

# LS2044ASE7QQB Datasheet



|                              |   |
|------------------------------|---|
| DiGi Electronics Part Number | LS2044ASE7QQB-DG  |
| Manufacturer                 | <a href="#">NXP USA Inc.</a>  |
| Manufacturer Product Number  | LS2044ASE7QQB   |
| Description                  | IC MPU QORIQ 1.6GHZ 1292FCPBGA  |
| Detailed Description         | ARM® Cortex®-A72 Microprocessor IC QorIQ® Layers cape 4 Core, 64-Bit 1.6GHz 1292-FCPBGA (37.5x37.5) |

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## Purchase and inquiry

**Manufacturer Product Number:**

LS2044ASE7QQB

**Series:**

QorIQ® Layerscape

**Core Processor:**

ARM® Cortex®-A72

**Speed:**

1.6GHz

**RAM Controllers:**

DDR4

**Display & Interface Controllers:**

-

**SATA:**

SATA 6Gbps (2)

**Voltage - I/O:**

-

**Security Features:**

Secure Boot, TrustZone®

**Package / Case:**

1292-BBGA, FCBGA

**Additional Interfaces:**

eMMC/SD/SDIO, I2C, PCIe, SPI, UART

**Manufacturer:**

NXP USA Inc.

**Product Status:**

Active

**Number of Cores/Bus Width:**

4 Core, 64-Bit

**Co-Processors/DSP:**

-

**Graphics Acceleration:**

No

**Ethernet:**

10GbE (8), 1GbE (16), 2.5GbE (1)

**USB:**

USB 3.0 + PHY (2)

**Operating Temperature:**

0°C ~ 105°C (TA)

**Mounting Type:**

Surface Mount

**Supplier Device Package:**

1292-FCPBGA (37.5x37.5)

**Base Product Number:**

LS2044

## Environmental & Export classification

**RoHS Status:**

ROHS3 Compliant

**REACH Status:**

REACH Unaffected

**Moisture Sensitivity Level (MSL):**

3 (168 Hours)

# LS2084A

## QorIQ LS2084A/LS2044A Data Sheet

### Features

- 64-bit Arm® Cortex®-A72 CPUs
  - LS2084A has eight A72 cores arranged as four clusters. Each cluster has two cores sharing a 1 MB L2 cache
  - LS2044A has four A72 cores arranged as two clusters. Each cluster has two cores sharing a 1 MB L2 cache
  - Up to 2.1 GHz
- 1 MB platform cache with ECC protection
- Hierarchical interconnect fabric
- Two 64-bit DDR4 SDRAM memory controllers with ECC and interleaving support
  - Up to 2.1 GT/s
- DPAA2 (Datapath acceleration architecture, second generation) incorporating acceleration for the following functions:
  - Wire-rate IO Processor(WRIOP) for packet parsing, classification, and distribution
  - Queue management for scheduling, packet sequencing, and congestion management; Hardware buffer management for buffer allocation and de-allocation (QBMan)
  - Cryptography acceleration (SEC 5.2) at up to 20 Gbps
  - RegEx pattern matching acceleration (PME 2.0) at up to 10 Gbps
  - Decompression/compression acceleration (DCE 1.0) at up to 20 Gbps
- qDMA engine
- 16 SerDes lanes at up to 10.3125 GHz
- Ethernet interfaces
  - Up to eight 10 Gbps Ethernet MACs
  - Up to sixteen 1 / 2.5 Gbps Ethernet MACs
- High-speed peripheral interfaces
  - Four PCIe 3.0 controllers. PCIe3 is capable of x8/x4/x2/x1 and SR-IOV and the other three (PCIe1, PCIe2 and PCIe4) are capable of x4/x2/x1 and do not support SR-IOV.
  - At platform speeds of 533 MHz or higher, there is no limitation to PCIe speed/width
  - At platform speed less than 533 MHz, all four PCIe controllers can run GEN1 and GEN2 speed at full width. For GEN3 speed, PCIe1/PCIe2/PCIe4 can only run x2 width, PCIe3 can only run x4 width.
- Additional peripheral interfaces
  - Two serial ATA (SATA 3.0) controllers
  - Two high-speed USB 3.0 controllers with integrated PHY
  - Enhanced secure digital host controller
  - Serial peripheral interface (SPI) controller
  - Quad Serial peripheral interface (QSPI) controller
  - Four I2C controllers
  - Two DUARTs
  - Integrated flash controller (IFC 2.0) supporting NAND and NOR flash
- Support for hardware virtualization and partitioning enforcement
- Implements trust architecture combined with TrustZone®
  - Service processor (SP) provides pre-boot initialization and secure-boot capabilities
- Automotive AEC-Q100 Grade 3 qualified (105°C Tj)
  - Maximum CPU speed 1.8 GHz, maximum DDR data rate 1.8 GT/s

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## 1 Overview

The LS2084A and LS2044A have eight and four, respectively, Arm® Cortex®-A72 cores built on Armv8-A architecture with high-performance data path acceleration and network and peripheral bus interfaces required for networking, telecom/datacom, wireless infrastructure, and military/aerospace applications.

This chip can be used for combined control, data path, and application layer processing in routers, switches, gateways, and general-purpose embedded computing systems, including vehicle management servers, gateways, and Advanced Driver Assist Systems (ADAS). Its high level of integration offers significant performance benefits compared to multiple discrete devices, while also simplifying the board design.

This figure shows the block diagram of the chip.

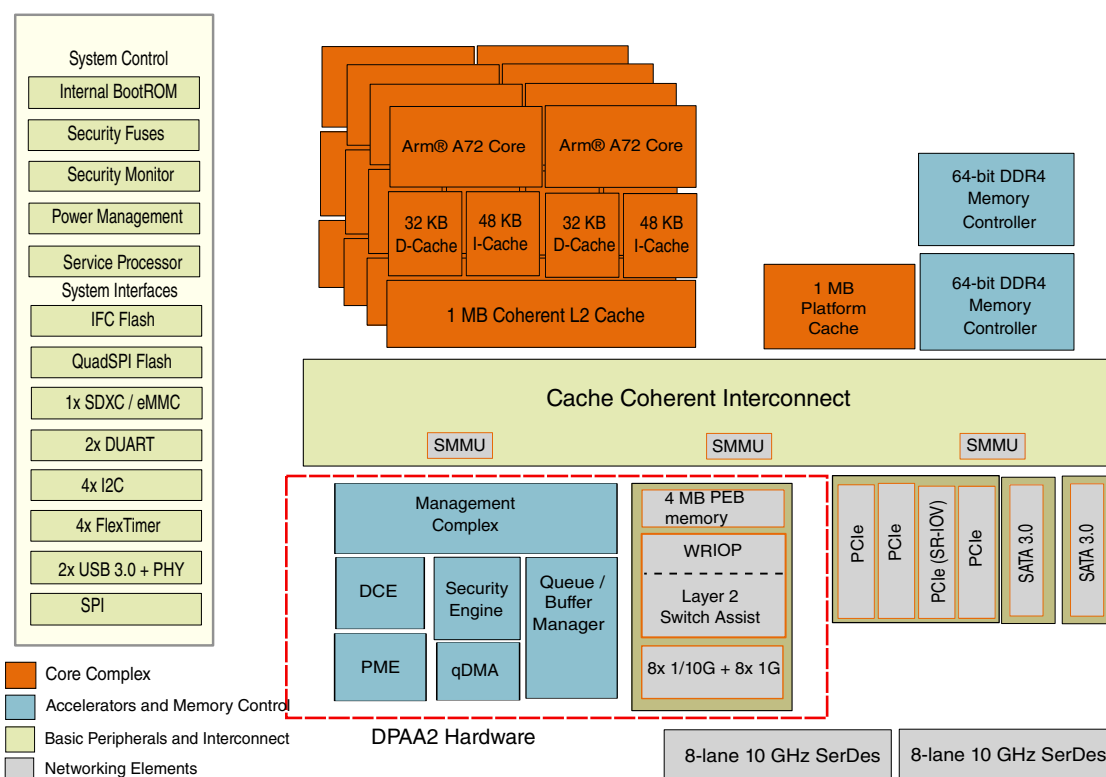


Figure 1. LS2084A block diagram

## 2 Pin assignments

## Pin assignments

### 2.1 1292 ball layout diagrams

This figure shows the complete view of the LS2084A ball map diagram. [Figure 3](#), [Figure 4](#), [Figure 5](#), and [Figure 6](#) show quadrant views.

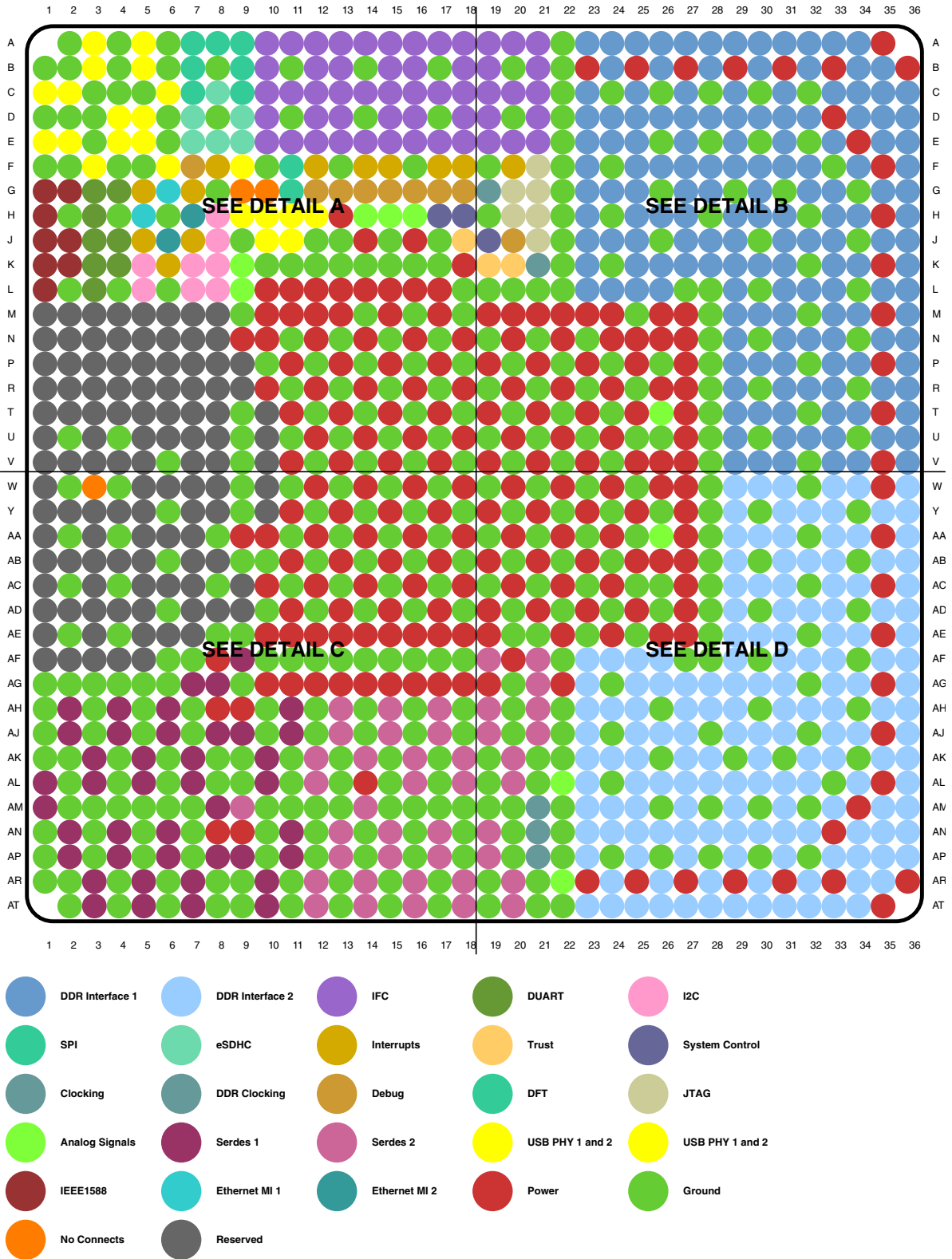
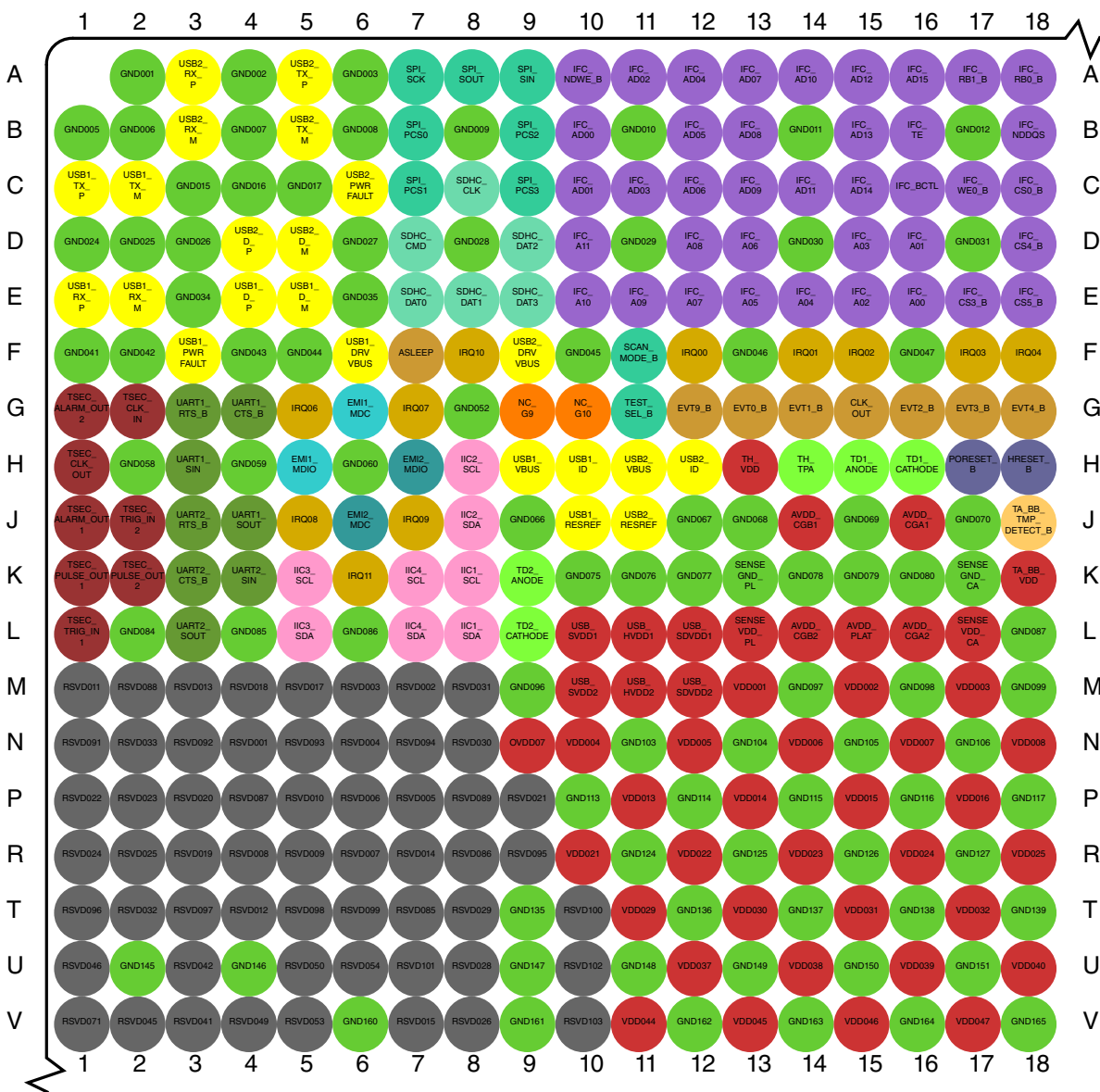


Figure 2. Complete BGA Map for the LS2084A

Pin assignments



|                 |                 |               |                 |                 |
|-----------------|-----------------|---------------|-----------------|-----------------|
| DDR Interface 1 | DDR Interface 2 | IFC           | DUART           | I2C             |
| SPI             | eSDHC           | Interrupts    | Trust           | System Control  |
| Clocking        | DDR Clocking    | Debug         | DFT             | JTAG            |
| Analog Signals  | Serdes 1        | Serdes 2      | USB PHY 1 and 2 | USB PHY 1 and 2 |
| IEEE1588        | Ethernet MI 1   | Ethernet MI 2 | Power           | Ground          |
| No Connects     | Reserved        |               |                 |                 |

Figure 3. Detail A

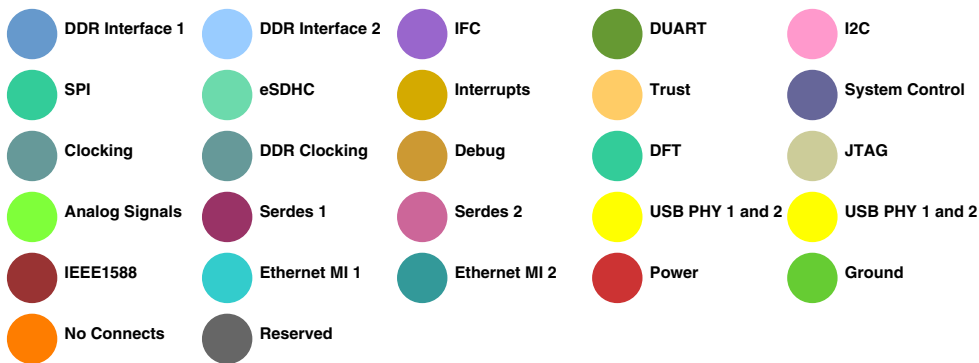
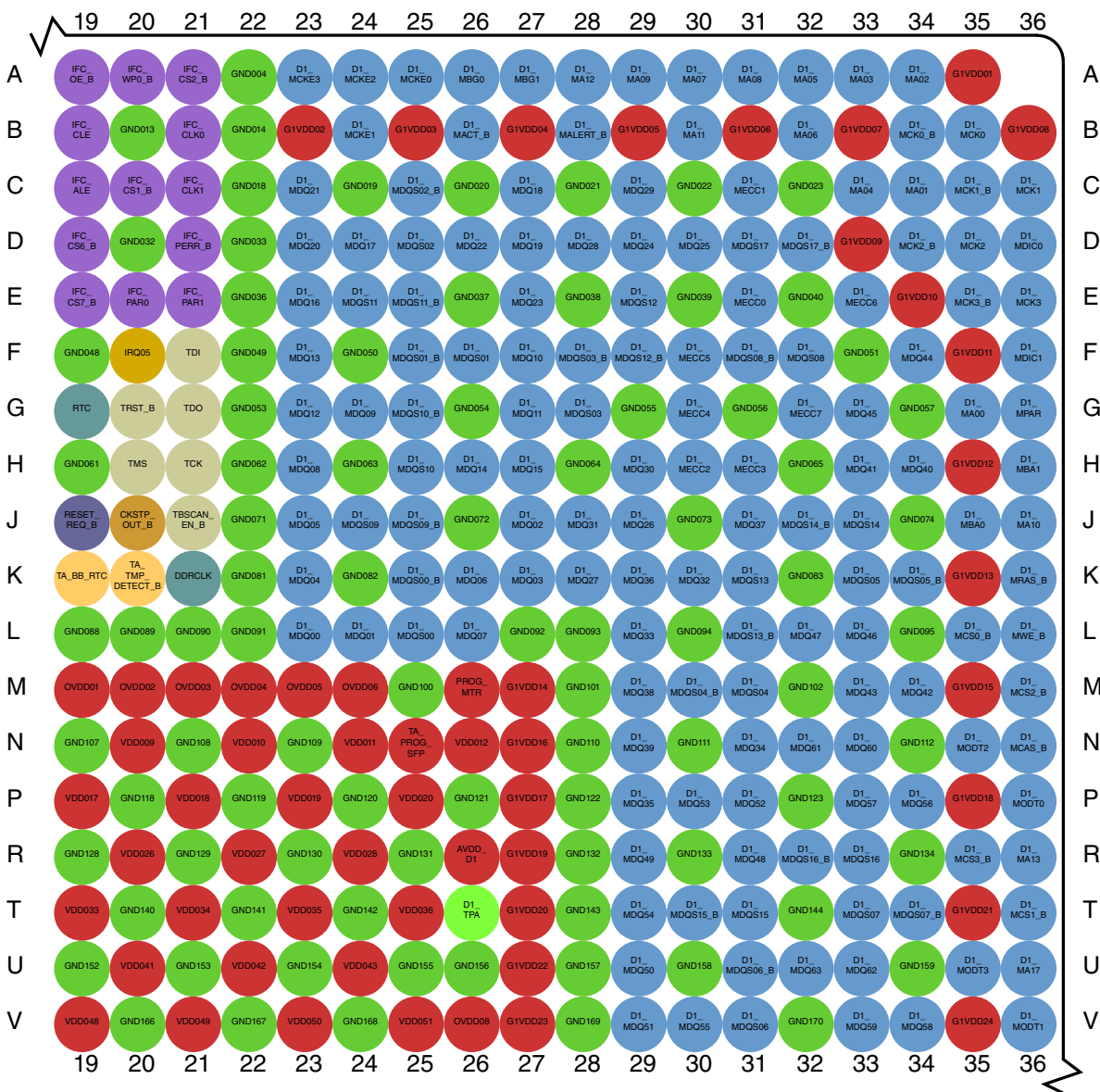


Figure 4. Detail B

Pin assignments

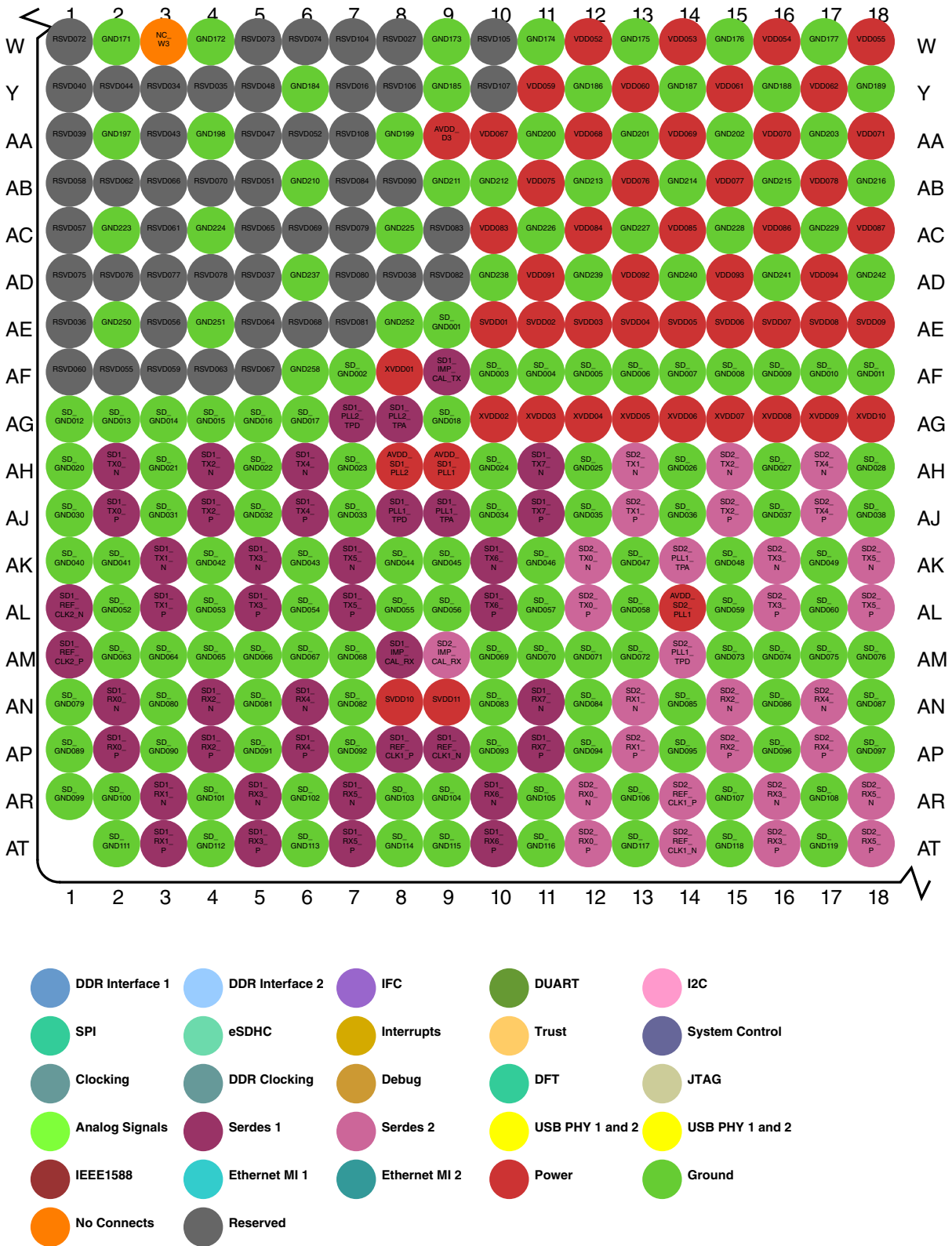


Figure 5. Detail C

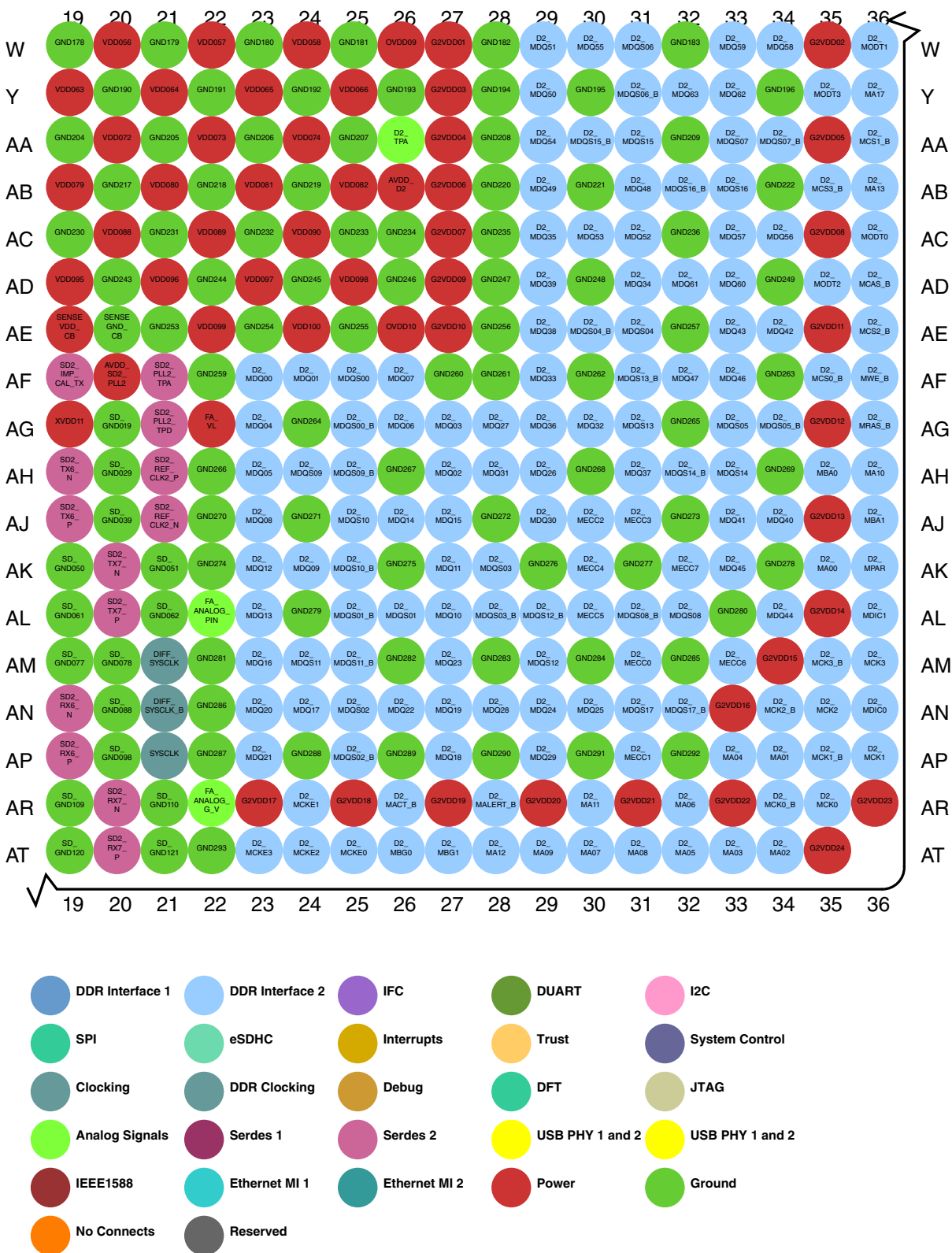


Figure 6. Detail D

## Pin assignments

## 2.2 Pinout list

This table provides the pinout listing for the LS2084A by bus. Primary functions are **bolded** in the table.

**Table 1. Pinout list by bus**

| Signal                              | Signal description             | Package pin number | Pin type | Power supply      | Notes |
|-------------------------------------|--------------------------------|--------------------|----------|-------------------|-------|
| <b>DDR SDRAM Memory Interface 1</b> |                                |                    |          |                   |       |
| <b>D1_MA00</b>                      | Address                        | G35                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA01</b>                      | Address                        | C34                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA02</b>                      | Address                        | A34                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA03</b>                      | Address                        | A33                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA04</b>                      | Address                        | C33                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA05</b>                      | Address                        | A32                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA06</b>                      | Address                        | B32                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA07</b>                      | Address                        | A30                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA08</b>                      | Address                        | A31                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA09</b>                      | Address                        | A29                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA10</b>                      | Address                        | J36                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA11</b>                      | Address                        | B30                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA12</b>                      | Address                        | A28                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA13</b>                      | Address                        | R36                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MA17</b>                      | Address                        | U36                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MACT_B</b>                    | Activate                       | B26                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MALERT_B</b>                  | Alert                          | B28                | I        | G1V <sub>DD</sub> | 1, 29 |
| <b>D1_MBA0</b>                      | Bank Select                    | J35                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MBA1</b>                      | Bank Select                    | H36                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MBG0</b>                      | Bank Group                     | A26                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MBG1</b>                      | Bank Group                     | A27                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MCAS_B</b>                    | Column Address Strobe / MA[15] | N36                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MCK0</b>                      | Clock                          | B35                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MCK0_B</b>                    | Clock Complement               | B34                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MCK1</b>                      | Clock                          | C36                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MCK1_B</b>                    | Clock Complement               | C35                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MCK2</b>                      | Clock                          | D35                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MCK2_B</b>                    | Clock Complement               | D34                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MCK3</b>                      | Clock                          | E36                | O        | G1V <sub>DD</sub> | ---   |
| <b>D1_MCK3_B</b>                    | Clock Complement               | E35                | O        | G1V <sub>DD</sub> | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal            | Signal description           | Package pin number | Pin type | Power supply      | Notes |
|-------------------|------------------------------|--------------------|----------|-------------------|-------|
| D1_MCKE0          | Clock Enable                 | A25                | O        | G1V <sub>DD</sub> | 2     |
| D1_MCKE1          | Clock Enable                 | B24                | O        | G1V <sub>DD</sub> | 2     |
| D1_MCKE2          | Clock Enable                 | A24                | O        | G1V <sub>DD</sub> | 2     |
| D1_MCKE3          | Clock Enable                 | A23                | O        | G1V <sub>DD</sub> | 2     |
| D1_MCS0_B         | Chip Select                  | L35                | O        | G1V <sub>DD</sub> | ---   |
| D1_MCS1_B         | Chip Select                  | T36                | O        | G1V <sub>DD</sub> | ---   |
| D1_MCS2_B         | Chip Select / MCID[0]        | M36                | O        | G1V <sub>DD</sub> | ---   |
| D1_MCS3_B         | Chip Select / MCID[1]        | R35                | O        | G1V <sub>DD</sub> | ---   |
| D1_MDIC0          | Driver Impedance Calibration | D36                | IO       | G1V <sub>DD</sub> | 3     |
| D1_MDIC1          | Driver Impedance Calibration | F36                | IO       | G1V <sub>DD</sub> | 3     |
| D1_MDM0/D1_MDQS09 | Data Mask                    | J24                | O        | G1V <sub>DD</sub> | 1     |
| D1_MDM1/D1_MDQS10 | Data Mask                    | H25                | O        | G1V <sub>DD</sub> | 1     |
| D1_MDM2/D1_MDQS11 | Data Mask                    | E24                | O        | G1V <sub>DD</sub> | 1     |
| D1_MDM3/D1_MDQS12 | Data Mask                    | E29                | O        | G1V <sub>DD</sub> | 1     |
| D1_MDM4/D1_MDQS13 | Data Mask                    | K31                | O        | G1V <sub>DD</sub> | 1     |
| D1_MDM5/D1_MDQS14 | Data Mask                    | J33                | O        | G1V <sub>DD</sub> | 1     |
| D1_MDM6/D1_MDQS15 | Data Mask                    | T31                | O        | G1V <sub>DD</sub> | 1     |
| D1_MDM7/D1_MDQS16 | Data Mask                    | R33                | O        | G1V <sub>DD</sub> | 1     |
| D1_MDM8/D1_MDQS17 | Data Mask                    | D31                | O        | G1V <sub>DD</sub> | 1     |
| D1_MDQ00          | Data                         | L23                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ01          | Data                         | L24                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ02          | Data                         | J27                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ03          | Data                         | K27                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ04          | Data                         | K23                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ05          | Data                         | J23                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ06          | Data                         | K26                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ07          | Data                         | L26                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ08          | Data                         | H23                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ09          | Data                         | G24                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ10          | Data                         | F27                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ11          | Data                         | G27                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ12          | Data                         | G23                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ13          | Data                         | F23                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ14          | Data                         | H26                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ15          | Data                         | H27                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ16          | Data                         | E23                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ17          | Data                         | D24                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ18          | Data                         | C27                | IO       | G1V <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal   | Signal description | Package pin number | Pin type | Power supply      | Notes |
|----------|--------------------|--------------------|----------|-------------------|-------|
| D1_MDQ19 | Data               | D27                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ20 | Data               | D23                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ21 | Data               | C23                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ22 | Data               | D26                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ23 | Data               | E27                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ24 | Data               | D29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ25 | Data               | D30                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ26 | Data               | J29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ27 | Data               | K28                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ28 | Data               | D28                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ29 | Data               | C29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ30 | Data               | H29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ31 | Data               | J28                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ32 | Data               | K30                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ33 | Data               | L29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ34 | Data               | N31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ35 | Data               | P29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ36 | Data               | K29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ37 | Data               | J31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ38 | Data               | M29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ39 | Data               | N29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ40 | Data               | H34                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ41 | Data               | H33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ42 | Data               | M34                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ43 | Data               | M33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ44 | Data               | F34                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ45 | Data               | G33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ46 | Data               | L33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ47 | Data               | L32                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ48 | Data               | R31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ49 | Data               | R29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ50 | Data               | U29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ51 | Data               | V29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ52 | Data               | P31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ53 | Data               | P30                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ54 | Data               | T29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ55 | Data               | V30                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ56 | Data               | P34                | IO       | G1V <sub>DD</sub> | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal            | Signal description       | Package pin number | Pin type | Power supply      | Notes |
|-------------------|--------------------------|--------------------|----------|-------------------|-------|
| D1_MDQ57          | Data                     | P33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ58          | Data                     | V34                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ59          | Data                     | V33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ60          | Data                     | N33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ61          | Data                     | N32                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ62          | Data                     | U33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQ63          | Data                     | U32                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS00         | Data Strobe              | L25                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS00_B       | Data Strobe              | K25                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS01         | Data Strobe              | F26                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS01_B       | Data Strobe              | F25                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS02         | Data Strobe              | D25                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS02_B       | Data Strobe              | C25                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS03         | Data Strobe              | G28                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS03_B       | Data Strobe              | F28                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS04         | Data Strobe              | M31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS04_B       | Data Strobe              | M30                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS05         | Data Strobe              | K33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS05_B       | Data Strobe              | K34                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS06         | Data Strobe              | V31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS06_B       | Data Strobe              | U31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS07         | Data Strobe              | T33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS07_B       | Data Strobe              | T34                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS08         | Data Strobe              | F32                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS08_B       | Data Strobe              | F31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS09/D1_MDM0 | Data Strobe (x4 support) | J24                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS09_B       | Data Strobe (x4 support) | J25                | IO       | G1V <sub>DD</sub> | 18    |
| D1_MDQS10/D1_MDM1 | Data Strobe (x4 support) | H25                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS10_B       | Data Strobe (x4 support) | G25                | IO       | G1V <sub>DD</sub> | 18    |
| D1_MDQS11/D1_MDM2 | Data Strobe (x4 support) | E24                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS11_B       | Data Strobe (x4 support) | E25                | IO       | G1V <sub>DD</sub> | 18    |
| D1_MDQS12/D1_MDM3 | Data Strobe (x4 support) | E29                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS12_B       | Data Strobe (x4 support) | F29                | IO       | G1V <sub>DD</sub> | 18    |
| D1_MDQS13/D1_MDM4 | Data Strobe (x4 support) | K31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS13_B       | Data Strobe (x4 support) | L31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS14/D1_MDM5 | Data Strobe (x4 support) | J33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS14_B       | Data Strobe (x4 support) | J32                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS15/D1_MDM6 | Data Strobe (x4 support) | T31                | IO       | G1V <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal                              | Signal description           | Package pin number | Pin type | Power supply      | Notes |
|-------------------------------------|------------------------------|--------------------|----------|-------------------|-------|
| D1_MDQS15_B                         | Data Strobe (x4 support)     | T30                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS16/D1_MDM7                   | Data Strobe (x4 support)     | R33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS16_B                         | Data Strobe (x4 support)     | R32                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS17/D1_MDM8                   | Data Strobe (x4 support)     | D31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MDQS17_B                         | Data Strobe (x4 support)     | D32                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MECC0                            | Error Correcting Code        | E31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MECC1                            | Error Correcting Code        | C31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MECC2                            | Error Correcting Code        | H30                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MECC3                            | Error Correcting Code        | H31                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MECC4                            | Error Correcting Code        | G30                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MECC5                            | Error Correcting Code        | F30                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MECC6                            | Error Correcting Code        | E33                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MECC7                            | Error Correcting Code        | G32                | IO       | G1V <sub>DD</sub> | ---   |
| D1_MODT0                            | On Die Termination           | P36                | O        | G1V <sub>DD</sub> | 2     |
| D1_MODT1                            | On Die Termination / MCID[2] | V36                | O        | G1V <sub>DD</sub> | 2     |
| D1_MODT2                            | On Die Termination           | N35                | O        | G1V <sub>DD</sub> | 2     |
| D1_MODT3                            | On Die Termination           | U35                | O        | G1V <sub>DD</sub> | 2     |
| D1_MPAR                             | Address Parity Out           | G36                | O        | G1V <sub>DD</sub> | ---   |
| D1_MRAS_B                           | Row Address Strobe / MA[16]  | K36                | O        | G1V <sub>DD</sub> | ---   |
| D1_MWE_B                            | Write Enable / MA[14]        | L36                | O        | G1V <sub>DD</sub> | ---   |
| <b>DDR SDRAM Memory Interface 2</b> |                              |                    |          |                   |       |
| D2_MA00                             | Address                      | AK35               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA01                             | Address                      | AP34               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA02                             | Address                      | AT34               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA03                             | Address                      | AT33               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA04                             | Address                      | AP33               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA05                             | Address                      | AT32               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA06                             | Address                      | AR32               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA07                             | Address                      | AT30               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA08                             | Address                      | AT31               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA09                             | Address                      | AT29               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA10                             | Address                      | AH36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA11                             | Address                      | AR30               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA12                             | Address                      | AT28               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA13                             | Address                      | AB36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MA17                             | Address                      | Y36                | O        | G2V <sub>DD</sub> | ---   |
| D2_MACT_B                           | Activate                     | AR26               | O        | G2V <sub>DD</sub> | ---   |
| D2_MALERT_B                         | Alert                        | AR28               | I        | G2V <sub>DD</sub> | 1, 29 |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal            | Signal description             | Package pin number | Pin type | Power supply      | Notes |
|-------------------|--------------------------------|--------------------|----------|-------------------|-------|
| D2_MBA0           | Bank Select                    | AH35               | O        | G2V <sub>DD</sub> | ---   |
| D2_MBA1           | Bank Select                    | AJ36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MBG0           | Bank Group                     | AT26               | O        | G2V <sub>DD</sub> | ---   |
| D2_MBG1           | Bank Group                     | AT27               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCAS_B         | Column Address Strobe / MA[15] | AD36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCK0           | Clock                          | AR35               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCK0_B         | Clock Complement               | AR34               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCK1           | Clock                          | AP36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCK1_B         | Clock Complement               | AP35               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCK2           | Clock                          | AN35               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCK2_B         | Clock Complement               | AN34               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCK3           | Clock                          | AM36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCK3_B         | Clock Complement               | AM35               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCKE0          | Clock Enable                   | AT25               | O        | G2V <sub>DD</sub> | 2     |
| D2_MCKE1          | Clock Enable                   | AR24               | O        | G2V <sub>DD</sub> | 2     |
| D2_MCKE2          | Clock Enable                   | AT24               | O        | G2V <sub>DD</sub> | 2     |
| D2_MCKE3          | Clock Enable                   | AT23               | O        | G2V <sub>DD</sub> | 2     |
| D2_MCS0_B         | Chip Select                    | AF35               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCS1_B         | Chip Select                    | AA36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCS2_B         | Chip Select / MCID[0]          | AE36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MCS3_B         | Chip Select / MCID[1]          | AB35               | O        | G2V <sub>DD</sub> | ---   |
| D2_MDIC0          | Driver Impedance Calibration   | AN36               | IO       | G2V <sub>DD</sub> | 3     |
| D2_MDIC1          | Driver Impedance Calibration   | AL36               | IO       | G2V <sub>DD</sub> | 3     |
| D2_MDM0/D2_MDQS09 | Data Mask                      | AH24               | O        | G2V <sub>DD</sub> | 1     |
| D2_MDM1/D2_MDQS10 | Data Mask                      | AJ25               | O        | G2V <sub>DD</sub> | 1     |
| D2_MDM2/D2_MDQS11 | Data Mask                      | AM24               | O        | G2V <sub>DD</sub> | 1     |
| D2_MDM3/D2_MDQS12 | Data Mask                      | AM29               | O        | G2V <sub>DD</sub> | 1     |
| D2_MDM4/D2_MDQS13 | Data Mask                      | AG31               | O        | G2V <sub>DD</sub> | 1     |
| D2_MDM5/D2_MDQS14 | Data Mask                      | AH33               | O        | G2V <sub>DD</sub> | 1     |
| D2_MDM6/D2_MDQS15 | Data Mask                      | AA31               | O        | G2V <sub>DD</sub> | 1     |
| D2_MDM7/D2_MDQS16 | Data Mask                      | AB33               | O        | G2V <sub>DD</sub> | 1     |
| D2_MDM8/D2_MDQS17 | Data Mask                      | AN31               | O        | G2V <sub>DD</sub> | 1     |
| D2_MDQ00          | Data                           | AF23               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ01          | Data                           | AF24               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ02          | Data                           | AH27               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ03          | Data                           | AG27               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ04          | Data                           | AG23               | IO       | G2V <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal   | Signal description | Package pin number | Pin type | Power supply      | Notes |
|----------|--------------------|--------------------|----------|-------------------|-------|
| D2_MDQ05 | Data               | AH23               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ06 | Data               | AG26               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ07 | Data               | AF26               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ08 | Data               | AJ23               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ09 | Data               | AK24               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ10 | Data               | AL27               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ11 | Data               | AK27               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ12 | Data               | AK23               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ13 | Data               | AL23               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ14 | Data               | AJ26               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ15 | Data               | AJ27               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ16 | Data               | AM23               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ17 | Data               | AN24               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ18 | Data               | AP27               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ19 | Data               | AN27               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ20 | Data               | AN23               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ21 | Data               | AP23               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ22 | Data               | AN26               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ23 | Data               | AM27               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ24 | Data               | AN29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ25 | Data               | AN30               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ26 | Data               | AH29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ27 | Data               | AG28               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ28 | Data               | AN28               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ29 | Data               | AP29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ30 | Data               | AJ29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ31 | Data               | AH28               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ32 | Data               | AG30               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ33 | Data               | AF29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ34 | Data               | AD31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ35 | Data               | AC29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ36 | Data               | AG29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ37 | Data               | AH31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ38 | Data               | AE29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ39 | Data               | AD29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ40 | Data               | AJ34               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ41 | Data               | AJ33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ42 | Data               | AE34               | IO       | G2V <sub>DD</sub> | ---   |

Table continues on the next page...

Table 1. Pinout list by bus (continued)

| Signal      | Signal description | Package pin number | Pin type | Power supply      | Notes |
|-------------|--------------------|--------------------|----------|-------------------|-------|
| D2_MDQ43    | Data               | AE33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ44    | Data               | AL34               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ45    | Data               | AK33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ46    | Data               | AF33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ47    | Data               | AF32               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ48    | Data               | AB31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ49    | Data               | AB29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ50    | Data               | Y29                | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ51    | Data               | W29                | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ52    | Data               | AC31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ53    | Data               | AC30               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ54    | Data               | AA29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ55    | Data               | W30                | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ56    | Data               | AC34               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ57    | Data               | AC33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ58    | Data               | W34                | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ59    | Data               | W33                | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ60    | Data               | AD33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ61    | Data               | AD32               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ62    | Data               | Y33                | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQ63    | Data               | Y32                | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS00   | Data Strobe        | AF25               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS00_B | Data Strobe        | AG25               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS01   | Data Strobe        | AL26               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS01_B | Data Strobe        | AL25               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS02   | Data Strobe        | AN25               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS02_B | Data Strobe        | AP25               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS03   | Data Strobe        | AK28               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS03_B | Data Strobe        | AL28               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS04   | Data Strobe        | AE31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS04_B | Data Strobe        | AE30               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS05   | Data Strobe        | AG33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS05_B | Data Strobe        | AG34               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS06   | Data Strobe        | W31                | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS06_B | Data Strobe        | Y31                | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS07   | Data Strobe        | AA33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS07_B | Data Strobe        | AA34               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS08   | Data Strobe        | AL32               | IO       | G2V <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal                             | Signal description           | Package pin number | Pin type | Power supply      | Notes |
|------------------------------------|------------------------------|--------------------|----------|-------------------|-------|
| D2_MDQS08_B                        | Data Strobe                  | AL31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS09/D2_MDM0                  | Data Strobe (x4 support)     | AH24               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS09_B                        | Data Strobe (x4 support)     | AH25               | IO       | G2V <sub>DD</sub> | 18    |
| D2_MDQS10/D2_MDM1                  | Data Strobe (x4 support)     | AJ25               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS10_B                        | Data Strobe (x4 support)     | AK25               | IO       | G2V <sub>DD</sub> | 18    |
| D2_MDQS11/D2_MDM2                  | Data Strobe (x4 support)     | AM24               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS11_B                        | Data Strobe (x4 support)     | AM25               | IO       | G2V <sub>DD</sub> | 18    |
| D2_MDQS12/D2_MDM3                  | Data Strobe (x4 support)     | AM29               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS12_B                        | Data Strobe (x4 support)     | AL29               | IO       | G2V <sub>DD</sub> | 18    |
| D2_MDQS13/D2_MDM4                  | Data Strobe (x4 support)     | AG31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS13_B                        | Data Strobe (x4 support)     | AF31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS14/D2_MDM5                  | Data Strobe (x4 support)     | AH33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS14_B                        | Data Strobe (x4 support)     | AH32               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS15/D2_MDM6                  | Data Strobe (x4 support)     | AA31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS15_B                        | Data Strobe (x4 support)     | AA30               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS16/D2_MDM7                  | Data Strobe (x4 support)     | AB33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS16_B                        | Data Strobe (x4 support)     | AB32               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS17/D2_MDM8                  | Data Strobe (x4 support)     | AN31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MDQS17_B                        | Data Strobe (x4 support)     | AN32               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MECC0                           | Error Correcting Code        | AM31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MECC1                           | Error Correcting Code        | AP31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MECC2                           | Error Correcting Code        | AJ30               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MECC3                           | Error Correcting Code        | AJ31               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MECC4                           | Error Correcting Code        | AK30               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MECC5                           | Error Correcting Code        | AL30               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MECC6                           | Error Correcting Code        | AM33               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MECC7                           | Error Correcting Code        | AK32               | IO       | G2V <sub>DD</sub> | ---   |
| D2_MODT0                           | On Die Termination           | AC36               | O        | G2V <sub>DD</sub> | 2     |
| D2_MODT1                           | On Die Termination / MCID[2] | W36                | O        | G2V <sub>DD</sub> | 2     |
| D2_MODT2                           | On Die Termination           | AD35               | O        | G2V <sub>DD</sub> | 2     |
| D2_MODT3                           | On Die Termination           | Y35                | O        | G2V <sub>DD</sub> | 2     |
| D2_MPAR                            | Address Parity Out           | AK36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MRAS_B                          | Row Address Strobe / MA[16]  | AG36               | O        | G2V <sub>DD</sub> | ---   |
| D2_MWE_B                           | Write Enable / MA[14]        | AF36               | O        | G2V <sub>DD</sub> | ---   |
| <b>Integrated Flash Controller</b> |                              |                    |          |                   |       |
| IFC_A00/GPIO1_16/<br>QSPI_A_CS0    | IFC Address                  | E16                | O        | OV <sub>DD</sub>  | 1, 5  |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal  | Signal description | Package pin number | Pin type | Power supply     | Notes |
|---|--------------------|--------------------|----------|------------------|-------|
| <b>IFC_A01</b> /GPIO1_17/<br>QSPI_A_CS1             | IFC Address        | D16                | O        | OV <sub>DD</sub> | 1, 5  |
| <b>IFC_A02</b> /GPIO1_18/<br>QSPI_A_SCK             | IFC Address        | E15                | O        | OV <sub>DD</sub> | 1, 5  |
| <b>IFC_A03</b> /GPIO1_19/<br>QSPI_B_CS0             | IFC Address        | D15                | O        | OV <sub>DD</sub> | 1, 5  |
| <b>IFC_A04</b> /GPIO1_20/<br>QSPI_B_CS1             | IFC Address        | E14                | O        | OV <sub>DD</sub> | 1, 5  |
| <b>IFC_A05</b> /GPIO1_21/<br>QSPI_B_SCK             | IFC Address        | E13                | O        | OV <sub>DD</sub> | 1, 5  |
| <b>IFC_A06</b> /GPIO2_00/<br>IFC_WP1_B/QSPI_A_DATA0 | IFC Address        | D13                | O        | OV <sub>DD</sub> | 1     |
| <b>IFC_A07</b> /GPIO2_01/<br>IFC_WP2_B/QSPI_A_DATA1 | IFC Address        | E12                | O        | OV <sub>DD</sub> | 1     |
| <b>IFC_A08</b> /GPIO2_02/<br>IFC_WP3_B/QSPI_A_DATA2 | IFC Address        | D12                | O        | OV <sub>DD</sub> | 1     |
| <b>IFC_A09</b> /GPIO2_03/<br>IFC_RB2_B/QSPI_A_DATA3 | IFC Address        | E11                | O        | OV <sub>DD</sub> | 1     |
| <b>IFC_A10</b> /GPIO2_04/<br>IFC_RB3_B/QSPI_A_DQS   | IFC Address        | E10                | O        | OV <sub>DD</sub> | 1     |
| <b>IFC_A11</b> /GPIO2_05/<br>IFC_RB4_B/QSPI_B_DQS   | IFC Address        | D10                | O        | OV <sub>DD</sub> | 1     |
| <b>IFC_AD00</b> /GPIO1_00/<br>cfg_gpininput00       | IFC Address / Data | B10                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD01</b> /GPIO1_01/<br>cfg_gpininput01       | IFC Address / Data | C10                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD02</b> /GPIO1_02/<br>cfg_gpininput02       | IFC Address / Data | A11                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD03</b> /GPIO1_03/<br>cfg_gpininput03       | IFC Address / Data | C11                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD04</b> /GPIO1_04/<br>cfg_gpininput04       | IFC Address / Data | A12                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD05</b> /GPIO1_05/<br>cfg_gpininput05       | IFC Address / Data | B12                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD06</b> /GPIO1_06/<br>cfg_gpininput06       | IFC Address / Data | C12                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD07</b> /GPIO1_07/<br>cfg_gpininput07       | IFC Address / Data | A13                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD08</b> /GPIO1_08/<br>cfg_rcw_src01         | IFC Address / Data | B13                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD09</b> /GPIO1_09/<br>cfg_rcw_src02         | IFC Address / Data | C13                | IO       | OV <sub>DD</sub> | 9     |
| <b>IFC_AD10</b> /GPIO1_10/<br>cfg_rcw_src03         | IFC Address / Data | A14                | IO       | OV <sub>DD</sub> | 9     |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal  | Signal description  | Package pin number | Pin type | Power supply     | Notes |
|---|---|--------------------|----------|------------------|-------|
| IFC_AD11/GPIO1_11/<br>cfg_rcw_src04                   | IFC Address / Data  | C14                | IO       | OV <sub>DD</sub> | 9     |
| IFC_AD12/GPIO1_12/<br>cfg_rcw_src05                   | IFC Address / Data  | A15                | IO       | OV <sub>DD</sub> | 9     |
| IFC_AD13/GPIO1_13/<br>cfg_rcw_src06                   | IFC Address / Data  | B15                | IO       | OV <sub>DD</sub> | 9     |
| IFC_AD14/GPIO1_14/<br>cfg_rcw_src07                   | IFC Address / Data  | C15                | IO       | OV <sub>DD</sub> | 9     |
| IFC_AD15/GPIO1_15/<br>cfg_rcw_src08                   | IFC Address / Data  | A16                | IO       | OV <sub>DD</sub> | 9     |
| IFC_ALE/GPIO1_24                                      | IFC Address Latch Enable  | C19                | O        | OV <sub>DD</sub> | 1, 5  |
| IFC_BCTL/GPIO2_12                                     | IFC Buffer control  | C16                | O        | OV <sub>DD</sub> | 1     |
| IFC_CLE/GPIO1_25/<br>cfg_rcw_src0                     | IFC NAND Command Latch Enable / Write Enable 1 / NOR Address active-low Valid | B19                | O        | OV <sub>DD</sub> | 1, 4  |
| IFC_CLK0/GPIO2_17                                     | IFC Clock   | B21                | O        | OV <sub>DD</sub> | 1     |
| IFC_CLK1/GPIO2_18                                     | IFC Clock   | C21                | O        | OV <sub>DD</sub> | 1     |
| IFC_CS0_B/GPIO2_08                                    | IFC Chip Select   | C18                | O        | OV <sub>DD</sub> | 1, 6  |
| IFC_CS1_B/GPIO2_09                                    | IFC Chip Select   | C20                | O        | OV <sub>DD</sub> | 1, 6  |
| IFC_CS2_B/GPIO2_10                                    | IFC Chip Select   | A21                | O        | OV <sub>DD</sub> | 1, 6  |
| IFC_CS3_B/GPIO2_11/<br>QSPI_B_DATA3/<br>QSPI_A_DATA7  | IFC Chip Select   | E17                | O        | OV <sub>DD</sub> | 1, 6  |
| IFC_CS4_B/GPIO3_02                                    | IFC Chip Select   | D18                | O        | OV <sub>DD</sub> | 1, 6  |
| IFC_CS5_B/GPIO3_03                                    | IFC Chip Select   | E18                | O        | OV <sub>DD</sub> | 1, 6  |
| IFC_CS6_B/GPIO3_04                                    | IFC Chip Select   | D19                | O        | OV <sub>DD</sub> | 1, 6  |
| IFC_CS7_B/GPIO3_05                                    | IFC Chip Select   | E19                | O        | OV <sub>DD</sub> | 1, 6  |
| IFC_NDDQS/GPIO2_13                                    | IFC DQS Strobe  | B18                | IO       | OV <sub>DD</sub> | 9     |
| IFC_NDWE_B/GPIO2_19                                   | IFC NAND Write Enable / NAND DDR Clock  | A10                | O        | OV <sub>DD</sub> | 1     |
| IFC_OE_B/GPIO1_26                                     | IFC Output Enable   | A19                | O        | OV <sub>DD</sub> | 1, 5  |
| IFC_PAR0/GPIO2_06/<br>QSPI_B_DATA0/<br>QSPI_A_DATA4   | IFC Address & Data Parity   | E20                | IO       | OV <sub>DD</sub> | 9     |
| IFC_PAR1/GPIO2_07/<br>QSPI_B_DATA1/<br>QSPI_A_DATA5   | IFC Address & Data Parity   | E21                | IO       | OV <sub>DD</sub> | 9     |
| IFC_PERR_B/GPIO2_16/<br>QSPI_B_DATA2/<br>QSPI_A_DATA6 | IFC Parity Error  | D21                | I        | OV <sub>DD</sub> | 1     |
| IFC_RB0_B/GPIO2_14                                    | IFC Ready/Busy CS0  | A18                | I        | OV <sub>DD</sub> | 1, 6  |
| IFC_RB1_B/GPIO2_15                                    | IFC Ready/Busy CS1  | A17                | I        | OV <sub>DD</sub> | 1, 6  |

Table continues on the next page...

