMING_GMAC_MII_TXCLK_02

Figure 7-53. Clock Timing (GMAC Transmit) - MII operation

Table 7-72 and Figure 7-54 present timing requirements for GMAC MII Receive 10/100Mbit/s.

Table 7-72. Timing Requirements for GMAC MIIn Receive 10/100 Mbit/s

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|--------------------------|--|-----|-----|------|
| 1 | $t_{su}(RXD-RX_CLK)$ | Setup time, receive selected signals valid before miin_rxclk | 8 | | ns |
| | $t_{su}(RX_DV-RX_CLK)$ | | | | |
| | $t_{su}(RX_ER-RX_CLK)$ | | | | |
| 2 | $t_h(RX_CLK-RXD)$ | Hold time, receive selected signals valid after miin_rxclk | 8 | | ns |
| | $t_h(RX_CLK-RX_DV)$ | | | | |
| | $t_h(RX_CLK-RX_ER)$ | | | | |



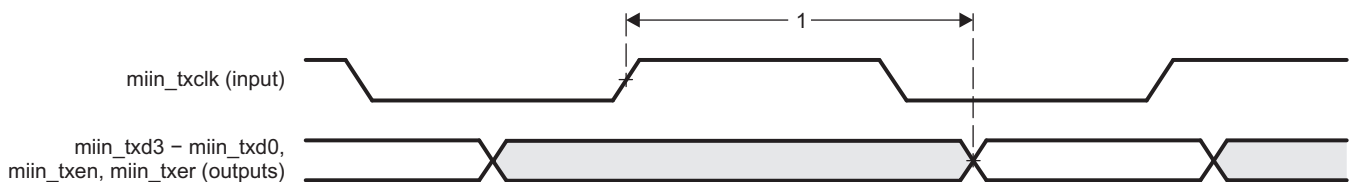
SPRS906_TIMING_GMAC_MIIRCV_03

Figure 7-54. GMAC Receive Interface Timing MIIn operation

Table 7-73 and Figure 7-55 present timing requirements for GMAC MIIn Transmit 10/100Mbit/s.

Table 7-73. Switching Characteristics Over Recommended Operating Conditions for GMAC MIIn Transmit 10/100 Mbits/s

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|-----------------------|---|-----|-----|------|
| 1 | $t_d(TX_CLK-TXD)$ | Delay time, miin_txclk to transmit selected signals valid | 0 | 25 | ns |
| | $t_d(TX_CLK-TX_EN)$ | | | | |
| | $t_d(TX_CLK-TX_ER)$ | | | | |



SPRS906_TIMING_GMAC_MITX_04

Figure 7-55. GMAC Transmit Interface Timing MIIn operation

In Table 7-74 are presented the specific groupings of signals (IOSET) for use with GMAC MII signals.

Table 7-74. GMAC MII IOSETs

| SIGNALS | IOSET5 | | IOSET6 | |
|------------------|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX |
| GMAC MII1 | | | | |
| mii1_txd3 | C5 | 8 | | |
| mii1_txd2 | D6 | 8 | | |
| mii1_txd1 | B2 | 8 | | |
| mii1_txd0 | C4 | 8 | | |
| mii1_rxd3 | F5 | 8 | | |
| mii1_rxd2 | E4 | 8 | | |
| mii1_rxd1 | C1 | 8 | | |

Table 7-74. GMAC MII IOSETs (continued)

| SIGNALS | IOSET5 | | IOSET6 | |
|------------|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX |
| mii1_rxd0 | E6 | 8 | | |
| mii1_col | B4 | 8 | | |
| mii1_rxer | B3 | 8 | | |
| mii1_txer | A3 | 8 | | |
| mii1_txen | A4 | 8 | | |
| mii1_crs | B5 | 8 | | |
| mii1_rxclk | D5 | 8 | | |
| mii1_txclk | C3 | 8 | | |
| mii1_rxdv | C2 | 8 | | |
| GMAC MII0 | | | | |
| mii0_txd3 | | | V5 | 3 |
| mii0_txd2 | | | V4 | 3 |
| mii0_txd1 | | | Y2 | 3 |
| mii0_txd0 | | | W2 | 3 |
| mii0_rxd3 | | | W9 | 3 |
| mii0_rxd2 | | | V9 | 3 |
| mii0_rxd1 | | | V6 | 3 |
| mii0_rxd0 | | | U6 | 3 |
| mii0_txclk | | | U5 | 3 |
| mii0_txer | | | U4 | 3 |
| mii0_rxer | | | U7 | 3 |
| mii0_rxdv | | | V2 | 3 |
| mii0_crs | | | V7 | 3 |
| mii0_col | | | V1 | 3 |
| mii0_rxclk | | | Y1 | 3 |
| mii0_txen | | | V3 | 3 |

7.23.2 GMAC MDIO Interface Timings

CAUTION

The I/O Timings provided in this section are valid only for some GMAC usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

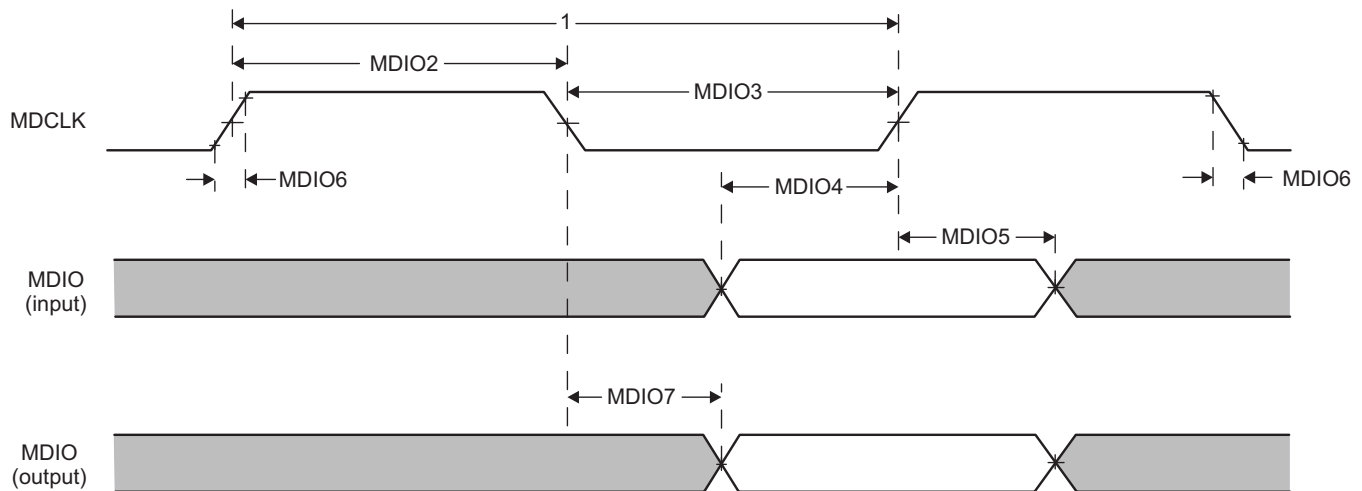
Table 7-75, Table 7-75 and Figure 7-56 present timing requirements for MDIO.

Table 7-75. Timing Requirements for MDIO Input

| No | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|--------------------|--|-----|-----|------|
| MDIO1 | $t_{c(MDC)}$ | Cycle time, MDC | 400 | | ns |
| MDIO2 | $t_{w(MDCH)}$ | Pulse Duration, MDC High | 160 | | ns |
| MDIO3 | $t_{w(MDCL)}$ | Pulse Duration, MDC Low | 160 | | ns |
| MDIO4 | $t_{su(MDIO-MDC)}$ | Setup time, MDIO valid before MDC High | 90 | | ns |
| MDIO5 | $t_{h(MDIO_MDC)}$ | Hold time, MDIO valid from MDC High | 0 | | ns |

Table 7-76. Switching Characteristics Over Recommended Operating Conditions for MDIO Output

| NO | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|-------------------|-----------------------------------|------|-----|------|
| MDIO6 | $t_{t(MDC)}$ | Transition time, MDC | | 5 | ns |
| MDIO7 | $t_{d(MDC-MDIO)}$ | Delay time, MDC low to MDIO valid | -150 | 150 | ns |



SPRS906_TIMING_GMAC_MDIO_05

Figure 7-56. GMAC MDIO diagrams

In [Table 7-77](#) are presented the specific groupings of signals (IOSET) for use with GMAC MDIO signals.

Table 7-77. GMAC MDIO IOSETS

| SIGNALS | IOSET7 | | IOSET8 | | IOSET9 | | IOSET10 | |
|-----------|--------|-----|--------|-----|--------|-----|---------|-----|
| | BALL | MUX | BALL | MUX | BALL | MUX | BALL | MUX |
| mdio_d | F6 | 3 | U4 | 0 | AB4 | 1 | B20 | 5 |
| mdio_mclk | D3 | 3 | V1 | 0 | AC5 | 1 | B21 | 5 |

7.23.3 GMAC RMIITimings

The main reference clock REF_CLK (RMII_50MHZ_CLK) of RMII interface is internally supplied from PRCM. The source of this clock could be either externally sourced from the RMII_MHZ_50_CLK pin of the device or internally generated from DPLL_GMAC output clock GMAC_RMII_HS_CLK. Please see the PRCM chapter of the device TRM for full details about RMII reference clock.

CAUTION

The I/O Timings provided in this section are valid only for some GMAC usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

[Table 7-78](#), [Table 7-79](#) and [Figure 7-57](#) present timing requirements for GMAC RMIIn Receive.

Table 7-78. Timing Requirements for GMAC REF_CLK - RMII Operation

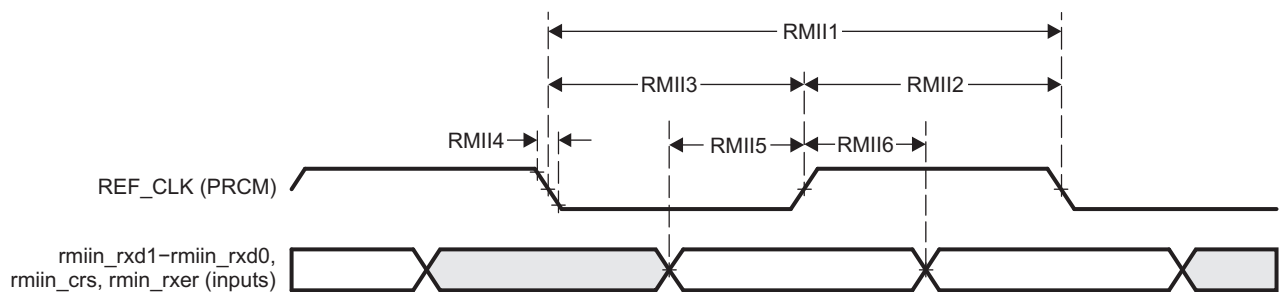
| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|--------------------|------------------------------|-----|-----|------|
| RMII1 | $t_{c(REF_CLK)}$ | Cycle time, REF_CLK | 20 | | ns |
| RMII2 | $t_{w(REF_CLKH)}$ | Pulse duration, REF_CLK high | 7 | 13 | ns |
| RMII3 | $t_{w(REF_CLKL)}$ | Pulse duration, REF_CLK low | 7 | 13 | ns |

Table 7-78. Timing Requirements for GMAC REF_CLK - RMIIOperation (continued)

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|---------------------------|---------------------------|-----|-----|------|
| RMIIO4 | $t_{tt}(\text{REF_CLK})$ | Transistion time, REF_CLK | | 3 | ns |

Table 7-79. Timing Requirements for GMAC RMIIOIn Receive

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|-----------------------------------|---|-----|-----|------|
| RMIIO5 | $t_{su}(\text{RXD-REF_CLK})$ | Setup time, receive selected signals valid before REF_CLK | 4 | | ns |
| | $t_{su}(\text{CRS_DV-REF_CLK})$ | | | | |
| | $t_{su}(\text{RX_ER-REF_CLK})$ | | | | |
| RMIIO6 | $t_h(\text{REF_CLK-RXD})$ | Hold time, receive selected signals valid after REF_CLK | 2 | | ns |
| | $t_h(\text{REF_CLK-CRS_DV})$ | | | | |
| | $t_h(\text{REF_CLK-RX_ER})$ | | | | |



SPRS906_TIMING_GMAC_RMIIOITX_09

Figure 7-57. GMAC Receive Interface Timing RMIIOIn operation

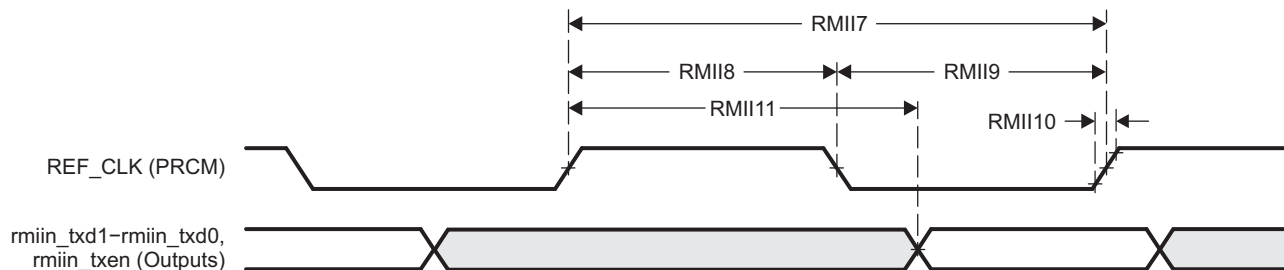
Table 7-80, Table 7-80 and Figure 7-58 present switching characteristics for GMAC RMIIOIn Transmit 10/100Mbit/s.

Table 7-80. Switching Characteristics Over Recommended Operating Conditions for GMAC REF_CLK - RMIIOperation

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|---------|-------------------------|------------------------------|-----|-----|------|
| RMIIO7 | $t_c(\text{REF_CLK})$ | Cycle time, REF_CLK | 20 | | ns |
| RMIIO8 | $t_w(\text{REF_CLKH})$ | Pulse duration, REF_CLK high | 7 | 13 | ns |
| RMIIO9 | $t_w(\text{REF_CLKL})$ | Pulse duration, REF_CLK low | 7 | 13 | ns |
| RMIIO10 | $t_t(\text{REF_CLK})$ | Transistion time, REF_CLK | | 3 | ns |

Table 7-81. Switching Characteristics Over Recommended Operating Conditions for GMAC RMIIOIn Transmit 10/100 Mbts/s

| NO. | PARAMETER | DESCRIPTION | RMIIOIn | MIN | MAX | UNIT |
|---------|--------------------------------|---|---------|-----|------|------|
| RMIIO11 | $t_d(\text{REF_CLK-TXD})$ | Delay time, REF_CLK high to selected transmit signals valid | RMIIO0 | 2 | 13.5 | ns |
| | $t_{dd}(\text{REF_CLK-TXEN})$ | | | | | |
| | $t_d(\text{REF_CLK-TXD})$ | | RMIIO1 | 2 | 13.8 | ns |
| | $t_{dd}(\text{REF_CLK-TXEN})$ | | | | | |



SPRS906_TIMING_GMAC_RMII_TX_07

Figure 7-58. GMAC Transmit Interface Timing RMIIn Operation

In Table 7-82 are presented the specific groupings of signals (IOSET) for use with GMAC RMII signals.

Table 7-82. GMAC RMII IOSETs

| SIGNALS | IOSET1 | | IOSET2 | |
|-------------------|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX |
| GMAC RMII1 | | | | |
| RMII_MHZ_50_CLK | U3 | 0 | | |
| rmi11_txd1 | V5 | 2 | | |
| rmi11_txd0 | V4 | 2 | | |
| rmi11_rxd1 | W9 | 2 | | |
| rmi11_rxd0 | V9 | 2 | | |
| rmi11_txer | Y1 | 2 | | |
| rmi11_txen | U5 | 2 | | |
| rmi11_crs | V2 | 2 | | |
| GMAC RMII0 | | | | |
| RMII_MHZ_50_CLK | | | U3 | 0 |
| rmi00_txd1 | | | Y2 | 1 |
| rmi00_txd0 | | | W2 | 1 |
| rmi00_rxd1 | | | V6 | 1 |
| rmi00_rxd0 | | | U6 | 1 |
| rmi00_txen | | | V3 | 1 |
| rmi00_txer | | | U7 | 1 |
| rmi00_crs | | | V7 | 1 |

Manual IO Timings Modes must be used to ensure some IO timings for GMAC. See Table 7-2 Modes Summary for a list of IO timings requiring the use of Manual IO Timings Modes. See Table 7-83 Manual Functions Mapping for GMAC RMII0 for a definition of the Manual modes.

Table 7-83 lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-83. Manual Functions Mapping for GMAC RMII0

| BALL | BALL NAME | GMAC_RMII0_MANUAL1 | | CFG REGISTER | MUXMODE | |
|------|-----------------|--------------------|--------------|------------------------|-----------------|------------|
| | | A_DELAY (ps) | G_DELAY (ps) | | 0 | 1 |
| U3 | RMII_MHZ_50_CLK | 0 | 0 | CFG_RMII_MHZ_50_CLK_IN | RMII_MHZ_50_CLK | |
| U6 | rgmii0_txd0 | 2444 | 804 | CFG_RGMII0_TXD0_IN | | rmi00_rxd0 |
| V6 | rgmii0_txd1 | 2453 | 981 | CFG_RGMII0_TXD1_IN | | rmi00_rxd1 |
| U7 | rgmii0_txd2 | 2356 | 847 | CFG_RGMII0_TXD2_IN | | rmi00_txer |
| V7 | rgmii0_txd3 | 2415 | 993 | CFG_RGMII0_TXD3_IN | | rmi00_crs |

Manual IO Timings Modes must be used to ensure some IO timings for GMAC. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-84 Manual Functions Mapping for GMAC RMII1](#) for a definition of the Manual modes.

[Table 7-84](#) list the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-84. Manual Functions Mapping for GMAC RMII1

| BALL | BALL NAME | GMAC_RMII1_MANUAL1 | | CFG REGISTER | MUXMODE | |
|------|-----------------|--------------------|--------------|------------------------|-----------------|------------|
| | | A_DELAY (ps) | G_DELAY (ps) | | 0 | 2 |
| U3 | RMII_MHZ_50_CLK | 0 | 0 | CFG_RMII_MHZ_50_CLK_IN | RMII_MHZ_50_CLK | |
| V9 | rgmii0_txctl | 2450 | 909 | CFG_RGMII0_TXCTL_IN | | rmii1_rxd0 |
| W9 | rgmii0_txc | 2327 | 926 | CFG_RGMII0_TXC_IN | | rmii1_rxd1 |
| Y1 | uart3_txd | 2553 | 443 | CFG_UART3_TXD_IN | | rmii1_rxer |
| V2 | uart3_rxd | 1943 | 1110 | CFG_UART3_RXD_IN | | rmii1_crs |

7.23.4 GMAC RGMII Timings

CAUTION

The I/O Timings provided in this section are valid only for some GMAC usage modes when the corresponding Virtual I/O Timings or Manual I/O Timings are configured as described in the tables found in this section.

[Table 7-85](#), [Table 7-86](#) and [Figure 7-59](#) present timing requirements for receive RGMIIIn operation.

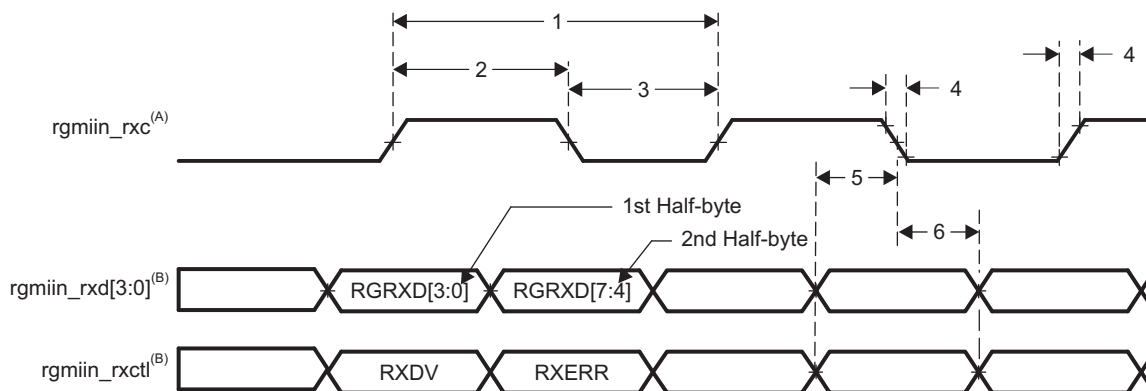
Table 7-85. Timing Requirements for rgmiin_rxc - RGMIIIn Operation

| NO. | PARAMETER | DESCRIPTION | SPEED | MIN | MAX | UNIT |
|-----|-----------------------|---------------------------------|-----------|-----|------|------|
| 1 | t _c (TXC) | Cycle time, rgmiin_txc | 10 Mbps | 360 | 440 | ns |
| | | | 100 Mbps | 36 | 44 | ns |
| | | | 1000 Mbps | 7.2 | 8.8 | ns |
| 2 | t _w (TXCH) | Pulse duration, rgmiin_txc high | 10 Mbps | 160 | 240 | ns |
| | | | 100 Mbps | 16 | 24 | ns |
| | | | 1000 Mbps | 3.6 | 4.4 | ns |
| 3 | t _w (TXCL) | Pulse duration, rgmiin_txc low | 10 Mbps | 160 | 240 | ns |
| | | | 100 Mbps | 16 | 24 | ns |
| | | | 1000 Mbps | 3.6 | 4.4 | ns |
| 4 | t _t (TXC) | Transition time, rgmiin_txc | 10 Mbps | | 0.75 | ns |
| | | | 100 Mbps | | 0.75 | ns |
| | | | 1000 Mbps | | 0.75 | ns |

Table 7-86. Timing Requirements for GMAC RGMIIIn Input Receive for 10/100/1000 Mbps ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|----------------------------|---|----------|-----|-----|------|
| 5 | t _{su} (RXD-RXCH) | Setup time, receive selected signals valid before rgmiin_rxc high/low | RGMII0/1 | 1 | | ns |
| 6 | t _h (RXCH-RXD) | Hold time, receive selected signals valid after rgmiin_rxc high/low | RGMII0/1 | 1 | | ns |

(1) For RGMII, receive selected signals include: rgmiin_rxd[3:0] and rgmiin_rxctl.



SPRS906_TIMING_GMAC_RGMII_RX_08

- A. rgmiin_rxc must be externally delayed relative to the data and control pins.
- B. Data and control information is received using both edges of the clocks. rgmiin_rxd[3:0] carries data bits 3-0 on the rising edge of rgmiin_rxc and data bits 7-4 on the falling edge of rgmiin_rxc. Similarly, rgmiin_rxctl carries RXDV on rising edge of rgmiin_rxc and RXERR on falling edge of rgmiin_rxc.

Figure 7-59. GMAC Receive Interface Timing, RGMII operation

Table 7-87, Table 7-88 and Figure 7-60 present switching characteristics for transmit - RGMII for 10/100/1000Mbit/s.

Table 7-87. Switching Characteristics Over Recommended Operating Conditions for rgmiin_txctl - RGMII Operation for 10/100/1000 Mbit/s

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

Table 7-88. Switching Characteristics for GMAC RGMII Output Transmit for 10/100/1000 Mbps ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|--------------------|---|---|---------------------|-----|------|
| 5 | $t_{osu(TXD-TXC)}$ | Output Setup time, transmit selected signals valid to rgmiin_txc high/low | RGMII0, Internal Delay Enabled, 1000 Mbps | 1.05 ⁽²⁾ | | ns |
| | | | RGMII0, Internal Delay Enabled, 10/100 Mbps | 1.2 | | ns |
| | | | RGMII1, Internal Delay Enabled, 1000 Mbps | 1.05 ⁽³⁾ | | ns |
| | | | RGMII1, Internal Delay Enabled, 10/100 Mbps | 1.2 | | ns |

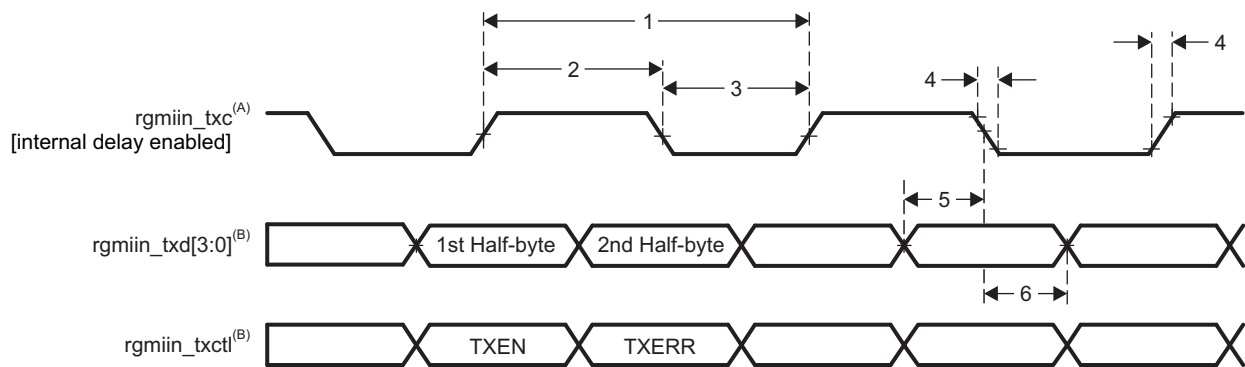
Table 7-88. Switching Characteristics for GMAC RGMII Output Transmit for 10/100/1000 Mbps
(1) (continued)

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|-------------------|---|---|-------------|-----|------|
| 6 | $t_{oh}(TXC-TXD)$ | Output Hold time, transmit selected signals valid after rgmiin_txc high/low | RGMIIO, Internal Delay Enabled, 1000 Mbps | 1.05 (2) | | ns |
| | | | RGMIIO, Internal Delay Enabled, 10/100 Mbps | 1.2 | | ns |
| | | | RGMI11, Internal Delay Enabled, 1000 Mbps | 1.05 (3) | | ns |
| | | | RGMI11, Internal Delay Enabled, 10/100 Mbps | 1.2 | | ns |

(1) For RGMII, transmit selected signals include: rgmiin_txd[3:0] and rgmiin_txctl.

(2) RGMIIO requires that the 4 data pins rgmii0_txd[3:0] and rgmii0_txctl have their board propagation delays matched within 50pS of rgmii0_txc.

(3) RGMII1 requires that the 4 data pins rgmii1_txd[3:0] and rgmii1_txctl have their board propagation delays matched within 50pS of rgmii1_txc.



SPRS906_TIMING_GMAC_RGMII_TX_09

- A. TXC is delayed internally before being driven to the rgmiin_txc pin. This internal delay is always enabled.
- B. Data and control information is transmitted using both edges of the clocks. rgmii_txd[3:0] carries data bits 3-0 on the rising edge of rgmiin_txc and data bits 7-4 on the falling edge of rgmiin_txc. Similarly, rgmii_txctl carries TXEN on rising edge of rgmiin_txc and TXERR on falling edge of rgmiin_txc.

Figure 7-60. GMAC Transmit Interface Timing RGMII operation

In [Table 7-89](#) are presented the specific groupings of signals (IOSET) for use with GMAC RGMII signals.

Table 7-89. GMAC RGMII IOSETs

| SIGNALS | IOSET3 | | IOSET4 | |
|--------------------|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX |
| GMAC RGMII1 | | | | |
| rgmii1_txd3 | C3 | 3 | | |
| rgmii1_txd2 | C4 | 3 | | |
| rgmii1_txd1 | B2 | 3 | | |
| rgmii1_txd0 | D6 | 3 | | |
| rgmii1_rxd3 | B3 | 3 | | |
| rgmii1_rxd2 | B4 | 3 | | |
| rgmii1_rxd1 | B5 | 3 | | |
| rgmii1_rxd0 | A4 | 3 | | |
| rgmii1_rxctl | A3 | 3 | | |
| rgmii1_txc | D5 | 3 | | |
| rgmii1_txctl | C2 | 3 | | |

Table 7-89. GMAC RGMII IOSETs (continued)

| SIGNALS | IOSET3 | | IOSET4 | |
|--------------------|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX |
| rgmii1_rxc | C5 | 3 | | |
| GMAC RGMII0 | | | | |
| rgmii0_txd3 | | | V7 | 0 |
| rgmii0_txd2 | | | U7 | 0 |
| rgmii0_txd1 | | | V6 | 0 |
| rgmii0_txd0 | | | U6 | 0 |
| rgmii0_rxd3 | | | V4 | 0 |
| rgmii0_rxd2 | | | V3 | 0 |
| rgmii0_rxd1 | | | Y2 | 0 |
| rgmii0_rxd0 | | | W2 | 0 |
| rgmii0_txc | | | W9 | 0 |
| rgmii0_rxctl | | | V5 | 0 |
| rgmii0_rxc | | | U5 | 0 |
| rgmii0_txctl | | | V9 | 0 |

NOTE

To configure the desired Manual IO Timing Mode the user must follow the steps described in section "*Manual IO Timing Modes*" of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information, see *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for GMAC. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-90 Manual Functions Mapping for GMAC RGMII0](#) for a definition of the Manual modes.

[Table 7-90](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-90. Manual Functions Mapping for GMAC RGMII0

| BALL | BALL NAME | GMAC_RGMII0_MANUAL1 | | CFG REGISTER | MUXMODE |
|------|--------------|---------------------|--------------|----------------------|--------------|
| | | A_DELAY (ps) | G_DELAY (ps) | | 0 |
| U5 | rgmii0_rxc | 413 | 0 | CFG_RGMII0_RXC_IN | rgmii0_rxc |
| V5 | rgmii0_rxctl | 27 | 2296 | CFG_RGMII0_RXCTL_IN | rgmii0_rxctl |
| W2 | rgmii0_rxd0 | 3 | 1721 | CFG_RGMII0_RXD0_IN | rgmii0_rxd0 |
| Y2 | rgmii0_rxd1 | 134 | 1786 | CFG_RGMII0_RXD1_IN | rgmii0_rxd1 |
| V3 | rgmii0_rxd2 | 40 | 1966 | CFG_RGMII0_RXD2_IN | rgmii0_rxd2 |
| V4 | rgmii0_rxd3 | 0 | 2057 | CFG_RGMII0_RXD3_IN | rgmii0_rxd3 |
| W9 | rgmii0_txc | 0 | 60 | CFG_RGMII0_TXC_OUT | rgmii0_txc |
| V9 | rgmii0_txctl | 0 | 60 | CFG_RGMII0_TXCTL_OUT | rgmii0_txctl |
| U6 | rgmii0_txd0 | 0 | 60 | CFG_RGMII0_TXD0_OUT | rgmii0_txd0 |
| V6 | rgmii0_txd1 | 0 | 0 | CFG_RGMII0_TXD1_OUT | rgmii0_txd1 |
| U7 | rgmii0_txd2 | 0 | 60 | CFG_RGMII0_TXD2_OUT | rgmii0_txd2 |
| V7 | rgmii0_txd3 | 0 | 120 | CFG_RGMII0_TXD3_OUT | rgmii0_txd3 |

Manual IO Timings Modes must be used to ensure some IO timings for GMAC. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-91 Manual Functions Mapping for GMAC RGMII1](#) for a definition of the Manual modes.

[Table 7-91](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-91. Manual Functions Mapping for GMAC RGMII1

| BALL | BALL NAME | GMAC_RGMII1_MANUAL1 | | CFG REGISTER | MUXMODE |
|------|-----------|---------------------|--------------|-------------------|--------------|
| | | A_DELAY (ps) | G_DELAY (ps) | | 3 |
| C5 | vin2a_d18 | 530 | 0 | CFG_VIN2A_D18_IN | rgmii1_rxc |
| A3 | vin2a_d19 | 71 | 1099 | CFG_VIN2A_D19_IN | rgmii1_rxctl |
| B3 | vin2a_d20 | 142 | 1337 | CFG_VIN2A_D20_IN | rgmii1_rxd3 |
| B4 | vin2a_d21 | 114 | 1517 | CFG_VIN2A_D21_IN | rgmii1_rxd2 |
| B5 | vin2a_d22 | 171 | 1331 | CFG_VIN2A_D22_IN | rgmii1_rxd1 |
| A4 | vin2a_d23 | 0 | 1328 | CFG_VIN2A_D23_IN | rgmii1_rxd0 |
| D5 | vin2a_d12 | 0 | 0 | CFG_VIN2A_D12_OUT | rgmii1_txc |
| C2 | vin2a_d13 | 170 | 0 | CFG_VIN2A_D13_OUT | rgmii1_txctl |
| C3 | vin2a_d14 | 150 | 0 | CFG_VIN2A_D14_OUT | rgmii1_txd3 |
| C4 | vin2a_d15 | 0 | 0 | CFG_VIN2A_D15_OUT | rgmii1_txd2 |
| B2 | vin2a_d16 | 60 | 0 | CFG_VIN2A_D16_OUT | rgmii1_txd1 |
| D6 | vin2a_d17 | 60 | 0 | CFG_VIN2A_D17_OUT | rgmii1_txd0 |

7.24 Media Local Bus (MLB) interface

The MLBSS allows connection to a MOST (Media Oriented Systems Transport) network controller for transport of media and control data between multimedia nodes. The MLBSS supports the following features:

- 3 pin mode compliant to MediaLB Physical Layer Specification v4.0
- 6 pin mode (3 differential pairs) compliant to MediaLB Physical Layer Specification v4.0
- Supports 256/512/1024Fs in 3 pin mode and 2048Fs in 6 pin mode
- Supports all types of transfer (Sync, Isoc, Async/Packet, Control) over 64 logical channels
- 16KB buffering for synchronous /isochronous/control/packet data in the subsystem

NOTE

For more information, see *Media Local Bus (MLB)* section in the device TRM.

NOTE

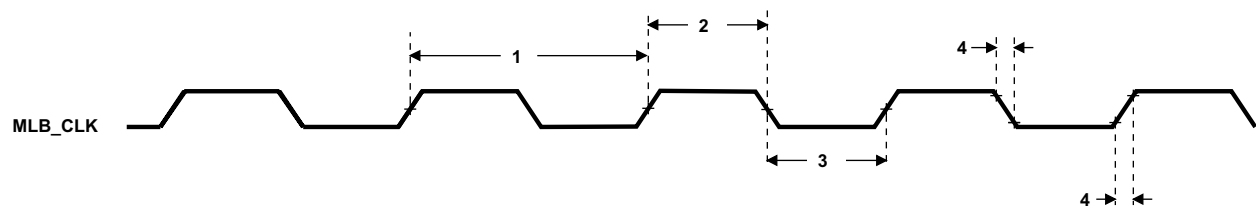
MLB in 6-pin mode may require pull ups/ downs on SIG and DAT bus signals. For additional details, please consult the MLB bus interface specification.

Table 7-92 and Figure 7-61 present Timing Requirements for MLKCLK 3-Pin Option.

Table 7-92. Timing Requirements for MLBCLK 3-Pin Option ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|-----------------|------------------------------|--------|------|-----|------|
| 1 | $t_{c(MLBCLK)}$ | Cycle time, MLB_CLK | 512FS | 39 | | ns |
| | | | 1024FS | 19.5 | | ns |
| 2 | $t_{w(MLBCLK)}$ | Pulse duration, MLB_CLK high | 512FS | 14 | | ns |
| | | | 1024FS | 9.3 | | ns |
| 3 | $t_{w(MLBCLK)}$ | Pulse duration, MLB_CLK low | 512FS | 14 | | ns |
| | | | 1024FS | 6.1 | | ns |

(1) The reference points for the rise and fall transitions are measured at $V_{OL\ MAX}$ and $V_{OH\ MIN}$.



SPRS906_TIMING_MLB_01

Figure 7-61. MLB_CLK Timing

Table 7-93 and Table 7-94 present Timing Requirements and Switching Characteristics for MLB 3-Pin Option.

Table 7-93. Timing Requirements for Receive Data for the MLB 3-Pin Option

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|--------------------------|--|--------|-----|-----|------|
| 5 | $t_{su(MLBDAT-MLBCLKL)}$ | Setup time, MLB_DAT/MLB_SIG input valid before MLB_CLK low | 512FS | 1 | | ns |
| | | | 1024FS | 1 | | ns |
| 6 | $t_{h(MLBCLKL-MLBDAT)}$ | Hold time, MLB_DAT/MLB_SIG input valid after MLB_CLK low | 512FS | 4 | | ns |
| | | | 1024FS | 2 | | ns |

Table 7-94. Switching Characteristics Over Recommended Operating Conditions for MLB 3-Pin Option

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|----------------------------|---|--------|-----|-----|------|
| 7 | $t_{d(MLBCLKH-MLBDATV)}$ | Delay time, MLBCLKH rising to MLB_DAT/MLB_SIG valid | 512FS | 0 | 10 | ns |
| | | | 1024FS | 0 | 7 | ns |
| 8 | $t_{dis(MLBCLKL-MLBDATZ)}$ | Disable time, MLBCLKH falling to MLB_DAT/MLB_SIG Hi-Z | 512FS | 0 | 14 | ns |
| | | | 1024FS | 0 | 6.1 | ns |

Table 7-95 and Figure 7-61 present Timing Requirements for MLKCLK 6-Pin Option.

Table 7-95. Timing Requirements for MLBCLK 6-Pin Option ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|----------------|---------------------------------|----------------|-----|-----|------|
| 1 | $t_c(MLBCLKx)$ | Cycle time, MLB_CLKP/N | 2048FS, 4096FS | 10 | | ns |
| 2 | $t_w(MLBCLKx)$ | Pulse duration, MLB_CLKP/N high | 2048FS, 4096FS | 4.5 | | ns |
| 3 | $t_w(MLBCLKx)$ | Pulse duration, MLB_CLKP/N low | 2048FS, 4096FS | 4.5 | | ns |

(1) The reference points for the rise and fall transitions are measured at 20%/80% of $V_{in+/-}$.

Table 7-96 and Table 7-97 present Timing Requirements and Switching Characteristics for MLB 6-Pin Option.

Table 7-96. Timing Requirements for Receive Data for the MLB 6-Pin Option

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|----------------------|---|--------|-------------------------------|-----|------|
| 5 | $t_{su(DATx-CLKxH)}$ | Setup time, MLBP_DATx/MLBP_SIGx input valid before MLBP_CLKx rising | 2048FS | 1 | | ns |
| | | | 4096FS | $0.5 - n \times P/2^{(1)(2)}$ | | ns |
| 6 | $t_h(CLKxH-DATx)$ | Hold time, MLBP_DATx/MLBP_SIGx input valid after MLBP_CLKx rising | 2048FS | 0.5 | | ns |
| | | | 4096FS | $0.6 + n \times P/2^{(1)(2)}$ | | ns |

(1) $P = t_c(MLBCLKx)$ period.

(2) $n=0$ or 1 , corresponding to two captures per clock cycle.

Table 7-97. Switching Characteristics Over Recommended Operating Conditions for MLB 6-Pin Option

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|-----|------------------------|--|--------|-------------------------------|----------------------|------|
| 7 | $t_{d(CLKxH-DATxV)}$ | Delay time, MLBPCLKxH rising to MLB_DATx/MLB_SIGx valid | 2048FS | 0.5 | 7 | ns |
| | | | 4096FS | $0.6 + n \times P/2^{(1)(2)}$ | $2.5 + n \times P/2$ | ns |
| 8 | $t_{dis(CLKPH-DATPZ)}$ | Disable time, MLBPCLKxH rising to MLBP_DATx/MLBP_SIGx Hi-Z | 2048FS | 0.5 | 7 | ns |
| | | | 4096FS | $0.6 + n \times P/2^{(1)(2)}$ | $3.5 + n \times P/2$ | ns |

(1) $P = t_c(MLBCLKx)$ period.

(2) $n=0$ or 1 , corresponding to two captures per clock cycle.

7.25 eMMC/SD/SDIO

The Device includes the following external memory interfaces 4 MultiMedia Card/Secure Digital/Secure Digital Input Output Interface (MMC/SD/SDIO)

NOTE

The eMMC/SD/SDIO_i ($i = 1$ to 4) controller is also referred to as MMC_i.

7.25.1 MMC1-SD Card Interface

MMC1 interface is compliant with the SD Standard v3.01 and it supports the following SD Card applications:

- Default speed, 4-bit data, SDR, half-cycle
- High speed, 4-bit data, SDR, half-cycle
- SDR12, 4-bit data, half-cycle
- SDR25, 4-bit data, half-cycle
- UHS-I SDR50, 4-bit data, half-cycle
- UHS-I SDR104, 4-bit data, half-cycle
- UHS-I DDR50, 4-bit data

NOTE

For more information, see *eMMC/SD/SDIO* chapter in the device TRM.

7.25.1.1 Default speed, 4-bit data, SDR, half-cycle

Table 7-98 and Table 7-99 present Timing requirements and Switching characteristics for MMC1 - Default Speed in receiver and transmitter mode (see Figure 7-62 and Figure 7-63).

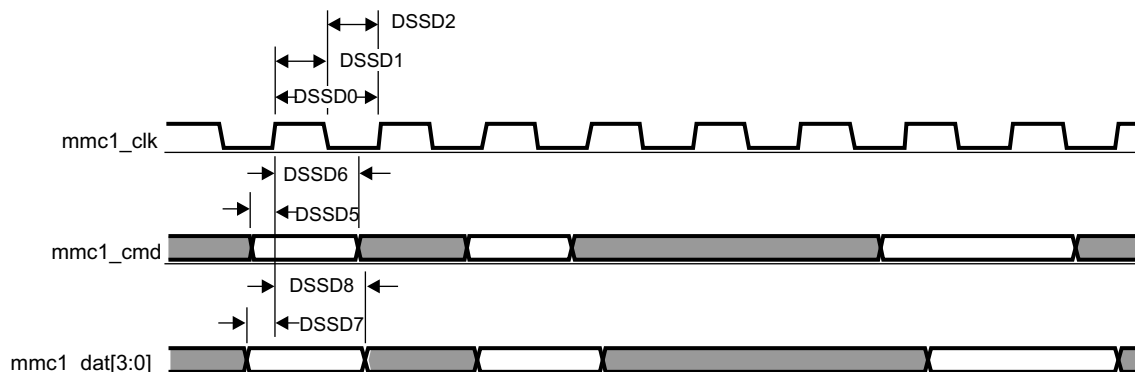
Table 7-98. Timing Requirements for MMC1 - SD Card Default Speed Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|---------------------|---|-------|-----|------|
| DSSD5 | $t_{su}(cmdV-clkH)$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge | 5.11 | | ns |
| DSSD6 | $t_h(clkH-cmdV)$ | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge | 20.46 | | ns |
| DSSD7 | $t_{su}(dV-clkH)$ | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge | 5.11 | | ns |
| DSSD8 | $t_h(clkH-dV)$ | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge | 20.46 | | ns |

Table 7-99. Switching Characteristics for MMC1 - SD Card Default Speed Mode

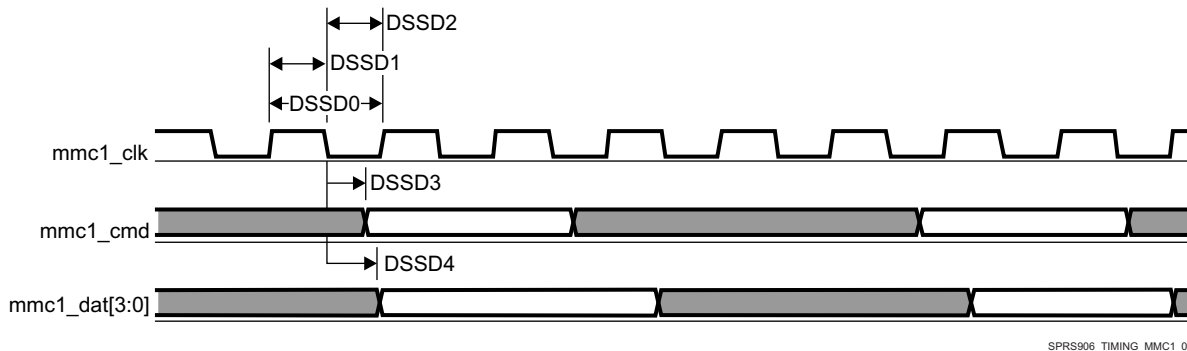
| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|------------------|---|------------------------------|-------|------|
| DSSD0 | fop(clk) | Operating frequency, mmc1_clk | | 24 | MHz |
| DSSD1 | $t_w(clkH)$ | Pulse duration, mmc1_clk high | $0.5 \times P - 0.185^{(1)}$ | | ns |
| DSSD2 | $t_w(clkL)$ | Pulse duration, mmc1_clk low | $0.5 \times P - 0.185^{(1)}$ | | ns |
| DSSD3 | $t_d(clkL-cmdV)$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition | -14.93 | 14.93 | ns |
| DSSD4 | $t_d(clkL-dV)$ | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -14.93 | 14.93 | ns |

(1) P = output mmc1_clk period in ns



SPRS906_TIMING_MMC1_01

Figure 7-62. MMC/SD/SDIO in - Default Speed - Receiver Mode



SPRS906_TIMING_MMC1_02

Figure 7-63. MMC/SD/SDIO in - Default Speed - Transmitter Mode

7.25.1.2 High speed, 4-bit data, SDR, half-cycle

Table 7-100 and Table 7-101 present Timing requirements and Switching characteristics for MMC1 - High Speed in receiver and transmitter mode (see Figure 7-64 and Figure 7-65).

Table 7-100. Timing Requirements for MMC1 - SD Card High Speed

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|---------------------|---|-----|-----|------|
| HSSD3 | $t_{su(cmdV-clkH)}$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge | 5.3 | | ns |
| HSSD4 | $t_{h(clkH-cmdV)}$ | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge | 2.6 | | ns |
| HSSD7 | $t_{su(dV-clkH)}$ | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge | 5.3 | | ns |
| HSSD8 | $t_{h(clkH-dV)}$ | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge | 2.6 | | ns |

Table 7-101. Switching Characteristics for MMC1 - SD Card High Speed

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|--------------------|---|------------------------------|-----|------|
| HSSD1 | fop(clk) | Operating frequency, mmc1_clk | | 48 | MHz |
| HSSD2H | $t_{w(clkH)}$ | Pulse duration, mmc1_clk high | $0.5 \times P - 0.185^{(1)}$ | | ns |
| HSSD2L | $t_{w(clkL)}$ | Pulse duration, mmc1_clk low | $0.5 \times P - 0.185^{(1)}$ | | ns |
| HSSD5 | $t_{d(clkL-cmdV)}$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition | -7.6 | 3.6 | ns |
| HSSD6 | $t_{d(clkL-dV)}$ | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -7.6 | 3.6 | ns |

(1) P = output mmc1_clk period in ns



SPRS906_TIMING_MMC1_03

Figure 7-64. MMC/SD/SDIO in - High Speed - Receiver Mode

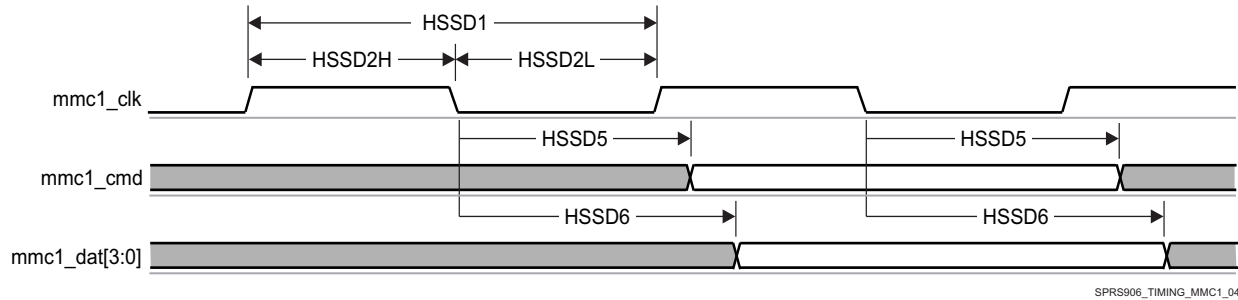


Figure 7-65. MMC/SD/SDIO in - High Speed - Transmitter Mode

7.25.1.3 SDR12, 4-bit data, half-cycle

Table 7-102 and Table 7-103 present Timing requirements and Switching characteristics for MMC1 - SDR12 in receiver and transmitter mode (see Figure 7-66 and Figure 7-67).