Table 1. Pinout list by bus (continued)

| Signal                                      | Signal description                  | Package pin number | Pin type | Power supply     | Notes |
|---|-------------------------------------|--------------------|----------|------------------|-------|
| IFC_RB2_B/IFC_A09/<br>GPIO2_03/QSPI_A_DATA3 | IFC Ready/Busy CS 2                 | E11                | I        | OV <sub>DD</sub> | 1     |
| IFC_RB3_B/IFC_A10/<br>GPIO2_04/QSPI_A_DQS   | IFC Ready/Busy CS 3                 | E10                | I        | OV <sub>DD</sub> | 1     |
| IFC_RB4_B/IFC_A11/<br>GPIO2_05/QSPI_B_DQS   | IFC Ready/Busy CS 4                 | D10                | I        | OV <sub>DD</sub> | 1     |
| IFC_TE/GPIO1_23/cfg_ifc_te                  | IFC External Transceiver Enable     | B16                | O        | OV <sub>DD</sub> | 1, 4  |
| IFC_WE0_B/GPIO1_22/<br>cfg_eng_use0         | IFC Write Enable 0 / Start of Frame | C17                | O        | OV <sub>DD</sub> | 1, 28 |
| IFC_WP0_B/GPIO1_27                          | IFC Write Protect                   | A20                | O        | OV <sub>DD</sub> | 1, 5  |
| IFC_WP1_B/IFC_A06/<br>GPIO2_00/QSPI_A_DATA0 | IFC Write Protect                   | D13                | O        | OV <sub>DD</sub> | 1     |
| IFC_WP2_B/IFC_A07/<br>GPIO2_01/QSPI_A_DATA1 | IFC Write Protect                   | E12                | O        | OV <sub>DD</sub> | 1     |
| IFC_WP3_B/IFC_A08/<br>GPIO2_02/QSPI_A_DATA2 | IFC Write Protect                   | D12                | O        | OV <sub>DD</sub> | 1     |
| <b>DUART</b>                                |                                     |                    |          |                  |       |
| UART1_CTS_B/GPIO3_10/<br>UART3_SIN          | Clear To Send                       | G4                 | I        | OV <sub>DD</sub> | 1     |
| UART1_RTS_B/GPIO3_08/<br>UART3_SOUT         | Ready to Send                       | G3                 | O        | OV <sub>DD</sub> | 1     |
| UART1_SIN                                   | Receive Data                        | H3                 | I        | OV <sub>DD</sub> | 1     |
| UART1_SOUT                                  | Transmit Data                       | J4                 | O        | OV <sub>DD</sub> | 1     |
| UART2_CTS_B/GPIO3_11/<br>UART4_SIN          | Clear To Send                       | K3                 | I        | OV <sub>DD</sub> | 1     |
| UART2_RTS_B/GPIO3_09/<br>UART4_SOUT         | Ready to Send                       | J3                 | O        | OV <sub>DD</sub> | 1     |
| UART2_SIN/GPIO3_07                          | Receive Data                        | K4                 | I        | OV <sub>DD</sub> | 1     |
| UART2_SOUT/GPIO3_06                         | Transmit Data                       | L3                 | O        | OV <sub>DD</sub> | 1     |
| UART3_SIN/UART1_CTS_B/<br>GPIO3_10          | Receive Data                        | G4                 | I        | OV <sub>DD</sub> | 1     |
| UART3_SOUT/<br>UART1_RTS_B/GPIO3_08         | Transmit Data                       | G3                 | O        | OV <sub>DD</sub> | 1     |
| UART4_SIN/UART2_CTS_B/<br>GPIO3_11          | Receive Data                        | K3                 | I        | OV <sub>DD</sub> | 1     |
| UART4_SOUT/<br>UART2_RTS_B/GPIO3_09         | Transmit Data                       | J3                 | O        | OV <sub>DD</sub> | 1     |
| <b>I2C</b>                                  |                                     |                    |          |                  |       |
| IIC1_SCL                                    | Serial Clock                        | K8                 | IO       | OV <sub>DD</sub> | 7, 8  |
| IIC1_SDA                                    | Serial Data                         | L8                 | IO       | OV <sub>DD</sub> | 7, 8  |
| IIC2_SCL/GPIO3_12/<br>SDHC_CD_B             | Serial Clock                        | H8                 | IO       | OV <sub>DD</sub> | 7, 8  |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal  | Signal description  | Package pin number | Pin type | Power supply     | Notes |
|---|---------------------|--------------------|----------|------------------|-------|
| IIC2_SDA/GPIO3_13/<br>SDHC_WP                       | Serial Data         | J8                 | IO       | OV <sub>DD</sub> | 7, 8  |
| IIC3_SCL/GPIO4_00/EVT5_B/<br>SPI_PCS4               | Serial Clock        | K5                 | IO       | OV <sub>DD</sub> | 7, 8  |
| IIC3_SDA/GPIO4_01/EVT6_B/<br>SPI_PCS5               | Serial Data         | L5                 | IO       | OV <sub>DD</sub> | 7, 8  |
| IIC4_SCL/GPIO4_02/EVT7_B                            | Serial Clock        | K7                 | IO       | OV <sub>DD</sub> | 7, 8  |
| IIC4_SDA/GPIO4_03/EVT8_B                            | Serial Data         | L7                 | IO       | OV <sub>DD</sub> | 7, 8  |
| <b>SPI Interface</b>                                |                     |                    |          |                  |       |
| SPI_PCS0/GPIO3_17/<br>SDHC_DAT4/SDHC_VS             | SPI Chip Select     | B7                 | IO       | OV <sub>DD</sub> | ---   |
| SPI_PCS1/GPIO3_18/<br>SDHC_DAT5/<br>SDHC_CMD_DIR    | SPI Chip Select     | C7                 | O        | OV <sub>DD</sub> | 1     |
| SPI_PCS2/GPIO3_19/<br>SDHC_DAT6/<br>SDHC_DAT0_DIR   | SPI Chip Select     | B9                 | O        | OV <sub>DD</sub> | 1     |
| SPI_PCS3/GPIO3_20/<br>SDHC_DAT7/<br>SDHC_DAT123_DIR | SPI Chip Select     | C9                 | O        | OV <sub>DD</sub> | 1     |
| SPI_PCS4/IIC3_SCL/<br>GPIO4_00/EVT5_B               | Chip Select 4       | K5                 | O        | OV <sub>DD</sub> | 1     |
| SPI_PCS5/IIC3_SDA/<br>GPIO4_01/EVT6_B               | Chips Select 5      | L5                 | O        | OV <sub>DD</sub> | 1     |
| SPI_SCK/GPIO3_16                                    | SPI Clock           | A7                 | IO       | OV <sub>DD</sub> | ---   |
| SPI_SIN/GPIO3_15                                    | Master In Slave Out | A9                 | I        | OV <sub>DD</sub> | 1     |
| SPI_SOUT/GPIO3_14                                   | Master Out Slave In | A8                 | O        | OV <sub>DD</sub> | 1     |
| <b>eSDHC</b>  |                     |                    |          |                  |       |
| SDHC_CD_B/IIC2_SCL/<br>GPIO3_12                     | SDHC Card Detect    | H8                 | I        | OV <sub>DD</sub> | 1     |
| SDHC_CLK/GPIO3_26                                   | Host to Card Clock  | C8                 | O        | OV <sub>DD</sub> | 1     |
| SDHC_CMD/GPIO3_21                                   | Command/Response    | D7                 | IO       | OV <sub>DD</sub> | 24    |
| SDHC_CMD_DIR/SPI_PCS1/<br>GPIO3_18/SDHC_DAT5        | DIR                 | C7                 | O        | OV <sub>DD</sub> | 1     |
| SDHC_DAT0/GPIO3_22                                  | Data                | E7                 | IO       | OV <sub>DD</sub> | 24    |
| SDHC_DAT0_DIR/SPI_PCS2/<br>GPIO3_19/SDHC_DAT6       | DIR                 | B9                 | O        | OV <sub>DD</sub> | 1     |
| SDHC_DAT1/GPIO3_23                                  | Data                | E8                 | IO       | OV <sub>DD</sub> | 24    |
| SDHC_DAT123_DIR/<br>SPI_PCS3/GPIO3_20/<br>SDHC_DAT7 | DIR                 | C9                 | O        | OV <sub>DD</sub> | 1     |
| SDHC_DAT2/GPIO3_24                                  | Data                | D9                 | IO       | OV <sub>DD</sub> | 24    |
| SDHC_DAT3/GPIO3_25                                  | Data                | E9                 | IO       | OV <sub>DD</sub> | 24    |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal  | Signal description                   | Package pin number | Pin type | Power supply          | Notes |
|---|--------------------------------------|--------------------|----------|-----------------------|-------|
| SDHC_DAT4/SPI_PCS0/<br>GPIO3_17/SDHC_VS             | Data                                 | B7                 | IO       | OV <sub>DD</sub>      | ---   |
| SDHC_DAT5/SPI_PCS1/<br>GPIO3_18/SDHC_CMD_DIR        | Data                                 | C7                 | IO       | OV <sub>DD</sub>      | ---   |
| SDHC_DAT6/SPI_PCS2/<br>GPIO3_19/SDHC_DAT0_DIR       | Data                                 | B9                 | IO       | OV <sub>DD</sub>      | ---   |
| SDHC_DAT7/SPI_PCS3/<br>GPIO3_20/<br>SDHC_DAT123_DIR | Data                                 | C9                 | IO       | OV <sub>DD</sub>      | ---   |
| SDHC_VS/SPI_PCS0/<br>GPIO3_17/SDHC_DAT4             | VS                                   | B7                 | O        | OV <sub>DD</sub>      | 1     |
| SDHC_WP/IIC2_SDA/<br>GPIO3_13                       | Write Protect                        | J8                 | I        | OV <sub>DD</sub>      | 1     |
| <b>Interrupt Controller</b>                         |                                      |                    |          |                       |       |
| IRQ00   | External Interrupt                   | F12                | I        | OV <sub>DD</sub>      | 1     |
| IRQ01   | External Interrupt                   | F14                | I        | OV <sub>DD</sub>      | 1     |
| IRQ02   | External Interrupt                   | F15                | I        | OV <sub>DD</sub>      | 1     |
| IRQ03/GPIO3_27                                      | External Interrupt                   | F17                | I        | OV <sub>DD</sub>      | 1     |
| IRQ04/GPIO3_28                                      | External Interrupt                   | F18                | I        | OV <sub>DD</sub>      | 1     |
| IRQ05/GPIO3_29                                      | External Interrupt                   | F20                | I        | OV <sub>DD</sub>      | 1     |
| IRQ06/GPIO4_04                                      | External Interrupt                   | G5                 | I        | OV <sub>DD</sub>      | 1     |
| IRQ07/GPIO4_05                                      | External Interrupt                   | G7                 | I        | OV <sub>DD</sub>      | 1     |
| IRQ08/GPIO4_06                                      | External Interrupt                   | J5                 | I        | OV <sub>DD</sub>      | 1     |
| IRQ09/GPIO4_07                                      | External Interrupt                   | J7                 | I        | OV <sub>DD</sub>      | 1     |
| IRQ10/GPIO4_08                                      | External Interrupt                   | F8                 | I        | OV <sub>DD</sub>      | 1     |
| IRQ11/GPIO4_09                                      | External Interrupt                   | K6                 | I        | OV <sub>DD</sub>      | 1     |
| <b>Trust</b>  |                                      |                    |          |                       |       |
| TA_BB_RTC   | Battery Backed Real Time Clock       | K19                | I        | TA_BB_V <sub>DD</sub> | 15    |
| TA_BB_TMP_DETECT_B                                  | Battery Backed Tamper Detect         | J18                | I        | TA_BB_V <sub>DD</sub> | ---   |
| TA_TMP_DETECT_B                                     | Tamper Detect                        | K20                | I        | OV <sub>DD</sub>      | ---   |
| <b>System Control</b>                               |                                      |                    |          |                       |       |
| HRESET_B  | Hard Reset                           | H18                | IO       | OV <sub>DD</sub>      | 7, 8  |
| PORESET_B   | Power On Reset                       | H17                | I        | OV <sub>DD</sub>      | ---   |
| RESET_REQ_B   | Reset Request (POR or Hard)          | J19                | O        | OV <sub>DD</sub>      | 1, 5  |
| <b>Clocking</b>                                     |                                      |                    |          |                       |       |
| DIFF_SYSCLK   | System Clock Differential (positive) | AM21               | I        | OV <sub>DD</sub>      | ---   |
| DIFF_SYSCLK_B                                       | System Clock Differential (negative) | AN21               | I        | OV <sub>DD</sub>      | ---   |
| RTC/GPIO3_30  | Real Time Clock                      | G19                | I        | OV <sub>DD</sub>      | 1     |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal  | Signal description                 | Package pin number | Pin type | Power supply      | Notes   |
|---|------------------------------------|--------------------|----------|-------------------|---------|
| <b>SYSCLK</b>                                 | System Clock                       | AP21               | I        | OV <sub>DD</sub>  | ---     |
| <b>DDR Clocking</b>                           |                                    |                    |          |                   |         |
| <b>DDRCLK</b>                                 | DDR Controller Reference Clock     | K21                | I        | OV <sub>DD</sub>  | ---     |
| <b>Debug</b>                                  |                                    |                    |          |                   |         |
| <b>ASLEEP/GPIO1_28</b>                        | Asleep                             | F7                 | O        | OV <sub>DD</sub>  | 1, 5    |
| <b>CKSTP_OUT_B</b>                            | Checkstop Out                      | J20                | O        | OV <sub>DD</sub>  | 1, 6, 7 |
| <b>CLK_OUT</b>                                | Clock Out                          | G15                | O        | OV <sub>DD</sub>  | ---     |
| <b>EVT0_B</b>                                 | Event 0                            | G13                | IO       | OV <sub>DD</sub>  | 9       |
| <b>EVT1_B</b>                                 | Event 1                            | G14                | IO       | OV <sub>DD</sub>  | 9       |
| <b>EVT2_B</b>                                 | Event 2                            | G16                | IO       | OV <sub>DD</sub>  | 9       |
| <b>EVT3_B</b>                                 | Event 3                            | G17                | IO       | OV <sub>DD</sub>  | 9       |
| <b>EVT4_B</b>                                 | Event 4                            | G18                | IO       | OV <sub>DD</sub>  | 9       |
| <b>EVT5_B/IIC3_SCL/GPIO4_00/<br/>SPI_PCS4</b> | Event 5                            | K5                 | IO       | OV <sub>DD</sub>  | ---     |
| <b>EVT6_B/IIC3_SDA/GPIO4_01/<br/>SPI_PCS5</b> | Event 6                            | L5                 | IO       | OV <sub>DD</sub>  | ---     |
| <b>EVT7_B/IIC4_SCL/GPIO4_02</b>               | Event 7                            | K7                 | IO       | OV <sub>DD</sub>  | ---     |
| <b>EVT8_B/IIC4_SDA/GPIO4_03</b>               | Event 8                            | L7                 | IO       | OV <sub>DD</sub>  | ---     |
| <b>EVT9_B/GPIO4_10</b>                        | Event 9                            | G12                | IO       | OV <sub>DD</sub>  | 6, 7    |
| <b>DFT</b>                                    |                                    |                    |          |                   |         |
| <b>SCAN_MODE_B</b>                            | Reserved                           | F11                | I        | OV <sub>DD</sub>  | 10      |
| <b>TEST_SEL_B</b>                             | Reserved                           | G11                | I        | OV <sub>DD</sub>  | 14      |
| <b>JTAG</b>                                   |                                    |                    |          |                   |         |
| <b>TBSCAN_EN_B</b>                            | Test Boundary Scan Enable          | J21                | I        | OV <sub>DD</sub>  | 13      |
| <b>TCK</b>                                    | Test Clock                         | H21                | I        | OV <sub>DD</sub>  | ---     |
| <b>TDI</b>                                    | Test Data In                       | F21                | I        | OV <sub>DD</sub>  | 9       |
| <b>TDO</b>                                    | Test Data Out                      | G21                | O        | OV <sub>DD</sub>  | 2       |
| <b>TMS</b>                                    | Test Mode Select                   | H20                | I        | OV <sub>DD</sub>  | 9       |
| <b>TRST_B</b>                                 | Test Reset                         | G20                | I        | OV <sub>DD</sub>  | 9       |
| <b>Analog Signals</b>                         |                                    |                    |          |                   |         |
| <b>D1_TPA</b>                                 | DDR Controller 1 Test Point Analog | T26                | IO       | G1V <sub>DD</sub> | 12      |
| <b>D2_TPA</b>                                 | DDR Controller 2 Test Point Analog | AA26               | IO       | G2V <sub>DD</sub> | 12      |
| <b>FA_ANALOG_G_V</b>                          | Reserved                           | AR22               | IO       | OV <sub>DD</sub>  | 15      |
| <b>FA_ANALOG_PIN</b>                          | Reserved                           | AL22               | IO       | OV <sub>DD</sub>  | 15      |
| <b>TD1_ANODE</b>                              | Thermal diode anode                | H15                | IO       | OV <sub>DD</sub>  | 17      |
| <b>TD1_CATHODE</b>                            | Thermal diode cathode              | H16                | IO       | OV <sub>DD</sub>  | 17      |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal          | Signal description                      | Package pin number | Pin type | Power supply     | Notes |
|-----------------|---|--------------------|----------|------------------|-------|
| TD2_ANODE       | Thermal diode anode                     | K9                 | IO       | OV <sub>DD</sub> | 17    |
| TD2_CATHODE     | Thermal diode cathode                   | L9                 | IO       | OV <sub>DD</sub> | 17    |
| TH_TPA          | Thermal Test Point Analog               | H14                | -        | OV <sub>DD</sub> | 12    |
| <b>SerDes 1</b> |   |                    |          |                  |       |
| SD1_IMP_CAL_RX  | SerDes Receive Impedance Calibration    | AM8                | I        | SV <sub>DD</sub> | 11    |
| SD1_IMP_CAL_TX  | SerDes Transmit Impedance Calibration   | AF9                | I        | XV <sub>DD</sub> | 16    |
| SD1_PLL1_TPA    | SerDes PLL 1 Test Point Analog          | AJ9                | O        | AVDD_SD1_PLL1    | 12    |
| SD1_PLL1_TPD    | SerDes Test Point Digital               | AJ8                | O        | XV <sub>DD</sub> | 12    |
| SD1_PLL2_TPA    | SerDes PLL 2 Test Point Analog          | AG8                | O        | AVDD_SD1_PLL2    | 12    |
| SD1_PLL2_TPD    | SerDes Test Point Digital               | AG7                | O        | XV <sub>DD</sub> | 12    |
| SD1_REF_CLK1_N  | SerDes PLL 1 Reference Clock Complement | AP9                | I        | SV <sub>DD</sub> | ---   |
| SD1_REF_CLK1_P  | SerDes PLL 1 Reference Clock            | AP8                | I        | SV <sub>DD</sub> | ---   |
| SD1_REF_CLK2_N  | SerDes PLL 2 Reference Clock Complement | AL1                | I        | SV <sub>DD</sub> | ---   |
| SD1_REF_CLK2_P  | SerDes PLL 2 Reference Clock            | AM1                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX0_N       | SerDes Receive Data (negative)          | AN2                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX0_P       | SerDes Receive Data (positive)          | AP2                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX1_N       | SerDes Receive Data (negative)          | AR3                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX1_P       | SerDes Receive Data (positive)          | AT3                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX2_N       | SerDes Receive Data (negative)          | AN4                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX2_P       | SerDes Receive Data (positive)          | AP4                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX3_N       | SerDes Receive Data (negative)          | AR5                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX3_P       | SerDes Receive Data (positive)          | AT5                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX4_N       | SerDes Receive Data (negative)          | AN6                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX4_P       | SerDes Receive Data (positive)          | AP6                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX5_N       | SerDes Receive Data (negative)          | AR7                | I        | SV <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

**Table 1. Pinout list by bus (continued)**

| Signal          | Signal description              | Package pin number | Pin type | Power supply     | Notes |
|-----------------|---------------------------------|--------------------|----------|------------------|-------|
| SD1_RX5_P       | SerDes Receive Data (positive)  | AT7                | I        | SV <sub>DD</sub> | ---   |
| SD1_RX6_N       | SerDes Receive Data (negative)  | AR10               | I        | SV <sub>DD</sub> | ---   |
| SD1_RX6_P       | SerDes Receive Data (positive)  | AT10               | I        | SV <sub>DD</sub> | ---   |
| SD1_RX7_N       | SerDes Receive Data (negative)  | AN11               | I        | SV <sub>DD</sub> | ---   |
| SD1_RX7_P       | SerDes Receive Data (positive)  | AP11               | I        | SV <sub>DD</sub> | ---   |
| SD1_TX0_N       | SerDes Transmit Data (negative) | AH2                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX0_P       | SerDes Transmit Data (positive) | AJ2                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX1_N       | SerDes Transmit Data (negative) | AK3                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX1_P       | SerDes Transmit Data (positive) | AL3                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX2_N       | SerDes Transmit Data (negative) | AH4                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX2_P       | SerDes Transmit Data (positive) | AJ4                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX3_N       | SerDes Transmit Data (negative) | AK5                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX3_P       | SerDes Transmit Data (positive) | AL5                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX4_N       | SerDes Transmit Data (negative) | AH6                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX4_P       | SerDes Transmit Data (positive) | AJ6                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX5_N       | SerDes Transmit Data (negative) | AK7                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX5_P       | SerDes Transmit Data (positive) | AL7                | O        | XV <sub>DD</sub> | ---   |
| SD1_TX6_N       | SerDes Transmit Data (negative) | AK10               | O        | XV <sub>DD</sub> | ---   |
| SD1_TX6_P       | SerDes Transmit Data (positive) | AL10               | O        | XV <sub>DD</sub> | ---   |
| SD1_TX7_N       | SerDes Transmit Data (negative) | AH11               | O        | XV <sub>DD</sub> | ---   |
| SD1_TX7_P       | SerDes Transmit Data (positive) | AJ11               | O        | XV <sub>DD</sub> | ---   |
| <b>SerDes 2</b> |                                 |                    |          |                  |       |

*Table continues on the next page...*

**Table 1. Pinout list by bus (continued)**

| Signal         | Signal description                      | Package pin number | Pin type | Power supply     | Notes |
|----------------|---|--------------------|----------|------------------|-------|
| SD2_IMP_CAL_RX | SerDes Receive Impedance Calibration    | AM9                | I        | SV <sub>DD</sub> | 11    |
| SD2_IMP_CAL_TX | SerDes Transmit Impedance Calibration   | AF19               | I        | XV <sub>DD</sub> | 16    |
| SD2_PLL1_TPA   | SerDes PLL 1 Test Point Analog          | AK14               | O        | AVDD_SD2_PLL1    | 12    |
| SD2_PLL1_TPD   | SerDes Test Point Digital               | AM14               | O        | XV <sub>DD</sub> | 12    |
| SD2_PLL2_TPA   | SerDes PLL 2 Test Point Analog          | AF21               | O        | AVDD_SD2_PLL2    | 12    |
| SD2_PLL2_TPD   | SerDes Test Point Digital               | AG21               | O        | XV <sub>DD</sub> | 12    |
| SD2_REF_CLK1_N | SerDes PLL 1 Reference Clock Complement | AT14               | I        | SV <sub>DD</sub> | ---   |
| SD2_REF_CLK1_P | SerDes PLL 1 Reference Clock            | AR14               | I        | SV <sub>DD</sub> | ---   |
| SD2_REF_CLK2_N | SerDes PLL 2 Reference Clock Complement | AJ21               | I        | SV <sub>DD</sub> | ---   |
| SD2_REF_CLK2_P | SerDes PLL 2 Reference Clock            | AH21               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX0_N      | SerDes Receive Data (negative)          | AR12               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX0_P      | SerDes Receive Data (positive)          | AT12               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX1_N      | SerDes Receive Data (negative)          | AN13               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX1_P      | SerDes Receive Data (positive)          | AP13               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX2_N      | SerDes Receive Data (negative)          | AN15               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX2_P      | SerDes Receive Data (positive)          | AP15               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX3_N      | SerDes Receive Data (negative)          | AR16               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX3_P      | SerDes Receive Data (positive)          | AT16               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX4_N      | SerDes Receive Data (negative)          | AN17               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX4_P      | SerDes Receive Data (positive)          | AP17               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX5_N      | SerDes Receive Data (negative)          | AR18               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX5_P      | SerDes Receive Data (positive)          | AT18               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX6_N      | SerDes Receive Data (negative)          | AN19               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX6_P      | SerDes Receive Data (positive)          | AP19               | I        | SV <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal                   | Signal description                  | Package pin number | Pin type | Power supply     | Notes |
|--------------------------|-------------------------------------|--------------------|----------|------------------|-------|
| SD2_RX7_N                | SerDes Receive Data (negative)      | AR20               | I        | SV <sub>DD</sub> | ---   |
| SD2_RX7_P                | SerDes Receive Data (positive)      | AT20               | I        | SV <sub>DD</sub> | ---   |
| SD2_TX0_N                | SerDes Transmit Data (negative)     | AK12               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX0_P                | SerDes Transmit Data (positive)     | AL12               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX1_N                | SerDes Transmit Data (negative)     | AH13               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX1_P                | SerDes Transmit Data (positive)     | AJ13               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX2_N                | SerDes Transmit Data (negative)     | AH15               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX2_P                | SerDes Transmit Data (positive)     | AJ15               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX3_N                | SerDes Transmit Data (negative)     | AK16               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX3_P                | SerDes Transmit Data (positive)     | AL16               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX4_N                | SerDes Transmit Data (negative)     | AH17               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX4_P                | SerDes Transmit Data (positive)     | AJ17               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX5_N                | SerDes Transmit Data (negative)     | AK18               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX5_P                | SerDes Transmit Data (positive)     | AL18               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX6_N                | SerDes Transmit Data (negative)     | AH19               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX6_P                | SerDes Transmit Data (positive)     | AJ19               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX7_N                | SerDes Transmit Data (negative)     | AK20               | O        | XV <sub>DD</sub> | ---   |
| SD2_TX7_P                | SerDes Transmit Data (positive)     | AL20               | O        | XV <sub>DD</sub> | ---   |
| <b>USB PHY 1 &amp; 2</b> |                                     |                    |          |                  |       |
| USB1_D_M                 | USB PHY Data Minus                  | E5                 | IO       | -                | ---   |
| USB1_D_P                 | USB PHY Data Plus                   | E4                 | IO       | -                | ---   |
| USB1_ID                  | USB PHY ID Detect                   | H10                | I        | -                | ---   |
| USB1_RESREF              | USB PHY Impedance Calibration       | J10                | IO       | -                | 25    |
| USB1_RX_M                | USB PHY 3.0 Receive Data (negative) | E2                 | I        | -                | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal                            | Signal description                   | Package pin number | Pin type | Power supply     | Notes |
|-----------------------------------|--------------------------------------|--------------------|----------|------------------|-------|
| USB1_RX_P                         | USB PHY 3.0 Receive Data (positive)  | E1                 | I        | -                | ---   |
| USB1_TX_M                         | USB PHY 3.0 Transmit Data (negative) | C2                 | O        | -                | ---   |
| USB1_TX_P                         | USB PHY 3.0 Transmit Data (positive) | C1                 | O        | -                | ---   |
| USB1_VBUS                         | USB PHY VBUS                         | H9                 | I        | -                | 27    |
| USB2_D_M                          | USB PHY Data Minus                   | D5                 | IO       | -                | ---   |
| USB2_D_P                          | USB PHY Data Plus                    | D4                 | IO       | -                | ---   |
| USB2_ID                           | USB PHY ID Detect                    | H12                | I        | -                | ---   |
| USB2_RESREF                       | USB PHY Impedance Calibration        | J11                | IO       | -                | 25    |
| USB2_RX_M                         | USB PHY 3.0 Receive Data (negative)  | B3                 | I        | -                | ---   |
| USB2_RX_P                         | USB PHY 3.0 Receive Data (positive)  | A3                 | I        | -                | ---   |
| USB2_TX_M                         | USB PHY 3.0 Transmit Data (negative) | B5                 | O        | -                | ---   |
| USB2_TX_P                         | USB PHY 3.0 Transmit Data (positive) | A5                 | O        | -                | ---   |
| USB2_VBUS                         | USB PHY VBUS                         | H11                | I        | -                | 27    |
| <b>USB PHY 1 &amp; 2</b>          |                                      |                    |          |                  |       |
| USB1_DRVVBUS/GPIO4_24             | USB PHY Digital signal - Drive VBUS  | F6                 | O        | OV <sub>DD</sub> | 1     |
| USB1_PWRFAULT/GPIO4_25            | USB PHY Digital signal - Power Fault | F3                 | I        | OV <sub>DD</sub> | 1     |
| USB2_DRVVBUS/GPIO4_26             | USB PHY Digital signal - Drive VBUS  | F9                 | O        | OV <sub>DD</sub> | 1     |
| USB2_PWRFAULT/GPIO4_27            | USB PHY Digital signal - Power Fault | C6                 | I        | OV <sub>DD</sub> | 1     |
| <b>IEEE1588</b>                   |                                      |                    |          |                  |       |
| TSEC_1588_ALARM_OUT1/<br>GPIO4_19 | Alarm Out 1                          | J1                 | O        | OV <sub>DD</sub> | ---   |
| TSEC_1588_ALARM_OUT2/<br>GPIO4_20 | Alarm Out 2                          | G1                 | O        | OV <sub>DD</sub> | ---   |
| TSEC_1588_CLK_IN/<br>GPIO4_16     | Clock In                             | G2                 | I        | OV <sub>DD</sub> | ---   |
| TSEC_1588_CLK_OUT/<br>GPIO4_21    | Clock Out                            | H1                 | O        | OV <sub>DD</sub> | ---   |
| TSEC_1588_PULSE_OUT1/<br>GPIO4_22 | Pulse Out 1                          | K1                 | O        | OV <sub>DD</sub> | ---   |
| TSEC_1588_PULSE_OUT2/<br>GPIO4_23 | Pulse Out 2                          | K2                 | O        | OV <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal                                 | Signal description           | Package pin number | Pin type | Power supply     | Notes |
|--|------------------------------|--------------------|----------|------------------|-------|
| TSEC_1588_TRIG_IN1/<br>GPIO4_17        | Trigger In 1                 | L1                 | I        | OV <sub>DD</sub> | ---   |
| TSEC_1588_TRIG_IN2/<br>GPIO4_18        | Trigger In 2                 | J2                 | I        | OV <sub>DD</sub> | ---   |
| <b>Ethernet Management Interface 1</b> |                              |                    |          |                  |       |
| EMI1_MDC                               | Management Data Clock        | G6                 | O        | OV <sub>DD</sub> | ---   |
| EMI1_MDIO                              | Management Data In/Out       | H5                 | IO       | OV <sub>DD</sub> | ---   |
| <b>Ethernet Management Interface 2</b> |                              |                    |          |                  |       |
| EMI2_MDC                               | Management Data Clock        | J6                 | O        | OV <sub>DD</sub> | ---   |
| EMI2_MDIO                              | Management Data In/Out       | H7                 | IO       | OV <sub>DD</sub> | ---   |
| <b>General Purpose Input/Output</b>    |                              |                    |          |                  |       |
| GPIO1_00/IFC_AD00/<br>cfg_gpininput00  | General Purpose Input/Output | B10                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_01/IFC_AD01/<br>cfg_gpininput01  | General Purpose Input/Output | C10                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_02/IFC_AD02/<br>cfg_gpininput02  | General Purpose Input/Output | A11                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_03/IFC_AD03/<br>cfg_gpininput03  | General Purpose Input/Output | C11                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_04/IFC_AD04/<br>cfg_gpininput04  | General Purpose Input/Output | A12                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_05/IFC_AD05/<br>cfg_gpininput05  | General Purpose Input/Output | B12                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_06/IFC_AD06/<br>cfg_gpininput06  | General Purpose Input/Output | C12                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_07/IFC_AD07/<br>cfg_gpininput07  | General Purpose Input/Output | A13                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_08/IFC_AD08/<br>cfg_rcw_src01    | General Purpose Input/Output | B13                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_09/IFC_AD09/<br>cfg_rcw_src02    | General Purpose Input/Output | C13                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_10/IFC_AD10/<br>cfg_rcw_src03    | General Purpose Input/Output | A14                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_11/IFC_AD11/<br>cfg_rcw_src04    | General Purpose Input/Output | C14                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_12/IFC_AD12/<br>cfg_rcw_src05    | General Purpose Input/Output | A15                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_13/IFC_AD13/<br>cfg_rcw_src06    | General Purpose Input/Output | B15                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_14/IFC_AD14/<br>cfg_rcw_src07    | General Purpose Input/Output | C15                | IO       | OV <sub>DD</sub> | ---   |
| GPIO1_15/IFC_AD15/<br>cfg_rcw_src08    | General Purpose Input/Output | A16                | IO       | OV <sub>DD</sub> | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal  | Signal description           | Package pin number | Pin type | Power supply     | Notes |
|---|------------------------------|--------------------|----------|------------------|-------|
| GPIO1_16/IFC_A00/<br>QSPI_A_CS0                     | General Purpose Input/Output | E16                | IO       | OV <sub>DD</sub> | 5     |
| GPIO1_17/IFC_A01/<br>QSPI_A_CS1                     | General Purpose Input/Output | D16                | IO       | OV <sub>DD</sub> | 5     |
| GPIO1_18/IFC_A02/<br>QSPI_A_SCK                     | General Purpose Input/Output | E15                | IO       | OV <sub>DD</sub> | 5     |
| GPIO1_19/IFC_A03/<br>QSPI_B_CS0                     | General Purpose Input/Output | D15                | IO       | OV <sub>DD</sub> | 5     |
| GPIO1_20/IFC_A04/<br>QSPI_B_CS1                     | General Purpose Input/Output | E14                | IO       | OV <sub>DD</sub> | 5     |
| GPIO1_21/IFC_A05/<br>QSPI_B_SCK                     | General Purpose Input/Output | E13                | IO       | OV <sub>DD</sub> | 5, 5  |
| GPIO1_22/IFC_WE0_B/<br>cfg_eng_use0                 | General Purpose Input/Output | C17                | IO       | OV <sub>DD</sub> | 28    |
| GPIO1_23/IFC_TE/cfg_ifc_te                          | General Purpose Input/Output | B16                | IO       | OV <sub>DD</sub> | 4     |
| GPIO1_24/IFC_ALE                                    | General Purpose Input/Output | C19                | IO       | OV <sub>DD</sub> | 5     |
| GPIO1_25/IFC_CLE/<br>cfg_rcw_src0                   | General Purpose Input/Output | B19                | IO       | OV <sub>DD</sub> | 4     |
| GPIO1_26/IFC_OE_B                                   | General Purpose Input/Output | A19                | IO       | OV <sub>DD</sub> | 5     |
| GPIO1_27/IFC_WP0_B                                  | General Purpose Input/Output | A20                | IO       | OV <sub>DD</sub> | 5     |
| GPIO1_28/ASLEEP                                     | General Purpose Input/Output | F7                 | IO       | OV <sub>DD</sub> | 5, 5  |
| GPIO2_00/IFC_A06/<br>IFC_WP1_B/QSPI_A_DATA0         | General Purpose Input/Output | D13                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_01/IFC_A07/<br>IFC_WP2_B/QSPI_A_DATA1         | General Purpose Input/Output | E12                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_02/IFC_A08/<br>IFC_WP3_B/QSPI_A_DATA2         | General Purpose Input/Output | D12                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_03/IFC_A09/<br>IFC_RB2_B/QSPI_A_DATA3         | General Purpose Input/Output | E11                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_04/IFC_A10/<br>IFC_RB3_B/QSPI_A_DQS           | General Purpose Input/Output | E10                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_05/IFC_A11/<br>IFC_RB4_B/QSPI_B_DQS           | General Purpose Input/Output | D10                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_06/IFC_PAR0/<br>QSPI_B_DATA0/<br>QSPI_A_DATA4 | General Purpose Input/Output | E20                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_07/IFC_PAR1/<br>QSPI_B_DATA1/<br>QSPI_A_DATA5 | General Purpose Input/Output | E21                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_08/IFC_CS0_B                                  | General Purpose Input/Output | C18                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_09/IFC_CS1_B                                  | General Purpose Input/Output | C20                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_10/IFC_CS2_B                                  | General Purpose Input/Output | A21                | IO       | OV <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal  | Signal description           | Package pin number | Pin type | Power supply     | Notes |
|---|------------------------------|--------------------|----------|------------------|-------|
| GPIO2_11/IFC_CS3_B/<br>QSPI_B_DATA3/<br>QSPI_A_DATA7  | General Purpose Input/Output | E17                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_12/IFC_BCTL                                     | General Purpose Input/Output | C16                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_13/IFC_NDDQS                                    | General Purpose Input/Output | B18                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_14/IFC_RB0_B                                    | General Purpose Input/Output | A18                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_15/IFC_RB1_B                                    | General Purpose Input/Output | A17                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_16/IFC_PERR_B/<br>QSPI_B_DATA2/<br>QSPI_A_DATA6 | General Purpose Input/Output | D21                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_17/IFC_CLK0                                     | General Purpose Input/Output | B21                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_18/IFC_CLK1                                     | General Purpose Input/Output | C21                | IO       | OV <sub>DD</sub> | ---   |
| GPIO2_19/IFC_NDWE_B                                   | General Purpose Input/Output | A10                | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_02/IFC_CS4_B                                    | General Purpose Input/Output | D18                | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_03/IFC_CS5_B                                    | General Purpose Input/Output | E18                | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_04/IFC_CS6_B                                    | General Purpose Input/Output | D19                | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_05/IFC_CS7_B                                    | General Purpose Input/Output | E19                | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_06/UART2_SOUT                                   | General Purpose Input/Output | L3                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_07/UART2_SIN                                    | General Purpose Input/Output | K4                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_08/UART1_RTS_B/<br>UART3_SOUT                   | General Purpose Input/Output | G3                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_09/UART2_RTS_B/<br>UART4_SOUT                   | General Purpose Input/Output | J3                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_10/UART1_CTS_B/<br>UART3_SIN                    | General Purpose Input/Output | G4                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_11/UART2_CTS_B/<br>UART4_SIN                    | General Purpose Input/Output | K3                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_12/IIC2_SCL/<br>SDHC_CD_B                       | General Purpose Input/Output | H8                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_13/IIC2_SDA/<br>SDHC_WP                         | General Purpose Input/Output | J8                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_14/SPI_SOUT                                     | General Purpose Input/Output | A8                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_15/SPI_SIN                                      | General Purpose Input/Output | A9                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_16/SPI_SCK                                      | General Purpose Input/Output | A7                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_17/SPI_PCS0/<br>SDHC_DAT4/SDHC_VS               | General Purpose Input/Output | B7                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_18/SPI_PCS1/<br>SDHC_DAT5/<br>SDHC_CMD_DIR      | General Purpose Input/Output | C7                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_19/SPI_PCS2/<br>SDHC_DAT6/<br>SDHC_DAT0_DIR     | General Purpose Input/Output | B9                 | IO       | OV <sub>DD</sub> | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal  | Signal description           | Package pin number | Pin type | Power supply     | Notes |
|---|------------------------------|--------------------|----------|------------------|-------|
| GPIO3_20/SPI_PCS3/<br>SDHC_DAT7/<br>SDHC_DAT123_DIR | General Purpose Input/Output | C9                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_21/SDHC_CMD                                   | General Purpose Input/Output | D7                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_22/SDHC_DAT0                                  | General Purpose Input/Output | E7                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_23/SDHC_DAT1                                  | General Purpose Input/Output | E8                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_24/SDHC_DAT2                                  | General Purpose Input/Output | D9                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_25/SDHC_DAT3                                  | General Purpose Input/Output | E9                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_26/SDHC_CLK                                   | General Purpose Input/Output | C8                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_27/IRQ03                                      | General Purpose Input/Output | F17                | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_28/IRQ04                                      | General Purpose Input/Output | F18                | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_29/IRQ05                                      | General Purpose Input/Output | F20                | IO       | OV <sub>DD</sub> | ---   |
| GPIO3_30/RTC  | General Purpose Input/Output | G19                | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_00/IIC3_SCL/EVT5_B/<br>SPI_PCS4               | General Purpose Input/Output | K5                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_01/IIC3_SDA/EVT6_B/<br>SPI_PCS5               | General Purpose Input/Output | L5                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_02/IIC4_SCL/EVT7_B                            | General Purpose Input/Output | K7                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_03/IIC4_SDA/EVT8_B                            | General Purpose Input/Output | L7                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_04/IRQ06                                      | General Purpose Input/Output | G5                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_05/IRQ07                                      | General Purpose Input/Output | G7                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_06/IRQ08                                      | General Purpose Input/Output | J5                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_07/IRQ09                                      | General Purpose Input/Output | J7                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_08/IRQ10                                      | General Purpose Input/Output | F8                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_09/IRQ11                                      | General Purpose Input/Output | K6                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_10/EVT9_B                                     | General Purpose Input/Output | G12                | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_16/<br>TSEC_1588_CLK_IN                       | General Purpose Input/Output | G2                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_17/<br>TSEC_1588_TRIG_IN1                     | General Purpose Input/Output | L1                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_18/<br>TSEC_1588_TRIG_IN2                     | General Purpose Input/Output | J2                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_19/<br>TSEC_1588_ALARM_OUT1                   | General Purpose Input/Output | J1                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_20/<br>TSEC_1588_ALARM_OUT2                   | General Purpose Input/Output | G1                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_21/<br>TSEC_1588_CLK_OUT                      | General Purpose Input/Output | H1                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_22/<br>TSEC_1588_PULSE_OUT1                   | General Purpose Input/Output | K1                 | IO       | OV <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal  | Signal description           | Package pin number | Pin type | Power supply     | Notes |
|---|------------------------------|--------------------|----------|------------------|-------|
| GPIO4_23/<br><b>TSEC_1588_PULSE_OUT2</b>                      | General Purpose Input/Output | K2                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_24/ <b>USB1_DRVVBUS</b>                                 | General Purpose Input/Output | F6                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_25/ <b>USB1_PWRFAULT</b>                                | General Purpose Input/Output | F3                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_26/ <b>USB2_DRVVBUS</b>                                 | General Purpose Input/Output | F9                 | IO       | OV <sub>DD</sub> | ---   |
| GPIO4_27/ <b>USB2_PWRFAULT</b>                                | General Purpose Input/Output | C6                 | IO       | OV <sub>DD</sub> | ---   |
| <b>Quad SPI</b>   |                              |                    |          |                  |       |
| QSPI_A_CS0/ <b>IFC_A00</b> /<br>GPIO1_16                      | Channel A Chip Select 0      | E16                | O        | OV <sub>DD</sub> | 1, 5  |
| QSPI_A_CS1/ <b>IFC_A01</b> /<br>GPIO1_17                      | Channel A Chip Select 1      | D16                | O        | OV <sub>DD</sub> | 1, 5  |
| QSPI_A_DATA0/ <b>IFC_A06</b> /<br>GPIO2_00/ <b>IFC_WP1_B</b>  | Channel A Data I/O 0         | D13                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_A_DATA1/ <b>IFC_A07</b> /<br>GPIO2_01/ <b>IFC_WP2_B</b>  | Channel A Data I/O 1         | E12                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_A_DATA2/ <b>IFC_A08</b> /<br>GPIO2_02/ <b>IFC_WP3_B</b>  | Channel A Data I/O 2         | D12                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_A_DATA3/ <b>IFC_A09</b> /<br>GPIO2_03/ <b>IFC_RB2_B</b>  | Channel A Data I/O 3         | E11                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_A_DATA4/ <b>IFC_PAR0</b> /<br>GPIO2_06/QSPI_B_DATA0      | Channel A Data I/O 4         | E20                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_A_DATA5/ <b>IFC_PAR1</b> /<br>GPIO2_07/QSPI_B_DATA1      | Channel A Data I/O 5         | E21                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_A_DATA6/<br><b>IFC_PERR_B</b> /GPIO2_16/<br>QSPI_B_DATA2 | Channel A Data I/O 6         | D21                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_A_DATA7/ <b>IFC_CS3_B</b> /<br>GPIO2_11/QSPI_B_DATA3     | Channel A Data I/O 7         | E17                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_A_DQS/ <b>IFC_A10</b> /<br>GPIO2_04/ <b>IFC_RB3_B</b>    | Channel A Data Strobe        | E10                | I        | OV <sub>DD</sub> | 1     |
| QSPI_A_SCK/ <b>IFC_A02</b> /<br>GPIO1_18                      | Channel A Clock              | E15                | O        | OV <sub>DD</sub> | 1, 5  |
| QSPI_B_CS0/ <b>IFC_A03</b> /<br>GPIO1_19                      | Channel B Chip Select 0      | D15                | O        | OV <sub>DD</sub> | 1, 5  |
| QSPI_B_CS1/ <b>IFC_A04</b> /<br>GPIO1_20                      | Channel B Chip Select 1      | E14                | O        | OV <sub>DD</sub> | 1, 5  |
| QSPI_B_DATA0/ <b>IFC_PAR0</b> /<br>GPIO2_06/QSPI_A_DATA4      | Channel B DATA I/O 0         | E20                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_B_DATA1/ <b>IFC_PAR1</b> /<br>GPIO2_07/QSPI_A_DATA5      | Channel B DATA I/O 1         | E21                | IO       | OV <sub>DD</sub> | ---   |
| QSPI_B_DATA2/<br><b>IFC_PERR_B</b> /GPIO2_16/<br>QSPI_A_DATA6 | Channel B DATA I/O 2         | D21                | IO       | OV <sub>DD</sub> | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal   | Signal description           | Package pin number | Pin type | Power supply     | Notes   |
|--|------------------------------|--------------------|----------|------------------|---------|
| QSPI_B_DATA3/IFC_CS3_B/<br>GPIO2_11/QSPI_A_DATA7 | Channel B DATA I/O 3         | E17                | IO       | OV <sub>DD</sub> | ---     |
| QSPI_B_DQS/IFC_A11/<br>GPIO2_05/IFC_RB4_B        | Channel B Data Strobe        | D10                | I        | OV <sub>DD</sub> | 1       |
| QSPI_B_SCK/IFC_A05/<br>GPIO1_21                  | Channel B Clock              | E13                | O        | OV <sub>DD</sub> | 1, 5, 5 |
| <b>Power-On Reset Configuration</b>              |                              |                    |          |                  |         |
| cfg_eng_use0/IFC_WE0_B/<br>GPIO1_22              | Power-on reset configuration | C17                | I        | OV <sub>DD</sub> | 1, 28   |
| cfg_gpinput00/IFC_AD00/<br>GPIO1_00              | Power-on reset configuration | B10                | I        | OV <sub>DD</sub> | 1       |
| cfg_gpinput01/IFC_AD01/<br>GPIO1_01              | Power-on reset configuration | C10                | I        | OV <sub>DD</sub> | 1       |
| cfg_gpinput02/IFC_AD02/<br>GPIO1_02              | Power-on reset configuration | A11                | I        | OV <sub>DD</sub> | 1       |
| cfg_gpinput03/IFC_AD03/<br>GPIO1_03              | Power-on reset configuration | C11                | I        | OV <sub>DD</sub> | 1       |
| cfg_gpinput04/IFC_AD04/<br>GPIO1_04              | Power-on reset configuration | A12                | I        | OV <sub>DD</sub> | 1       |
| cfg_gpinput05/IFC_AD05/<br>GPIO1_05              | Power-on reset configuration | B12                | I        | OV <sub>DD</sub> | 1       |
| cfg_gpinput06/IFC_AD06/<br>GPIO1_06              | Power-on reset configuration | C12                | I        | OV <sub>DD</sub> | 1       |
| cfg_gpinput07/IFC_AD07/<br>GPIO1_07              | Power-on reset configuration | A13                | I        | OV <sub>DD</sub> | 1       |
| cfg_ifc_te/IFC_TE/GPIO1_23                       | Power-on reset configuration | B16                | I        | OV <sub>DD</sub> | 1, 4    |
| cfg_rcw_src01/IFC_AD08/<br>GPIO1_08              | Power-on reset configuration | B13                | I        | OV <sub>DD</sub> | 1       |
| cfg_rcw_src02/IFC_AD09/<br>GPIO1_09              | Power-on reset configuration | C13                | I        | OV <sub>DD</sub> | 1       |
| cfg_rcw_src03/IFC_AD10/<br>GPIO1_10              | Power-on reset configuration | A14                | I        | OV <sub>DD</sub> | 1       |
| cfg_rcw_src04/IFC_AD11/<br>GPIO1_11              | Power-on reset configuration | C14                | I        | OV <sub>DD</sub> | 1       |
| cfg_rcw_src05/IFC_AD12/<br>GPIO1_12              | Power-on reset configuration | A15                | I        | OV <sub>DD</sub> | 1       |
| cfg_rcw_src06/IFC_AD13/<br>GPIO1_13              | Power-on reset configuration | B15                | I        | OV <sub>DD</sub> | 1       |
| cfg_rcw_src07/IFC_AD14/<br>GPIO1_14              | Power-on reset configuration | C15                | I        | OV <sub>DD</sub> | 1       |
| cfg_rcw_src08/IFC_AD15/<br>GPIO1_15              | Power-on reset configuration | A16                | I        | OV <sub>DD</sub> | 1       |
| <b>Power and Ground Signals</b>                  |                              |                    |          |                  |         |
| GND001   | GND                          | A2                 | ---      | ---              | ---     |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal | Signal description | Package pin number | Pin type | Power supply | Notes |
|--------|--------------------|--------------------|----------|--------------|-------|
| GND002 | GND                | A4                 | ---      | ---          | ---   |
| GND003 | GND                | A6                 | ---      | ---          | ---   |
| GND004 | GND                | A22                | ---      | ---          | ---   |
| GND005 | GND                | B1                 | ---      | ---          | ---   |
| GND006 | GND                | B2                 | ---      | ---          | ---   |
| GND007 | GND                | B4                 | ---      | ---          | ---   |
| GND008 | GND                | B6                 | ---      | ---          | ---   |
| GND009 | GND                | B8                 | ---      | ---          | ---   |
| GND010 | GND                | B11                | ---      | ---          | ---   |
| GND011 | GND                | B14                | ---      | ---          | ---   |
| GND012 | GND                | B17                | ---      | ---          | ---   |
| GND013 | GND                | B20                | ---      | ---          | ---   |
| GND014 | GND                | B22                | ---      | ---          | ---   |
| GND015 | GND                | C3                 | ---      | ---          | ---   |
| GND016 | GND                | C4                 | ---      | ---          | ---   |
| GND017 | GND                | C5                 | ---      | ---          | ---   |
| GND018 | GND                | C22                | ---      | ---          | ---   |
| GND019 | GND                | C24                | ---      | ---          | ---   |
| GND020 | GND                | C26                | ---      | ---          | ---   |
| GND021 | GND                | C28                | ---      | ---          | ---   |
| GND022 | GND                | C30                | ---      | ---          | ---   |
| GND023 | GND                | C32                | ---      | ---          | ---   |
| GND024 | GND                | D1                 | ---      | ---          | ---   |
| GND025 | GND                | D2                 | ---      | ---          | ---   |
| GND026 | GND                | D3                 | ---      | ---          | ---   |
| GND027 | GND                | D6                 | ---      | ---          | ---   |
| GND028 | GND                | D8                 | ---      | ---          | ---   |
| GND029 | GND                | D11                | ---      | ---          | ---   |
| GND030 | GND                | D14                | ---      | ---          | ---   |
| GND031 | GND                | D17                | ---      | ---          | ---   |
| GND032 | GND                | D20                | ---      | ---          | ---   |
| GND033 | GND                | D22                | ---      | ---          | ---   |
| GND034 | GND                | E3                 | ---      | ---          | ---   |
| GND035 | GND                | E6                 | ---      | ---          | ---   |
| GND036 | GND                | E22                | ---      | ---          | ---   |
| GND037 | GND                | E26                | ---      | ---          | ---   |
| GND038 | GND                | E28                | ---      | ---          | ---   |
| GND039 | GND                | E30                | ---      | ---          | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal | Signal description | Package pin number | Pin type | Power supply | Notes |
|--------|--------------------|--------------------|----------|--------------|-------|
| GND040 | GND                | E32                | ---      | ---          | ---   |
| GND041 | GND                | F1                 | ---      | ---          | ---   |
| GND042 | GND                | F2                 | ---      | ---          | ---   |
| GND043 | GND                | F4                 | ---      | ---          | ---   |
| GND044 | GND                | F5                 | ---      | ---          | ---   |
| GND045 | GND                | F10                | ---      | ---          | ---   |
| GND046 | GND                | F13                | ---      | ---          | ---   |
| GND047 | GND                | F16                | ---      | ---          | ---   |
| GND048 | GND                | F19                | ---      | ---          | ---   |
| GND049 | GND                | F22                | ---      | ---          | ---   |
| GND050 | GND                | F24                | ---      | ---          | ---   |
| GND051 | GND                | F33                | ---      | ---          | ---   |
| GND052 | GND                | G8                 | ---      | ---          | ---   |
| GND053 | GND                | G22                | ---      | ---          | ---   |
| GND054 | GND                | G26                | ---      | ---          | ---   |
| GND055 | GND                | G29                | ---      | ---          | ---   |
| GND056 | GND                | G31                | ---      | ---          | ---   |
| GND057 | GND                | G34                | ---      | ---          | ---   |
| GND058 | GND                | H2                 | ---      | ---          | ---   |
| GND059 | GND                | H4                 | ---      | ---          | ---   |
| GND060 | GND                | H6                 | ---      | ---          | ---   |
| GND061 | GND                | H19                | ---      | ---          | ---   |
| GND062 | GND                | H22                | ---      | ---          | ---   |
| GND063 | GND                | H24                | ---      | ---          | ---   |
| GND064 | GND                | H28                | ---      | ---          | ---   |
| GND065 | GND                | H32                | ---      | ---          | ---   |
| GND066 | GND                | J9                 | ---      | ---          | ---   |
| GND067 | GND                | J12                | ---      | ---          | ---   |
| GND068 | GND                | J13                | ---      | ---          | ---   |
| GND069 | GND                | J15                | ---      | ---          | ---   |
| GND070 | GND                | J17                | ---      | ---          | ---   |
| GND071 | GND                | J22                | ---      | ---          | ---   |
| GND072 | GND                | J26                | ---      | ---          | ---   |
| GND073 | GND                | J30                | ---      | ---          | ---   |
| GND074 | GND                | J34                | ---      | ---          | ---   |
| GND075 | GND                | K10                | ---      | ---          | ---   |
| GND076 | GND                | K11                | ---      | ---          | ---   |
| GND077 | GND                | K12                | ---      | ---          | ---   |

*Table continues on the next page...*

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal | Signal description | Package pin number | Pin type | Power supply | Notes |
|--------|--------------------|--------------------|----------|--------------|-------|
| GND078 | GND                | K14                | ---      | ---          | ---   |
| GND079 | GND                | K15                | ---      | ---          | ---   |
| GND080 | GND                | K16                | ---      | ---          | ---   |
| GND081 | GND                | K22                | ---      | ---          | ---   |
| GND082 | GND                | K24                | ---      | ---          | ---   |
| GND083 | GND                | K32                | ---      | ---          | ---   |
| GND084 | GND                | L2                 | ---      | ---          | ---   |
| GND085 | GND                | L4                 | ---      | ---          | ---   |
| GND086 | GND                | L6                 | ---      | ---          | ---   |
| GND087 | GND                | L18                | ---      | ---          | ---   |
| GND088 | GND                | L19                | ---      | ---          | ---   |
| GND089 | GND                | L20                | ---      | ---          | ---   |
| GND090 | GND                | L21                | ---      | ---          | ---   |
| GND091 | GND                | L22                | ---      | ---          | ---   |
| GND092 | GND                | L27                | ---      | ---          | ---   |
| GND093 | GND                | L28                | ---      | ---          | ---   |
| GND094 | GND                | L30                | ---      | ---          | ---   |
| GND095 | GND                | L34                | ---      | ---          | ---   |
| GND096 | GND                | M9                 | ---      | ---          | ---   |
| GND097 | GND                | M14                | ---      | ---          | ---   |
| GND098 | GND                | M16                | ---      | ---          | ---   |
| GND099 | GND                | M18                | ---      | ---          | ---   |
| GND100 | GND                | M25                | ---      | ---          | ---   |
| GND101 | GND                | M28                | ---      | ---          | ---   |
| GND102 | GND                | M32                | ---      | ---          | ---   |
| GND103 | GND                | N11                | ---      | ---          | ---   |
| GND104 | GND                | N13                | ---      | ---          | ---   |
| GND105 | GND                | N15                | ---      | ---          | ---   |
| GND106 | GND                | N17                | ---      | ---          | ---   |
| GND107 | GND                | N19                | ---      | ---          | ---   |
| GND108 | GND                | N21                | ---      | ---          | ---   |
| GND109 | GND                | N23                | ---      | ---          | ---   |
| GND110 | GND                | N28                | ---      | ---          | ---   |
| GND111 | GND                | N30                | ---      | ---          | ---   |
| GND112 | GND                | N34                | ---      | ---          | ---   |
| GND113 | GND                | P10                | ---      | ---          | ---   |
| GND114 | GND                | P12                | ---      | ---          | ---   |
| GND115 | GND                | P14                | ---      | ---          | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal | Signal description | Package pin number | Pin type | Power supply | Notes |
|--------|--------------------|--------------------|----------|--------------|-------|
| GND116 | GND                | P16                | ---      | ---          | ---   |
| GND117 | GND                | P18                | ---      | ---          | ---   |
| GND118 | GND                | P20                | ---      | ---          | ---   |
| GND119 | GND                | P22                | ---      | ---          | ---   |
| GND120 | GND                | P24                | ---      | ---          | ---   |
| GND121 | GND                | P26                | ---      | ---          | ---   |
| GND122 | GND                | P28                | ---      | ---          | ---   |
| GND123 | GND                | P32                | ---      | ---          | ---   |
| GND124 | GND                | R11                | ---      | ---          | ---   |
| GND125 | GND                | R13                | ---      | ---          | ---   |
| GND126 | GND                | R15                | ---      | ---          | ---   |
| GND127 | GND                | R17                | ---      | ---          | ---   |
| GND128 | GND                | R19                | ---      | ---          | ---   |
| GND129 | GND                | R21                | ---      | ---          | ---   |
| GND130 | GND                | R23                | ---      | ---          | ---   |
| GND131 | GND                | R25                | ---      | ---          | ---   |
| GND132 | GND                | R28                | ---      | ---          | ---   |
| GND133 | GND                | R30                | ---      | ---          | ---   |
| GND134 | GND                | R34                | ---      | ---          | ---   |
| GND135 | GND                | T9                 | ---      | ---          | ---   |
| GND136 | GND                | T12                | ---      | ---          | ---   |
| GND137 | GND                | T14                | ---      | ---          | ---   |
| GND138 | GND                | T16                | ---      | ---          | ---   |
| GND139 | GND                | T18                | ---      | ---          | ---   |
| GND140 | GND                | T20                | ---      | ---          | ---   |
| GND141 | GND                | T22                | ---      | ---          | ---   |
| GND142 | GND                | T24                | ---      | ---          | ---   |
| GND143 | GND                | T28                | ---      | ---          | ---   |
| GND144 | GND                | T32                | ---      | ---          | ---   |
| GND145 | GND                | U2                 | ---      | ---          | ---   |
| GND146 | GND                | U4                 | ---      | ---          | ---   |
| GND147 | GND                | U9                 | ---      | ---          | ---   |
| GND148 | GND                | U11                | ---      | ---          | ---   |
| GND149 | GND                | U13                | ---      | ---          | ---   |
| GND150 | GND                | U15                | ---      | ---          | ---   |
| GND151 | GND                | U17                | ---      | ---          | ---   |
| GND152 | GND                | U19                | ---      | ---          | ---   |
| GND153 | GND                | U21                | ---      | ---          | ---   |

*Table continues on the next page...*

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal | Signal description | Package pin number | Pin type | Power supply | Notes |
|--------|--------------------|--------------------|----------|--------------|-------|
| GND154 | GND                | U23                | ---      | ---          | ---   |
| GND155 | GND                | U25                | ---      | ---          | ---   |
| GND156 | GND                | U26                | ---      | ---          | ---   |
| GND157 | GND                | U28                | ---      | ---          | ---   |
| GND158 | GND                | U30                | ---      | ---          | ---   |
| GND159 | GND                | U34                | ---      | ---          | ---   |
| GND160 | GND                | V6                 | ---      | ---          | ---   |
| GND161 | GND                | V9                 | ---      | ---          | ---   |
| GND162 | GND                | V12                | ---      | ---          | ---   |
| GND163 | GND                | V14                | ---      | ---          | ---   |
| GND164 | GND                | V16                | ---      | ---          | ---   |
| GND165 | GND                | V18                | ---      | ---          | ---   |
| GND166 | GND                | V20                | ---      | ---          | ---   |
| GND167 | GND                | V22                | ---      | ---          | ---   |
| GND168 | GND                | V24                | ---      | ---          | ---   |
| GND169 | GND                | V28                | ---      | ---          | ---   |
| GND170 | GND                | V32                | ---      | ---          | ---   |
| GND171 | GND                | W2                 | ---      | ---          | ---   |
| GND172 | GND                | W4                 | ---      | ---          | ---   |
| GND173 | GND                | W9                 | ---      | ---          | ---   |
| GND174 | GND                | W11                | ---      | ---          | ---   |
| GND175 | GND                | W13                | ---      | ---          | ---   |
| GND176 | GND                | W15                | ---      | ---          | ---   |
| GND177 | GND                | W17                | ---      | ---          | ---   |
| GND178 | GND                | W19                | ---      | ---          | ---   |
| GND179 | GND                | W21                | ---      | ---          | ---   |
| GND180 | GND                | W23                | ---      | ---          | ---   |
| GND181 | GND                | W25                | ---      | ---          | ---   |
| GND182 | GND                | W28                | ---      | ---          | ---   |
| GND183 | GND                | W32                | ---      | ---          | ---   |
| GND184 | GND                | Y6                 | ---      | ---          | ---   |
| GND185 | GND                | Y9                 | ---      | ---          | ---   |
| GND186 | GND                | Y12                | ---      | ---          | ---   |
| GND187 | GND                | Y14                | ---      | ---          | ---   |
| GND188 | GND                | Y16                | ---      | ---          | ---   |
| GND189 | GND                | Y18                | ---      | ---          | ---   |
| GND190 | GND                | Y20                | ---      | ---          | ---   |
| GND191 | GND                | Y22                | ---      | ---          | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal | Signal description | Package pin number | Pin type | Power supply | Notes |
|--------|--------------------|--------------------|----------|--------------|-------|
| GND192 | GND                | Y24                | ---      | ---          | ---   |
| GND193 | GND                | Y26                | ---      | ---          | ---   |
| GND194 | GND                | Y28                | ---      | ---          | ---   |
| GND195 | GND                | Y30                | ---      | ---          | ---   |
| GND196 | GND                | Y34                | ---      | ---          | ---   |
| GND197 | GND                | AA2                | ---      | ---          | ---   |
| GND198 | GND                | AA4                | ---      | ---          | ---   |
| GND199 | GND                | AA8                | ---      | ---          | ---   |
| GND200 | GND                | AA11               | ---      | ---          | ---   |
| GND201 | GND                | AA13               | ---      | ---          | ---   |
| GND202 | GND                | AA15               | ---      | ---          | ---   |
| GND203 | GND                | AA17               | ---      | ---          | ---   |
| GND204 | GND                | AA19               | ---      | ---          | ---   |
| GND205 | GND                | AA21               | ---      | ---          | ---   |
| GND206 | GND                | AA23               | ---      | ---          | ---   |
| GND207 | GND                | AA25               | ---      | ---          | ---   |
| GND208 | GND                | AA28               | ---      | ---          | ---   |
| GND209 | GND                | AA32               | ---      | ---          | ---   |
| GND210 | GND                | AB6                | ---      | ---          | ---   |
| GND211 | GND                | AB9                | ---      | ---          | ---   |
| GND212 | GND                | AB10               | ---      | ---          | ---   |
| GND213 | GND                | AB12               | ---      | ---          | ---   |
| GND214 | GND                | AB14               | ---      | ---          | ---   |
| GND215 | GND                | AB16               | ---      | ---          | ---   |
| GND216 | GND                | AB18               | ---      | ---          | ---   |
| GND217 | GND                | AB20               | ---      | ---          | ---   |
| GND218 | GND                | AB22               | ---      | ---          | ---   |
| GND219 | GND                | AB24               | ---      | ---          | ---   |
| GND220 | GND                | AB28               | ---      | ---          | ---   |
| GND221 | GND                | AB30               | ---      | ---          | ---   |
| GND222 | GND                | AB34               | ---      | ---          | ---   |
| GND223 | GND                | AC2                | ---      | ---          | ---   |
| GND224 | GND                | AC4                | ---      | ---          | ---   |
| GND225 | GND                | AC8                | ---      | ---          | ---   |
| GND226 | GND                | AC11               | ---      | ---          | ---   |
| GND227 | GND                | AC13               | ---      | ---          | ---   |
| GND228 | GND                | AC15               | ---      | ---          | ---   |
| GND229 | GND                | AC17               | ---      | ---          | ---   |

*Table continues on the next page...*

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal | Signal description | Package pin number | Pin type | Power supply | Notes |
|--------|--------------------|--------------------|----------|--------------|-------|
| GND230 | GND                | AC19               | ---      | ---          | ---   |
| GND231 | GND                | AC21               | ---      | ---          | ---   |
| GND232 | GND                | AC23               | ---      | ---          | ---   |
| GND233 | GND                | AC25               | ---      | ---          | ---   |
| GND234 | GND                | AC26               | ---      | ---          | ---   |
| GND235 | GND                | AC28               | ---      | ---          | ---   |
| GND236 | GND                | AC32               | ---      | ---          | ---   |
| GND237 | GND                | AD6                | ---      | ---          | ---   |
| GND238 | GND                | AD10               | ---      | ---          | ---   |
| GND239 | GND                | AD12               | ---      | ---          | ---   |
| GND240 | GND                | AD14               | ---      | ---          | ---   |
| GND241 | GND                | AD16               | ---      | ---          | ---   |
| GND242 | GND                | AD18               | ---      | ---          | ---   |
| GND243 | GND                | AD20               | ---      | ---          | ---   |
| GND244 | GND                | AD22               | ---      | ---          | ---   |
| GND245 | GND                | AD24               | ---      | ---          | ---   |
| GND246 | GND                | AD26               | ---      | ---          | ---   |
| GND247 | GND                | AD28               | ---      | ---          | ---   |
| GND248 | GND                | AD30               | ---      | ---          | ---   |
| GND249 | GND                | AD34               | ---      | ---          | ---   |
| GND250 | GND                | AE2                | ---      | ---          | ---   |
| GND251 | GND                | AE4                | ---      | ---          | ---   |
| GND252 | GND                | AE8                | ---      | ---          | ---   |
| GND253 | GND                | AE21               | ---      | ---          | ---   |
| GND254 | GND                | AE23               | ---      | ---          | ---   |
| GND255 | GND                | AE25               | ---      | ---          | ---   |
| GND256 | GND                | AE28               | ---      | ---          | ---   |
| GND257 | GND                | AE32               | ---      | ---          | ---   |
| GND258 | GND                | AF6                | ---      | ---          | ---   |
| GND259 | GND                | AF22               | ---      | ---          | ---   |
| GND260 | GND                | AF27               | ---      | ---          | ---   |
| GND261 | GND                | AF28               | ---      | ---          | ---   |
| GND262 | GND                | AF30               | ---      | ---          | ---   |
| GND263 | GND                | AF34               | ---      | ---          | ---   |
| GND264 | GND                | AG24               | ---      | ---          | ---   |
| GND265 | GND                | AG32               | ---      | ---          | ---   |
| GND266 | GND                | AH22               | ---      | ---          | ---   |
| GND267 | GND                | AH26               | ---      | ---          | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal    | Signal description | Package pin number | Pin type | Power supply | Notes |
|-----------|--------------------|--------------------|----------|--------------|-------|
| GND268    | GND                | AH30               | ---      | ---          | ---   |
| GND269    | GND                | AH34               | ---      | ---          | ---   |
| GND270    | GND                | AJ22               | ---      | ---          | ---   |
| GND271    | GND                | AJ24               | ---      | ---          | ---   |
| GND272    | GND                | AJ28               | ---      | ---          | ---   |
| GND273    | GND                | AJ32               | ---      | ---          | ---   |
| GND274    | GND                | AK22               | ---      | ---          | ---   |
| GND275    | GND                | AK26               | ---      | ---          | ---   |
| GND276    | GND                | AK29               | ---      | ---          | ---   |
| GND277    | GND                | AK31               | ---      | ---          | ---   |
| GND278    | GND                | AK34               | ---      | ---          | ---   |
| GND279    | GND                | AL24               | ---      | ---          | ---   |
| GND280    | GND                | AL33               | ---      | ---          | ---   |
| GND281    | GND                | AM22               | ---      | ---          | ---   |
| GND282    | GND                | AM26               | ---      | ---          | ---   |
| GND283    | GND                | AM28               | ---      | ---          | ---   |
| GND284    | GND                | AM30               | ---      | ---          | ---   |
| GND285    | GND                | AM32               | ---      | ---          | ---   |
| GND286    | GND                | AN22               | ---      | ---          | ---   |
| GND287    | GND                | AP22               | ---      | ---          | ---   |
| GND288    | GND                | AP24               | ---      | ---          | ---   |
| GND289    | GND                | AP26               | ---      | ---          | ---   |
| GND290    | GND                | AP28               | ---      | ---          | ---   |
| GND291    | GND                | AP30               | ---      | ---          | ---   |
| GND292    | GND                | AP32               | ---      | ---          | ---   |
| GND293    | GND                | AT22               | ---      | ---          | ---   |
| SD_GND001 | Serdes GND         | AE9                | ---      | ---          | ---   |
| SD_GND002 | Serdes GND         | AF7                | ---      | ---          | ---   |
| SD_GND003 | Serdes GND         | AF10               | ---      | ---          | ---   |
| SD_GND004 | Serdes GND         | AF11               | ---      | ---          | ---   |
| SD_GND005 | Serdes GND         | AF12               | ---      | ---          | ---   |
| SD_GND006 | Serdes GND         | AF13               | ---      | ---          | ---   |
| SD_GND007 | Serdes GND         | AF14               | ---      | ---          | ---   |
| SD_GND008 | Serdes GND         | AF15               | ---      | ---          | ---   |
| SD_GND009 | Serdes GND         | AF16               | ---      | ---          | ---   |
| SD_GND010 | Serdes GND         | AF17               | ---      | ---          | ---   |
| SD_GND011 | Serdes GND         | AF18               | ---      | ---          | ---   |
| SD_GND012 | Serdes GND         | AG1                | ---      | ---          | ---   |

*Table continues on the next page...*

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal    | Signal description | Package pin number | Pin type | Power supply | Notes |
|-----------|--------------------|--------------------|----------|--------------|-------|
| SD_GND013 | Serdes GND         | AG2                | ---      | ---          | ---   |
| SD_GND014 | Serdes GND         | AG3                | ---      | ---          | ---   |
| SD_GND015 | Serdes GND         | AG4                | ---      | ---          | ---   |
| SD_GND016 | Serdes GND         | AG5                | ---      | ---          | ---   |
| SD_GND017 | Serdes GND         | AG6                | ---      | ---          | ---   |
| SD_GND018 | Serdes GND         | AG9                | ---      | ---          | ---   |
| SD_GND019 | Serdes GND         | AG20               | ---      | ---          | ---   |
| SD_GND020 | Serdes GND         | AH1                | ---      | ---          | ---   |
| SD_GND021 | Serdes GND         | AH3                | ---      | ---          | ---   |
| SD_GND022 | Serdes GND         | AH5                | ---      | ---          | ---   |
| SD_GND023 | Serdes GND         | AH7                | ---      | ---          | ---   |
| SD_GND024 | Serdes GND         | AH10               | ---      | ---          | ---   |
| SD_GND025 | Serdes GND         | AH12               | ---      | ---          | ---   |
| SD_GND026 | Serdes GND         | AH14               | ---      | ---          | ---   |
| SD_GND027 | Serdes GND         | AH16               | ---      | ---          | ---   |
| SD_GND028 | Serdes GND         | AH18               | ---      | ---          | ---   |
| SD_GND029 | Serdes GND         | AH20               | ---      | ---          | ---   |
| SD_GND030 | Serdes GND         | AJ1                | ---      | ---          | ---   |
| SD_GND031 | Serdes GND         | AJ3                | ---      | ---          | ---   |
| SD_GND032 | Serdes GND         | AJ5                | ---      | ---          | ---   |
| SD_GND033 | Serdes GND         | AJ7                | ---      | ---          | ---   |
| SD_GND034 | Serdes GND         | AJ10               | ---      | ---          | ---   |
| SD_GND035 | Serdes GND         | AJ12               | ---      | ---          | ---   |
| SD_GND036 | Serdes GND         | AJ14               | ---      | ---          | ---   |
| SD_GND037 | Serdes GND         | AJ16               | ---      | ---          | ---   |
| SD_GND038 | Serdes GND         | AJ18               | ---      | ---          | ---   |
| SD_GND039 | Serdes GND         | AJ20               | ---      | ---          | ---   |
| SD_GND040 | Serdes GND         | AK1                | ---      | ---          | ---   |
| SD_GND041 | Serdes GND         | AK2                | ---      | ---          | ---   |
| SD_GND042 | Serdes GND         | AK4                | ---      | ---          | ---   |
| SD_GND043 | Serdes GND         | AK6                | ---      | ---          | ---   |
| SD_GND044 | Serdes GND         | AK8                | ---      | ---          | ---   |
| SD_GND045 | Serdes GND         | AK9                | ---      | ---          | ---   |
| SD_GND046 | Serdes GND         | AK11               | ---      | ---          | ---   |
| SD_GND047 | Serdes GND         | AK13               | ---      | ---          | ---   |
| SD_GND048 | Serdes GND         | AK15               | ---      | ---          | ---   |
| SD_GND049 | Serdes GND         | AK17               | ---      | ---          | ---   |
| SD_GND050 | Serdes GND         | AK19               | ---      | ---          | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal    | Signal description | Package pin number | Pin type | Power supply | Notes |
|-----------|--------------------|--------------------|----------|--------------|-------|
| SD_GND051 | Serdes GND         | AK21               | ---      | ---          | ---   |
| SD_GND052 | Serdes GND         | AL2                | ---      | ---          | ---   |
| SD_GND053 | Serdes GND         | AL4                | ---      | ---          | ---   |
| SD_GND054 | Serdes GND         | AL6                | ---      | ---          | ---   |
| SD_GND055 | Serdes GND         | AL8                | ---      | ---          | ---   |
| SD_GND056 | Serdes GND         | AL9                | ---      | ---          | ---   |
| SD_GND057 | Serdes GND         | AL11               | ---      | ---          | ---   |
| SD_GND058 | Serdes GND         | AL13               | ---      | ---          | ---   |
| SD_GND059 | Serdes GND         | AL15               | ---      | ---          | ---   |
| SD_GND060 | Serdes GND         | AL17               | ---      | ---          | ---   |
| SD_GND061 | Serdes GND         | AL19               | ---      | ---          | ---   |
| SD_GND062 | Serdes GND         | AL21               | ---      | ---          | ---   |
| SD_GND063 | Serdes GND         | AM2                | ---      | ---          | ---   |
| SD_GND064 | Serdes GND         | AM3                | ---      | ---          | ---   |
| SD_GND065 | Serdes GND         | AM4                | ---      | ---          | ---   |
| SD_GND066 | Serdes GND         | AM5                | ---      | ---          | ---   |
| SD_GND067 | Serdes GND         | AM6                | ---      | ---          | ---   |
| SD_GND068 | Serdes GND         | AM7                | ---      | ---          | ---   |
| SD_GND069 | Serdes GND         | AM10               | ---      | ---          | ---   |
| SD_GND070 | Serdes GND         | AM11               | ---      | ---          | ---   |
| SD_GND071 | Serdes GND         | AM12               | ---      | ---          | ---   |
| SD_GND072 | Serdes GND         | AM13               | ---      | ---          | ---   |
| SD_GND073 | Serdes GND         | AM15               | ---      | ---          | ---   |
| SD_GND074 | Serdes GND         | AM16               | ---      | ---          | ---   |
| SD_GND075 | Serdes GND         | AM17               | ---      | ---          | ---   |
| SD_GND076 | Serdes GND         | AM18               | ---      | ---          | ---   |
| SD_GND077 | Serdes GND         | AM19               | ---      | ---          | ---   |
| SD_GND078 | Serdes GND         | AM20               | ---      | ---          | ---   |
| SD_GND079 | Serdes GND         | AN1                | ---      | ---          | ---   |
| SD_GND080 | Serdes GND         | AN3                | ---      | ---          | ---   |
| SD_GND081 | Serdes GND         | AN5                | ---      | ---          | ---   |
| SD_GND082 | Serdes GND         | AN7                | ---      | ---          | ---   |
| SD_GND083 | Serdes GND         | AN10               | ---      | ---          | ---   |
| SD_GND084 | Serdes GND         | AN12               | ---      | ---          | ---   |
| SD_GND085 | Serdes GND         | AN14               | ---      | ---          | ---   |
| SD_GND086 | Serdes GND         | AN16               | ---      | ---          | ---   |
| SD_GND087 | Serdes GND         | AN18               | ---      | ---          | ---   |
| SD_GND088 | Serdes GND         | AN20               | ---      | ---          | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal      | Signal description | Package pin number | Pin type | Power supply     | Notes |
|-------------|--------------------|--------------------|----------|------------------|-------|
| SD_GND089   | Serdes GND         | AP1                | ---      | ---              | ---   |
| SD_GND090   | Serdes GND         | AP3                | ---      | ---              | ---   |
| SD_GND091   | Serdes GND         | AP5                | ---      | ---              | ---   |
| SD_GND092   | Serdes GND         | AP7                | ---      | ---              | ---   |
| SD_GND093   | Serdes GND         | AP10               | ---      | ---              | ---   |
| SD_GND094   | Serdes GND         | AP12               | ---      | ---              | ---   |
| SD_GND095   | Serdes GND         | AP14               | ---      | ---              | ---   |
| SD_GND096   | Serdes GND         | AP16               | ---      | ---              | ---   |
| SD_GND097   | Serdes GND         | AP18               | ---      | ---              | ---   |
| SD_GND098   | Serdes GND         | AP20               | ---      | ---              | ---   |
| SD_GND099   | Serdes GND         | AR1                | ---      | ---              | ---   |
| SD_GND100   | Serdes GND         | AR2                | ---      | ---              | ---   |
| SD_GND101   | Serdes GND         | AR4                | ---      | ---              | ---   |
| SD_GND102   | Serdes GND         | AR6                | ---      | ---              | ---   |
| SD_GND103   | Serdes GND         | AR8                | ---      | ---              | ---   |
| SD_GND104   | Serdes GND         | AR9                | ---      | ---              | ---   |
| SD_GND105   | Serdes GND         | AR11               | ---      | ---              | ---   |
| SD_GND106   | Serdes GND         | AR13               | ---      | ---              | ---   |
| SD_GND107   | Serdes GND         | AR15               | ---      | ---              | ---   |
| SD_GND108   | Serdes GND         | AR17               | ---      | ---              | ---   |
| SD_GND109   | Serdes GND         | AR19               | ---      | ---              | ---   |
| SD_GND110   | Serdes GND         | AR21               | ---      | ---              | ---   |
| SD_GND111   | Serdes GND         | AT2                | ---      | ---              | ---   |
| SD_GND112   | Serdes GND         | AT4                | ---      | ---              | ---   |
| SD_GND113   | Serdes GND         | AT6                | ---      | ---              | ---   |
| SD_GND114   | Serdes GND         | AT8                | ---      | ---              | ---   |
| SD_GND115   | Serdes GND         | AT9                | ---      | ---              | ---   |
| SD_GND116   | Serdes GND         | AT11               | ---      | ---              | ---   |
| SD_GND117   | Serdes GND         | AT13               | ---      | ---              | ---   |
| SD_GND118   | Serdes GND         | AT15               | ---      | ---              | ---   |
| SD_GND119   | Serdes GND         | AT17               | ---      | ---              | ---   |
| SD_GND120   | Serdes GND         | AT19               | ---      | ---              | ---   |
| SD_GND121   | Serdes GND         | AT21               | ---      | ---              | ---   |
| SENSEGND_CA | GND Sense pin      | K17                | ---      | ---              | ---   |
| SENSEGND_CB | GND Sense pin      | AE20               | ---      | ---              | ---   |
| SENSEGND_PL | GND Sense pin      | K13                | ---      | ---              | ---   |
| OVDD01      | General I/O supply | M19                | ---      | OV <sub>DD</sub> | ---   |
| OVDD02      | General I/O supply | M20                | ---      | OV <sub>DD</sub> | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal  | Signal description    | Package pin number | Pin type | Power supply      | Notes |
|---------|-----------------------|--------------------|----------|-------------------|-------|
| OVDD03  | General I/O supply    | M21                | ---      | OV <sub>DD</sub>  | ---   |
| OVDD04  | General I/O supply    | M22                | ---      | OV <sub>DD</sub>  | ---   |
| OVDD05  | General I/O supply    | M23                | ---      | OV <sub>DD</sub>  | ---   |
| OVDD06  | General I/O supply    | M24                | ---      | OV <sub>DD</sub>  | ---   |
| OVDD07  | General I/O supply    | N9                 | ---      | OV <sub>DD</sub>  | ---   |
| OVDD08  | General I/O supply    | V26                | ---      | OV <sub>DD</sub>  | ---   |
| OVDD09  | General I/O supply    | W26                | ---      | OV <sub>DD</sub>  | ---   |
| OVDD10  | General I/O supply    | AE26               | ---      | OV <sub>DD</sub>  | ---   |
| G1VDD01 | DDR supply for port 1 | A35                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD02 | DDR supply for port 1 | B23                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD03 | DDR supply for port 1 | B25                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD04 | DDR supply for port 1 | B27                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD05 | DDR supply for port 1 | B29                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD06 | DDR supply for port 1 | B31                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD07 | DDR supply for port 1 | B33                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD08 | DDR supply for port 1 | B36                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD09 | DDR supply for port 1 | D33                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD10 | DDR supply for port 1 | E34                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD11 | DDR supply for port 1 | F35                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD12 | DDR supply for port 1 | H35                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD13 | DDR supply for port 1 | K35                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD14 | DDR supply for port 1 | M27                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD15 | DDR supply for port 1 | M35                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD16 | DDR supply for port 1 | N27                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD17 | DDR supply for port 1 | P27                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD18 | DDR supply for port 1 | P35                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD19 | DDR supply for port 1 | R27                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD20 | DDR supply for port 1 | T27                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD21 | DDR supply for port 1 | T35                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD22 | DDR supply for port 1 | U27                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD23 | DDR supply for port 1 | V27                | ---      | G1V <sub>DD</sub> | ---   |
| G1VDD24 | DDR supply for port 1 | V35                | ---      | G1V <sub>DD</sub> | ---   |
| G2VDD01 | DDR supply for port 2 | W27                | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD02 | DDR supply for port 2 | W35                | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD03 | DDR supply for port 2 | Y27                | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD04 | DDR supply for port 2 | AA27               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD05 | DDR supply for port 2 | AA35               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD06 | DDR supply for port 2 | AB27               | ---      | G2V <sub>DD</sub> | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal  | Signal description        | Package pin number | Pin type | Power supply      | Notes |
|---------|---------------------------|--------------------|----------|-------------------|-------|
| G2VDD07 | DDR supply for port 2     | AC27               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD08 | DDR supply for port 2     | AC35               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD09 | DDR supply for port 2     | AD27               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD10 | DDR supply for port 2     | AE27               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD11 | DDR supply for port 2     | AE35               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD12 | DDR supply for port 2     | AG35               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD13 | DDR supply for port 2     | AJ35               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD14 | DDR supply for port 2     | AL35               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD15 | DDR supply for port 2     | AM34               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD16 | DDR supply for port 2     | AN33               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD17 | DDR supply for port 2     | AR23               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD18 | DDR supply for port 2     | AR25               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD19 | DDR supply for port 2     | AR27               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD20 | DDR supply for port 2     | AR29               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD21 | DDR supply for port 2     | AR31               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD22 | DDR supply for port 2     | AR33               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD23 | DDR supply for port 2     | AR36               | ---      | G2V <sub>DD</sub> | ---   |
| G2VDD24 | DDR supply for port 2     | AT35               | ---      | G2V <sub>DD</sub> | ---   |
| SVDD01  | SerDes core logic supply  | AE10               | ---      | SV <sub>DD</sub>  | ---   |
| SVDD02  | SerDes core logic supply  | AE11               | ---      | SV <sub>DD</sub>  | ---   |
| SVDD03  | SerDes core logic supply  | AE12               | ---      | SV <sub>DD</sub>  | ---   |
| SVDD04  | SerDes core logic supply  | AE13               | ---      | SV <sub>DD</sub>  | ---   |
| SVDD05  | SerDes core logic supply  | AE14               | ---      | SV <sub>DD</sub>  | ---   |
| SVDD06  | SerDes core logic supply  | AE15               | ---      | SV <sub>DD</sub>  | ---   |
| SVDD07  | SerDes core logic supply  | AE16               | ---      | SV <sub>DD</sub>  | ---   |
| SVDD08  | SerDes core logic supply  | AE17               | ---      | SV <sub>DD</sub>  | ---   |
| SVDD09  | SerDes core logic supply  | AE18               | ---      | SV <sub>DD</sub>  | ---   |
| SVDD10  | SerDes core logic supply  | AN8                | ---      | SV <sub>DD</sub>  | ---   |
| SVDD11  | SerDes core logic supply  | AN9                | ---      | SV <sub>DD</sub>  | ---   |
| XVDD01  | SerDes transceiver supply | AF8                | ---      | XV <sub>DD</sub>  | ---   |
| XVDD02  | SerDes transceiver supply | AG10               | ---      | XV <sub>DD</sub>  | ---   |
| XVDD03  | SerDes transceiver supply | AG11               | ---      | XV <sub>DD</sub>  | ---   |
| XVDD04  | SerDes transceiver supply | AG12               | ---      | XV <sub>DD</sub>  | ---   |
| XVDD05  | SerDes transceiver supply | AG13               | ---      | XV <sub>DD</sub>  | ---   |
| XVDD06  | SerDes transceiver supply | AG14               | ---      | XV <sub>DD</sub>  | ---   |
| XVDD07  | SerDes transceiver supply | AG15               | ---      | XV <sub>DD</sub>  | ---   |
| XVDD08  | SerDes transceiver supply | AG16               | ---      | XV <sub>DD</sub>  | ---   |
| XVDD09  | SerDes transceiver supply | AG17               | ---      | XV <sub>DD</sub>  | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal      | Signal description                   | Package pin number | Pin type | Power supply       | Notes |
|-------------|--------------------------------------|--------------------|----------|--------------------|-------|
| XVDD10      | SerDes transceiver supply            | AG18               | ---      | XV <sub>DD</sub>   | ---   |
| XVDD11      | SerDes transceiver supply            | AG19               | ---      | XV <sub>DD</sub>   | ---   |
| FA_VL       | Reserved                             | AG22               | ---      | FA_VL              | 15    |
| PROG_MTR    | Reserved                             | M26                | ---      | PROG_MTR           | 15    |
| TA_PROG_SFP | SFP Fuse Programming Override supply | N25                | ---      | TA_PROG_SFP        | ---   |
| TH_VDD      | Thermal Monitor Unit supply          | H13                | ---      | TH_V <sub>DD</sub> | ---   |
| VDD001      | Supply for cores and platform        | M13                | ---      | V <sub>DD</sub>    | ---   |
| VDD002      | Supply for cores and platform        | M15                | ---      | V <sub>DD</sub>    | ---   |
| VDD003      | Supply for cores and platform        | M17                | ---      | V <sub>DD</sub>    | ---   |
| VDD004      | Supply for cores and platform        | N10                | ---      | V <sub>DD</sub>    | ---   |
| VDD005      | Supply for cores and platform        | N12                | ---      | V <sub>DD</sub>    | ---   |
| VDD006      | Supply for cores and platform        | N14                | ---      | V <sub>DD</sub>    | ---   |
| VDD007      | Supply for cores and platform        | N16                | ---      | V <sub>DD</sub>    | ---   |
| VDD008      | Supply for cores and platform        | N18                | ---      | V <sub>DD</sub>    | ---   |
| VDD009      | Supply for cores and platform        | N20                | ---      | V <sub>DD</sub>    | ---   |
| VDD010      | Supply for cores and platform        | N22                | ---      | V <sub>DD</sub>    | ---   |
| VDD011      | Supply for cores and platform        | N24                | ---      | V <sub>DD</sub>    | ---   |
| VDD012      | Supply for cores and platform        | N26                | ---      | V <sub>DD</sub>    | ---   |
| VDD013      | Supply for cores and platform        | P11                | ---      | V <sub>DD</sub>    | ---   |
| VDD014      | Supply for cores and platform        | P13                | ---      | V <sub>DD</sub>    | ---   |
| VDD015      | Supply for cores and platform        | P15                | ---      | V <sub>DD</sub>    | ---   |
| VDD016      | Supply for cores and platform        | P17                | ---      | V <sub>DD</sub>    | ---   |
| VDD017      | Supply for cores and platform        | P19                | ---      | V <sub>DD</sub>    | ---   |
| VDD018      | Supply for cores and platform        | P21                | ---      | V <sub>DD</sub>    | ---   |
| VDD019      | Supply for cores and platform        | P23                | ---      | V <sub>DD</sub>    | ---   |
| VDD020      | Supply for cores and platform        | P25                | ---      | V <sub>DD</sub>    | ---   |
| VDD021      | Supply for cores and platform        | R10                | ---      | V <sub>DD</sub>    | ---   |
| VDD022      | Supply for cores and platform        | R12                | ---      | V <sub>DD</sub>    | ---   |
| VDD023      | Supply for cores and platform        | R14                | ---      | V <sub>DD</sub>    | ---   |
| VDD024      | Supply for cores and platform        | R16                | ---      | V <sub>DD</sub>    | ---   |
| VDD025      | Supply for cores and platform        | R18                | ---      | V <sub>DD</sub>    | ---   |
| VDD026      | Supply for cores and platform        | R20                | ---      | V <sub>DD</sub>    | ---   |
| VDD027      | Supply for cores and platform        | R22                | ---      | V <sub>DD</sub>    | ---   |
| VDD028      | Supply for cores and platform        | R24                | ---      | V <sub>DD</sub>    | ---   |
| VDD029      | Supply for cores and platform        | T11                | ---      | V <sub>DD</sub>    | ---   |
| VDD030      | Supply for cores and platform        | T13                | ---      | V <sub>DD</sub>    | ---   |
| VDD031      | Supply for cores and platform        | T15                | ---      | V <sub>DD</sub>    | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal | Signal description            | Package pin number | Pin type | Power supply    | Notes |
|--------|-------------------------------|--------------------|----------|-----------------|-------|
| VDD032 | Supply for cores and platform | T17                | ---      | V <sub>DD</sub> | ---   |
| VDD033 | Supply for cores and platform | T19                | ---      | V <sub>DD</sub> | ---   |
| VDD034 | Supply for cores and platform | T21                | ---      | V <sub>DD</sub> | ---   |
| VDD035 | Supply for cores and platform | T23                | ---      | V <sub>DD</sub> | ---   |
| VDD036 | Supply for cores and platform | T25                | ---      | V <sub>DD</sub> | ---   |
| VDD037 | Supply for cores and platform | U12                | ---      | V <sub>DD</sub> | ---   |
| VDD038 | Supply for cores and platform | U14                | ---      | V <sub>DD</sub> | ---   |
| VDD039 | Supply for cores and platform | U16                | ---      | V <sub>DD</sub> | ---   |
| VDD040 | Supply for cores and platform | U18                | ---      | V <sub>DD</sub> | ---   |
| VDD041 | Supply for cores and platform | U20                | ---      | V <sub>DD</sub> | ---   |
| VDD042 | Supply for cores and platform | U22                | ---      | V <sub>DD</sub> | ---   |
| VDD043 | Supply for cores and platform | U24                | ---      | V <sub>DD</sub> | ---   |
| VDD044 | Supply for cores and platform | V11                | ---      | V <sub>DD</sub> | ---   |
| VDD045 | Supply for cores and platform | V13                | ---      | V <sub>DD</sub> | ---   |
| VDD046 | Supply for cores and platform | V15                | ---      | V <sub>DD</sub> | ---   |
| VDD047 | Supply for cores and platform | V17                | ---      | V <sub>DD</sub> | ---   |
| VDD048 | Supply for cores and platform | V19                | ---      | V <sub>DD</sub> | ---   |
| VDD049 | Supply for cores and platform | V21                | ---      | V <sub>DD</sub> | ---   |
| VDD050 | Supply for cores and platform | V23                | ---      | V <sub>DD</sub> | ---   |
| VDD051 | Supply for cores and platform | V25                | ---      | V <sub>DD</sub> | ---   |
| VDD052 | Supply for cores and platform | W12                | ---      | V <sub>DD</sub> | ---   |
| VDD053 | Supply for cores and platform | W14                | ---      | V <sub>DD</sub> | ---   |
| VDD054 | Supply for cores and platform | W16                | ---      | V <sub>DD</sub> | ---   |
| VDD055 | Supply for cores and platform | W18                | ---      | V <sub>DD</sub> | ---   |
| VDD056 | Supply for cores and platform | W20                | ---      | V <sub>DD</sub> | ---   |
| VDD057 | Supply for cores and platform | W22                | ---      | V <sub>DD</sub> | ---   |
| VDD058 | Supply for cores and platform | W24                | ---      | V <sub>DD</sub> | ---   |
| VDD059 | Supply for cores and platform | Y11                | ---      | V <sub>DD</sub> | ---   |
| VDD060 | Supply for cores and platform | Y13                | ---      | V <sub>DD</sub> | ---   |
| VDD061 | Supply for cores and platform | Y15                | ---      | V <sub>DD</sub> | ---   |
| VDD062 | Supply for cores and platform | Y17                | ---      | V <sub>DD</sub> | ---   |
| VDD063 | Supply for cores and platform | Y19                | ---      | V <sub>DD</sub> | ---   |
| VDD064 | Supply for cores and platform | Y21                | ---      | V <sub>DD</sub> | ---   |
| VDD065 | Supply for cores and platform | Y23                | ---      | V <sub>DD</sub> | ---   |
| VDD066 | Supply for cores and platform | Y25                | ---      | V <sub>DD</sub> | ---   |
| VDD067 | Supply for cores and platform | AA10               | ---      | V <sub>DD</sub> | ---   |
| VDD068 | Supply for cores and platform | AA12               | ---      | V <sub>DD</sub> | ---   |
| VDD069 | Supply for cores and platform | AA14               | ---      | V <sub>DD</sub> | ---   |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal        | Signal description                     | Package pin number | Pin type | Power supply    | Notes |
|---------------|--|--------------------|----------|-----------------|-------|
| VDD070        | Supply for cores and platform          | AA16               | ---      | V <sub>DD</sub> | ---   |
| VDD071        | Supply for cores and platform          | AA18               | ---      | V <sub>DD</sub> | ---   |
| VDD072        | Supply for cores and platform          | AA20               | ---      | V <sub>DD</sub> | ---   |
| VDD073        | Supply for cores and platform          | AA22               | ---      | V <sub>DD</sub> | ---   |
| VDD074        | Supply for cores and platform          | AA24               | ---      | V <sub>DD</sub> | ---   |
| VDD075        | Supply for cores and platform          | AB11               | ---      | V <sub>DD</sub> | ---   |
| VDD076        | Supply for cores and platform          | AB13               | ---      | V <sub>DD</sub> | ---   |
| VDD077        | Supply for cores and platform          | AB15               | ---      | V <sub>DD</sub> | ---   |
| VDD078        | Supply for cores and platform          | AB17               | ---      | V <sub>DD</sub> | ---   |
| VDD079        | Supply for cores and platform          | AB19               | ---      | V <sub>DD</sub> | ---   |
| VDD080        | Supply for cores and platform          | AB21               | ---      | V <sub>DD</sub> | ---   |
| VDD081        | Supply for cores and platform          | AB23               | ---      | V <sub>DD</sub> | ---   |
| VDD082        | Supply for cores and platform          | AB25               | ---      | V <sub>DD</sub> | ---   |
| VDD083        | Supply for cores and platform          | AC10               | ---      | V <sub>DD</sub> | ---   |
| VDD084        | Supply for cores and platform          | AC12               | ---      | V <sub>DD</sub> | ---   |
| VDD085        | Supply for cores and platform          | AC14               | ---      | V <sub>DD</sub> | ---   |
| VDD086        | Supply for cores and platform          | AC16               | ---      | V <sub>DD</sub> | ---   |
| VDD087        | Supply for cores and platform          | AC18               | ---      | V <sub>DD</sub> | ---   |
| VDD088        | Supply for cores and platform          | AC20               | ---      | V <sub>DD</sub> | ---   |
| VDD089        | Supply for cores and platform          | AC22               | ---      | V <sub>DD</sub> | ---   |
| VDD090        | Supply for cores and platform          | AC24               | ---      | V <sub>DD</sub> | ---   |
| VDD091        | Supply for cores and platform          | AD11               | ---      | V <sub>DD</sub> | ---   |
| VDD092        | Supply for cores and platform          | AD13               | ---      | V <sub>DD</sub> | ---   |
| VDD093        | Supply for cores and platform          | AD15               | ---      | V <sub>DD</sub> | ---   |
| VDD094        | Supply for cores and platform          | AD17               | ---      | V <sub>DD</sub> | ---   |
| VDD095        | Supply for cores and platform          | AD19               | ---      | V <sub>DD</sub> | ---   |
| VDD096        | Supply for cores and platform          | AD21               | ---      | V <sub>DD</sub> | ---   |
| VDD097        | Supply for cores and platform          | AD23               | ---      | V <sub>DD</sub> | ---   |
| VDD098        | Supply for cores and platform          | AD25               | ---      | V <sub>DD</sub> | ---   |
| VDD099        | Supply for cores and platform          | AE22               | ---      | V <sub>DD</sub> | ---   |
| VDD100        | Supply for cores and platform          | AE24               | ---      | V <sub>DD</sub> | ---   |
| TA_BB_VDD     | Battery Backed Security Monitor supply | K18                | ---      | TA_BB_VDD       | 19    |
| AVDD_PLAT     | Platform PLL supply                    | L15                | ---      | AVDD_PLAT       | ---   |
| AVDD_D1       | DDR1 PLL supply                        | R26                | ---      | AVDD_D1         | ---   |
| AVDD_D2       | DDR2 PLL supply                        | AB26               | ---      | AVDD_D2         | ---   |
| AVDD_D3       | DDR3 PLL supply                        | AA9                | ---      | AVDD_D3         | ---   |
| AVDD_SD1_PLL1 | SerDes1 PLL 1 supply                   | AH9                | ---      | AVDD_SD1_PLL1   | ---   |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal                    | Signal description                   | Package pin number | Pin type | Power supply          | Notes |
|---------------------------|--------------------------------------|--------------------|----------|-----------------------|-------|
| AVDD_SD1_PLL2             | SerDes1 PLL 2 supply                 | AH8                | ---      | AVDD_SD1_PLL2         | ---   |
| AVDD_SD2_PLL1             | SerDes2 PLL 1 supply                 | AL14               | ---      | AVDD_SD2_PLL1         | ---   |
| AVDD_SD2_PLL2             | SerDes2 PLL 2 supply                 | AF20               | ---      | AVDD_SD2_PLL2         | ---   |
| USB_HVDD1                 | USB PHY3.3V HS and SS Supply         | L11                | ---      | USB_HV <sub>DD</sub>  | 20    |
| USB_HVDD2                 | USB PHY3.3V HS and SS Supply         | M11                | ---      | USB_HV <sub>DD</sub>  | 20    |
| USB_SDVDD1                | USB PHY Analog and Digital HS Supply | L12                | ---      | USB_SDV <sub>DD</sub> | 20    |
| USB_SDVDD2                | USB PHY Analog and Digital HS Supply | M12                | ---      | USB_SDV <sub>DD</sub> | 20    |
| USB_SVDD1                 | USB PHY Analog and Digital SS Supply | L10                | ---      | USB_SV <sub>DD</sub>  | 20    |
| USB_SVDD2                 | USB PHY Analog and Digital SS Supply | M10                | ---      | USB_SV <sub>DD</sub>  | 20    |
| SENSEVDD_CA               | VDD Sense pin                        | L17                | ---      | SENSEVDD_CA           | ---   |
| SENSEVDD_CB               | VDD Sense pin                        | AE19               | ---      | SENSEVDD_CB           | ---   |
| SENSEVDD_PL               | VDD Sense pin                        | L13                | ---      | SENSEVDD_PL           | ---   |
| AVDD_CGA1                 | A72 Core Cluster Group A PLL1 supply | J16                | ---      | AVDD_CGA1             | ---   |
| AVDD_CGA2                 | A72 Core Cluster Group A PLL2 supply | L16                | ---      | AVDD_CGA2             | ---   |
| AVDD_CGB1                 | A72 Core Cluster Group B PLL1 supply | J14                | ---      | AVDD_CGB1             | ---   |
| AVDD_CGB2                 | A72 Core Cluster Group B PLL2 supply | L14                | ---      | AVDD_CGB2             | ---   |
| <b>No Connection Pins</b> |                                      |                    |          |                       |       |
| NC_G10                    | No Connection                        | G10                | ---      | ---                   | ---   |
| NC_G9                     | No Connection                        | G9                 | ---      | ---                   | ---   |
| NC_W3                     | No Connection                        | W3                 | ---      | ---                   | ---   |
| <b>Reserved Pins</b>      |                                      |                    |          |                       |       |
| RSVD001                   | ---                                  | N4                 | ---      | ---                   | 12    |
| RSVD002                   | ---                                  | M7                 | ---      | ---                   | 12    |
| RSVD003                   | ---                                  | M6                 | ---      | ---                   | 12    |
| RSVD004                   | ---                                  | N6                 | ---      | ---                   | 12    |
| RSVD005                   | ---                                  | P7                 | ---      | ---                   | 12    |
| RSVD006                   | ---                                  | P6                 | ---      | ---                   | 12    |
| RSVD007                   | ---                                  | R6                 | ---      | ---                   | 12    |
| RSVD008                   | ---                                  | R4                 | ---      | ---                   | 12    |
| RSVD009                   | ---                                  | R5                 | ---      | ---                   | 12    |
| RSVD010                   | ---                                  | P5                 | ---      | ---                   | 12    |

Table continues on the next page...

Table 1. Pinout list by bus (continued)

| Signal  | Signal description | Package pin number | Pin type | Power supply | Notes |
|---------|--------------------|--------------------|----------|--------------|-------|
| RSVD011 | ---                | M1                 | ---      | ---          | 12    |
| RSVD012 | ---                | T4                 | ---      | ---          | 12    |
| RSVD013 | ---                | M3                 | ---      | ---          | 12    |
| RSVD014 | ---                | R7                 | ---      | ---          | 12    |
| RSVD015 | ---                | V7                 | ---      | ---          | 12    |
| RSVD016 | ---                | Y7                 | ---      | ---          | 12    |
| RSVD017 | ---                | M5                 | ---      | ---          | 12    |
| RSVD018 | ---                | M4                 | ---      | ---          | 12    |
| RSVD019 | ---                | R3                 | ---      | ---          | 12    |
| RSVD020 | ---                | P3                 | ---      | ---          | 12    |
| RSVD021 | ---                | P9                 | ---      | ---          | 12    |
| RSVD022 | ---                | P1                 | ---      | ---          | 12    |
| RSVD023 | ---                | P2                 | ---      | ---          | 12    |
| RSVD024 | ---                | R1                 | ---      | ---          | 12    |
| RSVD025 | ---                | R2                 | ---      | ---          | 12    |
| RSVD026 | ---                | V8                 | ---      | ---          | 12    |
| RSVD027 | ---                | W8                 | ---      | ---          | 12    |
| RSVD028 | ---                | U8                 | ---      | ---          | 12    |
| RSVD029 | ---                | T8                 | ---      | ---          | 12    |
| RSVD030 | ---                | N8                 | ---      | ---          | 12    |
| RSVD031 | ---                | M8                 | ---      | ---          | 12    |
| RSVD032 | ---                | T2                 | ---      | ---          | 12    |
| RSVD033 | ---                | N2                 | ---      | ---          | 12    |
| RSVD034 | ---                | Y3                 | ---      | ---          | 12    |
| RSVD035 | ---                | Y4                 | ---      | ---          | 12    |
| RSVD036 | ---                | AE1                | ---      | ---          | 12    |
| RSVD037 | ---                | AD5                | ---      | ---          | 12    |
| RSVD038 | ---                | AD8                | ---      | ---          | 12    |
| RSVD039 | ---                | AA1                | ---      | ---          | 12    |
| RSVD040 | ---                | Y1                 | ---      | ---          | 12    |
| RSVD041 | ---                | V3                 | ---      | ---          | 12    |
| RSVD042 | ---                | U3                 | ---      | ---          | 12    |
| RSVD043 | ---                | AA3                | ---      | ---          | 12    |
| RSVD044 | ---                | Y2                 | ---      | ---          | 12    |
| RSVD045 | ---                | V2                 | ---      | ---          | 12    |
| RSVD046 | ---                | U1                 | ---      | ---          | 12    |
| RSVD047 | ---                | AA5                | ---      | ---          | 12    |
| RSVD048 | ---                | Y5                 | ---      | ---          | 12    |

Table continues on the next page...

## Pin assignments

Table 1. Pinout list by bus (continued)

| Signal  | Signal description | Package pin number | Pin type | Power supply | Notes |
|---------|--------------------|--------------------|----------|--------------|-------|
| RSVD049 | ---                | V4                 | ---      | ---          | 12    |
| RSVD050 | ---                | U5                 | ---      | ---          | 12    |
| RSVD051 | ---                | AB5                | ---      | ---          | 12    |
| RSVD052 | ---                | AA6                | ---      | ---          | 12    |
| RSVD053 | ---                | V5                 | ---      | ---          | 12    |
| RSVD054 | ---                | U6                 | ---      | ---          | 12    |
| RSVD055 | ---                | AF2                | ---      | ---          | 12    |
| RSVD056 | ---                | AE3                | ---      | ---          | 12    |
| RSVD057 | ---                | AC1                | ---      | ---          | 12    |
| RSVD058 | ---                | AB1                | ---      | ---          | 12    |
| RSVD059 | ---                | AF3                | ---      | ---          | 12    |
| RSVD060 | ---                | AF1                | ---      | ---          | 12    |
| RSVD061 | ---                | AC3                | ---      | ---          | 12    |
| RSVD062 | ---                | AB2                | ---      | ---          | 12    |
| RSVD063 | ---                | AF4                | ---      | ---          | 12    |
| RSVD064 | ---                | AE5                | ---      | ---          | 12    |
| RSVD065 | ---                | AC5                | ---      | ---          | 12    |
| RSVD066 | ---                | AB3                | ---      | ---          | 12    |
| RSVD067 | ---                | AF5                | ---      | ---          | 12    |
| RSVD068 | ---                | AE6                | ---      | ---          | 12    |
| RSVD069 | ---                | AC6                | ---      | ---          | 12    |
| RSVD070 | ---                | AB4                | ---      | ---          | 12    |
| RSVD071 | ---                | V1                 | ---      | ---          | 12    |
| RSVD072 | ---                | W1                 | ---      | ---          | 12    |
| RSVD073 | ---                | W5                 | ---      | ---          | 12    |
| RSVD074 | ---                | W6                 | ---      | ---          | 12    |
| RSVD075 | ---                | AD1                | ---      | ---          | 12    |
| RSVD076 | ---                | AD2                | ---      | ---          | 12    |
| RSVD077 | ---                | AD3                | ---      | ---          | 12    |
| RSVD078 | ---                | AD4                | ---      | ---          | 12    |
| RSVD079 | ---                | AC7                | ---      | ---          | 12    |
| RSVD080 | ---                | AD7                | ---      | ---          | 12    |
| RSVD081 | ---                | AE7                | ---      | ---          | 12    |
| RSVD082 | ---                | AD9                | ---      | ---          | 12    |
| RSVD083 | ---                | AC9                | ---      | ---          | 12    |
| RSVD084 | ---                | AB7                | ---      | ---          | 12    |
| RSVD085 | ---                | T7                 | ---      | ---          | 12    |
| RSVD086 | ---                | R8                 | ---      | ---          | 12    |

Table continues on the next page...