Table 7-102. Timing Requirements for MMC1 - SD Card SDR12 Mode

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|---------|---------------------|---|-------------------------|-------|-----|------|
| SDR12 5 | $t_{su}(cmdV-clkH)$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge | | 25.99 | | ns |
| SDR12 6 | $t_h(clkH-cmdV)$ | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge | Pad Loopback Clock | 1.6 | | ns |
| | | | Internal Loopback Clock | 1.6 | | ns |
| SDR12 7 | $t_{su}(dV-clkH)$ | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge | | 25.99 | | ns |
| SDR12 8 | $t_h(clkH-dV)$ | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge | Pad Loopback Clock | 1.6 | | ns |
| | | | Internal Loopback Clock | 1.6 | | ns |

Table 7-103. Switching Characteristics for MMC1 - SD Card SDR12 Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|------------------|---|------------------------------|-------|------|
| SDR120 | fop(clk) | Operating frequency, mmc1_clk | | 24 | MHz |
| SDR121 | $t_w(clkH)$ | Pulse duration, mmc1_clk high | $0.5 \times P - 0.185^{(1)}$ | | ns |
| SDR122 | $t_w(clkL)$ | Pulse duration, mmc1_clk low | $0.5 \times P - 0.185^{(1)}$ | | ns |
| SDR123 | $t_d(clkL-cmdV)$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition | -19.13 | 16.93 | ns |
| SDR124 | $t_d(clkL-dV)$ | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -19.13 | 16.93 | ns |

(1) P = output mmc1_clk period in ns

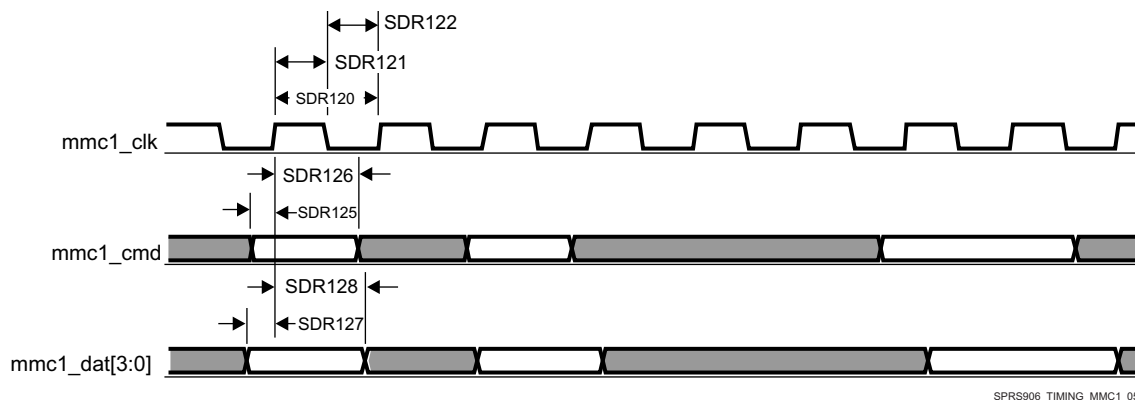


Figure 7-66. MMC/SD/SDIO in - High Speed SDR12 - Receiver Mode

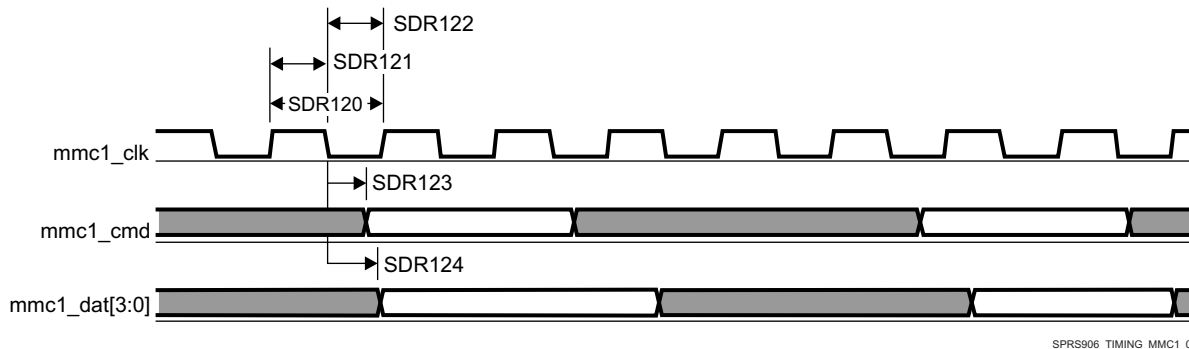


Figure 7-67. MMC/SD/SDIO in - High Speed SDR12 - Transmitter Mode

7.25.1.4 SDR25, 4-bit data, half-cycle

Table 7-104 and Table 7-105 present Timing requirements and Switching characteristics for MMC1 - SDR25 in receiver and transmitter mode (see Figure 7-68 and Figure 7-69).

Table 7-104. Timing Requirements for MMC1 - SD Card SDR25 Mode

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|--------|---------------------|---|-------------------------|-----|-----|------|
| SDR253 | $t_{su(cmdV-clkH)}$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge | | 5.3 | | ns |
| SDR254 | $t_h(clkH-cmdV)$ | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge | | 1.6 | | ns |
| SDR257 | $t_{su(dV-clkH)}$ | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge | | 5.3 | | ns |
| SDR258 | $t_h(clkH-dV)$ | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge | Pad Loopback Clock | 1.6 | | ns |
| | | | Internal Loopback Clock | 1.6 | | ns |

Table 7-105. Switching Characteristics for MMC1 - SD Card SDR25 Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|---------|------------------|---|------------------------------|-----|------|
| SDR251 | fop(clk) | Operating frequency, mmc1_clk | | 48 | MHz |
| SDR252H | $t_w(clkH)$ | Pulse duration, mmc1_clk high | $0.5 \times P - 0.185^{(1)}$ | | ns |
| SDR252L | $t_w(clkL)$ | Pulse duration, mmc1_clk low | $0.5 \times P - 0.185^{(1)}$ | | ns |
| SDR255 | $t_d(clkL-cmdV)$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition | -8.8 | 6.6 | ns |
| SDR256 | $t_d(clkL-dV)$ | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -8.8 | 6.6 | ns |

(1) P = output mmc1_clk period in ns

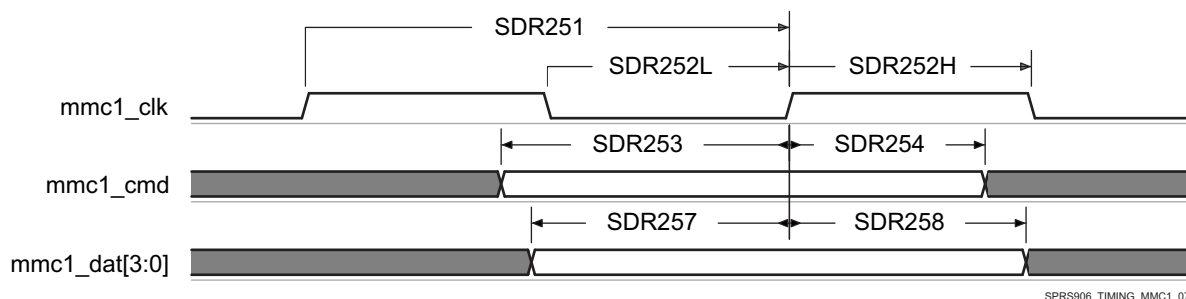


Figure 7-68. MMC/SD/SDIO in - High Speed SDR25 - Receiver Mode

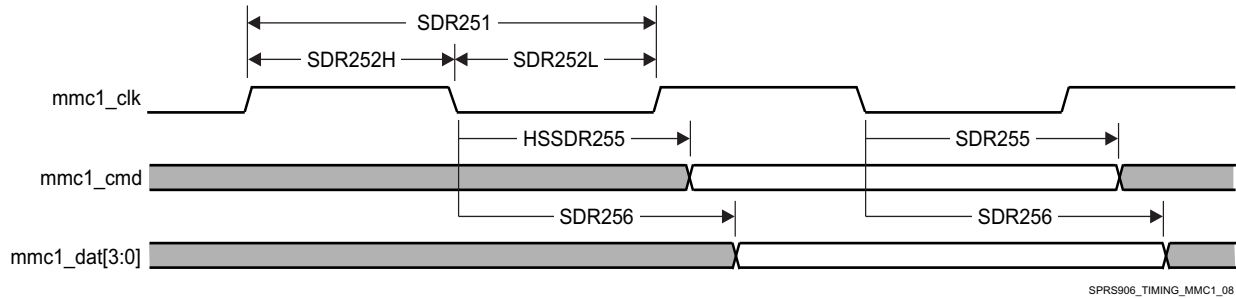


Figure 7-69. MMC/SD/SDIO in - High Speed SDR25 - Transmitter Mode

7.25.1.5 UHS-I SDR50, 4-bit data, half-cycle

Table 7-106 and Table 7-107 present Timing requirements and Switching characteristics for MMC1 - SDR50 in receiver and transmitter mode (see Figure 7-70 and Figure 7-71).

Table 7-106. Timing Requirements for MMC1 - SD Card SDR50 Mode

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|--------|---------------------|---|-------------------------|------|-----|------|
| SDR503 | $t_{su(cmdV-clkH)}$ | Setup time, mmc1_cmd valid before mmc1_clk rising clock edge | | 1.48 | | ns |
| SDR504 | $t_h(clkH-cmdV)$ | Hold time, mmc1_cmd valid after mmc1_clk rising clock edge | | 1.6 | | ns |
| SDR507 | $t_{su(dV-clkH)}$ | Setup time, mmc1_dat[3:0] valid before mmc1_clk rising clock edge | | 1.48 | | ns |
| SDR508 | $t_h(clkH-dV)$ | Hold time, mmc1_dat[3:0] valid after mmc1_clk rising clock edge | Pad Loopback Clock | 1.6 | | ns |
| | | | Internal Loopback Clock | 1.6 | | ns |

Table 7-107. Switching Characteristics for MMC1 - SD Card SDR50 Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|---------|------------------|---|--------------------------------|------|------|
| SDR501 | fop(clk) | Operating frequency, mmc1_clk | | 96 | MHz |
| SDR502H | $t_w(clkH)$ | Pulse duration, mmc1_clk high | 0.5 × P - 0.185 ⁽¹⁾ | | ns |
| | | | 0.5 × P - 0.185 ⁽¹⁾ | | ns |
| SDR502L | $t_w(clkL)$ | Pulse duration, mmc1_clk low | 0.5 × P - 0.185 ⁽¹⁾ | | ns |
| SDR505 | $t_d(clkL-cmdV)$ | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition | -3.66 | 1.46 | ns |
| SDR506 | $t_d(clkL-dV)$ | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -3.66 | 1.46 | ns |

(1) P = output mmc1_clk period in ns

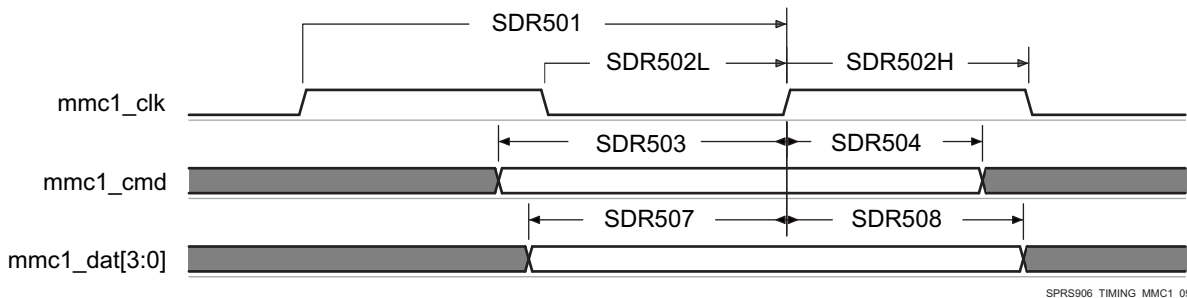


Figure 7-70. MMC/SD/SDIO in - High Speed SDR50 - Receiver Mode

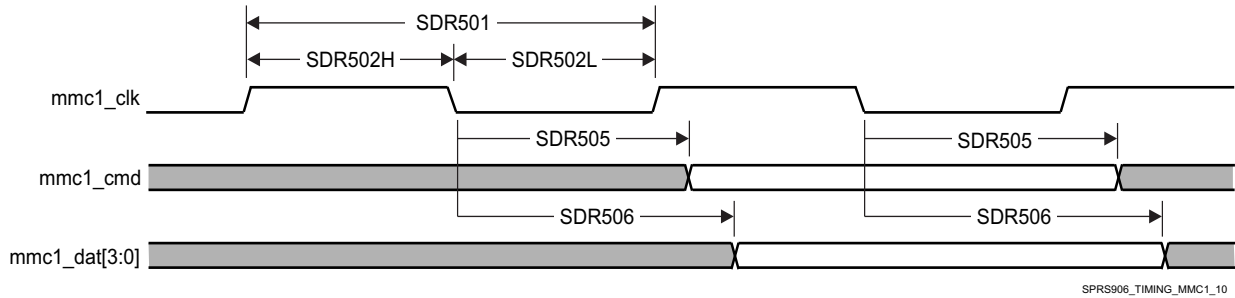


Figure 7-71. MMC/SD/SDIO in - High Speed SDR50 - Transmitter Mode

7.25.1.6 UHS-I SDR104, 4-bit data, half-cycle

Table 7-108 presents Timing requirements and Switching characteristics for MMC1 - SDR104 in receiver and transmitter mode (see Figure 7-72 and Figure 7-73).

Table 7-108. Switching Characteristics for MMC1 - SD Card SDR104 Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------------|----------------------------|---|--------------------------------|------|------|
| SDR1041 | fop(clk) | Operating frequency, mmc1_clk | | 192 | MHz |
| SDR1042 H | t _w (clkH) | Pulse duration, mmc1_clk high | 0.5 × P - 0.185 ⁽¹⁾ | | ns |
| SDR1042 L | t _w (clkL) | Pulse duration, mmc1_clk low | 0.5 × P - 0.185 ⁽¹⁾ | | ns |
| SDR1045 | t _d (clkL-cmdV) | Delay time, mmc1_clk falling clock edge to mmc1_cmd transition | -1.09 | 0.49 | ns |
| SDR1046 | t _d (clkL-dV) | Delay time, mmc1_clk falling clock edge to mmc1_dat[3:0] transition | -1.09 | 0.49 | ns |

(1) P = output mmc1_clk period in ns

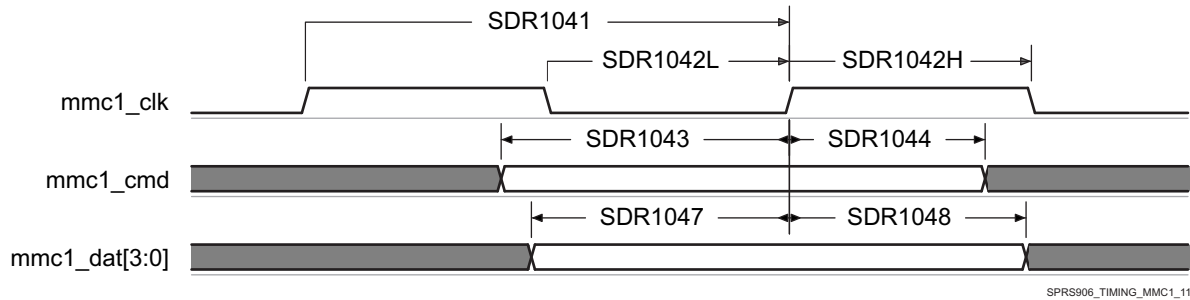


Figure 7-72. MMC/SD/SDIO in - High Speed SDR104 - Receiver Mode

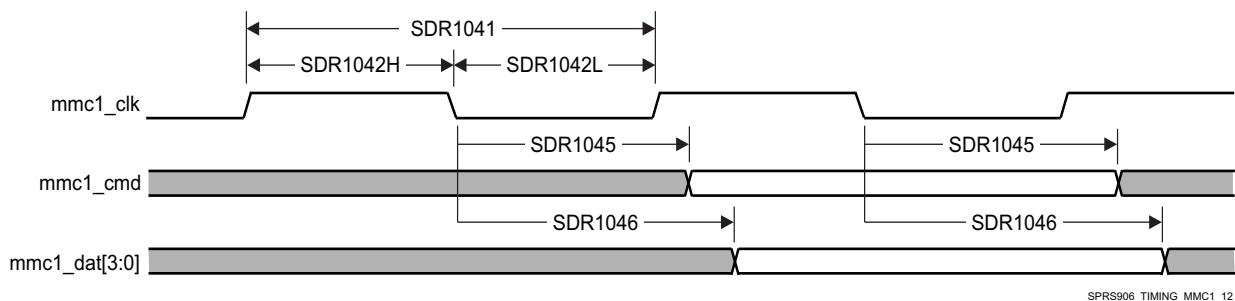


Figure 7-73. MMC/SD/SDIO in - High Speed SDR104 - Transmitter Mode

7.25.1.7 UHS-I DDR50, 4-bit data

Table 7-109 and Table 7-110 present Timing requirements and Switching characteristics for MMC1 - DDR50 in receiver and transmitter mode (see Figure 7-74 and Figure 7-75).

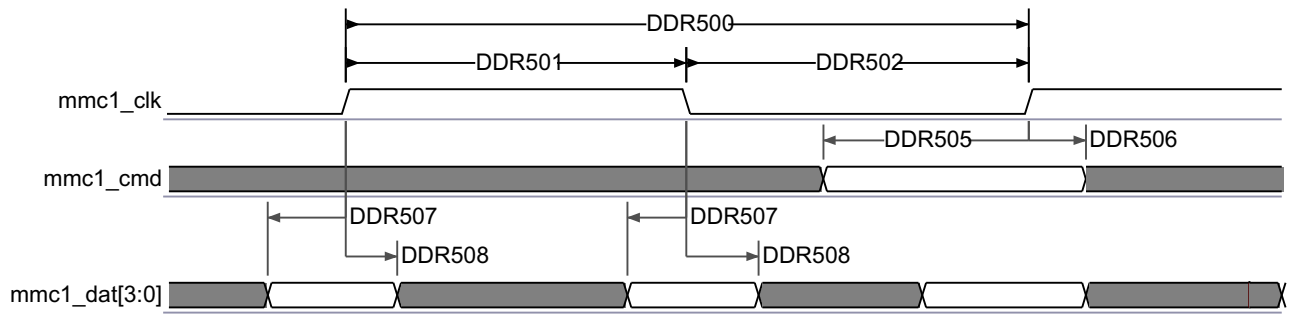
Table 7-109. Timing Requirements for MMC1 - SD Card DDR50 Mode

| NO. | PARAMETER | DESCRIPTION | MODE | MIN | MAX | UNIT |
|--------|--------------------|--|-------------------|------|-----|------|
| DDR505 | $t_{su(cmdV-clk)}$ | Setup time, mmc1_cmd valid before mmc1_clk transition | | 1.79 | | ns |
| DDR506 | $t_{h(clk-cmdV)}$ | Hold time, mmc1_cmd valid after mmc1_clk transition | | 1.6 | | ns |
| DDR507 | $t_{su(dV-clk)}$ | Setup time, mmc1_dat[3:0] valid before mmc1_clk transition | Pad Loopback | 1.79 | | ns |
| | | | Internal Loopback | 1.79 | | ns |
| DDR508 | $t_{h(clk-dV)}$ | Hold time, mmc1_dat[3:0] valid after mmc1_clk transition | Pad Loopback | 1.6 | | ns |
| | | | Internal Loopback | 1.6 | | ns |

Table 7-110. Switching Characteristics for MMC1 - SD Card DDR50 Mode

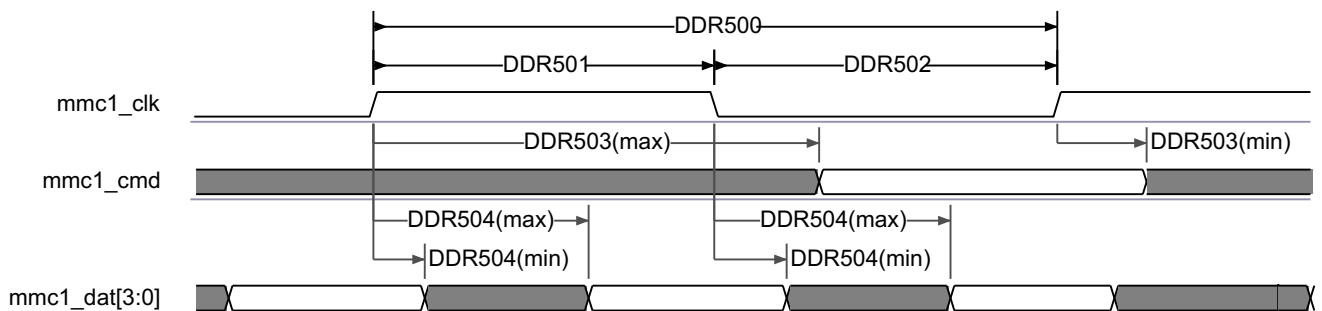
| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|-------------------|---|------------------------------|-----|------|
| DDR500 | fop(clk) | Operating frequency, mmc1_clk | | 48 | MHz |
| DDR501 | $t_{w(clkH)}$ | Pulse duration, mmc1_clk high | $0.5 \times P - 0.185^{(1)}$ | | ns |
| DDR502 | $t_{w(clkL)}$ | Pulse duration, mmc1_clk low | $0.5 \times P - 0.185^{(1)}$ | | ns |
| DDR503 | $t_{d(clk-cmdV)}$ | Delay time, mmc1_clk transition to mmc1_cmd transition | 1.225 | 6.6 | ns |
| DDR504 | $t_{d(clk-dV)}$ | Delay time, mmc1_clk transition to mmc1_dat[3:0] transition | 1.225 | 6.6 | ns |

(1) P = output mmc1_clk period in ns



SPRS906_TIMING_MMC1_13

Figure 7-74. SDMMC - High Speed SD - DDR - Data/Command Receive



MMC1_14

Figure 7-75. SDMMC - High Speed SD - DDR - Data/Command Transmit

NOTE

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bit field for each corresponding pad control register.

The pad control registers are presented in [Table 4-3](#) and described in Device TRM, *Control Module Chapter*.

Virtual IO Timings Modes must be used to ensure some IO timings for MMC1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 7-111 Virtual Functions Mapping for MMC1](#) for a definition of the Virtual modes.

[Table 7-111](#) presents the values for DELAYMODE bit field.

Table 7-111. Virtual Functions Mapping for MMC1

| BALL | BALL NAME | Delay Mode Value | | | | MUXMODE |
|------|-----------|------------------|---------------|---------------|---------------|-----------|
| | | MMC1_VIRTUAL1 | MMC1_VIRTUAL4 | MMC1_VIRTUAL5 | MMC1_VIRTUAL6 | 0 |
| W6 | mmc1_clk | 15 | 12 | 11 | 10 | mmc1_clk |
| Y6 | mmc1_cmd | 15 | 12 | 11 | 10 | mmc1_cmd |
| AA6 | mmc1_dat0 | 15 | 12 | 11 | 10 | mmc1_dat0 |
| Y4 | mmc1_dat1 | 15 | 12 | 11 | 10 | mmc1_dat1 |
| AA5 | mmc1_dat2 | 15 | 12 | 11 | 10 | mmc1_dat2 |
| Y3 | mmc1_dat3 | 15 | 12 | 11 | 10 | mmc1_dat3 |

NOTE

To configure the desired Manual IO Timing Mode the user must follow the steps described in section Manual IO Timing Modes of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information, see *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for MMC1. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-112 Manual Functions Mapping for MMC1](#) for a definition of the Manual modes.

[Table 7-112](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-112. Manual Functions Mapping for MMC1

| BALL | BALL NAME | MMC1_MANUAL1 | | MMC1_MANUAL2 | | CFG REGISTER | MUXMODE |
|------|-----------|--------------|--------------|--------------|--------------|-------------------|-----------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 0 |
| W6 | mmc1_clk | 588 | 0 | - | - | CFG_MMC1_CLK_IN | mmc1_clk |
| Y6 | mmc1_cmd | 1000 | 0 | - | - | CFG_MMC1_CMD_IN | mmc1_cmd |
| AA6 | mmc1_dat0 | 1375 | 0 | - | - | CFG_MMC1_DAT0_IN | mmc1_dat0 |
| Y4 | mmc1_dat1 | 1000 | 0 | - | - | CFG_MMC1_DAT1_IN | mmc1_dat1 |
| AA5 | mmc1_dat2 | 1000 | 0 | - | - | CFG_MMC1_DAT2_IN | mmc1_dat2 |
| Y3 | mmc1_dat3 | 1000 | 0 | - | - | CFG_MMC1_DAT3_IN | mmc1_dat3 |
| W6 | mmc1_clk | 1230 | 0 | 520 | 320 | CFG_MMC1_CLK_OUT | mmc1_clk |
| Y6 | mmc1_cmd | 0 | 0 | 0 | 0 | CFG_MMC1_CMD_OUT | mmc1_cmd |
| AA6 | mmc1_dat0 | 56 | 0 | 40 | 0 | CFG_MMC1_DAT0_OUT | mmc1_dat0 |
| Y4 | mmc1_dat1 | 76 | 0 | 83 | 0 | CFG_MMC1_DAT1_OUT | mmc1_dat1 |
| AA5 | mmc1_dat2 | 91 | 0 | 98 | 0 | CFG_MMC1_DAT2_OUT | mmc1_dat2 |
| Y3 | mmc1_dat3 | 99 | 0 | 106 | 0 | CFG_MMC1_DAT3_OUT | mmc1_dat3 |
| Y6 | mmc1_cmd | 0 | 0 | 51 | 0 | CFG_MMC1_CMD_OEN | mmc1_cmd |
| AA6 | mmc1_dat0 | 0 | 0 | 0 | 0 | CFG_MMC1_DAT0_OEN | mmc1_dat0 |
| Y4 | mmc1_dat1 | 0 | 0 | 363 | 0 | CFG_MMC1_DAT1_OEN | mmc1_dat1 |
| AA5 | mmc1_dat2 | 0 | 0 | 199 | 0 | CFG_MMC1_DAT2_OEN | mmc1_dat2 |
| Y3 | mmc1_dat3 | 0 | 0 | 273 | 0 | CFG_MMC1_DAT3_OEN | mmc1_dat3 |

7.25.2 MMC2 - eMMC

MMC2 interface is compliant with the JC64 eMMC Standard v4.5 and it supports the following eMMC applications:

- Standard JC64 SDR, 8-bit data, half cycle
- High Speed JC64 SDR, 8-bit data, half cycle
- High Speed HS200 JEDS84, 8-bit data, half cycle
- High Speed JC64 DDR, 8-bit data

NOTE

For more information, see *eMMC/SD/SDIO* chapter in the device TRM.

7.25.2.1 Standard JC64 SDR, 8-bit data, half cycle

Table 7-113 and Table 7-114 present Timing requirements and Switching characteristics for MMC2 - Standard SDR in receiver and transmitter mode (see Figure 7-76 and Figure 7-77).

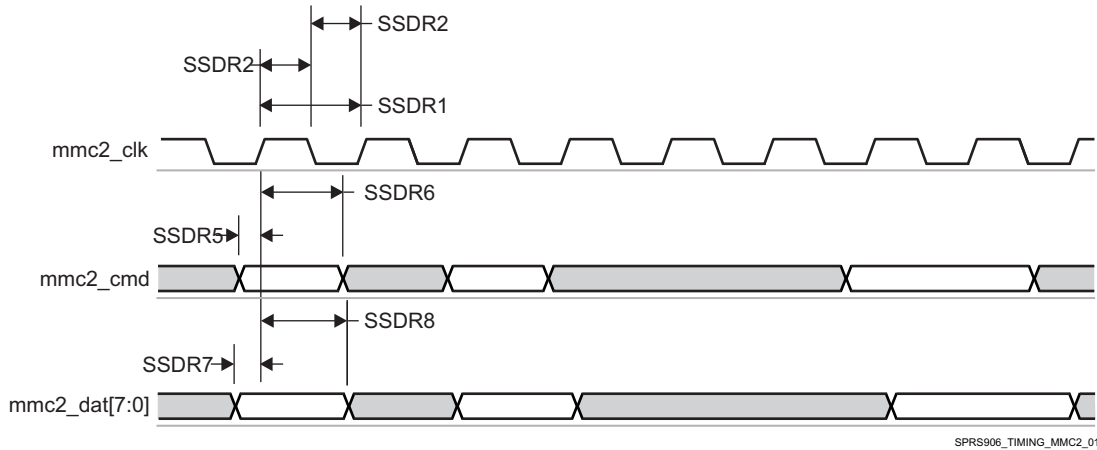
Table 7-113. Timing Requirements for MMC2 - JC64 Standard SDR Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|---------------------|---|-------|-----|------|
| SSDR5 | $t_{su(cmdV-clkH)}$ | Setup time, mmc2_cmd valid before mmc2_clk rising clock edge | 13.19 | | ns |
| SSDR6 | $t_{h(clkH-cmdV)}$ | Hold time, mmc2_cmd valid after mmc2_clk rising clock edge | 8.4 | | ns |
| SSDR7 | $t_{su(dV-clkH)}$ | Setup time, mmc2_dat[7:0] valid before mmc2_clk rising clock edge | 13.19 | | ns |
| SSDR8 | $t_{h(clkH-dV)}$ | Hold time, mmc2_dat[7:0] valid after mmc2_clk rising clock edge | 8.4 | | ns |

Table 7-114. Switching Characteristics for MMC2 - JC64 Standard SDR Mode

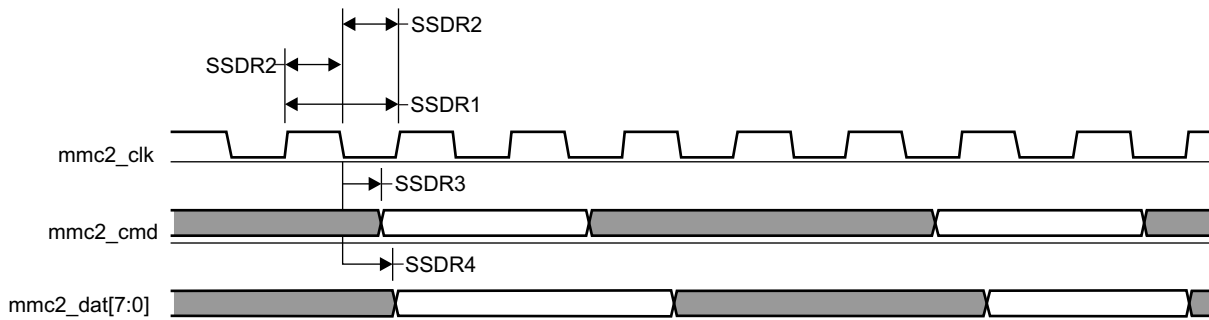
| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|----------------------------|---|---------------------|-------|------|
| SSDR1 | fop(clk) | Operating frequency, mmc2_clk | | 24 | MHz |
| SSDR2H | t _w (clkH) | Pulse duration, mmc2_clk high | 0.5 × P - 0.172 (1) | | ns |
| SSDR2L | t _w (clkL) | Pulse duration, mmc2_clk low | 0.5 × P - 0.172 (1) | | ns |
| SSDR3 | t _d (clkL-cmdV) | Delay time, mmc2_clk falling clock edge to mmc2_cmd transition | -16.96 | 16.96 | ns |
| SSDR4 | t _d (clkL-dV) | Delay time, mmc2_clk falling clock edge to mmc2_dat[7:0] transition | -16.96 | 16.96 | ns |

(1) P = output mmc2_clk period in ns



SPRS906_TIMING_MMC2_01

Figure 7-76. MMC/SD/SDIO in - Standard JC64 - Receiver Mode



SPRS906_TIMING_MMC2_02

Figure 7-77. MMC/SD/SDIO in - Standard JC64 - Transmitter Mode

7.25.2.2 High Speed JC64 SDR, 8-bit data, half cycle

Table 7-115 and Table 7-116 present Timing requirements and Switching characteristics for MMC2 - High speed SDR in receiver and transmitter mode (see Figure 7-78 and Figure 7-79).

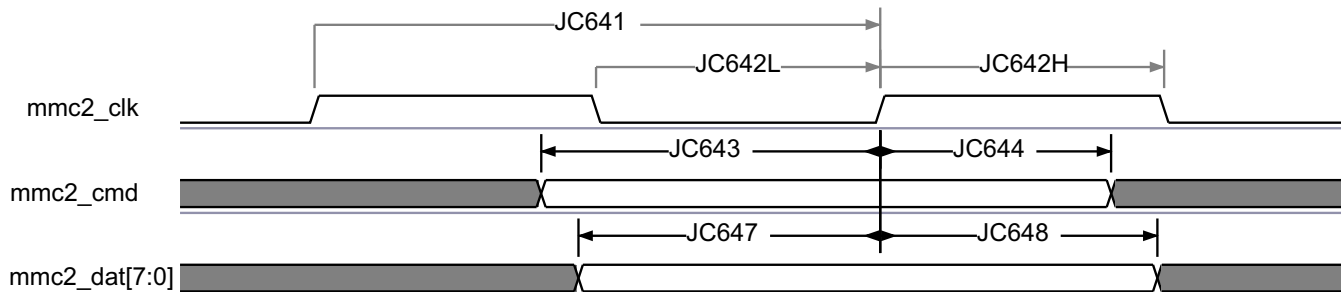
Table 7-115. Timing Requirements for MMC2 - JC64 High Speed SDR Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|-----------------------------|---|-----|-----|------|
| JC643 | t _{su} (cmdV-clkH) | Setup time, mmc2_cmd valid before mmc2_clk rising clock edge | 5.6 | | ns |
| JC644 | t _h (clkH-cmdV) | Hold time, mmc2_cmd valid after mmc2_clk rising clock edge | 2.6 | | ns |
| JC647 | t _{su} (dV-clkH) | Setup time, mmc2_dat[7:0] valid before mmc2_clk rising clock edge | 5.6 | | ns |
| JC648 | t _h (clkH-dV) | Hold time, mmc2_dat[7:0] valid after mmc2_clk rising clock edge | 2.6 | | ns |

Table 7-116. Switching Characteristics for MMC2 - JC64 High Speed SDR Mode

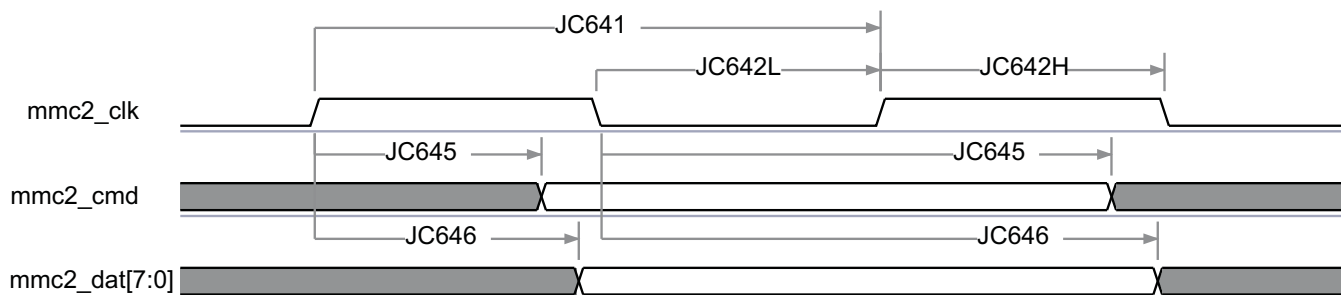
| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|----------------------------|---|---------------------|------|------|
| JC641 | fop(clk) | Operating frequency, mmc2_clk | | 48 | MHz |
| JC642H | t _w (clkH) | Pulse duration, mmc2_clk high | 0.5 × P - 0.172 (1) | | ns |
| JC642L | t _w (clkL) | Pulse duration, mmc2_clk low | 0.5 × P - 0.172 (1) | | ns |
| JC645 | t _d (clkL-cmdV) | Delay time, mmc2_clk falling clock edge to mmc2_cmd transition | -6.64 | 6.64 | ns |
| JC646 | t _d (clkL-dV) | Delay time, mmc2_clk falling clock edge to mmc2_dat[7:0] transition | -6.64 | 6.64 | ns |

(1) P = output mmc2_clk period in ns



SPRS906_TIMING_MMC2_03

Figure 7-78. MMC/SD/SDIO in - High Speed JC64 - Receiver Mode



MMC2_04

Figure 7-79. MMC/SD/SDIO in - High Speed JC64 - transmitter Mode

7.25.2.3 High Speed HS200 JEDS84 SDR, 8-bit data, half cycle

Table 7-117 presents Switching characteristics for MMC2 - HS200 in transmitter mode (see Figure 7-80).

Table 7-117. Switching Characteristics for MMC2 - JEDS84 HS200 Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|---------|----------------------------|---|---------------------|-------|------|
| HS2001 | fop(clk) | Operating frequency, mmc2_clk | | 192 | MHz |
| HS2002H | t _w (clkH) | Pulse duration, mmc2_clk high | 0.5 × P - 0.172 (1) | | ns |
| HS2002L | t _w (clkL) | Pulse duration, mmc2_clk low | 0.5 × P - 0.172 (1) | | ns |
| HS2005 | t _d (clkL-cmdV) | Delay time, mmc2_clk falling clock edge to mmc2_cmd transition | -1.136 | 0.536 | ns |
| HS2006 | t _d (clkL-dV) | Delay time, mmc2_clk falling clock edge to mmc2_dat[7:0] transition | -1.136 | 0.536 | ns |

(1) P = output mmc2_clk period in ns

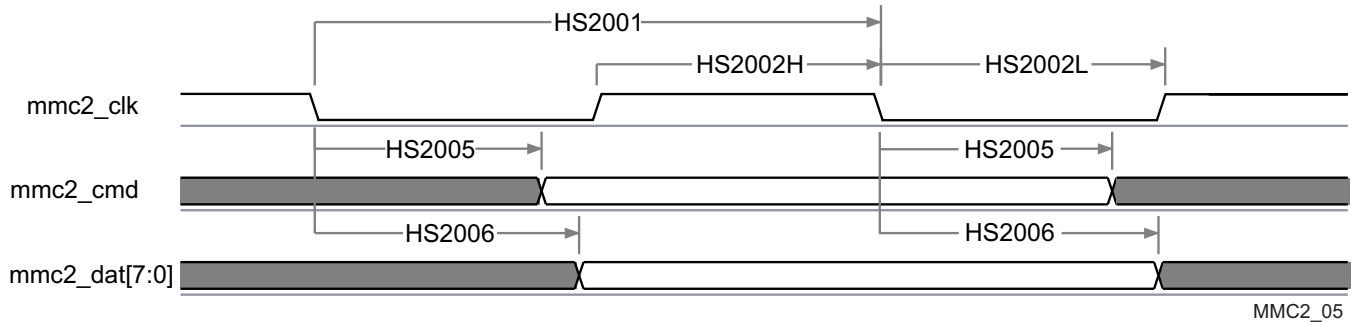


Figure 7-80. eMMC in - HS200 SDR - Transmitter Mode

7.25.2.4 High Speed JC64 DDR, 8-bit data

Table 7-118 and Table 7-119 present Timing requirements and Switching characteristics for MMC2 - High speed DDR in receiver and transmitter mode (see Figure 7-81 and Figure 7-82).

Table 7-118. Timing Requirements for MMC2 - JC64 High Speed DDR Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|------|----------------------------|--|-----|-----|------|
| DDR3 | t _{su} (cmdV-clk) | Setup time, mmc2_cmd valid before mmc2_clk transition | 1.8 | | ns |
| DDR4 | t _h (clk-cmdV) | Hold time, mmc2_cmd valid after mmc2_clk transition | 1.6 | | ns |
| DDR7 | t _{su} (dV-clk) | Setup time, mmc2_dat[7:0] valid before mmc2_clk transition | 1.8 | | ns |
| DDR8 | t _h (clk-dV) | Hold time, mmc2_dat[7:0] valid after mmc2_clk transition | 1.6 | | ns |

Table 7-119. Switching Characteristics for MMC2 - JC64 High Speed DDR Mode

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|---------------------------|---|-----------------|------|------|
| DDR1 | fop(clk) | Operating frequency, mmc2_clk | | 48 | MHz |
| DDR2H | t _w (clkH) | Pulse duration, mmc2_clk high | 0.5 × P - 0.172 | (1) | ns |
| DDR2L | t _w (clkL) | Pulse duration, mmc2_clk low | 0.5 × P - 0.172 | (1) | ns |
| DDR5 | t _d (clk-cmdV) | Delay time, mmc2_clk transition to mmc2_cmd transition | 3.4 | 7.14 | ns |
| DDR6 | t _d (clk-dV) | Delay time, mmc2_clk transition to mmc2_dat[7:0] transition | 2.9 | 7.14 | ns |

(1) P = output mmc2_clk period in ns

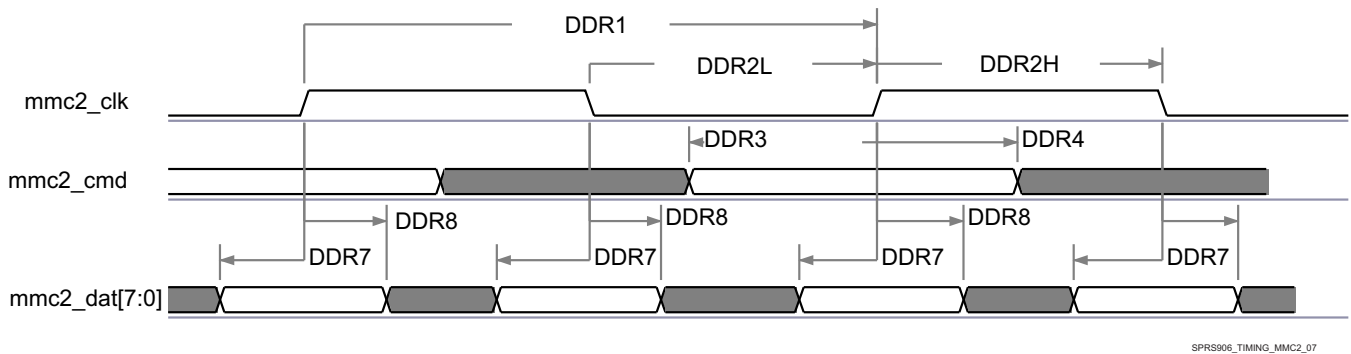


Figure 7-81. MMC/SD/SDIO in - High Speed DDR JC64 - Receiver Mode

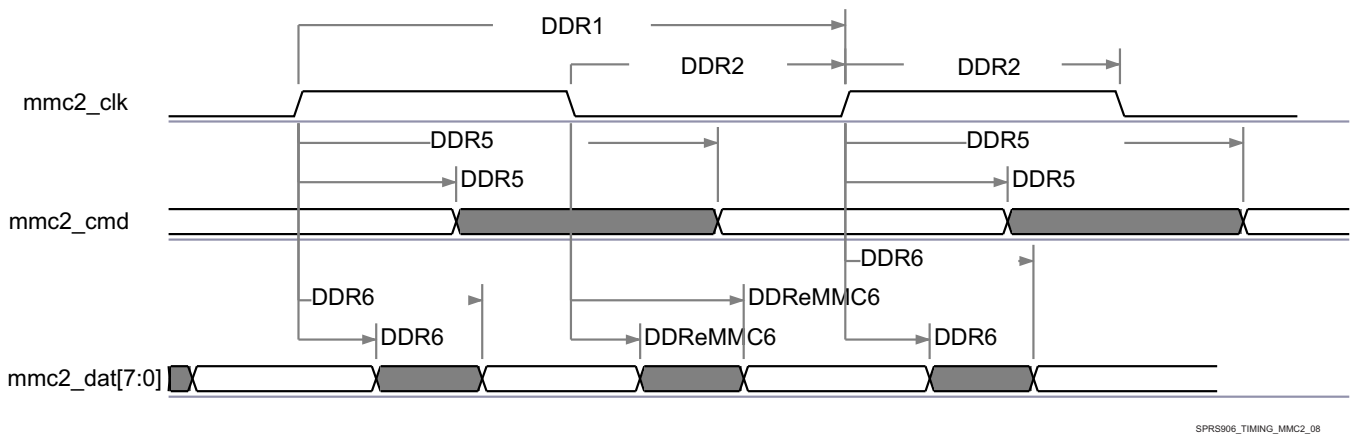


Figure 7-82. MMC/SD/SDIO in - High Speed DDR JC64 - Transmitter Mode

NOTE

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bit field for each corresponding pad control register.

The pad control registers are presented in [Table 4-3](#) and described in Device TRM, *Control Module Chapter*.

Virtual IO Timings Modes must be used to ensure some IO timings for MMC2. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Virtual IO Timings Modes. See [Table 7-120 Virtual Functions Mapping for MMC2](#) for a definition of the Virtual modes.

[Table 7-120](#) presents the values for DELAYMODE bit field.

Table 7-120. Virtual Functions Mapping for MMC2

| BALL | BALL NAME | Delay Mode Value | MUXMODE |
|------|-----------|------------------|-----------|
| | | MMC2_VIRTUAL2 | 1 |
| H6 | gpmc_cs1 | 13 | mmc2_cmd |
| K7 | gpmc_a19 | 13 | mmc2_dat4 |
| M7 | gpmc_a20 | 13 | mmc2_dat5 |
| J5 | gpmc_a21 | 13 | mmc2_dat6 |
| K6 | gpmc_a22 | 13 | mmc2_dat7 |
| J7 | gpmc_a23 | 13 | mmc2_clk |

Table 7-120. Virtual Functions Mapping for MMC2 (continued)

| BALL | BALL NAME | Delay Mode Value | MUXMODE |
|------|-----------|------------------|-----------|
| | | MMC2_VIRTUAL2 | 1 |
| J4 | gpmc_a24 | 13 | mmc2_dat0 |
| J6 | gpmc_a25 | 13 | mmc2_dat1 |
| H4 | gpmc_a26 | 13 | mmc2_dat2 |
| H5 | gpmc_a27 | 13 | mmc2_dat3 |

NOTE

To configure the desired Manual IO Timing Mode the user must follow the steps described in section Manual IO Timing Modes of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information, see *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for MMC2. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-121 Manual Functions Mapping for MMC2](#) for a definition of the Manual modes.

[Table 7-121](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-121. Manual Functions Mapping for MMC2

| BALL | BALL NAME | MMC2_MANUAL1 | | MMC2_MANUAL2 | | MMC2_MANUAL3 | | CFG REGISTER | MUXMODE |
|------|-----------|--------------|--------------|--------------|--------------|--------------|--------------|------------------|-----------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 1 |
| K7 | gpmc_a19 | 0 | 0 | 0 | 14 | - | - | CFG_GPMC_A19_IN | mmc2_dat4 |
| M7 | gpmc_a20 | 119 | 0 | 127 | 0 | - | - | CFG_GPMC_A20_IN | mmc2_dat5 |
| J5 | gpmc_a21 | 0 | 0 | 22 | 0 | - | - | CFG_GPMC_A21_IN | mmc2_dat6 |
| K6 | gpmc_a22 | 18 | 0 | 72 | 0 | - | - | CFG_GPMC_A22_IN | mmc2_dat7 |
| J7 | gpmc_a23 | 894 | 0 | 410 | 4000 | - | - | CFG_GPMC_A23_IN | mmc2_clk |
| J4 | gpmc_a24 | 30 | 0 | 82 | 0 | - | - | CFG_GPMC_A24_IN | mmc2_dat0 |
| J6 | gpmc_a25 | 0 | 0 | 0 | 0 | - | - | CFG_GPMC_A25_IN | mmc2_dat1 |
| H4 | gpmc_a26 | 23 | 0 | 77 | 0 | - | - | CFG_GPMC_A26_IN | mmc2_dat2 |
| H5 | gpmc_a27 | 0 | 0 | 0 | 0 | - | - | CFG_GPMC_A27_IN | mmc2_dat3 |
| H6 | gpmc_cs1 | 0 | 0 | 0 | 0 | - | - | CFG_GPMC_CS1_IN | mmc2_cmd |
| K7 | gpmc_a19 | 152 | 0 | 152 | 0 | 285 | 0 | CFG_GPMC_A19_OUT | mmc2_dat4 |
| M7 | gpmc_a20 | 206 | 0 | 206 | 0 | 189 | 0 | CFG_GPMC_A20_OUT | mmc2_dat5 |
| J5 | gpmc_a21 | 78 | 0 | 78 | 0 | 0 | 120 | CFG_GPMC_A21_OUT | mmc2_dat6 |
| K6 | gpmc_a22 | 2 | 0 | 2 | 0 | 0 | 70 | CFG_GPMC_A22_OUT | mmc2_dat7 |
| J7 | gpmc_a23 | 266 | 0 | 266 | 0 | 730 | 360 | CFG_GPMC_A23_OUT | mmc2_clk |
| J4 | gpmc_a24 | 0 | 0 | 0 | 0 | 0 | 0 | CFG_GPMC_A24_OUT | mmc2_dat0 |
| J6 | gpmc_a25 | 0 | 0 | 0 | 0 | 0 | 0 | CFG_GPMC_A25_OUT | mmc2_dat1 |
| H4 | gpmc_a26 | 43 | 0 | 43 | 0 | 70 | 0 | CFG_GPMC_A26_OUT | mmc2_dat2 |
| H5 | gpmc_a27 | 0 | 0 | 0 | 0 | 0 | 0 | CFG_GPMC_A27_OUT | mmc2_dat3 |
| H6 | gpmc_cs1 | 0 | 0 | 0 | 0 | 0 | 120 | CFG_GPMC_CS1_OUT | mmc2_cmd |
| K7 | gpmc_a19 | 0 | 0 | 0 | 0 | 0 | 0 | CFG_GPMC_A19_OEN | mmc2_dat4 |
| M7 | gpmc_a20 | 0 | 0 | 0 | 0 | 231 | 0 | CFG_GPMC_A20_OEN | mmc2_dat5 |
| J5 | gpmc_a21 | 0 | 0 | 0 | 0 | 39 | 0 | CFG_GPMC_A21_OEN | mmc2_dat6 |
| K6 | gpmc_a22 | 0 | 0 | 0 | 0 | 91 | 0 | CFG_GPMC_A22_OEN | mmc2_dat7 |
| J4 | gpmc_a24 | 0 | 0 | 0 | 0 | 176 | 0 | CFG_GPMC_A24_OEN | mmc2_dat0 |

Table 7-121. Manual Functions Mapping for MMC2 (continued)

| BALL | BALL NAME | MMC2_MANUAL1 | | MMC2_MANUAL2 | | MMC2_MANUAL3 | | CFG REGISTER | MUXMODE |
|------|-----------|--------------|--------------|--------------|--------------|--------------|--------------|------------------|-----------|
| | | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | A_DELAY (ps) | G_DELAY (ps) | | 1 |
| J6 | gpmc_a25 | 0 | 0 | 0 | 0 | 0 | 0 | CFG_GPMC_A25_OEN | mmc2_dat1 |
| H4 | gpmc_a26 | 0 | 0 | 0 | 0 | 101 | 0 | CFG_GPMC_A26_OEN | mmc2_dat2 |
| H5 | gpmc_a27 | 0 | 0 | 0 | 0 | 0 | 0 | CFG_GPMC_A27_OEN | mmc2_dat3 |
| H6 | gpmc_cs1 | 0 | 0 | 0 | 0 | 360 | 0 | CFG_GPMC_CS1_OEN | mmc2_cmd |

7.25.3 MMC3 and MMC4-SDIO/SD

MMC3 and MMC4 interfaces are compliant with the SDIO3.0 standard v1.0, SD Part E1 and for generic SDIO devices, it supports the following applications:

- MMC3 8-bit data and MMC4 4-bit data, SD Default speed, SDR
- MMC3 8-bit data and MMC4 4-bit data, SD High speed, SDR
- MMC3 8-bit data and MMC4 4-bit data, UHS-1 SDR12 (SD Standard v3.01), 4-bit data, SDR, half cycle
- MMC3 8-bit data and MMC4 4-bit data, UHS-I SDR25 (SD Standard v3.01), 4-bit data, SDR, half cycle
- MMC3 8-bit data, UHS-I SDR50

NOTE

The eMMC/SD/SDIO_j (j = 3 to 4) controller is also referred to as MMC_j.