**Table 1. Pinout list by bus (continued)**

| Signal  | Signal description | Package pin number | Pin type | Power supply | Notes |
|---------|--------------------|--------------------|----------|--------------|-------|
| RSVD087 | ---                | P4                 | ---      | ---          | 12    |
| RSVD088 | ---                | M2                 | ---      | ---          | 12    |
| RSVD089 | ---                | P8                 | ---      | ---          | 12    |
| RSVD090 | ---                | AB8                | ---      | ---          | 12    |
| RSVD091 | ---                | N1                 | ---      | ---          | 15    |
| RSVD092 | ---                | N3                 | ---      | ---          | 15    |
| RSVD093 | ---                | N5                 | ---      | ---          | 15    |
| RSVD094 | ---                | N7                 | ---      | ---          | 15    |
| RSVD095 | ---                | R9                 | ---      | ---          | 15    |
| RSVD096 | ---                | T1                 | ---      | ---          | 15    |
| RSVD097 | ---                | T3                 | ---      | ---          | 15    |
| RSVD098 | ---                | T5                 | ---      | ---          | 15    |
| RSVD099 | ---                | T6                 | ---      | ---          | 15    |
| RSVD100 | ---                | T10                | ---      | ---          | 15    |
| RSVD101 | ---                | U7                 | ---      | ---          | 15    |
| RSVD102 | ---                | U10                | ---      | ---          | 15    |
| RSVD103 | ---                | V10                | ---      | ---          | 15    |
| RSVD104 | ---                | W7                 | ---      | ---          | 15    |
| RSVD105 | ---                | W10                | ---      | ---          | 15    |
| RSVD106 | ---                | Y8                 | ---      | ---          | 15    |
| RSVD107 | ---                | Y10                | ---      | ---          | 15    |
| RSVD108 | ---                | AA7                | ---      | ---          | 15    |

1. Functionally, this pin is an output or an input, but structurally it is an I/O because it either sample configuration input during reset, is a muxed pin, or has other manufacturing test functions. This pin will therefore be described as an I/O for boundary scan.

2. This output is actively driven during reset rather than being tri-stated during reset.

3. MDIC[0] is grounded through an 162  $\Omega$  precision 1% resistor and MDIC[1] is connected to  $G_{V_{DD}}$  through an 162  $\Omega$  precision 1% resistor. For either full or half driver strength calibration of DDR I/Os, use the same MDIC resistor value of 162  $\Omega$ . Memory controller register setting can be used to determine automatic calibration is done to full or half drive strength. These pins are used for automatic calibration of the DDR4 I/Os. The MDIC[0:1] pins must be connected to 162  $\Omega$  precision 1% resistors.

## Pin assignments

4. This pin is a reset configuration pin. It has a weak ( $\sim 20\text{ k}\Omega$ ) internal pull-up P-FET that is enabled only when the processor is in its reset state. This pull-up is designed such that it can be overpowered by an external  $4.7\text{ k}\Omega$  resistor. However, if the signal is intended to be high after reset, and if there is any device on the net that might pull down the value of the net at reset, a pull-up or active driver is needed.
5. Pin must **NOT** be pulled down during power-on reset. This pin may be pulled up, driven high, or if there are any externally connected devices, left in tristate. If this pin is connected to a device that pulls down during reset, an external pull-up is required to drive this pin to a safe state during reset.
6. Recommend that a weak pull-up resistor ( $2\text{-}10\text{ k}\Omega$ ) be placed on this pin to the respective power supply.
7. This pin is an open-drain signal.
8. Recommend that a weak pull-up resistor ( $1\text{ k}\Omega$ ) be placed on this pin to the respective power supply.
9. This pin has a weak ( $\sim 20\text{ k}\Omega$ ) internal pull-up P-FET that is always enabled.
10. These are test signals for factory use only and must be pulled up ( $1\text{ k}\Omega$ ) to the respective power supply for normal operation.
11. This pin requires a  $200\ \Omega$  pull-up to respective power-supply.
12. Do not connect. These pins should be left floating.
13. TBSCAN\_EN\_B is an IEEE 1149.1 JTAG Compliance Enable pin. 0: To be compliant to the 1149.1 specification for boundary scan functions. The JTAG compliant state is documented in the BSDL. 1: JTAG connects to DAP controller for the ARM core debug. In normal operation, this pin must be pulled high to OVDD with  $4.7\text{ k}\Omega$ .
14. For LS2084A, this pin must be pulled high through  $1\text{ to }10\text{ k}\Omega$  resistor to OVDD. For LS2044A, this pin must be pulled low through  $1\text{ to }10\text{ k}\Omega$  resistor to GND.
15. These pins must be tied to ground (GND).
16. This pin requires a  $698\ \Omega$  pull-up to respective power supply.
17. These pins should be tied to ground if the diode is not used for temperature monitoring. For details, see the Connection Recommendations section.
18. When the Dn\_MDQS\_B[9:17] pins are not used, terminate the pin with  $50\ \Omega$  to VTT or  $100\ \Omega$  to GND. When using a discrete x8 or x16 DRAM, place the termination close to the device pin. When the signals are connected to a DIMM connector that is used only by DIMMs with an x8 or x16 DRAM, terminate the pin close to the DIMM connector.

19. This pin must be powered up all the time, even when the secure boot is not used, or the secure boot is used without the low power feature.
20. This pin supplies power to both the USB1 and USB2 controllers. If any of USB1 or USB2 is used, this pin must be powered.
24. Recommend that a weak pull-up resistor (10-100 k $\Omega$ ) be placed on this pin to the respective power supply.
25. This pin must be tied to GND through a 200  $\Omega$  1% precision resistor.
27. The permissible voltage range is 0-5.5 V.
28. For proper clock selection, terminate `cfg_eng_use0` with a pull up or pull down of 4.7 k $\Omega$  to ensure that the signal will have a valid state as soon as the IO voltage reach its operating condition.
29. When using discrete DRAM or RDIMM, the MALERT\_B pin needs a 50  $\Omega$  to 100  $\Omega$  pull-up resistor to GVDD.

### **Warning**

See "**Connection Recommendations**" for additional details on properly connecting these pins for specific applications.

## **3 Electrical characteristics**

This section provides the AC and DC electrical specifications for the chip. The chip is currently targeted to these specifications, some of which are independent of the I/O cell but are included for a more complete reference. These are not purely I/O buffer design specifications.

### **3.1 Overall DC electrical characteristics**

This section describes the ratings, conditions, and other characteristics.

#### **3.1.1 Absolute maximum ratings**

This table provides the absolute maximum ratings.

## Electrical characteristics

Table 2. Absolute maximum ratings<sup>1</sup>

| Characteristic   | Symbol   | Min Value            | Max Value | Unit                       | Notes |      |
|--|--|----------------------|-----------|----------------------------|-------|------|
| Core and platform supply voltage   | V <sub>DD</sub>  | -0.3                 | 1.1       | V                          | 2     |      |
| PLL supply voltage (core, platform, DDR)   | AV <sub>DD_CGA1</sub><br>AV <sub>DD_CGA2</sub><br>AV <sub>DD_CGB1</sub><br>AV <sub>DD_CGB2</sub><br>AV <sub>DD_PLAT</sub><br>AV <sub>DD_D1</sub><br>AV <sub>DD_D2</sub><br>AV <sub>DD_D3</sub> | -0.3                 | 1.98      | V                          | —     |      |
| PLL supply voltage (SerDes, filtered from XV <sub>DD</sub> )                                 | AV <sub>DD_SD1_PLL1</sub><br>AV <sub>DD_SD1_PLL2</sub><br>AV <sub>DD_SD2_PLL1</sub><br>AV <sub>DD_SD2_PLL2</sub>   | -0.3                 | 1.48      | V                          | —     |      |
| Fuse programming override supply   | TA_PROG_SFP  | -0.3                 | 1.98      | V                          | —     |      |
| Thermal monitor unit supply  | TH_V <sub>DD</sub>   | -0.3                 | 1.98      | V                          | —     |      |
| General I/O supply   | OV <sub>DD</sub>   | -0.3                 | 1.98      | V                          | —     |      |
| DDR4 DRAM I/O voltage  | G1V <sub>DD</sub> , G2V <sub>DD</sub>  | -0.3                 | 1.32      | V                          | —     |      |
| Main power supply for internal circuitry of SerDes and pad power supply for SerDes receivers | SV <sub>DD</sub>   | -0.3                 | 1.1       | V                          | —     |      |
| Pad power supply for SerDes transmitters   | XV <sub>DD</sub>   | -0.3                 | 1.45      | V                          | —     |      |
| USB PHY 3.3 V HS(High Speed) and SS(Super Speed) supply voltage                              | USB_HV <sub>DD</sub>   | -0.3                 | 3.63      | V                          | —     |      |
| USB PHY Analog and Digital HS supply voltage   | USB_SDV <sub>DD</sub>  | -0.3                 | 1.1       | V                          | —     |      |
| USB PHY Analog and Digital SS supply voltage   | USB_SV <sub>DD</sub>   | -0.3                 | 1.1       | V                          | —     |      |
| Battery Backed Security Monitor supply   | TA_BB_V <sub>DD</sub>  | -0.3                 | 1.1       | V                          | —     |      |
| Input voltage  | DDR4 DRAM signal   | MV <sub>IN</sub>     | -0.3      | GV <sub>DD</sub> + 0.3     | V     | 3    |
|  | General I/O signals  | OV <sub>IN</sub>     | -0.3      | OV <sub>DD</sub> + 0.3     | V     | 4, 5 |
|  | SerDes signals   | SV <sub>IN</sub>     | -0.4      | SV <sub>DD</sub> + 0.3     | V     | 4    |
|  | USB PHY 3.3 HS signals   | USB_HV <sub>IN</sub> | -0.3      | USB_HV <sub>DD</sub> + 0.3 | V     | 4    |
|  | USB PHY SS signals   | USB_SV <sub>IN</sub> | -0.3      | USB_SV <sub>DD</sub> + 0.3 | V     | 4    |
| Storage temperature range  | T <sub>STG</sub>   | -55                  | 150       | °C                         | —     |      |

**Notes:**

1. Functional operating conditions are given in [Table 3](#). Absolute maximum ratings are stress ratings only, and functional operation at the maximums is not guaranteed. Stresses beyond those listed may affect device reliability or cause permanent damage to the device.

2. Supply voltage specified at the voltage sense pin. Voltage input pins should be regulated to provide specified voltage at the sense pin.

**Table 2. Absolute maximum ratings<sup>1</sup>**

| Characteristic  | Symbol | Min Value | Max Value | Unit | Notes |
|---|--------|-----------|-----------|------|-------|
| 3. <b>Caution:</b> $MV_{IN}$ must not exceed $GnV_{DD}$ by more than 0.3 V. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences. |        |           |           |      |       |
| 4. $SV_{IN}$ , $USB\_HV_{IN}$ , $USB\_SV_{IN}$ may overshoot/undershoot to a voltage and for a maximum duration as shown in <a href="#">Figure 7</a> .                        |        |           |           |      |       |
| 5. <b>Caution:</b> $OV_{IN}$ must not exceed $OV_{DD}$ by more than 0.3 V. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences.  |        |           |           |      |       |

### 3.1.2 Recommended operating conditions

This table provides the recommended operating conditions for this chip.

#### NOTE

The values shown are the recommended operating conditions and proper device operation outside these conditions is not guaranteed.

**Table 3. Recommended operating conditions**

| Characteristic  |                         | Symbol   | Recommended value                         | Unit | Notes         |
|---|-------------------------|--|---|------|---------------|
| VID Core and platform supply voltage                  | At initial start-up     | $V_{DD}$   | $1.05 \pm 30$ mV<br>or<br>$VID \pm 30$ mV | V    | 1, 2, 3, 5, 6 |
|   | During normal operation |  | $VID \pm 30$ mV                           | V    | 1, 2, 3, 5, 6 |
| PLL supply voltage (core, platform, DDR)              |                         | $AV_{DD\_CGA1}$<br>$AV_{DD\_CGA2}$<br>$AV_{DD\_CGB1}$<br>$AV_{DD\_CGB2}$<br>$AV_{DD\_PLAT}$<br>$AV_{DD\_D1}$<br>$AV_{DD\_D2}$<br>$AV_{DD\_D3}$ | $1.8$ V $\pm$ 90 mV                       | V    | —             |
| PLL supply voltage (SerDes, filtered from $XV_{DD}$ ) |                         | $AV_{DD\_SD1\_PLL1}$<br>$AV_{DD\_SD1\_PLL2}$<br>$AV_{DD\_SD2\_PLL1}$<br>$AV_{DD\_SD2\_PLL2}$   | $1.35$ V $\pm$ 67 mV                      | V    | —             |
| Fuse programming override supply                      |                         | $TA\_PROG\_SFP$  | $1.80$ V $\pm$ 90 mV                      | V    | 4             |
| Thermal monitor unit supply                           |                         | $TH\_V_{DD}$   | $1.8$ V $\pm$ 90 mV                       | V    | —             |
| General I/O supply voltage                            |                         | $OV_{DD}$  | $1.8$ V $\pm$ 90 mV                       | V    | —             |

Table continues on the next page...

## Electrical characteristics

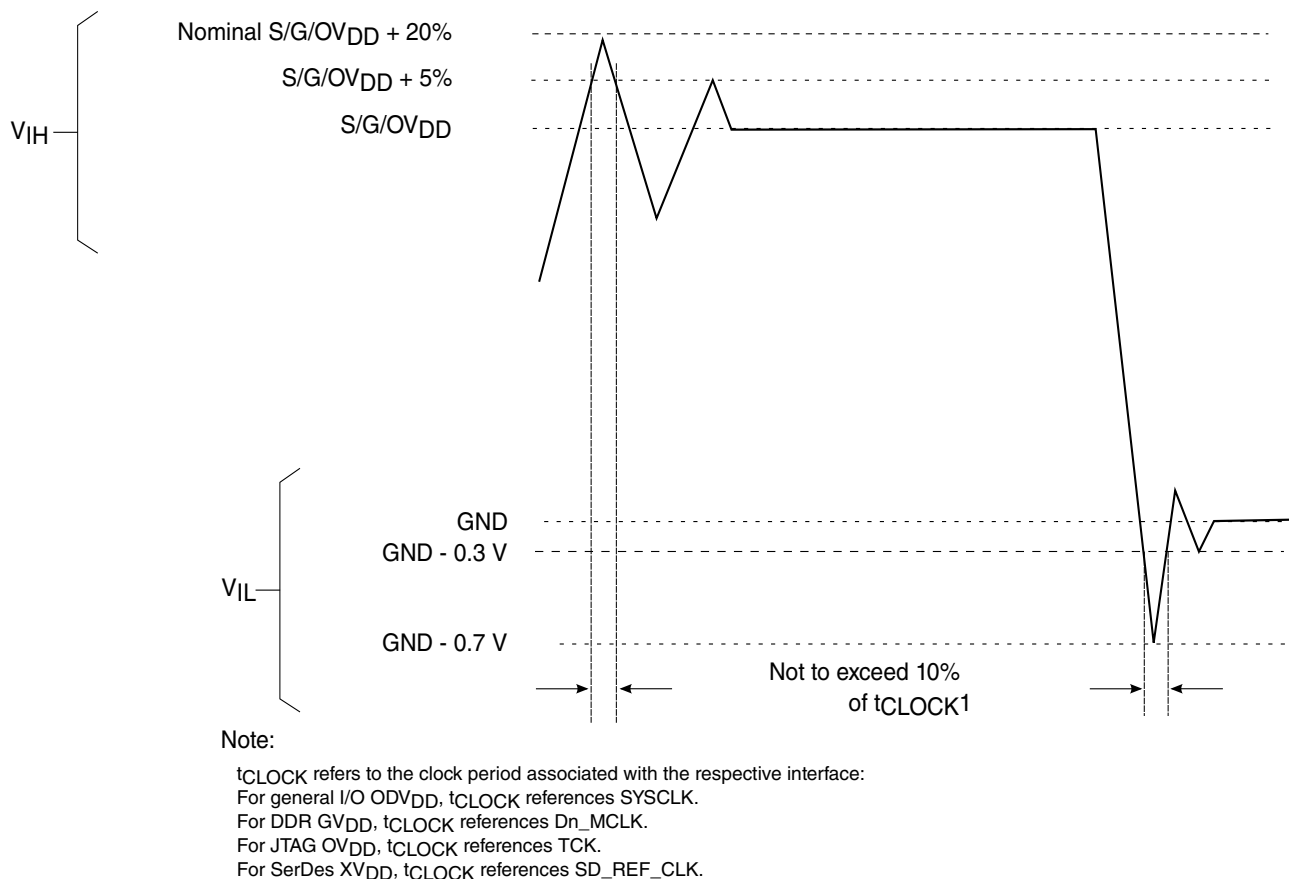
Table 3. Recommended operating conditions (continued)

| Characteristic   |                        | Symbol                        | Recommended value     | Unit        | Notes |
|--|------------------------|-------------------------------|-----------------------|-------------|-------|
| DDR4 I/O voltage   |                        | $G1V_{DD}, G2V_{DD}$          | 1.2 V $\pm$ 60 mV     | V           | —     |
| Main power supply for internal circuitry of SerDes and pad power supply for SerDes receivers |                        | $SV_{DD}$                     | 1.0 V $\pm$ 30mV      | V           | 6     |
| Pad power supply for SerDes transmitters   |                        | $XV_{DD}$                     | 1.35 V $\pm$ 67 mV    | V           | —     |
| USB PHY 3.3 V HS(High Speed) and SS(Super Speed) supply voltage                              |                        | $USB\_HV_{DD}$                | 3.3 V $\pm$ 165 mV    | V           | —     |
| USB PHY Analog and Digital HS supply voltage   |                        | $USB\_SDV_{DD}$               | 1.0 V +50 mV/-30mV    | V           | 6     |
| USB PHY Analog and Digital SS supply voltage   |                        | $USB\_SV_{DD}$                | 1.0 V +50 mV/-30mV    | V           | 6     |
| Battery Backed Security Monitor supply   |                        | $TA\_BB\_V_{DD}$              | 1.0 V +50 mV/-30mV    |             | 6     |
| Input voltage  | DDR4 DRAM signal       | $MV_{IN}$                     | GND to $GnV_{DD}$     | V           | —     |
|  | General I/O signals    | $OV_{IN}$                     | GND to $OV_{DD}$      | V           | —     |
|  | SerDes signals         | $SV_{IN}$                     | GND to $SV_{DD}$      | V           | —     |
|  | USB PHY 3.3 HS signals | $USB\_HV_{IN}$                | GND to $USB\_HV_{DD}$ | V           | —     |
|  | USB PHY SS signals     | $USB\_SV_{IN}$                | GND to $USB\_SV_{DD}$ | V           | —     |
| Operating temperature range  | Normal operation       | $T_A,$                        | $T_A = 0$ (min) to    | $^{\circ}C$ | —     |
|  |                        | $T_J$                         | $T_J = 105$ (max)     |             |       |
|  | Extended temperature   | $T_A,$                        | $T_A = -40$ (min) to  | $^{\circ}C$ | —     |
|  |                        | $T_J$                         | $T_J = 105$ (max)     |             |       |
| AEC-Q100 Grade 3 temperature   | $T_A$                  | $T_A = -40$ (min) to 85 (max) | $^{\circ}C$           | 7, 8        |       |
| Secure boot fuse programming   | $T_A,$                 | $T_A = 0$ (min) to            | $^{\circ}C$           | 4           |       |
|  | $T_J$                  | $T_J = 70$ (max)              |                       |             |       |

**Notes:**

- See [Voltage ID \(VID\) controllable supply](#) in this document and "Core and platform supply voltage filtering" in the design checklist for additional information.
- Supply voltage specified at the voltage sense pin. Voltage input pins should be regulated to provide specified voltage at the sense pin.
- Operation at 1.1 V is allowable for up to 25 ms at initial power on.
- $TA\_PROG\_SFP$  must be supplied 1.80 V and the chip must operate in the specified fuse programming temperature range (0 - 70°C) only during secure boot fuse programming. For all other operating conditions,  $TA\_PROG\_SFP$  must be tied to GND, subject to the power sequencing constraints shown in [Power sequencing](#).
- Voltage ID (VID) operating range is between 0.90 to 1.05 V. Regulator selection should be based on  $V_{out}$  range of at least 0.875 to 1.1 V, with resolution of 12.5 mV or better.
- For supported voltage requirement for a given part number, contact your NXP sales representative.
- Only available on automotive grade parts
- The  $T_j$  must not exceed 105°C. Proper thermal solution should be applied to meet this requirement.

This figure shows the undershoot and overshoot voltages at the interfaces of the chip.



**Figure 7. Overshoot/Undershoot voltage for  $GV_{\text{DD}}/OV_{\text{DD}}/SV_{\text{DD}}$**

The core and platform voltages must always be provided at nominal VID. See [Table 3](#) for actual recommended core voltage. Voltage to the processor interface I/Os are provided through separate sets of supply pins and must be provided at the voltages shown in [Table 3](#). The input voltage threshold scales with respect to the associated I/O supply voltage.  $OV_{\text{DD}}$  based receivers are simple CMOS I/O circuits and satisfy appropriate LVCMOS type specifications. The DDR SDRAM interface uses differential receivers referenced by the internally generated  $MV_{\text{REF}}$  signal. The DDR DQS receivers cannot be operated in single-ended fashion. The complement signal must be properly driven and cannot be grounded.

### 3.1.3 Output driver characteristics

This chip provides information on the characteristics of the output driver strengths.

#### NOTE

These values are preliminary estimates.

## Electrical characteristics

**Table 4. Output drive capability**

| Driver type   | Output impedance ( $\Omega$ )                      | Supply voltage           | Notes |
|---|--|--------------------------|-------|
| DDR4 signal   | 18 (full-strength mode)<br>27 (half-strength mode) | $GV_{DD} = 1.2\text{ V}$ | 1     |
| General I/O signals   | 45   | $OV_{DD} = 1.8\text{ V}$ | —     |
| <b>Notes:</b>   |  |                          |       |
| 1. The drive strength of the DDR4 interface in half-strength mode is at $T_j = 105\text{ }^\circ\text{C}$ and at $GV_{DD}$ (min). |  |                          |       |

### 3.2 Power sequencing

For power up, the following sequence should be followed:

1.  $V_{DD}$  must reach 90% of its value before  $GnV_{DD}$  reaches 10% of its value. During  $V_{DD}$  ramping,  $PORESET\_B$  must be held low and  $TA\_PROG\_SFP$  must be grounded. All other power supplies ( $OV_{DD}$ ,  $USB\_HV_{DD}$ ,  $USB\_SV_{DD}$ ,  $USB\_SDV_{DD}$ ,  $SV_{DD}$ ,  $XV_{DD}$ ,  $TA\_BB\_V_{DD}$ ,  $TH\_V_{DD}$ ,  $AV_{DD}$  (cores, platform, DDR), and  $AV_{DD\_SDm\_PLLn}$ ) have no ordering requirement with respect to one another and with respect to  $V_{DD}$  and  $GnV_{DD}$ . All supplies must be at their stable values within 400 ms.
2. Negate  $PORESET\_B$  input as long as the required assertion/hold time has been met per [Table 19](#).
3. For secure boot fuse programming, use the following steps:
  - a. After negation of  $PORESET\_B$ , drive  $TA\_PROG\_SFP = 1.80\text{ V}$  after a required minimum delay per [Table 5](#).
  - b. After fuse programming is completed, it is required to return  $TA\_PROG\_SFP = GND$  before the system is power cycled ( $PORESET\_B$  assertion) or powered down ( $V_{DD}$  ramp down) per the required timing specified in [Table 5](#). See [Security fuse processor](#), for additional details.

#### NOTE

If using Trust Architecture Security Monitor battery backed features, prior to  $V_{DD}$  ramping up to 0.5 V level, ensure that  $OV_{DD}$  is properly ramped and  $SYSCLK$  or  $DIFF\_SYSCLK / DIFF\_SYSCLK\_B$  is running. The clock should have a minimum frequency of 800 MHz and a maximum frequency no greater than the supported system clock frequency for the device.

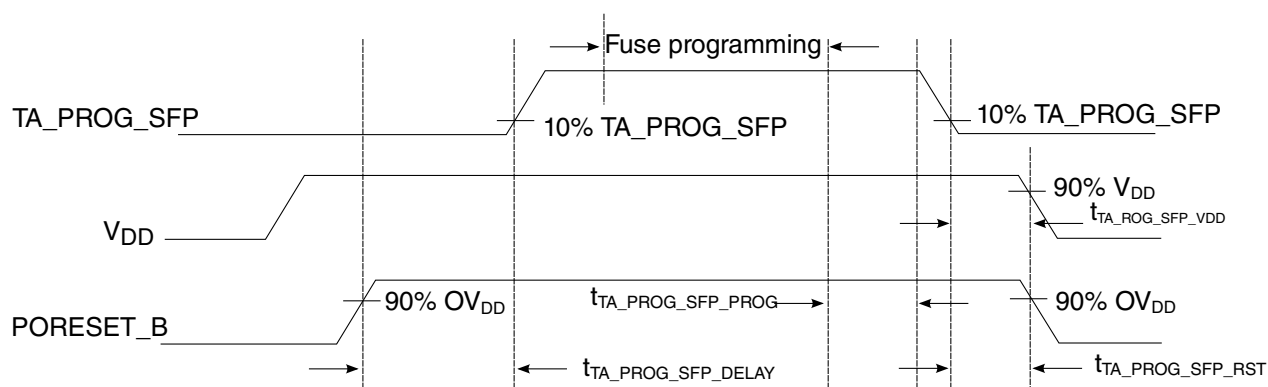
## Warning

No activity other than that required for secure boot fuse programming is permitted while TA\_PROG\_SFP is driven to any voltage above GND, including the reading of the fuse block. The reading of the fuse block may only occur while TA\_PROG\_SFP = GND.

From a system standpoint, if any of the I/O power supplies ramp prior to the V<sub>DD</sub> supplies, there will be a brief period as the V<sub>DD</sub> powers up that the I/Os associated with that I/O supply may go from being tristated to an indeterminate state (either driven to a logic one or zero) and extra current may be drawn by the device.

Only 300,000 POR cycles are permitted per lifetime of a device. Note that this value is based on design estimates and is preliminary.

This figure provides the TA\_PROG\_SFP timing diagram.



**NOTE:** TA\_PROG\_SFP must be stable at 1.80 V prior to initiating fuse programming.

**Figure 8. TA\_PROG\_SFP timing diagram**

This table provides information on the power-down and power-up sequence parameters for TA\_PROG\_SFP.

**Table 5. TA\_PROG\_SFP timing <sup>5</sup>**

| Driver type                    | Min | Max | Unit     | Notes |
|--------------------------------|-----|-----|----------|-------|
| t <sub>TA_PROG_SFP_DELAY</sub> | 100 | —   | SYSCCLKs | 1     |
| t <sub>TA_PROG_SFP_PROG</sub>  | 0   | —   | μs       | 2     |
| t <sub>TA_PROG_SFP_VDD</sub>   | 0   | —   | μs       | 3     |
| t <sub>TA_PROG_SFP_RST</sub>   | 0   | —   | μs       | 4     |

Table continues on the next page...

**Electrical characteristics****Table 5. TA\_PROG\_SFP timing <sup>5</sup> (continued)**

| Driver type  | Min | Max | Unit | Notes |
|--|-----|-----|------|-------|
| 1. Delay required from the de-assertion of PORESET_B to driving TA_PROG_SFP ramp up. Delay measured from PORESET_B deassertion at 90% OV <sub>DD</sub> to 10% TA_PROG_SFP ramp up.   |     |     |      |       |
| 2. Delay required from fuse programming finished to TA_PROG_SFP ramp down start. Fuse programming must complete while TA_PROG_SFP is stable at 1.80 V. No activity other than that required for secure boot fuse programming is permitted while TA_PROG_SFP driven to any voltage above GND, including the reading of the fuse block. The reading of the fuse block may only occur while TA_PROG_SFP = GND. After fuse programming is completed, it is required to return TA_PROG_SFP = GND. |     |     |      |       |
| 3. Delay required from TA_PROG_SFP ramp down complete to V <sub>DD</sub> ramp down start. TA_PROG_SFP must be grounded to minimum 10% TA_PROG_SFP before V <sub>DD</sub> is at 90% V <sub>DD</sub> .   |     |     |      |       |
| 4. Delay required from TA_PROG_SFP ramp down complete to PORESET_B assertion. TA_PROG_SFP must be grounded to minimum 10% TA_PROG_SFP before PORESET_B assertion reaches 90% OV <sub>DD</sub> .  |     |     |      |       |
| 5. Only two secure boot fuse programming events are permitted per lifetime of a device.  |     |     |      |       |

**Warning**

TA\_PROG\_SFP ramp up slew rate must not exceed 18,000V/s.  
Ramp down does not have a slew rate constraint.

**3.3 Power-down requirements**

The power-down cycle must complete such that power supply values are below 0.4 V before a new power-up cycle can be started.

If performing secure boot fuse programming per [Power sequencing](#), it is required that TA\_PROG\_SFP = GND before the system is power cycled (PORESET\_B assertion) or powered down (V<sub>DD</sub> ramp down) per the required timing specified in [Table 5](#).

**NOTE**

All input signals, including I/Os that are configured as inputs, driven into the chip need to monotonically increase/decrease through entire rise/fall durations.

**3.4 Power characteristics**

These tables show the thermal power dissipation of the V<sub>DD</sub> power supply for four A72 core/platform/DDR frequency combinations.

**Table 6. LS2084A VDD power dissipation for the thermal design at 85C**

| A72 frequency (MHz) | Coherency domain frequency (MHz) | Platform frequency (MHz) | Main DDR data rate (MT/s) | V <sub>DD</sub> (V) | Power (W) | Notes         |
|---------------------|----------------------------------|--------------------------|---------------------------|---------------------|-----------|---------------|
| 2100                | 1600                             | 800                      | 2133                      | VID                 | 34.9      | 1, 2, 3, 4    |
| 2000                | 1600                             | 800                      | 2133                      | VID                 | 34.3      | 1, 2, 3, 4    |
| 2000                | 1400                             | 700                      | 2133                      | VID                 | 34.0      | 1, 2, 3, 4, 5 |
| 1800                | 1400                             | 700                      | 1867                      | VID                 | 26.3      | 1, 2, 3, 4    |
| 1600                | 1200                             | 600                      | 1600                      | VID                 | 23.1      | 1, 2, 3, 4    |

**Notes:**

- VDD must run at VID voltage level, which is defined in FUSES<sub>R</sub> register
- Thermal power assumes Dhrystone running with activity factor of 60% (on all cores) and executing DMA on the platform at 100% activity factor.
- Thermal power are based on worst-case processed device. The above powers are measured at the junction temperature of 85C.
- Refer to AN4977 "QorIQ LS2088A Family Design Checklist":  
Section 4.2 "Maximum VDD Power and IO Power" shows the maximum power dissipation across junction temperature range. This should be used as guide for power supply design and regulator sizing.  
Section 7.23.1 "Thermal Power" shows the thermal power across junction temperature range. This data should be used thermal solution design.
- Valid for part numbers with "7" in option code

**Table 7. LS2044A VDD power dissipation for the thermal design at 85C**

| A72 frequency (MHz) | Coherency domain frequency (MHz) | Platform frequency (MHz) | Main DDR data rate (MT/s) | V <sub>DD</sub> (V) | Power (W) | Notes         |
|---------------------|----------------------------------|--------------------------|---------------------------|---------------------|-----------|---------------|
| 2100                | 1600                             | 800                      | 2133                      | VID                 | 25.8      | 1, 2, 3, 4    |
| 2000                | 1600                             | 800                      | 2133                      | VID                 | 25.4      | 1, 2, 3, 4    |
| 2000                | 1400                             | 700                      | 2133                      | VID                 | 25.1      | 1, 2, 3, 4, 5 |
| 1800                | 1400                             | 700                      | 1867                      | VID                 | 19.4      | 1, 2, 3, 4    |
| 1600                | 1200                             | 600                      | 1600                      | VID                 | 17.2      | 1, 2, 3, 4    |

**Notes:**

- VDD must run at VID voltage level, which is defined in FUSES<sub>R</sub> register
- Thermal power assumes Dhrystone running with activity factor of 70% (on all cores) and executing DMA on the platform at 100% activity factor.
- Thermal power are based on worst-case processed device. The above powers are measured at the junction temperature of 85C.
- Refer to AN4977 "QorIQ LS2088A Family Design Checklist":  
Section 4.2 "Maximum VDD Power and IO Power" shows the maximum power dissipation across junction temperature range. This should be used as guide for power supply design and regulator sizing.  
Section 7.23.1 "Thermal Power" shows the thermal power across junction temperature range. This data should be used thermal solution design.

## Electrical characteristics

**Table 7. LS2044A VDD power dissipation for the thermal design at 85C**

| A72 frequency (MHz)                               | Coherency domain frequency (MHz) | Platform frequency(MHz) | Main DDR data rate (MT/s) | V <sub>DD</sub> (V) | Power (W) | Notes |
|---|----------------------------------|-------------------------|---------------------------|---------------------|-----------|-------|
| 5. Valid for part numbers with "7" in option code |                                  |                         |                           |                     |           |       |

The following table shows the estimated power saving for the low power modes.

**Table 8. LS2084A/LS2044A low power mode power saving, 65°C<sup>1,2,3</sup>**

| Low Power Mode  |                       | Core/Platform/DDR            |                             |                              |                              | Units | Comments  | Notes |
|---|-----------------------|------------------------------|-----------------------------|------------------------------|------------------------------|-------|---|-------|
| NXP   | Arm®                  | 2100/800/2133 MHz, VDD=1.0 V | 2000/800/2133 MHz, VDD=1.0V | 1800/700/1867 MHz, VDD=1.0 V | 1600/600/1600 MHz, VDD=0.9 V |       |   |       |
| PW15  | STANDBYWFI/WFE        | 1.26                         | 1.19                        | 1.06                         | 0.74                         | Watts | Saving realized moving from run to PW15 per core              | 4     |
| PW20  | STANDBYWFI/WFE-retain | 1.31                         | 1.25                        | 1.12                         | 0.77                         | Watts | Saving realized moving from run to PW20 per core              | 4     |
| PCL10   | STANDBYWFIL2          | 0.20                         | 0.19                        | 0.19                         | 0.14                         | Watts | Saving realized moving from PW15 or PW20 to PCL10 per cluster |       |
| LPM20   | —                     | 0.75                         | 0.74                        | 0.71                         | 0.47                         | Watts | Saving realized moving from PCL10 to LPM20 per device         |       |
| <b>Notes:</b>   |                       |                              |                             |                              |                              |       |   |       |
| 1. Power for V <sub>DD</sub> only.  |                       |                              |                             |                              |                              |       |   |       |
| 2. Typical power assumes Dhrystone running with activity factor of 70%.   |                       |                              |                             |                              |                              |       |   |       |
| 3. Typical power based on nominal process device.   |                       |                              |                             |                              |                              |       |   |       |
| 4. PW15, PW20 power savings with one core. Maximum savings would be N times, where N is the number of used cores. |                       |                              |                             |                              |                              |       |   |       |

The following table shows the estimated power dissipation on the TA\_BB\_V<sub>DD</sub> supply for the LS2084A/LS2044A at allowable voltage levels.

**Table 9. TA\_BB\_V<sub>DD</sub> power dissipation**

| Supply   | Maximum | Unit | Notes |
|--|---------|------|-------|
| TA_BB_V <sub>DD</sub> (LS2084A/LS2044A off, 70°C)  | 55      | uW   | 1     |
| TA_BB_V <sub>DD</sub> (LS2084A/LS2044A off, 40°C)  | 40      | uW   | 1     |
| <b>Notes:</b>  |         |      |       |
| 1. When LS2084A/LS2044A is off, TA_BB_V <sub>DD</sub> may be supplied by battery power to retain the Zeroizable Master Key and other trust architecture state. Board should implement a PMIC, which switches TA_BB_V <sub>DD</sub> to battery when SoC powered down. See the LS2084A reference manual trust architecture chapter for more information. |         |      |       |

### 3.5 Power-on ramp rate

This section describes the AC electrical specifications for the power-on ramp rate requirements. Controlling the maximum power-on ramp rate is required to avoid excess in-rush current.

This table provides the power supply ramp rate specifications.

**Table 10. Power supply ramp rate**

| Parameter  | Min | Max | Unit | Notes |
|--|-----|-----|------|-------|
| Required ramp rate for all voltage supplies (including OV <sub>DD</sub> /GnV <sub>DD</sub> /SV <sub>DD</sub> /XV <sub>DD</sub> /V <sub>DD</sub> , all AV <sub>DD</sub> supplies.)  | —   | 25  | V/ms | 1, 2  |
| Required ramp rate for TA_PROG_SFP   | —   | 18  | V/ms | 1, 2  |
| <b>Notes:</b>  |     |     |      |       |
| 1. Ramp rate is specified as a linear ramp from 10 to 90%. If non-linear (for example, exponential), the maximum rate of change from 200 to 500 mV is the most critical as this range might falsely trigger the ESD circuitry. |     |     |      |       |
| 2. Over full recommended operating temperature range (see <a href="#">Table 3</a> ).   |     |     |      |       |

### 3.6 Input clocks

#### 3.6.1 System clock (SYSCLK) timing specifications

This section provides the system clock DC and AC timing specifications.

##### 3.6.1.1 System clock DC timing specifications

This table provides the system clock (SYSCLK) DC characteristics.

**Table 11. SYSCLK DC electrical characteristics<sup>3</sup>**

| Characteristic   | Symbol          | Min | Typical | Max  | Unit | Notes |
|--|-----------------|-----|---------|------|------|-------|
| Input high voltage   | V <sub>IH</sub> | 1.2 | —       | —    | V    | 1     |
| Input low voltage  | V <sub>IL</sub> | —   | —       | 0.6  | V    | 1     |
| Input capacitance  | C <sub>IN</sub> | —   | 7       | 12   | pF   | —     |
| Input current (OV <sub>IN</sub> = 0 V or OV <sub>IN</sub> = OV <sub>DD</sub> )   | I <sub>IN</sub> | —   | —       | ± 50 | μA   | 2, 3  |
| <b>Note:</b>   |                 |     |         |      |      |       |
| 1. The min V <sub>IL</sub> and max V <sub>IH</sub> values are based on the respective min and max OV <sub>IN</sub> values found in <a href="#">Table 3</a> . |                 |     |         |      |      |       |
| 2. The symbol OV <sub>IN</sub> , in this case, represents the OV <sub>IN</sub> symbol referenced in <a href="#">Table 3</a> .                                |                 |     |         |      |      |       |
| 3. At recommended operating conditions with OV <sub>DD</sub> = 1.8 V, see <a href="#">Table 3</a> .  |                 |     |         |      |      |       |

## Electrical characteristics

### 3.6.1.2 System clock AC timing specifications

This table provides the system clock (SYSCLK) AC timing specifications.

**Table 12. SYSCLK AC timing specifications<sup>5</sup>**

| Parameter/condition                  | Symbol                               | Min                          | Typ | Max              | Unit | Notes |
|--------------------------------------|--------------------------------------|------------------------------|-----|------------------|------|-------|
| SYSCLK frequency                     | $f_{\text{SYSCLK}}$                  | 83.3                         | —   | 133.3            | MHz  | 1, 2  |
| SYSCLK cycle time                    | $t_{\text{SYSCLK}}$                  | 7.5                          | —   | 12               | ns   | 1, 2  |
| SYSCLK duty cycle                    | $t_{\text{KHK}} / t_{\text{SYSCLK}}$ | 40                           | —   | 60               | %    | 2     |
| SYSCLK slew rate                     | —                                    | 1                            | —   | 4                | V/ns | 3     |
| SYSCLK peak period jitter            | —                                    | —                            | —   | ± 150            | ps   | —     |
| SYSCLK jitter phase noise at -56 dBc | —                                    | —                            | —   | 500              | KHz  | 4     |
| AC input swing limits                | $\Delta V_{\text{AC}}$               | $0.60 \times OV_{\text{DD}}$ | —   | $OV_{\text{DD}}$ | V    | —     |

**Notes:**

- 1. Caution:** The relevant clock ratio settings must be chosen such that the resulting SYSCLK frequency do not exceed their respective maximum or minimum operating frequencies.
- Measured at the rising edge and/or the falling edge at  $OV_{\text{DD}}/2$ .
- Slew rate as measured from  $0.35 \times OV_{\text{DD}}$  to  $0.65 \times OV_{\text{DD}}$ .
- Phase noise is calculated as FFT of TIE jitter.
- At recommended operating conditions with  $OV_{\text{DD}} = 1.8\text{V}$ , see [Table 3](#).

### 3.6.2 Spread-spectrum sources

Spread-spectrum clock sources are an increasingly popular way to control electromagnetic interference emissions (EMI) by spreading the emitted noise to a wider spectrum and reducing the peak noise magnitude in order to meet industry and government requirements. These clock sources intentionally add long-term jitter to diffuse the EMI spectral content.

The jitter specification given in this table considers short-term (cycle-to-cycle) jitter only. The clock generator's cycle-to-cycle output jitter should meet the chip's input cycle-to-cycle jitter requirement. Frequency modulation and spread are separate concerns; the chip is compatible with spread-spectrum sources if the recommendations listed in this table are observed.

**Table 13. Spread-spectrum clock source recommendations<sup>1</sup>**

| Parameter            | Min | Max | Unit | Notes |
|----------------------|-----|-----|------|-------|
| Frequency modulation | —   | 60  | kHz  | —     |

*Table continues on the next page...*

**Table 13. Spread-spectrum clock source recommendations<sup>1</sup> (continued)**

| Parameter  | Min | Max | Unit | Notes |
|--|-----|-----|------|-------|
| Frequency spread   | —   | 1.0 | %    | 2, 3  |
| <b>Notes:</b>  |     |     |      |       |
| 1. At recommended operating conditions with $OV_{DD} = 1.8\text{ V}$ , see <a href="#">Table 3</a> .   |     |     |      |       |
| 2. SYSCLK frequencies that result from frequency spreading and the resulting core frequency must meet the minimum and maximum specifications given in <a href="#">Table 12</a> . |     |     |      |       |
| 3. Maximum spread-spectrum frequency may not result in exceeding any maximum operating frequency of the device.  |     |     |      |       |

### CAUTION

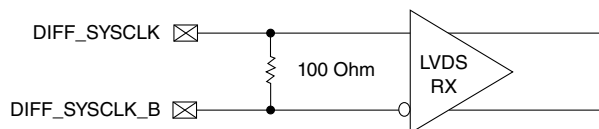
The processor's minimum and maximum SYSCLK and core/platform/DDR frequencies must not be exceeded regardless of the type of clock source. Therefore, systems in which the processor is operated at its maximum rated core/platform/DDR frequency should avoid violating the stated limits by using down-spreading only.

### 3.6.3 Differential System clock (DIFF\_SYSCLK/DIFF\_SYSCLK\_B) timing specifications

Differential system clocking mode requires an onboard oscillator to provide reference clock input to Differential System clock pair (DIFF\_SYSCLK/DIFF\_SYSCLK\_B).

This Differential clock pair can be configured to provide clock to Core, Platform and USB PLLs.

This figure shows a receiver reference diagram of the Differential System clock.

**Figure 9. LVDS receiver**

This section provides the differential system clock DC and AC timing specifications.

#### 3.6.3.1 Differential System clock DC timing specifications

The differential system clock receiver voltage requirements are as specified in the [Recommended operating conditions](#) table.

**Electrical characteristics**

The differential system clock can also be single-ended. For this, DIFF\_SYSCLK\_B should be connected to  $OV_{DD}/2$ .

This table provides the differential system clock (DIFF\_SYSCLK/DIFF\_SYSCLK\_B) DC specifications.

**Table 14. Differential system clock DC electrical characteristics<sup>1</sup>**

| Parameter  | Symbol    | Min  | Typical | Max  | Unit | Notes |
|--|-----------|------|---------|------|------|-------|
| Input differential voltage swing   | $V_{id}$  | 100  | -       | 600  | mV   | 2     |
| Input common mode voltage  | $V_{icm}$ | 50   | -       | 1570 | mV   | -     |
| Power supply current   | $I_{cc}$  | -    | -       | 5    | mA   | -     |
| Input capacitance  | $C_{in}$  | 1.45 | 1.5     | 1.55 | pF   | -     |
| <b>Note:</b>   |           |      |         |      |      |       |
| 1. At recommended operating conditions with $OV_{DD} = 1.8$ V, see <a href="#">Table 3</a> for details.              |           |      |         |      |      |       |
| 2. Input differential voltage swing ( $V_{id}$ ) specified is equal to $IV_{DIFF\_SYSCLK\_P} - V_{DIFF\_SYSCLK\_NI}$ |           |      |         |      |      |       |

**3.6.3.2 Differential System clock AC timing specifications**

Differential System clock(DIFF\_SYSCLK/DIFF\_SYSCLK\_B) input pair supports input clock frequency of 83.3-133.3MHz

Spread spectrum clocking is not supported on differential system clock pair input.

This table provides the differential system clock (DIFF\_SYSCLK/DIFF\_SYSCLK\_B) AC specifications.

**Table 15. Differential system clock AC electrical characteristics<sup>1</sup>**

| Parameter  | Symbol             | Min  | Typical | Max   | Unit | Notes |
|--|--------------------|------|---------|-------|------|-------|
| DIFF_SYSCLK/DIFF_SYSCLK_B frequency range  | $t_{DIFF\_SYSCLK}$ | 83.3 |         | 133.3 | MHz  | -     |
| DIFF_SYSCLK/DIFF_SYSCLK_B frequency tolerance  | $t_{DIFF\_TOL}$    | -300 | -       | +300  | ppm  | -     |
| Duty cycle   | $t_{DIFF\_DUTY}$   | 40   | 50      | 60    | %    | -     |
| Clock period jitter (peak to peak)   | $t_{DIFF\_TJ}$     | -    | -       | 100   | ps   | 1     |
| <b>Note:</b>   |                    |      |         |       |      |       |
| 1. This is evaluated with supply noise profile at +/- 5% sine wave                         |                    |      |         |       |      |       |
| 2. At recommended operating conditions with $OV_{DD} = 1.8$ V, see <a href="#">Table 3</a> |                    |      |         |       |      |       |

### 3.6.4 USB reference clock specification

USB PHY needs a reference clock. There are two options for the reference clock: SYSCLK or DIFF\_SYSCLK/DIFF\_SYSCLK\_B.

This table provides the additional requirements when SYSCLK or DIFF\_SYSCLK/DIFF\_SYSCLK\_B is used as USB REFCLK.

**Table 16. REFCLK requirements for USB PHY**

| Parameter/condition          | Symbol                 | Min  | Typ | Max | Unit | Notes |
|------------------------------|------------------------|------|-----|-----|------|-------|
| REFCLK duty cycle            | $t_{KHK} / t_{SYSCLK}$ | 45   | —   | 55  | —    | —     |
| REFCLK frequency             | $f_{SYSCLK}$           | —    | 100 | —   | MHz  | —     |
| REFCLK frequency offset      | FREF_OFFSET            | -300 | —   | 300 | ppm  | —     |
| REFCLK random jitter         | RMSJREF_CLK            | —    | —   | 3   | ps   | 1, 2  |
| REFCLK cycle-to-cycle jitter | DJREF_CLK              | -150 | —   | 150 | ps   | 3     |

**Notes:**

- 1.5 MHz to Nyquist frequency. For example, for 100 MHz reference clock, the Nyquist frequency is 50 MHz.
- The peak-to-peak Rj specification is calculated as 14.069 times the RMS Rj for 10-12 BER.
- DJ across all frequencies.

### 3.6.5 Real-time clock timing

The real-time clock timing (RTC) input is sampled by the platform clock. The output of the sampling latch is then used as an input to the time base unit of the core; there is no need for jitter specification. The minimum period of the RTC signal should be greater than or equal to 16x the period of the platform clock with a 50% duty cycle. There is no minimum RTC frequency; RTC may be grounded if not needed.

### 3.6.6 DDR clock timing

This section provides the DDR clock DC and AC timing specifications.

#### 3.6.6.1 DDR clock DC electrical characteristics

This table provides the DDR clock (DDRCLK) DC electrical characteristics.

**Table 17. DDRCLK DC electrical characteristics<sup>3</sup>**

| Characteristic     | Symbol   | Min  | Typical | Max | Unit | Notes |
|--------------------|----------|------|---------|-----|------|-------|
| Input high voltage | $V_{IH}$ | 1.25 | —       | —   | V    | 1     |

*Table continues on the next page...*

## Electrical characteristics

Table 17. DDRCLK DC electrical characteristics<sup>3</sup> (continued)

| Characteristic   | Symbol   | Min | Typical | Max      | Unit    | Notes |
|--|----------|-----|---------|----------|---------|-------|
| Input low voltage  | $V_{IL}$ | —   | —       | 0.6      | V       | 1     |
| Input capacitance  | $C_{IN}$ | —   | 7       | 12       | pF      | —     |
| Input current ( $OV_{IN} = 0$ V or $OV_{IN} = OV_{DD}$ ) | $I_{IN}$ | —   | —       | $\pm 50$ | $\mu$ A | 2     |

**Note:**

1. The min  $V_{IL}$  and max  $V_{IH}$  values are based on the respective min and max  $OV_{IN}$  values found in Table 3.
2. The symbol  $OV_{IN}$ , in this case, represents the  $OV_{IN}$  symbol referenced in Table 3.
3. At recommended operating conditions with  $OV_{DD} = 1.8$  V, see Table 3.

## 3.6.6.2 DDR clock AC timing specifications

This table provides the DDR clock (DDRCLK) AC timing specifications.

Table 18. DDRCLK AC timing specifications<sup>5</sup>

| Parameter/Condition                  | Symbol                 | Min                   | Typ | Max       | Unit | Notes |
|--------------------------------------|------------------------|-----------------------|-----|-----------|------|-------|
| DDRCLK frequency                     | $f_{DDRCLK}$           | 100                   | —   | 133.3     | MHz  | 1, 2  |
| DDRCLK cycle time                    | $t_{DDRCLK}$           | 7.5                   | —   | 10        | ns   | 1, 2  |
| DDRCLK duty cycle                    | $t_{KHK} / t_{DDRCLK}$ | 40                    | —   | 60        | %    | 2     |
| DDRCLK slew rate                     | —                      | 1                     | —   | 4         | V/ns | 3     |
| DDRCLK peak period jitter            | —                      | —                     | —   | $\pm 150$ | ps   | —     |
| DDRCLK jitter phase noise at -56 dBc | —                      | —                     | —   | 500       | kHz  | 4     |
| AC Input Swing Limits                | $\Delta V_{AC}$        | $0.60 \times OV_{DD}$ | —   | $OV_{DD}$ | V    | —     |

**Notes:**

1. **Caution:** The relevant clock ratio settings must be chosen such that the resulting DDRCLK frequency do not exceed their respective maximum or minimum operating frequencies.
2. Measured at the rising edge and/or the falling edge at  $OV_{DD}/2$ .
3. Slew rate as measured from  $0.35 \times OV_{DD}$  to  $0.65 \times OV_{DD}$ .
4. Phase noise is calculated as FFT of TIE jitter.
5. At recommended operating conditions with  $OV_{DD} = 1.8$  V, see Table 3.

## 3.6.7 Other input clocks

A description of the overall clocking of this device is available in the chip reference manual in the form of a clock subsystem block diagram. For information about the input clock requirements of functional modules sourced external of the chip, such as SerDes, see the specific interface section.

### 3.7 RESET initialization

This section describes the AC electrical specifications for the RESET initialization timing requirements. This table describes the AC electrical specifications for the RESET initialization timing.

**Table 19. RESET initialization timing specifications**

| Parameter/Condition  | Min | Max | Unit    | Notes |
|--|-----|-----|---------|-------|
| Required assertion time of PORESET_B   | 1   | —   | ms      | 1     |
| Required assertion time of PORESET_B after stable SYSCLK   | 1   | -   | μs      | 2     |
| Required input assertion time of HRESET_B  | 32  | —   | SYSCLKs | 2, 3  |
| Maximum rise/fall time of HRESET_B   | —   | 10  | SYSCLK  | 4     |
| Maximum rise/fall time of PORESET_B  | —   | 1   | SYSCLK  | 4     |
| Input setup time for POR configs (other than cfg_eng_use0) with respect to negation of PORESET_B           | 4   | —   | SYSCLKs | 2,5   |
| Input hold time for all POR configs with respect to negation of PORESET_B                                  | 2   | —   | SYSCLKs | 2     |
| Maximum valid-to-high impedance time for actively driven POR configs with respect to negation of PORESET_B | —   | 5   | SYSCLKs | 2     |

**Notes:**

1. PORESET\_B must be driven asserted before the core and platform power supplies are powered up.
2. SYSCLK is the primary clock input for the chip.
3. The device asserts HRESET\_B as an output when PORESET\_B is asserted to initiate the power-on reset process. The device releases HRESET\_B sometime after PORESET\_B is deasserted. The exact sequencing of HRESET\_B deassertion is documented in section "Power-On Reset Sequence" in the chip reference manual.
4. System/board must be designed to ensure the input requirement to the device is achieved. Proper device operation is guaranteed for inputs meeting this requirement by design, simulation, characterization, or functional testing.
5. For proper clock selection, terminate cfg\_eng\_use0 with a pull up or pull down of 4.7 kΩ to ensure that the signal will have a valid state as soon as the IO voltage reach its operating condition.

### 3.8 DDR4 SDRAM controller

This section describes the DC and AC electrical specifications for the DDR4 SDRAM controller interface. Note that the required  $GV_{DD}(typ)$  voltage is 1.2 V when interfacing to DDR4 SDRAM.

#### NOTE

When operating at a DDR data rate of 1866 MT/s or higher, only one dual-ranked module per memory controller is supported.

## Electrical characteristics

### 3.8.1 DDR4 SDRAM interface DC electrical characteristics

This table provides the recommended operating conditions for the DDR SDRAM controller when interfacing to DDR4 SDRAM.

**Table 20. DDR4 SDRAM interface DC electrical characteristics ( $GV_{DD} = 1.2 V$ )<sup>7</sup>**

| Parameter           | Symbol   | Min                          | Max                          | Unit    | Notes |
|---------------------|----------|------------------------------|------------------------------|---------|-------|
| Input low           | $V_{IL}$ | —                            | $0.7 \times GV_{DD} - 0.175$ | V       | 3, 5  |
| Input high          | $V_{IH}$ | $0.7 \times GV_{DD} + 0.175$ | —                            | V       | 3, 5  |
| I/O leakage current | $I_{OZ}$ | -200                         | 200                          | $\mu A$ | 4     |

**Notes:**

- $GV_{DD}$  is expected to be within 60 mV of the DRAM's voltage supply at all times. The DRAM's and memory controller's voltage supply may or may not be from the same source.
- $V_{TT}$  and  $V_{REFCA}$  are applied directly to the DRAM device. Both  $V_{TT}$  and  $V_{REFCA}$  voltages must track  $GV_{DD}/2$ .
- Input capacitance load for DQ, DQS, and DQS\_B are available in the IBIS models.
- Output leakage is measured with all outputs disabled,  $0V \leq V_{OUT} \leq GV_{DD}$ .
- Internal  $V_{ref}$  for data bus must be set to  $0.7 \times GV_{DD}$ .
- See the IBIS model for the complete output IV curve characteristics.
- For recommended operating conditions, see [Table 3](#).

### 3.8.2 DDR4 SDRAM interface AC timing specifications

This section provides the AC timing specifications for the DDR SDRAM controller interface. The DDR controller supports DDR4 memories. Note that the required  $GV_{DD}(\text{typ})$  voltage is 1.2 V when interfacing to DDR4 SDRAM.

#### 3.8.2.1 DDR4 SDRAM interface input AC timing specifications

This table provides the input AC timing specifications for the DDR controller when interfacing to DDR4 SDRAM.

**Table 21. DDR4 SDRAM interface input AC timing specifications ( $GV_{DD} = 1.2 V \pm 5\%$ )<sub>1</sub>**

| Parameter   | Symbol     | Min                          | Max                          | Unit | Notes |
|---|------------|------------------------------|------------------------------|------|-------|
| AC input low voltage<br>$\leq 2133$ MT/s data rate  | $V_{ILAC}$ | —                            | $0.7 \times GV_{DD} - 0.175$ | V    | —     |
| AC input high voltage<br>$\leq 2133$ MT/s data rate | $V_{IHAC}$ | $0.7 \times GV_{DD} + 0.175$ | —                            | V    | —     |

**Note:**

- For recommended operating conditions, see [Table 3](#).

This table provides the input AC timing specifications for the DDR controller when interfacing to DDR4 SDRAM.

**Table 22. DDR4 SDRAM interface input AC timing specifications ( $GV_{DD} = 1.2 V \pm 5\%$  for DDR4)<sub>3</sub>**

| Parameter                         | Symbol       | Min  | Max | Unit | Notes |
|-----------------------------------|--------------|------|-----|------|-------|
| Controller skew for MDQS-MDQ/MECC | $t_{CISKEW}$ | —    | —   | ps   | 1     |
| 2133 MT/s data rate               |              | -80  | 80  |      |       |
| 1866 MT/s data rate               |              | -93  | 93  |      |       |
| 1600 MT/s data rate               |              | -112 | 112 |      |       |
| 1333 MT/s data rate               |              | -125 | 125 |      |       |
| Tolerated Skew for MDQS-MDQ/MECC  | $t_{DISKEW}$ | —    | —   | ps   | 2     |
| 2133 MT/s data rate               |              | -154 | 154 |      |       |
| 1866 MT/s data rate               |              | -175 | 175 |      |       |
| 1600 MT/s data rate               |              | -200 | 200 |      |       |
| 1333 MT/s data rate               |              | -250 | 250 |      |       |

**Notes:**

- $t_{CISKEW}$  represents the total amount of skew consumed by the controller between MDQS[n] and any corresponding bit that is captured with MDQS[n]. This must be subtracted from the total timing budget.
- The amount of skew that can be tolerated from MDQS to a corresponding MDQ signal is called  $t_{DISKEW}$ . This can be determined by the following equation:  $t_{DISKEW} = \pm(T \div 4 - \text{abs}(t_{CISKEW}))$  where T is the clock period and  $\text{abs}(t_{CISKEW})$  is the absolute value of  $t_{CISKEW}$ .
- For recommended operating conditions, see [Table 3](#).

This figure shows the DDR4 SDRAM interface input timing diagram.

## Electrical characteristics

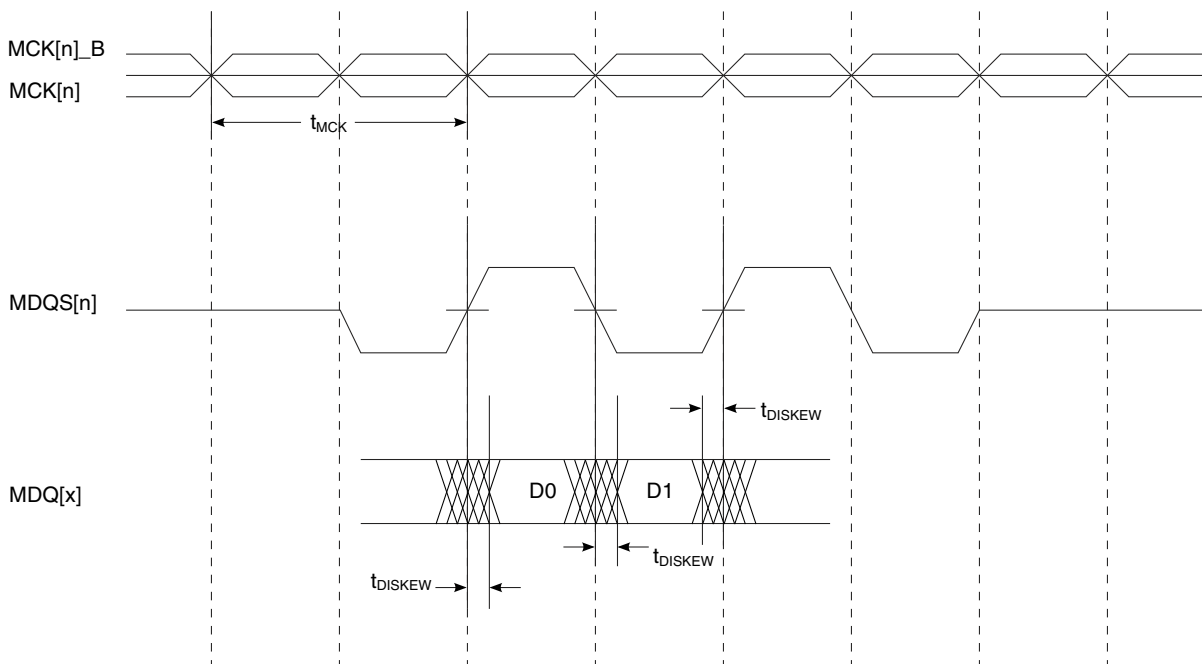


Figure 10. DDR4 SDRAM interface input timing diagram

### 3.8.2.2 DDR4 SDRAM interface output AC timing specifications

This table contains the output AC timing targets for the DDR4 SDRAM interface.

Table 23. DDR4 SDRAM interface output AC timing specifications ( $G_{V_{DD}} = 1.2 V$ )<sup>7</sup>

| Parameter                                      | Symbol <sup>1</sup> | Min  | Max  | Unit | Notes |
|--|---------------------|------|------|------|-------|
| MCK[n] cycle time                              | $t_{MCK}$           | 938  | 1500 | ps   | 2     |
| ADDR/CMD/CNTL output setup with respect to MCK | $t_{DDKHAS}$        | —    | —    | ps   | 3     |
| 2133 MT/s data rate                            |                     | 350  | —    |      |       |
| 1866 MT/s data rate                            |                     | 410  | —    |      |       |
| 1600 MT/s data rate                            |                     | 495  | —    |      |       |
| 1333 MT/s data rate                            |                     | 606  | —    |      |       |
| ADDR/CMD/CNTL output hold with respect to MCK  | $t_{DDKHAX}$        | —    | —    | ps   | 3     |
| 2133 MT/s data rate                            |                     | 350  | —    |      |       |
| 1866 MT/s data rate                            |                     | 390  | —    |      |       |
| 1600 MT/s data rate                            |                     | 495  | —    |      |       |
| 1333 MT/s data rate                            |                     | 606  | —    |      |       |
| MCK to MDQS Skew                               | $t_{DDKMHM}$        | -150 | 150  | ps   | 4,7   |
| MDQ/MECC/MDM output data eye                   | $t_{DDKXDEYE}$      | —    | —    | ps   | 5     |
| 2133 MT/s data rate                            |                     | 320  | —    |      |       |
| 1866 MT/s data rate                            |                     | 350  | —    |      |       |

Table continues on the next page...

**Table 23. DDR4 SDRAM interface output AC timing specifications ( $V_{DD} = 1.2 V$ )<sup>7</sup>  
(continued)**

| Parameter           | Symbol <sup>1</sup> | Min                  | Max                  | Unit | Notes |
|---------------------|---------------------|----------------------|----------------------|------|-------|
| 1600 MT/s data rate |                     | 400                  | —                    |      |       |
| 1333 MT/s data rate |                     | 500                  | —                    |      |       |
| MDQS preamble       | $t_{DDKHMP}$        | $0.9 \times t_{MCK}$ | —                    | ps   | —     |
| MDQS postamble      | $t_{DDKHME}$        | $0.4 \times t_{MCK}$ | $0.6 \times t_{MCK}$ | ps   | —     |

1. The symbols used for timing specifications follow the pattern of  $t_{(\text{first two letters of functional block})(\text{signal})(\text{state}) (\text{reference})(\text{state})}$  for inputs and  $t_{(\text{first two letters of functional block})(\text{reference})(\text{state})(\text{signal})(\text{state})}$  for outputs. Output hold time can be read as DDR timing (DD) from the rising or falling edge of the reference clock (KH or KL) until the output went invalid (AX or DX). For example,  $t_{DDKHAS}$  symbolizes DDR timing (DD) for the time  $t_{MCK}$  memory clock reference (K) goes from the high (H) state until outputs (A) are setup (S) or output valid time. Also,  $t_{DDKLDX}$  symbolizes DDR timing (DD) for the time  $t_{MCK}$  memory clock reference (K) goes low (L) until data outputs (D) are invalid (X) or data output hold time.

2. All MCK/MCK\_B and MDQS/MDQS\_B referenced measurements are made from the crossing of the two signals.

3. ADDR/CMD/CNTL includes all DDR SDRAM output signals except MCK/MCK\_B, MCS\_B, and MDQ/MECC/MDM/MDQS.

4. Note that  $t_{DDKHMH}$  follows the symbol conventions described in note 1. For example,  $t_{DDKHMH}$  describes the DDR timing (DD) from the rising edge of the MCK[n] clock (KH) until the MDQS signal is valid (MH).  $t_{DDKHMH}$  can be modified through control of the MDQS override bits (called WR\_DATA\_DELAY) in the TIMING\_CFG\_2 register. This is typically set to the same delay as in DDR\_SDRAM\_CLK\_CNTL[CLK\_ADJUST]. The timing parameters listed in the table assume that these two parameters have been set to the same adjustment value. See the chip reference manual for a description and explanation of the timing modifications enabled by the use of these bits.

5. Available eye for data (MDQ), ECC (MECC), and data mask (MDM) outputs at the pin of the processor. Memory controller will center the strobe (MDQS) in the available data eye at the DRAM (end point) during the initialization.

6. Note that this is required to program the start value of the DQS adjust for write leveling.

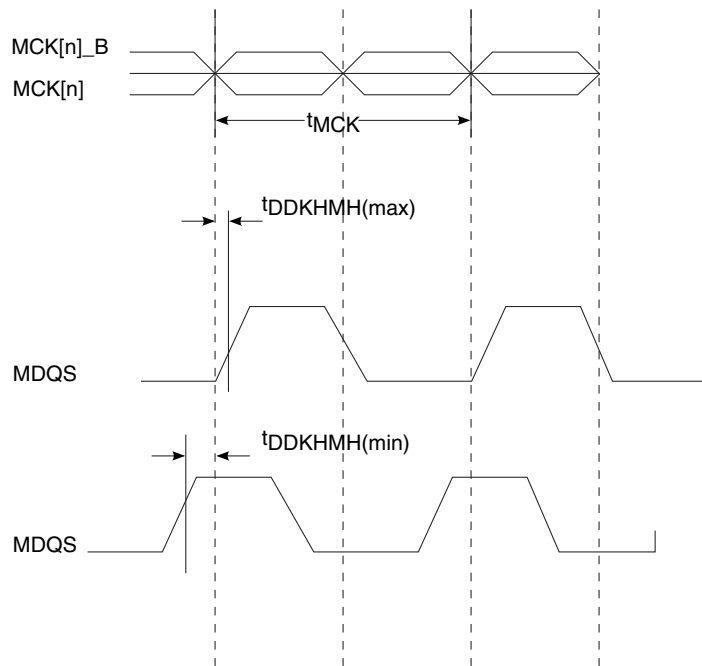
7. For recommended operating conditions, see [Table 3](#).

**NOTE**

For the ADDR/CMD/CNTL setup and hold specifications in [Table 23](#), it is assumed that the clock control register is set to adjust the memory clocks by  $\frac{1}{2}$  applied cycle.

This figure shows the DDR4 SDRAM interface output timing for the MCK to MDQS skew measurement ( $t_{DDKHMH}$ ).

## Electrical characteristics



**Figure 11.  $t_{DDKMH}$  timing diagram**

This figure shows the DDR4 SDRAM output timing diagram.

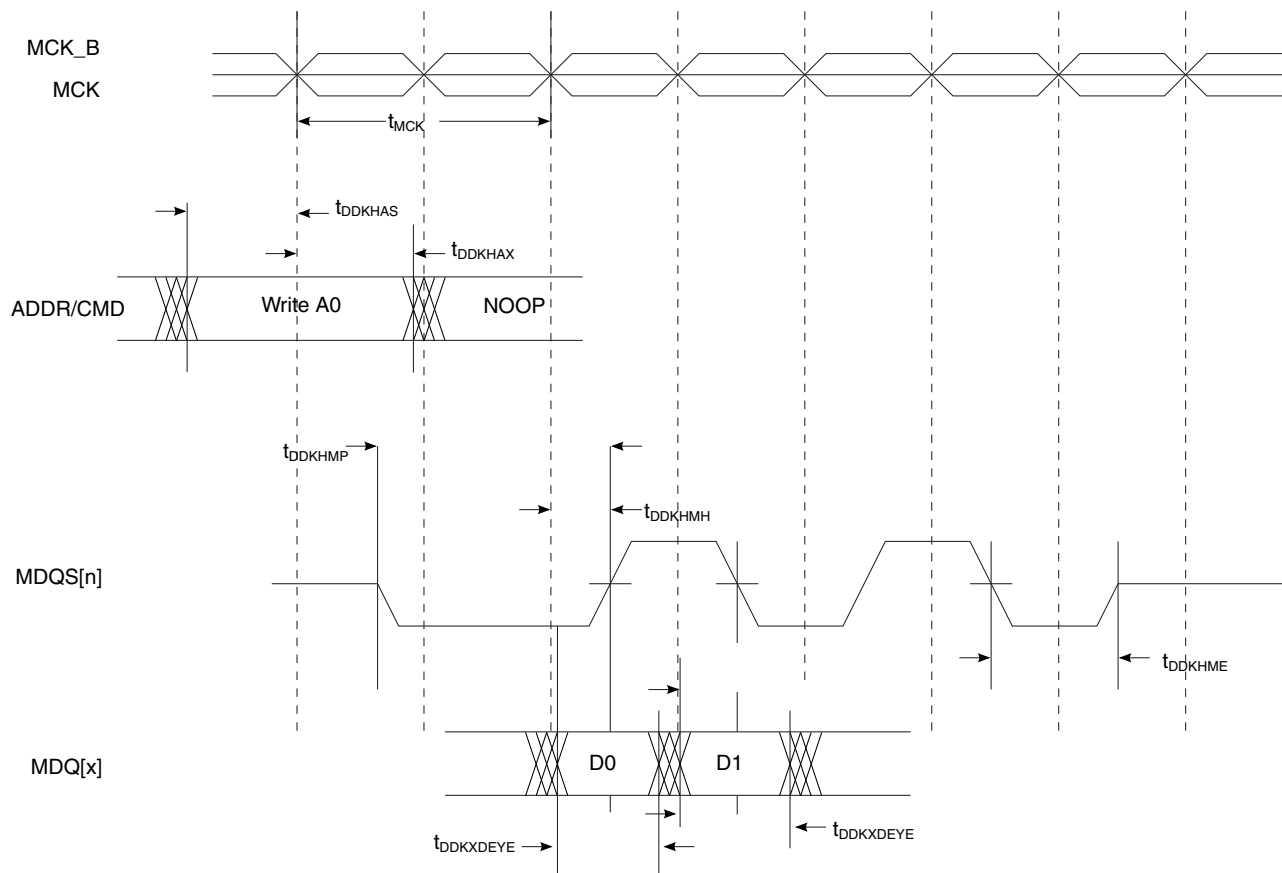


Figure 12. DDR4 output timing diagram

## 3.9 SPI interface

This section describes the DC and AC electrical characteristics for the SPI interface.

### 3.9.1 SPI DC electrical characteristics

This table provides the DC electrical characteristics for the SPI interface operating at  $OV_{DD} = 1.8\text{ V}$ .

Table 24. SPI DC electrical characteristics (1.8 V)<sup>3</sup>

| Parameter   | Symbol   | Min                  | Max                  | Unit          | Notes |
|---|----------|----------------------|----------------------|---------------|-------|
| Input high voltage  | $V_{IH}$ | $0.7 \times OV_{DD}$ | —                    | V             | 1     |
| Input low voltage   | $V_{IL}$ | —                    | $0.2 \times OV_{DD}$ | V             | 1     |
| Input current ( $V_{IN} = 0\text{ V}$ or $V_{IN} = OV_{DD}$ ) | $I_{IN}$ | —                    | $\pm 50$             | $\mu\text{A}$ | 2     |
| Output high voltage   | $V_{OH}$ | 1.35                 | —                    | V             | —     |

Table continues on the next page...

## Electrical characteristics

**Table 24. SPI DC electrical characteristics (1.8 V)<sup>3</sup> (continued)**

| Parameter  | Symbol          | Min | Max | Unit | Notes |
|--|-----------------|-----|-----|------|-------|
| (OV <sub>DD</sub> = min, I <sub>OH</sub> = -0.5 mA)  |                 |     |     |      |       |
| Output low voltage<br>(OV <sub>DD</sub> = min, I <sub>OL</sub> = 0.5 mA)   | V <sub>OL</sub> | —   | 0.4 | V    | —     |
| <b>Notes:</b>  |                 |     |     |      |       |
| 1. The min V <sub>IL</sub> and max V <sub>IH</sub> values are based on the respective min and max OV <sub>IN</sub> values found in <a href="#">Table 3</a> . |                 |     |     |      |       |
| 2. The symbol V <sub>IN</sub> , in this case, represents the OV <sub>IN</sub> symbol referenced in <a href="#">Table 3</a> .                                 |                 |     |     |      |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a> .   |                 |     |     |      |       |

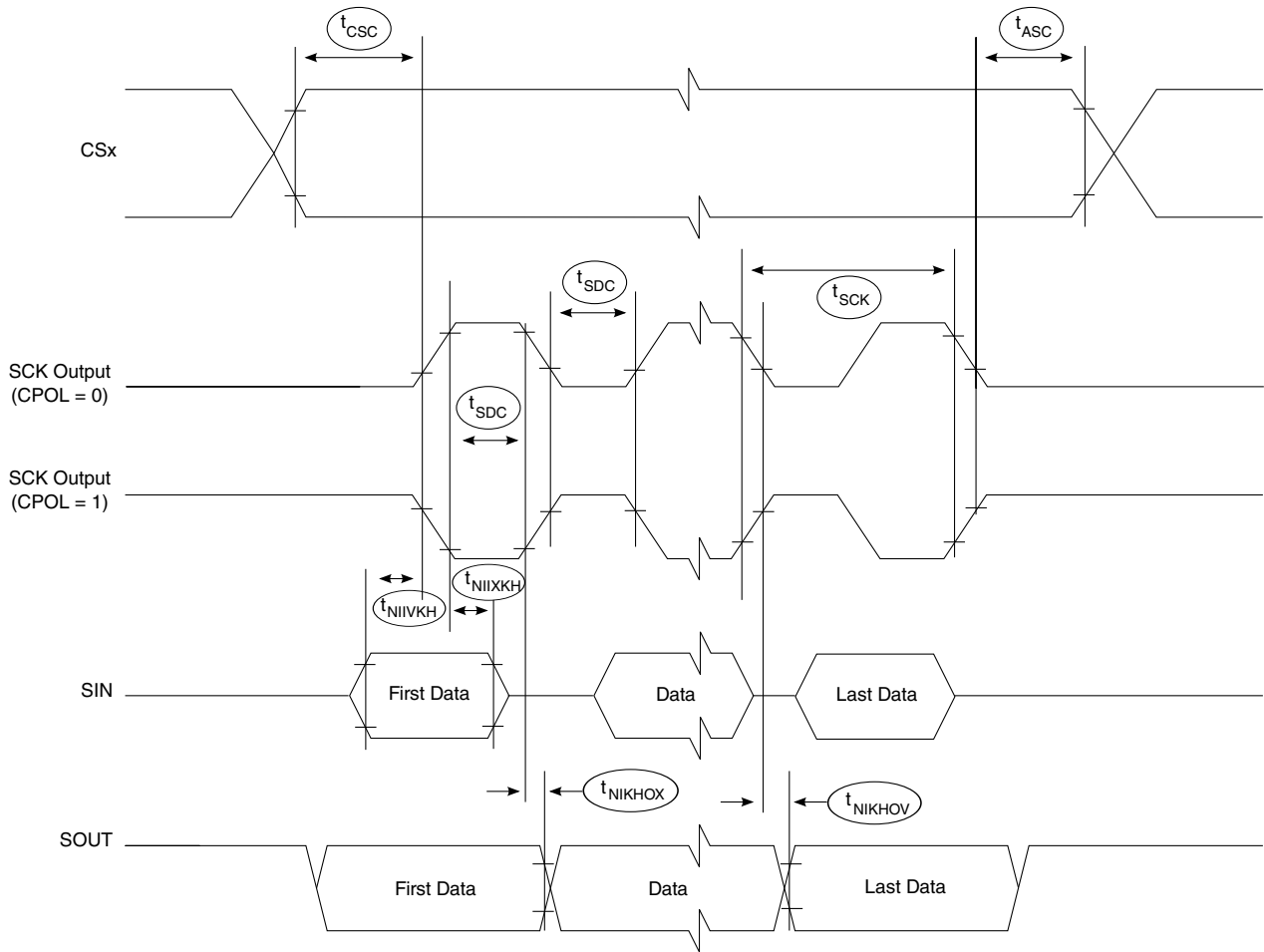
**3.9.2 SPI AC timing specifications**

This table provides the SPI timing specifications.

**Table 25. SPI AC timing specifications**

| Parameter   | Symbol              | Condition | Min                  | Max | Unit             | Notes |
|---|---------------------|-----------|----------------------|-----|------------------|-------|
| SCK Cycle Time  | t <sub>SCK</sub>    | —         | t <sub>sys</sub> * 2 | —   | ns               |       |
| SCK Clock Pulse Width   | t <sub>SDC</sub>    | —         | 40%                  | 60% | t <sub>SCK</sub> |       |
| CS to SCK Delay   | t <sub>CSC</sub>    | Master    | tp*2-6               | —   | ns               | 1,2   |
| After SCK Delay   | t <sub>ASC</sub>    | Master    | tp*2-1               | —   | ns               | 1,2   |
| Slave Access Time (SS active to SOUT driven)  | t <sub>A</sub>      | Slave     | —                    | 15  | ns               |       |
| Slave Disable Time (SS inactive to SOUT High-Z or invalid)                            | t <sub>DI</sub>     | Slave     | —                    | 10  | ns               |       |
| Data Setup Time for Inputs  | t <sub>NIIVKH</sub> | Master    | 9                    | —   | ns               |       |
|   | t <sub>NEIVKH</sub> | Slave     | 4                    | —   |                  |       |
| Data Hold Time for Inputs   | t <sub>NIIXKH</sub> | Master    | 0                    | —   | ns               |       |
|   | t <sub>NEIXKH</sub> | Slave     | 2                    | —   |                  |       |
| Data Valid (after SCK edge) for Outputs   | t <sub>NIKHOV</sub> | Master    | —                    | 5   | ns               |       |
|   | t <sub>NEKHOV</sub> | Slave     | —                    | 10  |                  |       |
| Data Hold Time for Outputs  | t <sub>NIKHOX</sub> | Master    | 0                    | —   | ns               |       |
|   | t <sub>NEKHOX</sub> | Slave     | 0                    | —   |                  |       |
| <b>Notes:</b>   |                     |           |                      |     |                  |       |
| 1. tp is the input clock period for the SPI controller. 1/tp is the platform clock/2. |                     |           |                      |     |                  |       |
| 2. The delay is programmable. Refer to CTARx register in LS2088A RM for more details. |                     |           |                      |     |                  |       |

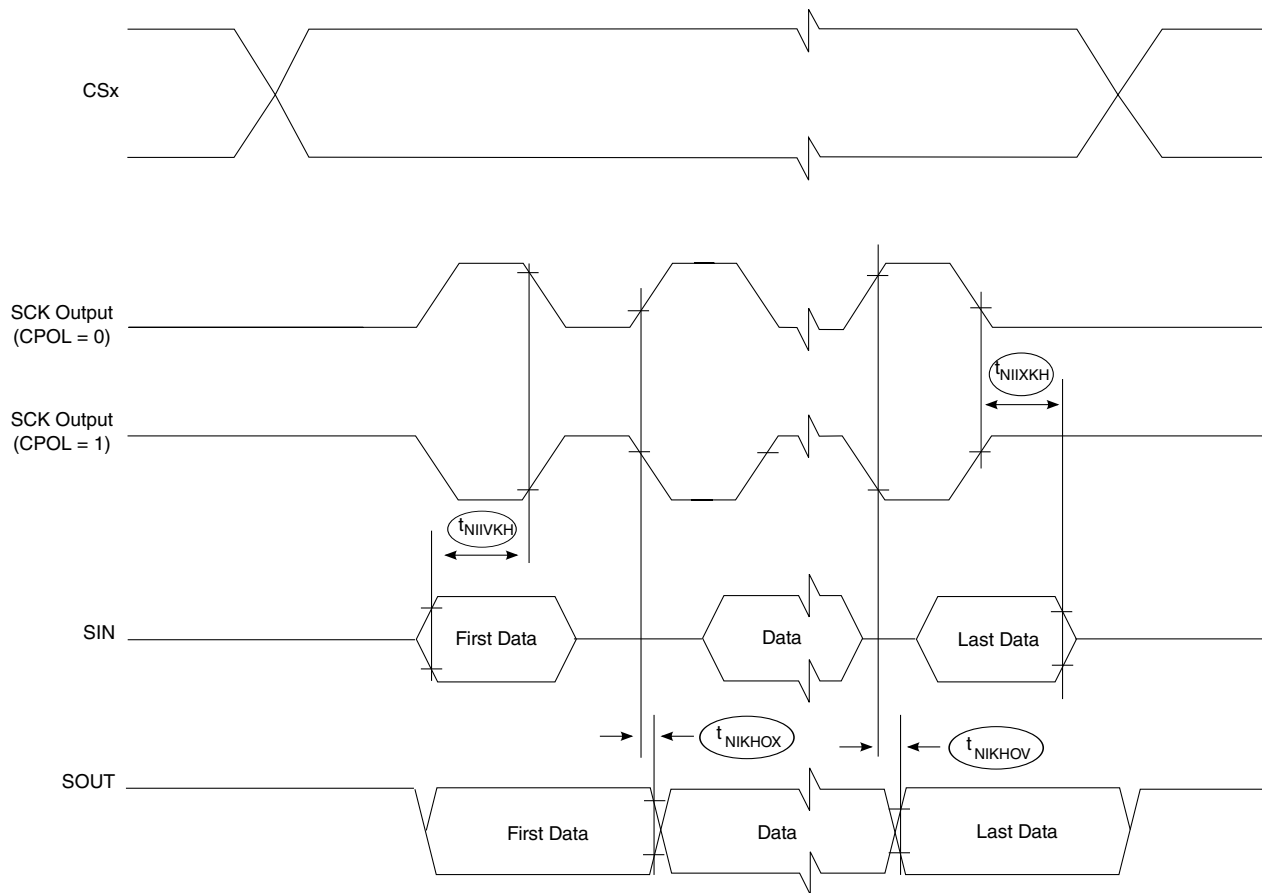
This figure shows the SPI timing master when CPHA = 0.



**Figure 13. SPI classic SPI timing master, CPHA = 0**

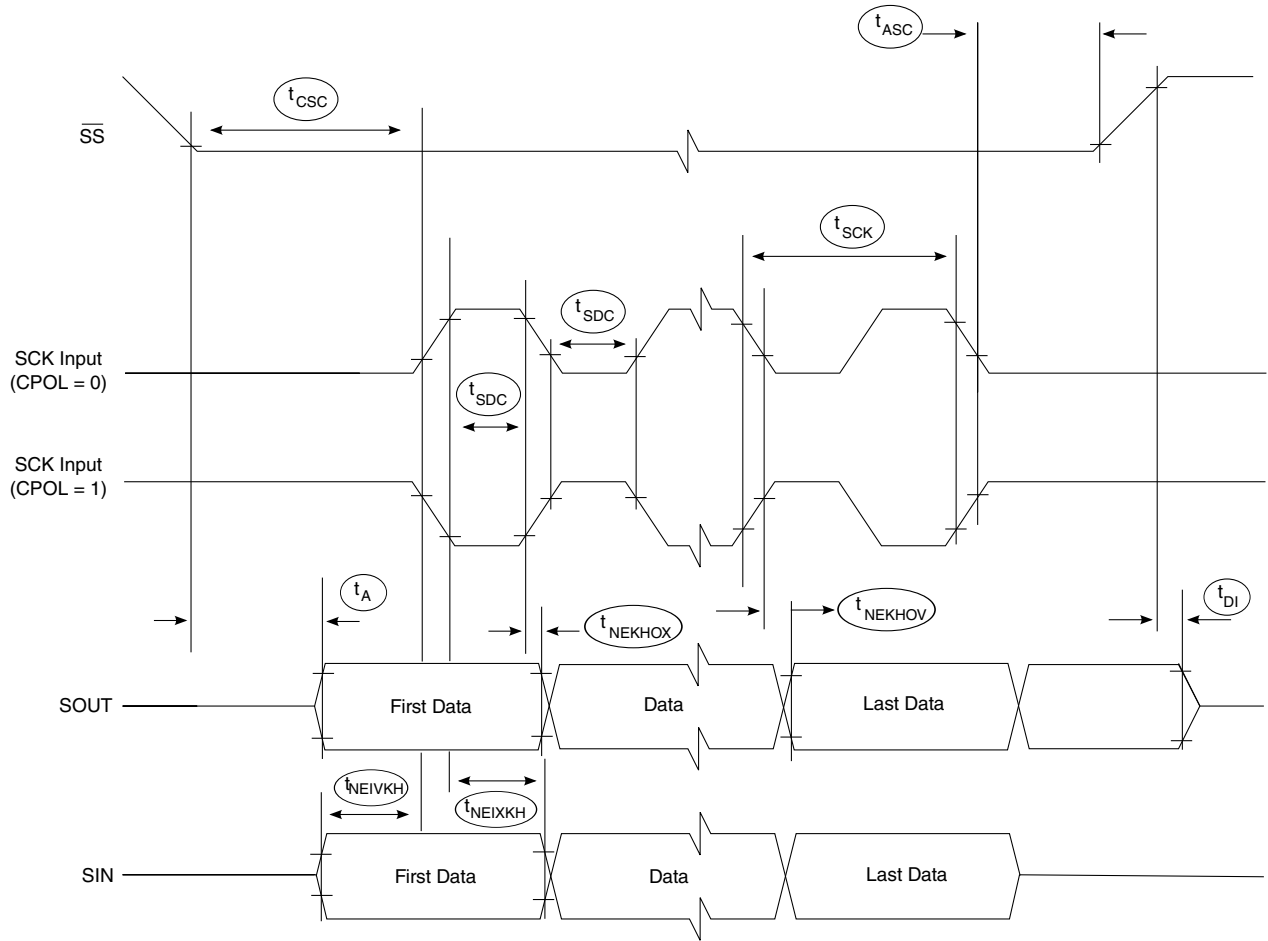
This figure shows the SPI timing master when CPHA = 1.

**Electrical characteristics**



**Figure 14. SPI classic SPI timing master, CPHA = 1**

This figure shows the SPI timing slave when CPHA = 0.



**Figure 15. SPI classic SPI timing slave, CPHA = 0**

This figure shows the SPI timing slave when CPHA = 1.

## Electrical characteristics

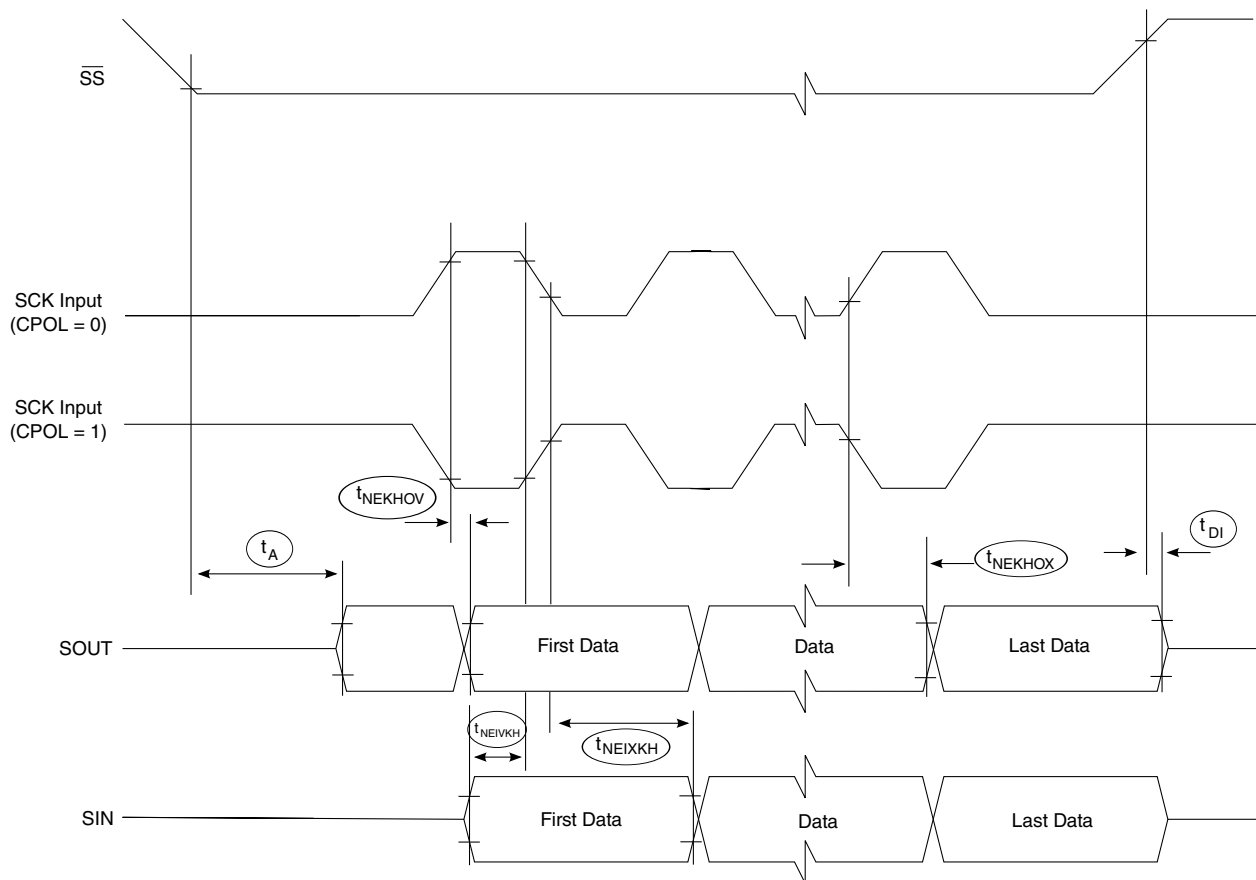


Figure 16. SPI classic SPI timing slave, CPHA = 1

## 3.10 QuadSPI interface

This section describes the DC and AC electrical characteristics for the QuadSPI interface.

### 3.10.1 QuadSPI DC electrical characteristics

This table provides the DC electrical characteristics for the QuadSPI interface operating at  $OV_{DD} = 1.8\text{ V}$ .

Table 26. QuadSPI DC electrical characteristics (1.8 V)<sup>3</sup>

| Parameter  | Symbol   | Min                 | Max                 | Unit          | Notes |
|--|----------|---------------------|---------------------|---------------|-------|
| Input high voltage                                   | $V_{IH}$ | $0.7 \cdot OV_{DD}$ | —                   | V             | 1     |
| Input low voltage                                    | $V_{IL}$ | —                   | $0.2 \cdot OV_{DD}$ | V             | 1     |
| Input current ( $0\text{ V} \leq V_{IN} \leq$ )      | $I_{IN}$ | —                   | $\pm 50$            | $\mu\text{A}$ | 2     |
| Output high voltage ( $I_{OH} = -100\ \mu\text{A}$ ) | $V_{OH}$ | $OV_{DD} - 0.2$     | —                   | V             | —     |

Table continues on the next page...

**Table 26. QuadSPI DC electrical characteristics (1.8 V)<sup>3</sup> (continued)**

| Parameter   | Symbol   | Min | Max | Unit | Notes |
|---|----------|-----|-----|------|-------|
| Output low voltage ( $I_{OL} = 100 \mu A$ )   | $V_{OL}$ | —   | 0.2 | V    | —     |
| <b>Notes:</b>   |          |     |     |      |       |
| 1. The min $V_{IL}$ and max $V_{IH}$ values are based on the respective min and max $OV_{IN}$ values found in <a href="#">Table 3</a> . |          |     |     |      |       |
| 2. The symbol $V_{IN}$ , in this case, represents the $OV_{IN}$ symbol referenced in <a href="#">Table 3</a> .                          |          |     |     |      |       |
| 3. At recommended operating conditions with $OV_{DD} = 1.8 V$ .   |          |     |     |      |       |

### 3.10.2 QuadSPI AC timing specifications

This section describes the QuadSPI timing specifications in both SDR and DDR modes. All data is based on a negative edge data launch from the device and a positive edge data capture, as shown in the timing figures in this section.

#### 3.10.2.1 QuadSPI timing SDR mode

This table provides the QuadSPI input and output timing in SDR mode ( $MCR[DQS\_EN] = 0$ , regarding to the 1st sample point. See  $qSPI\_SMPR[xSDLY, xSPHS]$  in the corresponding reference manual for different sampling points).

**Table 27. SDR mode QuadSPI input and output timing**

| Parameter                               | Symbol              | Min        | Max  | Unit |
|---|---------------------|------------|------|------|
| Clock rise/fall time                    | $T_{RISE}/T_{FALL}$ | 1          | —    | ns   |
| CS output hold time                     | $t_{NIKHGX2^-}$     | $-3.3+j*T$ | —    | ns   |
| CS valid to clock                       | $t_{NIKHGX2}$       | $-3.0+k*T$ | —    | ns   |
| Setup time for incoming data            | $t_{NIIVKH}$        | 5.59       | —    | ns   |
| Hold time requirement for incoming data | $t_{NIIXKH}$        | 1.0        | —    | ns   |
| Output data delay                       | $t_{NIKHGX}$        | —          | 1.45 | ns   |
| Output data hold                        | $t_{NIKHGX}$        | -1.45      | —    | ns   |

Note: T: Clock period. j:  $qSPI\_FLSHCR[TCSS]$ ; k: depends  $qSPI\_FLSHCR[TCSS]$ .

This table provides the QuadSPI input and output timing in SDR mode with internal DQS ( $MCR[DQS\_EN] = 1$ , regarding to the 1st sample point).

**Table 28. SDR mode QuadSPI input and output timing**

| Parameter            | Symbol              | Min         | Max | Unit |
|----------------------|---------------------|-------------|-----|------|
| Clock rise/fall time | $T_{RISE}/T_{FALL}$ | 1           | —   | ns   |
| CS output hold time  | $t_{NIKHGX2^-}$     | $-0.45+j*T$ | —   | ns   |

Table continues on the next page...

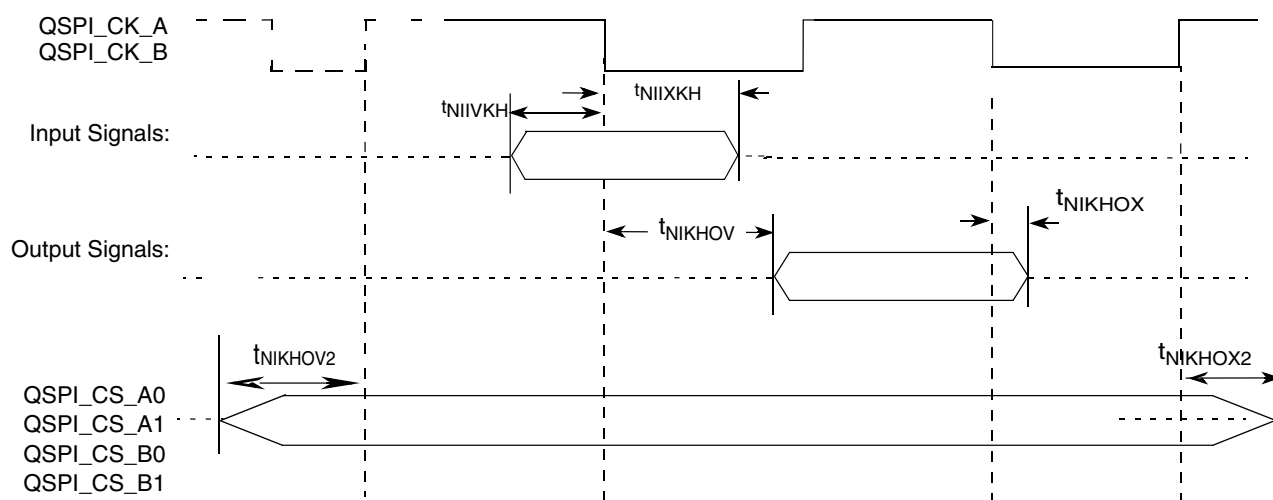
## Electrical characteristics

**Table 28. SDR mode QuadSPI input and output timing (continued)**

| Parameter                               | Symbol               | Min                                    | Max  | Unit |
|---|----------------------|--|------|------|
| CS valid to clock                       | $t_{\text{NIKHOV2}}$ | $-3.0+k*T$                             | —    | ns   |
| Setup time for incoming data            | $t_{\text{NIIVKH}}$  | $2.59-T_{\text{coars}}-T_{\text{tap}}$ | —    | ns   |
| Hold time requirement for incoming data | $t_{\text{NIIXKH}}$  | $0.01+T_{\text{coars}}+T_{\text{tap}}$ | —    | ns   |
| Output data delay                       | $t_{\text{NIKHOV}}$  | —                                      | 1.45 | ns   |
| Output data hold                        | $t_{\text{NIKHOX}}$  | -1.45                                  | —    | ns   |

Note: T: Clock period. i: depending qSPI\_SMPR[xSDLY, xSPHS]; j: qSPI\_FLSHCR[TCSSH]; k: depends qSPI\_FLSHCR[TCSS]; Ttapx: SOCCFG[7:0]/SOCCFG[23:16].

This figure shows the QuadSPI AC timing in SDR mode.

**Figure 17. QuadSPI AC timing — SDR mode****3.10.2.2 QuadSPI timing DDR mode**

This table provides the QuadSPI input and output timing in DDR mode with external DQS/delay chain (MCR[DQS\_EN] = 1, regarding to the 1st sample point.)

**Table 29. DDR mode QuadSPI input and output timing**

| Parameter            | Symbol               | Min        | Max | Unit |
|----------------------|----------------------|------------|-----|------|
| Clock rise/fall time | $T_{\text{RISE}}$    | 1          | —   | ns   |
|                      | $T_{\text{FALL}}$    |            |     |      |
| CS output hold time  | $t_{\text{NIKHOX2}}$ | $-3.3+j*T$ | —   | ns   |

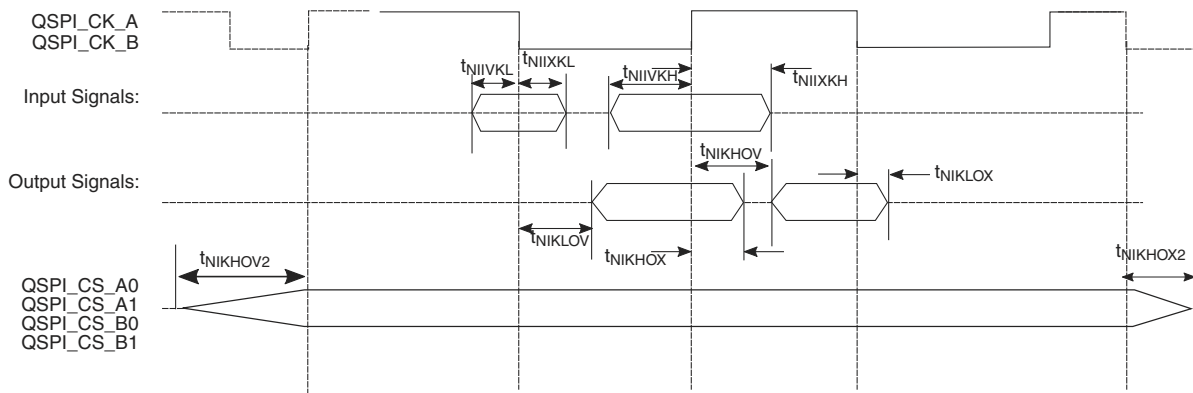
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**Table 29. DDR mode QuadSPI input and output timing (continued)**

| Parameter             | Symbol                       | Min          | Max         | Unit |
|-----------------------|------------------------------|--------------|-------------|------|
| CS valid to clock     | $t_{NIKHOV2}$                | $-3.0+k*T$   | —           | ns   |
| DQS to data skew (ns) | $t_{NIIVKH}$<br>$t_{NIIVKL}$ | -0.91        | 0.9         | ns   |
| Output Data Valid     | $t_{NIKHOV}$                 | —            | $0.9+m*T/8$ | ns   |
| Output Data Hold      | $t_{NIKHOX}$                 | $-0.9+m*T/8$ | —           | ns   |

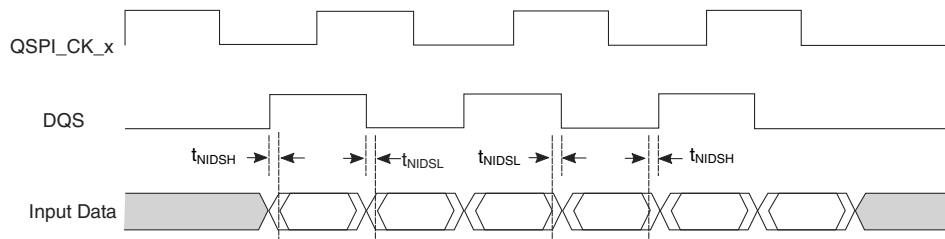
Note: T: Clock period. j: qSPI\_FLSHCR[TCSSH]; k:depends qSPI\_FLSHCR[TCSS]; m: QSPI\_FLSHCR[TDH].

This figure shows the QuadSPI AC timing in DDR mode.



**Figure 18. QuadSPI AC timing — DDR mode**

This figure shows the QuadSPI data input timing in DDR mode with an external DQS.



**Figure 19. QuadSPI input AC timing — DDR mode with an external DQS**

This figure shows the QuadSPI clock input timing diagram.

## Electrical characteristics

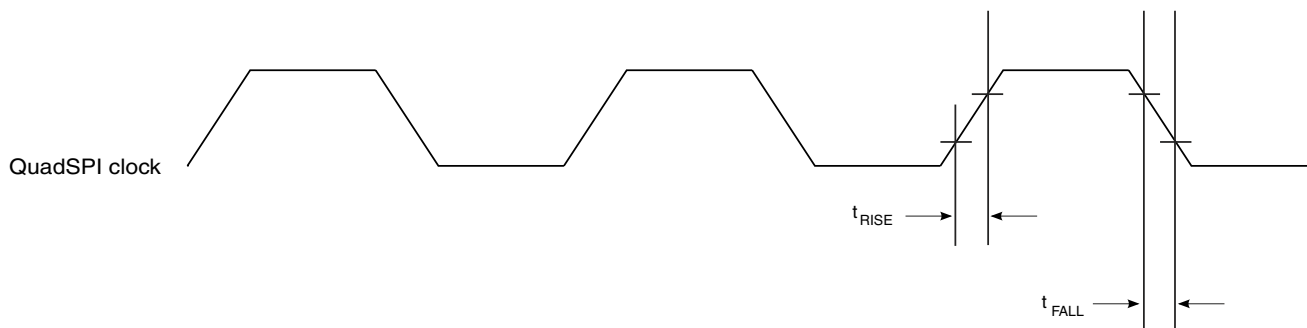


Figure 20. QuadSPI clock input timing diagram

This figure shows the AC test load for QuadSPI.

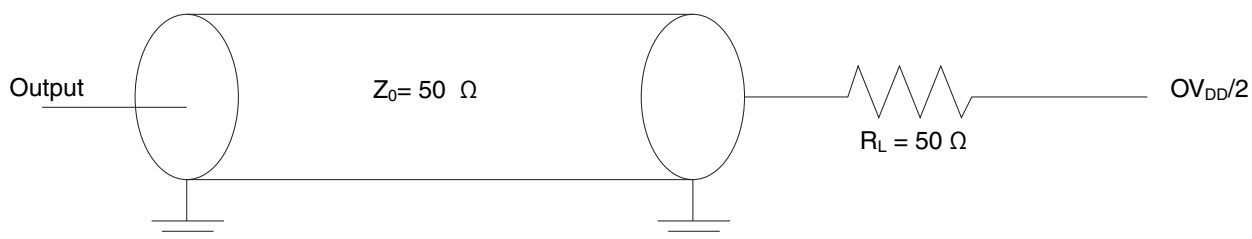


Figure 21. AC test load for QuadSPI

## 3.11 DUART interface

This section describes the DC and AC electrical specifications for the DUART interface.

### 3.11.1 DUART DC electrical characteristics

This table provides the DC electrical characteristics for the DUART interface at  $OV_{DD} = 1.8\text{ V}$ .

Table 30. DUART DC electrical characteristics(1.8 V)<sup>3</sup>

| Parameter  | Symbol   | Min  | Max      | Unit          | Notes |
|--|----------|------|----------|---------------|-------|
| Input high voltage   | $V_{IH}$ | 1.25 | —        | V             | 1     |
| Input low voltage  | $V_{IL}$ | —    | 0.6      | V             | 1     |
| Input current ( $OV_{IN} = 0\text{ V}$ or $OV_{IN} = OV_{DD}$ )            | $I_{IN}$ | —    | $\pm 50$ | $\mu\text{A}$ | 2     |
| Output high voltage ( $OV_{DD} = \text{min}$ , $I_{OH} = -0.5\text{ mA}$ ) | $V_{OH}$ | 1.35 | —        | V             | —     |
| Output low voltage ( $OV_{DD} = \text{min}$ , $I_{OL} = 0.5\text{ mA}$ )   | $V_{OL}$ | —    | 0.4      | V             | —     |

Notes:

**Table 30. DUART DC electrical characteristics(1.8 V)<sup>3</sup>**

| Parameter   | Symbol | Min | Max | Unit | Notes |
|---|--------|-----|-----|------|-------|
| 1. The min $V_{IL}$ and max $V_{IH}$ values are based on the min and max $OV_{IN}$ respective values found in <a href="#">Table 3</a> . |        |     |     |      |       |
| 2. The symbol $OV_{IN}$ represents the input voltage of the supply. It is referenced in <a href="#">Table 3</a> .                       |        |     |     |      |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a> .  |        |     |     |      |       |

### 3.11.2 DUART AC electrical specifications

This table provides the AC timing parameters for the DUART interface.

**Table 31. DUART AC timing specifications**

| Parameter  | Value                           | Unit | Notes |
|--|---------------------------------|------|-------|
| Minimum baud rate  | $f_{PLAT}/(2 \times 1,048,576)$ | baud | 1, 3  |
| Maximum baud rate  | $f_{PLAT}/(2 \times 16)$        | baud | 1, 2  |
| <b>Notes:</b>  |                                 |      |       |
| 1. $f_{PLAT}$ refers to the internal platform clock.   |                                 |      |       |
| 2. The actual attainable baud rate is limited by the latency of interrupt processing.  |                                 |      |       |
| 3. The middle of a start bit is detected as the eighth sampled 0 after the 1-to-0 transition of the start bit. Subsequent bit values are sampled each 16 <sup>th</sup> sample. |                                 |      |       |

## 3.12 Ethernet management interface 1 and 2, IEEE Std 1588<sup>TM</sup>

This section provides the AC and DC electrical characteristics for the Ethernet controller and the Ethernet management interfaces.

### 3.12.1 Ethernet management interface (EMI)

This section discusses the electrical characteristics for the EMI1 and EMI2 interfaces.

Both EMI1 and EMI2 interfaces support IEEE Std 802.3<sup>TM</sup> Clause 22 and Clause 45.

Note that both EMI1 and EMI2 are powered by 1.8V  $OV_{DD}$ , so external voltage level translators are needed to connect to PHY devices.

#### 3.12.1.1 Ethernet management interface DC electrical characteristics

The DC electrical characteristics for EMI1\_MDIO, EMI1\_MDC, EMI2\_MDIO and EMI2\_MDC are provided in this section.

## Electrical characteristics

**Table 32. Ethernet management interface DC electrical characteristics ( $OV_{DD} = 1.8\text{ V}$ )<sup>3</sup>**

| Parameters   | Symbol   | Min                | Max             | Unit          | Notes |
|--|----------|--------------------|-----------------|---------------|-------|
| Input high voltage   | $V_{IH}$ | 1.25               | —               | V             | 1     |
| Input low voltage  | $V_{IL}$ | —                  | 0.6             | V             | 1     |
| Input high current ( $V_{IN} = OV_{DD}$ )                                  | $I_{IH}$ | —                  | 50              | $\mu\text{A}$ | 2     |
| Input low current ( $V_{IN} = \text{GND}$ )                                | $I_{IL}$ | -50                | —               | $\mu\text{A}$ | —     |
| Output high voltage ( $OV_{DD} = \text{min}$ , $I_{OH} = -1.0\text{ mA}$ ) | $V_{OH}$ | 1.35               | $OV_{DD} + 0.3$ | V             | —     |
| Output low voltage ( $OV_{DD} = \text{min}$ , $I_{OL} = 1.0\text{ mA}$ )   | $V_{OL}$ | $\text{GND} - 0.3$ | 0.40            | V             | —     |

**Notes:**

1. The min  $V_{IL}$  and max  $V_{IH}$  values are based on the respective min and max  $OV_{IN}$  values found in [Table 3](#).
2. The symbol  $V_{IN}$ , in this case, represents the  $OV_{IN}$  symbol referenced in [Table 3](#).
3. For recommended operating conditions, see [Table 3](#).

**3.12.1.2 Ethernet management interface AC electrical specifications**

This table provides the Ethernet management interface AC timing specifications.