NOTE

For more information, see eMMC/SD/SDIO chapter in the device TRM.

7.25.3.1 MMC3 and MMC4, SD Default Speed

Figure 7-83 , Figure 7-84, and Table 7-122 through Table 7-125 present Timing requirements and Switching characteristics for MMC3 and MMC4 - SD Default speed in receiver and transmitter mode.

Table 7-122. Timing Requirements for MMC3 - Default Speed Mode ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|----------------------------|---|-------|-----|------|
| DS5 | t _{su(cmdV-clkH)} | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge | 5.11 | | ns |
| DS6 | t _{h(clkH-cmdV)} | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge | 20.46 | | ns |
| DS7 | t _{su(dV-clkH)} | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 5.11 | | ns |
| DS8 | t _{h(clkH-dV)} | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge | 20.46 | | ns |

(1) i in [i:0] = 7

Table 7-123. Switching Characteristics for MMC3 - SD/SDIO Default Speed Mode ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|---------------------------|---|--------------------------------|-------|------|
| DS0 | fop(clk) | Operating frequency, mmc3_clk | | 24 | MHz |
| DS1 | t _{w(clkH)} | Pulse duration, mmc3_clk high | 0.5 × P - 0.270 ⁽¹⁾ | | ns |
| DS2 | t _{w(clkL)} | Pulse duration, mmc3_clk low | 0.5 × P - 0.270 ⁽¹⁾ | | ns |
| DS3 | t _{d(clkL-cmdV)} | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition | -14.93 | 14.93 | ns |
| DS4 | t _{d(clkL-dV)} | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -14.93 | 14.93 | ns |

- (1) P = output mmc3_clk period in ns
- (2) i in [i:0] = 7

Table 7-124. Timing Requirements for MMC4 - Default Speed Mode ⁽¹⁾

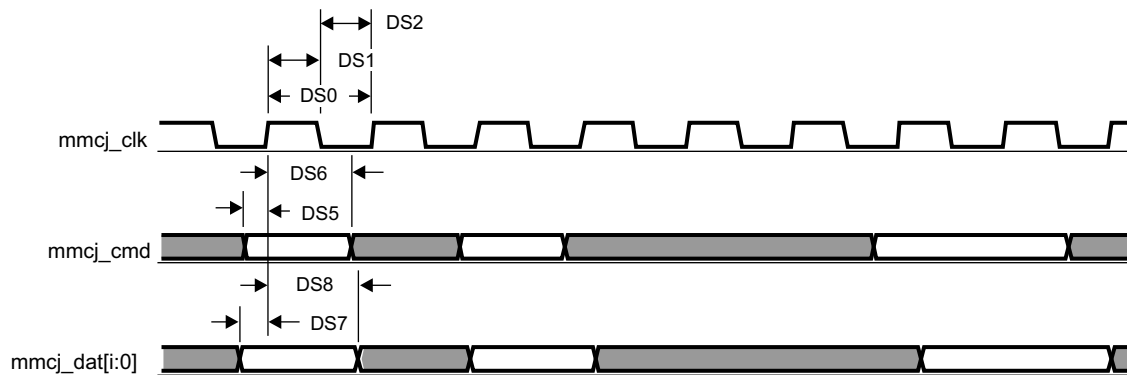
| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|---------------------|---|-------|-----|------|
| DS5 | $t_{su}(cmdV-clkH)$ | Setup time, mmc4_cmd valid before mmc4_clk rising clock edge | 5.11 | | ns |
| DS6 | $t_h(clkH-cmdV)$ | Hold time, mmc4_cmd valid after mmc4_clk rising clock edge | 20.46 | | ns |
| DS7 | $t_{su}(dV-clkH)$ | Setup time, mmc4_dat[i:0] valid before mmc4_clk rising clock edge | 5.11 | | ns |
| DS8 | $t_h(clkH-dV)$ | Hold time, mmc4_dat[i:0] valid after mmc4_clk rising clock edge | 20.46 | | ns |

- (1) i in [i:0] = 3

Table 7-125. Switching Characteristics for MMC4 - Default Speed Mode ⁽²⁾

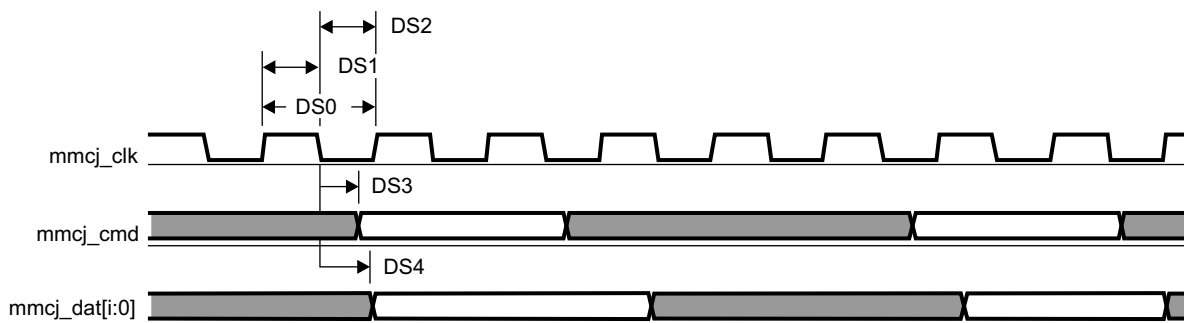
| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|------------------|---|---------------------------------------|-------|------|
| DS0 | fop(clk) | Operating frequency, mmc4_clk | | 24 | MHz |
| DS1 | $t_w(clkH)$ | Pulse duration, mmc4_clk high | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| DS2 | $t_w(clkL)$ | Pulse duration, mmc4_clk low | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| DS3 | $t_d(clkL-cmdV)$ | Delay time, mmc4_clk falling clock edge to mmc4_cmd transition | -14.93 | 14.93 | ns |
| DS4 | $t_d(clkL-dV)$ | Delay time, mmc4_clk falling clock edge to mmc4_dat[i:0] transition | -14.93 | 14.93 | ns |

- (1) P = output mmc4_clk period in ns
- (2) i in [i:0] = 3



SPRS906_TIMING_MMC3_07

Figure 7-83. MMC/SD/SDIOj in - Default Speed - Receiver Mode



SPRS906_TIMING_MMC3_08

Figure 7-84. MMC/SD/SDIOj in - Default Speed - Transmitter Mode

7.25.3.2 MMC3 and MMC4, SD High Speed

Figure 7-85, Figure 7-86, and Table 7-126 through Table 7-129 present Timing requirements and Switching characteristics for MMC3 and MMC4 - SD and SDIO High speed in receiver and transmitter mode.

Table 7-126. Timing Requirements for MMC3 - SD/SDIO High Speed Mode ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|---------------------|---|-----|-----|------|
| HS3 | $t_{su(cmdV-clkH)}$ | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge | 5.3 | | ns |
| HS4 | $t_h(clkH-cmdV)$ | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge | 2.6 | | ns |
| HS7 | $t_{su(dV-clkH)}$ | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 5.3 | | ns |
| HS8 | $t_h(clkH-dV)$ | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge | 2.6 | | ns |

(1) i in [i:0] = 7

Table 7-127. Switching Characteristics for MMC3 - SD/SDIO High Speed Mode ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|------|------------------|---|---------------------------------------|-----|------|
| HS1 | fop(clk) | Operating frequency, mmc3_clk | | 48 | MHz |
| HS2H | $t_w(clkH)$ | Pulse duration, mmc3_clk high | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| HS2L | $t_w(clkL)$ | Pulse duration, mmc3_clk low | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| HS5 | $t_d(clkL-cmdV)$ | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition | -7.6 | 3.6 | ns |
| HS6 | $t_d(clkL-dV)$ | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -7.6 | 3.6 | ns |

(1) P = output mmc3_clk period in ns

(2) i in [i:0] = 7

Table 7-128. Timing Requirements for MMC4 - High Speed Mode ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|---------------------|---|-----|-----|------|
| HS3 | $t_{su(cmdV-clkH)}$ | Setup time, mmc4_cmd valid before mmc4_clk rising clock edge | 5.3 | | ns |
| HS4 | $t_h(clkH-cmdV)$ | Hold time, mmc4_cmd valid after mmc4_clk rising clock edge | 1.6 | | ns |
| HS7 | $t_{su(dV-clkH)}$ | Setup time, mmc4_dat[i:0] valid before mmc4_clk rising clock edge | 5.3 | | ns |
| HS8 | $t_h(clkH-dV)$ | Hold time, mmc4_dat[i:0] valid after mmc4_clk rising clock edge | 1.6 | | ns |

(1) i in [i:0] = 3

Table 7-129. Switching Characteristics for MMC4 - High Speed Mode ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|------|------------------|---|---------------------------------------|-----|------|
| HS1 | fop(clk) | Operating frequency, mmc4_clk | | 48 | MHz |
| HS2H | $t_w(clkH)$ | Pulse duration, mmc4_clk high | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| HS2L | $t_w(clkL)$ | Pulse duration, mmc4_clk low | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| HS5 | $t_d(clkL-cmdV)$ | Delay time, mmc4_clk falling clock edge to mmc4_cmd transition | -8.8 | 6.6 | ns |
| HS6 | $t_d(clkL-dV)$ | Delay time, mmc4_clk falling clock edge to mmc4_dat[i:0] transition | -8.8 | 6.6 | ns |

- (1) P = output mmc4_clk period in ns
- (2) i in [i:0] = 3

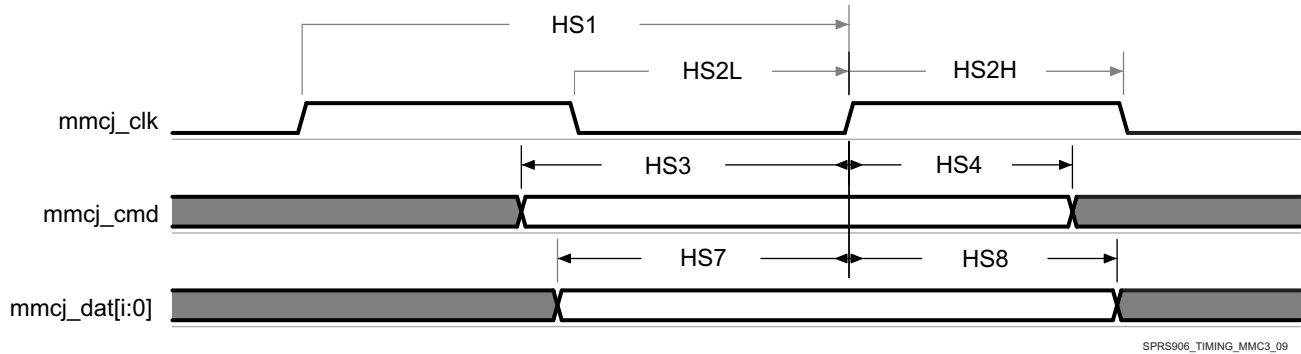


Figure 7-85. MMC/SD/SDIOj in - High Speed 3.3V Signaling - Receiver Mode

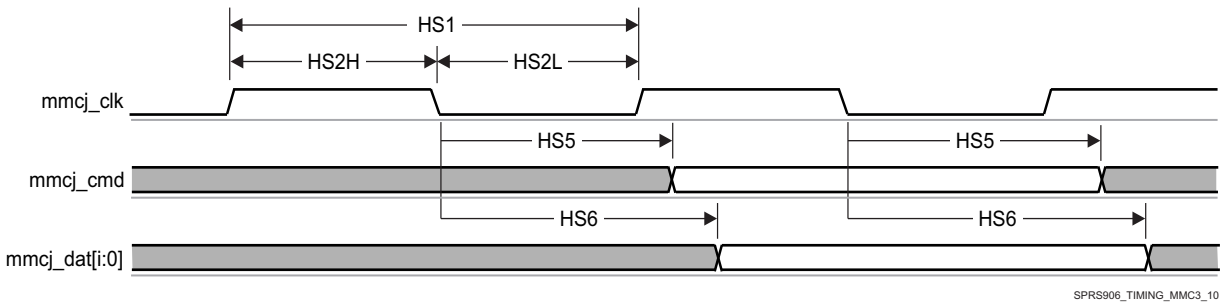


Figure 7-86. MMC/SD/SDIOj in - High Speed 3.3V Signaling - Transmitter Mode

7.25.3.3 MMC3 and MMC4, SD and SDIO SDR12 Mode

Figure 7-87, Figure 7-88, and Table 7-130, through Table 7-133 present Timing requirements and Switching characteristics for MMC3 and MMC4 - SD and SDIO SDR12 in receiver and transmitter mode.

Table 7-130. Timing Requirements for MMC3 - SDR12 Mode ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|---------------------|---|-------|-----|------|
| SDR125 | $t_{su}(cmdV-clkH)$ | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge | 25.99 | | ns |
| SDR126 | $t_h(clkH-cmdV)$ | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge | 1.6 | | ns |
| SDR127 | $t_{su}(dV-clkH)$ | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 25.99 | | ns |
| SDR128 | $t_h(clkH-dV)$ | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge | 1.6 | | ns |

- (1) i in [i:0] = 7

Table 7-131. Switching Characteristics for MMC3 - SDR12 Mode ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|------------------|---|---------------------------------------|-------|------|
| SDR120 | fop(clk) | Operating frequency, mmc3_clk | | 24 | MHz |
| SDR121 | $t_w(clkH)$ | Pulse duration, mmc3_clk high | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR122 | $t_w(clkL)$ | Pulse duration, mmc3_clk low | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR123 | $t_d(clkL-cmdV)$ | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition | -19.13 | 16.93 | ns |
| SDR124 | $t_d(clkL-dV)$ | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -19.13 | 16.93 | ns |

- (1) P = output mmc3_clk period in ns
- (2) i in [i:0] = 7

Table 7-132. Timing Requirements for MMC4 - SDR12 Mode ⁽¹⁾

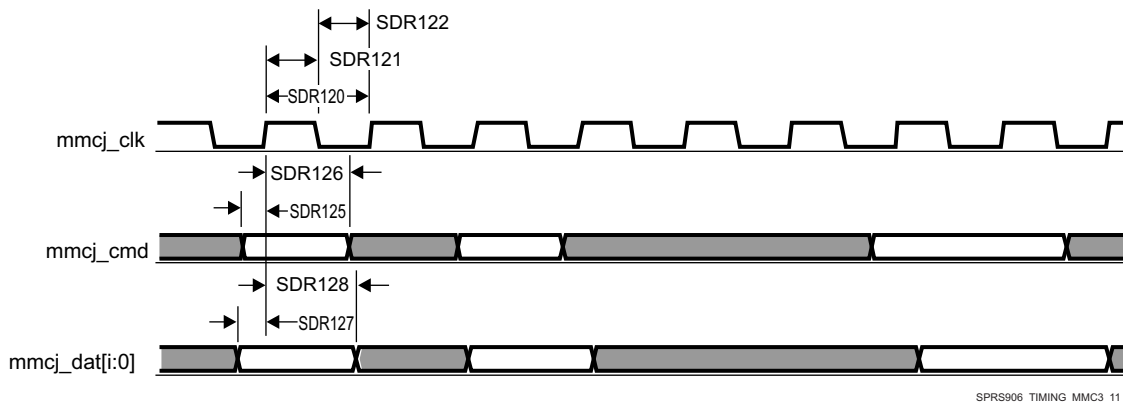
| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|---------------------|---|-------|-----|------|
| SDR125 | $t_{su(cmdV-clkH)}$ | Setup time, mmc4_cmd valid before mmc4_clk rising clock edge | 25.99 | | ns |
| SDR126 | $t_{h(clkH-cmdV)}$ | Hold time, mmc4_cmd valid after mmc4_clk rising clock edge | 1.6 | | ns |
| SDR127 | $t_{su(dV-clkH)}$ | Setup time, mmc4_dat[i:0] valid before mmc4_clk rising clock edge | 25.99 | | ns |
| SDR128 | $t_{h(clkH-dV)}$ | Hold time, mmc4_dat[i:0] valid after mmc4_clk rising clock edge | 1.6 | | ns |

- (1) j in [i:0] = 3

Table 7-133. Switching Characteristics for MMC4 - SDR12 Mode ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|--------------------|---|---------------------------------------|-------|------|
| SDR120 | fop(clk) | Operating frequency, mmc4_clk | | 24 | MHz |
| SDR121 | $t_{w(clkH)}$ | Pulse duration, mmc4_clk high | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR122 | $t_{w(clkL)}$ | Pulse duration, mmc4_clk low | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR125 | $t_{d(clkL-cmdV)}$ | Delay time, mmc4_clk falling clock edge to mmc4_cmd transition | -19.13 | 16.93 | ns |
| SDR126 | $t_{d(clkL-dV)}$ | Delay time, mmc4_clk falling clock edge to mmc4_dat[i:0] transition | -19.13 | 16.93 | ns |

- (1) P = output mmc4_clk period in ns
- (2) j in [i:0] = 3



SPRS906_TIMING_MMC3_11

Figure 7-87. MMC/SD/SDIOj in - SDR12 - Receiver Mode



SPRS906_TIMING_MMC3_12

Figure 7-88. MMC/SD/SDIOj in - SDR12 - Transmitter Mode

7.25.3.4 MMC3 and MMC4, SD SDR25 Mode

Figure 7-89, Figure 7-90, and Table 7-134, through Table 7-137 present Timing requirements and Switching characteristics for MMC3 and MMC4 - SD and SDIO SDR25 in receiver and transmitter mode.

Table 7-134. Timing Requirements for MMC3 - SDR25 Mode ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|---------------------|---|-----|-----|------|
| SDR253 | $t_{su(cmdV-clkH)}$ | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge | 5.3 | | ns |
| SDR254 | $t_h(clkH-cmdV)$ | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge | 1.6 | | ns |
| SDR257 | $t_{su(dV-clkH)}$ | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 5.3 | | ns |
| SDR258 | $t_h(clkH-dV)$ | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge | 1.6 | | ns |

(1) i in [i:0] = 7

Table 7-135. Switching Characteristics for MMC3 - SDR25 Mode ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------------|------------------|---|---------------------------------------|-----|------|
| SDR251 | fop(clk) | Operating frequency, mmc3_clk | | 48 | MHz |
| SDR252 H | $t_w(clkH)$ | Pulse duration, mmc3_clk high | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR252L | $t_w(clkL)$ | Pulse duration, mmc3_clk low | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR255 | $t_d(clkL-cmdV)$ | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition | -8.8 | 6.6 | ns |
| SDR256 | $t_d(clkL-dV)$ | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -8.8 | 6.6 | ns |

(1) P = output mmc3_clk period in ns

(2) i in [i:0] = 7

Table 7-136. Timing Requirements for MMC4 - SDR25 Mode ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|---------------------|---|-----|-----|------|
| SDR255 | $t_{su(cmdV-clkH)}$ | Setup time, mmc4_cmd valid before mmc4_clk rising clock edge | 5.3 | | ns |
| SDR256 | $t_h(clkH-cmdV)$ | Hold time, mmc4_cmd valid after mmc4_clk rising clock edge | 1.6 | | ns |
| SDR257 | $t_{su(dV-clkH)}$ | Setup time, mmc4_dat[i:0] valid before mmc4_clk rising clock edge | 5.3 | | ns |
| SDR258 | $t_h(clkH-dV)$ | Hold time, mmc4_dat[i:0] valid after mmc4_clk rising clock edge | 1.6 | | ns |

(1) i in [i:0] = 3

Table 7-137. Switching Characteristics for MMC4 - SDR25 Mode ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------------|------------------|---|---------------------------------------|-----|------|
| SDR251 | fop(clk) | Operating frequency, mmc4_clk | | 48 | MHz |
| SDR252 H | $t_w(clkH)$ | Pulse duration, mmc4_clk high | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR252L | $t_w(clkL)$ | Pulse duration, mmc4_clk low | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR255 | $t_d(clkL-cmdV)$ | Delay time, mmc4_clk falling clock edge to mmc4_cmd transition | -8.8 | 6.6 | ns |
| SDR256 | $t_d(clkL-dV)$ | Delay time, mmc4_clk falling clock edge to mmc4_dat[i:0] transition | -8.8 | 6.6 | ns |

- (1) P = output mmc4_clk period in ns
- (2) i in [i:0] = 3



Figure 7-89. MMC/SD/SDIOj in - SDR25 - Receiver Mode

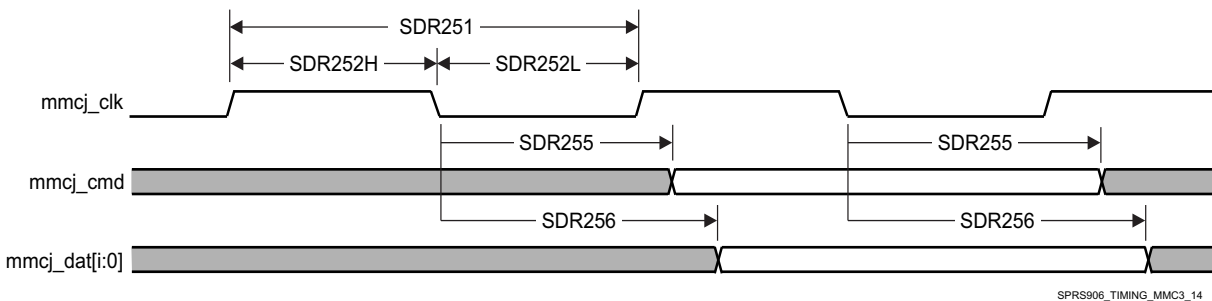


Figure 7-90. MMC/SD/SDIOj in - SDR25 - Transmitter Mode

7.25.3.5 MMC3 SDIO High Speed UHS-I SDR50 Mode, Half Cycle

Figure 7-91, Figure 7-92, Table 7-138, and Table 7-139 present Timing requirements and Switching characteristics for MMC3 - SDIO High speed SDR50 in receiver and transmitter mode.

Table 7-138. Timing Requirements for MMC3 - SDR50 Mode ⁽¹⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|--------|---------------------|---|------|-----|------|
| SDR503 | $t_{su}(cmdV-clkH)$ | Setup time, mmc3_cmd valid before mmc3_clk rising clock edge | 1.48 | | ns |
| SDR504 | $t_h(clkH-cmdV)$ | Hold time, mmc3_cmd valid after mmc3_clk rising clock edge | 1.6 | | ns |
| SDR507 | $t_{su}(dV-clkH)$ | Setup time, mmc3_dat[i:0] valid before mmc3_clk rising clock edge | 1.48 | | ns |
| SDR508 | $t_h(clkH-dV)$ | Hold time, mmc3_dat[i:0] valid after mmc3_clk rising clock edge | 1.6 | | ns |

- (1) i in [i:0] = 7

Table 7-139. Switching Characteristics for MMC3 - SDR50 Mode ⁽²⁾

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------------|------------------|---|---------------------------------------|------|------|
| SDR501 | fop(clk) | Operating frequency, mmc3_clk | | 96 | MHz |
| SDR502 H | $t_w(clkH)$ | Pulse duration, mmc3_clk high | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR502L | $t_w(clkL)$ | Pulse duration, mmc3_clk low | $0.5 \times P - 0.270$ ⁽¹⁾ | | ns |
| SDR505 | $t_d(clkL-cmdV)$ | Delay time, mmc3_clk falling clock edge to mmc3_cmd transition | -3.66 | 1.46 | ns |
| SDR506 | $t_d(clkL-dV)$ | Delay time, mmc3_clk falling clock edge to mmc3_dat[i:0] transition | -3.66 | 1.46 | ns |

- (1) P = output mmc3_clk period in ns
- (2) i in [i:0] = 7

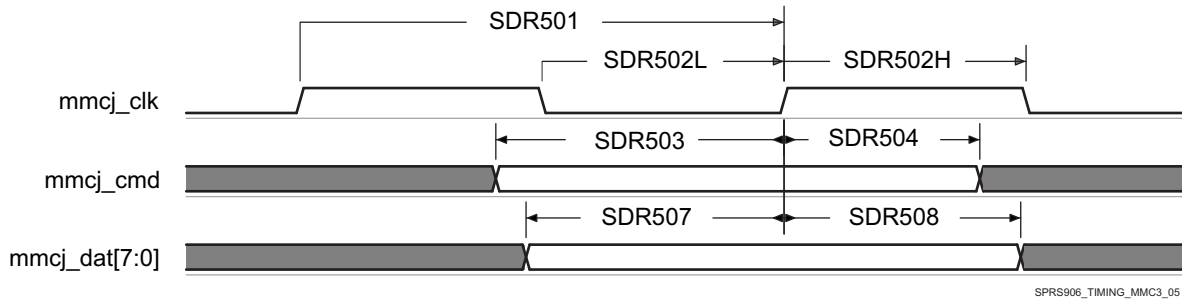


Figure 7-91. MMC/SD/SDIOj in - High Speed SDR50 - Receiver Mode

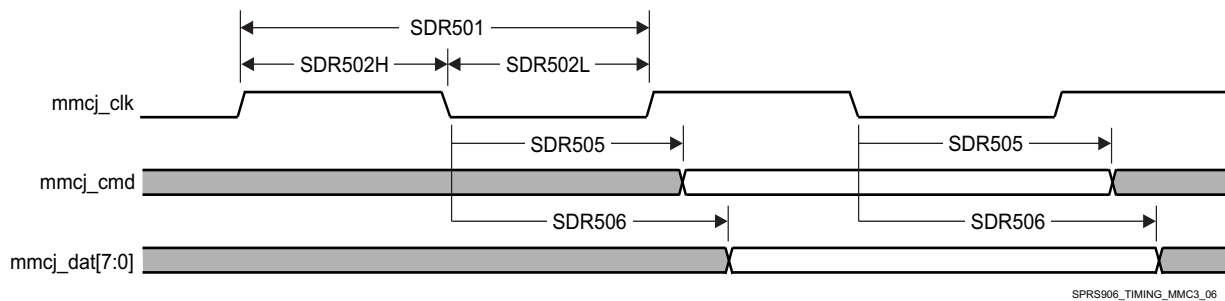


Figure 7-92. MMC/SD/SDIOj in - High Speed SDR50 - Transmitter Mode

NOTE

To configure the desired Manual IO Timing Mode the user must follow the steps described in section Manual IO Timing Modes of the Device TRM.

The associated registers to configure are listed in the **CFG REGISTER** column. For more information, see *Control Module* chapter in the device TRM.

Manual IO Timings Modes must be used to ensure some IO timings for MMC3. See [Table 7-2 Modes Summary](#) for a list of IO timings requiring the use of Manual IO Timings Modes. See [Table 7-140 Manual Functions Mapping for MMC3](#) for a definition of the Manual modes.

[Table 7-140](#) lists the A_DELAY and G_DELAY values needed to calculate the correct values to be set in the CFG_x registers.

Table 7-140. Manual Functions Mapping for MMC3

| BALL | BALL NAME | MMC3_MANUAL1 | | CFG REGISTER | MUXMODE |
|------|-----------|--------------|--------------|-------------------|-----------|
| | | A_DELAY (ps) | G_DELAY (ps) | | 0 |
| AD4 | mmc3_clk | 1085 | 21 | CFG_MMC3_CLK_IN | mmc3_clk |
| AD4 | mmc3_clk | 1269 | 0 | CFG_MMC3_CLK_OUT | mmc3_clk |
| AC4 | mmc3_cmd | 0 | 0 | CFG_MMC3_CMD_IN | mmc3_cmd |
| AC4 | mmc3_cmd | 128 | 0 | CFG_MMC3_CMD_OEN | mmc3_cmd |
| AC4 | mmc3_cmd | 98 | 0 | CFG_MMC3_CMD_OUT | mmc3_cmd |
| AC7 | mmc3_dat0 | 0 | 0 | CFG_MMC3_DAT0_IN | mmc3_dat0 |
| AC7 | mmc3_dat0 | 362 | 0 | CFG_MMC3_DAT0_OEN | mmc3_dat0 |
| AC7 | mmc3_dat0 | 0 | 0 | CFG_MMC3_DAT0_OUT | mmc3_dat0 |
| AC6 | mmc3_dat1 | 7 | 0 | CFG_MMC3_DAT1_IN | mmc3_dat1 |
| AC6 | mmc3_dat1 | 333 | 0 | CFG_MMC3_DAT1_OEN | mmc3_dat1 |

Table 7-140. Manual Functions Mapping for MMC3 (continued)

| BALL | BALL NAME | MMC3_MANUAL1 | | CFG REGISTER | MUXMODE |
|------|-----------|--------------|--------------|-------------------|-----------|
| | | A_DELAY (ps) | G_DELAY (ps) | | 0 |
| AC6 | mmc3_dat1 | 0 | 0 | CFG_MMC3_DAT1_OUT | mmc3_dat1 |
| AC9 | mmc3_dat2 | 0 | 0 | CFG_MMC3_DAT2_IN | mmc3_dat2 |
| AC9 | mmc3_dat2 | 402 | 0 | CFG_MMC3_DAT2_OEN | mmc3_dat2 |
| AC9 | mmc3_dat2 | 0 | 0 | CFG_MMC3_DAT2_OUT | mmc3_dat2 |
| AC3 | mmc3_dat3 | 203 | 0 | CFG_MMC3_DAT3_IN | mmc3_dat3 |
| AC3 | mmc3_dat3 | 549 | 0 | CFG_MMC3_DAT3_OEN | mmc3_dat3 |
| AC3 | mmc3_dat3 | 1 | 0 | CFG_MMC3_DAT3_OUT | mmc3_dat3 |
| AC8 | mmc3_dat4 | 121 | 0 | CFG_MMC3_DAT4_IN | mmc3_dat4 |
| AC8 | mmc3_dat4 | 440 | 0 | CFG_MMC3_DAT4_OEN | mmc3_dat4 |
| AC8 | mmc3_dat4 | 206 | 0 | CFG_MMC3_DAT4_OUT | mmc3_dat4 |
| AD6 | mmc3_dat5 | 336 | 0 | CFG_MMC3_DAT5_IN | mmc3_dat5 |
| AD6 | mmc3_dat5 | 283 | 0 | CFG_MMC3_DAT5_OEN | mmc3_dat5 |
| AD6 | mmc3_dat5 | 174 | 0 | CFG_MMC3_DAT5_OUT | mmc3_dat5 |
| AB8 | mmc3_dat6 | 320 | 0 | CFG_MMC3_DAT6_IN | mmc3_dat6 |
| AB8 | mmc3_dat6 | 443 | 0 | CFG_MMC3_DAT6_OEN | mmc3_dat6 |
| AB8 | mmc3_dat6 | 0 | 0 | CFG_MMC3_DAT6_OUT | mmc3_dat6 |
| AB5 | mmc3_dat7 | 2 | 0 | CFG_MMC3_DAT7_IN | mmc3_dat7 |
| AB5 | mmc3_dat7 | 344 | 0 | CFG_MMC3_DAT7_OEN | mmc3_dat7 |
| AB5 | mmc3_dat7 | 0 | 0 | CFG_MMC3_DAT7_OUT | mmc3_dat7 |

NOTE

To configure the desired virtual mode the user must set MODESELECT bit and DELAYMODE bit field for each corresponding pad control register.

The pad control registers are presented in [Table 4-3](#) and described in Device TRM, *Control Module Chapter*.

7.26 General-Purpose Interface (GPIO)

The general-purpose interface combines eight general-purpose input/output (GPIO) banks. Each GPIO module provides up to 32 dedicated general-purpose pins with input and output capabilities; thus, the general-purpose interface supports up to 215 pins.

These pins can be configured for the following applications:

- Data input (capture)/output (drive)
- Keyboard interface with a debounce cell
- Interrupt generation in active mode upon the detection of external events. Detected events are processed by two parallel independent interrupt-generation submodules to support biprocessor operations
- Wake-up request generation in idle mode upon the detection of external events

NOTE

For more information, see *General-Purpose Interface* chapter in the device TRM.

NOTE

The general-purpose input/output *i* (*i* = 1 to 8) bank is also referred to as GPIO_{*i*}.

7.27 Audio Tracking Logic (ATL)

The device contains four ATL modules that can be used for asynchronous sample rate conversion of audio. The ATL calculates the error between two time bases, such as audio syncs, and optionally generates an averaged clock using cycle stealing via software.

NOTE

For more information, see *Audio Tracking Logic* chapter in the device TRM.

NOTE

Audio Tracking Logic x (x= 1 to 4) module is also referred to as ATLx.

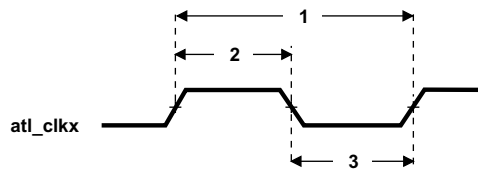
7.27.1 ATL Electrical Data/Timing

Table 7-141 and Figure 7-93 present switching characteristics for ATL

Table 7-141. Switching Characteristics Over Recommended Operating Conditions for ATL_CLKOUTx

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|---------------------|----------------------------------|---------------------------|-----|------|
| 1 | $t_{c(ATLCLKOUT)}$ | Cycle time, ATL_CLKOUTx | 20 | | ns |
| 2 | $t_{w(ATLCLKOUTL)}$ | Pulse Duration, ATL_CLKOUTx low | $0.45 \times P - M^{(1)}$ | | ns |
| 3 | $t_{w(ATLCLKOUTH)}$ | Pulse Duration, ATL_CLKOUTx high | $0.45 \times P - M^{(1)}$ | | ns |

(1) P = ATL_CLKOUTx period.
M = internal ATL PCLK period.



SPRS906_TIMING_ATL_01

Figure 7-93. ATL_CLKOUTx Timing

7.28 System and Miscellaneous interfaces

The Device includes the following System and Miscellaneous interfaces:

- Sysboot Interface
- System DMA Interface
- Interrupt Controllers (INTC) Interface
- Observability Signal (OBS) Interface

7.29 Test Interfaces

The Device includes the following Test interfaces:

- IEEE 1149.1 Standard-Test-Access Port (JTAG)
- Trace Port Interface Unit (TPIU)
- Advanced Event Triggering Interface (AET)

7.29.1 IEEE 1149.1 Standard-Test-Access Port (JTAG)

The JTAG (IEEE Standard 1149.1-1990 Standard-Test-Access Port and Boundary Scan Architecture) interface is used for BSDL testing and emulation of the device. The *trstn* pin only needs to be released when it is necessary to use a JTAG controller to debug the device or exercise the device's boundary scan functionality. For maximum reliability, the device includes an internal Pulldown (IPD) on the *trstn* pin to ensure that *trstn* is always asserted upon power up and the device's internal emulation logic is always properly initialized. JTAG controllers from Texas Instruments actively drive *trstn* high. However, some third-party JTAG controllers may not drive *trstn* high but expect the use of a Pullup resistor on *trstn*. When using this type of JTAG controller, assert *trstn* to initialize the device after powerup and externally drive *trstn* high before attempting any emulation or boundary-scan operations.

The main JTAG features include:

- 32KB embedded trace buffer (ETB)
- 5-pin system trace interface for debug
- Supports Advanced Event Triggering (AET)
- All processors can be emulated via JTAG ports
- All functions on EMU pins of the device:
 - EMU[1:0] - cross-triggering, boot mode (WIR), STM trace
 - EMU[4:2] - STM trace only (single direction)

7.29.1.1 JTAG Electrical Data/Timing

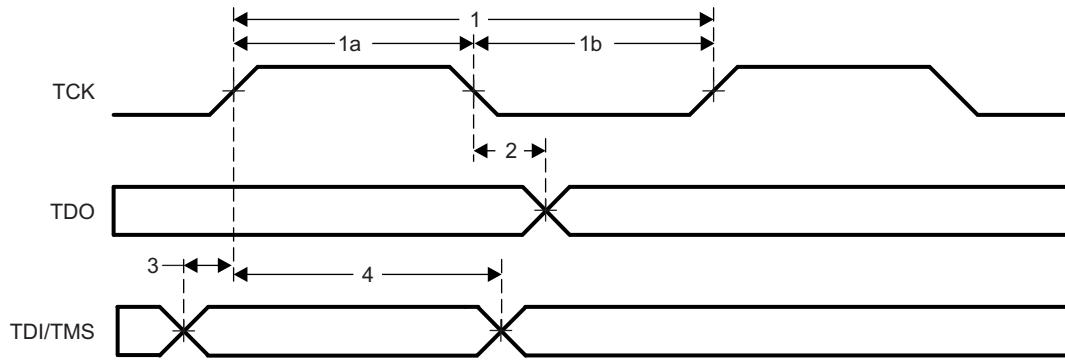
Table 7-142, Table 7-143 and Figure 7-94 assume testing over the recommended operating conditions and electrical characteristic conditions below.

Table 7-142. Timing Requirements for IEEE 1149.1 JTAG

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|--------------------------|--|-------|-----|------|
| 1 | $t_c(\text{TCK})$ | Cycle time, TCK | 62.29 | | ns |
| 1a | $t_w(\text{TCKH})$ | Pulse duration, TCK high (40% of t_c) | 24.92 | | ns |
| 1b | $t_w(\text{TCKL})$ | Pulse duration, TCK low (40% of t_c) | 24.92 | | ns |
| 3 | $t_{su}(\text{TDI-TCK})$ | Input setup time, TDI valid to TCK high | 6.23 | | ns |
| | $t_{su}(\text{TMS-TCK})$ | Input setup time, TMS valid to TCK high | 6.23 | | ns |
| 4 | $t_h(\text{TCK-TDI})$ | Input hold time, TDI valid from TCK high | 31.15 | | ns |
| | $t_h(\text{TCK-TMS})$ | Input hold time, TMS valid from TCK high | 31.15 | | ns |

Table 7-143. Switching Characteristics Over Recommended Operating Conditions for IEEE 1149.1 JTAG

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|-------------------------|----------------------------------|-----|------|------|
| 2 | $t_d(\text{TCKL-TDOV})$ | Delay time, TCK low to TDO valid | 0 | 30.5 | ns |



SPRS906_TIMING_JTAG_01

Figure 7-94. JTAG Timing

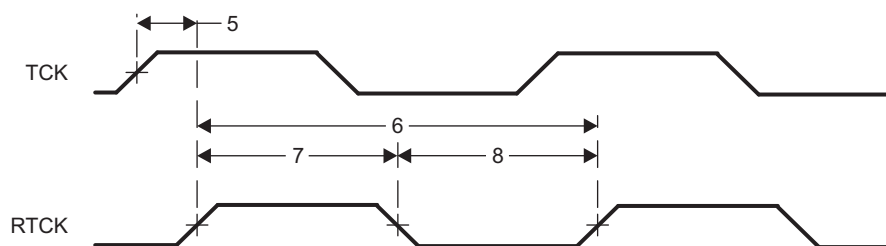
Table 7-144, Table 7-145 and Figure 7-95 assume testing over the recommended operating conditions and electrical characteristic conditions below.

Table 7-144. Timing Requirements for IEEE 1149.1 JTAG With RTCK

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|--------------------------|--|-------|-----|------|
| 1 | $t_c(\text{TCK})$ | Cycle time, TCK | 62.29 | | ns |
| 1a | $t_w(\text{TCKH})$ | Pulse duration, TCK high (40% of t_c) | 24.92 | | ns |
| 1b | $t_w(\text{TCKL})$ | Pulse duration, TCK low (40% of t_c) | 24.92 | | ns |
| 3 | $t_{su}(\text{TDI-TCK})$ | Input setup time, TDI valid to TCK high | 6.23 | | ns |
| | $t_{su}(\text{TMS-TCK})$ | Input setup time, TMS valid to TCK high | 6.23 | | ns |
| 4 | $t_h(\text{TCK-TDI})$ | Input hold time, TDI valid from TCK high | 31.15 | | ns |
| | $t_h(\text{TCK-TMS})$ | Input hold time, TMS valid from TCK high | 31.15 | | ns |

Table 7-145. Switching Characteristics Over Recommended Operating Conditions for IEEE 1149.1 JTAG With RTCK

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-----|------------------------|--|-------|-----|------|
| 5 | $t_d(\text{TCK-RTCK})$ | Delay time, TCK to RTCK with no selected subpaths (that is, ICEPick is the only tap selected - when the Arm is in the scan chain, the delay time is a function of the Arm functional clock). | 0 | 27 | ns |
| 6 | $t_c(\text{RTCK})$ | Cycle time, RTCK | 62.29 | | ns |
| 7 | $t_w(\text{RTCKH})$ | Pulse duration, RTCK high (40% of t_c) | 24.92 | | ns |
| 8 | $t_w(\text{RTCKL})$ | Pulse duration, RTCK low (40% of t_c) | 24.92 | | ns |



SPRS906_TIMING_JTAG_02

Figure 7-95. JTAG With RTCK Timing

7.29.2 Trace Port Interface Unit (TPIU)

CAUTION

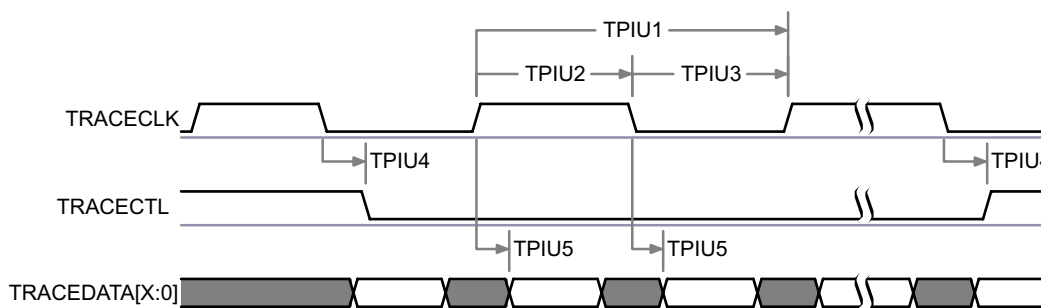
The I/O timings provided in this section are valid only if signals within a single IOSET are used. The IOSETs are defined in [Table 7-147](#).

7.29.2.1 TPIU PLL DDR Mode

[Table 7-146](#) and [Figure 7-96](#) assume testing over the recommended operating conditions and electrical characteristic conditions below.

Table 7-146. Switching Characteristics for TPIU

| NO. | PARAMETER | DESCRIPTION | MIN | MAX | UNIT |
|-------|---------------------------|---|-------|------|------|
| TPIU1 | $t_{c(\text{clk})}$ | Cycle time, TRACECLK period | 5.56 | | ns |
| TPIU4 | $t_{d(\text{clk-ctlV})}$ | Skew time, TRACECLK transition to TRACECTL transition | -1.61 | 1.98 | ns |
| TPIU5 | $t_{d(\text{clk-dataV})}$ | Skew time, TRACECLK transition to TRACEDATA[17:0] | -1.61 | 1.98 | ns |



SPRS906_TIMING_TIMER_01

Figure 7-96. TPIU-PLL DDR Transmit Mode⁽¹⁾

(1) In d[X:0], X is equal to 15 or 17.

In [Table 7-147](#) are presented the specific groupings of signals (IOSET) for use with TPIU signals.

Table 7-147. TPIU IOSETs

| SIGNALS | IOSET1 | | IOSET2 | |
|---------|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX |
| emu19 | E6 | 5 | A10 | 2 |
| emu18 | F5 | 5 | B9 | 2 |
| emu17 | E4 | 5 | A9 | 2 |
| emu16 | C1 | 5 | C9 | 2 |
| emu15 | F4 | 5 | A8 | 2 |
| emu14 | D2 | 5 | C7 | 2 |
| emu13 | E2 | 5 | C8 | 2 |
| emu12 | D1 | 5 | C6 | 2 |
| emu11 | F3 | 5 | A5 | 2 |
| emu10 | F2 | 5 | D8 | 2 |
| emu9 | G6 | 5 | E7 | 2 |
| emu8 | G1 | 5 | F8 | 2 |
| emu7 | H7 | 5 | F9 | 2 |
| emu6 | G2 | 5 | E9 | 2 |

Table 7-147. TPIU IOSETs (continued)

| SIGNALS | IOSET1 | | IOSET2 | |
|---------|--------|-----|--------|-----|
| | BALL | MUX | BALL | MUX |
| emu5 | E1 | 5 | G11 | 2 |
| emu4 | A7 | 2 | A7 | 2 |
| emu3 | D7 | 2 | D7 | 2 |
| emu2 | F10 | 2 | F10 | 2 |
| emu1 | D24 | 0 | D24 | 0 |
| emu0 | G21 | 0 | G21 | 0 |

8 Applications, Implementation, and Layout

NOTE

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

8.1 Introduction

This chapter is intended to communicate, guide and illustrate a PCB design strategy resulting in a PCB that can support TI's latest Application Processor. This Processor is a high-performance processor designed for automotive Infotainment based on enhanced OMAP™ architecture integrated on a 28-nm CMOS process technology.

These guidelines first focus on designing a robust Power Delivery Network (PDN) which is essential to achieve the desirable high performance processing available on Device. The general principles and step-by-step approach for implementing good power integrity (PI) with specific requirements will be described for the key Device power domains.

TI strongly believes that simulating a PCB's proposed PDN is required for first pass PCB design success. Key Device processor high-current power domains need to be evaluated for Power Rail IR Drop, Decoupling Capacitor Loop-Inductance and Power Rail Target Impedance. Only then can a PCB's PDN performance be truly accessed by comparing these model PI parameters vs. TI's recommended values. Ultimately for any high-volume product, TI recommends conducting a "Processor PDN Validation" test on prototype PCBs across processor "split lots" to verify PDN robustness meets desired performance goals for each customer's worst-case scenario. Please contact your TI representative to receive guidance on PDN PI modeling and validation testing.

Likewise, the methodology and requirements needed to route Device high speed, differential interfaces (that is, USB2.0, USB3.0, HDMI, PCI, SATA), single-ended interfaces (that is, DDR3, QSPI) and general purpose interfaces using LVCMOS drivers that meet timing requirements while minimizing signal integrity (SI) distortions on the PCB's signaling traces. Signal trace lengths and flight times are aligned with FR-4 standard specification for PCBs.

Several different PCB layout stack-up examples have been presented to illustrate a typical number of layers, signal assignments and controlled impedance requirements. Different Device interface signals demand more or less complexity for routing and controlled impedance stack-ups. Optimizing the PCB's PDN stack-up needs with all of these different types of signal interfaces will ultimately determine the final layer count and layer assignments in each customer's PCB design.

This guideline must be used as a supplement in complement to TI's Application Processor, Power Management IC (PMIC) and Audio Companion components along with other TI component technical documentation (that is, Technical Reference Manual, Data Manual, Data Sheets, Silicon Errata, Pin-Out Spreadsheet, Application Notes, etc.).

NOTE

Notwithstanding any provision to the contrary, TI makes no warranty expressed, implied, or statutory, including any implied warranty of merchantability of fitness for a specific purpose, for customer boards. The data described in this appendix are intended as guidelines only.

NOTE

These PCB guidelines are in a draft maturity and consequently, are subject to change depending on design verification testing conducted during IC development and validation.

8.1.1 Initial Requirements and Guidelines

Unless otherwise specified, the characteristic impedance for single-ended interfaces is recommended to be between 35 Ω and 65 Ω to minimize the overshoot or undershoot on far-end loads.

Characteristic impedance for differential interfaces must be routed as differential traces on the same layer. The trace width and spacing must be chosen to yield the recommended differential impedance. For more information see [Section 8.5.1](#).

The PDN must be optimized for low trace resistance and low trace inductance for all high-current power nets from PMIC to the device.

An external interface using a connector must be protected following the IEC61000-4-2 level 4 system ESD.

8.2 Power Optimizations

This section describes the necessary steps for designing a robust Power Distribution Network (PDN):

- [Section 8.2.1, Step 1](#): PCB Stack-up
- [Section 8.2.2, Step 2](#): Physical Placement
- [Section 8.2.3, Step 3](#): Static Analysis
- [Section 8.2.4, Step 4](#): Frequency Analysis

8.2.1 Step 1: PCB Stack-up

The PCB stack-up (layer assignment) is an important factor in determining the optimal performance of the power distribution system. An optimized PCB stack-up for higher power integrity performance can be achieved by following these recommendations:

- Power and ground plane pairs must be closely coupled together. The capacitance formed between the planes can decouple the power supply at high frequencies. Whenever possible, the power and ground planes must be solid to provide continuous return path for return current.
- Use a thin dielectric between the power and ground plane pair. Capacitance is inversely proportional to the separation of the plane pair. Minimizing the separation distance (the dielectric thickness) maximizes the capacitance.
- Optimize the power and ground plane pair carrying high current supplies to key component power domains as close as possible to the same surface where these components are placed (see [Figure 8-1](#)). This will help to minimize “loop inductance” encountered between supply decoupling capacitors and component supply inputs and between power and ground plane pairs.

NOTE

1-2oz Cu weight for power / ground plane is preferred to enable better PCB heat spreading, helping to reduce Processor junction temperatures. In addition, it is preferable to have the power / ground planes be adjacent to the PCB surface on which the Processor is mounted.

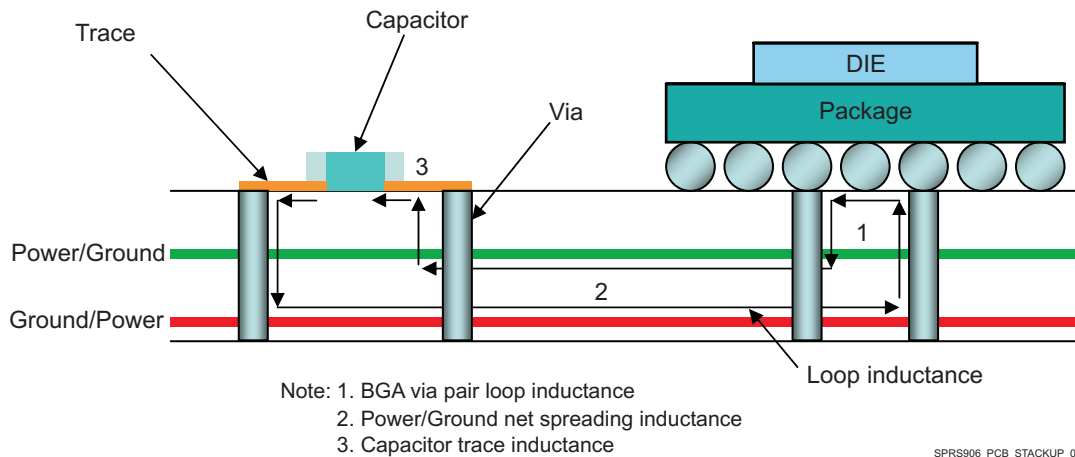


Figure 8-1. Minimize Loop Inductance With Proper Layer Assignment

The placement of power and ground planes in the PCB stackup (determined by layer assignment) has a significant impact on the parasitic inductances of power current path as shown in Figure 8-1. For this reason, it is recommended to consider layer order in the early stages of the PCB PDN design cycle, putting high-priority supplies in the top half of the stackup (assuming high load and priority components are mounted on the top-side of PCB) and low-priority supplies in the bottom half of the stackup as shown in the examples below (vias have parasitic inductances which impact the bottom layers more, so it is advised to put the sensitive and high-priority power supplies on the top/same layers).

8.2.2 Step 2: Physical Placement

A critical step in designing an optimized PDN is that proper care must be taken to making sure that the initial floor planning of the PCB layout is done with good power integrity design guidelines in mind. The following points are important for optimizing a PCB's PDN:

- Minimizing the physical distance between power sources and key high load components is the first step toward optimization. Placing source and load components on the same side of the PCB is desirable. This will minimize via inductance impact for high current loads and steps
- External trace routing between components must be as wide as possible. The wider the traces, the lower the DC resistance and consequently the lower the static IR drop.
- Whenever possible for the internal layers (routing and plane), wide traces and copper area fills are preferred for PDN layout. The routing of power nets in plane provide for more interplane capacitance and improved high frequency performance of the PDN.
- Whenever possible, use a via to component pin/pad ratio of 1:1 or better (that is, especially decoupling capacitors, power inductors and current sensing resistors). Do not share vias among multiple capacitors for connecting power supply and ground planes.
- Placement of vias must be as close as possible or even within a component's solder pad if the PCB technology you are using provides this capability.
- To avoid any "ampacity" issue – maximum current-carrying capacity of each transitional via should be evaluated to determine the appropriate number of vias required to connect components.

Adding vias to bring the "via-to-pad" ratio to 1:1 will improve PDN performance.

- For noise sensitive power supplies (that is, Phase Lock-Loops, analog signals like audio and video), a Gnd shield can be used to isolate coplanar supplies that may have high step currents or high frequency switching transitions from coupling into low-noise supplies.

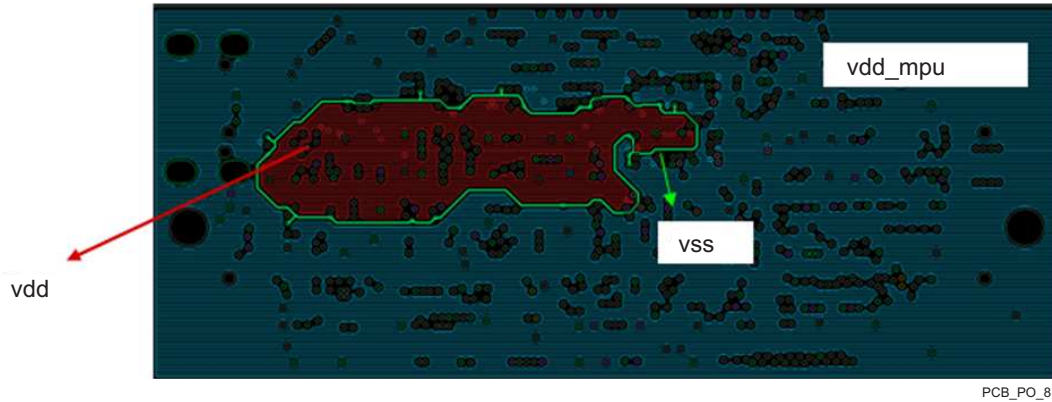


Figure 8-2. Coplanar Shielding of Power Net Using Ground Guard-band

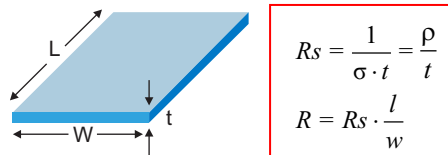
8.2.3 Step 3: Static Analysis

Delivering reliable power to circuits is always of critical importance because voltage drops (also known as IR drops) can happen at every level within an electronic system, on-chip, within a package, and across the board. Robust system performance can only be ensured by understanding how the system elements will perform under typical stressful Use Cases. Therefore, it is a good practice to perform a Static or DC Analysis.

Static or DC analysis and design methodology results in a PDN design that minimizes voltage or IR drops across power and ground planes, traces and vias. This ensures the application processor’s internal transistors will be operating within their specified voltage ranges for proper functionality. The amount of IR drop that will be encountered is based upon amount power drawn for a desired Use Case and PCB trace (widths, geometry and number of parallel traces) and via (size, type and number) characteristics.

Components that are distant from their power source are particularly susceptible to IR drop. Designs that rely on battery power must minimize voltage drops to avoid unacceptable power loss that can negatively impact system performance. Early assessments a PDN’s static (DC) performance helps to determine basic power distribution parameters such as best system input power point, optimal PCB layer stackup, and copper area needed for load currents.

The resistance R_s of a plane conductor for a unit length and unit width is called the **surface resistivity** (ohms per square).



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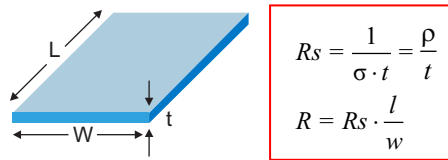
Figure 8-3. Depiction of Sheet Resistivity and Resistance

Ohm’s Law ($V = I \times R$) relates conduction current to voltage drop. At DC, the relation coefficient is a constant and represents the resistance of the conductor. Even current carrying conductors will dissipate power at high currents even though their resistance may be very small. Both voltage drop and power dissipation are proportional to the resistance of the conductor.

Figure 8-4 shows a PCB-level static IR drop budget defined between the power management device (PMIC) pins and the application processor’s balls when the PMIC is supplying power.

- It is highly recommended to physically place the PMIC as close as possible to the processor and on the same side. The orientation of the PMIC vs. processor should be aligned to minimize distance for the highest current rail.

The resistance R_s of a plane conductor for a unit length and unit width is called the **surface resistivity** (ohms per square).



SPRS906_PCB_STATIC_01

Figure 8-4. Static IR Drop Budget for PCB Only

The system-level IR drop budget is made up of three portions: on-chip, package, and PCB board. Static IR or DC analysis/design methodology consists of designing the PDN such that the voltage drop (under DC operating conditions) across power and ground pads of the transistors of the application processor device is within a specified value of the nominal voltage for proper functionality of the device.

A PCB system-level voltage drop budget for proper device functionality is typically 1.5% of nominal voltage. For a 1.35-V supply, this would be ≤ 20 mV.

To accurately analyze PCB static IR drop, the actual geometry of the PDN must be modeled properly and simulated to accurately characterize long distribution paths, copper weight impacts, electro-migration violations of current-carrying vias, and “Swiss-cheese” effects via placement has on power rails. It is recommended to perform the following analyses:

- Lumped resistance/IR drop analysis
- Distributed resistance/IR drop analysis

NOTE

The PMIC companion device supporting this processor has been designed with voltage sensing feedback loop capabilities that enable a remote sense of the SMPS output voltage at the point of use.

The NOTE above means the SMPS feedback signals and returns must be routed across PCB and connected to the Device input power ball for which a particular SMPS is supplying power. This feedback loop provides compensation for some of the voltage drop encountered across the PDN within limits. As such, the effective resistance of the PDN within this loop should be determined in order to optimize voltage compensation loop performance. The resistance of two PDN segments are of interest: one from the power inductor/bulk power filtering capacitor node to the Processor's input power and second is the entire PDN route from SMPS output pin/ball to the Processor input power.

In the following sections each methodology is described in detail and an example has been provided of analysis flow that can be used by the PCB designer to validate compliance to the requirements on their PCB PDN design.

8.2.3.1 PDN Resistance and IR Drop

Lumped methodology consists of grouping all of the power pins on both the PMIC (voltage source) and processor (current sink) devices. Then the PMIC source is set to an expected Use Case voltage level and the processor load has its Use Case current sink value set as well. Now the lumped/effective resistance for the power rail trace/plane routes can be determine based upon the actual layout's power rail etch wide, shape, length, via count and placement [Figure 8-5](#) illustrates the pin-grouping/lumped concept.

The lumped methodology consists of importing the PCB layout database (from Cadence Allegro tool or any other layout design tool) into the static IR drop modeling and simulation tool of preference for the PCB designer. This is followed by applying the correct PCB stack-up information (thickness, material properties) of the PCB dielectric and metallization layers. The material properties of dielectric consist of permittivity (Dk) and loss tangent (Df).

For the conductor layers, the correct conductivity needs to be programmed into the simulation tool. This is followed by pin-grouping of the power and ground nets, and applying appropriate voltage/current sources. The current and voltage information can be obtained from the power and voltage specifications of the device under different operating conditions / Use Cases.

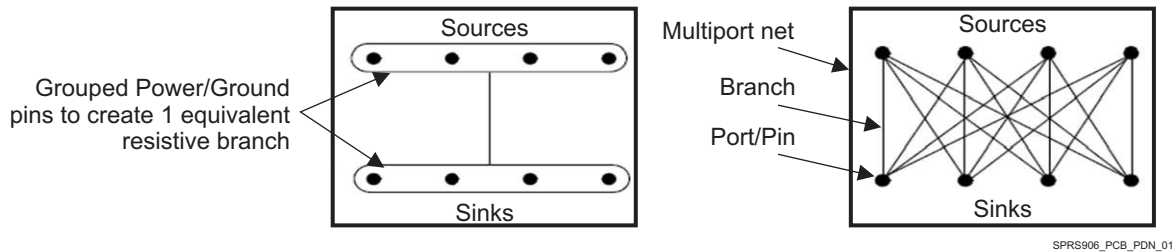


Figure 8-5. Pin-grouping concept: Lumped and Distributed Methodologies

8.2.4 Step 4: Frequency Analysis

Delivering low noise voltage sources are very important to allowing a system to operate at the lowest possible Operational Performance Point (OPP) for any one Use Case. An OPP is a combination of the supply voltage level and clocking rate for key internal processor domains. A SCH and PCB designed to provide low noise voltage supplies will then enable the processor to enter optimal OPPs for each Use Case that in turn will minimize power dissipation and junction temperatures on-die. Therefore, it is a good engineering practice to perform a Frequency Analysis over the key power domains.

Frequency analysis and design methodology results in a PDN design that minimizes transient noise voltages at the processor's input power balls. This allows the processor's internal transistors to operate near the minimum specified operating supply voltage levels. To accomplish this one must evaluate how a voltage supply will change due to impedance variations over frequency. This analysis will focus on the decoupling capacitor network (VDD_xxx and VSS/Gnd rails) at the load. Sufficient capacitance with a distribution of self-resonant points will provide for an overall lower impedance vs frequency response for each power domain.

Decoupling components that are distant from their load's input power are susceptible to encountering spreading loop inductance from the PCB design. Early analysis of each key power domain's frequency response helps to determine basic decoupling capacitor placement, optimal footprint, layer assignment, and types needed for minimizing supply voltage noise/fluctuations due to switching and load current transients.

NOTE

Evaluation of loop inductance values for decoupling capacitors placed ~300mils closer to the load's input power balls has shown an 18% reduction in loop inductance due to reduced distance.

- Decoupling capacitors must be carefully placed in order to minimize loop inductance impact on supply voltage transients. A real capacitor has characteristics not only of capacitance but also inductance and resistance.

Figure 8-6 shows the parasitic model of a real capacitor. A real capacitor must be treated as an RLC circuit with effective series resistance (ESR) and effective series inductance (ESL).

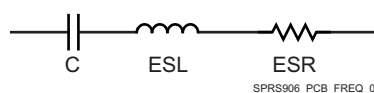


Figure 8-6. Characteristics of a Real Capacitor With ESL and ESR

The magnitude of the impedance of this series model is given as:

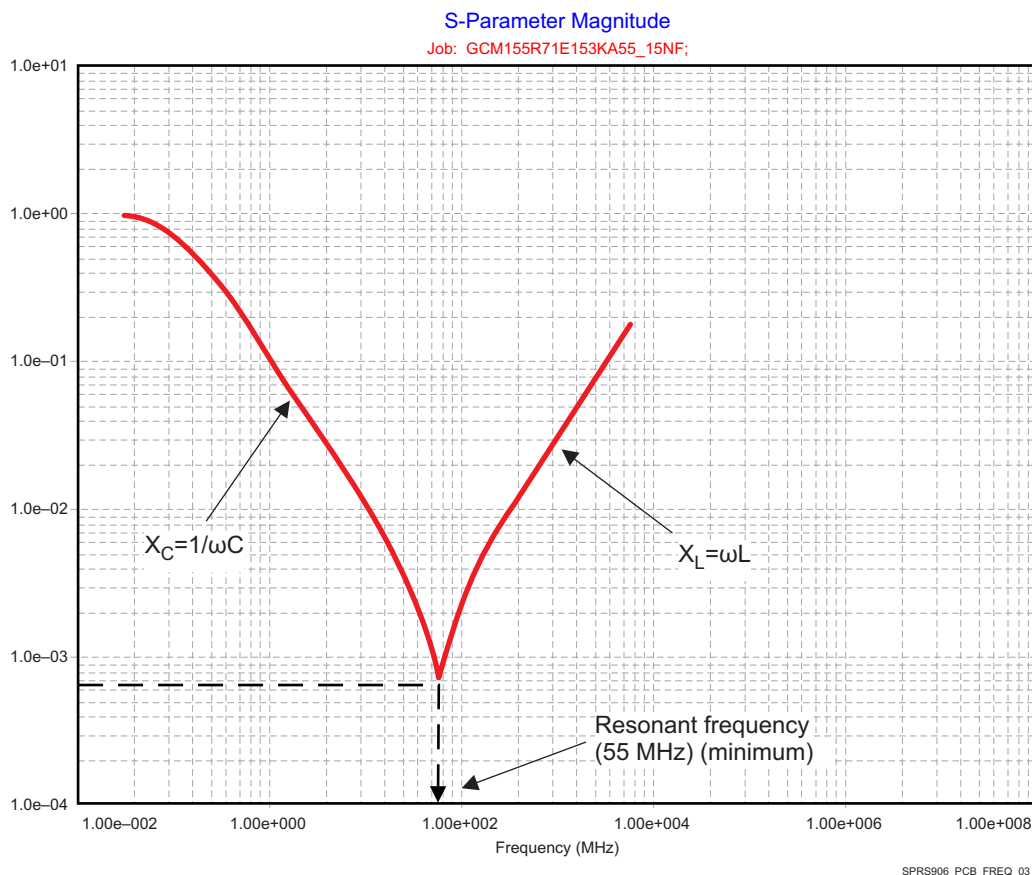
$$|Z| = \sqrt{ESR^2 + \left(\omega ESL - \frac{1}{\omega C}\right)^2}$$

where : $\omega = 2\pi f$

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Figure 8-7. Series Model Impedance Equation

Figure 8-8 shows the resonant frequency response of a typical capacitor with a self-resonant frequency of 55 MHz. The impedance of the capacitor is a combination of its series resistance and reactive capacitance and inductance as shown in the equation above.



SPRS906_PCB_FREQ_03

Figure 8-8. Typical Impedance Profile of a Capacitor

Because a capacitor has series inductance and resistance that impacts its effectiveness, it is important that the following recommendations are adopted in placing capacitors on the PDN.

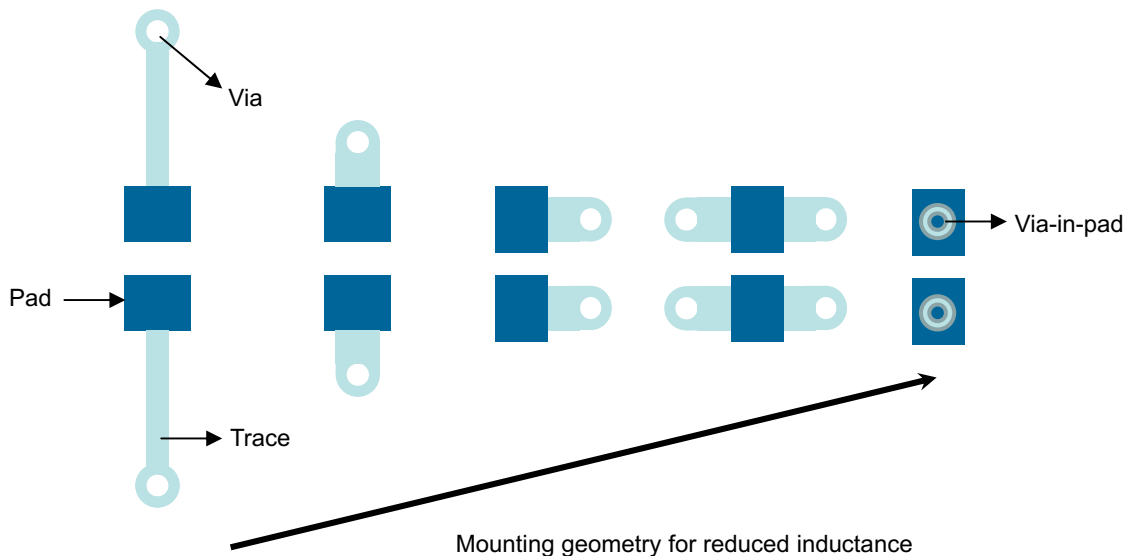
Wherever possible, mount the capacitor with the geometry that minimizes the mounting inductance and resistance. This was shown earlier in Figure 8-1. The capacitor mounting inductance and resistance values include the inductance and resistance of the pads, trace, and vias. Whenever possible, use footprints that have the lowest inductance configuration as shown in Figure 8-9

The length of a trace used to connect a capacitor has a big impact on parasitic inductance and resistance of the mounting. This trace must be as short and as wide as possible. wherever possible, minimize distance to supply and Gnd vias by locating vias nearby or within the capacitor's solder pad landing. Further improvements can be made to the mounting by placing vias to the side of capacitor lands or doubling the number of vias as shown in Figure 8-9. If the PCB manufacturing processes allow it and if cost-effective, via-in-pad (VIP) geometries are strongly recommended.

In addition to mounting inductance and resistance associated with placing a capacitor on the PCB, the effectiveness of a decoupling capacitor also depends on the spreading inductance and resistance that the capacitor sees with respect to the load. The spreading inductance and resistance is strongly dependent on the layer assignment in the PCB stack-up. Therefore, try to minimize X, Y and Z dimensions where the Z is due to PCB thickness (as shown in [Figure 8-9](#)).

From left (highest inductance) to right (lowest inductance) the capacitor footprint types shown in [Figure 8-9](#) are known as:

- 2-via, Skinny End Exit (2vSEE)
- 2-via, Wide End Exit (2vWEE)
- 2-via, Wide Side Exit (2vWSE)
- 4-via, Wide Side Exit (4vWSE)
- 2-via, In-Pad (2vIP)



SPRS906_PCB_FREQ_04

Figure 8-9. Capacitor Placement Geometry for Improved Mounting Inductance

NOTE

Evaluation of loop inductance values for decoupling capacitor footprints 2vSEE (worst case) vs 4vWSE (2nd best) has shown a 30% reduction in inductance when 4vWSE footprint was used in place of 2vSEE.

Decoupling Capacitor (Dcap) Strategy:

1. Use lowest inductance footprint and trace connection scheme possible for given PCB technology and layout area in order to minimize Dcap loop inductance to power pin as much as possible (see [Figure 8-9](#)).
2. Place Dcaps on “same-side” as component within their power plane outline to minimize “decoupling loop inductance”. Target distance to power pin should be less than ~500mils depending upon PCB layout characteristics (plane's layer assignment and solid nature). Use PI modeling CAD tool to verify minimum inductance for top vs bottom-side placement.
3. Place Dcaps on “opposite-side” as component within their power plane outline if “same-side” is not feasible or if distance to power pin is greater than ~500mils for top-side location. Use PI modeling CAD tool to verify minimum inductance for top vs bottom-side placement.
4. Use minimum 10mil trace width for all voltage and gnd planes connections (that is, Dcap pads, component power pins, etc.).

5. Place all voltage and gnd plane vias “as close as possible” to point of use (that is, Dcap pads, component power pins, etc.).
6. Use a “Power/Gnd pad/pin to via” ratio of 1:1 whenever possible. Do not exceed 2:1 ratio for small number of vias within restricted PCB areas (that is, underneath BGA components).

Frequency analysis for the CORE power domain has yielded the vdd Impedance vs Frequency response shown in [Section 8.3.8.2](#), vdd Example Analysis. As the example shows the overall CORE PDN R_{eff} meets the maximum recommended PDN resistance of 10m Ω .

8.2.5 System ESD Generic Guidelines

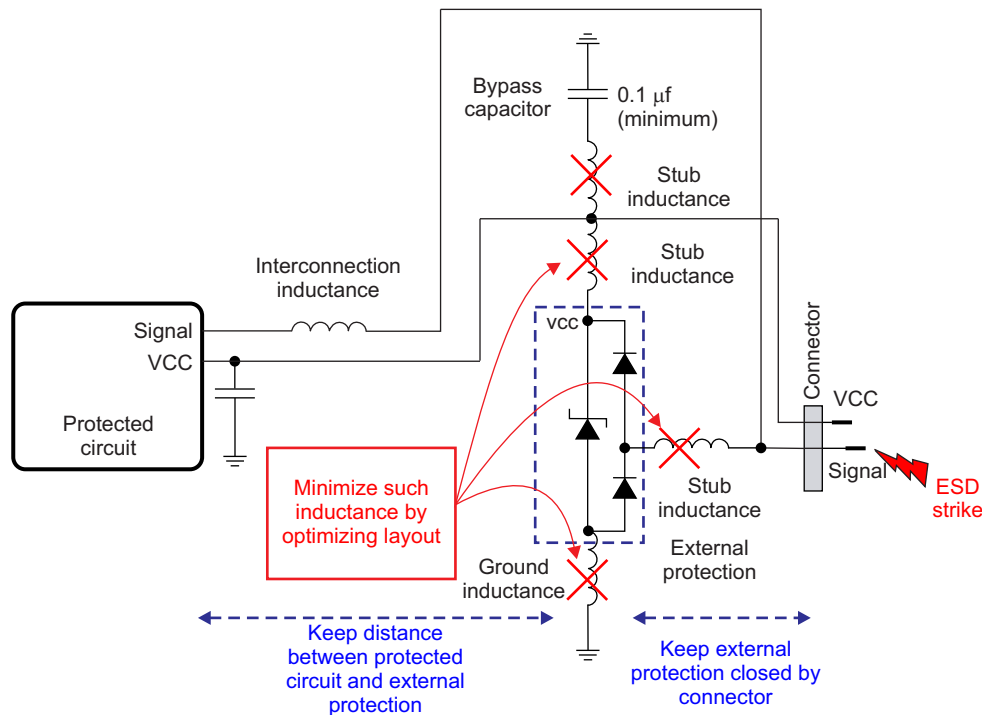
8.2.5.1 System ESD Generic PCB Guideline

Protection devices must be placed close to the ESD source which means close to the connector. This allows the device to subtract the energy associated with an ESD strike before it reaches the internal circuitry of the application board.

To help minimize the residual voltage pulse that will be built-up at the protection device due to its nonzero turn-on impedance, it is mandatory to route the ESD device with minimum stub length so that the low-resistive, low-inductive path from the signal to the ground is granted and not increasing the impedance between signal and ground.

For ESD protection array being railed to a power supply when no decoupling capacitor is available in close vicinity, consider using a decoupling capacitor ($\geq 0.1 \mu\text{F}$) tight to the VCC pin of the ESD protection. A positive strike will be partially diverted to this capacitance resulting in a lower residual voltage pulse.

Ensure that there is sufficient metallization for the supply of signals at the interconnect side (VCC and GND in [Figure 8-10](#)) from connector to external protection because the interconnect may see between 15-A to 30-A current in a short period of time during the ESD event.



SPRS906_PCB_ESD_01

Figure 8-10. Placement Recommendation for an ESD External Protection

NOTE

To ensure normal behavior of the ESD protection (unwanted leakage), it is better to ground the ESD protection to the board ground rather than any local ground (example isolated shield or audio ground).

8.2.5.2 Miscellaneous EMC Guidelines to Mitigate ESD Immunity

- Avoid running critical signal traces (clocks, resets, interrupts, control signals, and so forth) near PCB edges.
- Add high frequency filtering: Decoupling capacitors close to the receivers rather than close to the drivers to minimize ESD coupling.
- Put a ground (guard) ring around the entire periphery of the PCB to act as a lightning rod.
- Connect the guard ring to the PCB ground plane to provide a low impedance path for ESD-coupled current on the ring.
- Fill unused portions of the PCB with ground plane.
- Minimize circuit loops between power and ground by using multilayer PCB with dedicated power and ground planes.
- Shield long line length (strip lines) to minimize radiated ESD.
- Avoid running traces over split ground planes. It is better to use a bridge connecting the two planes in one area.

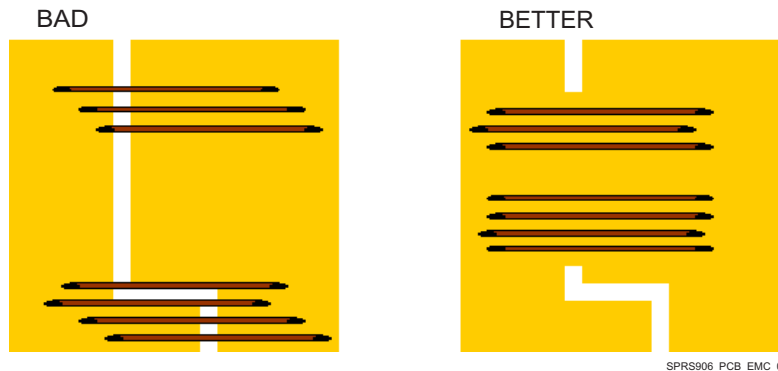


Figure 8-11. Trace Examples

- Always route signal traces and their associated ground returns as close to one another as possible to minimize the loop area enclosed by current flow:
 - At high frequencies current follows the path of least inductance.
 - At low frequencies current flows through the path of least resistance.

8.2.5.3 ESD Protection System Design Consideration

ESD protection system design consideration is covered in [Section 8.5.2.2](#) of this document. The following are additional considerations for ESD protection in a system.

- Metallic shielding for both ESD and EMI
- Chassis GND isolation from the board GND
- Air gap designed on board to absorb ESD energy
- Clamping diodes to absorb ESD energy
- Capacitors to divert ESD energy
- The use of external ESD components on the DP/DM lines may affect signal quality and are not recommended.

8.2.6 EMI / EMC Issues Prevention

All high speed digital integrated circuits can be sources of unwanted radiation, which can affect nearby sensitive circuitry and cause the final product to have radiated emissions levels above the limits allowed by the EMC regulations if some preventative steps are not taken.

Likewise, analog and digital circuits can be susceptible to interference from the outside world and picked up by the circuitry interconnections.

To minimize the potential for EMI/EMC issues, the following guidelines are recommended to be followed.

8.2.6.1 Signal Bandwidth

To evaluate the frequency of a digital signal, an estimated rule of thumb is to consider its bandwidth f_{BW} with respect to its rise time, t_R :

$$f_{BW} \approx 0.35 / t_R$$

This frequency actually corresponds to the break point in the signal spectrum, where the harmonics start to decay at 40 dB per decade instead of 20 dB per decade.

8.2.6.2 Signal Routing

8.2.6.2.1 Signal Routing—Sensitive Signals and Shielding

Keep radio frequency (RF) sensitive circuitry (like GPS receivers, GSM/WCDMA, Bluetooth/WLAN transceivers, frequency modulation (FM) radio) away from high speed ICs (the device, power and audio manager, chargers, memories, and so forth) and ideally on the opposite side of the PCB. For improved protection it is recommended to place these emission sources in a shield can. If the shield can have a removable lid (two-piece shield), ensure there is low contact impedance between the fence and the lid. Leave some space between the lid and the components under it to limit the high-frequency currents induced in the lid. Limit the shield size to put any potential shield resonances above the frequencies of interest; see [Figure 8-8](#), *Typical Impedance Profile of a Capacitor*.

8.2.6.2.2 Signal Routing—Outer Layer Routing

In case there is a need to use the outer layers for routing outside of shielded areas, it is recommended to route only static signals and ensure that these static signals do not carry any high-frequency components (due to parasitic coupling with other signals). In case of long traces, make provision for a bypass capacitor near the signal source.

Routing of high-frequency clock signals on outer layers, even for a short distance, is discouraged, because their emissions energy is concentrated at the discrete harmonics and can become significant even with poor radiators.

Coplanar shielding of traces on outer layers (placing ground near the sides of a track along its length) is effective only if the distance between the trace sides and the ground is smaller than the trace height above the ground reference plane. For modern multilayer PCBs this is often not possible, so coplanar shielding will not be effective. Do not route high-frequency traces near the periphery of the PCB, as the lack of a ground reference near the trace edges can increase EMI: see [Section 8.2.6.3](#), *Ground Guidelines*.

8.2.6.3 Ground Guidelines

8.2.6.3.1 PCB Outer Layers

Ideally the areas on the top and bottom layers of the PCB that are not enclosed by a shield should be filled with ground after the routing is completed and connected with an adequate number of vias to the ground on the inner ground planes.

8.2.6.3.2 Metallic Frames

Ensure that all metallic parts are well connected to the PCB ground (like LCD screens metallic frames, antennas reference planes, connector cages, flex cables grounds, and so forth). If using flex PCB ribbon cables to bring high-frequency signals off the PCB, ensure they are adequately shielded (coaxial cables or flex ribbons with a solid reference ground).

8.2.6.3.3 Connectors

For high-frequency signals going to connectors choose a fully shielded connector, if possible (for example, SD card connectors). For signals going to external connectors or which are routed over long distances, it is recommended to reduce their bandwidth by using low-pass filters (resistor, capacitor (RC) combinations or lossy ferrite inductors). These filters will help to prevent emissions from the board and can also improve the immunity from external disturbances.

8.2.6.3.4 Guard Ring on PCB Edges

The major advantage of a multilayer PCB with ground-plane is the ground return path below each and every signal or power trace.

As shown in [Figure 8-12](#) the field lines of the signal return to PCB ground as long as an infinite ground is available.

Traces near the PCB-edges do not have this infinite ground and therefore may radiate more than the others. Thus, signals (clocks) or power traces (core power) identified to be critical must not be routed in the vicinity of PCB edges, or, if not avoidable, must be accompanied by a guard ring on the PCB edge.

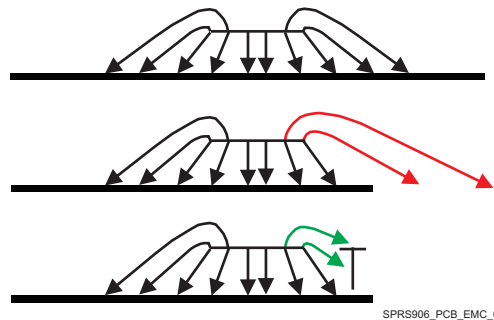


Figure 8-12. Field Lines of a Signal Above Ground



Figure 8-13. Guard Ring Routing

The intention of the guard ring is that HF-energy, that otherwise would have been emitted from the PCB edge, is reflected back into the board where it partially will be absorbed. For this purpose ground traces on the borders of all layers (including power layer) must be applied as shown in [Figure 8-13](#).

As these traces must have the same (HF-) potential as the ground plane they must be connected to the ground plane at least every 10 mm.

8.2.6.3.5 Analog and Digital Ground

For the optimum solution, the AGND and the DGND planes must be connected together at the power supply source in a same point. This ensures that both planes are at the same potential, while the transfer of noise from the digital to the analog domain is minimized.

8.3 Core Power Domains

This section provides boundary conditions and theoretical background to be applied as a guide for optimizing a PCB design. The decoupling capacitor and PDN characteristics tables shown below give recommended capacitors and PCB parameters to be followed for schematic and PCB designs. Board designs that meet the static and dynamic PDN characteristics shown in tables below will be aligned to the expected PDN performance needed to optimize SoC performance.

8.3.1 General Constraints and Theory

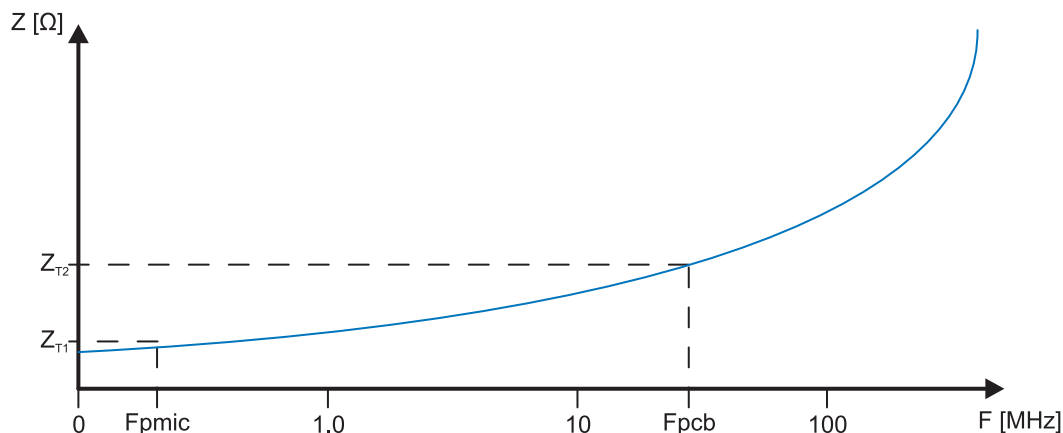
- Max PCB static/DC voltage drop (IRd) budget of **1.5% of supply voltage** when using PMICs **without remote sensing** as measured from PMIC's power inductor and filter capacitor node to Processor input including any ground return losses.
- Max PCB static/DC voltage drop (IRd) budget can be relaxed to **5% of supply voltage** when using PMICs **with remote sensing at the load** as measured from PMIC's power inductor and filter capacitor node to Device's supply input including any ground return losses.
- PMIC component DM and guidelines should be referenced for the following:
 - Routing remote feedback sensing to optimize per each SMPS's implementation
 - Selecting power filtering capacitor values and PCB placement.
- Max Effective Resistance (Reff) budget can range from **4 – 50mΩ** for key Device power rails not including ground returns depending upon maximum load currents and maximum DC voltage drop budget (as discussed above).
- Max Device supply input voltage difference budget of **5mV** under max current loading shall be maintained across all balls connected to a common power rail. This represents any voltage difference that may exist between a remote sense point to any power input.
- Max PCB Loop Inductance (LL) budget between Device's power inputs and local bulk and high frequency decoupling capacitors including ground returns should range from **0.4 – 2.5nH depending upon maximum transient load currents**.
- Max PCB dynamic/AC peak-to-peak transient noise voltage budgets between PMIC and Device including ground returns are as follows:
 - **+/-3% of nominal supply voltage** for frequencies below the PMIC bandwidth (typ Fpmic ~ 200kHz)
 - **+/-5% of nominal supply voltage** for frequencies between Fpmic to Fpcb (typ 20 – 100MHz)

- Max PCB Impedance (Z) vs Frequency (F) budget between Device's power inputs and PMIC's output power filter node including ground return is determined by applying the Frequency Domain Target Impedance Method to determine the PCB's maximum frequency of interest (Fpcb). Ideally a properly designed and decoupled PDN will exhibit smoothly increasing Z vs. F curve. There are 2 general regions of interest as can be seen in [Figure 8-14](#).
 - 1st area is from DC (0Hz) up to Fpmic (typ a few 100 kHz) where a PMIC's transient response characteristic (that is, Switching Freq, Compensation Loop BW) dominate. A PDN's Z is typically very low due to power filtering & bulk capacitor values when PDN has very low trace resistance (that is, good Reff performance). The goal is to maintain a smoothly increasing Z that is less than Zt1 over this low frequency range. This will ensure that a max transient current event will not cause a voltage drop more than the PMIC's current step response can support (typ 3%).
 - 2nd area is from Fpmic up to Fpcb (typ 20-100MHz) where a PCB's inherent characteristics (that is, parasitic capacitance, planar spreading inductances) dominate. A PDN's Z will naturally increase with frequency. At frequencies between Fpmic up to Fpcb, the goal is to maintain a smoothly increasing Z to be less than Zt2. This will ensue that the high frequency content of a max transient current event will not cause a voltage drop to be more than 5% of the min supply voltage.

$$Z_T = \frac{\text{Max Voltage Rail Drop}^{\text{Note1}}}{\text{Max Transient Current}^{\text{Note2}}}$$

$$Z_{T1} = \frac{(\text{Min Voltage}) \times (\text{PMIC's Step Responce})}{(\sim 50\% \text{ of Max DC Current})} = \frac{V_{\text{min}} \times 3\%(\text{typ})}{I_{\text{max}} \times \sim 50\%}$$

$$Z_{T2} = \frac{(\text{Min Voltage}) \times (\text{High-Freq Transient Noise})}{(\sim 50\% \text{ of Max DC Current})} = \frac{V_{\text{min}} \times 5\%(\text{typ})}{I_{\text{max}} \times \sim 50\%}$$



PCB_CPD_8

Figure 8-14. PDN's Target impedance

1.Voltage Rail Drop includes regulation accuracy, voltage distribution drops, and all dynamic events such as transient noise, AC ripple, voltage dips etc.

2. Typical max transient current is defined as 50% of max current draw possible.

8.3.2 Voltage Decoupling

Recommended power supply decoupling capacitors main characteristics for commercial products whose ambient temperature is not to exceed +85C are shown in table below:

Table 8-1. Commercial Applications Recommended Decoupling Capacitors Characteristics⁽¹⁾⁽²⁾⁽³⁾

| Value | Voltage [V] | Package | Stability | Dielectric | Capacitance Tolerance | Temp Range [°C] | Temp Sensitivity [%] | REFERENCE |
|-------|-------------|---------|-----------|------------|-----------------------|-----------------|----------------------|--------------------|
| 22µF | 6,3 | 0603 | Class 2 | X5R | - / + 20% | -55 to + 85 | - / + 15 | GRM188R60J226MEA0L |
| 10µF | 4,0 | 0402 | Class 2 | X5R | - / + 20% | -55 to + 85 | - / + 15 | GRM155R60G106ME44 |
| 4.7µF | 6,3 | 0402 | Class 2 | X5R | - / + 20% | -55 to + 85 | - / + 15 | GRM155R60J475ME95 |
| 2.2µF | 6,3 | 0402 | Class 2 | X5R | - / + 20% | -55 to + 85 | - / + 15 | GRM155R60J225ME95 |
| 1µF | 6,3 | 0201 | Class 2 | X5R | - / + 20% | -55 to + 85 | - / + 15 | GRM033R60J105MEA2 |
| 470nF | 6,3 | 0201 | Class 2 | X5R | - / + 20% | -55 to + 85 | - / + 15 | GRM033R60G474ME90 |
| 220nF | 6,3 | 0201 | Class 2 | X5R | - / + 20% | -55 to + 85 | - / + 15 | GRM033R60J224ME90 |
| 100nF | 6,3 | 0201 | Class 2 | X5R | - / + 20% | -55 to + 85 | - / + 15 | GRM033R60J104ME19 |

(1) Minimum value for each PCB capacitor: 100 nF.

(2) Among the different capacitors, 470 nF is recommended (not required) to filter at 5-MHz to 10-MHz frequency range.

(3) In comparison with the EIA Class 1 dielectrics, Class 2 dielectric capacitors tend to have severe temperature drift, high dependence of capacitance on applied voltage, high voltage coefficient of dissipation factor, high frequency coefficient of dissipation, and problems with aging due to gradual change of crystal structure. Aging causes gradual exponential loss of capacitance and decrease of dissipation factor.

Recommended power supply decoupling capacitors main characteristics for automotive products are shown in table below:

Table 8-2. Automotive Applications Recommended Decoupling Capacitors Characteristics⁽¹⁾⁽²⁾

| Value | Voltage [V] | Package | Stability | Dielectric | Capacitance Tolerance | Temp Range [°C] | Temp Sensitivity [%] | REFERENCE |
|-------|-------------|---------|-----------|------------|-----------------------|-----------------|----------------------|-------------------|
| 22µF | 6,3 | 1206 | Class 2 | X7R | - / + 20% | -55 to + 125 | - / + 15 | GCM31CR70J226ME23 |
| 10µF | 6,3 | 0805 | Class 2 | X7R | - / + 20% | -55 to + 125 | - / + 15 | GCM21BR70J106ME22 |
| 4.7µF | 10 | 0805 | Class 2 | X7R | - / + 20% | -55 to + 125 | - / + 15 | GCM21BC71A475MA73 |
| 2.2µF | 6,3 | 0603 | Class 2 | X7R | - / + 20% | -55 to + 125 | - / + 15 | GCM188R70J225ME22 |
| 1µF | 16 | 0603 | Class 2 | X7R | - / + 20% | -55 to + 125 | - / + 15 | GCM188R71C105MA64 |
| 470nF | 16 | 0603 | Class 2 | X7R | - / + 20% | -55 to + 125 | - / + 15 | GCM188R71C474MA55 |
| 220nF | 25 | 0603 | Class 2 | X7R | - / + 20% | -55 to + 125 | - / + 15 | GCM188L81C224MA37 |
| 100nF | 16 | 0402 | Class 2 | X7R | - / + 20% | -55 to + 125 | - / + 15 | GCM155R71C104MA55 |

(1) Minimum value for each PCB capacitor: 100 nF.

(2) Among the different capacitors, 470 nF is recommended (not required) to filter at 5-MHz to 10-MHz frequency range.

8.3.3 Static PDN Analysis

One power net parameter derived from a PCB's PDN static analysis is the Effective Resistance (R_{eff}). This is the total PCB power net routing resistance that is the sum of all the individual power net segments used to deliver a supply voltage to the point of load and includes any series resistive elements (that is, current sensing resistor) that may be installed between the PMIC outputs and Processor inputs.

8.3.4 Dynamic PDN Analysis

Three power net parameters derived from a PCB's PDN dynamic analysis are the Loop Inductance (LL), Impedance (Z) and PCB Frequency of Interest (F_{pcb}).

- LL values shown are the recommended max PCB trace inductance between a decoupling capacitor's power supply and ground reference terminals when viewed from the decoupling capacitor with a "theoretical shorted" applied across the Processor's supply inputs to ground reference.
- Z values shown are the recommended max PCB trace impedances allowed between Fpmic up to Fpcb frequency range that limits transient noise drops to no more than 5% of min supply voltage during max transient current events.
- Fpcb (Frequency of Interest) is defined to be a power rail's max frequency after which adding a reasonable number of decoupling capacitors no longer significantly reduces the power rail impedance below the desired impedance target (Zt2). This is due to the dominance of the PCB's parasitic planar spreading and internal package inductances.

Table 8-3. Recommended PDN and Decoupling Characteristics ⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾⁽⁵⁾

| PDN Analysis: Supply | Static | | Dynamic | | Number of Recommended Decoupling Capacitors per Supply | | | | | | | |
|-----------------------------|---|--|-----------------------|--------------------------------------|--|--------|--------|-----|--------|--------|-------|-------|
| | Max R _{eff} ⁽⁷⁾ [mΩ] | Dec. Cap. Max LL ^{(8) (6)} [nH] | Max Impedance [mΩ] | Frequency range of Interest [MHz] | 100 nF ⁽⁶⁾ | 220 nF | 470 nF | 1μF | 2.2 μF | 4.7 μF | 10 μF | 22 μF |
| vdd_mpu | 10 | 2 | 57 | ≤20 | 8 | 1 | 1 | 1 | 1 | 1 | | 1 |
| vdd_dsp, vdd_gpu, vdd_iva | 13 | 2.5 | 54 | ≤20 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| vdd | 27 | 2 | 87 | ≤50 | 6 | 1 | 1 | 1 | 1 | 1 | | |
| vdds_ddr1 | 10 | 2.5 | 200 | ≤100 | 8 | 4 | | 2 | | 2 | | 1 |
| cap_vbbldo_dsp | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vbbldo_gpu | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vbbldo_iva | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vbbldo_mpu | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vddram_core1 | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vddram_core3 | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vddram_core4 | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vddram_dsp | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vddram_gpu | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vddram_iva | N/A | 6 | N/A | N/A | | | | 1 | | | | |
| cap_vddram_mpu | N/A | 6 | N/A | N/A | | | | 1 | | | | |

(1) For more information on peak-to-peak noise values, see the Recommended Operating Conditions table of the Specifications chapter.

(2) ESL must be as low as possible and must not exceed 0.5 nH.

(3) The PDN (Power Delivery Network) impedance characteristics are defined versus the device activity (that runs at different frequency) based on the Recommended Operating Conditions table of the Specifications chapter.

(4) The static drop requirement drives the maximum acceptable PCB resistance between the PMIC or the external SMPS and the processor power balls.

(5) Assuming that the external SMPS (power IC) feedback sense is taken close to processor power balls.

(6) High-frequency (30 to 70MHz) PCB decoupling capacitors

(7) Maximum R_{eff} from SMPS to Processor.

(8) Maximum Loop Inductance for decoupling capacitor.

8.3.5 Power Supply Mapping

[TPS65917](#) or [TPS659039](#) are the Power Management ICs (PMICs) that should be used for the Device designs. TI requires use of these PMICs for the following reasons:

- TI has validated their use with the Device
- Board level margins including transient response and output accuracy are analyzed and optimized for the entire system

- Support for power sequencing requirements (refer to [Section 5.10 Power Supply Sequences](#))
- Support for Adaptive Voltage Scaling (AVS) Class 0 requirements, including TI provided software

Whenever we allow for combining of rails mapped on any of the SMPSes, the PDN guidelines that are the most stringent of the rails combined should be implemented for the particular supply rail.

It is possible that some voltage domains on the device are unused in some systems. In such cases, to ensure device reliability, it is still required that the supply pins for the specific voltage domains are connected to some core power supply output.

These unused supplies though can be combined with any of the core supplies that are used (active) in the system. For example if IVA and GPU domains are not used, they can be combined with the CORE domain, thereby having a single power supply driving the combined CORE, IVA and GPU domains.

For the combined rail, the following relaxations do apply:

- The AVS voltage of active rail in the combined rail needs to be used to set the power supply
- The decoupling capacitance should be set according to the active rail in the combined rail

[Table 8-4](#) illustrates the approved and validated power supply connections to the Device for the SMPS outputs of the TPS659039 PMIC.