**Table 33. Ethernet management interface AC timing specifications<sup>4</sup>**

| Parameter/Condition        | Symbol <sup>1</sup> | Min              | Typ | Max              | Unit | Notes |
|----------------------------|---------------------|------------------|-----|------------------|------|-------|
| MDC frequency              | $f_{MDC}$           | —                | —   | 5                | MHz  | 2     |
| MDC clock pulse width high | $t_{MDCH}$          | 80               | —   | —                | ns   | —     |
| MDC to MDIO delay          | $t_{MDKHDX}$        | $V - 3\text{ns}$ | —   | $V + 3\text{ns}$ | ns   | 3     |
| MDIO to MDC setup time     | $t_{MDDVKH}$        | 8                | —   | —                | ns   | —     |
| MDIO to MDC hold time      | $t_{MDDXKH}$        | 0                | —   | —                | ns   | —     |

**Notes:**

1. The symbols used for timing specifications follow the pattern of  $t_{(\text{first two letters of functional block})(\text{signal})(\text{state})(\text{reference})(\text{state})}$  for inputs and  $t_{(\text{first two letters of functional block})(\text{reference})(\text{state})(\text{signal})(\text{state})}$  for outputs. For example,  $t_{MDKHDX}$  symbolizes management data timing (MD) for the time  $t_{MDC}$  from clock reference (K) high (H) until data outputs (D) are invalid (X) or data hold time. Also,  $t_{MDDVKH}$  symbolizes management data timing (MD) with respect to the time data input signals (D) reach the valid state (V) relative to the  $t_{MDC}$  clock reference (K) going to the high (H) state or setup time.
2. This parameter is dependent on the Ethernet clock frequency (MDIO\_CFG [MDIO\_CLK\_DIV] field determines the clock frequency of the MgmtClk Clock EC\_MDC).
3. MDIO timing is configurable by programming MDIO\_CFG. V value is determined by MDIO\_CFG[NEG], MDIO\_CFG[MDIO\_HOLD] and MDIO[EHOL]. The easiest way is to program NEG=1, then MDIO is driven at negative edge of MDC, satisfying both setup and hold time requirement of Ethernet PHY. If using MDIO\_HOLD/EHOL to control the timing,  $\text{enet\_clk}$  in the manual is equal to platform clock speed. See *Data Path Acceleration Architecture, Second Generation (DPAA2) Hardware Reference Manual*.
4. For recommended operating conditions, see [Table 3](#).

**3.12.2 IEEE 1588 electrical specifications**

### 3.12.2.1 IEEE 1588 DC Electrical Characteristics

This table shows IEEE 1588 DC electrical characteristics when operating at  $OV_{DD} = 1.8$  V supply.

**Table 34. IEEE 1588 DC electrical characteristics ( $OV_{DD} = 1.8$  V)<sup>3</sup>**

| Parameters   | Symbol   | Min       | Max             | Unit    | Notes |
|--|----------|-----------|-----------------|---------|-------|
| Input high voltage   | $V_{IH}$ | 1.25      | —               | V       | 1     |
| Input low voltage  | $V_{IL}$ | —         | 0.6             | V       | 1     |
| Input current ( $OV_{IN} = 0$ V or $OV_{IN} = OV_{DD}$ )           | $I_{IH}$ | —         | $\pm 50$        | $\mu A$ | 2     |
| Output high voltage ( $OV_{DD} = \text{min}$ , $I_{OH} = -0.5$ mA) | $V_{OH}$ | 1.35      | $OV_{DD} + 0.3$ | V       | —     |
| Output low voltage ( $OV_{DD} = \text{min}$ , $I_{OL} = 0.5$ mA)   | $V_{OL}$ | GND - 0.3 | 0.40            | V       | —     |

1. The min  $V_{IL}$  and max  $V_{IH}$  values are based on the respective min and max  $OV_{IN}$  values found in [Table 3](#).  
2. The symbol  $OV_{IN}$ , in this case, represents the  $OV_{IN}$  symbol referenced in [Table 3](#).  
3. For recommended operating conditions, see [Table 3](#).

### 3.12.2.2 IEEE 1588 AC specifications

This table provides the IEEE 1588 AC timing specifications.

**Table 35. IEEE 1588 AC timing specifications<sup>2</sup>**

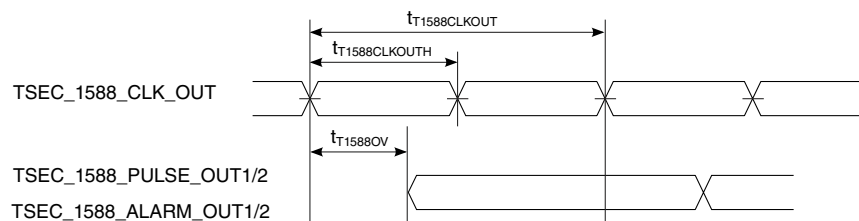
| Parameter/Condition                               | Symbol                                  | Min                     | Typ | Max | Unit | Notes |
|---|---|-------------------------|-----|-----|------|-------|
| TSEC_1588_CLK_IN clock period                     | $t_{T1588CLK}$                          | 6.0                     | —   | —   | ns   | —     |
| TSEC_1588_CLK_IN duty cycle                       | $t_{T1588CLKH}/$<br>$t_{T1588CLK}$      | 40                      | 50  | 60  | %    | —     |
| TSEC_1588_CLK_IN peak-to-peak jitter              | $t_{T1588CLKINJ}$                       | —                       | —   | 250 | ps   | —     |
| Rise time TSEC_1588_CLK_IN (20% -80%)             | $t_{T1588CLKINR}$                       | 1.0                     | —   | 2.0 | ns   | —     |
| Fall time TSEC_1588_CLK_IN (80% -20%)             | $t_{T1588CLKINF}$                       | 1.0                     | —   | 2.0 | ns   | —     |
| TSEC_1588_CLK_OUT clock period                    | $t_{T1588CLKOUT}$                       | $2 \times t_{T1588CLK}$ | —   | —   | ns   | —     |
| TSEC_1588_CLK_OUT duty cycle                      | $t_{T1588CLKOTH}/$<br>$t_{T1588CLKOUT}$ | 30                      | 50  | 70  | %    | —     |
| TSEC_1588_PULSE_OUT1/2,<br>TSEC_1588_ALARM_OUT1/2 | $t_{T1588OV}$                           | 0.5                     | —   | 4.0 | ns   | —     |
| TSEC_1588_TRIG_IN1/2 pulse width                  | $t_{T1588TRIGH}$                        | $2 \times t_{T1588CLK}$ | —   | —   | ns   | 1     |

**Notes:**

1. It needs to be at least two times the clock period of the clock selected by TMR\_CTRL[CKSEL]. See the chip reference manual for a description of TMR\_CTRL registers.  
2. For recommended operating conditions, see [Table 3](#).

This figure shows the data and command output AC timing diagram.

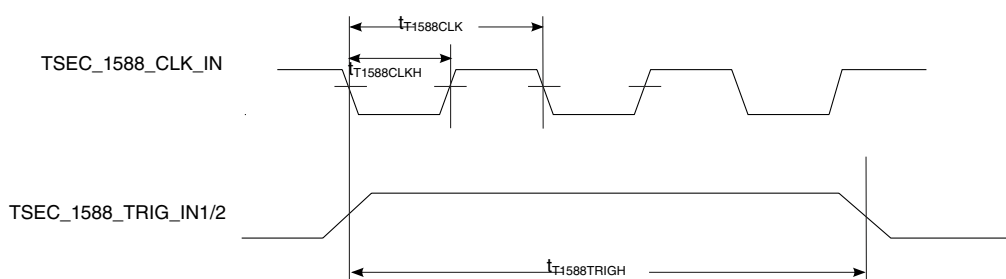
## Electrical characteristics



**Note:** The output delay is counted starting at the rising edge if  $t_{T1588CLKOUT}$  is non-inverting. Otherwise, it is counted starting at the falling edge.

**Figure 22. IEEE 1588 output AC timing**

This figure shows the data and command input AC timing diagram.



**Figure 23. IEEE 1588 input AC timing**

## 3.13 USB 2.0 interface

This section provides the AC and DC electrical specifications for the USB 2.0 interface.

### 3.13.1 USB 2.0 DC electrical characteristics

This table provides the DC electrical characteristics for the USB 2.0 interface at  $USB\_HV_{DD} = 3.3\text{ V}$ .

**Table 36. USB 2.0 DC electrical characteristics ( $USB\_HV_{DD} = 3.3\text{ V}$ )<sup>3</sup>**

| Parameter  | Symbol   | Min | Max      | Unit          | Notes |
|--|----------|-----|----------|---------------|-------|
| Input high voltage   | $V_{IH}$ | 2.0 | -        | V             | 1     |
| Input low voltage  | $V_{IL}$ | -   | 0.8      | V             | 1     |
| Input current ( $USB\_HV_{IN} = 0\text{ V}$ or $USB\_HV_{IN} = USB\_HV_{DD}$ ) | $I_{IN}$ | -   | $\pm 50$ | $\mu\text{A}$ | 2     |
| Output high voltage ( $USB\_HV_{DD} = \text{min}$ , $I_{OH} = -2\text{ mA}$ )  | $V_{OH}$ | 2.8 | -        | V             | -     |
| Output low voltage ( $USB\_HV_{DD} = \text{min}$ , $I_{OL} = 2\text{ mA}$ )    | $V_{OL}$ | -   | 0.3      | V             | -     |

**Notes:**

**Table 36. USB 2.0 DC electrical characteristics (USB\_HV<sub>DD</sub> = 3.3 V)<sup>3</sup>**

| Parameter  | Symbol | Min | Max | Unit | Notes |
|--|--------|-----|-----|------|-------|
| 1. The min V <sub>IL</sub> and max V <sub>IH</sub> values are based on the respective min and max USB_HV <sub>IN</sub> values found in <a href="#">Table 3</a> . |        |     |     |      |       |
| 2. The symbol USB_HV <sub>IN</sub> , in this case, represents the USB_HV <sub>IN</sub> symbol referenced in <a href="#">Table 3</a>                              |        |     |     |      |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a>   |        |     |     |      |       |

### 3.13.2 USB 2.0 AC timing specifications

This section describes the AC timing specifications for the on-chip USB PHY. See Chapter 7 in the *Universal Serial Bus Revision 2.0 Specification* for more information.

## 3.14 USB 3.0 interface

This section describes the DC and AC electrical specifications for the USB 3.0 interface.

### 3.14.1 USB 3.0 DC electrical characteristics

This table provides the USB 3.0 transmitter (Tx) DC electrical characteristics at package pins.

**Table 37. USB 3.0 transmitter DC electrical characteristics<sup>1</sup>**

| Characteristic                                    | Symbol                                 | Min | Typ  | Max  | Unit              |
|---|--|-----|------|------|-------------------|
| Differential output voltage                       | V <sub>tx-diff-pp</sub>                | 800 | 1000 | 1200 | mV <sub>p-p</sub> |
| Low power differential output voltage             | V <sub>tx-diff-pp-low</sub>            | 400 | —    | 1200 | mV <sub>p-p</sub> |
| Transmitter de-emphasis                           | V <sub>tx-de-ratio</sub>               | 3   | —    | 4    | dB                |
| Differential impedance                            | Z <sub>diffTX</sub>                    | 72  | 100  | 120  | Ω                 |
| Transmitter common mode impedance                 | R <sub>TX-DC</sub>                     | 18  | —    | 30   | Ω                 |
| Absolute DC common mode voltage between U1 and U0 | T <sub>TX-CM-DC-ACTIVEIDLE-DELTA</sub> | —   | —    | 200  | mV                |
| DC electrical idle differential output voltage    | V <sub>TX-IDLE-DIFF-DC</sub>           | 0   | —    | 10   | mV                |

**Note:**

1. For recommended operating conditions, see [Table 3](#).

This table provides the USB 3.0 receiver DC electrical characteristics at the receive package pins.

## Electrical characteristics

**Table 38. USB 3.0 receiver DC electrical characteristics**

| Characteristic   | Symbol                             | Min  | Typ | Max | Unit | Notes |
|--|------------------------------------|------|-----|-----|------|-------|
| Differential receiver input impedance                            | R <sub>RX-DIFF-DC</sub>            | 72   | 100 | 120 | Ω    | —     |
| Receiver DC common mode impedance                                | R <sub>RX-DC</sub>                 | 18   | —   | 30  | Ω    | —     |
| DC input CM input impedance for V > 0 during reset or power down | Z <sub>RX-HIGH-IMP-DC</sub>        | 25 K | —   | —   | Ω    | —     |
| LFPS detect threshold  | V <sub>RX-IDLE-DET-DC-DIFFpp</sub> | 100  | —   | 300 | mV   | 1     |

**Note:**

- Below the minimum is noise. Must wake up above the maximum.

**3.14.2 USB 3.0 AC timing specifications**

This table provides the USB 3.0 transmitter AC timing specifications at package pins.

**Table 39. USB 3.0 transmitter AC timing specifications<sup>1</sup>**

| Parameter             | Symbol                | Min    | Typ | Max    | Unit | Notes |
|-----------------------|-----------------------|--------|-----|--------|------|-------|
| Speed                 | —                     | —      | 5.0 | —      | Gb/s | —     |
| Transmitter eye       | t <sub>TX-Eye</sub>   | 0.625  | —   | —      | UI   | —     |
| Unit interval         | UI                    | 199.94 | —   | 200.06 | ps   | 2     |
| AC coupling capacitor | AC coupling capacitor | 75     | —   | 200    | nF   | —     |

**Note:**

- For recommended operating conditions, see [Table 3](#).
- UI does not account for SSC-caused variations.

This table provides the USB 3.0 receiver AC timing specifications at receive package pins.

**Table 40. USB 3.0 receiver AC timing specifications<sup>1</sup>**

| Parameter     | Symbol | Min    | Typ | Max    | Unit | Notes |
|---------------|--------|--------|-----|--------|------|-------|
| Unit interval | UI     | 199.94 | —   | 200.06 | ps   | 2     |

**Notes:**

- For recommended operating conditions, see [Table 3](#).
- UI does not account for SSC-caused variations.

### 3.14.3 USB 3.0 LFPS specifications

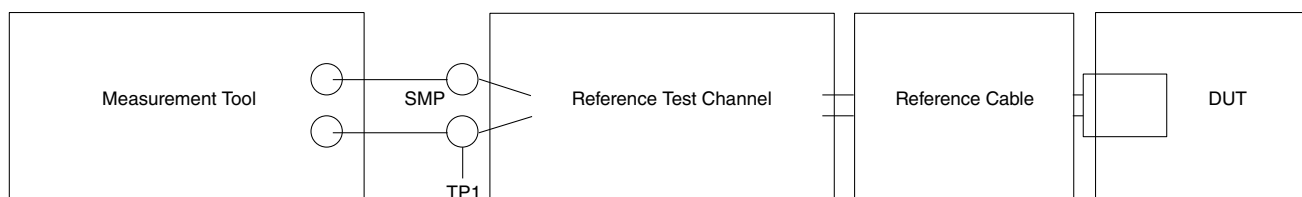
This table provides the key LFPS electrical specifications at the transmitter.

**Table 41. LFPS electrical specifications at the transmitter**

| Parameter                                     | Symbol                   | Min | Typ | Max  | Unit | Notes |
|---|--------------------------|-----|-----|------|------|-------|
| Period  | tPeriod                  | 20  | —   | 100  | ns   | —     |
| Peak-to-peak differential amplitude           | $V_{TX-DIFF-PP-LFPS}$    | 800 | —   | 1200 | mV   | —     |
| Low-power peak-to-peak differential amplitude | $V_{TX-DIFF-PP-LFPS-LP}$ | 400 | —   | 600  | mV   | —     |
| Rise/fall time                                | $t_{RiseFall2080}$       | —   | —   | 4    | ns   | 1     |
| Duty cycle                                    | Duty cycle               | 40  | —   | 60   | %    | 1     |

**Note:**  
1. Measured at compliance TP1. See [Figure 24](#) for details.

This figure shows the transmitter normative setup with reference channel as per USB 3.0 specifications.



**Figure 24. Transmitter normative setup**

## 3.15 Integrated flash controller

This section describes the DC and AC electrical specifications for the integrated flash controller.

### 3.15.1 Integrated flash controller DC electrical characteristics

This table provides the DC electrical characteristics for the integrated flash controller when operating at  $OV_{DD} = 1.8\text{ V}$ .

**Table 42. Integrated flash controller DC electrical characteristics ( $OV_{DD} = 1.8\text{ V}$ )<sup>3</sup>**

| Parameter          | Symbol   | Min | Max | Unit | Note |
|--------------------|----------|-----|-----|------|------|
| Input high voltage | $V_{IH}$ | 1.2 | -   | V    | 1    |
| Input low voltage  | $V_{IL}$ | -   | 0.6 | V    | 1    |

Table continues on the next page...

## Electrical characteristics

**Table 42. Integrated flash controller DC electrical characteristics ( $OV_{DD} = 1.8\text{ V}$ )<sup>3</sup> (continued)**

| Parameter   | Symbol   | Min | Max      | Unit          | Note |
|---|----------|-----|----------|---------------|------|
| Input current<br>( $V_{IN} = 0\text{ V}$ or $V_{IN} = OV_{DD}$ )              | $I_{IN}$ | -   | $\pm 50$ | $\mu\text{A}$ | 2    |
| Output high voltage<br>( $OV_{DD} = \text{min}$ , $I_{OH} = -0.5\text{ mA}$ ) | $V_{OH}$ | 1.6 | -        | V             | -    |
| Output low voltage<br>( $OV_{DD} = \text{min}$ , $I_{OL} = 0.5\text{ mA}$ )   | $V_{OL}$ | -   | 0.32     | V             | -    |

**NOTE:**

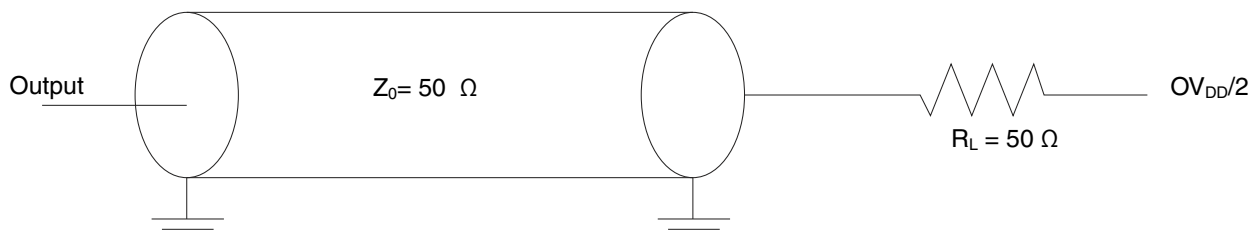
1. The min  $V_{IL}$  and max  $V_{IH}$  values are based on the respective min and max  $OV_{IN}$  values found in [Table 3](#).
2. The symbol  $V_{IN}$ , in this case, represents the  $OV_{IN}$  symbol referenced in [Table 3](#).
3. For recommended operating conditions, see [Table 3](#).

### 3.15.2 Integrated flash controller AC timing specifications

This section describes the AC timing specifications for the integrated flash controller.

#### 3.15.2.1 Test Condition

This figure provides the AC test load for the integrated flash controller.



**Figure 25. Integrated Flash Controller AC Test Load**

#### 3.15.2.2 IFC AC timing specifications (GPCM/GASIC)

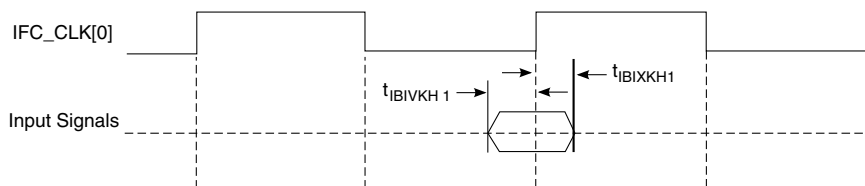
This table describes the input AC timing specifications of the IFC-GPCM and IFC-GASIC interface.

**Table 43. Integrated flash controller input timing specifications for GPCM and GASIC mode ( $OV_{DD} = 1.8\text{ V}$ )<sup>1</sup>**

| Parameter   | Symbol       | Min | Max | Unit | Notes |
|-------------|--------------|-----|-----|------|-------|
| Input setup | $t_{BIVKH1}$ | 4   | -   | ns   | -     |
| Input hold  | $t_{BIXKH1}$ | 1   | -   | ns   | -     |

**NOTE:**  
1. For recommended operating conditions, see [Table 3](#).

This figure shows the input AC timing diagram for IFC-GPCM, IFC-GASIC interface.

**Figure 26. IFC-GPCM, IFC-GASIC input AC timings**

This table describes the output AC timing specifications of IFC-GPCM and IFC-GASIC interface.

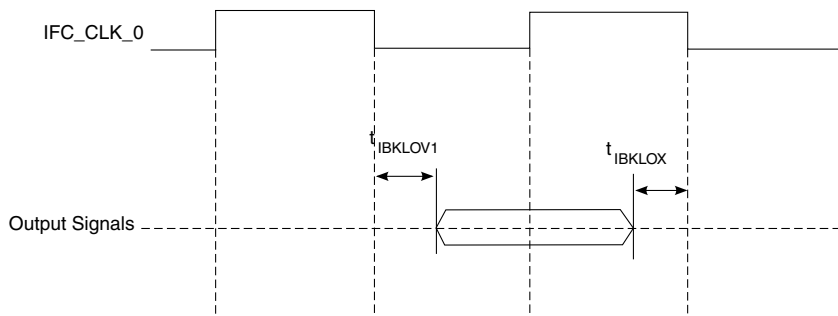
**Table 44. Integrated flash controller IFC-GPCM and IFC-GASIC interface output timing specifications ( $OV_{DD} = 1.8\text{ V}$ )<sup>2</sup>**

| Parameter                     | Symbol           | Min | Max      | Unit | Notes |
|-------------------------------|------------------|-----|----------|------|-------|
| IFC_CLK cycle time            | $t_{BK}$         | 10  | -        | ns   | -     |
| IFC_CLK duty cycle            | $t_{BKH}/t_{BK}$ | 45  | 55       | %    | -     |
| Output delay                  | $t_{BKLOV1}$     | -   | 1.59     | ns   | -     |
| Output hold                   | $t_{BKLOX}$      | -   | -2       | ns   | 1     |
| IFC_CLK[0] to IFC_CLK[m] skew | $t_{BKSKEW}$     | 0   | $\pm 75$ | ps   | -     |

**NOTE:**  
1. Output hold is negative. This means that output transition happens earlier than the falling edge of IFC\_CLK.  
2. For recommended operating conditions, see [Table 3](#).

This figure shows the output AC timing diagram for IFC-GPCM, IFC-GASIC interface.

## Electrical characteristics



**Figure 27. IFC-GPCM, IFC-GASIC signals**

### 3.15.2.3 IFC AC timing specifications (NOR)

This table describes the input timing specifications of the IFC-NOR interface.

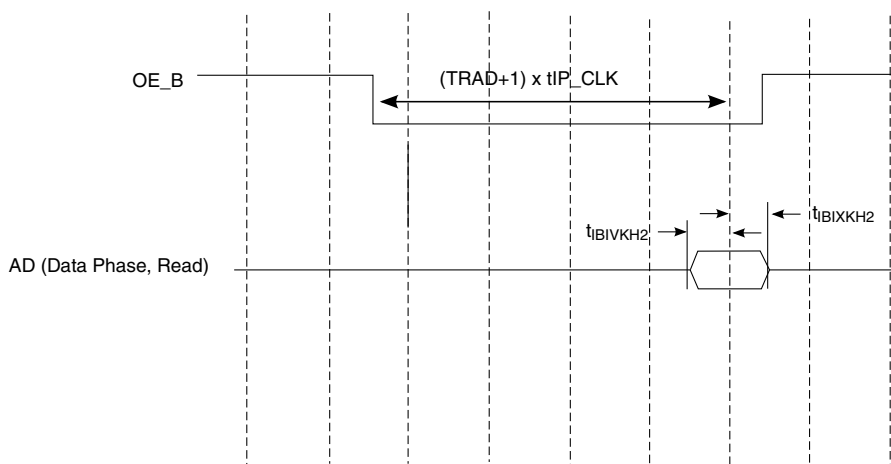
**Table 45. Integrated Flash Controller input timing specifications for NOR mode ( $OV_{DD} = 1.8 V$ )<sup>2</sup>**

| Parameter   | Symbol        | Min                          | Max | Unit | Notes |
|-------------|---------------|------------------------------|-----|------|-------|
| Input setup | $t_{IBIVKH2}$ | $(2 \times t_{IP\_CLK}) + 2$ | —   | ns   | 1     |
| Input hold  | $t_{IBIXKH2}$ | $(1 \times t_{IP\_CLK}) + 1$ | —   | ns   | 1     |

**Notes:**

- $t_{IP\_CLK}$  is the period of ip clock (not the IFC\_CLK) on which IFC is running.
- For recommended operating conditions, see [Table 3](#).
- The NOR flash state machine will de-assert OE\_B once the flash controller samples data. Hold time given in the datasheet  $t_{IBIXKH2}$  is not a requirement for customer but rather an information used internally for test purpose.

This figure shows the AC input timing diagram for input signals of IFC-NOR interface. Here TRAD is a programmable delay parameter. See the IFC section of the reference manual for more information.



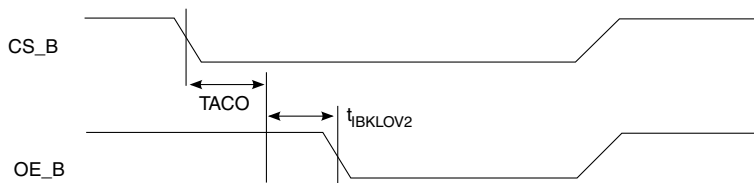
**Figure 28. IFC-NOR Interface input AC timings**

This table describes the output AC timing specifications of IFC-NOR interface.

**Table 46. Integrated Flash Controller IFC-NOR interface output timing specifications ( $OV_{DD} = 1.8 V$ )<sup>2</sup>**

| Parameter   | Symbol        | Min | Max       | Unit | Notes |
|---|---------------|-----|-----------|------|-------|
| Output delay  | $t_{IBKLOV2}$ | —   | $\pm 1.5$ | ns   | 1     |
| <b>Notes:</b>   |               |     |           |      |       |
| 1. This effectively means that a signal change may appear anywhere within $\pm t_{IBKLOV2}$ (max) duration, from the point where it's expected to change. |               |     |           |      |       |
| 2. For recommended operating conditions, see <a href="#">Table 3</a> .  |               |     |           |      |       |

This figure shows the AC timing diagram for output signals of IFC-NOR interface. The timing specs have been illustrated here by taking timings between two signals, CS\_B and OE\_B as an example. In a read operation, OE\_B is supposed to change TACO (a programmable delay, see the IFC section of the reference manual for more information) time after CS\_B. Because of skew between the signals, OE\_B may change anywhere within the time window defined by  $t_{IBKLOV2}$ . This concept applies to other output signals of IFC-NOR interface, as well. The figure is an example to show the skew between any two chronological toggling signals as per the protocol. Here is the list of IFC-NOR output signals: NRALE, NRAVD\_B, NRWE\_B, NROE\_B, CS\_B, AD(Address phase).



**Figure 29. IFC-NOR interface output AC timings**

## Electrical characteristics

## 3.15.2.4 IFC AC timing specifications (NAND)

This table describes the input timing specifications of the IFC-NAND interface.

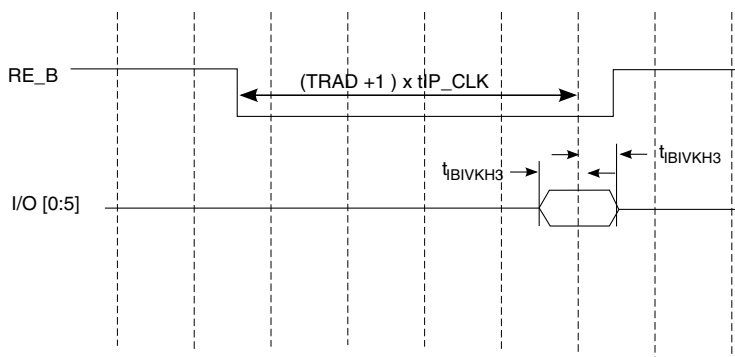
**Table 47. Integrated flash controller input timing specifications for NAND mode ( $V_{DD} = 1.8 V$ )<sup>2</sup>**

| Parameter            | Symbol        | Min                          | Max | Unit          | Notes |
|----------------------|---------------|------------------------------|-----|---------------|-------|
| Input setup          | $t_{IBIVKH3}$ | $(2 \times t_{IP\_CLK}) + 2$ | -   | ns            | 1     |
| Input hold           | $t_{BIXKH3}$  | 1                            | -   | ns            | 1     |
| IFC_RB_B pulse width | $t_{IBCH}$    | 2                            | -   | $t_{IP\_CLK}$ | 1     |

**NOTE:**

- $t_{IP\_CLK}$  is the period of IP clock on which the IFC is running.
- For recommended operating conditions, see [Table 3](#).

This figure shows the AC input timing diagram for IFC-NAND interface input signals. Note that TRAD is a programmable delay parameter. See the IFC section of the chip reference manual for more information.



**Figure 30. IFC-NAND interface input AC timing diagram**

**NOTE**

$t_{IP\_CLK}$  is the period of the IP clock (not the IFC\_CLK) on which the IFC is running.

This table describes the output AC timing specifications for the IFC-NAND interface.

**Table 48. Integrated flash controller IFC-NAND interface output timing specifications ( $V_{DD} = 1.8 V$ )<sup>2</sup>**

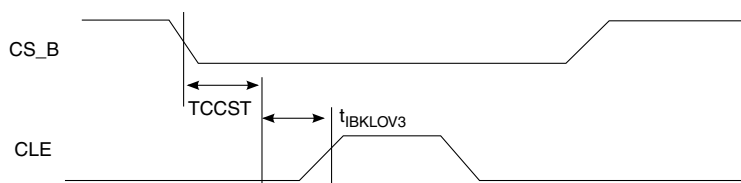
| Parameter    | Symbol        | Min | Max        | Unit | Notes |
|--------------|---------------|-----|------------|------|-------|
| Output delay | $t_{IBKLOV3}$ | -   | $\pm 1.55$ | ns   | 1     |

**NOTE:**

**Table 48. Integrated flash controller IFC-NAND interface output timing specifications ( $V_{DD} = 1.8\text{ V}$ )<sup>2</sup>**

| Parameter   | Symbol | Min | Max | Unit | Notes |
|---|--------|-----|-----|------|-------|
| 1. This effectively means that a signal change may appear anywhere within $t_{IBKLOV3}$ (min) to $t_{IBKLOV3}$ (max) duration, from the point where it is expected to change. |        |     |     |      |       |
| 2. For recommended operating conditions, see <a href="#">Table 3</a> .  |        |     |     |      |       |

This figure shows the AC timing diagram for output signals of the IFC-NAND interface. The timing specifications illustrated here are derived by taking timings between two signals, for example, CS\_B and CLE. CLE is expected to change TCCST (a programmable delay) time after CS\_B. For more information, see the IFC section of the chip reference manual. Because of skew between the signals, CLE may change anywhere within the time window defined by  $t_{IBKLOV3}$ . This concept applies to other output signals of the IFC-NAND interface as well. The diagram is an example that shows the skew between any two chronological toggling signals, as per the protocol. The list of output signals is as follows: NDWE\_B, NDRE\_B, NDALE, WP\_B, NDCLE, CS\_B, and AD.

**Figure 31. IFC-NAND interface output AC timing diagram**

### 3.15.2.5 IFC-NAND SDR AC timing specifications

This table describes the AC timing specifications for the IFC-NAND SDR interface. These specifications are compliant with the SDR mode for ONFI specification revision 3.0.

**Table 49. Integrated flash controller IFC-NAND SDR interface AC timing specifications ( $OV_{DD} = 1.8\text{ V}$ )**

| Parameter                          | Symbol | I/O | Min             | Max             | Unit                | Fig                       |
|------------------------------------|--------|-----|-----------------|-----------------|---------------------|---------------------------|
| Address cycle to data loading time | tADL   | O   | TADLE - 1.5(ns) | TADLE + 1.5(ns) | t <sub>IP_CLK</sub> | <a href="#">Figure 32</a> |
| ALE hold time                      | tALH   | O   | TWCHT - 1.5(ns) | TWCHT + 1.5(ns) | t <sub>IP_CLK</sub> | <a href="#">Figure 34</a> |
| ALE setup time                     | tALS   | O   | TWP - 1.5(ns)   | TWP + 1.5(ns)   | t <sub>IP_CLK</sub> | <a href="#">Figure 34</a> |

Table continues on the next page...

## Electrical characteristics

**Table 49. Integrated flash controller IFC-NAND SDR interface AC timing specifications (OV<sub>DD</sub> = 1.8 V) (continued)**

| Parameter   | Symbol          | I/O | Min                  | Max                  | Unit                | Fig       |
|---|-----------------|-----|----------------------|----------------------|---------------------|-----------|
| ALE to RE_n delay   | tAR             | O   | TWHRE - 1.5(ns)      | TWHRE + 1.5(ns)      | t <sub>IP_CLK</sub> | Figure 35 |
| CE_n hold time  | tCH             | O   | 5 + 1.5(ns)          | -                    | ns                  | Figure 33 |
| CE_n high to input hi-Z   | tCHZ            | I   | TRHZ - 1.5(ns)       | TRHZ + 1.5(ns)       | t <sub>IP_CLK</sub> | Figure 36 |
| CLE hold time   | tCLH            | O   | TWCHT - 1.5(ns)      | TWCHT + 1.5(ns)      | t <sub>IP_CLK</sub> | Figure 34 |
| CLE to RE_n delay   | tCLR            | O   | TWHRE - 1.5(ns)      | TWHRE - 1.5(ns)      | t <sub>IP_CLK</sub> | Figure 37 |
| CLE setup time  | tCLS            | O   | TWP - 1.5(ns)        | TWP + 1.5(ns)        | t <sub>IP_CLK</sub> | Figure 34 |
| CE_n high to input hold   | tCOH            | I   | 150 - 1.5(ns)        | -                    | ns                  | Figure 36 |
| CE_n setup time   | tCS             | O   | TCS - 1.5(ns)        | TCS + 1.5(ns)        | t <sub>IP_CLK</sub> | Figure 34 |
| Data hold time  | tDH             | O   | TWCHT - 1.5(ns)      | TWCHT + 1.5(ns)      | t <sub>IP_CLK</sub> | Figure 34 |
| Data setup time   | tDS             | O   | TWP - 1.5(ns)        | TWP + 1.5(ns)        | t <sub>IP_CLK</sub> | Figure 34 |
| Busy time for Set Features and Get Features   | tFEAT           | O   | -                    | FTOCNT               | t <sub>IP_CLK</sub> | Figure 38 |
| Output hi-Z to RE_n low   | tIR             | O   | TWHRE - 1.5(ns)      | TWHRE + 1.5(ns)      | t <sub>IP_CLK</sub> | Figure 39 |
| Interface and Timing Mode Change time   | tITC            | O   | -                    | FTOCNT               | t <sub>IP_CLK</sub> | Figure 38 |
| RE_n cycle time   | tRC             | O   | TRP + TREH - 1.5(ns) | TRP + TREH + 1.5(ns) | t <sub>IP_CLK</sub> | Figure 36 |
| RE_n access time  | tREA            | I   | -                    | (TRAD - 1) + 2(ns)   | t <sub>IP_CLK</sub> | Figure 36 |
| RE_n high hold time   | tREH            | I   | TREH                 | TREH                 | t <sub>IP_CLK</sub> | Figure 36 |
| RE_n high to input hold   | tRHOH           | I   | 0                    | -                    | ns                  | Figure 36 |
| RE_n high to WE_n low   | tRHW            | O   | 100 + 1.5(ns)        | -                    | ns                  | Figure 40 |
| RE_n high to input hi-Z   | tRHZ            | I   | TRHZ - 1.5(ns)       | TRHZ + 1.5(ns)       | t <sub>IP_CLK</sub> | Figure 36 |
| RE_n low to input data hold   | tRLOH           | I   | 0                    | -                    | ns                  | Figure 41 |
| RE_n pulse width  | tRP             | O   | TRP                  | TRP                  | t <sub>IP_CLK</sub> | Figure 36 |
| Ready to data input cycle (data only)   | tRR             | O   | TRR - 1.5(ns)        | TRR + 1.5(ns)        | t <sub>IP_CLK</sub> | Figure 36 |
| Device reset time, measured from the falling edge of R/B_n to the rising edge of R/B_n. | tRST (raw NAND) | O   | -                    | FTOCNT               | t <sub>IP_CLK</sub> | Figure 42 |
| Device reset time, measured from the falling edge of R/B_n to the rising edge of R/B_n. | tRST2 (EZ NAND) | O   | -                    | FTOCNT               | t <sub>IP_CLK</sub> | Figure 42 |
| (WE_n high or CLK rising edge) to SR[6] low   | tWB             | O   | TWBE + TWH - 1.5(ns) | TWBE + TWH + 1.5(ns) | t <sub>IP_CLK</sub> | Figure 34 |
| WE_n cycle time   | tWC             | O   | TWP + TWH            | TWP + TWH            | t <sub>IP_CLK</sub> | Figure 43 |
| WE_n high hold time   | tWH             | O   | TWH                  | TWH                  | t <sub>IP_CLK</sub> | Figure 43 |

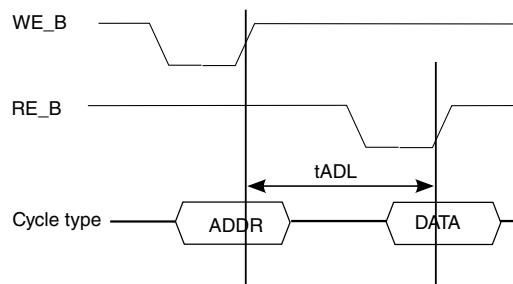
Table continues on the next page...

**Table 49. Integrated flash controller IFC-NAND SDR interface AC timing specifications (OV<sub>DD</sub> = 1.8 V) (continued)**

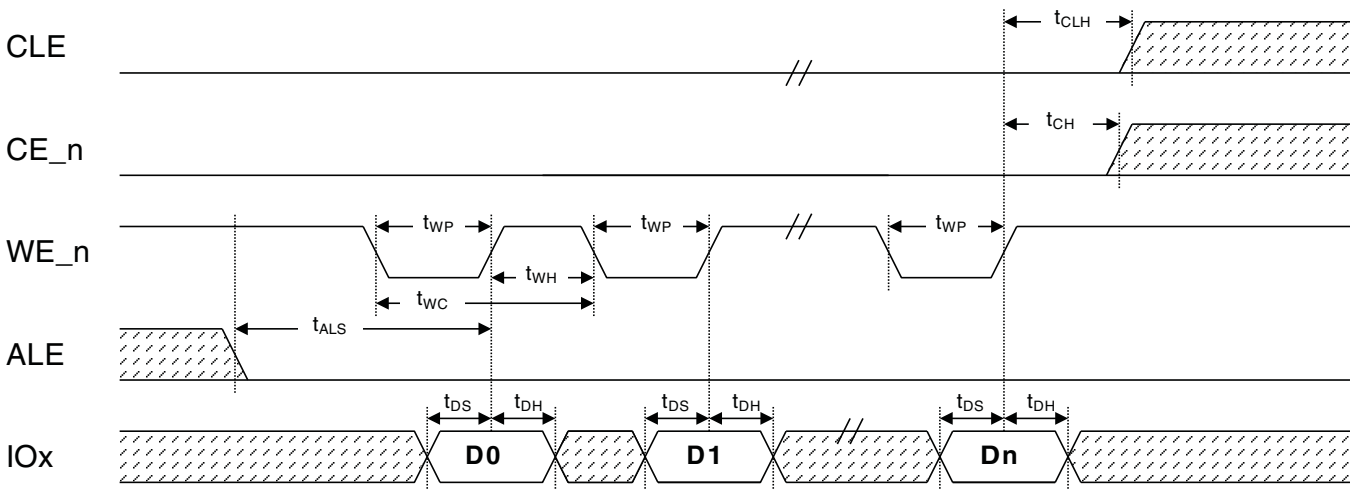
| Parameter  | Symbol   | I/O | Min                   | Max                   | Unit                | Fig       |
|--|----------|-----|-----------------------|-----------------------|---------------------|-----------|
| Command, address, or data input cycle to data output cycle | tWHR     | O   | TWHRE + TWH - 1.5(ns) | TWHRE + TWH + 1.5(ns) | t <sub>IP_CLK</sub> | Figure 44 |
| WE_n pulse width   | tWP      | O   | TWP                   | TWP                   | t <sub>IP_CLK</sub> | Figure 34 |
| WP_n transition to command cycle                           | tWW      | O   | TWW - 1.5(ns)         | TWW + 1.5(ns)         | t <sub>IP_CLK</sub> | Figure 45 |
| Data Input hold  | tIBIXKH4 | I   | 1                     | -                     | t <sub>IP_CLK</sub> | Figure 46 |

**NOTE:**

- t<sub>IP\_CLK</sub> is the clock period of IP clock (on which IFC IP is running). Note that that the IFC IP clock doesn't come out of device.
- For the definition of parameters (like TADL) mentioned in min/max columns check the IFC section of the device's reference manual.

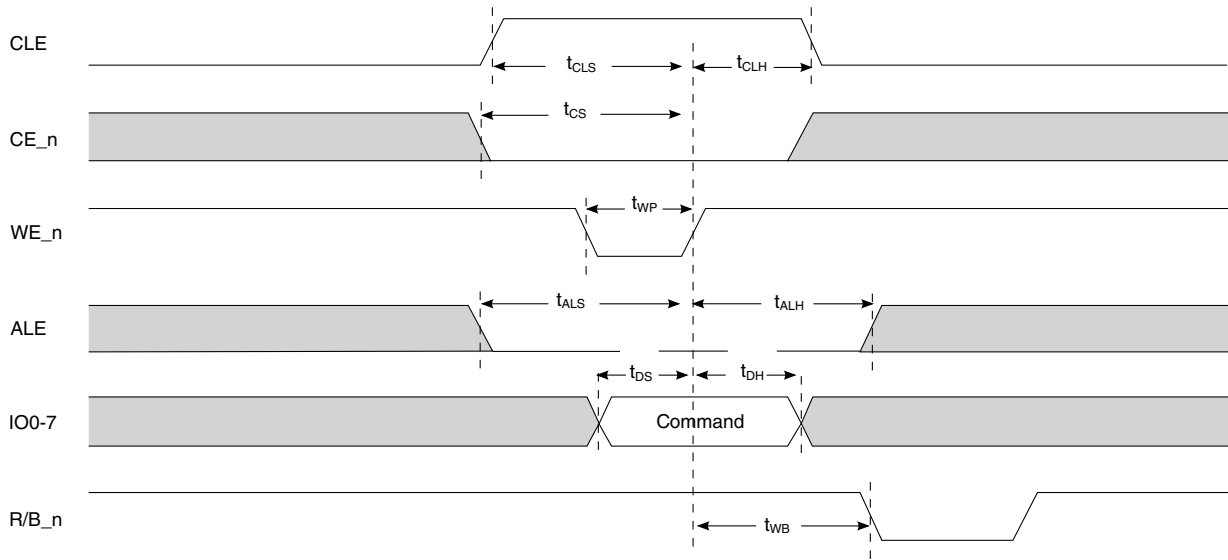


**Figure 32. tADL timing**

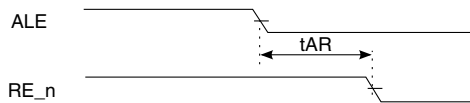


**Figure 33. Data output cycle timings**

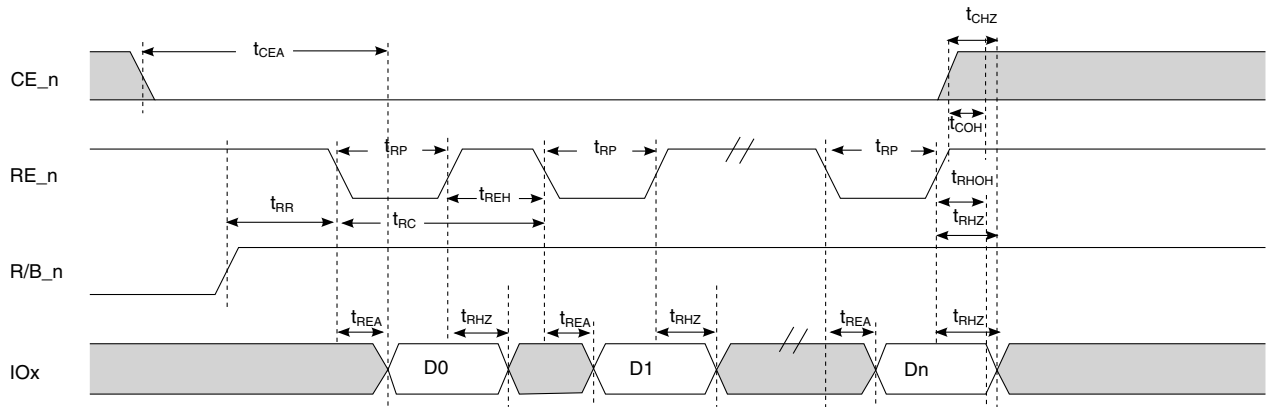
**Electrical characteristics**



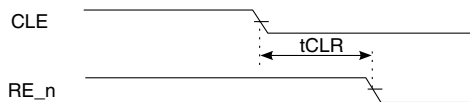
**Figure 34. Command cycle**



**Figure 35. tAR timings**



**Figure 36. Data input cycle timings**



**Figure 37. tCLR timings**

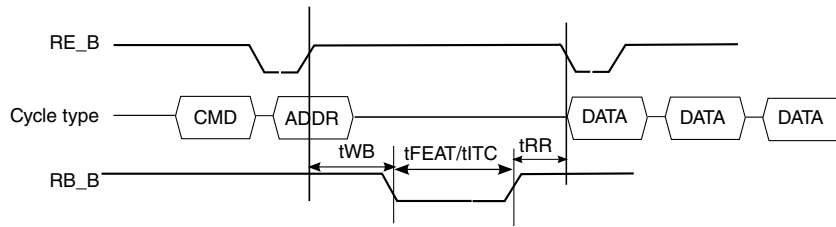


Figure 38. tWB, tFEAT, tTC, tRR timings

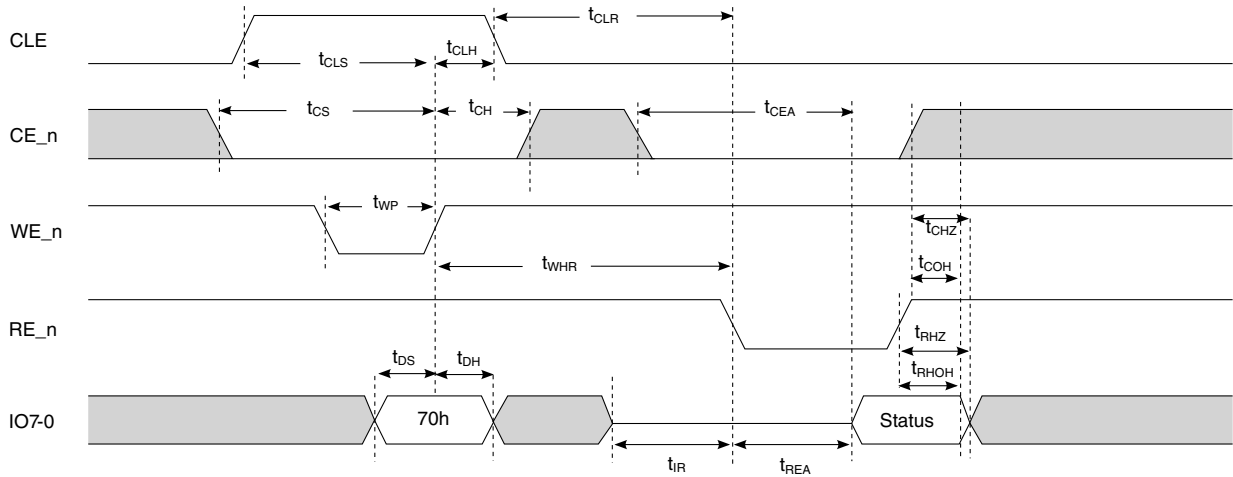


Figure 39. Read status timings

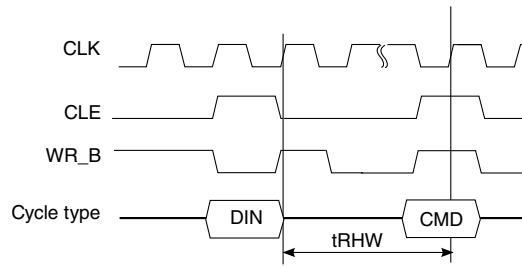


Figure 40. tRHW timings

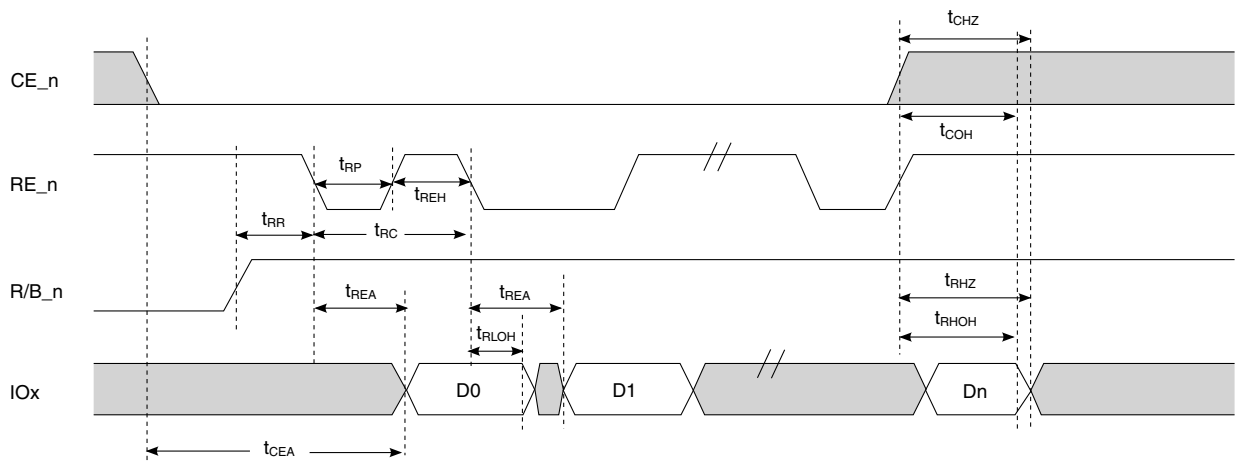


Figure 41. EDO mode data input cycle timings

Electrical characteristics

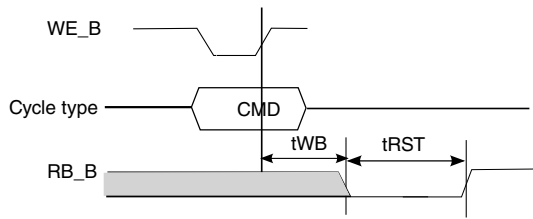


Figure 42.  $t_{WB}$ ,  $t_{RST}$  timings

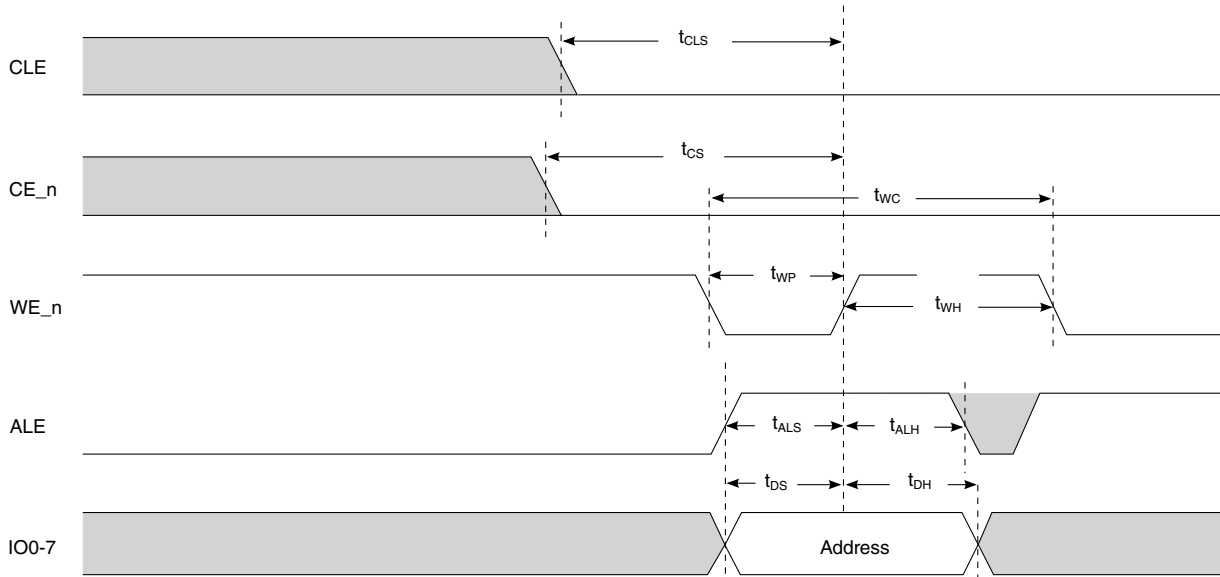


Figure 43. Address latch timings

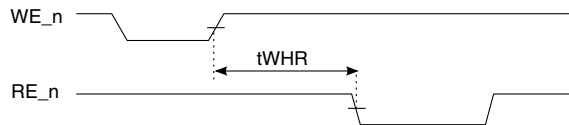


Figure 44.  $t_{WHR}$  timings

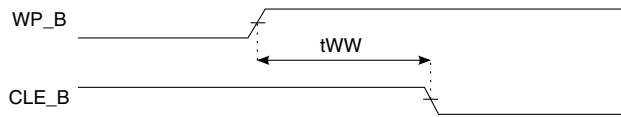


Figure 45.  $t_{WW}$  timings

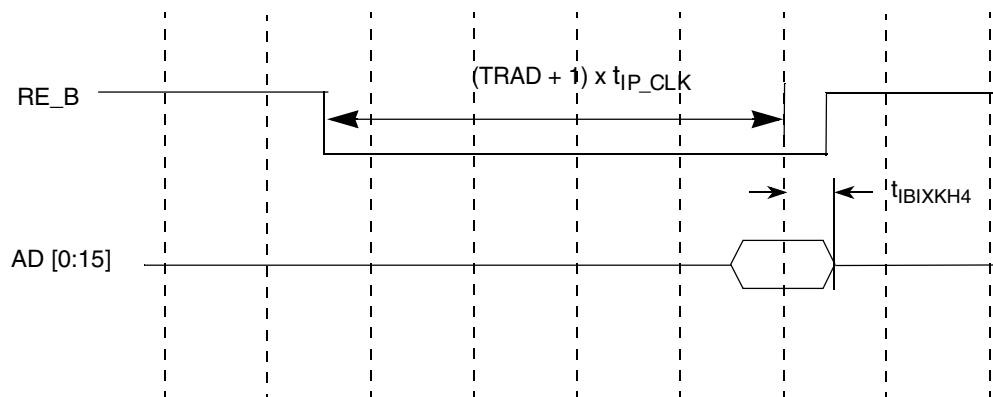


Figure 46. tIBIXKH4 timings

### 3.15.2.6 IFC-NAND NVDDR AC timing specification

Table below describes the AC timing specifications of IFC-NAND NVDDR interface. These specifications are compliant to NVDDR mode of ONFI specification revision 3.0.