Table 8-4. TPS659039 Power Supply Connections⁽¹⁾

| SMPS | Valid Combination 1: Reference Platform | Valid Combination 2: MPU Centric | TPS659039 Current Rating Limitation ^{(3) (4)} |
|--------------------------|--|-------------------------------------|---|
| SMPS1/2/3 ⁽²⁾ | vdd_mpu | vdd_mpu | SMPS1/2: 6A SMPS1/2/3: 9A |
| SMPS3 ⁽²⁾ | vdds_ddr1 | vdds_ddr1 | SMPS3: 3A |
| SMPS4/5 | vdd_dsp | vdd_dsp, vdd_gpu, vdd_iva | SMPS4/5: 4A |
| SMPS6 | vdd_gpu | vdd | SMPS6: 2-3A (BOOST_CURRENT=0/1) |
| SMPS7 | vdd | Free | 2A |
| SMPS8 | vdd_iva | Free | 1A |
| SMPS9 | vdds18v | vdds18v | 1A |

- (1) Power consumption is highly application-specific. Separate analysis must be performed to ensure output current ratings (average and peak) is within the limits of the PMIC for all rails of the device.
- (2) Dual phase (SMPS1/2) can be used as long as the peak power consumption is maintained below the SMPS1/2 capacity
 - a. For the latest rated output current specifications for the [TPS659039](#) device, please refer to the PMIC data manual.
 - b. MPU power consumption is highly system dependent. A detailed power consumption estimate must be performed to confirm compatibility. Example: Single vs Dual MPU, OPP_NOM vs OPP_OD vs OPP_HIGH, TPS659039 configured with $V_I \geq 3V$ vs $V_I < 3V$, etc. Contact your TI representative for details.
- (3) Refer to the PMIC data manual for the latest [TPS659039](#) specifications.
- (4) A product's maximum ambient temperature, thermal system design & heat spreading performance could limit the maximum power dissipation below the full PMIC capacity in order to not exceed recommended SoC max Tj.

[Table 8-5](#) illustrates the approved and validated power supply connections to the Device for the SMPS outputs of the TPS65917 PMIC.

Table 8-5. TPS65917 Power Supply Connections

| TPS65917 | Valid Combination 1: | Valid Combination 2: | TPS65917 Current Rating Limitation ^{(1) (3)} |
|----------|----------------------------|-------------------------|---|
| SMPS1 | vdd_mpu | vdd_mpu | 3.5A |

Table 8-5. TPS65917 Power Supply Connections (continued)

| TPS65917 | Valid Combination 1: | Valid Combination 2: | TPS65917 Current Rating Limitation ^{(1) (3)} |
|----------------------|---------------------------------|------------------------------------|---|
| SMPS2 ⁽²⁾ | vdd_dsp, vdd_gpu, vdd_iva | vdd | 3.5A |
| SMPS3 ⁽²⁾ | vdd | vdd_dspeve, vdd_gpu, vdd_iva | 3A |
| SMPS4 ⁽³⁾ | vdds18v | vdds18v | 1.5A |
| SMPS5 ⁽⁴⁾ | vdds_dds1 | vdds_dds1 | 2A |

(1) Refer to the [TPS65917](#) Data Manual for exact current rating limitations, including assumed V_{IN} and other parameters. Values provided in this table are for comparison purposes.

(2) DSP, EVE, GPU, and IVAHD power consumption is highly application-specific. Separate analysis must be performed to ensure output current ratings (average and peak) is within the limits of the PMIC. VDD only supports OPP_NOM.

(3) Highly application-specific. Separate analysis must be performed to ensure average and peak power is within the limits of the PMIC.

(4) Furthermore, if SMPS5 is used for DDR power, both total memory + SoC power must be within the PMIC limits.

8.3.6 DPLL Voltage Requirement

The voltage input to the DPLLs has a low noise requirement. Board designs should supply these voltage inputs with a low noise LDO to ensure they are isolated from any potential digital switching noise. The TPS65917 PMIC LDOLN output is specifically designed to meet this low noise requirement.

NOTE

For more information about Input Voltage Sources, see [Section 6.2 DPLLs, DLLs Specifications](#).

[Table 8-4](#) presents the voltage inputs that supply the DPLLs.

Table 8-6. Input Voltage Power Supplies for the DPLLs

| POWER SUPPLY | DPLLs |
|----------------|--|
| vdda_per | DPLL_PER and PER HSDIVIDER analog power supply |
| vdda_dds | DPLL_DDR and DDR HSDIVIDER analog power supply |
| vdda_debug | DPLL_DEBUG analog power supply |
| vdda_dsp_iva | DPLL_DSP and DPLL_IVA analog power supply |
| vdda_core_gmac | DPLL_CORE and HSDIVIDER analog power supply |
| vdda_gpu | DPLL_GPU analog power supply |
| vdda_video | DPLL_VIDEO1 analog power supply |
| vdda_mpu_abe | DPLL_MPU and DPLL_ABE analog power supply |
| vdda_osc | not DPLL input but is required to be supplied by low noise input voltage |
| vdda_pll_spare | DPLL_SPARE analog power supply |

8.3.7 Loss of Input Power Event

A few key PDN design items needed to enable a controlled and compliant SoC power down sequence for a “Loss of Input Power” event are:

- “Loss of Input Power” early warning.
 - TI EVM and Reference Design Study SCHs and PDNs achieve this by using the First Stage Converter’s (that is, LM536033-Q1) Power Good status output to enable and disable the Second Stage PMIC devices (that is, TPS65917/919, LP8733, and LP8732). If a different First Stage Converter is used, care must be taken to ensure an adequate “PG_Status” or “Vbatt_Status” signal is provided that can disable Second Stage PMIC to begin a controlled and compliant SoC power down sequence. The total elapsed time from asserting “PG_Status” low until SoC’s PMIC input voltage reaches minimum level of 2.75 V should be minimum of 1.5 ms and 2 ms preferred.
- Maximize discharge time of First Stage Vout (VSYS_3V3 power rail = input voltage to SoC PMIC).
 - TI EVM and Reference Design Study SCHs and PDNs achieve this by opening an in-line load switch immediately upon “PG_Status” low assertion in order to remove the SoC’s 3.3 V IO load current from VSYS_3V3. This will extend the VSYS_3V3 power rail’s discharge time in order to maximize elapsed time for allowing SoC PMIC to execute a controlled and compliant power down sequence. Care should be taken to either disable or isolate any additional peripheral components that may be loading the VSYS_3V3 rail as well.
- Sufficient bulk decoupling capacitance on the First Stage Vout (VSYS_3V3 per PDN) that allows for desired 1.5 – 2 ms elapsed time as described above.
 - TI EVM and Reference Design Study SCHs and PDNs achieve this by using 200 μ F of total capacitance on VSYS_3V3. The First Stage Converter (that is, LM536033-Q1) can typically drive a max of 400 μ F to help extend VSYS_3V3 discharge time for a compliant SoC power down sequence.
- Optimizing the Second Stage SoC PMIC’s OTP settings that determines SoC power up and down sequences and total elapsed time needed for a controlled sequence.
 - TI EVM and Reference Design Study SCHs and PDNs achieve this by using optimized OTPs per the SCH and components used. The definition of these OTPs is captured in the detailed timing diagrams for both power up and down sequences. The PDN diagram typically shows a recommended PMIC OTP ID based upon the SoC and DDR memory types.

8.3.8 Example PCB Design

The following sections describe an example PCB design and its resulting PDN performance for the vdd_mpu key processor power domain.

NOTE

Materials presented in this section are based on generic PDN analysis on PCB boards and are not specific to systems integrating the Device.

8.3.8.1 Example Stack-up

Layer Assignments:

- Layer Top: Signal and Segmented Power Plane
 - Processor and PMIC components placed on Top-side
- Layer 2: Gnd Plane1
- Layer 3: Signals
- Layer n: Power Plane1
- Layer n+1: Power Plane 2
- Layer n+2: Signal
- Layer n+3: Gnd Plane2
- Layer Bottom: Signal and Segmented Power Planes
 - Decoupling caps, etc.

Via Technology: Through-hole

Copper Weight:

- ½ oz for all signal layers.
- 1-2oz for all power plane for improved PCB heat spreading

8.3.8.2 vdd Example Analysis

Maximum acceptable PCB resistance (R_{eff}) between the PMIC and Processor input power balls should not exceed 10m Ω .

Maximum decoupling capacitance loop inductance (LL) between Processor input power balls and decoupling capacitances should not exceed 2.0nH (ESL NOT included)

Impedance target for key frequency of interest between Processor input power balls and PMIC's SMPS output power balls should not exceed 57m Ω at 20MHz.

Table 8-7. Example PCB vdd PI Analysis Summary

| Parameter | Recommendation | Example PCB |
|--|----------------------|----------------------|
| OPP | OPP_NOM | |
| Clocking Rate | 266 MHz | |
| Voltage Level | 1 V | 1 V |
| Max Current Draw | 1 A | 1 A |
| Max Effective Resistance: Power Inductor Segment Total R_{eff} | 10m Ω | 9.7 m Ω |
| Max Loop Inductance | 2.0nH | 0.97 –1.75nH |
| Impedance Target | 57m Ω F<20Mhz | 57m Ω F<20Mhz |

Figure 8-15 show a PCB layout example and the resulting PI analysis results.

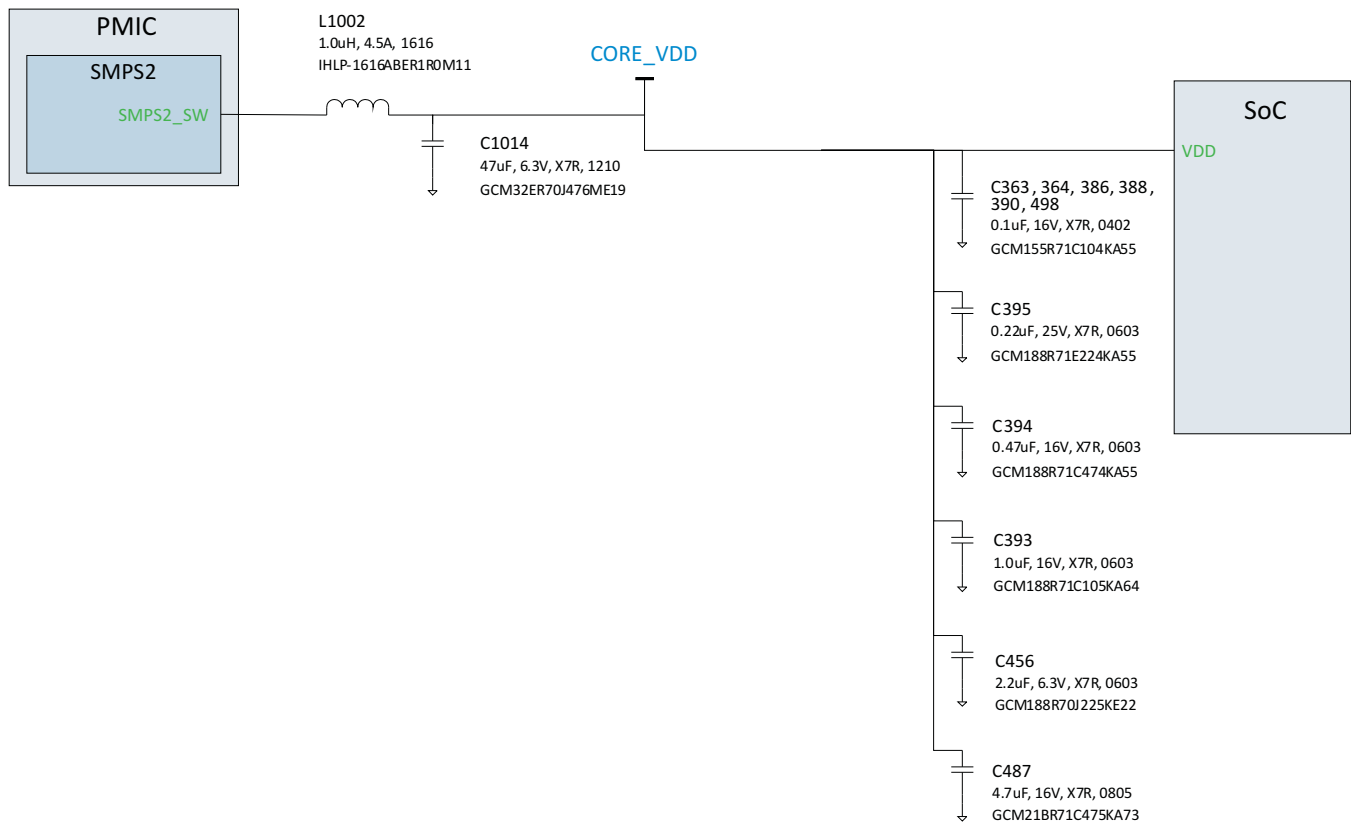


Figure 8-15. vdd Simplified SCH Diagram

NOTE

PCB Etch Resistance Breakdown, PDN Effective Resistance, and vdd routings are UNDER DEVELOPMENT!

IR Drop: vdd (PCB Rev Oct25, CAD sPSI v13.1.1)

- Source Conditions: 1V @ 1A
- Power Plane/Trace Effective Resistances
 - From PMIC SMPS to SoC load = 9.7mohm
 - From Power Inductor to SoC load = 6mohm
 - "Open-Loop" Voltage/IR Drop for 1A = 6mV

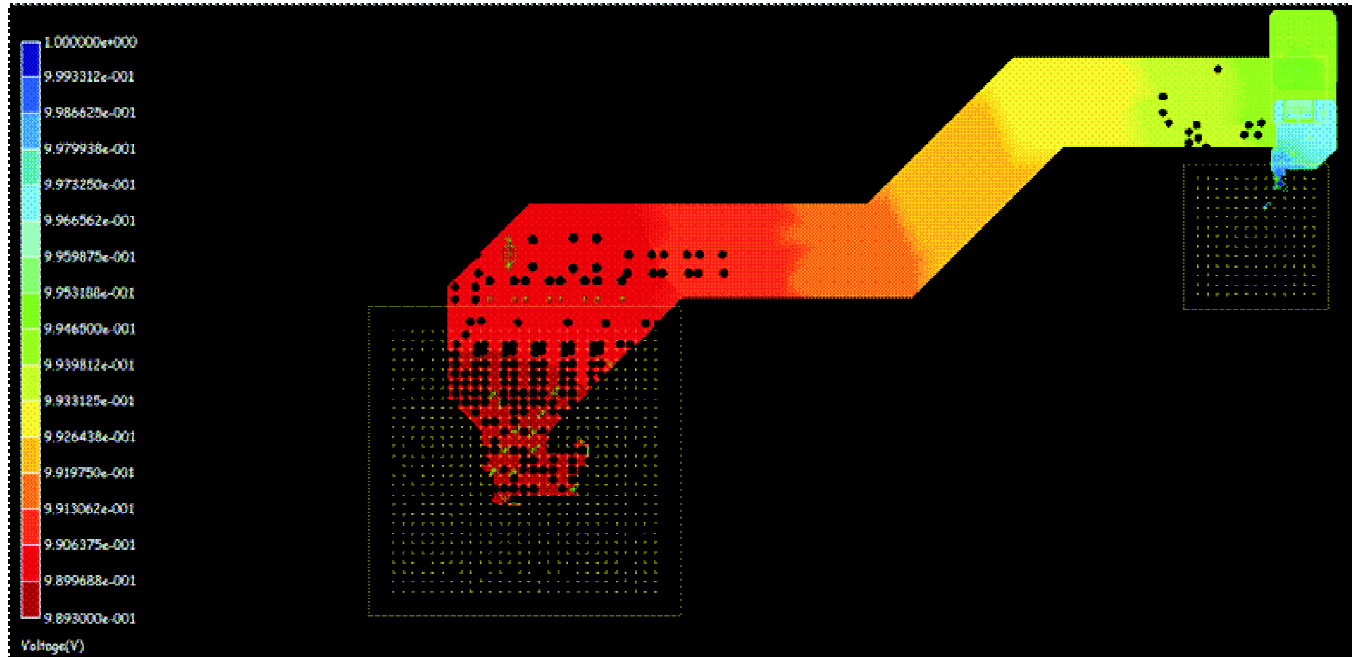


Figure 8-16. vdd Voltage/IR Drop [All Layers]

Dynamic analysis of this PCB design for the CORE power domain determined the vdd decoupling capacitor loop inductance and impedance vs frequency analysis shown below. As you can see, the loop inductance values ranged from 0.97 –1.75nH and were less than maximum 2.0nH recommended.

NOTE

Comparing loop inductances for capacitors at different distances from the SoC’s input power balls shows an 18% reduction for caps placed closer. This was derived by averaging the inductances for the 3 caps with distances over 800mils (Avg LL = 1.33nH) vs the 3 caps with distances less than 600mils (Avg LL = 1.096nH).

Table 8-8. Rail - vdd

| Cap Ref Des | Model Port # | Loop Inductance [nH] | Footprint Types | PCB Side | Distance to Ball-Field [mils] | Value [µF] | Size |
|-------------|--------------|----------------------|-----------------|----------|-------------------------------|------------|------|
| C487 | 10 | 0.97 | 4vWSE | Top | 521 | 4.7 | 0805 |
| C393 | 6 | 1.11 | 4vWSE | Bottom | 358 | 1.0 | 0603 |
| C394 | 7 | 1.12 | 4vWSE | Bottom | 357 | 0.47 | 0603 |
| C456 | 9 | 1.13 | 4vWSE | Bottom | 403 | 2.2 | 0603 |
| C386 | 3 | 1.16 | 2vWSE | Bottom | 40 | 0.1 | 0402 |
| C395 | 8 | 1.18 | 4vWSE | Bottom | 460 | 0.22 | 0603 |
| C363 | 1 | 1.46 | 2vWSE | Bottom | 40 | 0.1 | 0402 |
| C390 | 5 | 1.48 | 2vWSE | Bottom | 40 | 0.1 | 0402 |
| C364 | 2 | 1.74 | 2vWSE | Bottom | 40 | 0.1 | 0402 |
| C498 | 11 | 1.74 | 2vWSE | Bottom | 40 | 0.1 | 0402 |
| C388 | 4 | 1.75 | 2vWSE | Bottom | 40 | 0.1 | 0402 |

Loop Inductance range: 0.97 – 1.75nH

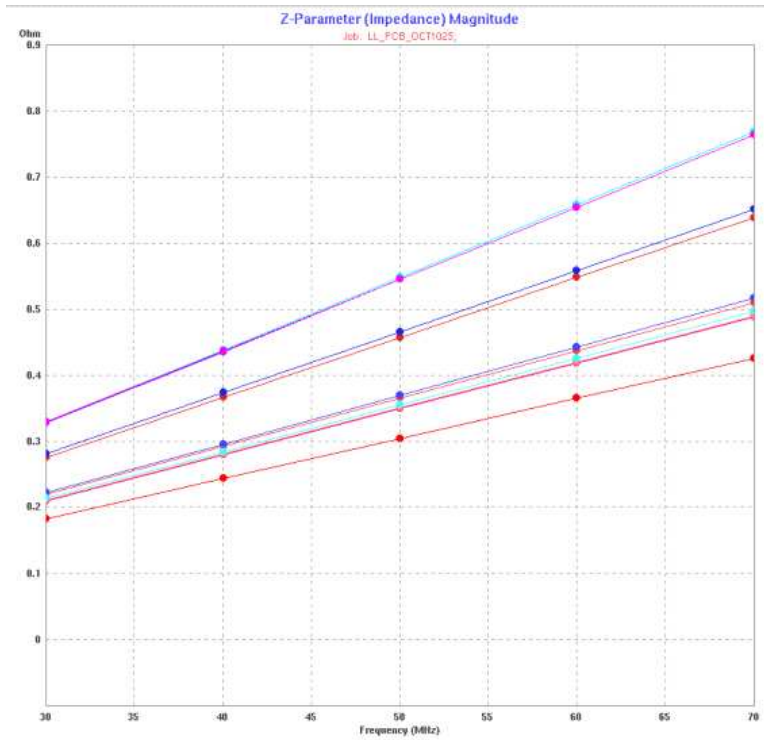


Figure 8-17. vdd Decoupling Cap Loop Inductances

Figure 8-18 shows vdd Impedance vs Frequency characteristics.

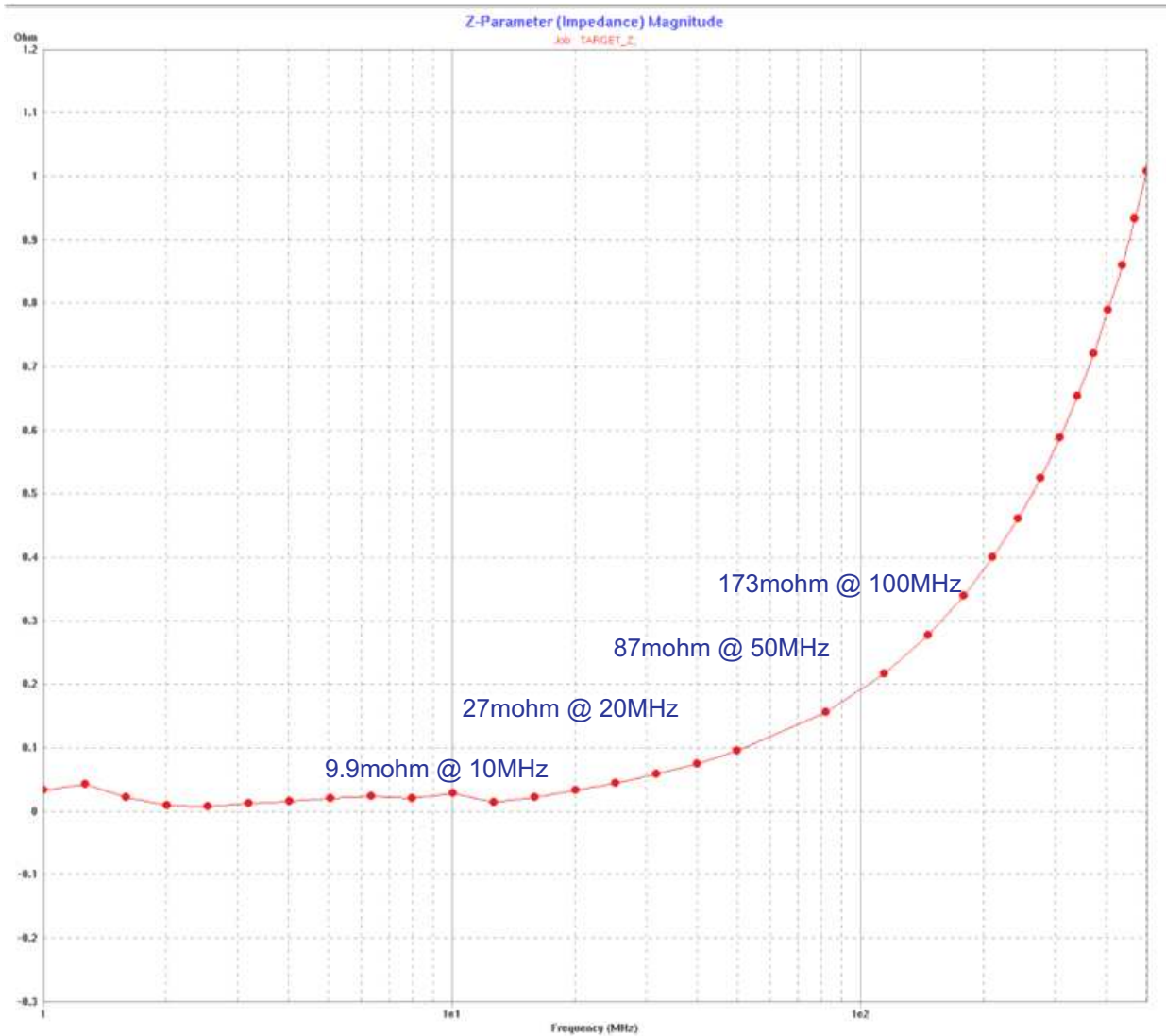


Figure 8-18. vdd Impedance vs Frequency

8.4 Single-Ended Interfaces

8.4.1 General Routing Guidelines

The following paragraphs detail the routing guidelines that must be observed when routing the various functional LVCMOS interfaces.

- Line spacing:
 - For a line width equal to W , the spacing between two lines must be $2W$, at least. This minimizes the crosstalk between switching signals between the different lines. On the PCB, this is not achievable everywhere (for example, when breaking signals out from the device package), but it is recommended to follow this rule as much as possible. When violating this guideline, minimize the length of the traces running parallel to each other (see [Figure 8-19](#)).

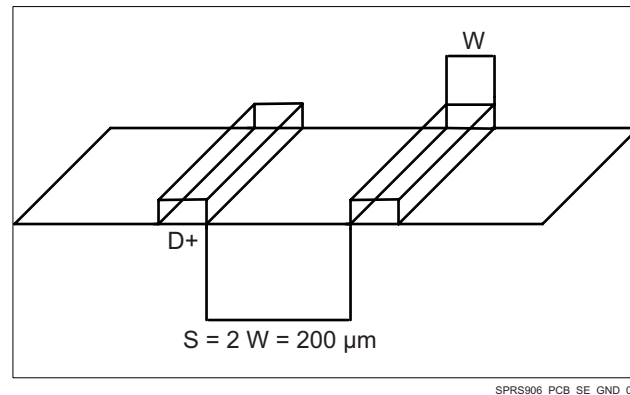


Figure 8-19. Ground Guard Illustration

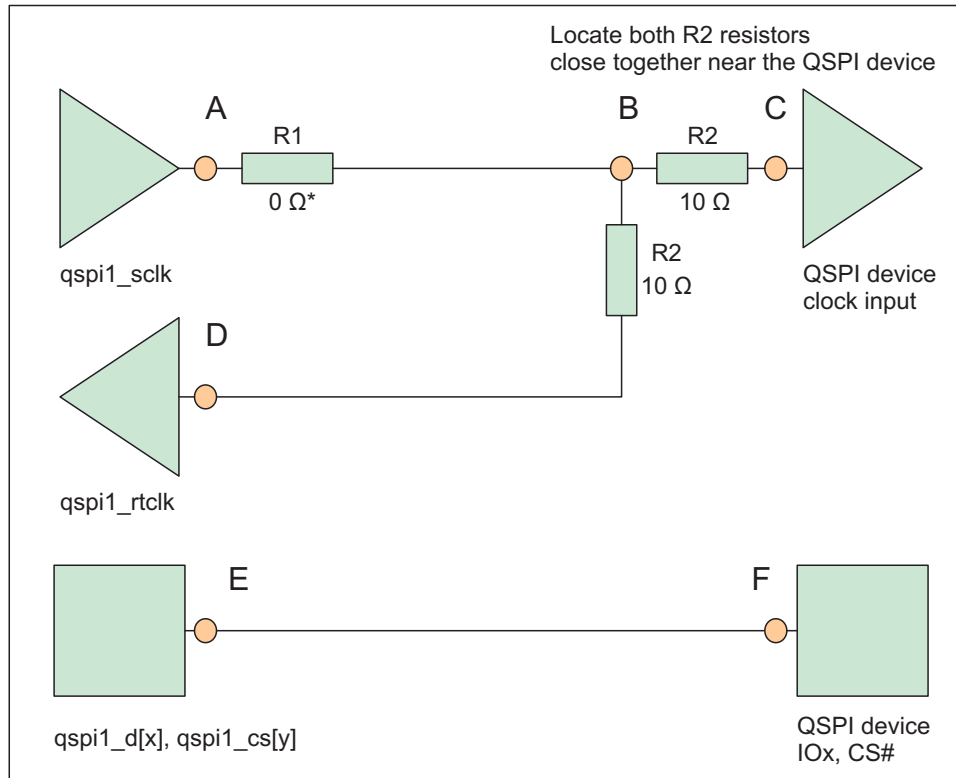
- Length matching (unless otherwise specified):
 - For bus or traces at frequencies less than 10 MHz, the trace length matching (maximum length difference between the longest and the shortest lines) must be less than 25 mm.
 - For bus or traces at frequencies greater than 10 MHz, the trace length matching (maximum length difference between the longest and the shortest lines) must be less than 2.5 mm.
- Characteristic impedance
 - Unless otherwise specified, the characteristic impedance for single-ended interfaces is recommended to be between 35- Ω and 65- Ω .
- Multiple peripheral support
 - For interfaces where multiple peripherals have to be supported in the star topology, the length of each branch has to be balanced. Before closing the PCB design, it is highly recommended to verify signal integrity based on simulations including actual PCB extraction.

8.4.2 QSPI Board Design and Layout Guidelines

The following section details the routing guidelines that must be observed when routing the QSPI interfaces.

- The `qspi1_sclk` output signal must be looped back into the `qspi1_rtclk` input.
- The signal propagation delay from the `qspi1_sclk` ball to the QSPI device CLK input pin (A to C) must be approximately equal to the signal propagation delay from the QSPI device CLK pin to the `qspi1_rtclk` ball (C to D).
- The signal propagation delay from the QSPI device CLK pin to the `qspi1_rtclk` ball (C to D) must be approximately equal to the signal propagation delay of the control and data signals between the QSPI device and the SoC device (E to F, or F to E).
- The signal propagation delay from the `qspi1_sclk` signal to the series terminators ($R2 = 10 \Omega$) near the QSPI device must be $< 450\text{pS}$ ($\sim 7\text{cm}$ as stripline or $\sim 8\text{cm}$ as microstrip)
- 50 Ω PCB routing is recommended along with series terminations, as shown in [Figure 8-20](#).

- Propagation delays and matching:
 - A to C = C to D = E to F.
 - Matching skew: < 60pS
 - A to B < 450pS
 - B to C = as small as possible (<60pS)



SPRS906_PCB_QSPI_01

*0 Ω resistor (R1), located as close as possible to the qspi1_sclk pin, is placeholder for fine-tuning if needed.

Figure 8-20. QSPI Interface High Level Schematic

8.5 Differential Interfaces

8.5.1 General Routing Guidelines

To maximize signal integrity, proper routing techniques for differential signals are important for high speed designs. The following general routing guidelines describe the routing guidelines for differential lanes and differential signals.

- As much as possible, no other high-frequency signals must be routed in close proximity to the differential pair.
- Must be routed as differential traces on the same layer. The trace width and spacing must be chosen to yield the differential impedance value recommended.
- Minimize external components on differential lanes (like external ESD, probe points).
- Through-hole pins are not recommended.
- Differential lanes mustn't cross image planes (ground planes).
- No sharp bend on differential lanes.
- Number of vias on the differential pairs must be minimized, and identical on each line of the differential pair. In case of multiple differential lanes in the same interface, all lines should have the same number of vias.

- Shielded routing is to be promoted as much as possible (for instance, signals must be routed on internal layers that are inside power and/or ground planes).

8.5.2 USB 2.0 Board Design and Layout Guidelines

This section discusses schematic guidelines when designing a universal serial bus (USB) system.

8.5.2.1 Background

Clock frequencies generate the main source of energy in a USB design. The USB differential DP/DM pairs operate in high speed mode at 480 Mbps. System clocks can operate at 12 MHz, 48 MHz, and 60 MHz. The USB cable can behave as a monopole antenna; take care to prevent RF currents from coupling onto the cable.

When designing a USB board, the signals of most interest are:

- Device interface signals: Clocks and other signal/data lines that run between devices on the PCB.
- Power going into and out of the cable: The USB connector socket pin 1 (VBUS) may be heavily filtered and need only pass low frequency signals of less than ~100 KHz. The USB socket pin 4 (analog ground) must be able to return the current during data transmission, and must be filtered sparingly.
- Differential twisted pair signals going out on cable, DP and DM: Depending upon the data transfer rate, these device terminals can have signals with fundamental frequencies of 240 MHz (high speed), 6 MHz (full speed), and 750 kHz (low speed).
- External crystal circuit (device terminals XI and X0): 12 MHz, 19.2 MHz, 24 MHz, and 48 MHz fundamental. When using an external crystal as a reference clock, a 24 MHz and higher crystal is highly recommended.

8.5.2.2 USB PHY Layout Guide

The following sections describe in detail the specific guidelines for USB PHY Layout.

8.5.2.2.1 General Routing and Placement

Use the following routing and placement guidelines when laying out a new design for the USB physical layer (PHY). These guidelines help minimize signal quality and electromagnetic interference (EMI) problems on a four-or-more layer evaluation module (EVM).

- Place the USB PHY and major components on the un-routed board first. For more details, see [Section 8.5.2.2.3](#).
- Route the high speed clock and high speed USB differential signals with minimum trace lengths.
- Route the high speed USB signals on the plane closest to the ground plane, whenever possible.
- Route the high speed USB signals using a minimum of vias and corners. This reduces signal reflections and impedance changes.
- When it becomes necessary to turn 90°, use two 45° turns or an arc instead of making a single 90° turn. This reduces reflections on the signal traces by minimizing impedance discontinuities.
- Do not route USB traces under or near crystals, oscillators, clock signal generators, switching regulators, mounting holes, magnetic devices or IC's that use or duplicate clock signals.
- Avoid stubs on the high speed USB signals because they cause signal reflections. If a stub is unavoidable, then the stub should be less than 200 mils.
- Route all high speed USB signal traces over continuous planes (V_{CC} or GND), with no interruptions. Avoid crossing over anti-etch, commonly found with plane splits.

8.5.2.2.2 Specific Guidelines for USB PHY Layout

The following sections describe in detail the specific guidelines for USB PHY Layout.

8.5.2.2.2.1 Analog, PLL, and Digital Power Supply Filtering

To minimize EMI emissions, add decoupling capacitors with a ferrite bead at power supply terminals for the analog, phase-locked loop (PLL), and digital portions of the chip. Place this array as close to the chip as possible to minimize the inductance of the line and noise contributions to the system. An analog and digital supply example is shown in Figure 8-21. In case of multiple power supply pins with the same function, tie them up to a single low-impedance point in the board and then add the decoupling capacitors, in addition to the ferrite bead. This array of caps and ferrite bead improve EMI and jitter performance. Take both EMI and jitter into account before altering the configuration.

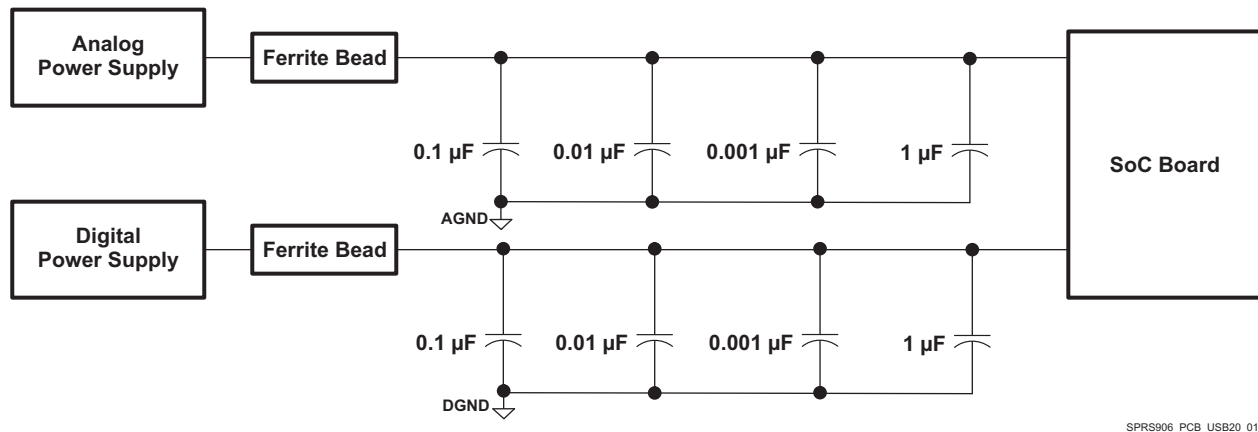


Figure 8-21. Suggested Array Capacitors and a Ferrite Bead to Minimize EMI

Consider the recommendations listed below to achieve proper ESD/EMI performance:

- Use a 0.01 μF cap on each cable power VBUS line to chassis GND close to the USB connector pin.
- Use a 0.01 μF cap on each cable ground line to chassis GND next to the USB connector pin.
- If voltage regulators are used, place a 0.01 μF cap on both input and output. This is to increase the immunity to ESD and reduce EMI. For other requirements, see the device-specific datasheet.

8.5.2.2.2.2 Analog, Digital, and PLL Partitioning

If separate power planes are used, they must be tied together at one point through a low-impedance bridge or preferably through a ferrite bead. Care must be taken to capacitively decouple each power rail close to the device. The analog ground, digital ground, and PLL ground must be tied together to the low-impedance circuit board ground plane.

8.5.2.2.2.3 Board Stackup

Because of the high frequencies associated with the USB, a printed circuit board with at least four layers is recommended; two signal layers separated by a ground and power layer as shown in Figure 8-22.

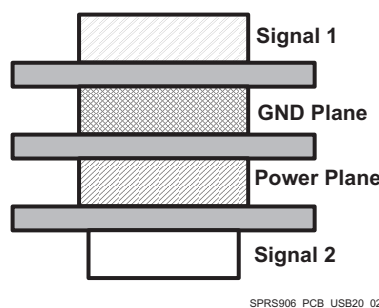


Figure 8-22. Four-Layer Board Stack-Up

The majority of signal traces should run on a single layer, preferably SIGNAL1. Immediately next to this layer should be the GND plane, which is solid with no cuts. Avoid running signal traces across a split in the ground or power plane. When running across split planes is unavoidable, sufficient decoupling must be used. Minimizing the number of signal vias reduces EMI by reducing inductance at high frequencies.

8.5.2.2.2.4 Cable Connector Socket

Short the cable connector sockets directly to a small chassis ground plane (GND *strap*) that exists immediately underneath the connector sockets. This shorts EMI (and ESD) directly to the chassis ground before it gets onto the USB cable. This etch plane should be as large as possible, but all the conductors coming off connector pins 1 through 6 must have the board signal GND plane run under. If needed, scoop out the chassis GND strap etch to allow for the signal ground to extend under the connector pins. Note that the etches coming from pins 1 and 4 (VBUS power and GND) should be wide and via-ed to their respective planes as soon as possible, respecting the filtering that may be in place between the connector pin and the plane. See [Figure 8-23](#) for a schematic example.

Place a ferrite in series with the cable shield pins near the USB connector socket to keep EMI from getting onto the cable shield. The ferrite bead between the cable shield and ground may be valued between 10 Ω and 50 Ω at 100 MHz; it should be resistive to approximately 1 GHz. To keep EMI from getting onto the cable bus power wire (a very large antenna) a ferrite may be placed in series with cable bus power, VBUS, near the USB connector pin 1. The ferrite bead between connector pin 1 and bus power may be valued between 47 Ω and approximately 1000 Ω at 100 MHz. It should continue being resistive out to approximately 1 GHz, as shown in [Figure 8-23](#).

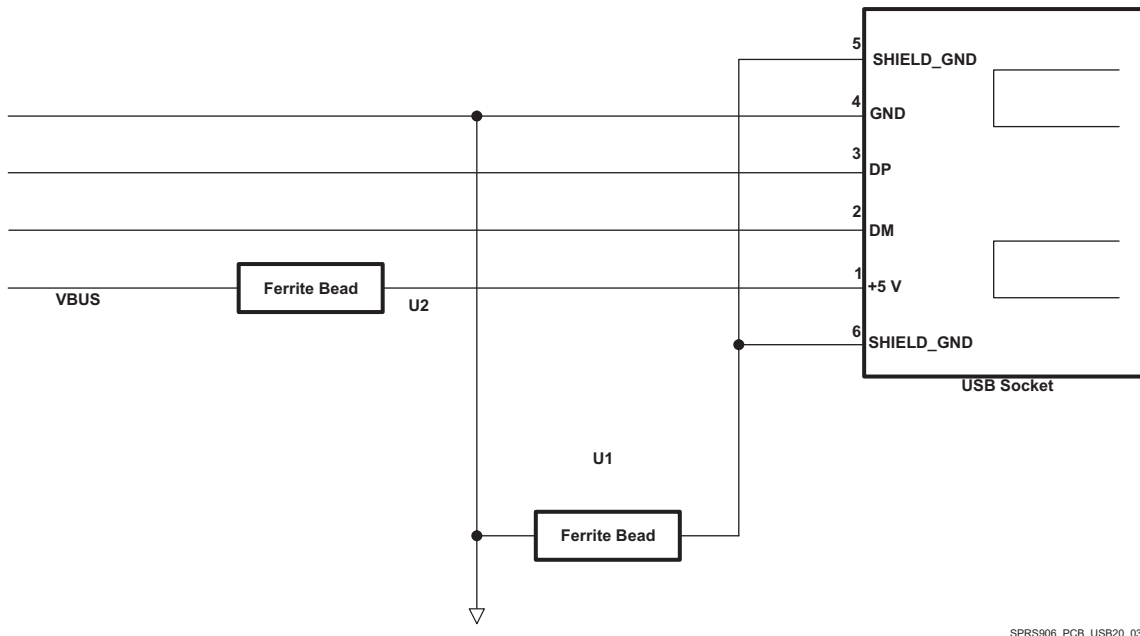
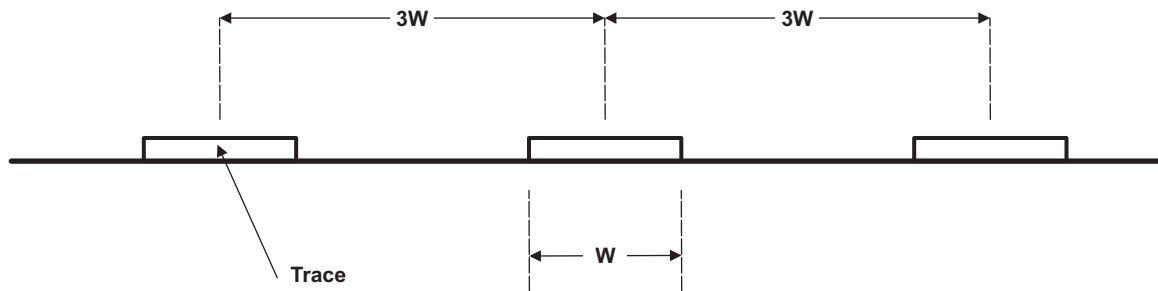


Figure 8-23. USB Connector

8.5.2.2.2.5 Clock Routings

To address the system clock emissions between devices, place a ~10 to 130 Ω resistor in series with the clock signal. Use a trial and error method of looking at the shape of the clock waveform on a high speed oscilloscope and of tuning the value of the resistance to minimize waveform distortion. The value on this resistor should be as small as possible to get the desired effect. Place the resistor close to the device generating the clock signal. If an external crystal is used, follow the guidelines detailed in the [Selection and Specification of Crystals for Texas Instruments USB 2.0 Devices](#).

When routing the clock traces from one device to another, try to use the 3W spacing rule. The distance from the center of the clock trace to the center of any adjacent signal trace should be at least three times the width of the clock trace. Many clocks, including slow frequency clocks, can have fast rise and fall times. Using the 3W rule cuts down on crosstalk between traces. In general, leave space between each of the traces running parallel between the devices. Avoid using right angles when routing traces to minimize the routing distance and impedance discontinuities. For further protection from crosstalk, run guard traces beside the clock signals (GND pin to GND pin), if possible. This lessens clock signal coupling, as shown in Figure 8-24.



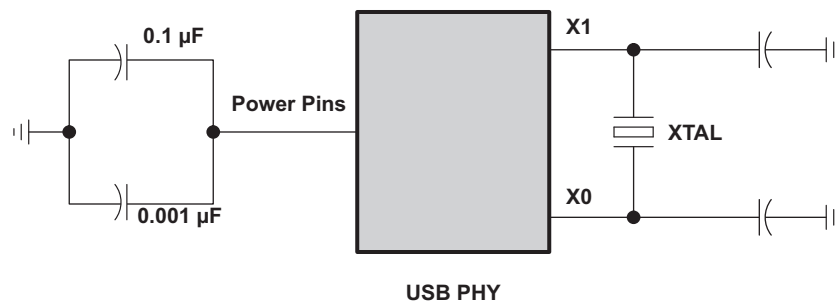
SPRS906_PCB_USB20_04

Figure 8-24. 3W Spacing Rule

8.5.2.2.2.6 Crystals/Oscillator

Keep the crystal and its load capacitors close to the USB PHY pins, X1 and X0 (see Figure 8-25). Note that frequencies from power sources or large capacitors can cause modulations within the clock and should not be placed near the crystal. In these instances, errors such as dropped packets occur. A placeholder for a resistor, in parallel with the crystal, can be incorporated in the design to assist oscillator startup.

Power is proportional to the current squared. The current is $I = C \cdot dv/dt$, because dv/dt is a function of the PHY, current is proportional to the capacitive load. Cutting the load to 1/2 decreases the current by 1/2 and the power to 1/4 of the original value. For more details on crystal selection, see the [Selection and Specification of Crystals for Texas Instruments USB 2.0 Devices](#).



SPRS906_PCB_USB20_05

Figure 8-25. Power Supply and Clock Connection to the USB PHY

8.5.2.2.2.7 DP/DM Trace

Place the USB PHY as close as possible to the USB 2.0 connector. The signal swing during high speed operation on the DP/DM lines is relatively small ($400 \text{ mV} \pm 10\%$), so any differential noise picked up on the twisted pair can affect the received signal. When the DP/DM traces do not have any shielding, the traces tend to behave like an antenna and picks up noise generated by the surrounding components in the environment. To minimize the effect of this behavior:

- DP/DM traces should always be matched lengths and must be no more than 4 inches in length; otherwise, the eye opening may be degraded (see Figure 8-26).

- Route DP/DM traces close together for noise rejection on differential signals, parallel to each other and within two mils in length of each other. The measurement for trace length must be started from device's balls.
- A high speed USB connection is made through a shielded, twisted pair cable with a differential characteristic impedance of $90 \Omega \pm 15\%$. In layout, the impedance of DP and DM should each be $45 \Omega \pm 10\%$.
- DP/DM traces should not have any extra components to maintain signal integrity. For example, traces cannot be routed to two USB connectors.

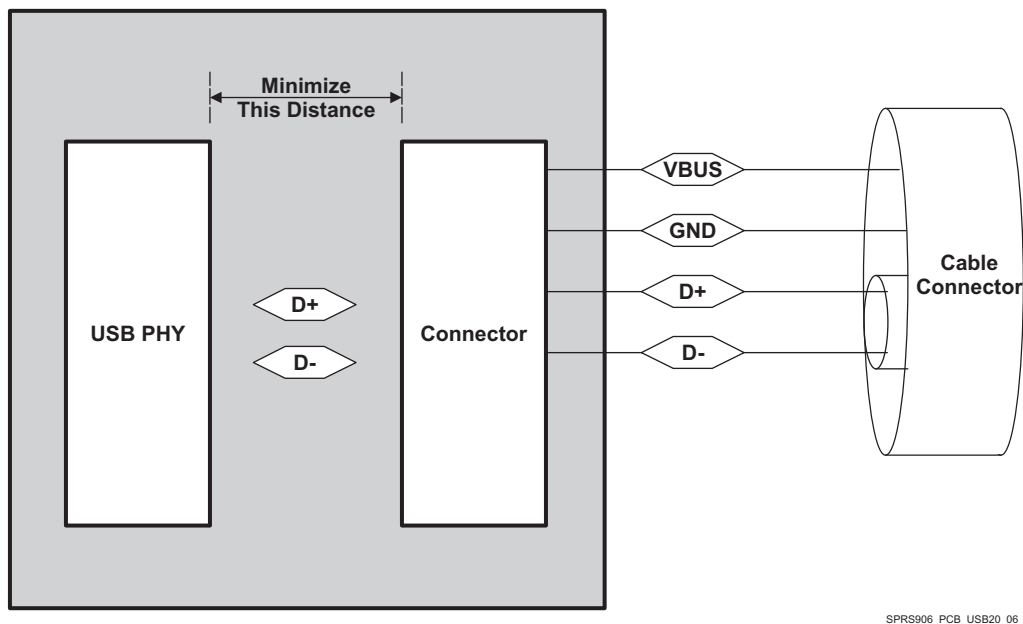


Figure 8-26. USB PHY Connector and Cable Connector

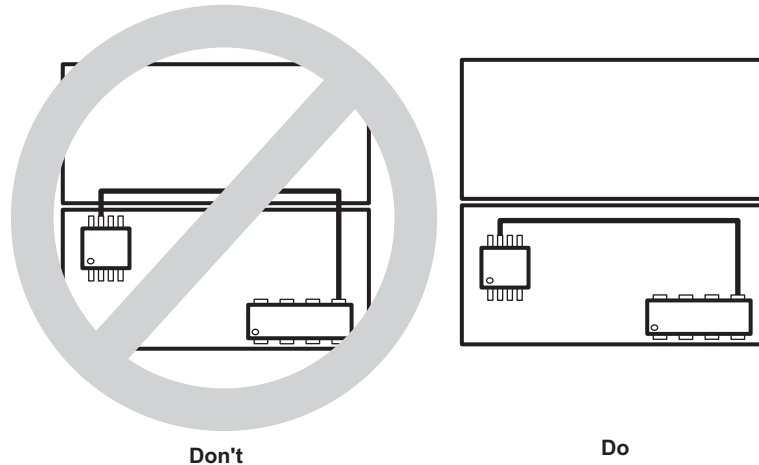
8.5.2.2.2.8 DP/DM Vias

When a via must be used, increase the clearance size around it to minimize its capacitance. Each via introduces discontinuities in the signal's transmission line and increases the chance of picking up interference from the other layers of the board. Be careful when designing test points on twisted pair lines; through-hole pins are not recommended.

8.5.2.2.2.9 Image Planes

An image plane is a layer of copper (voltage plane or ground plane), physically adjacent to a signal routing plane. Use of image planes provides a low impedance, shortest possible return path for RF currents. For a USB board, the best image plane is the ground plane because it can be used for both analog and digital circuits.