**Table 50. Integrated Flash Controller IFC-NAND NVDDR interface AC timing specifications (OV<sub>DD</sub> = 1.8 V)<sup>2</sup>**

| Parameter  | Symbol          | I/O | Min                      | Max                      | Unit                | Fig       |
|--|-----------------|-----|--------------------------|--------------------------|---------------------|-----------|
| Access window of DQ[7:0] from CLK  | tAC             | I   | 3 - 150 (ps)             | 20 + 150 (ps)            | ns                  | Figure 50 |
| Address cycle to data loading time   | tADL            | I   | TADL                     | —                        | t <sub>IP_CLK</sub> | Figure 51 |
| Command, Address, Data delay (command to command, address to address, command to address, address to command, command/address to start of data) Fast | tCADf           | O   | TCAD - 150 (ps)          | TCAD + 150 (ps)          | t <sub>IP_CLK</sub> | Figure 47 |
| Command, Address, Data delay (command to command, address to address, command to address, address to command, command/address to start of data) slow | tCADs           | O   | TCAD - 150 (ps)          | TCAD + 150 (ps)          | t <sub>IP_CLK</sub> | Figure 47 |
| Command/address DQ hold time   | tCAH            | O   | 2 + 150 (ps)             | —                        | ns                  | Figure 47 |
| CLE and ALE hold time  | tCALH           | O   | 2 + 150 (ps)             | —                        | ns                  | Figure 47 |
| CLE and ALE setup time   | tCALS           | O   | 2 + 150 (ps)             | —                        | ns                  | Figure 47 |
| Command/address DQ setup time  | tCAS            | O   | 2 + 150 (ps)             | —                        | ns                  | Figure 47 |
| CE# hold time  | tCH             | O   | 2 + 150 (ps)             | —                        | ns                  | Figure 47 |
| Average clock cycle time, also known as tCK  | tCK(avg) or tCK | O   | 10                       | —                        | ns                  | Figure 47 |
| Absolute clock period, measured from rising edge to the next consecutive rising edge   | tCK(abs)        | O   | tCK(avg) + tJIT(per) min | tCK(avg) + tJIT(per) max | ns                  | Figure 47 |
| Clock cycle high   | tCKH(abs)       | O   | 0.45                     | 0.55                     | tCK                 | Figure 47 |

Table continues on the next page...

## Electrical characteristics

**Table 50. Integrated Flash Controller IFC-NAND NVDDR interface AC timing specifications (OV<sub>DD</sub> = 1.8 V)<sup>2</sup> (continued)**

| Parameter   | Symbol          | I/O | Min                   | Max              | Unit                | Fig       |
|---|-----------------|-----|-----------------------|------------------|---------------------|-----------|
| Clock cycle low   | tCKL(abs)       | O   | 0.45                  | 0.55             | tCK                 | Figure 47 |
| Data input end to W/R# high B16   | tCKWR           | O   | TCKWR - 150 (ps)      | TCKWR + 150 (ps) | t <sub>IP_CLK</sub> | Figure 50 |
| CE# setup time  | tCS             | O   | TCS - 150 (ps)        | TCS + 150 (ps)   | t <sub>IP_CLK</sub> | Figure 49 |
| Data DQ hold time   | tDH             | O   | 1050                  | —                | ps                  | Figure 49 |
| Access window of DQS from CLK   | tDQSK           | I   | —                     | 20 + 150 (ps)    | ns                  | Figure 50 |
| W/R# low to DQS/DQ driven by device   | tDQSD           | I   | -150 (ps)             | 18 + 150 (ps)    | ns                  | Figure 50 |
| DQS output high pulse width   | tDQSH           | O   | 0.45                  | 0.55             | tCK                 | Figure 49 |
| W/R# high to DQS/DQ tri-state by device   | tDQSHZ          | O   | RHZ - 150 (ps)        | RHZ + 150 (ps)   | t <sub>IP_CLK</sub> | Figure 47 |
| DQS output low pulse width  | tDQSL           | O   | 0.45                  | 0.55             | tCK                 | Figure 49 |
| DQS-DQ skew, DQS to last DQ valid, per access   | tDQSQ           | I   | —                     | 1000             | ps                  | Figure 50 |
| Data output to first DQS latching transition  | tDQSS           | O   | 0.75 + 150 (ps)       | 1.25 - 150 (ps)  | tCK                 | Figure 49 |
| Data DQ setup time  | tDS             | O   | 1050                  | —                | ps                  | Figure 49 |
| DQS falling edge to CLK rising - hold time  | tDSH            | O   | 0.2 + 150 (ps)        | —                | tCK                 | Figure 49 |
| DQS falling edge to CLK rising - setup time   | tDSS            | O   | 0.2 + 150 (ps)        | —                | tCK                 | Figure 49 |
| Input data valid window   | tDVW            | I   | tDVW = tQH - tDQSQ    | —                | ns                  | Figure 50 |
| Busy time for Set Features and Get Features   | tFEAT           | I   | —                     | FTOCNT           | t <sub>IP_CLK</sub> | Figure 52 |
| Half-clock period   | tHP             | O   | tHP = min(tCKL, tCKH) | —                | ns                  | Figure 50 |
| Interface and Timing Mode Change time   | tITC            | I   | —                     | FTOCNT           | t <sub>IP_CLK</sub> | Figure 52 |
| The deviation of a given tCK(abs) from tCK(avg)                                       | tJIT(per)       | O   | -0.5                  | 0.5              | ns                  | NA        |
| DQ-DQS hold, DQS to first DQ to go non-valid, per access                              | tQH             | I   | tQH = tHP - tQHS      | —                | t <sub>IP_CLK</sub> | Figure 50 |
| Data hold skew factor   | tQHS            | I   | -                     | 1 + 150(ps)      | ns                  | NA        |
| Data input cycle to command, address, or data output cycle                            | tRHW            | O   | TRHW                  | —                | t <sub>IP_CLK</sub> | Figure 53 |
| Ready to data input cycle (data only)   | tRR             | I   | TRR                   | —                | t <sub>IP_CLK</sub> | Figure 52 |
| Device reset time, measured from the falling edge of R/B# to the rising edge of R/B#. | tRST (raw NAND) | O   | FTOCNT                | FTOCNT           | t <sub>IP_CLK</sub> | Figure 54 |
| Device reset time, measured from the falling edge of R/B# to the rising edge of R/B#. | tRST2 (EZ NAND) | O   | FTOCNT                | FTOCNT           | t <sub>IP_CLK</sub> | Figure 54 |

Table continues on the next page...

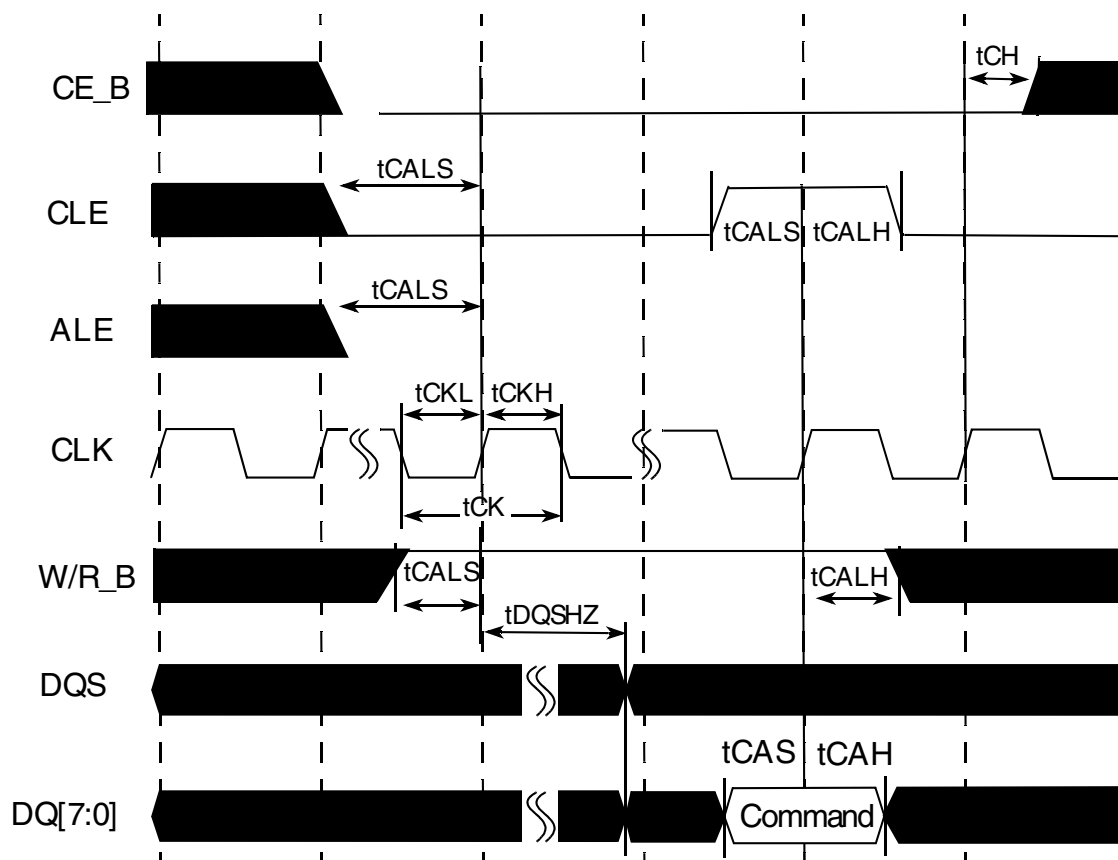
**Table 50. Integrated Flash Controller IFC-NAND NVDDR interface AC timing specifications (OV<sub>DD</sub> = 1.8 V)<sup>2</sup> (continued)**

| Parameter   | Symbol | I/O | Min              | Max              | Unit                | Fig       |
|---|--------|-----|------------------|------------------|---------------------|-----------|
| CLK rising edge to SR[6] low                              | tWB    | O   | TWB - 150 (ps)   | TWB + 150 (ps)   | t <sub>IP_CLK</sub> | Figure 54 |
| Command, address or data output cycle to data input cycle | tWHR   | O   | TWHR             | —                | t <sub>IP_CLK</sub> | Figure 55 |
| DQS write preamble  | tWPRE  | O   | 1.5              | —                | tCK                 | Figure 49 |
| DQS write postamble                                       | tWPST  | O   | 1.5              | —                | tCK                 | Figure 49 |
| W/R# low to data input cycle                              | tWRCK  | I   | TWRCK - 150 (ps) | TWRCK + 150 (ps) | t <sub>IP_CLK</sub> | Figure 50 |
| WP# transition to command cycle                           | tWW    | O   | TWW - 150 (ps)   | TWW + 150 (ps)   | t <sub>IP_CLK</sub> | Figure 56 |

**NOTE:**

1. t<sub>IP\_CLK</sub> is the clock period of IP clock (on which IFC IP is running). Note that that the IFC IP clock doesn't come out of device.
2. For the definition of parameters (like TADL) mentioned in min/max columns check the IFC section of the device's reference manual.

Following diagrams show the AC timing diagram for IFC-NAND NVDDR interface.

**Figure 47. Command cycle**

Electrical characteristics

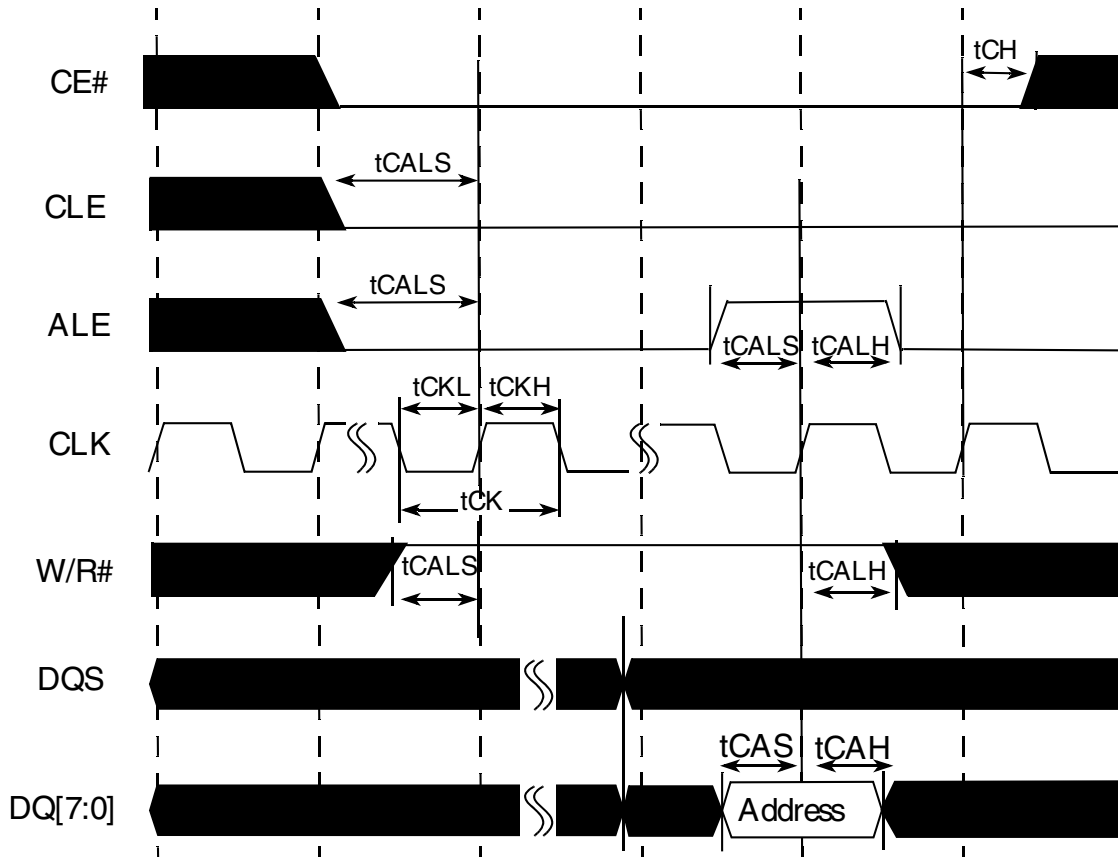


Figure 48. Address cycle

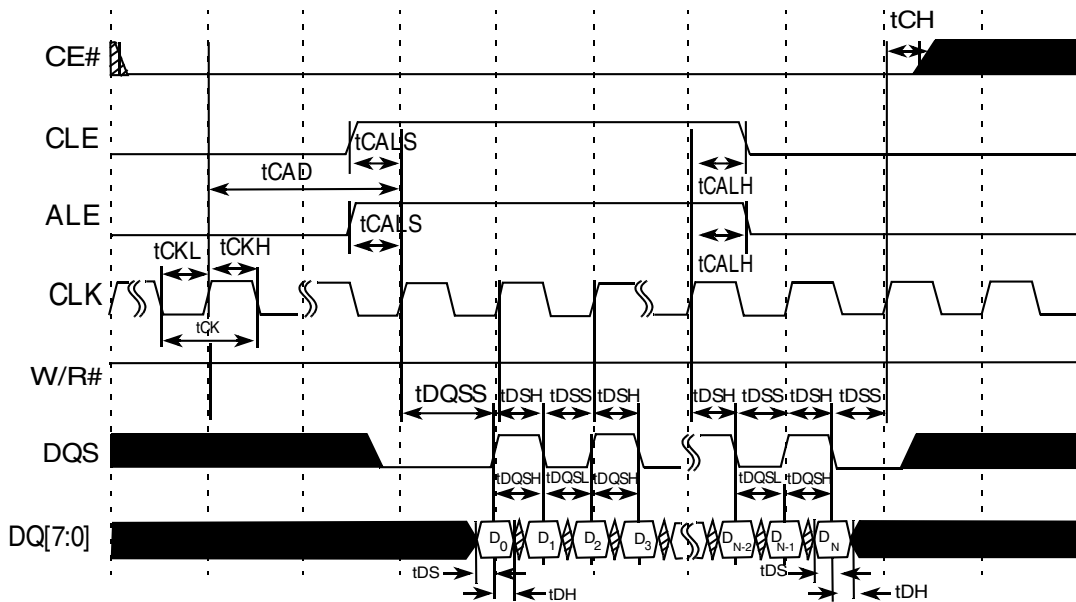


Figure 49. Write cycle



Electrical characteristics

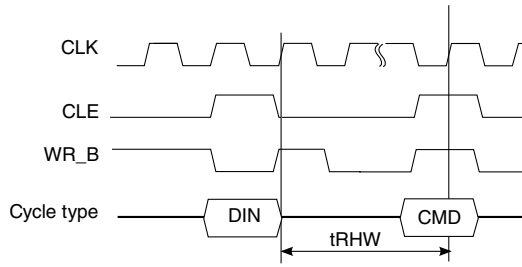


Figure 53. tRHW timings

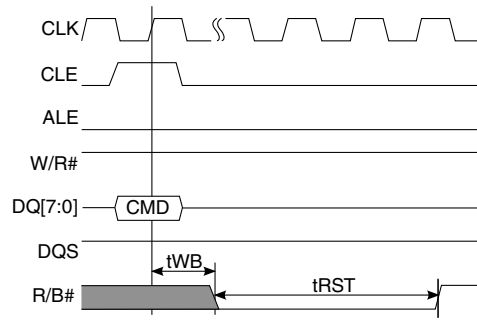


Figure 54. tWB, tRST timings

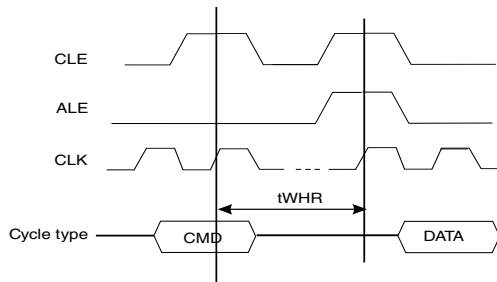


Figure 55. tWHR timings

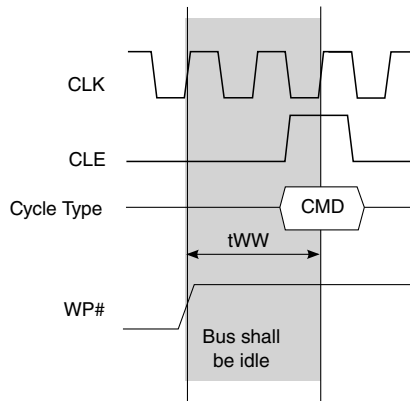


Figure 56. tWW timings

## 3.16 Enhanced secure digital host controller (eSDHC)

This section describes the DC and AC electrical specifications for the eSDHC interface.

### 3.16.1 eSDHC DC electrical characteristics

This table provides the DC electrical characteristics for the eSDHC interface.

**Table 51. eSDHC interface DC electrical characteristics (dual-voltage cards)<sup>3</sup>**

| Characteristic               | Symbol          | Condition                                 | Min                  | Max                  | Unit    | Notes |
|------------------------------|-----------------|---|----------------------|----------------------|---------|-------|
| Input high voltage           | $V_{IH}$        | —   | $0.7 \times OV_{DD}$ | —                    | V       | 1     |
| Input low voltage            | $V_{IL}$        | —   | —                    | $0.3 \times OV_{DD}$ | V       | 1     |
| Input/Output leakage current | $I_{IN}/I_{OZ}$ | —   | -50                  | 50                   | $\mu A$ | —     |
| Output high voltage          | $V_{OH}$        | $I_{OH} = -100 \mu A$ at $OV_{DD}$<br>min | $OV_{DD} - 0.2 V$    | —                    | V       | —     |
| Output low voltage           | $V_{OL}$        | $I_{OL} = 100 \mu A$ at $OV_{DD}$<br>min  | —                    | 0.2                  | V       | —     |
| Output high voltage          | $V_{OH}$        | $I_{OH} = -100 mA$                        | $OV_{DD} - 0.2$      | -                    | V       | 2     |
| Output low voltage           | $V_{OL}$        | $I_{OL} = 2 mA$                           | -                    | 0.3                  | V       | 2     |

1. The min  $V_{IL}$  and  $V_{IH}$  values are based on the respective min and max  $OV_{IN}$  values found in [Table 3](#).  
2. Open-drain mode is for MMC cards only.  
3. For recommended operating conditions, see [Table 3](#).

### 3.16.2 eSDHC AC timing specifications

**Table 52. eSDHC AC timing specifications<sup>6</sup>**

| Parameter   | Symbol <sup>1</sup>           | Min  | Max   | Unit | Notes   |
|---|-------------------------------|------|-------|------|---------|
| SD_CLK clock frequency:                             | $f_{SHSCK}$                   | 0    | 25/50 | MHz  | 2, 4    |
| SD/SDIO Full-speed/high-speed mode                  |                               |      | 20/52 |      |         |
| MMC Full-speed/high-speed mode                      |                               |      |       |      |         |
| SD_CLK clock low time-Full-speed/High-speed mode    | $t_{SHSCKL}$                  | 10/7 | —     | ns   | 4       |
| SD_CLK clock high time-Full-speed/High-speed mode   | $t_{SHSCKH}$                  | 10/7 | —     | ns   | 4       |
| SD_CLK clock rise and fall times                    | $t_{SHSCKR}/$<br>$t_{SHSCKF}$ | —    | 3     | ns   | 4       |
| Input setup times: SD_CMD, SD_DATx, SD_CD to SD_CLK | $t_{SHSIVKH}$                 | 2.5  | —     | ns   | 3, 4, 5 |
| Input hold times: SD_CMD, SD_DATx, SD_CD to SD_CLK  | $t_{SHSIXKH}$                 | 2.5  | —     | ns   | 4, 5    |
| Output hold time: SD_CLK to SD_CMD, SD_DATx valid   | $t_{SHSKHOX}$                 | -3   | —     | ns   | 4, 5    |
| Output delay time: SD_CLK to SD_CMD, SD_DATx valid  | $t_{SHSKHOV}$                 | —    | 3     | ns   | 4, 5    |

**Notes:**

## Electrical characteristics

Table 52. eSDHC AC timing specifications<sup>6</sup>

| Parameter  | Symbol <sup>1</sup> | Min | Max | Unit | Notes |
|--|---------------------|-----|-----|------|-------|
| <p>1. The symbols used for timing specifications herein follow the pattern of <math>t_{(\text{first three letters of functional block})(\text{signal})(\text{state}) (\text{reference})(\text{state})}</math> for inputs and <math>t_{(\text{first three letters of functional block})(\text{reference})(\text{state})(\text{signal})(\text{state})}</math> for outputs. For example, <math>t_{\text{FHSKH0V}}</math> symbolizes eSDHC high-speed mode device timing (SHS) clock reference (K) going to the high (H) state, with respect to the output (O) reaching the invalid state (X) or output hold time. Note that in general, the clock reference symbol is based on five letters representing the clock of a particular functional. For rise and fall times, the latter convention is used with the appropriate letter: R (rise) or F (fall).</p> <p>2. In full-speed mode, the clock frequency value can be 0-25 MHz for an SD/SDIO card and 0-20 MHz for an MMC card. In high-speed mode, the clock frequency value can be 0-50 MHz for an SD/SDIO card and 0-52 MHz for an MMC card.</p> <p>3. To satisfy setup timing, one-way board-routing delay between Host and Card, on SD_CLK, SD_CMD, and SD_DATx should not exceed 1 ns for any high speed MMC card. For any high speed or default speed mode SD card, the one way board routing delay between Host and Card, on SD_CLK, SD_CMD, and SD_DATx should not exceed 1.5ns.</p> <p>4. <math>C_{\text{CARD}} \leq 10 \text{ pF}</math>, (1 card), and <math>C_{\text{L}} = C_{\text{BUS}} + C_{\text{HOST}} + C_{\text{CARD}} \leq 40 \text{ pF}</math>.</p> <p>5. The parameter values apply to both full-speed and high-speed modes.</p> <p>6. For recommended operating conditions, see Table 3.</p> |                     |     |     |      |       |

This figure provides the eSDHC clock input timing diagram.

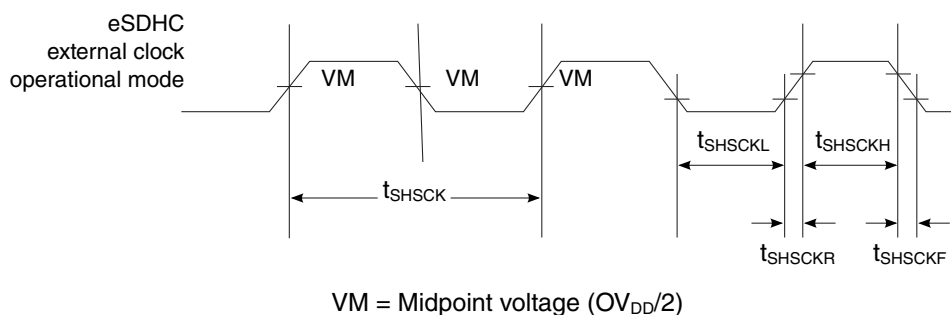
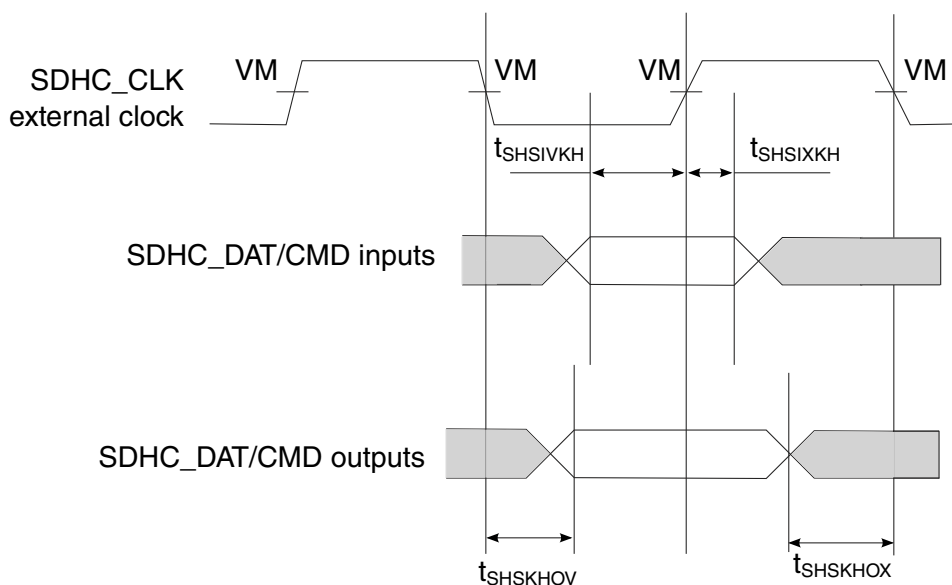


Figure 57. eSDHC clock input timing diagram

This figure provides the data and command input/output timing diagram.



$VM = \text{Midpoint voltage } (OV_{DD}/2)$

**Figure 58. eSDHC data and command input/output timing diagram referenced to clock**

This table provides the eSDHC AC timing specifications for eMMC HS200 mode.

**Table 53. eSDHC AC timing specifications (eMMC HS200)**

| Parameter   | Symbol <sup>1</sup>   | Min   | Max | Unit          | Notes |
|---|-----------------------|-------|-----|---------------|-------|
| SDHC_CLK clock frequency  | $f_{SHCK}$            | -     | 200 | MHz           | -     |
| SDHC_CLK clock rise and fall times  | $t_{SHCKR}/t_{SHCKF}$ | -     | 1   | ns            | 1     |
| Output hold time: SDHC_CLK to SDHC_CMD, SDHC_DATx valid, SDHC_CMD_DIR, SDHC_DATx_DIR  | $T_{SHKHOX}$          | 1.6   | -   | ns            | 1     |
| Output delay time: SDHC_CLK to SDHC_CMD, SDHC_DATx valid, SDHC_CMD_DIR, SDHC_DATx_DIR | $T_{SHKHOV}$          | -     | 2.9 | ns            | 1     |
| Input data window (UI)  | $t_{SHIDV}$           | 0.475 | -   | Unit Interval | 1     |
| <b>Notes:</b>   |                       |       |     |               |       |
| 1. $C_L = C_{BUS} + C_{HOST} + C_{CARD} \leq 15\text{pF}$ .                           |                       |       |     |               |       |
| 2. At recommended operating conditions with $=1.8\text{ V}$ .                         |                       |       |     |               |       |

This figure provides the eSDHC HS200 mode timing diagram.

## Electrical characteristics

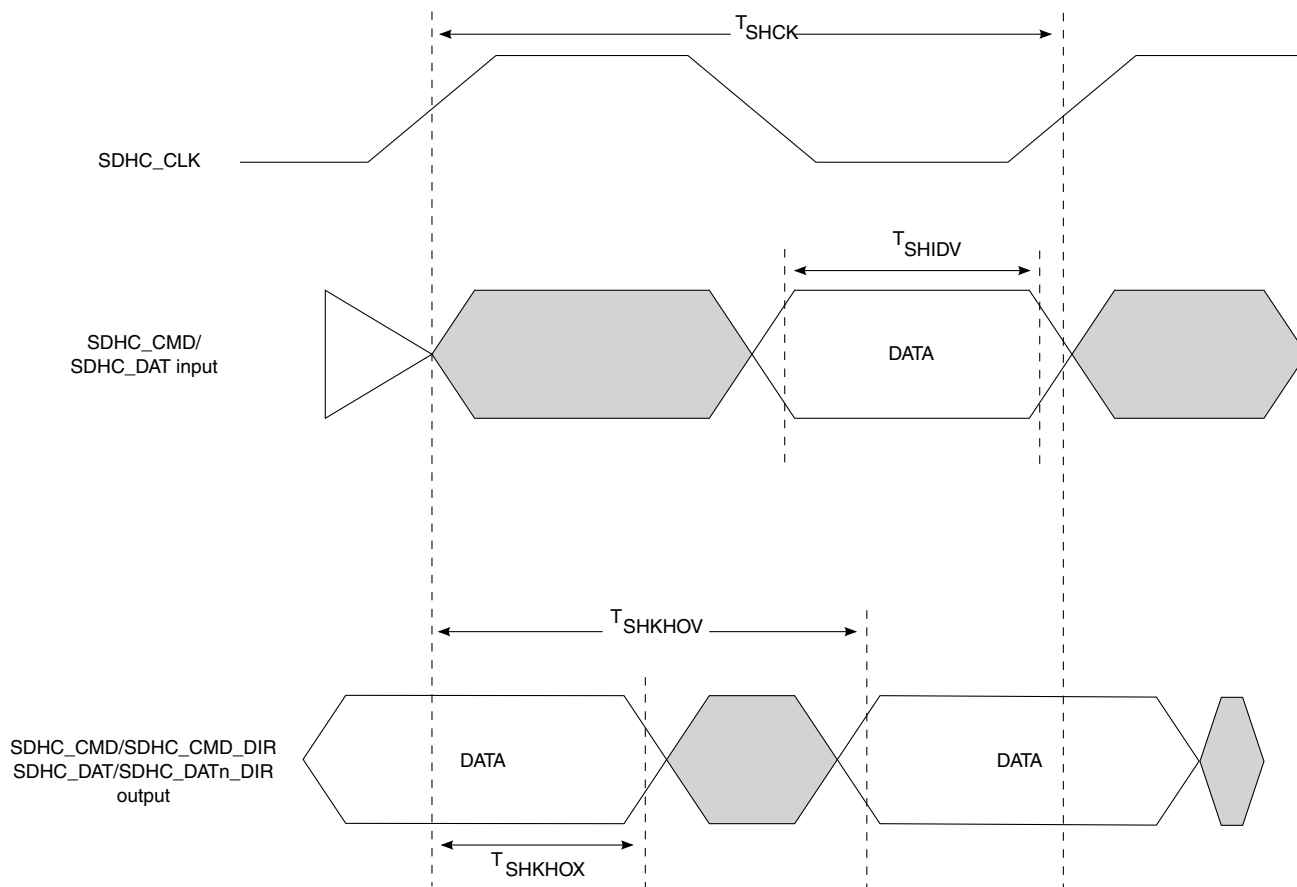


Figure 59. eSDHC HS200 mode timing diagram

## 3.17 Generic interrupt controller (GIC)

This section describes the DC and AC electrical specifications for the generic interrupt controller.

### 3.17.1 GIC DC characteristics

This figure provides the DC electrical characteristics for IRQ[0:11] and EVT[0:9]\_B.

Table 54. GIC DC electrical characteristics ( $OV_{DD} = 1.8\text{ V}$ )<sup>3</sup>

| Characteristic   | Symbol   | Min  | Max      | Unit          | Notes |
|--|----------|------|----------|---------------|-------|
| Input high voltage   | $V_{IH}$ | 1.2  | —        | V             | 1     |
| Input low voltage  | $V_{IL}$ | —    | 0.6      | V             | 1     |
| Input current ( $OV_{IN} = 0\text{ V}$ or $OV_{IN} = OV_{DD}$ )            | $I_{IN}$ | —    | $\pm 50$ | $\mu\text{A}$ | 2     |
| Output high voltage ( $OV_{DD} = \text{min}$ , $I_{OH} = -0.5\text{ mA}$ ) | $V_{OH}$ | 1.35 | —        | V             | —     |

Table continues on the next page...

**Table 54. GIC DC electrical characteristics ( $OV_{DD} = 1.8\text{ V}$ )<sup>3</sup> (continued)**

| Characteristic  | Symbol   | Min | Max | Unit | Notes |
|---|----------|-----|-----|------|-------|
| Output low voltage ( $OV_{DD} = \text{min}$ , $I_{OL} = 0.5\text{ mA}$ )  | $V_{OL}$ | —   | 0.4 | V    | —     |
| <b>Note:</b>  |          |     |     |      |       |
| 1. The min $V_{IL}$ and max $V_{IH}$ values are based on the min and max $OV_{IN}$ respective values found in <a href="#">Table 3</a> . |          |     |     |      |       |
| 2. The symbol $OV_{IN}$ , in this case, represents the $OV_{IN}$ symbol referenced in <a href="#">Table 3</a> .                         |          |     |     |      |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a> .  |          |     |     |      |       |

### 3.17.2 GIC AC timing specifications

This table provides the GIC input and output AC timing specifications for  $IRQ[0:11]$  and  $EVT[0:9]_B$ .

**Table 55. GIC Input AC timing specifications<sup>2</sup>**

| Characteristic  | Symbol      | Min | Max | Unit     | Notes |
|---|-------------|-----|-----|----------|-------|
| GIC inputs-minimum pulse width  | $t_{PIWID}$ | 3   | —   | SYSCCLKs | 1     |
| 1. GIC inputs and outputs are asynchronous to any visible clock. GIC outputs must be synchronized before use by any external synchronous logic. GIC inputs are required to be valid for at least $t_{PIWID}$ ns to ensure proper operation when working in edge triggered mode. |             |     |     |          |       |
| 2. For recommended operating conditions, see <a href="#">Table 3</a> .  |             |     |     |          |       |

## 3.18 JTAG controller

This section describes the DC and AC electrical specifications for the IEEE 1149.1 (JTAG) interface.

### 3.18.1 JTAG DC electrical characteristics

This table provides the JTAG DC electrical characteristics.

**Table 56. JTAG DC electrical characteristics ( $OV_{DD} = 1.8\text{ V}$ )<sup>3</sup>**

| Parameter  | Symbol   | Min  | Max      | Unit          | Notes |
|--|----------|------|----------|---------------|-------|
| Input high voltage   | $V_{IH}$ | 1.2  | —        | V             | 1     |
| Input low voltage  | $V_{IL}$ | —    | 0.6      | V             | 1     |
| Input current ( $OV_{IN} = 0\text{ V}$ or $OV_{IN} = OV_{DD}$ )            | $I_{IN}$ | —    | -100/+50 | $\mu\text{A}$ | 2,4   |
| Output high voltage ( $OV_{DD} = \text{min}$ , $I_{OH} = -0.5\text{ mA}$ ) | $V_{OH}$ | 1.35 | —        | V             | —     |

Table continues on the next page...

## Electrical characteristics

**Table 56. JTAG DC electrical characteristics ( $OV_{DD} = 1.8V$ )<sup>3</sup> (continued)**

| Parameter   | Symbol   | Min | Max | Unit | Notes |
|---|----------|-----|-----|------|-------|
| Output low voltage ( $OV_{DD} = \text{min}$ , $I_{OL} = 0.5 \text{ mA}$ )   | $V_{OL}$ | —   | 0.4 | V    | —     |
| <b>Notes:</b>   |          |     |     |      |       |
| 1. The min $V_{IL}$ and max $V_{IH}$ values are based on the respective min and max $OV_{IN}$ values found in <a href="#">Table 3</a> . |          |     |     |      |       |
| 2. The symbol $V_{IN}$ , in this case, represents the $OV_{IN}$ symbol found in <a href="#">Table 3</a> .                               |          |     |     |      |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a> .  |          |     |     |      |       |
| 4. TDI, TMS, TRST_B have internal pull-ups per IEEE Std 1149.1 specification.   |          |     |     |      |       |

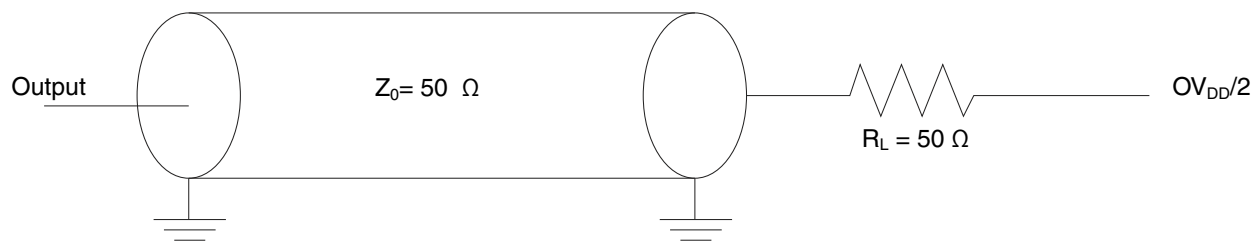
**3.18.2 JTAG AC timing specifications**

This table provides the JTAG AC timing specifications as defined in [Figure 60](#) through [Figure 63](#).

**Table 57. JTAG AC timing specifications<sup>4</sup>**

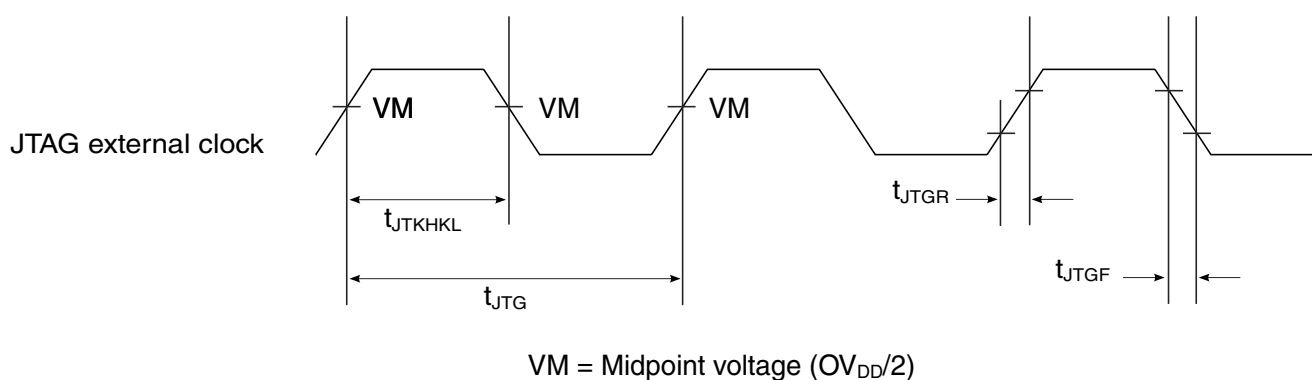
| Parameter   | Symbol <sup>1</sup> | Min | Max  | Unit | Notes |
|---|---------------------|-----|------|------|-------|
| JTAG external clock frequency of operation  | $f_{JTG}$           | 0   | 33.3 | MHz  | —     |
| JTAG external clock cycle time  | $t_{JTG}$           | 30  | —    | ns   | —     |
| JTAG external clock pulse width measured at 1.4 V   | $t_{JKHKL}$         | 15  | —    | ns   | —     |
| JTAG external clock rise and fall times   | $t_{JGR}/t_{JGF}$   | 0   | 2    | ns   | —     |
| TRST_B assert time  | $t_{TRST}$          | 25  | —    | ns   | 2     |
| Input setup times   | $t_{JDVKH}$         | 4   | —    | ns   | —     |
| Input hold times  | $t_{JDXKH}$         | 10  | —    | ns   | —     |
| Output valid times  | $t_{JKLDV}$         |     |      | ns   | 3     |
| Boundary-scan data  |                     | —   | 15   |      |       |
| TDO   |                     | —   | 10   |      |       |
| Output hold times   | $t_{JKLDX}$         | 0   | —    | ns   | 3     |
| <b>Notes:</b>   |                     |     |      |      |       |
| 1. The symbols used for timing specifications follow the pattern $t_{(\text{first two letters of functional block})(\text{signal})(\text{state})(\text{reference})(\text{state})}$ for inputs and $t_{(\text{first two letters of functional block})(\text{reference})(\text{state})(\text{signal})(\text{state})}$ for outputs. For example, $t_{JDVKH}$ symbolizes JTAG device timing (JT) with respect to the time data input signals (D) reaching the valid state (V) relative to the $t_{JTG}$ clock reference (K) going to the high (H) state or setup time. Also, $t_{JDXKH}$ symbolizes JTAG timing (JT) with respect to the time data input signals (D) reaching the invalid state (X) relative to the $t_{JTG}$ clock reference (K) going to the high (H) state. Note that in general, the clock reference symbol representation is based on three letters representing the clock of a particular functional. For rise and fall times, the latter convention is used with the appropriate letter: R (rise) or F (fall). |                     |     |      |      |       |
| 2. TRST_B is an asynchronous level sensitive signal. The setup time is for test purposes only.  |                     |     |      |      |       |
| 3. All outputs are measured from the midpoint voltage of the falling edge of $t_{CLK}$ to the midpoint of the signal in question. The output timings are measured at the pins. All output timings assume a purely resistive 50- $\Omega$ load. Time-of-flight delays must be added for trace lengths, vias, and connectors in the system.   |                     |     |      |      |       |
| 4. For recommended operating conditions, see <a href="#">Table 3</a> .  |                     |     |      |      |       |

This figure provides the AC test load for TDO and the boundary-scan outputs of the device.



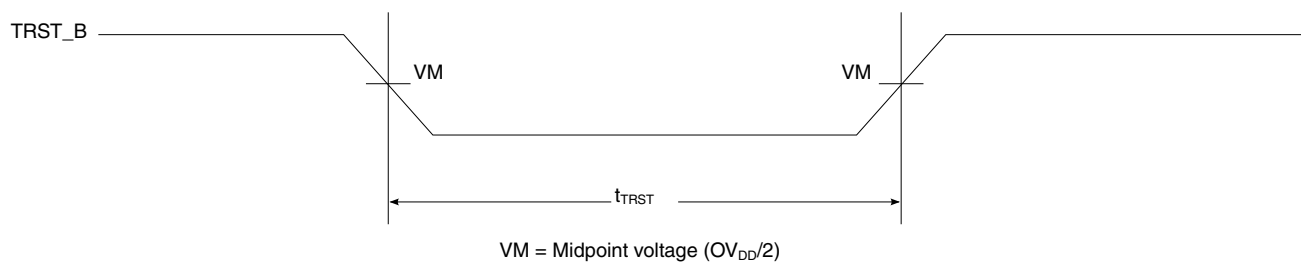
**Figure 60. AC test load for the JTAG interface**

This figure provides the JTAG clock input timing diagram.



**Figure 61. JTAG clock input timing diagram**

This figure provides the TRST\_B timing diagram.



**Figure 62. TRST\_B timing diagram**

This figure provides the boundary-scan timing diagram.

## Electrical characteristics

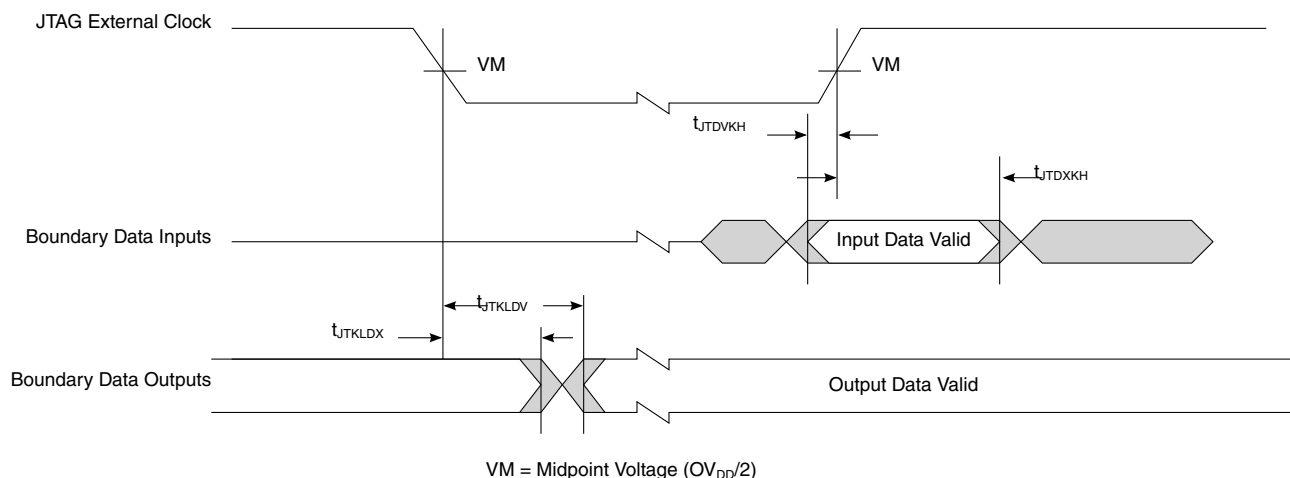


Figure 63. Boundary-scan timing diagram

## 3.19 I<sup>2</sup>C interface

This section describes the DC and AC electrical characteristics for the I<sup>2</sup>C interface.

### 3.19.1 I<sup>2</sup>C DC electrical characteristics

This table provides the DC electrical characteristics for the I<sup>2</sup>C interfaces operating at 1.8 V.

Table 58. I<sup>2</sup>C DC electrical characteristics ( $OV_{DD} = 1.8 V$ )<sup>4</sup>

| Parameter  | Symbol       | Min  | Max  | Unit          | Notes |
|--|--------------|------|------|---------------|-------|
| Input high voltage   | $V_{IH}$     | 1.25 | —    | V             | 1     |
| Input low voltage  | $V_{IL}$     | —    | 0.6  | V             | 1     |
| Output low voltage ( $OV_{DD} = \text{min}$ , $I_{OL} = 2 \text{ mA}$ )  | $V_{OL}$     | 0    | 0.36 | V             |       |
| Pulse width of spikes which must be suppressed by the input filter   | $t_{I2KHKL}$ | 0    | 50   | ns            | 2     |
| Input current each I/O pin (input voltage is between $0.1 \times OV_{DD}$ and $0.9 \times OV_{DD}(\text{max})$ ) | $I_I$        | -50  | 50   | $\mu\text{A}$ | 3     |
| Capacitance for each I/O pin   | $C_I$        | —    | 10   | pF            | —     |

#### Notes:

1. The min  $V_{IL}$  and max  $V_{IH}$  values are based on the respective min and max  $OV_{IN}$  values found in [Table 3](#).
2. See the chip reference manual for information about the digital filter used.
3. I/O pins obstruct the SDA and SCL lines if  $OV_{DD}$  is switched off.
4. For recommended operating conditions, see [Table 3](#).

### 3.19.2 I<sup>2</sup>C AC timing specifications

This table provides the AC timing parameters for the I<sup>2</sup>C interfaces.

**Table 59. I<sup>2</sup>C AC timing specifications<sup>5</sup>**

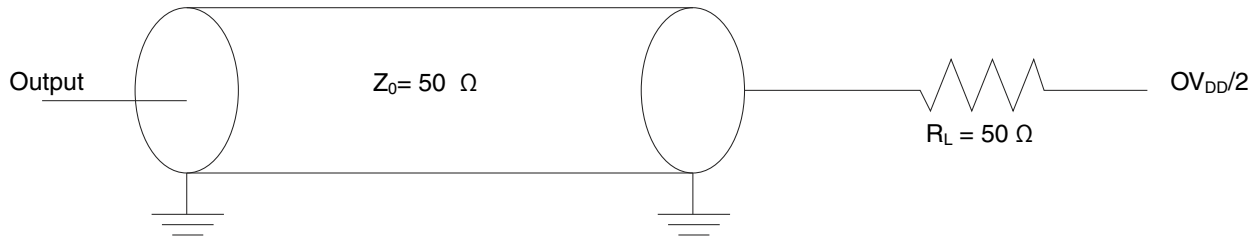
| Parameter  | Symbol <sup>1</sup> | Min                    | Max | Unit | Notes |
|--|---------------------|------------------------|-----|------|-------|
| SCL clock frequency  | f <sub>I2C</sub>    | 0                      | 400 | kHz  | 2     |
| Low period of the SCL clock  | t <sub>I2CL</sub>   | 1.3                    | —   | μs   | —     |
| High period of the SCL clock   | t <sub>I2CH</sub>   | 0.6                    | —   | μs   | —     |
| Setup time for a repeated START condition  | t <sub>I2SVKH</sub> | 0.6                    | —   | μs   | —     |
| Hold time (repeated) START condition (after this period, the first clock pulse is generated) | t <sub>I2SXKL</sub> | 0.6                    | —   | μs   | —     |
| Data setup time  | t <sub>I2DVKH</sub> | 100                    | —   | ns   | —     |
| Data input hold time:  | t <sub>I2DXKL</sub> | —                      | —   | μs   | 3     |
| CBUS compatible masters  |                     | —                      | —   |      |       |
| I <sup>2</sup> C bus devices   | 0                   | —                      | —   | —    | —     |
| Data output delay time   | t <sub>I2OVKL</sub> | —                      | 0.9 | μs   | 4     |
| Setup time for STOP condition  | t <sub>I2PVKH</sub> | 0.6                    | —   | μs   | —     |
| Bus free time between a STOP and START condition   | t <sub>I2KHDX</sub> | 1.3                    | —   | μs   | —     |
| Noise margin at the LOW level for each connected device (including hysteresis)               | V <sub>NL</sub>     | 0.1 x OV <sub>DD</sub> | —   | V    | —     |
| Noise margin at the HIGH level for each connected device (including hysteresis)              | V <sub>NH</sub>     | 0.2 x OV <sub>DD</sub> | —   | V    | —     |
| Capacitive load for each bus line  | C <sub>b</sub>      | —                      | 400 | pF   | —     |

**Notes:**

- The symbols used for timing specifications herein follow the pattern t<sub>(first two letters of functional block)(signal)(state)(reference)(state)</sub> for inputs and t<sub>(first two letters of functional block)(reference)(state)(signal)(state)</sub> for outputs. For example, t<sub>I2DVKH</sub> symbolizes I<sup>2</sup>C timing (I2) with respect to the time data input signals (D) reaching the valid state (V) relative to the t<sub>I2C</sub> clock reference (K) going to the high (H) state or setup time. Also, t<sub>I2SXKL</sub> symbolizes I<sup>2</sup>C timing (I2) for the time that the data with respect to the START condition (S) went invalid (X) relative to the t<sub>I2C</sub> clock reference (K) going to the low (L) state or hold time. Also, t<sub>I2PVKH</sub> symbolizes I<sup>2</sup>C timing (I2) for the time that the data with respect to the STOP condition (P) reaches the valid state (V) relative to the t<sub>I2C</sub> clock reference (K) going to the high (H) state or setup time.
- The requirements for I<sup>2</sup>C frequency calculation must be followed. See *Determining the I<sup>2</sup>C Frequency Divider Ratio for SCL* (AN2919).
- As a transmitter, the chip provides a delay time of at least 300 ns for the SDA signal (referred to the V<sub>IHmin</sub> of the SCL signal) to bridge the undefined region of the falling edge of SCL to avoid unintended generation of a START or STOP condition. When the chip acts as the I<sup>2</sup>C bus master while transmitting, it drives both SCL and SDA. As long as the load on SCL and SDA are balanced, the chip does not generate an unintended START or STOP condition. Therefore, the 300 ns SDA output delay time is not a concern. If, under some rare condition, the 300 ns SDA output delay time is required for the chip as transmitter, see *Determining the I<sup>2</sup>C Frequency Divider Ratio for SCL* (AN2919).
- The maximum t<sub>I2OVKL</sub> has to be met only if the device does not stretch the LOW period (t<sub>I2CL</sub>) of the SCL signal.
- For recommended operating conditions, see [Table 3](#).

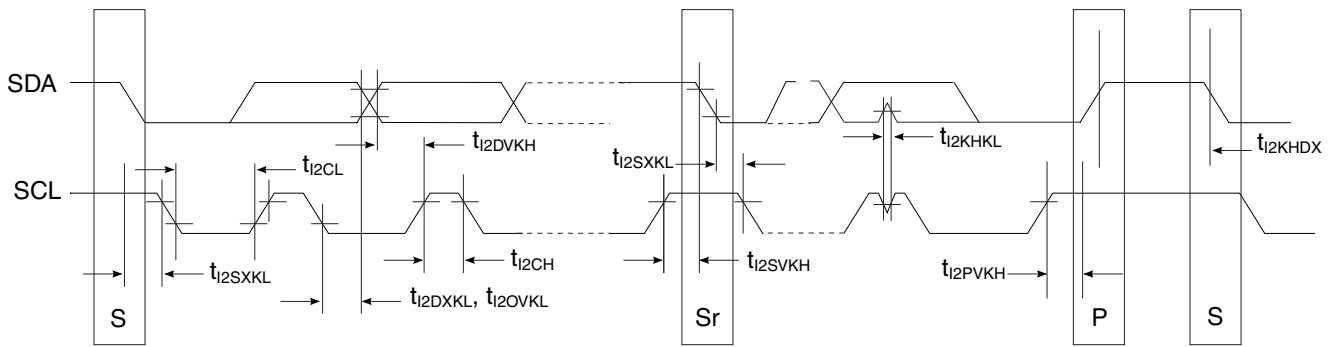
This figure provides the AC test load for the I<sup>2</sup>C.

**Electrical characteristics**



**Figure 64. I²C AC test load**

This figure shows the AC timing diagram for the I²C bus.



**Figure 65. I²C Bus AC timing diagram**

**3.20 GPIO interface**

This section describes the DC and AC electrical characteristics for the GPIO interface.

**3.20.1 GPIO DC electrical characteristics**

This table provides the DC electrical characteristics for GPIO pins operating at  $OV_{DD}$  or  $OV_{DD} = 1.8$  V.