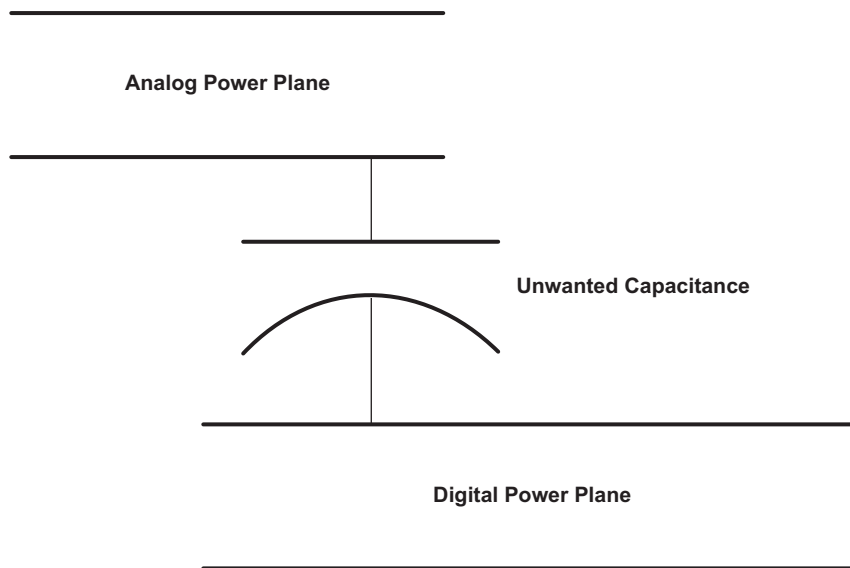
- Do not route traces so they cross from one plane to the other. This can cause a broken RF return path resulting in an EMI radiating loop as shown in [Figure 8-27](#). This is important for higher frequency or repetitive signals. Therefore, on a multi-layer board, it is best to run all clock signals on the signal plane above a solid ground plane.
- Avoid crossing the image power or ground plane boundaries with high speed clock signal traces immediately above or below the separated planes. This also holds true for the twisted pair signals (DP, DM). Any unused area of the top and bottom signal layers of the PCB can be filled with copper that is connected to the ground plane through vias.



SPRS906_PCB_USB20_07

Figure 8-27. Do Not Cross Plane Boundaries

- Do not overlap planes that do not reference each other. For example, do not overlap a digital power plane with an analog power plane as this produces a capacitance between the overlapping areas that could pass RF emissions from one plane to the other, as shown in [Figure 8-28](#).



SPRS906_PCB_USB20_08

Figure 8-28. Do Not Overlap Planes

- Avoid image plane violations. Traces that route over a slot in an image plane results in a possible RF return loop, as shown in [Figure 8-29](#).

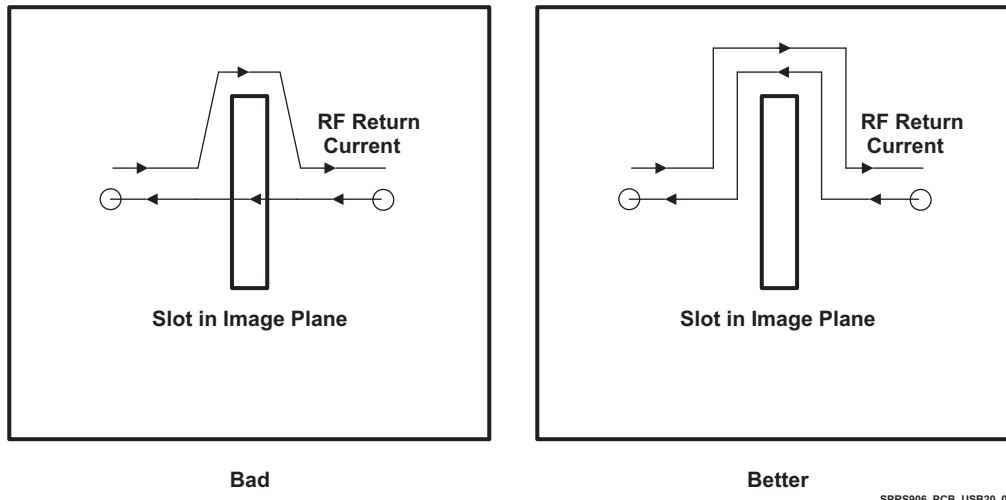


Figure 8-29. Do Not Violate Image Planes

8.5.2.2.2.10 Power Regulators

Switching power regulators are a source of noise and can cause noise coupling if placed close to sensitive areas on a circuit board. Therefore, the switching power regulator should be kept away from the DP/DM signals, the external clock crystal (or clock oscillator), and the USB PHY.

8.5.2.3 References

- [USB 2.0 Specification, Intel, 2000,](#)
- [High Speed USB Platform Design Guidelines, Intel, 2000,](#)
- [Selection and Specification of Crystals for Texas Instruments USB 2.0 Devices](#)

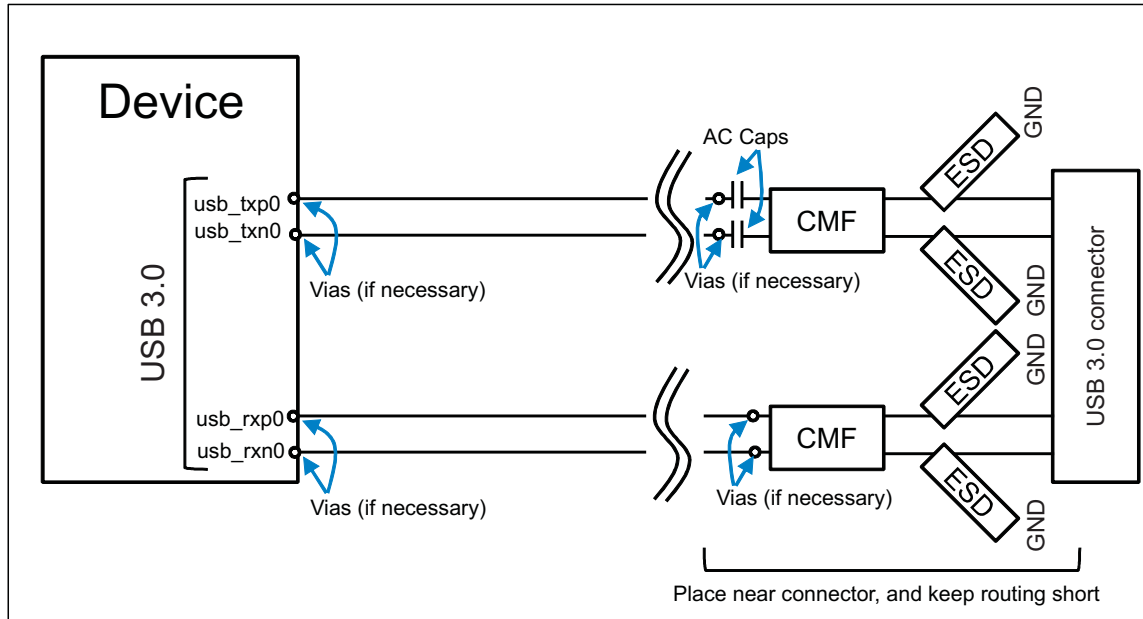
8.5.3 USB 3.0 Board Design and Layout Guidelines

This section provides the timing specification for the USB3.0 (USB1 in the device) 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. TI has performed the simulation and system design work to ensure the USB3.0 interface requirements are met. The design rules stated within this document are targeted at DEVICE mode electrical compliance. HOST mode and/or systems that do not include the 3m USB cable and far-end 11-inch PCB trace required by DEVICE mode compliance testing may not need the complete list of optimizations shown in this document; however, applying these optimizations to HOST mode systems will lead to optimal DEVICE mode performance.

8.5.3.1 USB 3.0 interface introduction

The USB 3.0 has two unidirectional differential pairs: TXp/TXn pair and RXp/RXn pair. AC coupling caps are needed on the board for TX traces.

[Figure 8-30](#) present high level schematic diagram for USB 3.0 interface.



SPRS85x_PCB_USB30_1

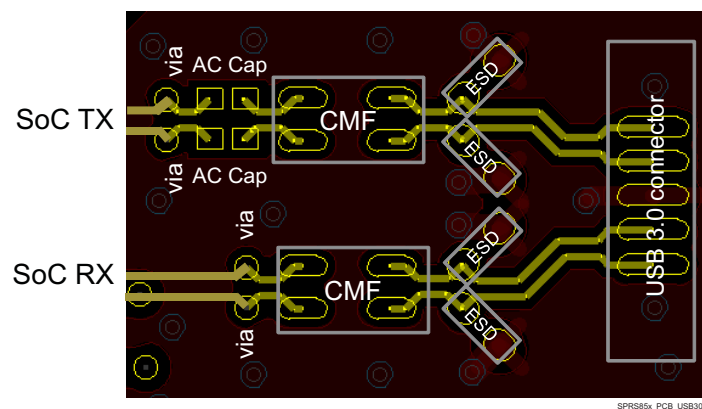
Figure 8-30. USB 3.0 Interface High Level Schematic

NOTE

ESD components should be on a PCB layer next to a system GND plane layer so the inductance of the via to GND will be minimal.

If vias are used, place the vias near the AC Caps or CMFs and under the SoC BGA, if necessary.

Figure 8-31 present placement diagram for USB 3.0 interface.



SPRS85x_PCB_USB30_2

Figure 8-31. USB 3.0 placement diagram

Table 8-9. USB1 Component Reference

| INTERFACE | COMPONENT | SUPPLIER | PART NUMBER |
|-----------|-----------|----------|----------------------------|
| USB3 PHY | ESD | TI | TPD1E05U06 |
| | CMF | Murata | DLW21SN900HQ2 |
| | C | - | 100nF (typical size: 0201) |

8.5.3.2 USB 3.0 General routing rules

Some general routing guidelines regarding USB 3.0:

- Avoid crossing splits reference plane(s).
- Shorter trace length is preferred.
- Minimize the via usage and layer transition
- Keep large spacing between TX and RX pairs.
- Intra-lane delay mismatch between DP and DM less than 1ps. Same for RXp and RXn.
- Distance between common mode filter (CMF) and ESD protection device should be as short as possible
- Distance between ESD protection device and USB connector should be as short as possible.
- Distance between AC capacitors (TX only) and CMF should be as short as possible.
- USB 3.0 signals should always be routed over an adjacent ground plane.

Table 8-10 and Table 8-11 present routing specification and recommendations for USB1 in the device.

Table 8-10. USB1 Routing Specifications

| PARAMETER | MIN | TYP | MAX | UNIT |
|---|------|------|------|----------|
| Device balls to USB 3.0 connector trace length | | | 3500 | Mils |
| Skew within a differential pair | | 3 | 6 | Mils |
| Number of stubs allowed on TX/RX traces | | | 0 | Stubs |
| TX/RX pair differential impedance | 83.7 | 90 | 96.3 | Ω |
| Number of vias on each TX/RX trace | | | 2 | Vias |
| Differential pair to any other trace spacing | 2xDS | 3xDS | | |
| Number of ground plane cuts allowed within USB3 routing region (except for specific ground carving as explained in this document) | | | 0 | Cuts |
| Number of layers between USB3.0 routing region and reference ground plane | | | 0 | Layers |
| PCB trace width | | 6 | | Mils |
| PCB BGA escape via pad size | | 18 | | Mils |
| PCB BGA escape via hole size | | 10 | | Mils |

1. Vias must be used in pairs and spaced equally along a signal path.
2. DS = differential spacing of the traces.
3. Exceptions may be necessary in the SoC package BGA area.
4. GND guard-bands on the same layer may be closer, but should not be allowed to affect the impedance of the differential pair routing. GND guard-bands to isolate USB3.0 differential pairs from all other signals are recommended.

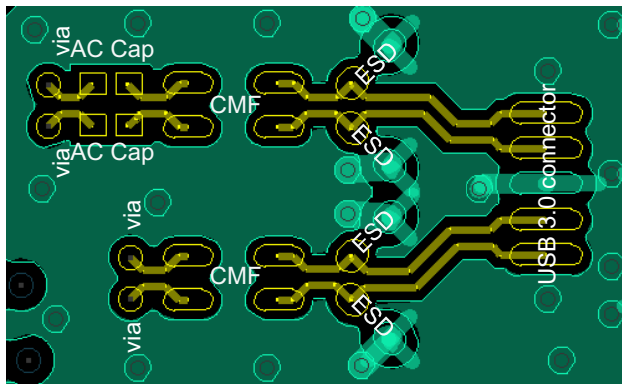
Table 8-11. USB1 Routing Recommendations

| Item | Description | Reason |
|-----------------|--|--|
| ESD location | Place ESD component on same layer as connector (no via or stub to ESD component) | Eliminate reflection loss from via & stub to ESD |
| ESD part number | TPD1E05U06 | Minimize capacitance (0.42pF) |
| CMF part number | DLW21SN900HQ2 | Manufacturer's recommended device |
| Connector | Use USB3.0 connector with supporting s-parameter model | Enable full signal chain simulation |
| Carve Ground | Carve GND underneath AC Caps, ESD, CMF, and connector | Minimize capacitance under ESD and CMF |

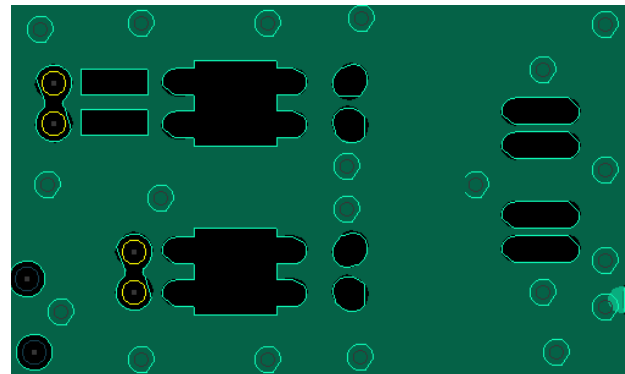
Table 8-11. USB1 Routing Recommendations (continued)

| Item | Description | Reason |
|------------|---|---|
| Round pads | Minimize pad size and round the corners of the pads for the ESD and CMF components | Minimize capacitance |
| Vias | Max 2 vias per signal trace. If vias are required, place vias close to the AC Caps and CMFs. Vias under the SoC grid array may be used if necessary to route signals away from BGA pattern. | Vias significantly degrade signal integrity at 2.5GHz |

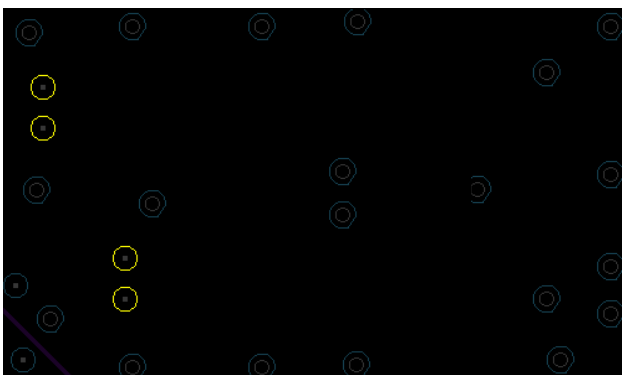
Figure 8-32 presents an example layout, demonstrating the “carve GND” concept.



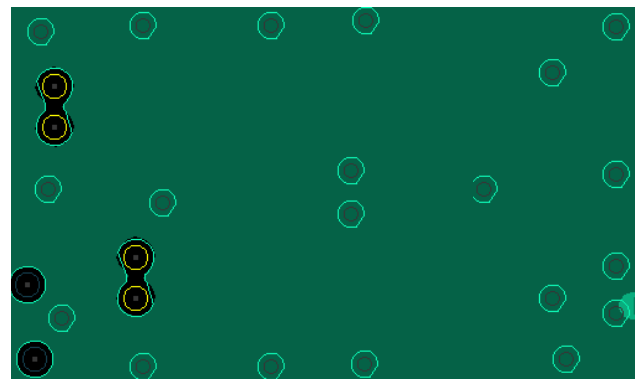
Top Layer: Routing from SoC through AC Caps, CMF, and ESD to connector.



Layer2, GND: Gaps carved in GND underneath AC Caps, CMF, ESD, and connector.



Layer3, Signal: Implement as keep-out zone underneath carved GND areas.



Layer4, GND Plane underneath AC Caps, CMF, ESD, and connector.

SPRS85x_PCB_USB30_3

Figure 8-32. USB 3.0 Example “carve GND” layout

8.5.4 HDMI Board Design and Layout Guidelines

This section provides the timing specification for the HDMI 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. TI has performed the simulation and system design work to ensure the HDMI interface requirements are met. The design rules stated within this document are targeted at resolutions less than or equal to 1080p60 with 8-bit color; deep color (10-bit) requires further signal integrity optimization.

8.5.4.1 HDMI Interface Schematic

The HDMI bus is separated into three main sections (HDMI Ethernet and the optional Audio Return Channel are not specifically supported by this Device):

1. Transition Minimized Differential Signaling (TMDS) high speed digital video interface
2. Display Data Channel (I2C bus for configuration and status exchange between two devices)
3. Consumer Electronics Control (optional) for remote control of connected devices.

The DDC and CEC are low speed interfaces, so nothing special is required for PCB layout of these signals.

The TMDS channels are high speed differential pairs and therefore require the most care in layout. Specifications for TMDS layout are below.

Figure 8-33 shows the HDMI interface schematic.

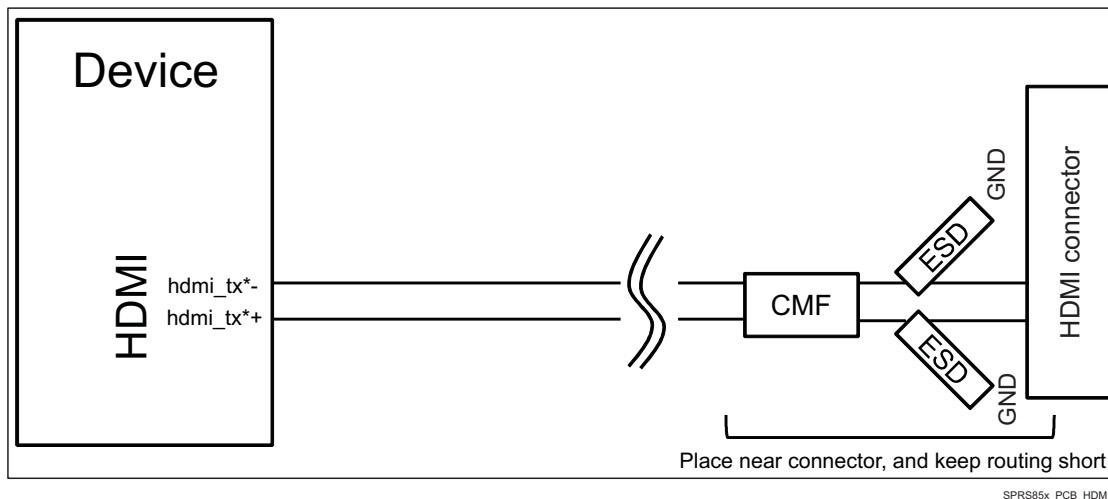


Figure 8-33. HDMI Interface High Level Schematic

Figure 8-34 presents placement diagram for HDMI interface.

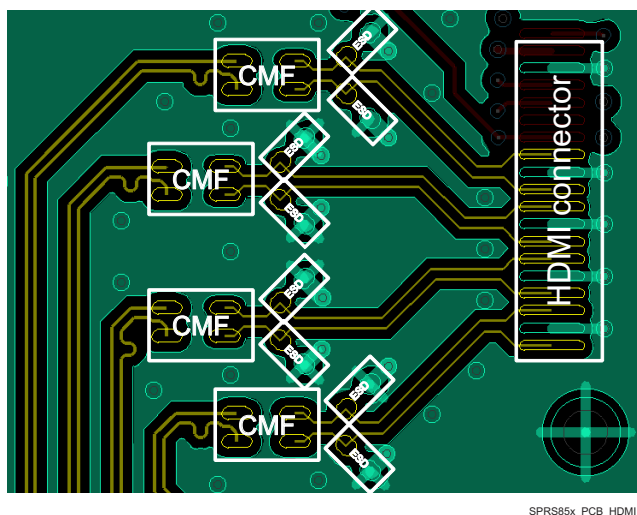


Figure 8-34. HDMI Placement Diagram

Table 8-12. HDMI Component Reference

| INTERFACE | DEVICE | SUPPLIER | PART NUMBER |
|-----------|--------|----------|---------------|
| HDMI | ESD | TI | TPD1E05U06 |
| | CMF | Murata | DLW21SN900HQ2 |

8.5.4.2 TMDS General Routing Guidelines

The TMDS signals are high speed differential pairs. Care must be taken in the PCB layout of these signals to ensure good signal integrity.

The TMDS differential signal traces must be routed to achieve 100 Ohms (+/- 10%) differential impedance and 60 ohms (+/-10%) single ended impedance. Single ended impedance control is required because differential signals can't be closely coupled on PCBs and therefore single ended impedance becomes important.

These impedances are impacted by trace width, trace spacing, distance to reference planes, and dielectric material. Verify with a PCB design tool that the trace geometry for both data signal pairs results in as close to 60 ohms impedance traces as possible. For best accuracy, work with your PCB fabricator to ensure this impedance is met.

In general, closely coupled differential signal traces are not an advantage on PCBs. When differential signals are closely coupled, tight spacing and width control is necessary. Very small width and spacing variations affect impedance dramatically, so tight impedance control can be more problematic to maintain in production.

Loosely coupled PCB differential signals make impedance control much easier. Wider traces and spacing make obstacle avoidance easier, and trace width variations don't affect impedance as much, therefore it's easier to maintain accurate impedance over the length of the signal. The wider traces also show reduced skin effect and therefore often result in better signal integrity.

Some general routing guidelines regarding TMDS:

- Avoid crossing splits reference plane(s).
- Shorter trace length is preferred.
- Distance between common mode filter (CMF) and ESD protection device should be as short as possible
- Distance between ESD protection device and HDMI connector should be as short as possible.

Table 8-13 shows the routing specifications for the TMDS signals.

Table 8-13. TMDS Routing Specifications

| PARAMETER | MIN | TYP | MAX | UNIT |
|---|------|------|------|--------|
| Device balls to HDMI header trace length | | | 4000 | Mils |
| Skew within a differential pair | | 3 | 5 | Mils |
| Number of stubs allowed on TMDS traces | | | 0 | stubs |
| TMDS pair differential impedance | 90 | 100 | 110 | Ω |
| TMDS single-ended impedance | 54 | 60 | 66 | Ω |
| Number of vias on each TMDS trace | | | 0 | Vias |
| TMDS differential pair to any other trace spacing ^{(1) (2) (3)} | 2xDS | 3xDS | | Mils |
| Number of ground plane cuts allowed within HDMI routing region (except for specific ground carving as explained in this document) | | | 0 | Cuts |
| Number of layers between HDMI routing region and reference ground plane | | | 0 | Layers |
| PCB trace width | | 4.4 | | Mils |

(1) DS = differential spacing of the traces.

(2) Exceptions may be necessary in the SoC package BGA area.

(3) GND guard-bands may be closer, but should not be allowed to affect the impedance of the differential pair routing. GND guard-bands to isolate HDMI differential pairs from all other signals is recommended.

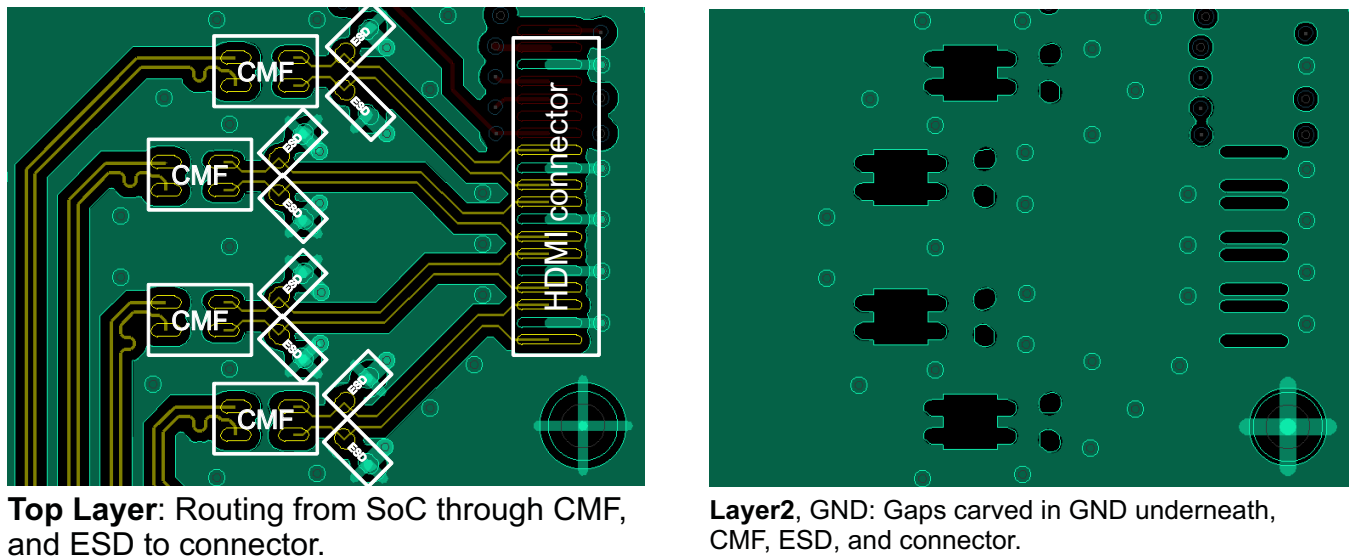
Table 8-14. TDMS Routing Recommendations

| Item | Description | Reason |
|-----------------|-------------|-------------------------------|
| ESD part number | TPD1E05U06 | Minimize capacitance (0.42pF) |

Table 8-14. TDMS Routing Recommendations (continued)

| Item | Description | Reason |
|---------------|--|--|
| Carve Ground | Carve GND underneath ESD and CMF | Minimize capacitance under ESD and CMF |
| Round pads | Reduce pad size and round the corners of the pads for the ESD and CMF components | Minimize capacitance |
| Routing layer | Route all signals only on the same layer as SoC | Minimize reflection loss |

Figure 8-35 presents an example layout, demonstrating the “carve GND” concept.



SPRS95x_PCB_HDMI_3

Figure 8-35. HDMI Example “carve GND” layout

8.5.4.3 TPD5S115

The TPD5S115 is an integrated HDMI companion chip solution. The device provides a regulated 5 V output (5VOUT) for sourcing the HDMI power line. The TPD5S115 exceeds the IEC61000-4-2 (Level 4) ESD protection level.

8.5.4.4 HDMI ESD Protection Device (Required)

Interfaces that connect to a cable such as HDMI generally require more ESD protection than can be built into the processor’s outputs. Therefore this HDMI interface requires the use of an ESD protection chip to provide adequate ESD.

When selecting an ESD protection chip, choose the lowest capacitance ESD protection available to minimize signal degradation. In no case should be ESD protection circuit capacitance be more than 5pF.

TI manufactures these devices that provide ESD protection for HDMI signals such as the TPDxE05U06. For more information see the ti.com website.

8.5.4.5 PCB Stackup Specifications

Table 8-15 shows the stackup and feature sizes required for HDMI.

Table 8-15. HDMI PCB Stackup Specifications

| PARAMETER | MIN | TYP | MAX | UNIT |
|--------------------------|-----|-----|-----|--------|
| PCB Routing/Plane Layers | 4 | 6 | - | Layers |

Table 8-15. HDMI PCB Stackup Specifications (continued)

| PARAMETER | MIN | TYP | MAX | UNIT |
|---|-----|-----|-----|--------|
| Signal Routing Layers | 2 | 3 | - | Layers |
| Number of ground plane cuts allowed within HDMI routing region | - | - | 0 | Cuts |
| Number of layers between HDMI routing region and reference ground plane | - | - | 0 | Layers |
| PCB Trace width | | 4 | | Mils |

8.5.4.6 Grounding

Each TMDS channel has its own shield pin and they should be grounded to provide a return current path for the TMDS signal.

8.5.5 SATA Board Design and Layout Guidelines

The device provides one SATA port. This section provides the timing specification for the SATA 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. TI has performed the simulation and system design work to ensure the SATA interface requirements are met.

8.5.5.1 SATA Interface Schematic

Figure 8-36 shows the data portion of the SATA interface schematic.

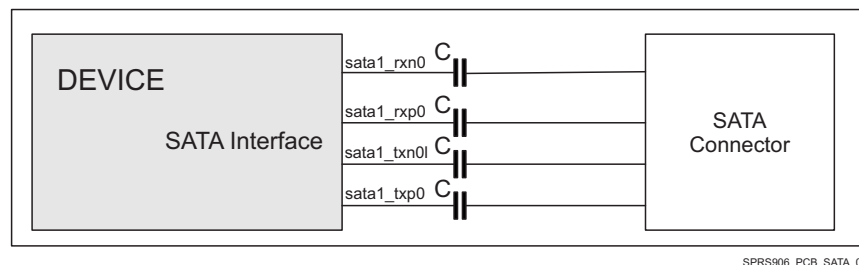


Figure 8-36. SATA Interface High Level Schematic

NOTE

AC coupling capacitors (C) are required on the receive and transmit data pairs. Table 8-16 shows the requirements for these capacitors.

Table 8-16. SATA AC Coupling Capacitors Requirements

| PARAMETER | MIN | TYP | MAX | UNIT |
|---|-----|------|------|-----------------------|
| SATA AC coupling capacitor value | 0.3 | 10 | 12 | nF |
| SATA AC coupling capacitor package size | | 0402 | 0603 | EIA ⁽¹⁾⁽²⁾ |

(1) EIA LxW units, that is, a 0402 is a 40x20 mils surface mount capacitor.

(2) The physical size of the capacitor should be as small as practical. Use the same size on both lines in each pair placed side by side.

8.5.5.2 Compatible SATA Components and Modes

Table 8-17 shows the compatible SATA components and supported modes. Note that the only supported configuration is an internal cable from the processor host to the SATA device.

Table 8-17. Compatible SATA Components and Modes

| PARAMETER | MIN | MAX | UNIT | SUPPORTED |
|----------------|-----|-----|------|-----------|
| Transfer Rates | 1.5 | 3 | Gbps | |

Table 8-17. Compatible SATA Components and Modes (continued)

| PARAMETER | MIN | MAX | UNIT | SUPPORTED |
|----------------|-----|-----|------|-----------|
| Internal Cable | - | - | - | YES |

8.5.5.3 PCB Stackup Specifications

Table 8-18 shows the stackup and feature sizes required for these types of SATA connections.

Table 8-18. SATA PCB Stackup Specifications

| PARAMETER | MIN | TYP | MAX | UNIT |
|--|-----|-----|-----|--------|
| Number of ground plane cuts allowed within SATA routing region | - | - | 0 | Cuts |
| Number of layers between SATA routing area and reference plane | - | - | 0 | Layers |
| PCB Routing clearance | | 4 | | Mils |
| PCB Trace width | | 4 | | Mils |

8.5.5.4 Routing Specifications

The SATA data signal traces must be routed to achieve 100 Ohms (+/-10%) differential impedance and 60 ohms (+/-10%) single ended impedance. The signal ended impedance is required because differential signals can't be closely coupled on PCBs and therefore single ended impedance becomes important. 60 ohms is chosen for the single ended impedance to minimize problems caused by too low an impedance.

These impedances are impacted by trace width, trace spacing, distance to reference planes, and dielectric material. Verify with a PCB design tool that the trace geometry for both data signal pairs results in as close to 100 ohms differential and 60 ohms single ended impedance traces as possible. For best accuracy, work with your PCB fabricator to ensure this impedance is met.

Table 8-19 shows the routing specifications for the SATA data signals.

Table 8-19. SATA Routing Specifications

| PARAMETER | MIN | TYP | MAX | UNIT |
|---|---------------------|-----|---------------------|-------|
| SATA signal trace length (device balls to SATA connector) | | | 3050 ⁽¹⁾ | Mils |
| Differential pair trace skew matching | | | 5 | Mils |
| Number of stubs allowed on SATA traces ⁽²⁾ | | | 0 | stubs |
| TX/RX pair differential impedance | 90 | 100 | 110 | Ω |
| TX/RX single-ended impedance | 54 | 60 | 66 | Ω |
| Number of vias on each SATA trace | | | 0 | Vias |
| SATA differential pair to any other trace spacing | 2xDS ⁽³⁾ | | | |

(1) Beyond this, signal integrity may suffer.

(2) Inline pads may be used for probing.

(3) DS = differential spacing of the SATA traces.

Table 8-20. SATA Routing Recommendations

| Item | Description | Reason |
|-----------------|-------------|--|
| ESD part number | None | ESD suppression generally not used on SATA |

8.5.6 PCIe Board Design and Layout Guidelines

The PCIe interface on the device provides support for a 5.0 Gbps lane with polarity inversion.

8.5.6.1 PCIe Connections and Interface Compliance

The PCIe interface on the device is compliant with the PCIe revision 3.0 specification. Please refer to the PCIe specifications for all connections that are described in it. Those recommendations are more descriptive and exhaustive than what is possible here.

The use of PCIe compatible bridges and switches is allowed for interfacing with more than one other processor or PCIe device.

8.5.6.1.1 Coupling Capacitors

AC coupling capacitors are required on the transmit data pair. [Table 8-21](#) shows the requirements for these capacitors.

Table 8-21. PCIe AC Coupling Capacitors Requirements

| PARAMETER | MIN | TYP | MAX | UNIT |
|---|-----|------|------|-----------------------|
| PCIe AC coupling capacitor value | 90 | 100 | 110 | nF |
| PCIe AC coupling capacitor package size | | 0402 | 0603 | EIA ⁽¹⁾⁽²⁾ |

(1) EIA LxW units, that is, a 0402 is a 40x20 mils surface mount capacitor.

(2) The physical size of the capacitor should be as small as practical. Use the same size on both lines in each pair placed side by side.

8.5.6.1.2 Polarity Inversion

The PCIe specification requires polarity inversion support. This means for layout purposes, polarity is unimportant because each signal can change its polarity on die inside the chip. This means polarity within a lane is unimportant for layout.

8.5.6.2 Non-standard PCIe connections

The following sections contain suggestions for any PCIe connection that is NOT described in the official PCIe specification, such as an on-board Device to Device or Device to other PCIe compliant processor connection.

8.5.6.2.1 PCB Stackup Specifications

[Table 8-22](#) shows the stackup and feature sizes required for these types of PCIe connections.

Table 8-22. PCIe PCB Stackup Specifications

| PARAMETER | MIN | TYP | MAX | UNIT |
|---|-----|-----|-----|--------|
| Number of ground plane cuts allowed within PCIe routing region | - | - | 0 | Cuts |
| Number of layers between PCIe routing area and reference plane ⁽¹⁾ | - | - | 0 | Layers |
| PCB Routing clearance | | 4 | | Mils |
| PCB Trace width | | 4 | | Mils |

(1) A reference plane may be a ground plane or the power plane referencing the PCIe signals.

8.5.6.2.2 Routing Specifications

8.5.6.2.2.1 Impedance

The PCIe data signal traces must be routed to achieve 100-Ω (±10%) differential impedance and 60-Ω (±10%) single-ended impedance. The single-ended impedance is required because differential signals are extremely difficult to closely couple on PCBs and, therefore, single-ended impedance becomes important. These requirements are the same as those recommended in the PCIe Motherboard Checklist 1.0 document, available from PCI-SIG (www.pcisig.com).

These impedances are impacted by trace width, trace spacing, distance between signals and referencing planes, and dielectric material. Verify with a PCB design tool that the trace geometry for both data signal pairs result in as close to 100-Ω differential impedance and 60-Ω single-ended impedance as possible. For best accuracy, work with your PCB fabricator to ensure this impedance is met. See [Table 8-23](#) below.

8.5.6.2.2.2 Differential Coupling

In general, closely coupled differential signal traces are not an advantage on PCBs. When differential signals are closely coupled, tight spacing and width control is necessary. Very small width and spacing variations affect impedance dramatically, so tight impedance control can be more problematic to maintain in production. For PCBs with very tight space limitations (which are usually small) this can work, but for most PCBs, the loosely coupled option is probably best.

Loosely coupled PCB differential signals make impedance control much easier. Wider traces and spacing make obstacle avoidance easier (because each trace is not so fixed in position relative to the other), and trace width variations don't affect impedance as much, therefore it's easier to maintain an accurate impedance over the length of the signal. For longer routes, the wider traces also show reduced skin effect and therefore often result in better signal integrity with a larger eye diagram opening.

[Table 8-23](#) shows the routing specifications for the PCIe data signals.

Table 8-23. PCI-E Routing Specifications

| PARAMETER | MIN | TYP | MAX | UNIT |
|---|---------------------|-----|---------------------|-------|
| PCIe signal trace length (device balls to PCIe connector) | | | 4700 ⁽¹⁾ | Mils |
| Differential pair trace matching | | | 5 ⁽²⁾ | Mils |
| Number of stubs allowed on PCIe traces ⁽³⁾ | | | 0 | stubs |
| TX/RX pair differential impedance | 90 | 100 | 110 | Ω |
| TX/RX single-ended impedance | 54 | 60 | 66 | Ω |
| Pad size of vias on PCIe trace | | | 25 ⁽⁴⁾ | Mils |
| Hole size of vias on PCIe trace | | | 14 | Mils |
| Number of vias on each PCIe trace | | | 0 | Vias |
| PCIe differential pair to any other trace spacing | 2xDS ⁽⁵⁾ | | | |

(1) Beyond this, signal integrity may suffer.

(2) For example, RXP0 within 5 Mils of RXN0.

(3) Inline pads may be used for probing.

(4) 35-Mil antipad maximum recommended.

(5) DS = differential spacing of the PCIe traces.

Table 8-24. PCI-E Routing Recommendations

| Item | Description | Reason |
|-----------------|-------------|--|
| ESD part number | None | ESD suppression generally not used on PCIe |

8.5.6.2.2.3 Pair Length Matching

Each signal in the differential pair should be matched to within 5 mils of its matching differential signal. Length matching should be done as close to the mismatch as possible.

8.5.6.3 LJCB_REFN/P Connections

A Common Refclk Rx Architecture is required to be used for the device PCIe interface. Specifically, two modes of Common Refclk Rx Architecture are supported:

- **External REFCLK Mode:** An common external 100MHz clock source is distributed to both the Device and the link partner
- **Output REFCLK Mode:** A 100MHz HCSL clock source is output by the device and used by the link partner

In **External REFCLK Mode**, a high-quality, low-jitter, differential HCSL 100MHz clock source compliant to the PCIe REFCLK AC Specifications should be provided on the Device's ljcb_clkn / ljcb_clkp inputs. Alternatively, an LVDS clock source can be used with the following additional requirements:

- External AC coupling capacitors described in [Table 8-25](#) should be populated at the ljcb_clkn / ljcb_clkp inputs.
- All termination requirements (ex. parallel 100ohm termination) from the clock source manufacturer should be followed.

In **Output REFCLK Mode**, the 100MHz clock from the Device's DPLL_PCIE_REF should be output on the Device's ljcb_clkn / ljcb_clkp pins and used as the HCSL REFCLK by the link partner. External near-side termination to ground described in [Table 8-26](#) is required on both of the ljcb_clkn / ljcb_clkp outputs in this mode.

Table 8-25. LJCB_REFN/P Requirements in External LVDS REFCLK Mode

| PARAMETER | MIN | TYP | MAX | UNIT |
|--|-----|------|------|-----------------------|
| ljcb_clkn / ljcb_clkp AC coupling capacitor value | | 100 | | nF |
| ljcb_clkn / ljcb_clkp AC coupling capacitor package size | | 0402 | 0603 | EIA ⁽¹⁾⁽²⁾ |

(1) EIA LxW units, that is, a 0402 is a 40x20 mils surface mount capacitor.

(2) The physical size of the capacitor should be as small as practical. Use the same size on both lines in each pair placed side by side.

Table 8-26. LJCB_REFN/P Requirements in Output REFCLK Mode

| PARAMETER | MIN | TYP | MAX | UNIT |
|---|------|-----|------|------|
| ljcb_clkn / ljcb_clkp near-side termination to ground value | 47.5 | 50 | 52.5 | Ω |

8.5.7 CSI2 Board Design and Routing Guidelines

The MIPI D-PHY signals include the CSI2_0 and CSI2_1 camera serial interfaces to or from the Device.

For more information regarding the MIPI-PHY signals and corresponding balls, see [Table 4-7, CSI2 Signal Descriptions](#).

For more information, you can also see the MIPI D-PHY specification v1-01-00_r0-03 (specifically the Interconnect and Lane Configuration and Annex B Interconnect Design Guidelines chapters).

In the next section, the PCB guidelines of the following differential interfaces are presented:

- CSI2_0 and CSI2_1 MIPI CSI-2 at 1.5 Gbps

[Table 8-27](#) lists the MIPI D-PHY interface signals in the Device.

Table 8-27. MIPI D-PHY Interface Signals in the Device

| SIGNAL NAME | BOTTOM BALL | SIGNAL NAME | BOTTOM BALL |
|-------------|-------------|-------------|-------------|
| csi2_0_dx0 | AE1 | csi2_0_dy0 | AD2 |

Table 8-27. MIPI D-PHY Interface Signals in the Device (continued)

| SIGNAL NAME | BOTTOM BALL | SIGNAL NAME | BOTTOM BALL |
|-------------|-------------|-------------|-------------|
| csi2_0_dx1 | AF1 | csi2_0_dy1 | AE2 |
| csi2_0_dx2 | AF2 | csi2_0_dy2 | AF3 |
| csi2_0_dx3 | AH4 | csi2_0_dy3 | AG4 |
| csi2_0_dx4 | AH3 | csi2_0_dy4 | AG3 |
| csi2_1_dx0 | AG5 | csi2_1_dy0 | AH5 |
| csi2_1_dx1 | AG6 | csi2_1_dy1 | AH6 |
| csi2_1_dx2 | AH7 | csi2_1_dy2 | AG7 |

8.5.7.1 CSI2_0 and CSI2_1 MIPI CSI-2 (1.5 Gbps)

8.5.7.1.1 General Guidelines

The general guidelines for the PCB differential lines are:

- Differential trace impedance $Z_0 = 100 \Omega$ (minimum = 85Ω , maximum = 115Ω)
- Total conductor length from the Device package pins to the peripheral device package pins is 25 to 30 cm with common FR4 PCB and flex materials.

NOTE

Longer interconnect length can be supported at the expense of detailed simulations of the complete link including driver and receiver models.

The general rule of thumb for the space $S = 2 \times W$ is not designated (see [Figure 8-19, Guard Illustration](#)). It is because although the $S = 2 \times W$ rule is a good rule of thumb, it is not always the best solution. The electrical performance will be checked with the frequency-domain specification. Even though the designer does not follow the $S = 2 \times W$ rule, the differential lines are ok if the lines satisfy the frequency-domain specification.

Because the MIPI signals are used for low-power, single-ended signaling in addition to their high speed differential implementation, the pairs must be loosely coupled.

8.5.7.1.2 Length Mismatch Guidelines

8.5.7.1.2.1 CSI2_0 and CSI2_1 MIPI CSI-2 (1.5 Gbps)

The guidelines of the length mismatch for CSI-2 are presented in [Table 8-28](#).

Table 8-28. Length Mismatch Guidelines for CSI-2 (1.5 Gbps)

| PARAMETER | TYPICAL VALUE | UNIT |
|--------------------------------|---|------|
| Operating speed | 1500 | Mbps |
| UI (bit time) | 667 | ps |
| Intralane skew | Have to satisfy mode-conversion S parameters ⁽¹⁾ | |
| Interlane skew (UI / 50) | 13.34 | ps |
| PCB lane-to-lane skew (0.1 UI) | 66.7 | ps |

(1) sdc12, sdc21, sdc12, sdc21, sdc11, sdc11, sdc22, and sdc22

8.5.7.1.3 Frequency-domain Specification Guidelines

After the PCB design is finished, the S-parameters of the PCB differential lines will be extracted with a 3D Maxwell Equation Solver such as the high-frequency structure simulator (HFSS) or equivalent, and compared to the frequency-domain specification as defined in the section 7 of the MIPI Alliance Specification for D-PHY Version v1-01-00_r0-03.

If the PCB lines satisfy the frequency-domain specification, the design is finished. Otherwise, the design needs to be improved.

8.6 Clock Routing Guidelines

8.6.1 32-kHz Oscillator Routing

When designing the printed-circuit board:

- Keep the crystal as close as possible to the crystal pins X1 and X2.
- Keep the trace lengths short and small to reduce capacitor loading and prevent unwanted noise pickup.
- Place a guard ring around the crystal and tie the ring to ground to help isolate the crystal from unwanted noise pickup.
- Keep all signals out from beneath the crystal and the X1 and X2 pins to prevent noise coupling.
- Finally, an additional local ground plane on an adjacent PCB layer can be added under the crystal to shield it from unwanted pickup from traces on other layers of the board. This plane must be isolated from the regular PCB ground plane and tied to the GND pin of the RTC. The plane must not be any larger than the perimeter of the guard ring. Make sure that this ground plane does not contribute to significant capacitance (a few pF) between the signal line and ground on the connections that run from X1 and X2 to the crystal.

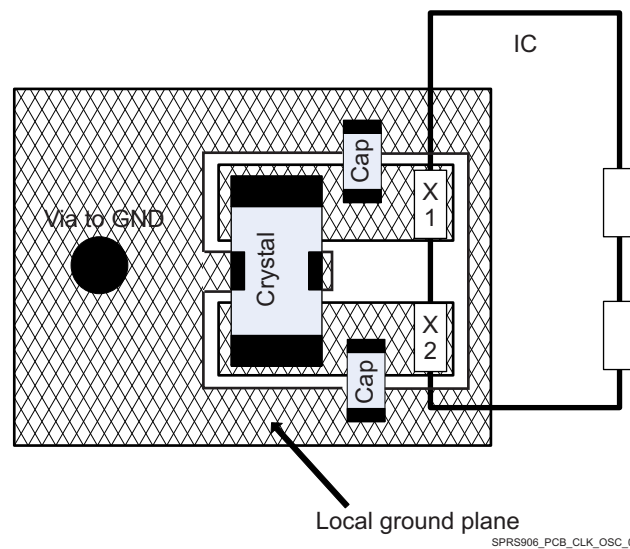


Figure 8-37. Slow Clock PCB Requirements

8.6.2 Oscillator Ground Connection

Although the impedance of a ground plane is low it is, of course, not zero. Therefore, any noise current in the ground plane causes a voltage drop in the ground. Figure 8-38 shows the grounding scheme for slow (low frequency) clock generated from the internal oscillator.

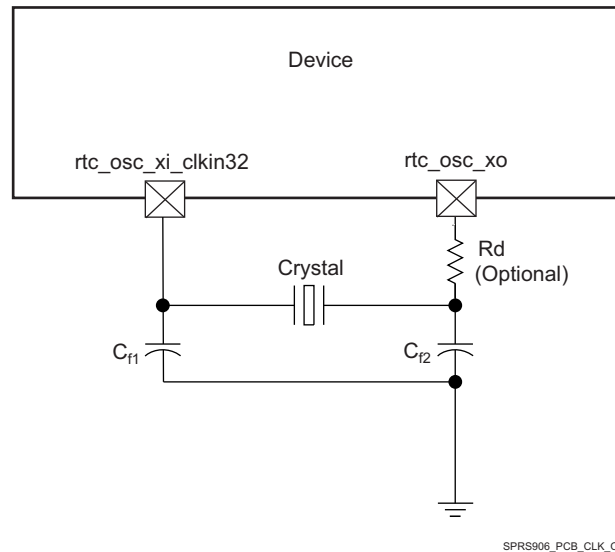
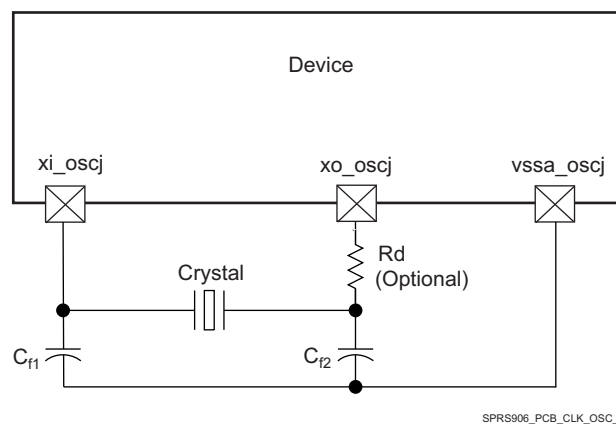


Figure 8-38. Grounding Scheme for Low-Frequency Clock

Figure 8-39 shows the grounding scheme for high-frequency clock.



(1) j in *_osc = 0 or 1

Figure 8-39. Grounding Scheme for High-Frequency Clock

8.7 DDR3 Board Design and Layout Guidelines

8.7.1 DDR3 General Board Layout Guidelines

To help ensure good signaling performance, consider the following board design guidelines:

- Avoid crossing splits in the power plane.
- Minimize Vref noise.
- Use the widest trace that is practical between decoupling capacitors and memory module.
- Maintain a single reference.
- Minimize ISI by keeping impedances matched.
- Minimize crosstalk by isolating sensitive bits, such as strobes, and avoiding return path discontinuities.
- Use proper low-pass filtering on the Vref pins.
- Keep the stub length as short as possible.
- Add additional spacing for on-clock and strobe nets to eliminate crosstalk.
- Maintain a common ground reference for all bypass and decoupling capacitors.

- Take into account the differences in propagation delays between microstrip and stripline nets when evaluating timing constraints.

8.7.2 DDR3 Board Design and Layout Guidelines

8.7.2.1 Board Designs

TI only supports board designs using DDR3 memory that follow the guidelines in this document. The switching characteristics and timing diagram for the DDR3 memory controller are shown in [Table 8-29](#) and [Figure 8-40](#).

Table 8-29. Switching Characteristics Over Recommended Operating Conditions for DDR3 Memory Controller

| NO. | PARAMETER | | MIN | MAX | UNIT |
|-----|-------------------|---------------------|-----|--------------------|------|
| 1 | $t_{c(DDR_CLK)}$ | Cycle time, DDR_CLK | 1.5 | 2.5 ⁽¹⁾ | ns |

(1) This is the absolute maximum the clock period can be. Actual maximum clock period may be limited by DDR3 speed grade and operating frequency (see the DDR3 memory device data sheet).

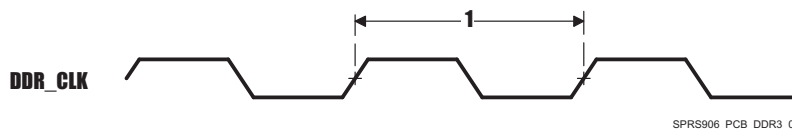


Figure 8-40. DDR3 Memory Controller Clock Timing

8.7.2.2 DDR3 EMIF

The processor contains one DDR3 EMIF.

8.7.2.3 DDR3 Device Combinations

Because there are several possible combinations of device counts and single- or dual-side mounting, [Table 8-30](#) summarizes the supported device configurations.

Table 8-30. Supported DDR3 Device Combinations

| NUMBER OF DDR3 DEVICES | DDR3 DATA DEVICE WIDTH (BITS) | MIRRORED? | DDR3 EMIF WIDTH (BITS) |
|------------------------|-------------------------------|---------------------|------------------------|
| 1 | 16 | N | 16 |
| 2 | 8 | Y ⁽¹⁾ | 16 |
| 2 | 16 | N | 32 |
| 2 | 16 | Y ⁽¹⁾ | 32 |
| 3 | 16 | N ⁽³⁾⁽⁴⁾ | 32 |
| 4 | 8 | N | 32 |
| 4 | 8 | Y ⁽²⁾ | 32 |
| 5 | 8 | N ⁽³⁾⁽⁴⁾ | 32 |

- (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.
- (2) This is two mirrored pairs of DDR3 devices.
- (3) Three or five DDR3 device combination is not available on this device, but combination types are retained for consistency with the DRA7xx family of devices.
- (4) The DDR memory connected to the DDR ECC bus does NOT need to be the same part number as the DDR memories connected to the DDR data bus. However, some constraints do apply. When selecting a memory for the DDR ECC bus, the following restrictions must be adhered to as compared to the DDR memories on the data bus:
 - Match the same DDR3 speed grade
 - Have an equal number of internal banks
 - Have an equal number of columns
 - Have a greater or equal number of rows

8.7.2.4 DDR3 Interface Schematic

8.7.2.4.1 32-Bit DDR3 Interface

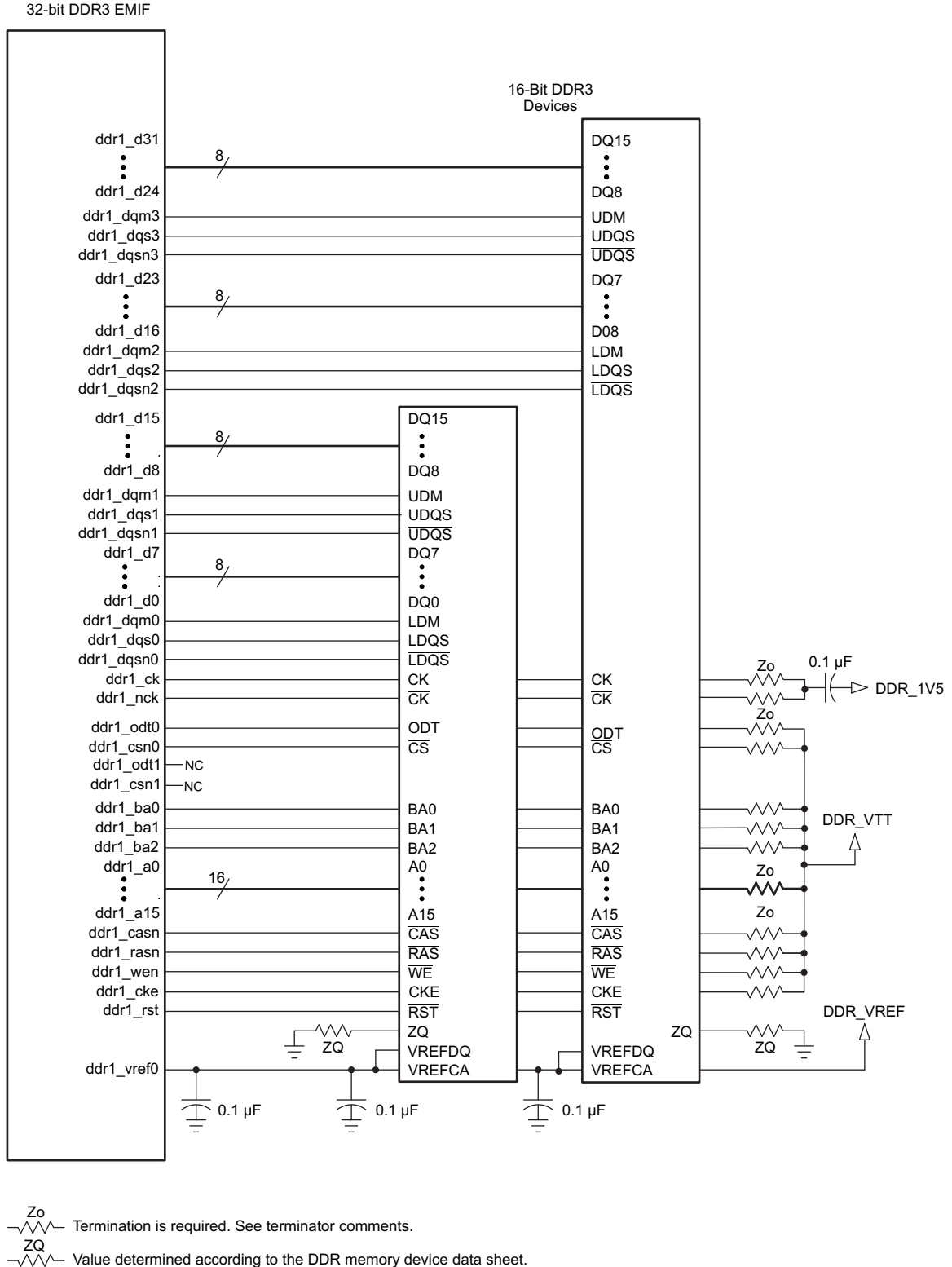
The DDR3 interface schematic varies, depending upon the width of the DDR3 devices used and the width of the bus used (16 or 32 bits). General connectivity is straightforward and very similar. 16-bit DDR devices look like two 8-bit devices. [Figure 8-41](#) and [Figure 8-42](#) show the schematic connections for 32-bit interfaces using x16 devices.

8.7.2.4.2 16-Bit DDR3 Interface

Note that the 16-bit wide interface schematic is practically identical to the 32-bit interface (see [Figure 8-41](#) and [Figure 8-42](#)); only the high-word DDR memories are removed and the unused DQS inputs are tied off.

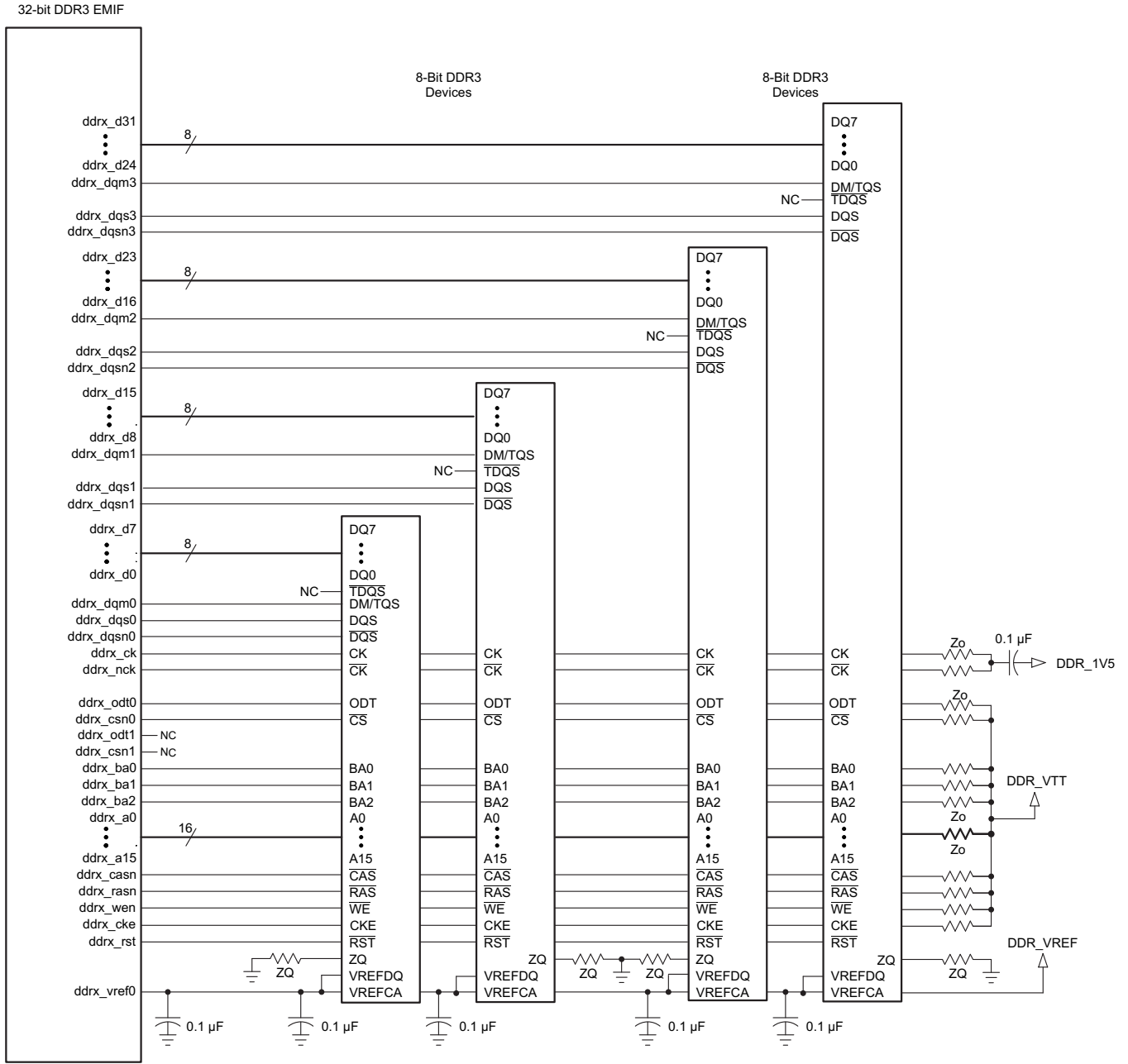
When not using all or part of a DDR interface, the proper method of handling the unused pins is to tie off the `ddrx_dqsi` pins to ground via a 1k- Ω resistor and to tie off the `ddrx_dqsn` pins to the corresponding `vdds_ddrx` supply via a 1k- Ω resistor. This needs to be done for each byte not used. Although these signals have internal pullups and pulldowns, external pullups and pulldowns provide additional protection against external electrical noise causing activity on the signals.

The `vdds_ddrx` and `ddrx_vref0` power supply pins need to be connected to their respective power supplies even if `ddrx` is not being used. All other DDR interface pins can be left unconnected. Note that the supported modes for use of the DDR EMIF are 32-bits wide, 16-bits wide, or not used.



SPRS906_PCB_DDR3_02

Figure 8-41. 32-Bit, One-Bank DDR3 Interface Schematic Using Two 16-Bit DDR3 Devices



Z_0 Termination is required. See terminator comments.
 Z_Q Value determined according to the DDR memory device data sheet.

SPRS906_PCB_DDR3_03

Figure 8-42. 32-Bit, One-Bank DDR3 Interface Schematic Using Four 8-Bit DDR3 Devices

8.7.2.5 Compatible JEDEC DDR3 Devices

Table 8-31 shows the parameters of the JEDEC DDR3 devices that are compatible with this interface. Generally, the DDR3 interface is compatible with DDR3-1333 devices in the x8 or x16 widths.

Table 8-31. Compatible JEDEC DDR3 Devices (Per Interface)

| N O. | PARAMETER | CONDITION | MIN | MAX | UNIT |
|------|--|----------------------------------|-----------|-----------|---------|
| 1 | JEDEC DDR3 device speed grade ⁽¹⁾ | DDR clock rate = 400MHz | DDR3-800 | DDR3-1600 | |
| | | 400MHz < DDR clock rate ≤ 533MHz | DDR3-1066 | DDR3-1600 | |
| | | 533MHz < DDR clock rate ≤ 667MHz | DDR3-1333 | DDR3-1600 | |
| 2 | JEDEC DDR3 device bit width | | x8 | x16 | Bits |
| 3 | JEDEC DDR3 device count ⁽²⁾ | | 2 | 4 | Devices |

(1) Refer to Table 8-29 Switching Characteristics Over Recommended Operating Conditions for DDR3 Memory Controller for the range of supported DDR clock rates.

(2) For valid DDR3 device configurations and device counts, see Section 8.7.2.4, Figure 8-41, and Figure 8-42.

8.7.2.6 PCB Stackup

The minimum stackup for routing the DDR3 interface is a six-layer stack up as shown in Table 8-32. Additional layers may be added to the PCB stackup to accommodate other circuitry, enhance SI/EMI performance, or to reduce the size of the PCB footprint. Complete stackup specifications are provided in Table 8-33.

Table 8-32. Six-Layer PCB Stackup Suggestion

| LAYER | TYPE | DESCRIPTION |
|-------|--------|---------------------------------------|
| 1 | Signal | Top routing mostly vertical |
| 2 | Plane | Ground |
| 3 | Plane | Split power plane |
| 4 | Plane | Split power plane or Internal routing |
| 5 | Plane | Ground |
| 6 | Signal | Bottom routing mostly horizontal |

Table 8-33. PCB Stackup Specifications

| NO. | PARAMETER | MIN | TYP | MAX | UNIT |
|------|---|-----|-----|-----|------|
| PS1 | PCB routing/plane layers | 6 | | | |
| PS2 | Signal routing layers | 3 | | | |
| PS3 | Full ground reference layers under DDR3 routing region ⁽¹⁾ | 1 | | | |
| PS4 | Full 1.5-V power reference layers under the DDR3 routing region ⁽¹⁾ | 1 | | | |
| PS5 | Number of reference plane cuts allowed within DDR routing region ⁽²⁾ | | | 0 | |
| PS6 | Number of layers between DDR3 routing layer and reference plane ⁽³⁾ | | | 0 | |
| PS7 | PCB routing feature size | | 4 | | Mils |
| PS8 | PCB trace width, w | | 4 | | Mils |
| PS9 | Single-ended impedance, Z ₀ | 50 | | 75 | Ω |
| PS10 | Impedance control ⁽⁵⁾ | Z-5 | Z | Z+5 | Ω |

- (1) 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.
- (2) No traces should cross reference plane cuts within the DDR routing region. High Speed signal traces crossing reference plane cuts create large return current paths which can lead to excessive crosstalk and EMI radiation.
- (3) Reference planes are to be directly adjacent to the signal plane to minimize the size of the return current loop.
- (4) 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.
- (5) Z is the nominal singled-ended impedance selected for the PCB specified by PS9.

8.7.2.7 Placement

Figure 8-43 shows the required placement for the processor as well as the DDR3 devices. The dimensions for this figure are defined in Table 8-34. 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 a 16-bit DDR memory system, the high-word DDR3 devices are omitted from the placement.

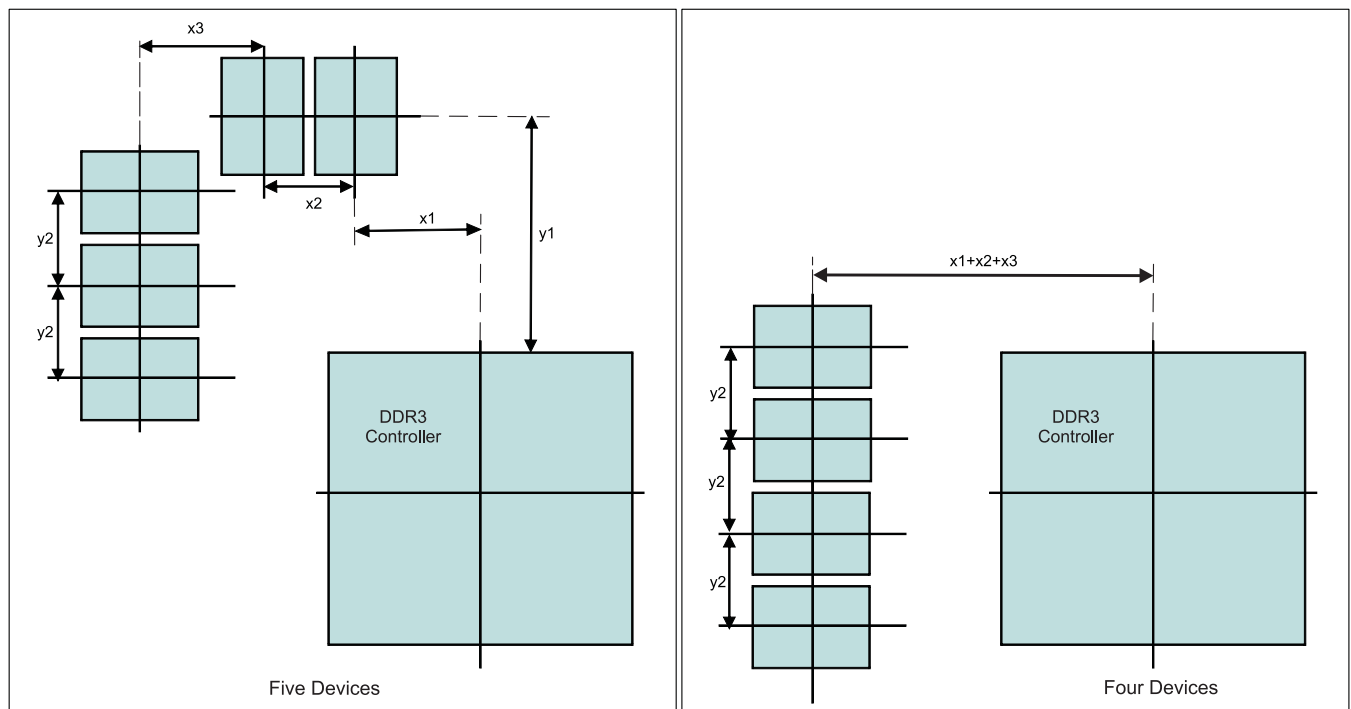


Figure 8-43. Placement Specifications

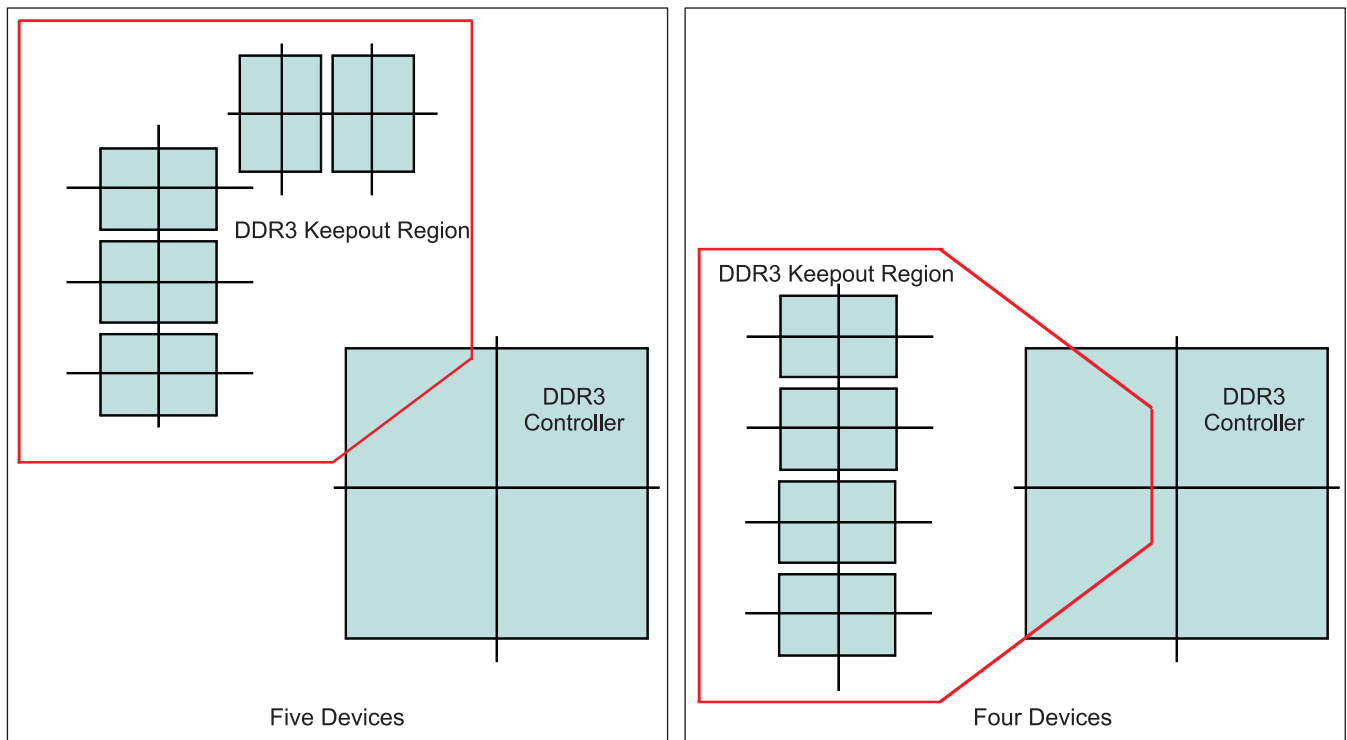
Table 8-34. Placement Specifications DDR3

| NO. | PARAMETER | MIN | MAX | UNIT |
|-------|--|-----|------|------|
| KOD31 | X1 | | 500 | Mils |
| KOD32 | X2 | | 600 | Mils |
| KOD33 | X3 | | 600 | Mils |
| KOD34 | Y1 | | 1800 | Mils |
| KOD35 | Y2 | | 600 | Mils |
| KOD36 | DDR3 keepout region ⁽¹⁾ | | | |
| KOD37 | Clearance from non-DDR3 signal to DDR3 keepout region ^{(2) (3)} | 4 | | W |

- (1) DDR3 keepout region to encompass entire DDR3 routing area.
- (2) Non-DDR3 signals allowed within DDR3 keepout region provided they are separated from DDR3 routing layers by a ground plane.
- (3) If a device has more than one DDR controller, the signals from the other controller(s) are considered non-DDR3 and should be separated by this specification.

8.7.2.8 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 8-44](#). The size of this region varies with the placement and DDR routing. Additional clearances required for the keepout region are shown in [Table 8-34](#). Non-DDR3 signals should not be routed on the DDR signal layers within the DDR3 keepout region. Non-DDR3 signals may be routed in the region, provided they are routed on layers separated from the DDR signal layers by a ground layer. No breaks should be allowed in the reference ground layers in this region. In addition, the 1.5-V DDR3 power plane should cover the entire keepout region. Also note that the two signals from the DDR3 controller should be separated from each other by the specification in [Table 8-34](#) (see [KOD37](#)).



SPRS906_PCB_DDR3_05

Figure 8-44. DDR3 Keepout Region

8.7.2.9 Bulk Bypass Capacitors

Bulk bypass capacitors are required for moderate speed bypassing of the DDR3 and other circuitry. [Table 8-35](#) contains the minimum numbers and capacitance required for the bulk bypass capacitors. Note that this table only covers the bypass needs of the DDR3 controllers and DDR3 devices. Additional bulk bypass capacitance may be needed for other circuitry.

Table 8-35. Bulk Bypass Capacitors

| NO. | PARAMETER | MIN | MAX | UNIT |
|-----|--|-----|-----|---------|
| 1 | vdds_ddrx bulk bypass capacitor count ⁽¹⁾ | 1 | | Devices |
| 2 | vdds_ddrx bulk bypass total capacitance | 22 | | 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.

8.7.2.10 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, processor/DDR power, and processor/DDR ground connections. [Table 8-36](#) 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 pins/balls 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 limites on via sharing shown in [Table 8-36](#).

Table 8-36. High Speed Bypass Capacitors

| NO. | PARAMETER | MIN | TYP | MAX | UNIT |
|-----|---|------|---|------|---------|
| 1 | HS bypass capacitor package size ⁽¹⁾ | | 0201 | 0402 | 10 Mils |
| 2 | Distance, HS bypass capacitor to processor being bypassed ⁽²⁾⁽³⁾⁽⁴⁾ | | | 400 | Mils |
| 3 | Processor HS bypass capacitor count per vdds_ddrx rail ⁽¹²⁾ | | See Table 8-3 and ⁽¹¹⁾ | | Devices |
| 4 | Processor HS bypass capacitor total capacitance per vdds_ddrx rail ⁽¹²⁾ | | See Table 8-3 and ⁽¹¹⁾ | | μF |
| 5 | Number of connection vias for each device power/ground ball ⁽⁵⁾ | | | | Vias |
| 6 | Trace length from device power/ground ball to connection via ⁽²⁾ | | 35 | 70 | Mils |
| 7 | Distance, HS bypass capacitor to DDR device being bypassed ⁽⁶⁾ | | | 150 | Mils |
| 8 | DDR3 device HS bypass capacitor count ⁽⁷⁾ | 12 | | | Devices |
| 9 | DDR3 device HS bypass capacitor total capacitance ⁽⁷⁾ | 0.85 | | | μF |
| 10 | Number of connection vias for each HS capacitor ⁽⁸⁾⁽⁹⁾ | 2 | | | Vias |
| 11 | Trace length from bypass capacitor connect to connection via ⁽²⁾⁽⁹⁾ | | 35 | 100 | Mils |
| 12 | Number of connection vias for each DDR3 device power/ground ball ⁽¹⁰⁾ | 1 | | | Vias |
| 13 | Trace length from DDR3 device power/ground ball to connection via ⁽²⁾⁽⁸⁾ | | 35 | 60 | Mils |

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

(2) Closer/shorter is better.

(3) Measured from the nearest processor power/ground ball to the center of the capacitor package.

(4) Three of these capacitors should be located underneath the processor, between the cluster of DDR_1V5 balls and ground balls, between the DDR interfaces on the package.

(5) See the Via Channel™ escape for the processor package.

(6) Measured from the DDR3 device power/ground ball to the center of the capacitor package.

(7) Per DDR3 device.

(8) 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.

- (9) An HS bypass capacitor may share a via with a DDR 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 DDR device pad should be less than 150 mils.
- (10) Up to a total of two pairs of DDR power/ground balls may share a via.
- (11) The capacitor recommendations in this data manual reflect only the needs of this processor. Please see the memory vendor's guidelines for determining the appropriate decoupling capacitor arrangement for the memory device itself.
- (12) For more information, see [Section 8.3, Core Power Domains](#).

8.7.2.10.1 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. Because these are returns for signal current, the signal via size may be used for these capacitors.

8.7.2.11 Net Classes

[Table 8-37](#) lists the clock net classes for the DDR3 interface. [Table 8-38](#) 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 8-37. Clock Net Class Definitions

| CLOCK NET CLASS | processor PIN NAMES |
|---------------------|------------------------|
| CK | ddrx_ck/ddrx_nck |
| DQS0 | ddrx_dqs0 / ddrx_dqsn0 |
| DQS1 | ddrx_dqs1 / ddrx_dqsn1 |
| DQS2 ⁽¹⁾ | ddrx_dqs2 / ddrx_dqsn2 |
| DQS3 ⁽¹⁾ | ddrx_dqs3 / ddrx_dqsn3 |

- (1) Only used on 32-bit wide DDR3 memory systems.

Table 8-38. Signal Net Class Definitions

| SIGNAL NET CLASS | ASSOCIATED CLOCK NET CLASS | processor PIN NAMES |
|--------------------|----------------------------|---|
| ADDR_CTRL | CK | ddrx_ba[2:0], ddrx_a[14:0], ddrx_csnj, ddrx_casn, ddrx_rasn, ddrx_wen, ddrx_cke, ddrx_odt |
| DQ0 | DQS0 | ddrx_d[7:0], ddrx_dqm0 |
| DQ1 | DQS1 | ddrx_d[15:8], ddrx_dqm1 |
| DQ2 ⁽¹⁾ | DQS2 | ddrx_d[23:16], ddrx_dqm2 |
| DQ3 ⁽¹⁾ | DQS3 | ddrx_d[31:24], ddrx_dqm3 |

- (1) Only used on 32-bit wide DDR3 memory systems.

8.7.2.12 DDR3 Signal Termination

Signal terminators are required for the CK and ADDR_CTRL net classes. The data lines are terminated by ODT and, thus, the PCB traces should be unterminated. Detailed termination specifications are covered in the routing rules in the following sections.

8.7.2.13 VREF_DDR Routing

ddrx_vref0 (VREF) is used as a reference by the input buffers of the DDR3 memories as well as the processor. VREF is intended to be half the DDR3 power supply voltage and is typically generated with the DDR3 VDD5 and VTT power supply. It should be routed as a nominal 20-mil wide trace with 0.1 μ F bypass capacitors near each device connection. Narrowing of VREF is allowed to accommodate routing congestion.

8.7.2.14 VTT

Like VREF, the nominal value of the VTT supply is half the DDR3 supply voltage. Unlike VREF, VTT is expected to source and sink current, specifically the termination current for the ADDR_CTRL net class Thevinen 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.

8.7.2.15 CK and ADDR_CTRL Topologies and Routing Definition

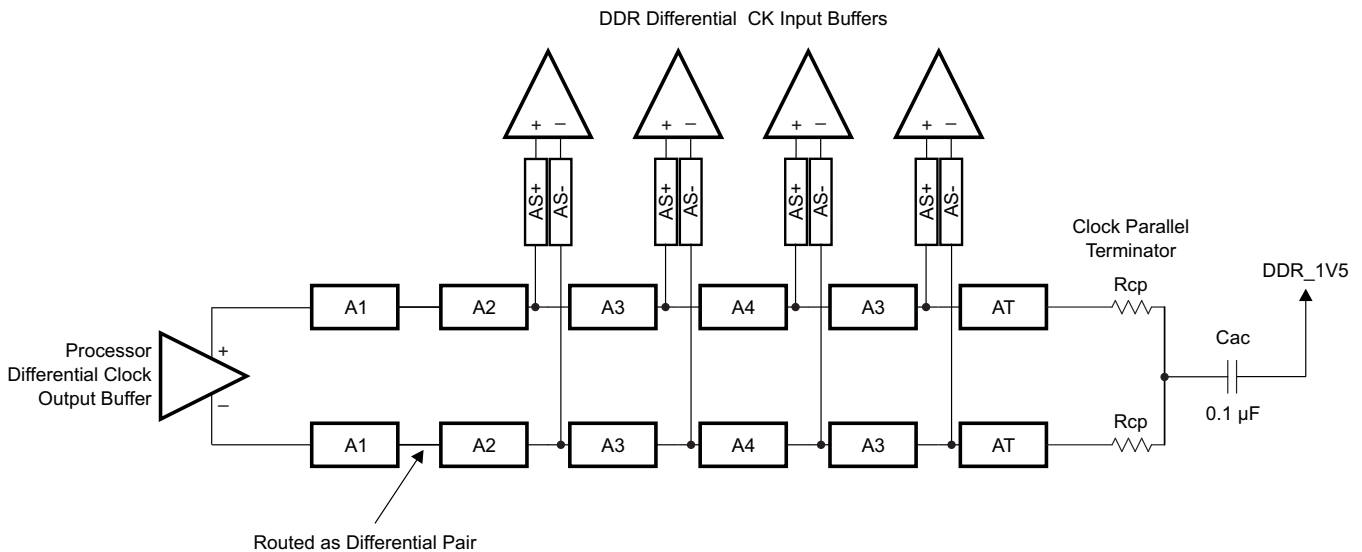
The CK and ADDR_CTRL net classes are routed in a fly-by topology. They are routed in a similar manner and are length matched to minimize skew between them. CK is a bit more complicated because it runs at a higher transition rate and is differential. The following subsections show the topology and routing 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 8-39. Balanced-T routing is not recommended.

8.7.2.15.1 Four DDR3 Devices

Four DDR3 devices are supported on the DDR EMIF consisting of four x8 DDR3 devices arranged as one bank (CS). These four devices may be mounted on a single side of the PCB, or may be mirrored in two pairs to save board space at a cost of increased routing complexity and parts on the backside of the PCB.

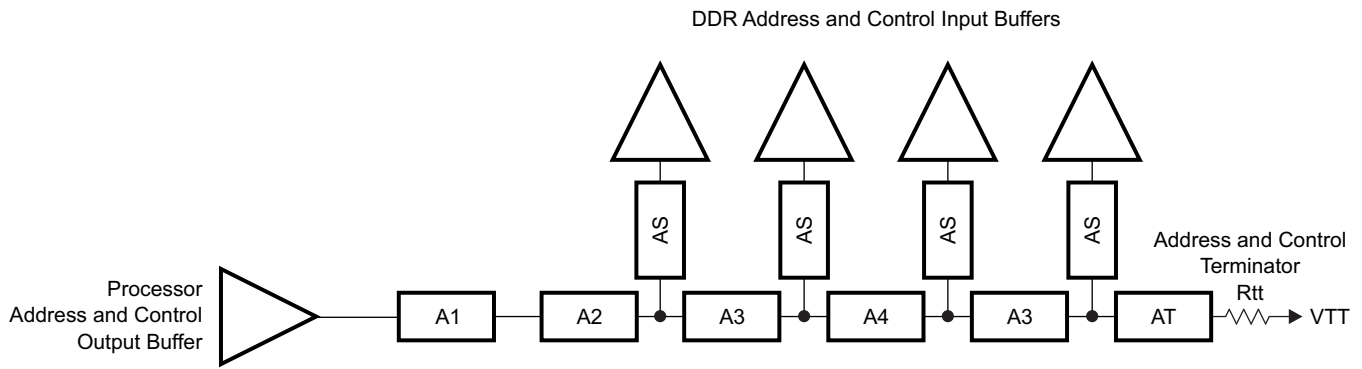
8.7.2.15.1.1 CK and ADDR_CTRL Topologies, Four DDR3 Devices

Figure 8-45 shows the topology of the CK net classes and Figure 8-46 shows the topology for the corresponding ADDR_CTRL net classes.



SPRS906_PCB_DDR3_06

Figure 8-45. CK Topology for Four x8 DDR3 Devices

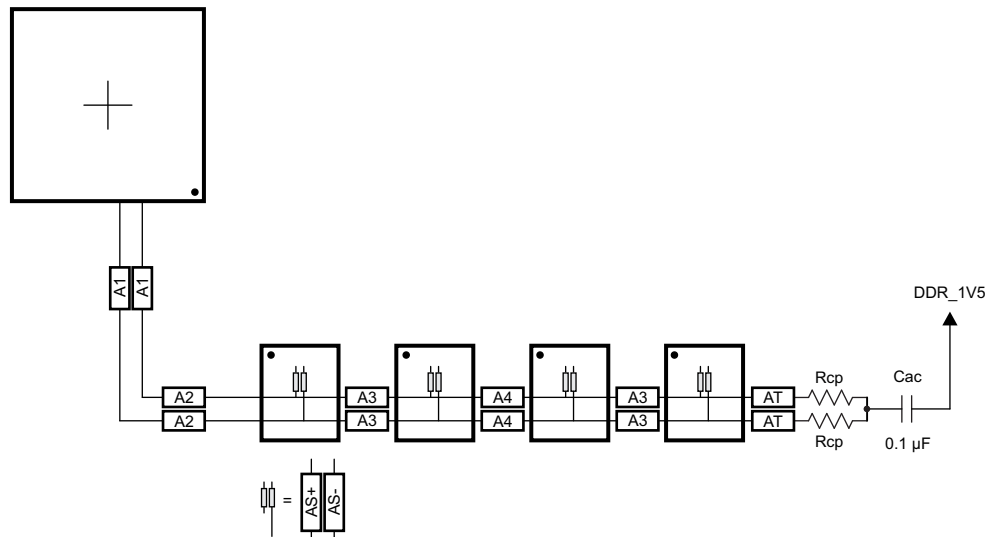


SPRS906_PCB_DDR3_07

Figure 8-46. ADDR_CTRL Topology for Four x8 DDR3 Devices

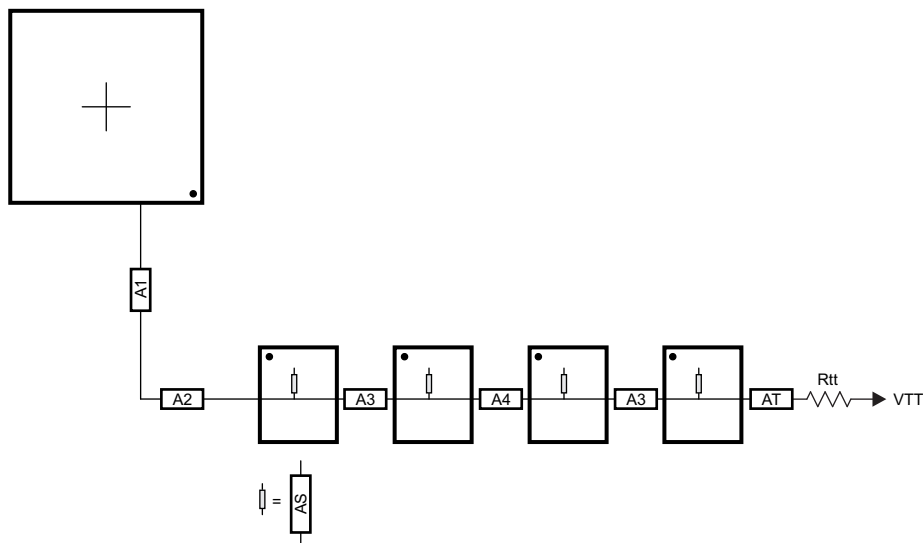
8.7.2.15.1.2 CK and ADDR_CTRL Routing, Four DDR3 Devices

Figure 8-47 shows the CK routing for four DDR3 devices placed on the same side of the PCB. Figure 8-48 shows the corresponding ADDR_CTRL routing.



SPRS906_PCB_DDR3_08

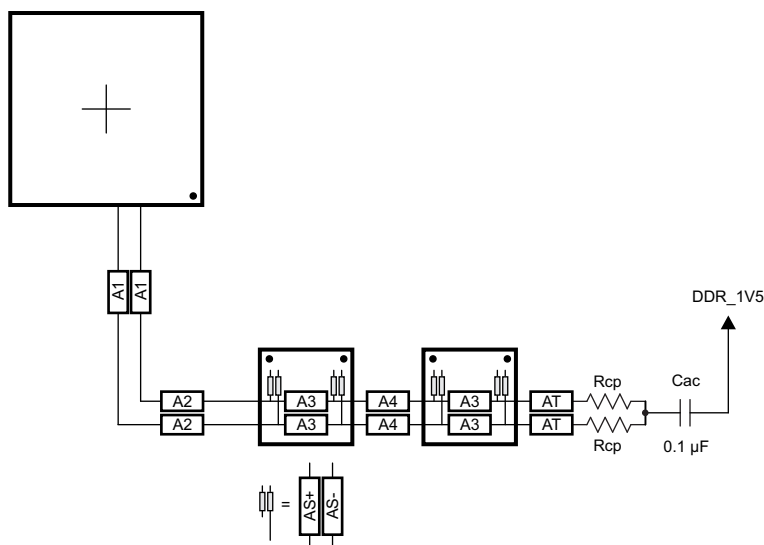
Figure 8-47. CK Routing for Four Single-Side DDR3 Devices



SPRS906_PCB_DDR3_09

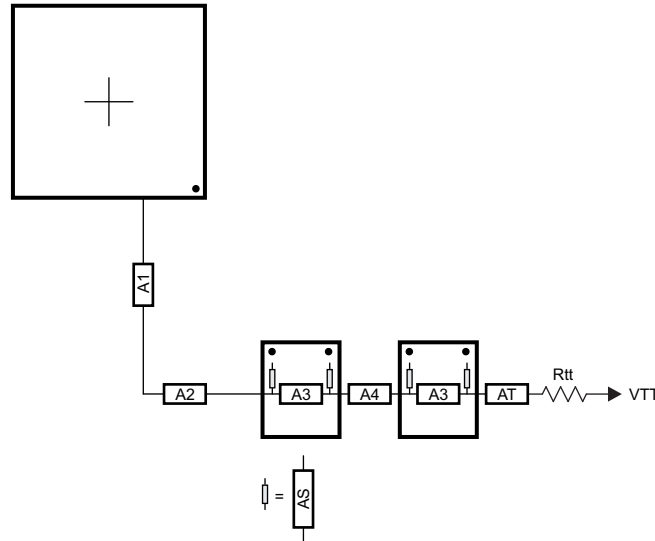
Figure 8-48. ADDR_CTRL Routing for Four Single-Side DDR3 Devices

To save PCB space, the four DDR3 memories may be mounted as two mirrored pairs at a cost of increased routing and assembly complexity. Figure 8-49 and Figure 8-50 show the routing for CK and ADDR_CTRL, respectively, for four DDR3 devices mirrored in a two-pair configuration.



SPRS906_PCB_DDR3_10

Figure 8-49. CK Routing for Four Mirrored DDR3 Devices



SPRS906_PCB_DDR3_11

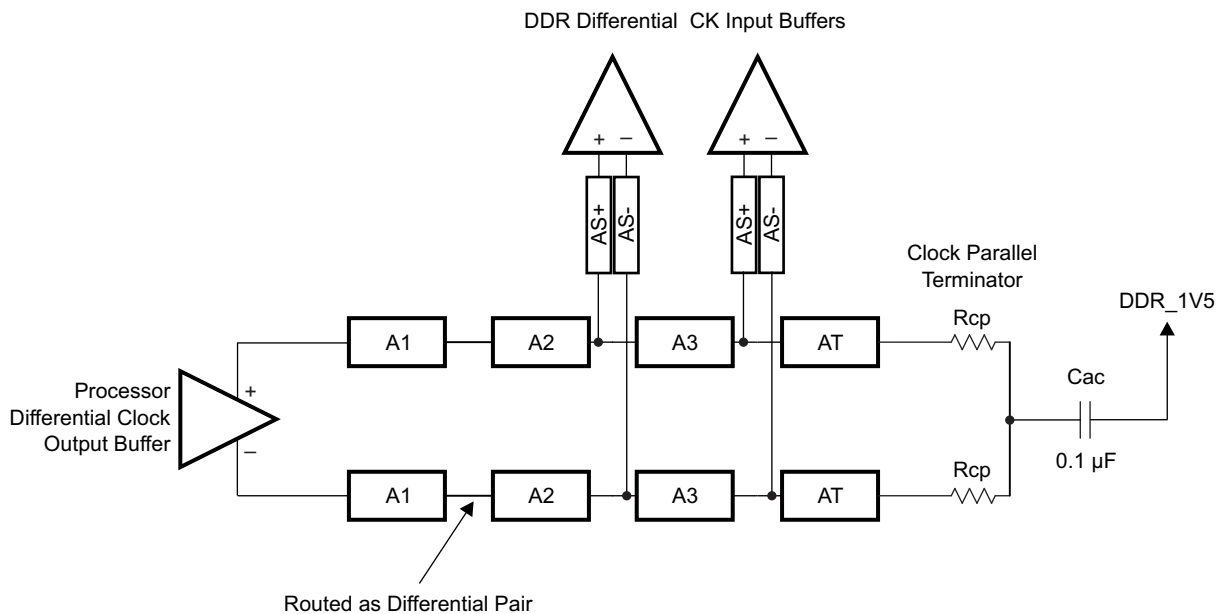
Figure 8-50. ADDR_CTRL Routing for Four Mirrored DDR3 Devices

8.7.2.15.2 Two DDR3 Devices

Two DDR3 devices are supported on the DDR EMIF consisting of two x8 DDR3 devices arranged as one bank (CS), 16 bits wide, or two x16 DDR3 devices arranged as one bank (CS), 32 bits wide. 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.

8.7.2.15.2.1 CK and ADDR_CTRL Topologies, Two DDR3 Devices

Figure 8-51 shows the topology of the CK net classes and Figure 8-52 shows the topology for the corresponding ADDR_CTRL net classes.



SPRS906_PCB_DDR3_12

Figure 8-51. CK Topology for Two DDR3 Devices

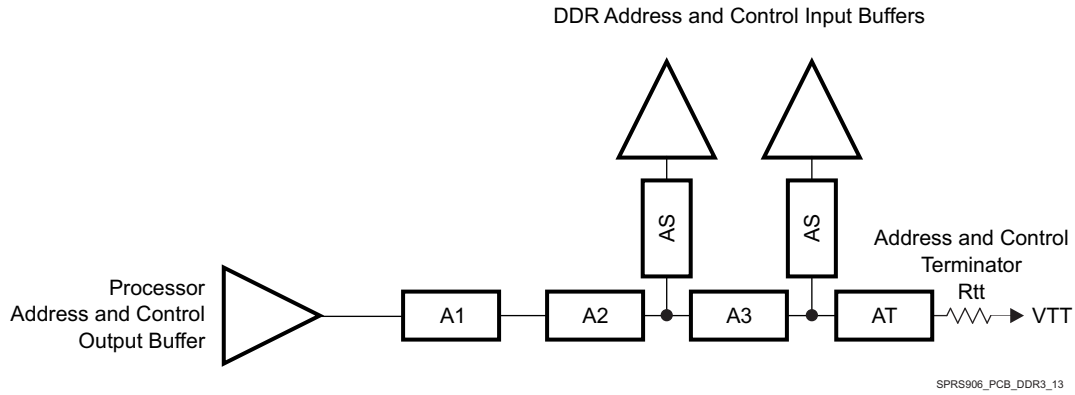


Figure 8-52. ADDR_CTRL Topology for Two DDR3 Devices

8.7.2.15.2.2 CK and ADDR_CTRL Routing, Two DDR3 Devices

Figure 8-53 shows the CK routing for two DDR3 devices placed on the same side of the PCB. Figure 8-54 shows the corresponding ADDR_CTRL routing.

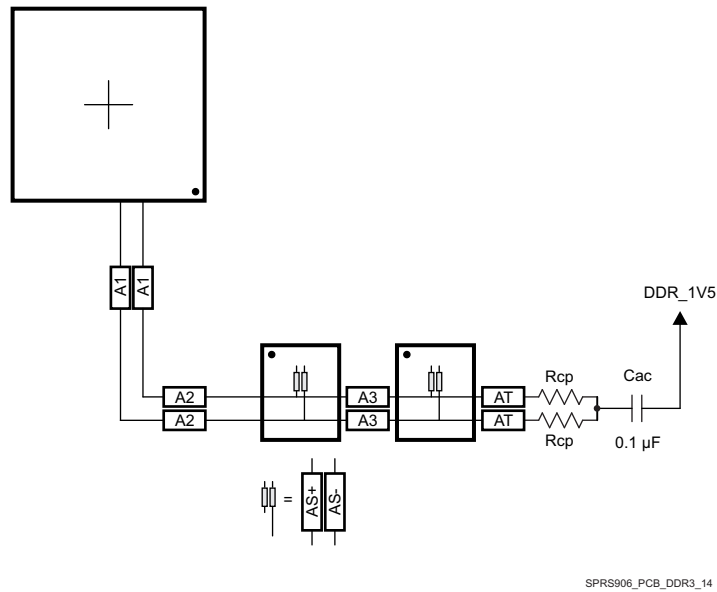
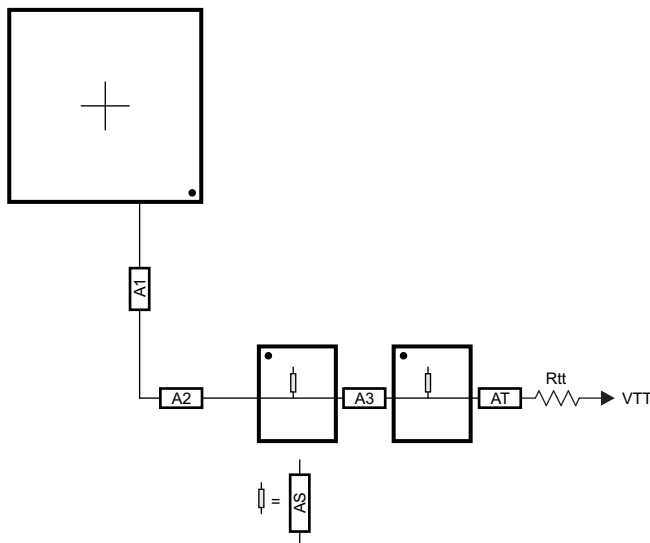


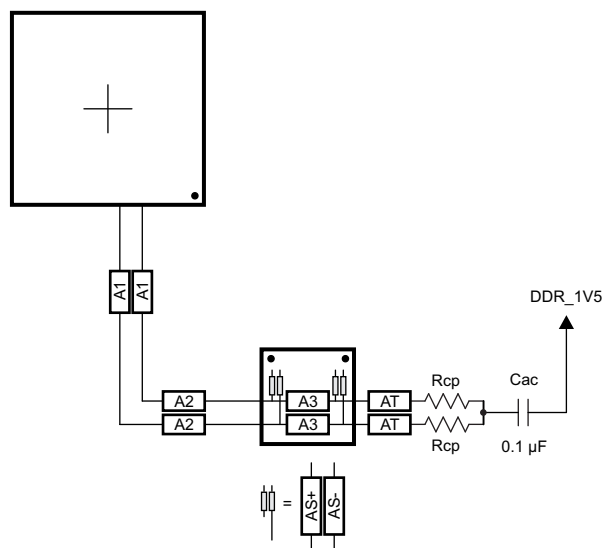
Figure 8-53. CK Routing for Two Single-Side DDR3 Devices



SPRS906_PCB_DDR3_15

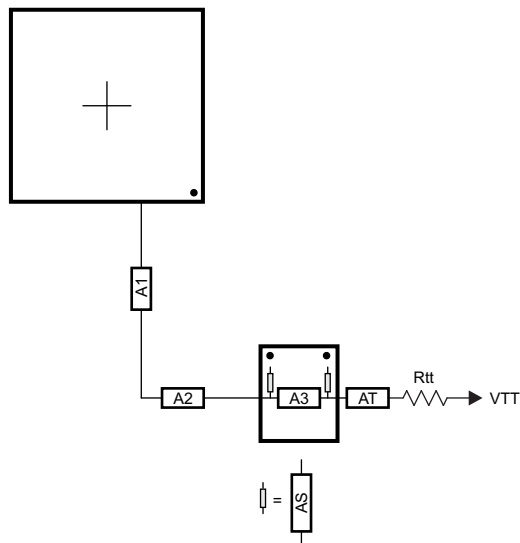
Figure 8-54. ADDR_CTRL Routing for Two Single-Side DDR3 Devices

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 8-55](#) and [Figure 8-56](#) show the routing for CK and ADDR_CTRL, respectively, for two DDR3 devices mirrored in a single-pair configuration.



SPRS906_PCB_DDR3_16

Figure 8-55. CK Routing for Two Mirrored DDR3 Devices



SPRS906_PCB_DDR3_17

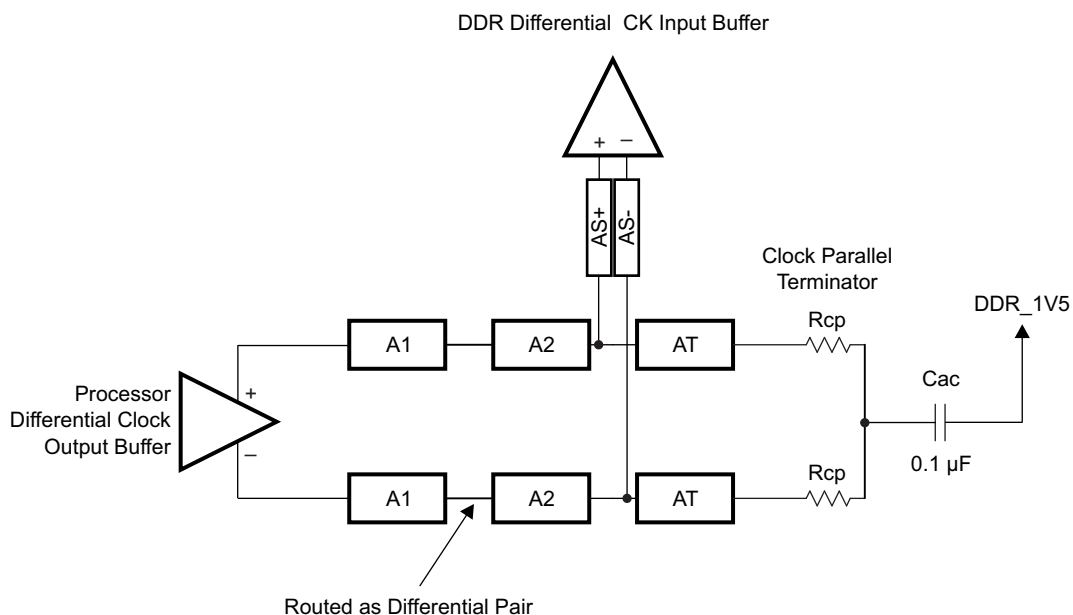
Figure 8-56. ADDR_CTRL Routing for Two Mirrored DDR3 Devices

8.7.2.15.3 One DDR3 Device

A single DDR3 device is supported on the DDR EMIF consisting of one x16 DDR3 device arranged as one bank (CS), 16 bits wide.

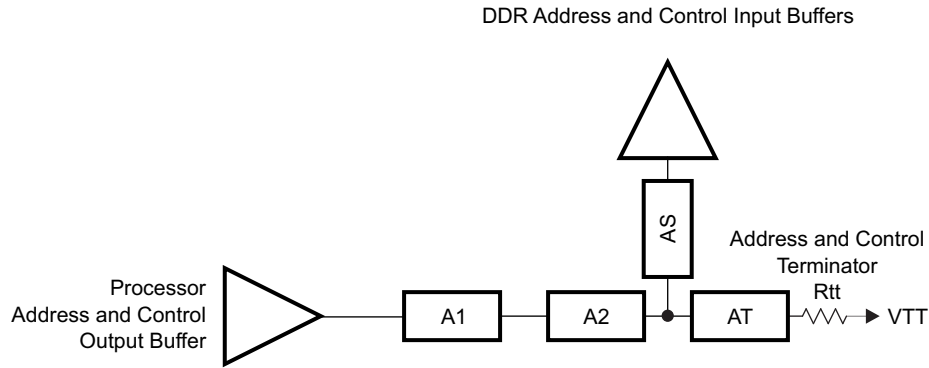
8.7.2.15.3.1 CK and ADDR_CTRL Topologies, One DDR3 Device

Figure 8-57 shows the topology of the CK net classes and Figure 8-58 shows the topology for the corresponding ADDR_CTRL net classes.



SPRS906_PCB_DDR3_18

Figure 8-57. CK Topology for One DDR3 Device

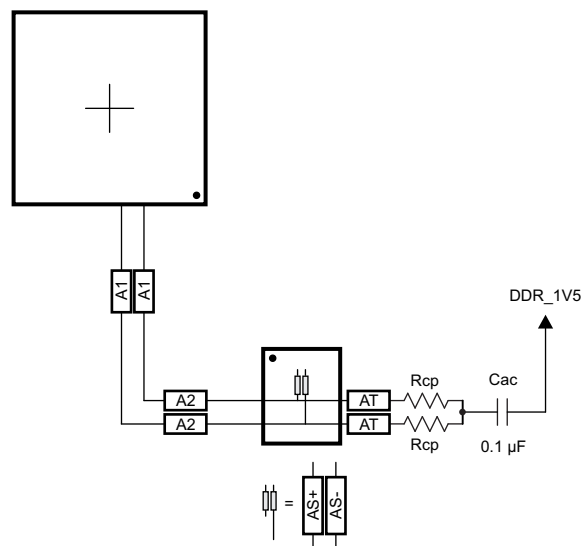


SPRS906_PCB_DDR3_19

Figure 8-58. ADDR_CTRL Topology for One DDR3 Device

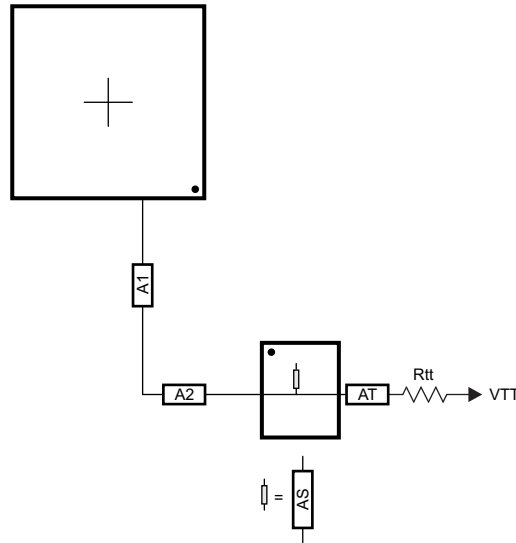
8.7.2.15.3.2 CK and ADDR/CTRL Routing, One DDR3 Device

Figure 8-59 shows the CK routing for one DDR3 device placed on the same side of the PCB. Figure 8-60 shows the corresponding ADDR_CTRL routing.



SPRS906_PCB_DDR3_20

Figure 8-59. CK Routing for One DDR3 Device



SPRS906_PCB_DDR3_21

Figure 8-60. ADDR_CTRL Routing for One DDR3 Device

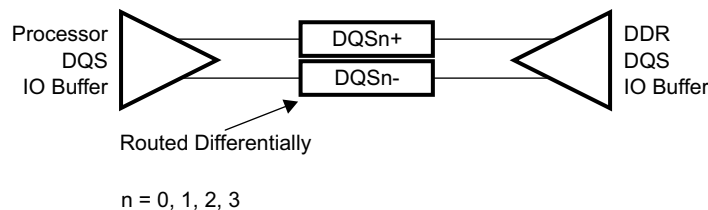
8.7.2.16 Data Topologies and Routing Definition

No matter the number of DDR3 devices used, the data line topology is always point to point, so its definition is simple.

Care should be taken to minimize layer transitions during routing. If a layer transition is necessary, it is better to transition to a layer using the same reference plane. If this cannot be accommodated, ensure there are nearby ground vias to allow the return currents to transition between reference planes if both reference planes are ground or vdds_ddr. Ensure there are nearby bypass capacitors to allow the return currents to transition between reference planes if one of the reference planes is ground. The goal is to minimize the size of the return current loops.

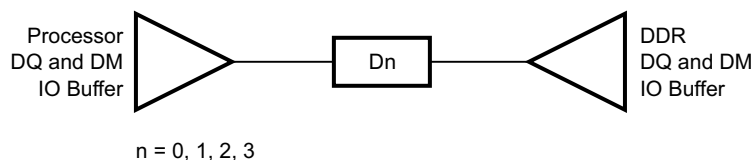
8.7.2.16.1 DQS and DQ/DM Topologies, Any Number of Allowed DDR3 Devices

DQS lines are point-to-point differential, and DQ/DM lines are point-to-point singled ended. Figure 8-61 and Figure 8-62 show these topologies.



SPRS906_PCB_DDR3_22

Figure 8-61. DQS Topology



SPRS906_PCB_DDR3_23

Figure 8-62. DQ/DM Topology

8.7.2.16.2 DQS and DQ/DM Routing, Any Number of Allowed DDR3 Devices

Figure 8-63 and Figure 8-64 show the DQS and DQ/DM routing.

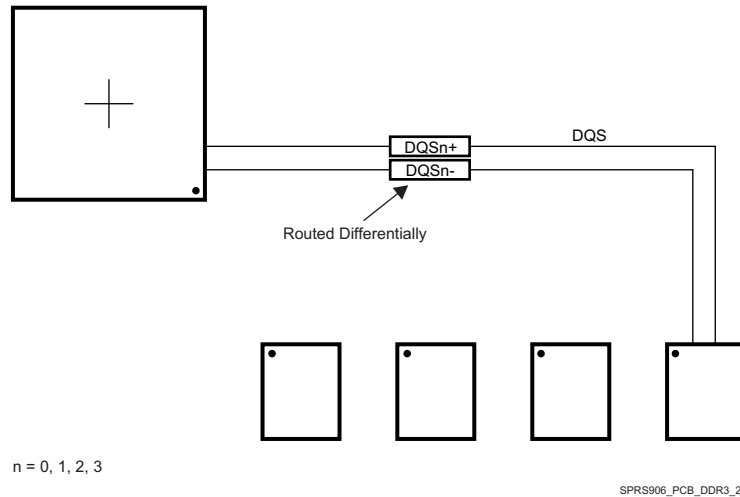


Figure 8-63. DQS Routing With Any Number of Allowed DDR3 Devices

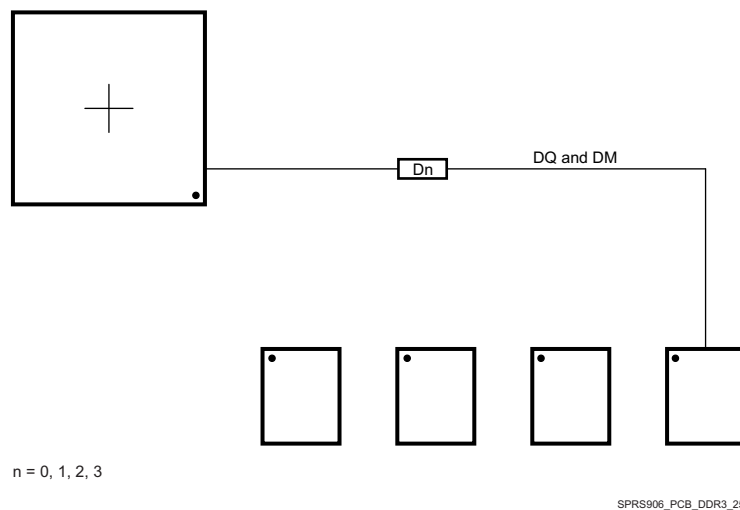


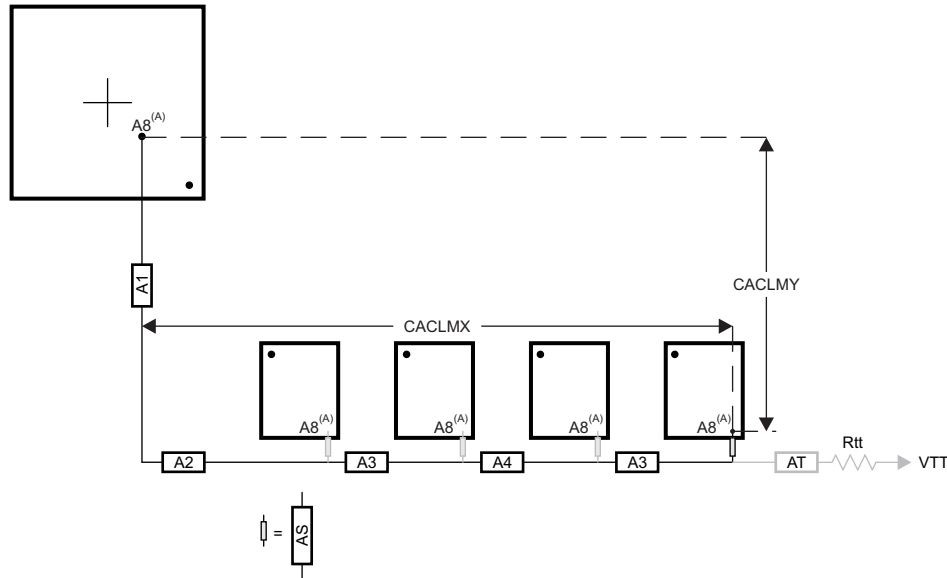
Figure 8-64. DQ/DM Routing With Any Number of Allowed DDR3 Devices

8.7.2.17 Routing Specification

8.7.2.17.1 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 processor and the DDR3 memories, the maximum possible Manhattan distance can be determined given the placement. Figure 8-65 and Figure 8-66 show this distance for four loads and two loads, respectively. 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/ADDR_CTRL net class. For CK and ADDR_CTRL routing, these specifications are contained in Table 8-39.



SPRS906_PCB_DDR3_26

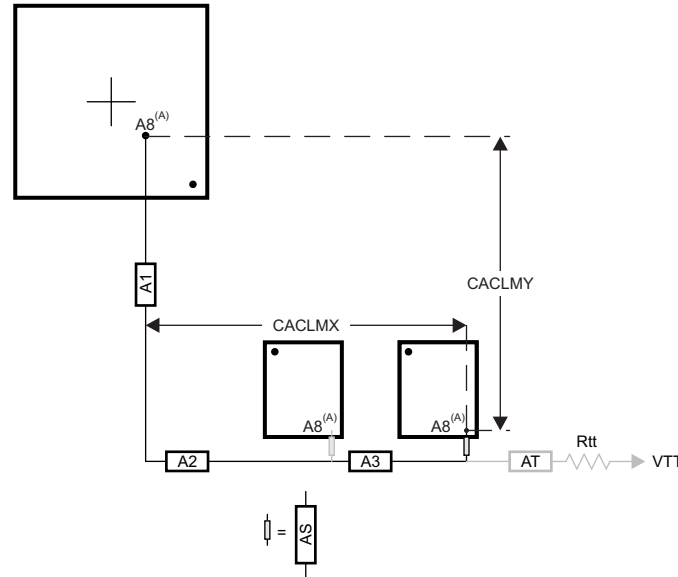
- A. It is very likely that the longest CK/ADDR_CTRL Manhattan distance will be for Address Input 8 (A8) on the DDR3 memories. CACLM is based on the longest Manhattan distance due to the device placement. Verify the net class that satisfies this criteria and use as the baseline for CK/ADDR_CTRL skew matching and length control.

The length of shorter CK/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 8-65. CACLM for Four Address Loads on One Side of PCB



SPRS906_PCB_DDR3_27

- A. It is very likely that the longest CK/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/ADDR_CTRL skew matching and length control.

The length of shorter CK/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 8-66. CACLM for Two Address Loads on One Side of PCB

Table 8-39. CK and ADDR_CTRL Routing Specification⁽²⁾⁽³⁾

| NO. | PARAMETER | MIN | TYP | MAX | UNIT |
|---------|--|-----|-----|--------------------|------|
| CARS31 | A1+A2 length | | | 500 ⁽¹⁾ | ps |
| CARS32 | A1+A2 skew | | | 29 | ps |
| CARS33 | A3 length | | | 125 | ps |
| CARS34 | A3 skew ⁽⁴⁾ | | | 6 | ps |
| CARS35 | A3 skew ⁽⁵⁾ | | | 6 | ps |
| CARS36 | A4 length | | | 125 | ps |
| CARS37 | A4 skew | | | 6 | ps |
| CARS38 | AS length | | 5 | 17 ⁽¹⁾ | ps |
| CARS39 | AS skew | | 1.3 | 14 ⁽¹⁾ | ps |
| CARS310 | AS+/AS- length | | 5 | 12 | ps |
| CARS311 | AS+/AS- skew | | | 1 | ps |
| CARS312 | AT length ⁽⁶⁾ | | 75 | | ps |
| CARS313 | AT skew ⁽⁷⁾ | | 14 | | ps |
| CARS314 | AT skew ⁽⁸⁾ | | | 1 | ps |
| CARS315 | CK/ADDR_CTRL trace length | | | 1020 | ps |
| CARS316 | Vias per trace | | | 3 ⁽¹⁾ | vias |
| CARS317 | Via count difference | | | 1 ⁽¹⁵⁾ | vias |
| CARS318 | Center-to-center CK to other DDR3 trace spacing ⁽⁹⁾ | 4w | | | |
| CARS319 | Center-to-center ADDR_CTRL to other DDR3 trace spacing ⁽⁹⁾⁽¹⁰⁾ | 4w | | | |
| CARS320 | Center-to-center ADDR_CTRL to other ADDR_CTRL trace spacing ⁽⁹⁾ | 3w | | | |

Table 8-39. CK and ADDR_CTRL Routing Specification⁽²⁾⁽³⁾ (continued)

| NO. | PARAMETER | MIN | TYP | MAX | UNIT |
|---------|---|------|-----|------|------|
| CARS321 | CK center-to-center spacing ⁽¹¹⁾⁽¹²⁾ | | | | |
| CARS322 | CK spacing to other net ⁽⁹⁾ | 4w | | | |
| CARS323 | Rcp ⁽¹³⁾ | Zo-1 | Zo | Zo+1 | Ω |
| CARS324 | Rtt ⁽¹³⁾⁽¹⁴⁾ | Zo-5 | Zo | Zo+5 | Ω |

- (1) Max value is based upon conservative signal integrity approach. This value could be extended only if detailed signal integrity analysis of rise time and fall time confirms desired operation.
- (2) The use of vias should be minimized.
- (3) Additional bypass capacitors are required when using the DDR_1V5 plane as the reference plane to allow the return current to jump between the DDR_1V5 plane and the ground plane when the net class switches layers at a via.
- (4) Non-mirrored configuration (all DDR3 memories on same side of PCB).
- (5) Mirrored configuration (one DDR3 device on top of the board and one DDR3 device on the bottom).
- (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) Center-to-center spacing is allowed to fall to minimum 2w for up to 1250 mils of routed length.
- (10) The ADDR_CTRL net class of the other DDR EMIF is considered *other DDR3 trace spacing*.
- (11) CK spacing set to ensure proper differential impedance.
- (12) The most important thing to do is control the impedance so inadvertent impedance mismatches are not created. Generally speaking, center-to-center spacing should be either 2w or slightly larger than 2w to achieve a differential impedance equal to twice the singleended impedance, Zo.
- (13) Source termination (series resistor at driver) is specifically not allowed.
- (14) Termination values should be uniform across the net class.
- (15) Via count difference may increase by 1 only if accurate 3-D modeling of the signal flight times – including accurately modeled signal propagation through vias – has been applied to ensure all segment skew maximums are not exceeded.

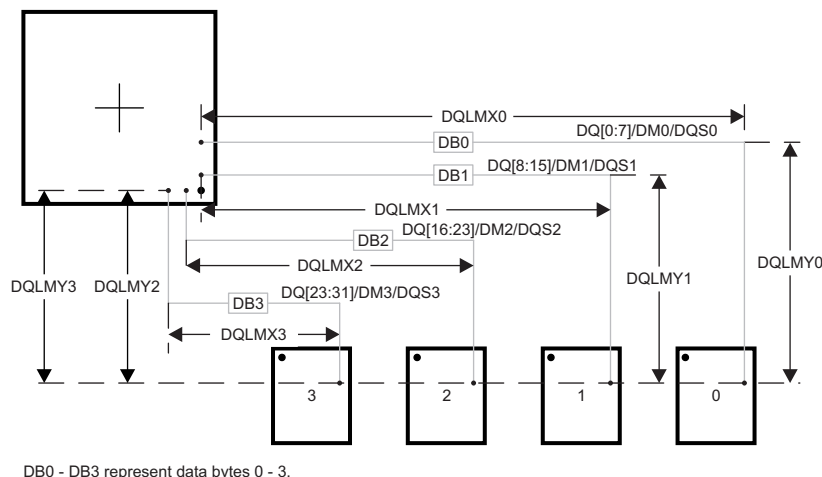
8.7.2.17.2 DQS and DQ Routing Specification

Skew within the DQS and DQ/DM 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. As with CK and ADDR_CTRL, a reasonable trace route length is to within a percentage of its Manhattan distance. DQLMn is defined as DQ Longest Manhattan distance n, where n is the byte number. For a 32-bit interface, there are four DQLMs, DQLM0-DQLM3. Likewise, 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 and DQ/DM pin locations on the processor and the DDR3 memories, the maximum possible Manhattan distance can be determined given the placement. [Figure 8-67](#) shows this distance for four loads. It is from this distance that the specifications on the lengths of the transmission lines for the data bus are determined. For DQS and DQ/DM routing, these specifications are contained in [Table 8-40](#).



DB0 - DB3 represent data bytes 0 - 3.

SPRS906_PCB_DDR3_28

There are four DQLMs, one for each byte (32-bit interface). Each DQLM is the longest Manhattan distance of the byte; therefore:

$$DQLM0 = DQLMX0 + DQLMY0$$

$$DQLM1 = DQLMX1 + DQLMY1$$

$$DQLM2 = DQLMX2 + DQLMY2$$

$$DQLM3 = DQLMX3 + DQLMY3$$

Figure 8-67. DQLM for Any Number of Allowed DDR3 Devices

Table 8-40. Data Routing Specification⁽²⁾

| NO. | PARAMETER | MIN | TYP | MAX | UNIT |
|--------|---|-----|-----|-------------------|------------------|
| DRS31 | DB0 length | | | 340 | ps |
| DRS32 | DB1 length | | | 340 | ps |
| DRS33 | DB2 length | | | 340 | ps |
| DRS34 | DB3 length | | | 340 | ps |
| DRS35 | DBn skew ⁽³⁾ | | | 5 | ps |
| DRS36 | DQSn+ to DQSn- skew | | | 1 | ps |
| DRS37 | DQSn to DBn skew ⁽³⁾⁽⁴⁾ | | | 5 ⁽¹⁰⁾ | ps |
| DRS38 | Vias per trace | | | 2 ⁽¹⁾ | vias |
| DRS39 | Via count difference | | | 0 ⁽¹⁰⁾ | vias |
| DRS310 | Center-to-center DBn to other DDR3 trace spacing ⁽⁶⁾ | 4 | | | w ⁽⁵⁾ |
| DRS311 | Center-to-center DBn to other DBn trace spacing ⁽⁷⁾ | 3 | | | w ⁽⁵⁾ |
| DRS312 | DQSn center-to-center spacing ⁽⁸⁾⁽⁹⁾ | | | | |
| DRS313 | DQSn center-to-center spacing to other net | 4 | | | w ⁽⁵⁾ |

- (1) Max value is based upon conservative signal integrity approach. This value could be extended only if detailed signal integrity analysis of rise time and fall time confirms desired operation.
- (2) External termination disallowed. Data termination should use built-in ODT functionality.
- (3) Length matching is only done within a byte. Length matching across bytes is neither required nor recommended.
- (4) Each DQS pair is length matched to its associated byte.
- (5) Center-to-center spacing is allowed to fall to minimum 2w for up to 1250 mils of routed length.
- (6) Other DDR3 trace spacing means other DDR3 net classes not within the byte.
- (7) This applies to spacing within the net classes of a byte.
- (8) DQS pair spacing is set to ensure proper differential impedance.
- (9) The most important thing to do is control the impedance so inadvertent impedance mismatches are not created. Generally speaking, center-to-center spacing should be either 2w or slightly larger than 2w to achieve a differential impedance equal to twice the single-ended impedance, Z_0 .
- (10) Via count difference may increase by 1 only if accurate 3-D modeling of the signal flight times – including accurately modeled signal propagation through vias – has been applied to ensure DBn skew and DQSn to DBn skew maximums are not exceeded.

9 Device and Documentation Support

TI offers an extensive line of development tools, including methods to evaluate the performance of the processors, generate code, develop algorithm implementations, and fully integrate and debug software and hardware modules as listed below.

9.1 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, DRA72x). 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.

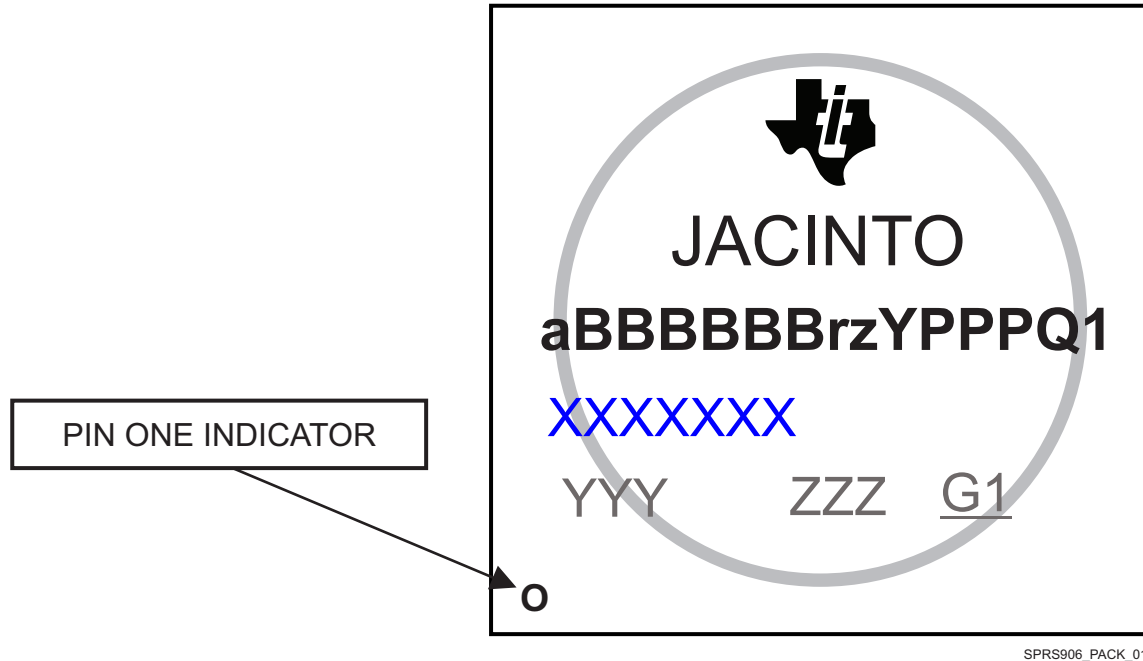
Predictions show that prototype devices (X or P) have a greater failure rate than the standard production devices. Texas Instruments recommends that these devices not be used in any production system because their expected end-use failure rate still is undefined. Only qualified production devices are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

For orderable part numbers of DRA72x devices in the ABC package type, see the Package Option Addendum of this document, the TI website (ti.com), or contact your TI sales representative.

9.1.1 Standard Package Symbolization

NOTE

Some devices may have a cosmetic circular marking visible on the top of the device package which results from the production test process. In addition, some devices may also show a color variation in the package substrate which results from the substrate manufacturer. These differences are cosmetic only with no reliability impact.



SPRS906_PACK_01

Figure 9-1. Printed Device Reference

9.1.2 Device Naming Convention

Table 9-1. Nomenclature Description

| FIELD PARAMETER | FIELD DESCRIPTION | VALUE | DESCRIPTION |
|-----------------|---------------------------------------|--------|--|
| a | Device evolution stage ⁽¹⁾ | X | Prototype |
| | | P | Preproduction (production test flow, no reliability data) |
| | | BLANK | Production |
| BBBBBB | Base production part number | DRA722 | J6Eco Ultra Low Tier |
| | | DRA724 | J6Eco Low Tier |
| | | DRA725 | J6Eco Mid Tier |
| | | DRA726 | J6Eco High Tier |
| r | Device revision | BLANK | SR 1.0 |
| | | A | SR 2.0 |
| | | B | SR 2.1 |
| z | Device Speed | P | Indicates the speed grade for each of the cores in the device. For more information see Table 5-5, Speed Grade Maximum Frequency . |
| | | L | |
| | | J | |
| | | H | |
| | | OTHER | |
| Y | Device type | G | General purpose (Prototype and Production) |
| | | E | Emulation (E) devices |
| | | S | High-Security device, Secure Boot Supported |
| | | D | High security prototype devices with TI Development keys (D) |
| | | Yn | Letter followed by number indicates HS device with customer key |
| PPP | Package designator | ABC | ABC S-PBGA-N760 (23 mm x 23 mm) Package |
| Q1 | Automotive Designator | BLANK | Not meeting automotive qualification |
| | | Q1 | Meeting Q100 equal requirements, with exceptions as specified in DM. |

Table 9-1. Nomenclature Description (continued)

| FIELD PARAMETER | FIELD DESCRIPTION | VALUE | DESCRIPTION |
|-----------------|----------------------------------|-------|-------------|
| XXXXXXX | Lot Trace Code | | |
| YYY | Production Code, For TI use only | | |
| ZZZ | Production Code, For TI use only | | |
| O | Pin one designator | | |
| G1 | ECAT—Green package designator | | |

- (1) To designate the stages in the product development cycle, TI assigns prefixes to the part numbers. These prefixes represent evolutionary stages of product development from engineering prototypes through fully qualified production devices. Prototype devices are shipped against the following disclaimer:
 "This product is still under development and is intended for internal evaluation purposes."
 Notwithstanding any provision to the contrary, TI makes no warranty expressed, implied, or statutory, including any implied warranty of merchantability of fitness for a specific purpose, of this device.
- (2) Applies to device max junction temperature.

NOTE

BLANK in the symbol or part number is collapsed so there are no gaps between characters.

9.2 Tools and Software

The following products support development for DRA72x platforms:

Design Kits and Evaluation Modules

DRA72x Evaluation Module Jacinto™ DRA72x Evaluation Module (EVM) is an evaluation platform designed to speed up development efforts and reduce time to market for applications such as infotainment, reconfigurable digital cluster or integrated digital cockpit. To allow scalability and re-use across Jacinto DRA72x Infotainment SoCs, the EVM is based on the Jacinto DRA726 SoC which incorporates a heterogeneous, scalable architecture that includes a mix of an Arm® Cortex®-A15 core, two Arm Cortex-M4 processing subsystems, one C66x Digital Signal Processors (DSPs), 2D- and 3D-graphics processing units including Imagination Technologies POWERVR™ SGX544 and a high-definition image and video accelerator. It also integrates a host of peripherals including multi-camera interfaces (both parallel and serial) for LVDS-based surround view systems, displays, CAN and Gigabit Ethernet AVB.

Development tools

Clock Tree Tool for Sitara, Automotive, Vision Analytics, and Digital Signal Processors The Clock Tree Tool (CTT) for Sitara™ Arm®, Automotive, and Digital Signal Processors is an interactive clock tree configuration software that provides information about the clocks and modules in these TI devices. It allows the user to:

- Visualize the device clock tree
- Interact with clock tree elements and view the effect on PRCM registers
- Interact with the PRCM registers and view the effect on the device clock tree
- View a trace of all the device registers affected by the user interaction with clock tree

XDS110 JTAG Debug Probe The Texas Instruments XDS110 is a new class of debug probe (emulator) for TI embedded processors. The XDS110 replaces the XDS100 family while supporting a wider variety of standards (IEEE1149.1, IEEE1149.7, SWD) in a single pod. Also, all XDS debug probes support Core and System Trace in all Arm and DSP processors that feature an Embedded Trace Buffer (ETB). The Texas Instruments XDS110 connects to the target board via a TI 20-pin connector (with multiple adapters for TI 14-pin and, Arm 10-pin and Arm 20-pin) and to the host PC via USB2.0 High Speed (480Mbps). It also features two additional connections: the Auxiliary 14-pin port connector that enables EnergyTrace™, a full duplex UART port and four General-Purpose I/Os, and the Expansion 30-pin connector to connect the XDS110 EnergyTrace HDR add-on.

For a complete listing of development-support tools for the processor platform, visit the Texas Instruments website at ti.com. For information on pricing and availability, contact the nearest TI field sales office or authorized distributor.

9.3 Documentation Support

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

The following documents describe the DRA72x devices.

Technical Reference Manual

[DRA72x \(SR 2.0, 1.0\) and DRA71x \(SR 2.1, 2.0\) SoC for Automotive Infotainment Technical Reference Manual](#) Details the integration, the environment, the functional description, and the programming models for each peripheral and subsystem in the DRA72x and DRA71x family of devices.

Errata

[DRA72x \(SR 2.0, 1.0\) and DRA71x \(SR 2.1, 2.0\) SoC for Automotive Infotainment Silicon Errata](#) Describes the known exceptions to the functional specifications for the device.

9.4 Related Links

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

Table 9-2. Related Links

| PARTS | PRODUCT FOLDER | ORDER NOW | TECHNICAL DOCUMENTS | TOOLS & SOFTWARE | SUPPORT & COMMUNITY |
|--------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| DRA722 | Click here | Click here | Click here | Click here | Click here |
| DRA724 | Click here | Click here | Click here | Click here | Click here |
| DRA725 | Click here | Click here | Click here | Click here | Click here |
| DRA726 | Click here | Click here | Click here | Click here | Click here |

9.5 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is 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](#).

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9.7 Electrostatic Discharge Caution



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

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

9.8 Glossary







[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

10 Mechanical, Packaging, and Orderable Information

10.1 Packaging Information

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

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|---|---|
| DRA722AHGABCQ1 | ACTIVE | FCBGA | ABC | 760 | 60 | RoHS & Green | Call TI | Level-3-250C-168 HR | | DRA722AHGABCQ1 JACINTO 784 784 ABC |  |
| DRA722AHGABCRQ1 | ACTIVE | FCBGA | ABC | 760 | 250 | RoHS & Green | Call TI | Level-3-250C-168 HR | | DRA722AHGABCQ1 JACINTO 784 784 ABC |  |
| DRA724JGABCRQ1 | PREVIEW | FCBGA | ABC | 760 | 250 | RoHS & Green | Call TI | Level-3-250C-168 HR | -40 to 125 | DRA724JGABCQ1 784 784 ABC | |
| DRA725AGGABCQ1 | ACTIVE | FCBGA | ABC | 760 | 60 | RoHS & Green | Call TI | Level-3-250C-168 HR | | DRA725AGGABCQ1 784 784 ABC |  |
| DRA725AGGABCRQ1 | ACTIVE | FCBGA | ABC | 760 | 250 | RoHS & Green | Call TI | Level-3-250C-168 HR | | DRA725AGGABCQ1 784 784 ABC |  |
| DRA725LGABCRQ1 | PREVIEW | FCBGA | ABC | 760 | 250 | RoHS & Green | Call TI | Level-3-250C-168 HR | -40 to 125 | DRA725LGABCQ1 784 784 ABC | |
| DRA726APGABCQ1 | ACTIVE | FCBGA | ABC | 760 | 60 | RoHS & Green | Call TI | Level-3-250C-168 HR | -40 to 125 | DRA726APGABCQ1 784 784 ABC |  |
| DRA726APGABCRQ1 | ACTIVE | FCBGA | ABC | 760 | 250 | RoHS & Green | Call TI | Level-3-250C-168 HR | -40 to 125 | DRA726APGABCQ1 784 784 ABC |  |

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

ACTIVE: Product device recommended for new designs.

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

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

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

OBSELETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of ≤ 1000 ppm threshold. Antimony trioxide based flame retardants must also meet the ≤ 1000 ppm threshold requirement.

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

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

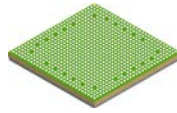
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

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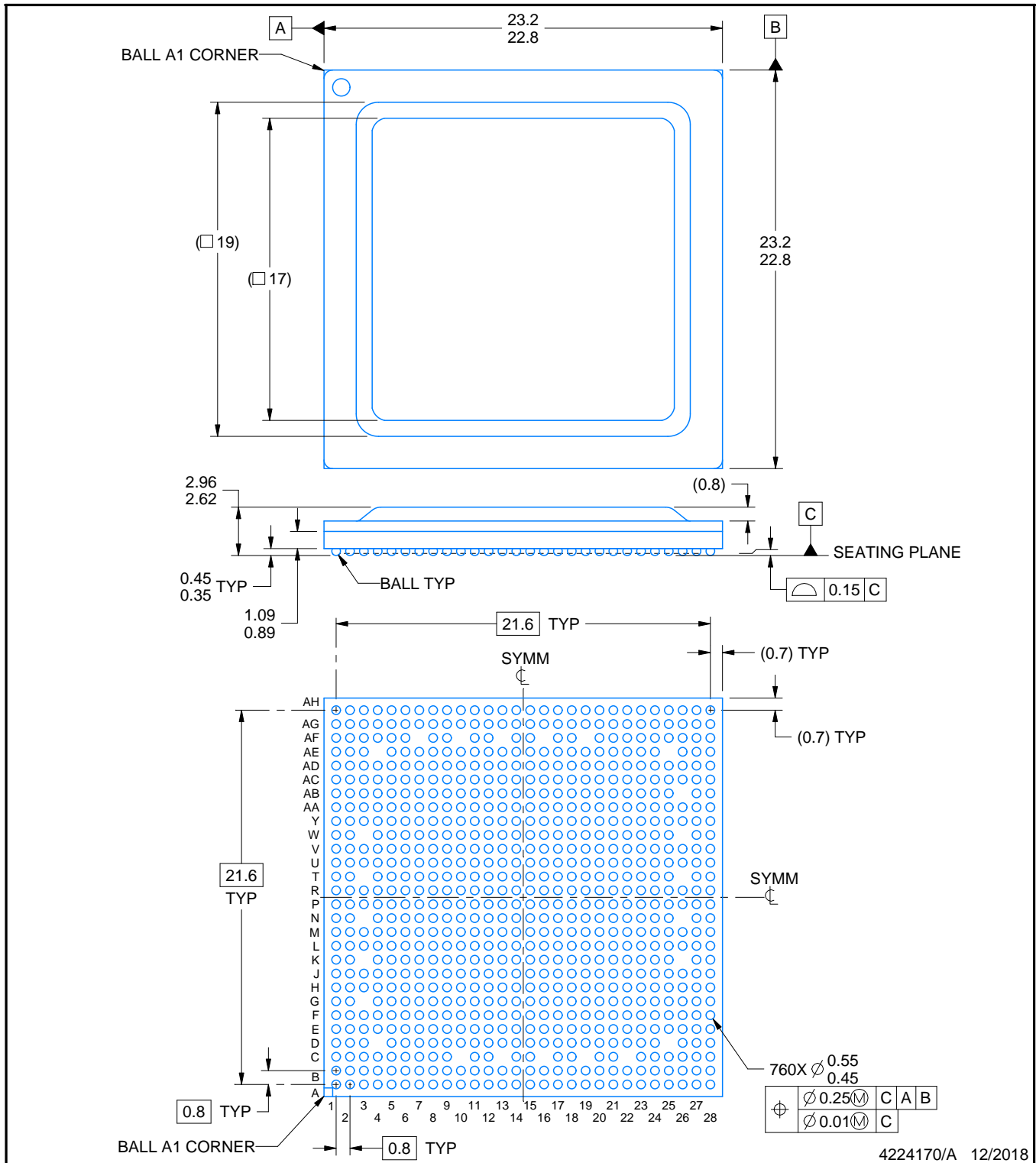
ABC0760A



PACKAGE OUTLINE

FCBGA - 2.96 mm max height

PLASTIC BALL GRID ARRAY



4224170/A 12/2018

NOTES:

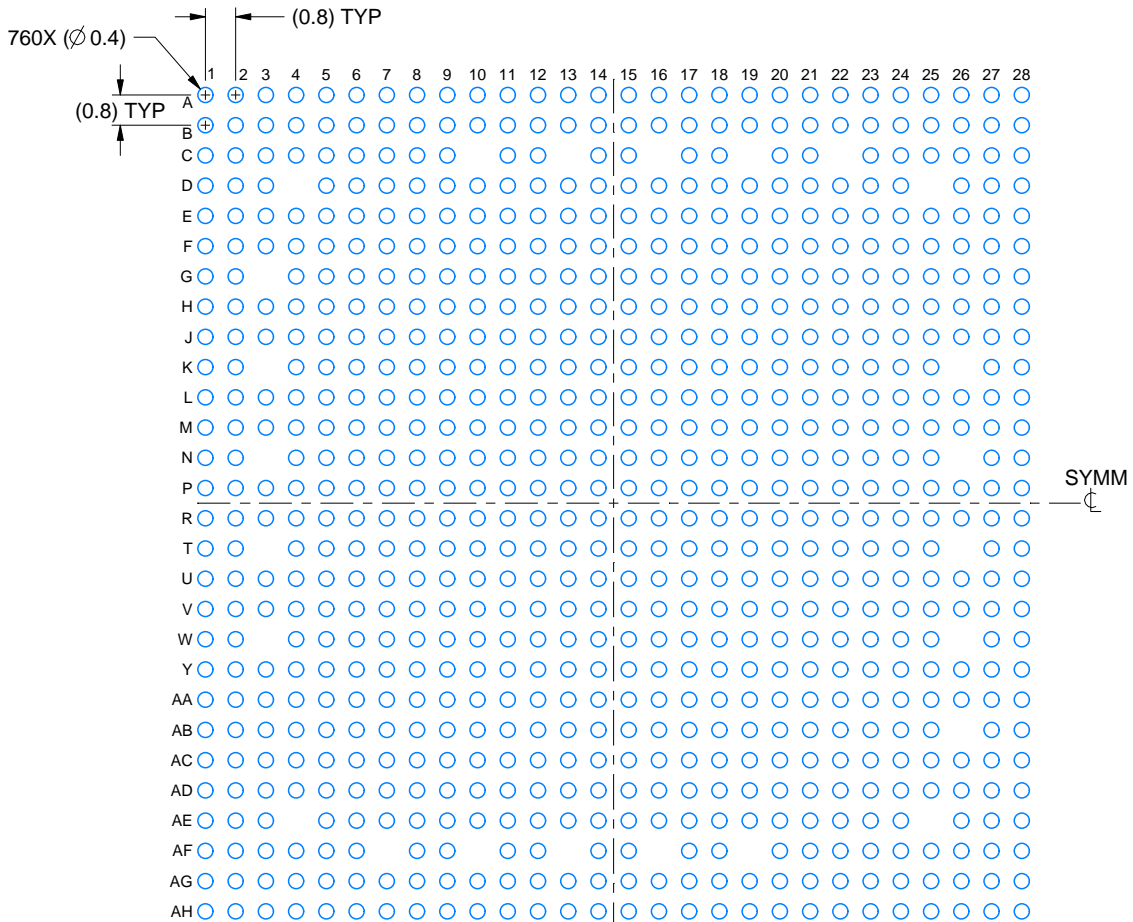
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

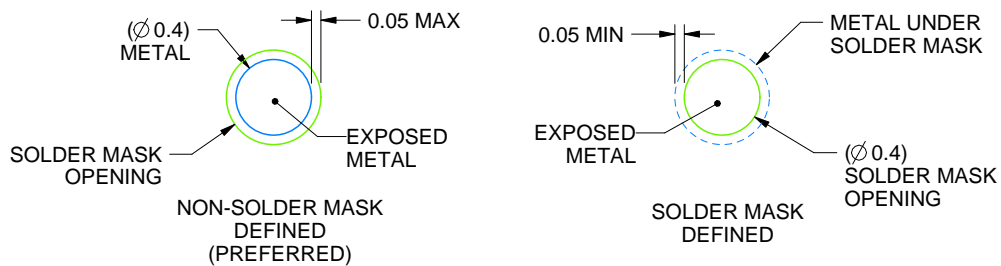
ABC0760A

FCBGA - 2.96 mm max height

PLASTIC BALL GRID ARRAY



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:5X



SOLDER MASK DETAILS
NOT TO SCALE

4224170/A 12/2018

NOTES: (continued)

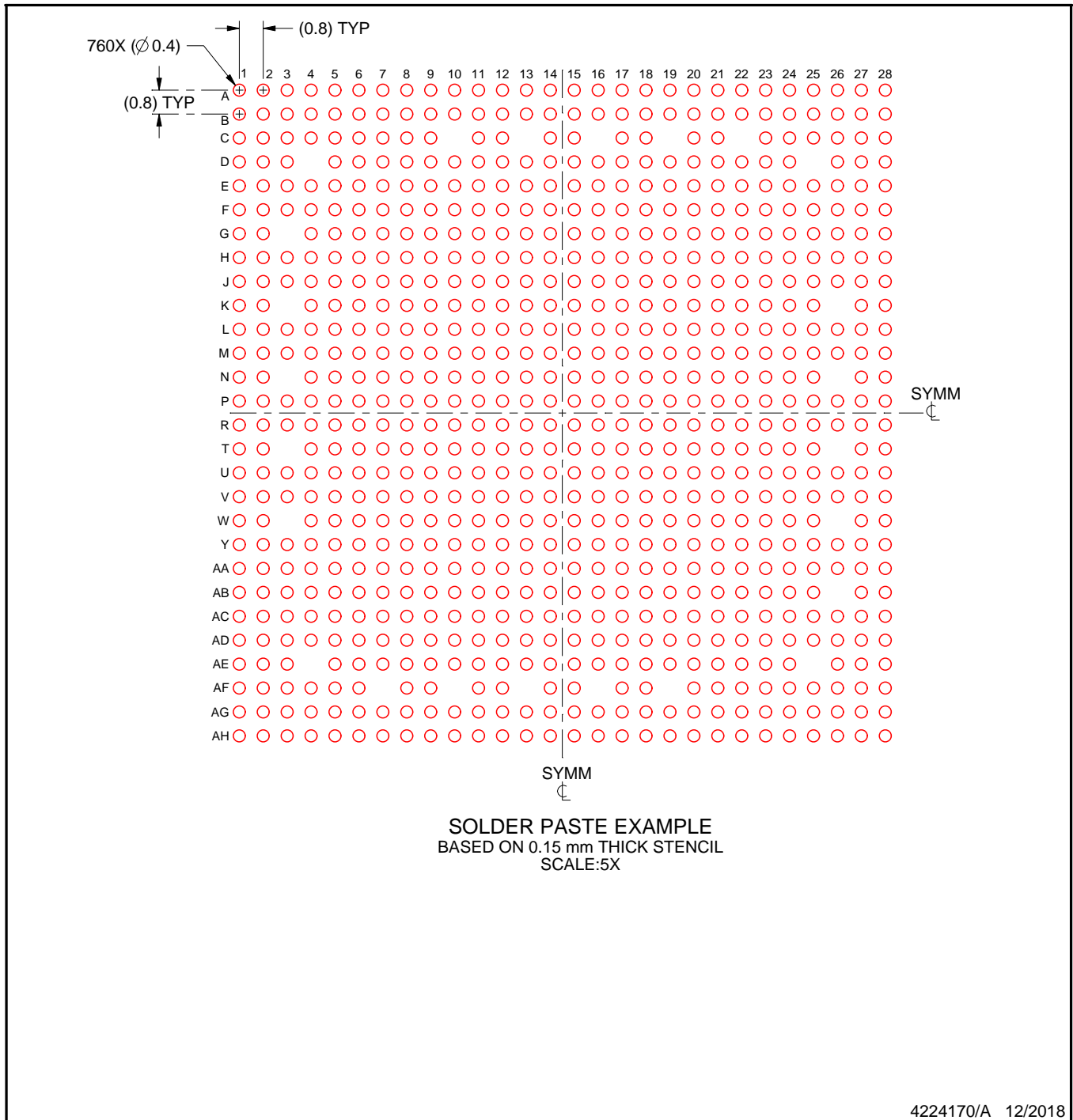
- Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For information, see Texas Instruments literature number SPRU811 (www.ti.com/lit/spru811).

EXAMPLE STENCIL DESIGN

ABC0760A

FCBGA - 2.96 mm max height

PLASTIC BALL GRID ARRAY



NOTES: (continued)

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

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