**Table 60. GPIO DC electrical characteristics (1.8 V)<sup>3</sup>**

| Parameter   | Symbol   | Min  | Max      | Unit    | Notes |
|---|----------|------|----------|---------|-------|
| Input high voltage  | $V_{IH}$ | 1.2  | —        | V       | 1     |
| Input low voltage   | $V_{IL}$ | —    | 0.6      | V       | 1     |
| Input current ( $V_{IN} = 0$ V or $V_{IN} = OV_{DD}$ )                | $I_{IN}$ | —    | $\pm 50$ | $\mu A$ | 2     |
| Output high voltage<br>( $OV_{DD} = \text{min}$ , $I_{OH} = -0.5$ mA) | $V_{OH}$ | 1.35 | —        | V       | —     |

*Table continues on the next page...*

**Table 60. GPIO DC electrical characteristics (1.8 V)<sup>3</sup> (continued)**

| Parameter   | Symbol   | Min | Max | Unit | Notes |
|---|----------|-----|-----|------|-------|
| Output low voltage<br>( $OV_{DD} = \text{min}$ , $I_{OL} = 0.5 \text{ mA}$ )  | $V_{OL}$ | —   | 0.4 | V    | —     |
| 1. The min $V_{IL}$ and max $V_{IH}$ values are based on the respective min and max $OV_{IN}$ values found in <a href="#">Table 3</a> .<br>2. The symbol $V_{IN}$ , in this case, represents the $OV_{IN}$ symbol referenced in <a href="#">Table 3</a> .<br>3. For recommended operating conditions, see <a href="#">Table 3</a> . |          |     |     |      |       |

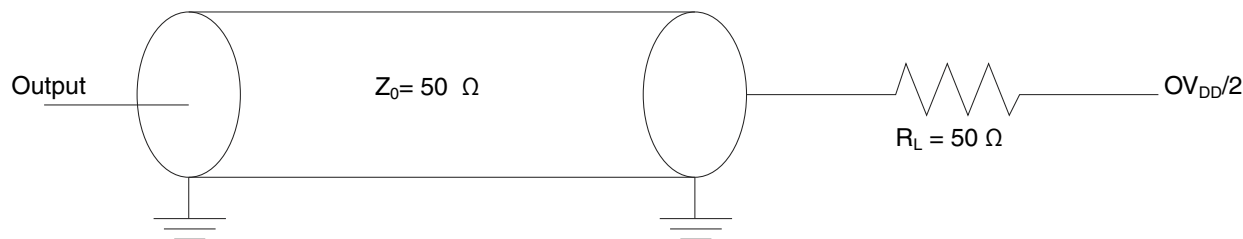
### 3.20.2 GPIO AC timing specifications

This table provides the GPIO input and output AC timing specifications.

**Table 61. GPIO input AC timing specifications<sup>2</sup>**

| Parameter  | Symbol      | Min | Unit | Notes |
|--|-------------|-----|------|-------|
| GPIO inputs—minimum pulse width  | $t_{PIWID}$ | 20  | ns   | 1     |
| <b>Notes:</b><br>1. GPIO inputs and outputs are asynchronous to any visible clock. GPIO outputs should be synchronized before use by any external synchronous logic. GPIO inputs are required to be valid for at least $t_{PIWID}$ to ensure proper operation.<br>2. For recommended operating conditions, see <a href="#">Table 3</a> . |             |     |      |       |

This figure provides the AC test load for the GPIO.

**Figure 66. GPIO AC test load**

## 3.21 Battery-backed security monitor interface

This section describes the DC and AC electrical characteristics for the battery-backed security monitor interface, which includes the TA\_BB\_TMP\_DETECT\_B pin.

## Electrical characteristics

### 3.21.1 Battery-backed security monitor interface DC electrical characteristics

This table provides the DC electrical characteristics for the battery-backed security monitor interface operating at 1.0 V ( $TA\_BB\_V_{DD}$ ).

**Table 62. Battery-backed security monitor interface DC electrical characteristics (1.0 V)<sup>3</sup>**

| Parameter   | Symbol   | Min | Max      | Unit    | Notes |
|---|----------|-----|----------|---------|-------|
| Input high voltage  | $V_{IH}$ | 0.8 | —        | V       | 1     |
| Input low voltage   | $V_{IL}$ | —   | 0.3      | V       | 1     |
| Input current ( $V_{IN} = 0$ V or $V_{IN} = TA\_BB\_V_{DD}$ )   | $I_{IN}$ | —   | $\pm 50$ | $\mu A$ | 2     |
| 1. The min $V_{IL}$ and max $V_{IH}$ values are based on the respective min and max $TA\_BB\_V_{DD}$ values found in <a href="#">Table 3</a> .<br>2. The symbol $V_{IN}$ , in this case, represents the $TA\_BB\_V_{DD}$ symbol referenced in <a href="#">Table 3</a> .<br>3. For recommended operating conditions, see <a href="#">Table 3</a> . |          |     |          |         |       |

### 3.21.2 Battery-backed security monitor interface AC timing specifications

This table provides the AC timing specifications for the battery-backed security monitor interface.

**Table 63. Battery-backed security monitor interface AC timing specifications<sup>2</sup>**

| Parameter  | Symbol    | Min | Typ | Max | Unit | Notes |
|--|-----------|-----|-----|-----|------|-------|
| $TA\_BB\_TMP\_DETECT\_B$   | $t_{TMP}$ | 100 | —   | —   | ns   | 1     |
| <b>Notes:</b><br>1. $TA\_BB\_TMP\_DETECT\_B$ is asynchronous to any clock.<br>2. For recommended operating conditions, see <a href="#">Table 3</a> . |           |     |     |     |      |       |

## 3.22 High-speed serial interfaces (HSSI)

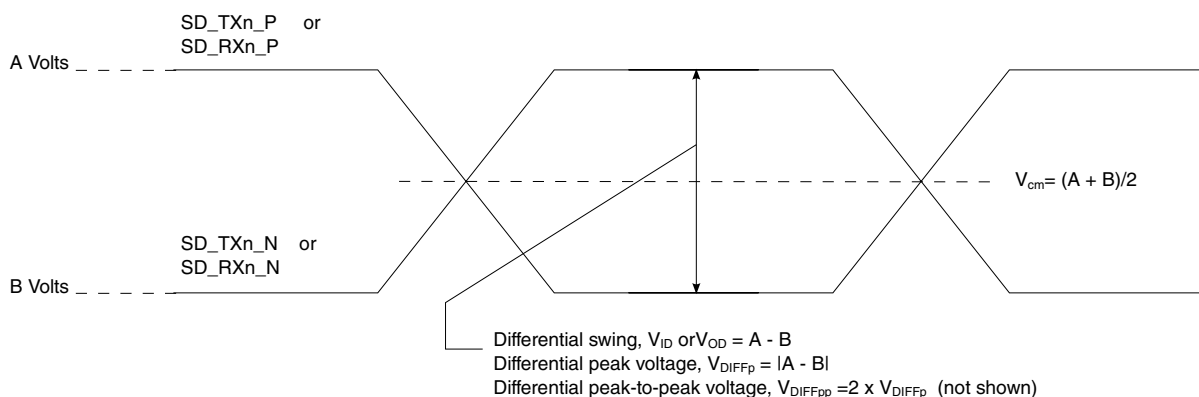
The chip features a serializer/deserializer (SerDes) interface to be used for high-speed serial interconnect applications. The SerDes interface can be used for PCI Express, SATA, XAUI, XFI, SGMII, and QSGMII data transfers.

This section describes the common portion of SerDes DC electrical specifications: the DC requirement for SerDes reference clocks. The SerDes data lane's transmitter (Tx) and receiver (Rx) reference circuits are also shown.

### 3.22.1 Signal terms definition

The SerDes uses differential signaling to transfer data across the serial link. This section defines the terms that are used in the description and specification of differential signals.

This figure shows how the signals are defined. For illustration purposes only, one SerDes lane is used in the description. This figure shows the waveform for either a transmitter output (SD\_TX $n$ \_P and SD\_TX $n$ \_N) or a receiver input (SD\_RX $n$ \_P and SD\_RX $n$ \_N). Each signal swings between A volts and B volts where  $A > B$ .



**Figure 67. Differential voltage definitions for transmitter or receiver**

Using this waveform, the definitions are as shown in the following list. To simplify the illustration, the definitions assume that the SerDes transmitter and receiver operate in a fully symmetrical differential signaling environment:

#### Single-Ended Swing

The transmitter output signals and the receiver input signals SD\_TX $n$ \_P, SD\_TX $n$ \_N, SD\_RX $n$ \_P and SD\_RX $n$ \_N each have a peak-to-peak swing of  $A - B$  volts. This is also referred as each signal wire's single-ended swing.

#### Differential Output Voltage, $V_{OD}$ (or Differential Output Swing)

The differential output voltage (or swing) of the transmitter,  $V_{OD}$ , is defined as the difference of the two complementary output voltages:  $V_{SD\_TXn\_P} - V_{SD\_TXn\_N}$ . The  $V_{OD}$  value can be either positive or negative.

#### Differential Input Voltage, $V_{ID}$ (or Differential Input Swing)

The differential input voltage (or swing) of the receiver,  $V_{ID}$ , is defined as the difference of the two complementary input voltages:  $V_{SD\_RXn\_P} - V_{SD\_RXn\_N}$ . The  $V_{ID}$  value can be either positive or negative.

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### Differential Peak Voltage, $V_{DIFFp}$

The peak value of the differential transmitter output signal or the differential receiver input signal is defined as the differential peak voltage,  $V_{DIFFp} = |A - B|$  volts.

### Differential Peak-to-Peak, $V_{DIFFp-p}$

Since the differential output signal of the transmitter and the differential input signal of the receiver each range from  $A - B$  to  $-(A - B)$  volts, the peak-to-peak value of the differential transmitter output signal or the differential receiver input signal is defined as differential peak-to-peak voltage,  $V_{DIFFp-p} = 2 \times V_{DIFFp} = 2 \times |A - B|$  volts, which is twice the differential swing in amplitude, or twice of the differential peak. For example, the output differential peak-to-peak voltage can also be calculated as  $V_{TX-DIFFp-p} = 2 \times |V_{OD}|$ .

### Differential Waveform

The differential waveform is constructed by subtracting the inverting signal ( $SD\_TXn\_N$ , for example) from the non-inverting signal ( $SD\_TXn\_P$ , for example) within a differential pair. There is only one signal trace curve in a differential waveform. The voltage represented in the differential waveform is not referenced to ground. See [Figure 72](#) as an example for differential waveform.

### Common Mode Voltage, $V_{cm}$

The common mode voltage is equal to half of the sum of the voltages between each conductor of a balanced interchange circuit and ground. In this example, for SerDes output,  $V_{cm\_out} = (V_{SD\_TXn\_P} + V_{SD\_TXn\_N}) \div 2 = (A + B) \div 2$ , which is the arithmetic mean of the two complementary output voltages within a differential pair. In a system, the common mode voltage may often differ from one component's output to the other's input. It may be different between the receiver input and driver output circuits within the same component. It is also referred to as the DC offset on some occasions.

To illustrate these definitions using real values, consider the example of a current mode logic (CML) transmitter that has a common mode voltage of 2.25 V and outputs, TD and TD\_B. If these outputs have a swing from 2.0 V to 2.5 V, the peak-to-peak voltage swing of each signal (TD or TD\_B) is 500 mV p-p, which is referred to as the single-ended swing for each signal. Because the differential signaling environment is fully symmetrical in this example, the transmitter output's differential swing ( $V_{OD}$ ) has the same amplitude as each signal's single-ended swing. The differential output signal ranges between 500 mV and -500 mV. In other words,  $V_{OD}$  is 500 mV in one phase and -500 mV in the other phase. The peak differential voltage ( $V_{DIFFp}$ ) is 500 mV. The peak-to-peak differential voltage ( $V_{DIFFp-p}$ ) is 1000 mV p-p.

### 3.22.2 SerDes reference clocks

The SerDes reference clock inputs are applied to an internal PLL whose output creates the clock used by the corresponding SerDes lanes. The SerDes reference clocks inputs are SD1\_REF\_CLK[1:2]\_P and SD1\_REF\_CLK[1:2]\_N for SerDes 1, SD2\_REF\_CLK[1:2]\_P and SD2\_REF\_CLK[1:2]\_N for SerDes 2.

SerDes 1-2 may be used for various combinations of the following IP blocks based on the RCW Configuration field SRDS\_PRTCLn:

- SerDes 1: XFI, XAUI, SGMII, QSGMII, PCIe
- SerDes 2: PCIe, SGMII, SATA

The following sections describe the SerDes reference clock requirements and provide application information.

#### 3.22.2.1 SerDes spread-spectrum clock source recommendations

SDn\_REF\_CLKn\_P/SDn\_REF\_CLKn\_N are designed to work with spread-spectrum clock for PCI Express protocol only with the spreading specification defined in [Table 64](#). When using spread-spectrum clocking for PCI Express, both ends of the link partners should use the same reference clock. For best results, a source without significant unintended modulation must be used.

For SATA protocol, the SerDes transmitter does not support spread-spectrum clocking. The SerDes receiver does support spread-spectrum clocking on receive, which means the SerDes receiver can receive data correctly from a SATA serial link partner using spread-spectrum clocking

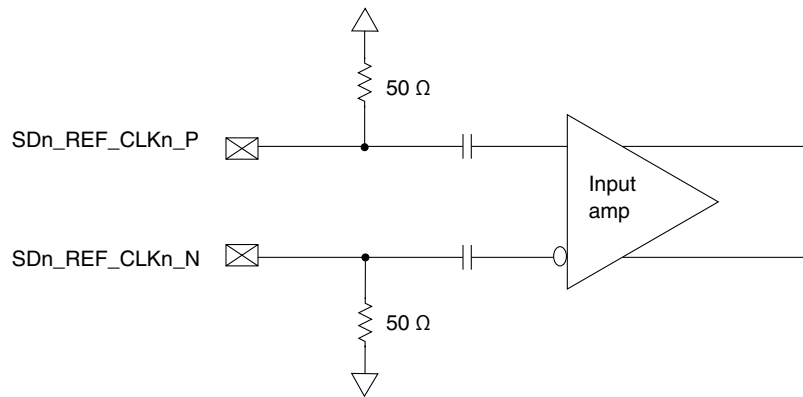
The spread-spectrum clocking cannot be used if the same SerDes reference clock is shared with other non-spread-spectrum supported protocols. For example, if the spread-spectrum clocking is desired on a SerDes reference clock for PCI Express and the same reference clock is used for any other protocol such as SATA/SGMII/QSGMII/XAUI/XFI due to the SerDes lane usage mapping option, spread-spectrum clocking cannot be used at all.

**Table 64. SerDes spread-spectrum clock source recommendations<sup>1</sup>**

| Parameter   | Min | Max  | Unit | Notes |
|---|-----|------|------|-------|
| Frequency modulation  | 30  | 33   | kHz  | —     |
| Frequency spread  | +0  | -0.5 | %    | 2     |
| <b>Notes:</b>   |     |      |      |       |
| 1. At recommended operating conditions. See <a href="#">Table 3</a> . |     |      |      |       |
| 2. Only down-spreading is allowed.                                    |     |      |      |       |

### 3.22.2.2 SerDes reference clock receiver characteristics

This figure shows a receiver reference diagram of the SerDes reference clocks.



**Figure 68. Receiver of SerDes reference clocks**

The characteristics of the clock signals are as follows:

- The SerDes transceivers core power supply voltage requirements ( $SV_{DDn}$ ) are as specified in [Table 3](#).
- The SerDes reference clock receiver reference circuit structure is as follows:
  - They are internally AC-coupled differential inputs as shown in [Figure 68](#). Each differential clock input (SDn\_REF\_CLKn\_P or SDn\_REF\_CLKn\_N) has on-chip 50-Ω termination to SD\_GND followed by on-chip AC-coupling.
  - The external reference clock driver must be able to drive this termination.
  - The SerDes reference clock input can be either differential or single-ended. See the differential mode and single-ended mode descriptions below for detailed requirements.
- The maximum average current requirement also determines the common mode voltage range.
  - When the SerDes reference clock differential inputs are DC coupled externally with the clock driver chip, the maximum average current allowed for each input pin is 8 mA. In this case, the exact common mode input voltage is not critical as long as it is within the range allowed by the maximum average current of 8 mA because the input is AC-coupled on-chip.
  - This current limitation sets the maximum common mode input voltage to be less than 0.4 V ( $0.4 \text{ V} \div 50 = 8 \text{ mA}$ ) while the minimum common mode input level is 0.1 V above SD\_GND. For example, a clock with a 50/50 duty cycle can be produced by a clock driver with output driven by its current source from 0 mA to

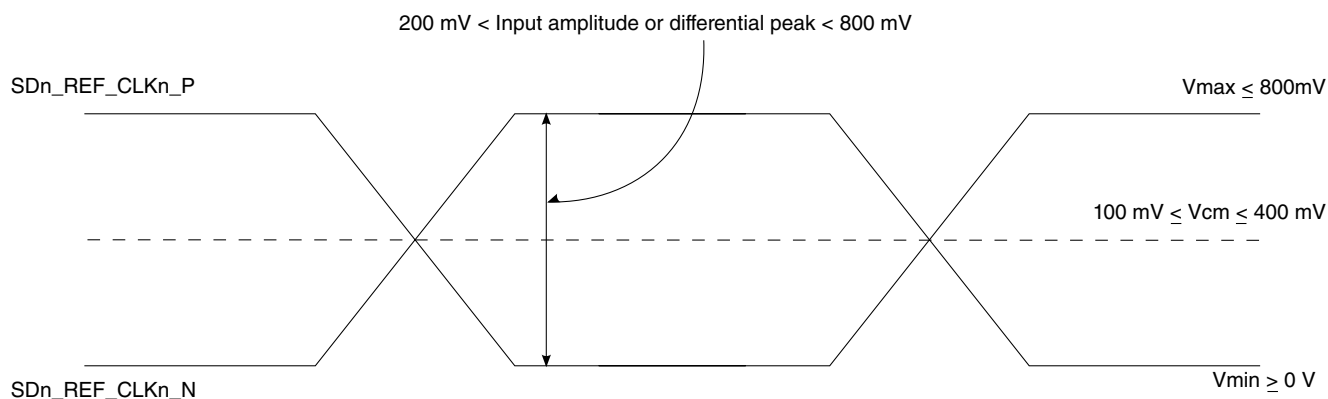
- 16 mA (0-0.8 V), such that each phase of the differential input has a single-ended swing from 0 V to 800 mV with the common mode voltage at 400 mV.
- If the device driving the  $SDn\_REF\_CLKn\_P$  and  $SDn\_REF\_CLKn\_N$  inputs cannot drive 50  $\Omega$  to  $SD\_GND$  DC or the drive strength of the clock driver chip exceeds the maximum input current limitations, it must be AC-coupled off-chip.
  - The input amplitude requirement is described in detail in the following sections.

### 3.22.2.3 DC-level requirement for SerDes reference clocks

The DC level requirement for the SerDes reference clock inputs is different depending on the signaling mode used to connect the clock driver chip and SerDes reference clock inputs, as described below.

Differential mode:

- The input amplitude of the differential clock must be between 400 mV and 1600 mV differential peak-to-peak (or between 200 mV and 800 mV differential peak). In other words, each signal wire of the differential pair must have a single-ended swing of less than 800 mV and greater than 200 mV. This requirement is the same for both external DC-coupled or AC-coupled connection.
- For an external DC-coupled connection, as described in [SerDes reference clock receiver characteristics](#), the maximum average current requirements sets the requirement for average voltage (common mode voltage) as between 100 mV and 400 mV. [Figure 69](#) shows the SerDes reference clock input requirement for DC-coupled connection scheme.

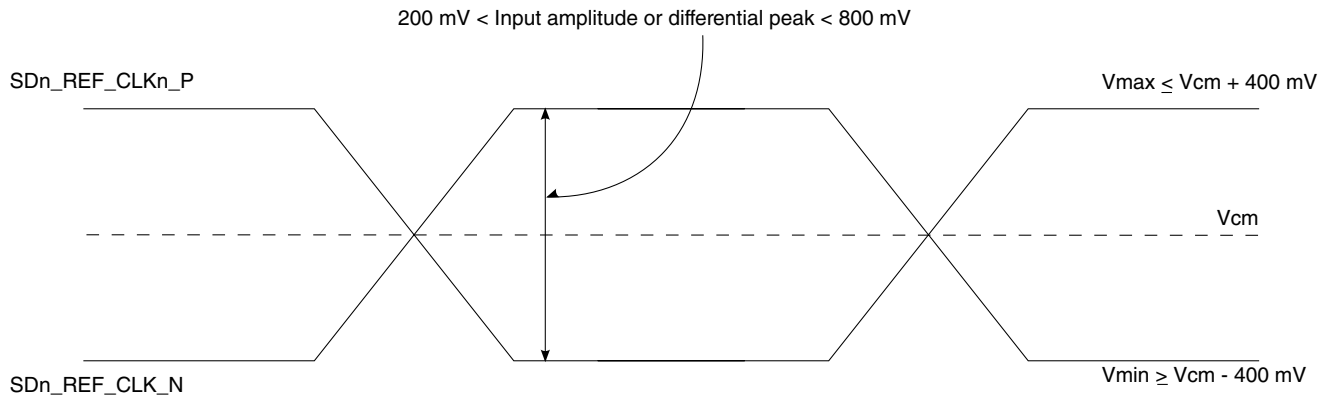


**Figure 69. Differential reference clock input DC requirements (external DC-coupled)**

- For an external AC-coupled connection, there is no common mode voltage requirement for the clock driver. Because the external AC-coupling capacitor blocks the DC level, the clock driver and the SerDes reference clock receiver operate in different common mode voltages. The SerDes reference clock receiver in this connection scheme has its common mode voltage set to  $SD\_GND$ . Each signal wire

## Electrical characteristics

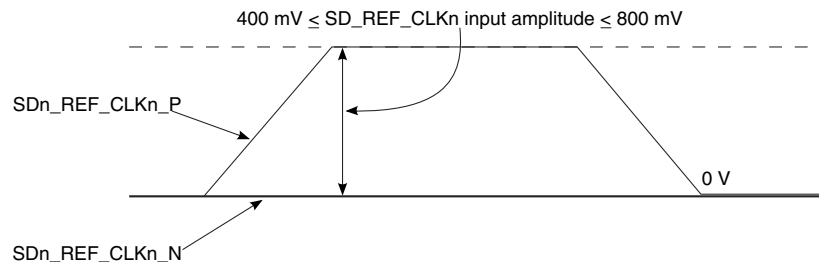
of the differential inputs is allowed to swing below and above the common mode voltage (SD\_GND). [Figure 70](#) shows the SerDes reference clock input requirement for AC-coupled connection scheme.



**Figure 70. Differential reference clock input DC requirements (external AC-coupled)**

Single-ended mode:

- The reference clock can also be single-ended. The  $SDn\_REF\_CLKn\_P$  input amplitude (single-ended swing) must be between 400 mV and 800 mV peak-to-peak (from  $V_{MIN}$  to  $V_{MAX}$ ) with  $SDn\_REF\_CLKn\_N$  either left unconnected or tied to ground.
- The  $SDn\_REF\_CLKn\_P$  input average voltage must be between 200 and 400 mV. [Figure 71](#) shows the SerDes reference clock input requirement for single-ended signaling mode.
- To meet the input amplitude requirement, the reference clock inputs may need to be DC- or AC-coupled externally. For the best noise performance, the reference of the clock could be DC- or AC-coupled into the unused phase ( $SDn\_REF\_CLKn\_N$ ) through the same source impedance as the clock input ( $SDn\_REF\_CLKn\_P$ ) in use.



**Figure 71. Single-ended reference clock input DC requirements**

### 3.22.2.4 AC requirements for SerDes reference clocks

This table lists the AC requirements for SerDes reference clocks for protocols running at data rates up to 8 Gb/s.

This includes PCI Express (2.5, 5, 8 GT/s), SGMII (1.25Gbps), 2.5x SGMII (3.125Gbps), QSGMII (5Gbps), XAUI (3.125 Gbps), and SerDes reference clocks to be guaranteed by the customer's application design.

**Table 65. SDn\_REF\_CLKn\_P/SDn\_REF\_CLKn\_N input clock requirements (SV<sub>Dn</sub> = 1.0 V)<sup>1</sup>**

| Parameter  | Symbol                                 | Min  | Typ            | Max  | Unit      | Notes  |
|--|--|------|----------------|------|-----------|--------|
| frequency range  | t <sub>CLK_REF</sub>                   | —    | 100/125/156.25 | —    | MHz       | 2      |
| clock frequency tolerance  | t <sub>CLK_TOL</sub>                   | -300 | —              | 300  | ppm       | 3      |
| clock frequency tolerance  | t <sub>CLK_TOL</sub>                   | -100 | —              | 100  | ppm       | 4      |
| reference clock duty cycle   | t <sub>CLK_DUTY</sub>                  | 40   | 50             | 60   | %         | 5      |
| max deterministic peak-to-peak jitter at 10 <sup>-6</sup> BER                              | t <sub>CLK_DJ</sub>                    | —    | —              | 42   | ps        | —      |
| total reference clock jitter at 10 <sup>-6</sup> BER (peak-to-peak jitter at refClk input) | t <sub>CLK_TJ</sub>                    | —    | —              | 86   | ps        | 6      |
| 10 kHz to 1.5 MHz RMS jitter   | t <sub>REFCLK-LF-RMS</sub>             | —    | —              | 3    | ps<br>RMS | 7      |
| > 1.5 MHz to Nyquist RMS jitter  | t <sub>REFCLK-HF-RMS</sub>             | —    | —              | 3.1  | ps<br>RMS | 7      |
| RMS reference clock jitter   | t <sub>REFCLK-RMS-DC</sub>             | —    | —              | 1    | ps<br>RMS | 8      |
| rising/falling edge rate   | t <sub>CLKRR</sub> /t <sub>CLKFR</sub> | 1    | —              | 4    | V/ns      | 9      |
| Differential input high voltage  | V <sub>IH</sub>                        | 200  | —              | —    | mV        | 5      |
| Differential input low voltage   | V <sub>IL</sub>                        | —    | —              | -200 | mV        | 5      |
| Rising edge rate to falling edge rate matching   | Rise-Fall Matching                     | —    | —              | 20   | %         | 10, 11 |

**Notes:**

- For recommended operating conditions, see [Table 3](#).
- Caution:** Only 100, 125 and 156.25 have been tested. Inbetween values do not work correctly with the rest of the system.
- For PCI Express (2.5, 5, 8 GT/s)
- For SGMII, 2.5x SGMII, QSGMII, XAUI
- Measurement taken from differential waveform
- Limits from PCI Express CEM Rev 2.0
- For PCI Express-5 GT/s, per PCI Express base specification rev 3.0
- For PCI-Express-8 GT/s, per PCI-Express base specification rev 3.0
- Measured from -200 mV to +200 mV on the differential waveform (derived from minus ). The signal must be monotonic through the measurement region for rise and fall time. The 400 mV measurement window is centered on the differential zero crossing. See [Figure 72](#).
- Measurement taken from single-ended waveform
- Matching applies to rising edge for and falling edge rate for . It is measured using a 200 mV window centered on the median cross point where SDn\_REF\_CLKn\_P rising meets SDn\_REF\_CLKn\_N falling. The median cross point is used to calculate the voltage thresholds that the oscilloscope uses for the edge rate calculations. The rise edge rate of SDn\_REF\_CLKn\_P must be compared to the fall edge rate of SDn\_REF\_CLKn\_N, the maximum allowed difference should not exceed 20% of the slowest edge rate. See [Figure 73](#).

## Electrical characteristics

This table lists the AC requirements for SerDes reference clocks for protocols running at data rates greater than 8 Gb/s.

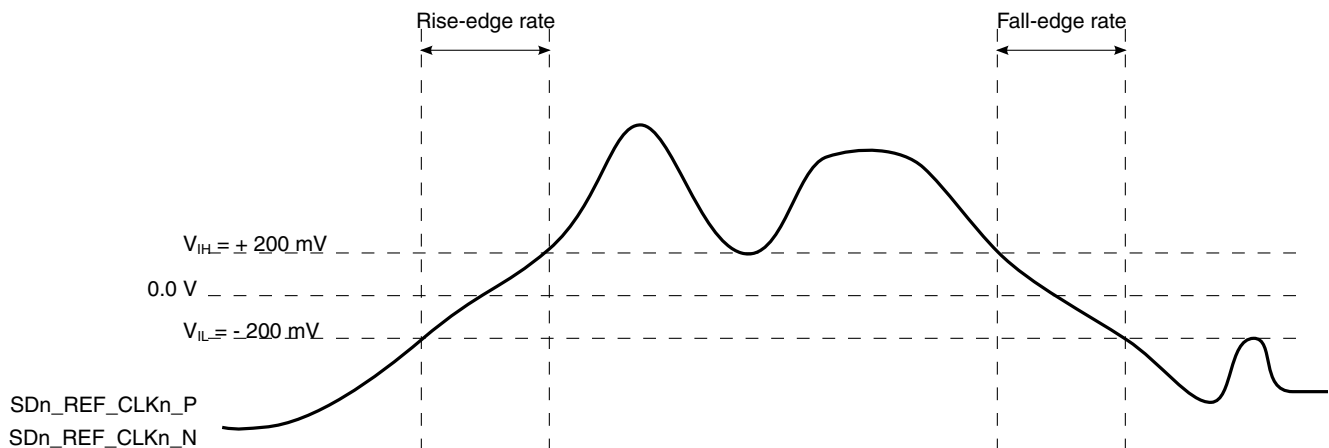
This includes XFI (10.3125 Gbps) SerDes reference clocks to be guaranteed by the customer's application design.

**Table 66. input clock requirements for XFI (10.3125)<sup>1</sup>**

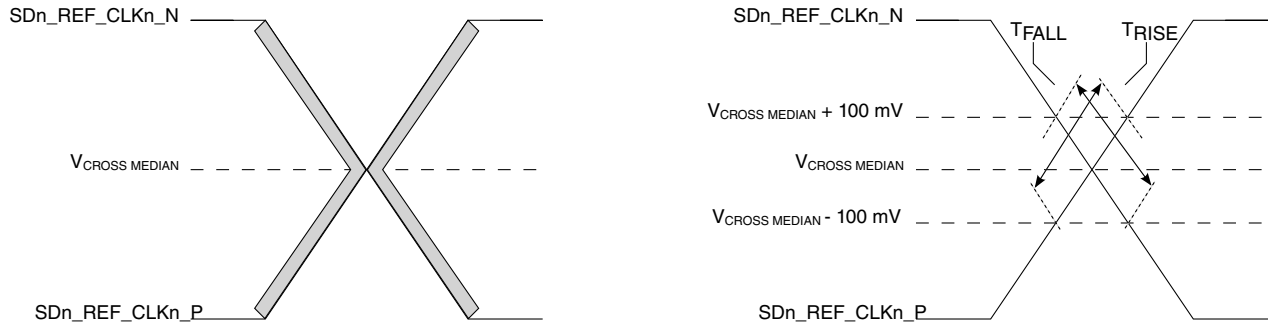
| Parameter  | Symbol                 | Min  | Typ    | Max  | Unit   | Notes |
|--|------------------------|------|--------|------|--------|-------|
| frequency range  | $t_{\text{CLK\_REF}}$  | —    | 156.25 | —    | MHz    | 2     |
| clock frequency tolerance  | $t_{\text{CLK\_TOL}}$  | -100 | —      | 100  | ppm    | —     |
| reference clock duty cycle   | $t_{\text{CLK\_DUTY}}$ | 40   | 50     | 60   | %      | 3     |
| single side band noise   | @ 1 kHz                | —    | —      | -85  | dBC/Hz | 4     |
| single side band noise   | @ 10 kHz               | —    | —      | -108 | dBC/Hz | 4     |
| single side band noise   | @ 100 kHz              | —    | —      | -128 | dBC/Hz | 4     |
| single side band noise   | @ 1 MHz                | —    | —      | -138 | dBC/Hz | 4     |
| single side band noise   | @ 10MHz                | —    | —      | -138 | dBC/Hz | 4     |
| random jitter (1.2 MHz to 15 MHz)                                  | $t_{\text{CLK\_RJ}}$   | —    | —      | 0.8  | ps     | —     |
| total reference clock jitter at $10^{-12}$ BER (1.2 MHz to 15 MHz) | $t_{\text{CLK\_TJ}}$   | —    | —      | 11   | ps     | —     |
| spurious noise (1.2 MHz to 15 MHz)                                 | —                      | —    | —      | -75  | dBC    | —     |

### Notes:

1. For recommended operating conditions, see [Table 3](#).
2. **Caution:** Only 156.25 have been tested. Inbetween values do not work correctly with the rest of the system.
3. Measurement taken from differential waveform.
4. Per XFP Spec. Rev 4.5, the Module Jitter Generation spec at XFI Optical Output is 10mUI (RMS) and 100 mUI (p-p). In the CDR mode the host is contributing 7 mUI (RMS) and 50 mUI (p-p) jitter.



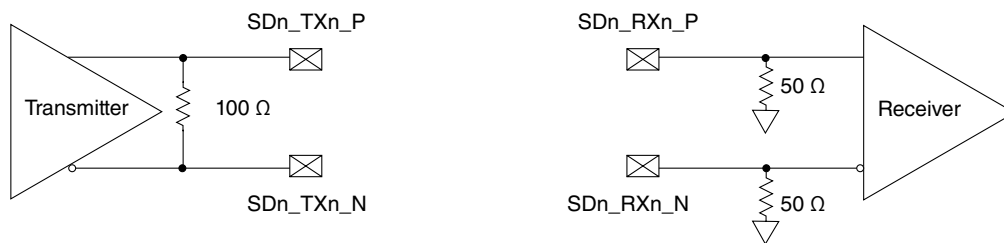
**Figure 72. Differential measurement points for rise and fall time**



**Figure 73. Single-ended measurement points for rise and fall time matching**

### 3.22.3 SerDes transmitter and receiver reference circuits

This figure shows the reference circuits for SerDes data lane's transmitter and receiver.



**Figure 74. SerDes transmitter and receiver reference circuits**

The DC and AC specification of SerDes data lanes are defined in each interface protocol section below based on the application usage:

- [PCI Express](#)
- [XAUI interface](#)
- [Serial ATA \(SATA\) interface](#)
- [SGMII interface](#)
- [QSGMII interface](#)
- [XFI interface](#)

Note that external AC-coupling capacitor is required for the above serial transmission protocols with the capacitor value defined in the specification of each protocol section.

### 3.22.4 PCI Express

This section describes the clocking dependencies, DC and AC electrical specifications for the PCI Express bus.

## Electrical characteristics

If the platform speed runs at 533 MHz, there is no limitation to PCIe speed/width. If the platform speed runs at 500 MHz, all four PCIe controllers can run GEN1 and GEN2 speed at full width. For GEN3 speed, PEX1/PEX2/PEX4 can only run x2 width, PEX3 can only run x4 width.

### 3.22.4.1 Clocking dependencies

The ports on the two ends of a link must transmit data at a rate that is within 600 parts per million (ppm) of each other at all times. This is specified to allow bit rate clock sources with a  $\pm 300$  ppm tolerance.

### 3.22.4.2 PCI Express clocking requirements for SDn\_REF\_CLKn\_P and SDn\_REF\_CLKn\_N

SerDes 1-2 (SD[1:2]\_REF\_CLK[1:2]\_P and SD[1:2]\_REF\_CLK[1:2]\_N) may be used for various SerDes PCI Express configurations based on the RCW Configuration field SRDS\_PRTCL. PCI Express is supported on SerDes 1 and 2.

For more information on these specifications, see [SerDes reference clocks](#).

### 3.22.4.3 PCI Express DC physical layer characteristics

This section contains the DC characteristics for the physical layer of PCI Express on this chip.

#### 3.22.4.3.1 PCI Express DC physical layer transmitter characteristics

This section discusses the PCI Express DC physical layer transmitter specifications for 2.5 GT/s, 5 GT/s and 8 GT/s.

This table defines the PCI Express 2.0 (2.5 GT/s) DC characteristics for the differential output at all transmitters. The parameters are specified at the component pins.

**Table 67. PCI Express 2.5 GT/s differential transmitter output DC characteristics ( $XV_{DD} = 1.35\text{ V}$ )<sup>1</sup>**

| Characteristic                                    | Symbol            | Min | Typical | Max  | Units    | Notes  |
|---|-------------------|-----|---------|------|----------|--|
| Differential peak-to-peak output voltage          | $V_{TX-DIFFp-p}$  | 800 | 1000    | 1200 | mV       | $V_{TX-DIFFp-p} = 2 \times  V_{TX-D+} - V_{TX-D-} $  |
| De-emphasized differential output voltage (ratio) | $V_{TX-DE-RATIO}$ | 3.0 | 3.5     | 4.0  | dB       | Ratio of the $V_{TX-DIFFp-p}$ of the second and following bits after a transition divided by the $V_{TX-DIFFp-p}$ of the first bit after a transition. |
| DC differential transmitter impedance             | $Z_{TX-DIFF-DC}$  | 80  | 100     | 120  | $\Omega$ | Transmitter DC differential mode low Impedance   |

Table continues on the next page...

**Table 67. PCI Express 2.5 GT/s differential transmitter output DC characteristics ( $XV_{DD} = 1.35\text{ V}$ )<sup>1</sup> (continued)**

| Characteristic   | Symbol      | Min | Typical | Max | Units    | Notes  |
|--|-------------|-----|---------|-----|----------|--|
| Transmitter DC impedance   | $Z_{TX-DC}$ | 40  | 50      | 60  | $\Omega$ | Required transmitter D+ as well as D- DC Impedance during all states |
| <b>Notes:</b>  |             |     |         |     |          |  |
| 1. For recommended operating conditions, see <a href="#">Table 3</a> . |             |     |         |     |          |  |

This table defines the PCI Express 2.0 (5 GT/s) DC characteristics for the differential output at all transmitters. The parameters are specified at the component pins.

**Table 68. PCI Express 5 GT/s differential transmitter output DC characteristics ( $XV_{DD} = 1.35\text{ V}$ )<sup>1</sup>**

| Parameter  | Symbol                  | Min | Typical | Max  | Units    | Notes  |
|--|-------------------------|-----|---------|------|----------|--|
| Differential peak-to-peak output voltage                               | $V_{TX-DIFFp-p}$        | 800 | 1000    | 1200 | mV       | $V_{TX-DIFFp-p} = 2 \times  V_{TX-D+} - V_{TX-D-} $  |
| Low power differential peak-to-peak output voltage                     | $V_{TX-DIFFp-p\_low}$   | 400 | 500     | 1200 | mV       | $V_{TX-DIFFp-p} = 2 \times  V_{TX-D+} - V_{TX-D-} $  |
| De-emphasized differential output voltage (ratio)                      | $V_{TX-DE-RATIO-3.5dB}$ | 3.0 | 3.5     | 4.0  | dB       | Ratio of the $V_{TX-DIFFp-p}$ of the second and following bits after a transition divided by the $V_{TX-DIFFp-p}$ of the first bit after a transition. |
| De-emphasized differential output voltage (ratio)                      | $V_{TX-DE-RATIO-6.0dB}$ | 5.5 | 6.0     | 6.5  | dB       | Ratio of the $V_{TX-DIFFp-p}$ of the second and following bits after a transition divided by the $V_{TX-DIFFp-p}$ of the first bit after a transition. |
| DC differential transmitter impedance                                  | $Z_{TX-DIFF-DC}$        | 80  | 100     | 120  | $\Omega$ | Transmitter DC differential mode low impedance   |
| Transmitter DC Impedance   | $Z_{TX-DC}$             | 40  | 50      | 60   | $\Omega$ | Required transmitter D+ as well as D- DC impedance during all states   |
| <b>Notes:</b>  |                         |     |         |      |          |  |
| 1. For recommended operating conditions, see <a href="#">Table 3</a> . |                         |     |         |      |          |  |

This table defines the PCI Express 3.0 (8 GT/s) DC characteristics for the differential output at all transmitters. The parameters are specified at the component pins.

**Table 69. PCI Express 8 GT/s differential transmitter output DC characteristics ( $XV_{DD} = 1.35\text{ V}$ )<sup>3</sup>**

| Parameter                                       | Symbol            | Min | Typical | Max  | Units | Notes       |
|---|-------------------|-----|---------|------|-------|-------------|
| Full swing transmitter voltage with no TX Eq    | $V_{TX-FS-NO-EQ}$ | 800 | —       | 1300 | mVp-p | See Note 1. |
| Reduced swing transmitter voltage with no TX Eq | $V_{TX-RS-NO-EQ}$ | 400 | —       | 1300 | mV    | See Note 1. |

Table continues on the next page...

## Electrical characteristics

**Table 69. PCI Express 8 GT/s differential transmitter output DC characteristics ( $XV_{DD} = 1.35\text{ V}$ )<sup>3</sup> (continued)**

| Parameter   | Symbol                  | Min | Typical | Max | Units    | Notes  |
|---|-------------------------|-----|---------|-----|----------|--|
| De-emphasized differential output voltage (ratio) | $V_{TX-DE-RATIO-3.5dB}$ | 3.0 | 3.5     | 4.0 | dB       | —  |
| De-emphasized differential output voltage (ratio) | $V_{TX-DE-RATIO-6.0dB}$ | 5.5 | 6.0     | 6.5 | dB       | —  |
| Minimum swing during EIEOS for full swing         | $V_{TX-EIEOS-FS}$       | 250 | —       | —   | mVp-p    | See Note 2   |
| Minimum swing during EIEOS for reduced swing      | $V_{TX-EIEOS-RS}$       | 232 | —       | —   | mVp-p    | See Note 2   |
| DC differential transmitter impedance             | $Z_{TX-DIFF-DC}$        | 80  | 100     | 120 | $\Omega$ | Transmitter DC differential mode low impedance                       |
| Transmitter DC Impedance                          | $Z_{TX-DC}$             | 40  | 50      | 60  | $\Omega$ | Required transmitter D+ as well as D- DC impedance during all states |

**Notes:**

1. Voltage measurements for  $V_{TX-FS-NO-EQ}$  and  $V_{TX-RS-NO-EQ}$  are made using the 64-zeroes/64-ones pattern in the compliance pattern.
2. Voltage limits comprehend both full swing and reduced swing modes. The transmitter must reject any changes that would violate this specification. The maximum level is covered in the  $V_{TX-FS-NO-EQ}$  measurement which represents the maximum peak voltage the transmitter can drive. The  $V_{TX-EIEOS-FS}$  and  $V_{TX-EIEOS-RS}$  voltage limits are imposed to guarantee the EIEOS threshold of 175 mV<sub>P-P</sub> at the receiver pin. This parameter is measured using the actual EIEOS pattern that is part of the compliance pattern and then removing the ISI contribution of the breakout channel.
3. For recommended operating conditions, see [Table 3](#).

**3.22.4.4 PCI Express DC physical layer receiver specifications**

This section discusses the PCI Express DC physical layer receiver specifications for 2.5 GT/s, 5 GT/s and 8 GT/s.

This table defines the DC characteristics for the PCI Express 1.0 (2.5 GT/s) differential input at all receivers. The parameters are specified at the component pins.

**Table 70. PCI Express 2.5 GT/s differential receiver input DC characteristics ( $SV_{DD} = 1.0\text{ V}$ )<sup>4</sup>**

| Characteristic                          | Symbol           | Min | Typ  | Max  | Units    | Notes  |
|---|------------------|-----|------|------|----------|--|
| Differential input peak-to-peak voltage | $V_{RX-DIFFp-p}$ | 120 | 1000 | 1200 | mV       | $V_{RX-DIFFp-p} = 2 \times  V_{RX-D+} - V_{RX-D-} $ See Note 1.                                |
| DC differential input impedance         | $Z_{RX-DIFF-DC}$ | 80  | 100  | 120  | $\Omega$ | Receiver DC differential mode impedance. See Note 2  |
| DC input impedance                      | $Z_{RX-DC}$      | 40  | 50   | 60   | $\Omega$ | Required receiver D+ as well as D- DC Impedance ( $50 \pm 20\%$ tolerance). See Notes 1 and 2. |

Table continues on the next page...

**Table 70. PCI Express 2.5 GT/s differential receiver input DC characteristics (SV<sub>DD</sub> = 1.0 V)<sup>4</sup> (continued)**

| Characteristic                   | Symbol                           | Min | Typ | Max | Units | Notes   |
|----------------------------------|----------------------------------|-----|-----|-----|-------|---|
| Powered down DC input impedance  | Z <sub>RX-HIGH-IMP-DC</sub>      | 50  | —   | —   | kΩ    | Required receiver D+ as well as D- DC Impedance when the receiver terminations do not have power. See Note 3. |
| Electrical idle detect threshold | V <sub>RX-IDLE-DET-DIFFp-p</sub> | 65  | —   | 175 | mV    | $V_{RX-IDLE-DET-DIFFp-p} = 2 \times  V_{RX-D+} - V_{RX-D-} $<br>Measured at the package pins of the receiver  |

**Notes:**

1. Measured at the package pins with a test load of 50 Ω to GND on each pin.
2. Impedance during all LTSSM states. When transitioning from a fundamental reset to detect (the initial state of the LTSSM) there is a 5 ms transition time before receiver termination values must be met on all unconfigured lanes of a port.
3. The receiver DC common mode impedance that exists when no power is present or fundamental reset is asserted. This helps ensure that the receiver detect circuit does not falsely assume a receiver is powered on when it is not. This term must be measured at 300 mV above the receiver ground.
4. For recommended operating conditions, see [Table 3](#).

This table defines the DC characteristics for the PCI Express 2.0 (5 GT/s) differential input at all receivers. The parameters are specified at the component pins.

**Table 71. PCI Express 5 GT/s differential receiver input DC characteristics (SV<sub>DD</sub> = 1.0 V)<sup>4</sup>**

| Characteristic                          | Symbol                           | Min | Typ  | Max  | Units | Notes   |
|---|----------------------------------|-----|------|------|-------|---|
| Differential input peak-to-peak voltage | V <sub>RX-DIFFp-p</sub>          | 120 | 1000 | 1200 | mV    | $V_{RX-DIFFp-p} = 2 \times  V_{RX-D+} - V_{RX-D-} $<br>See Note 1.  |
| DC differential input impedance         | Z <sub>RX-DIFF-DC</sub>          | 80  | 100  | 120  | Ω     | Receiver DC differential mode impedance. See Note 2   |
| DC input impedance                      | Z <sub>RX-DC</sub>               | 40  | 50   | 60   | Ω     | Required receiver D+ as well as D- DC Impedance (50 ± 20% tolerance). See Notes 1 and 2.                      |
| Powered down DC input impedance         | Z <sub>RX-HIGH-IMP-DC</sub>      | 50  | —    | —    | kΩ    | Required receiver D+ as well as D- DC Impedance when the receiver terminations do not have power. See Note 3. |
| Electrical idle detect threshold        | V <sub>RX-IDLE-DET-DIFFp-p</sub> | 65  | —    | 175  | mV    | $V_{RX-IDLE-DET-DIFFp-p} = 2 \times  V_{RX-D+} - V_{RX-D-} $<br>Measured at the package pins of the receiver  |

**Notes:**

1. Measured at the package pins with a test load of 50 Ω to GND on each pin.
2. Impedance during all LTSSM states. When transitioning from a fundamental reset to detect (the initial state of the LTSSM) there is a 5 ms transition time before receiver termination values must be met on all unconfigured lanes of a port.

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**Table 71. PCI Express 5 GT/s differential receiver input DC characteristics ( $SV_{DD} = 1.0 V$ )<sup>4</sup>**

| Characteristic  | Symbol | Min | Typ | Max | Units | Notes |
|---|--------|-----|-----|-----|-------|-------|
| 3. The receiver DC common mode impedance that exists when no power is present or fundamental reset is asserted. This helps ensure that the receiver detect circuit does not falsely assume a receiver is powered on when it is not. This term must be measured at 300 mV above the receiver ground. |        |     |     |     |       |       |
| 4. For recommended operating conditions, see <a href="#">Table 3</a> .  |        |     |     |     |       |       |

This table defines the DC characteristics for the PCI Express 3.0 (8 GT/s) differential input at all receivers. The parameters are specified at the component pins.

**Table 72. PCI Express 8 GT/s differential receiver input DC characteristics ( $SV_{DD} = 1.0 V$ )<sup>6</sup>**

| Characteristic                   | Symbol                    | Min | Typ | Max | Units      | Notes   |
|----------------------------------|---------------------------|-----|-----|-----|------------|---|
| DC differential input impedance  | $Z_{RX-DIFF-DC}$          | 80  | 100 | 120 | $\Omega$   | Receiver DC differential mode impedance. See Note 2   |
| DC input impedance               | $Z_{RX-DC}$               | 40  | 50  | 60  | $\Omega$   | Required receiver D+ as well as D- DC Impedance ( $50 \pm 20\%$ tolerance). See Notes 1 and 2.                |
| Powered down DC input impedance  | $Z_{RX-HIGH-IMP-DC}$      | 50  | —   | —   | k $\Omega$ | Required receiver D+ as well as D- DC Impedance when the receiver terminations do not have power. See Note 3. |
| Generator launch voltage         | $V_{RX-LAUNCH-8G}$        | —   | 800 | —   | mV         | Measured at TP1 per PCI Express base spec. rev 3.0  |
| Eye height (-20dB Channel)       | $V_{RX-SV-8G}$            | 25  | —   | —   | mV         | Measured at TP2P per PCI Express base spec. rev 3.0. See Notes 4, 5   |
| Eye height (-12dB Channel)       | $V_{RX-SV-8G}$            | 50  | —   | —   | mV         | Measured at TP2P per PCI Express base spec. rev 3.0. See Notes 4, 5   |
| Eye height (-3dB Channel)        | $V_{RX-SV-8G}$            | 200 | —   | —   | mV         | Measured at TP2P per PCI Express base spec. rev 3.0. See Notes 4, 5   |
| Electrical idle detect threshold | $V_{RX-IDLE-DET-DIFFp-p}$ | 65  | —   | 175 | mV         | $V_{RX-IDLE-DET-DIFFp-p} = 2 \times  V_{RX-D+} - V_{RX-D-} $<br>Measured at the package pins of the receiver  |

**Notes:**

1. Measured at the package pins with a test load of  $50 \Omega$  to GND on each pin.
2. Impedance during all LTSSM states. When transitioning from a fundamental reset to detect (the initial state of the LTSSM) there is a 5 ms transition time before receiver termination values must be met on all unconfigured lanes of a port.
3. The receiver DC common mode impedance that exists when no power is present or fundamental reset is asserted. This helps ensure that the receiver detect circuit does not falsely assume a receiver is powered on when it is not. This term must be measured at 300 mV above the receiver ground.
4.  $V_{RX-SV-8G}$  is tested at three different voltages to ensure the receiver device under test is capable of equalizing over a range of channel loss profiles. The "SV" in the parameter names refers to stressed voltage.
5.  $V_{RX-SV-8G}$  is referenced to TP2P and is obtained after post processing data captured at TP2.
6. For recommended operating conditions, see [Table 3](#).

### 3.22.4.5 PCI Express AC physical layer specifications

This section contains the AC specifications for the physical layer of PCI Express on this device.

#### 3.22.4.5.1 PCI Express AC physical layer transmitter specifications

This section discusses the PCI Express AC physical layer transmitter specifications for 2.5 GT/s, 5 GT/s and 8 GT/s.

This table defines the PCI Express 1.0 (2.5 GT/s) AC specifications for the differential output at all transmitters. The parameters are specified at the component pins. The AC timing specifications do not include RefClk jitter.

**Table 73. PCI Express 2.5 GT/s differential transmitter output AC specifications<sup>4</sup>**

| Parameter  | Symbol                                   | Min    | Typ | Max    | Units | Notes  |
|--|--|--------|-----|--------|-------|--|
| Unit interval  | UI                                       | 399.88 | 400 | 400.12 | ps    | Each UI is 400 ps $\pm$ 300 ppm. UI does not account for spread-spectrum clock dictated variations.  |
| Minimum transmitter eye width  | T <sub>TX-EYE</sub>                      | 0.75   | —   | —      | UI    | The maximum transmitter jitter can be derived as T <sub>TX-MAX-JITTER</sub> = 1 - T <sub>TX-EYE</sub> = 0.25 UI. Does not include spread-spectrum or RefCLK jitter. Includes device random jitter at 10 <sup>-12</sup> .<br>See Notes 1 and 2.   |
| Maximum time between the jitter median and maximum deviation from the median | T <sub>TX-EYE-MEDIAN-to-MAX-JITTER</sub> | —      | —   | 0.125  | UI    | Jitter is defined as the measurement variation of the crossing points (V <sub>TX-DIFFp-p</sub> = 0 V) in relation to a recovered transmitter UI. A recovered transmitter UI is calculated over 3500 consecutive unit intervals of sample data. Jitter is measured using all edges of the 250 consecutive UI in the center of the 3500 UI used for calculating the transmitter UI. See Notes 1 and 2. |
| AC coupling capacitor  | C <sub>TX</sub>                          | 75     | —   | 200    | nF    | All transmitters must be AC coupled. The AC coupling is required either within the media or within the transmitting component itself. See Note 3.  |

**Notes:**

1. Specified at the measurement point into a timing and voltage test load as shown in [Figure 76](#) and measured over any 250 consecutive transmitter UIs.
2. A T<sub>TX-EYE</sub> = 0.75 UI provides for a total sum of deterministic and random jitter budget of T<sub>TX-JITTER-MAX</sub> = 0.25 UI for the transmitter collected over any 250 consecutive transmitter UIs. The T<sub>TX-EYE-MEDIAN-to-MAX-JITTER</sub> median is less than half of the total transmitter jitter budget collected over any 250 consecutive transmitter UIs. It must be noted that the median is not the same as the mean. The jitter median describes the point in time where the number of jitter points on either side is approximately equal as opposed to the averaged time value.
3. The chip's SerDes transmitter does not have C<sub>TX</sub> built-in. An external AC coupling capacitor is required.
4. For recommended operating conditions, see [Table 3](#).

**Electrical characteristics**

This table defines the PCI Express 2.0 (5 GT/s) AC specifications for the differential output at all transmitters. The parameters are specified at the component pins. The AC timing specifications do not include RefClk jitter.

**Table 74. PCI Express 5 GT/s differential transmitter output AC specifications<sup>3</sup>**

| Parameter                                      | Symbol                   | Min    | Typ    | Max    | Units | Notes   |
|--|--------------------------|--------|--------|--------|-------|---|
| Unit Interval                                  | UI                       | 199.94 | 200.00 | 200.06 | ps    | Each UI is 200 ps $\pm$ 300 ppm. UI does not account for spread-spectrum clock dictated variations.   |
| Minimum transmitter eye width                  | T <sub>TX-EYE</sub>      | 0.75   | —      | —      | UI    | The maximum transmitter jitter can be derived as: T <sub>TX-MAX-JITTER</sub> = 1 - T <sub>TX-EYE</sub> = 0.25 UI.<br>See Note 1.                  |
| Transmitter RMS deterministic jitter > 1.5 MHz | T <sub>TX-HF-DJ-DD</sub> | —      | —      | 0.15   | ps    | —   |
| Transmitter RMS deterministic jitter < 1.5 MHz | T <sub>TX-LF-RMS</sub>   | —      | 3.0    | —      | ps    | Reference input clock RMS jitter (< 1.5 MHz) at pin < 1 ps  |
| AC coupling capacitor                          | C <sub>TX</sub>          | 75     | —      | 200    | nF    | All transmitters must be AC coupled. The AC coupling is required either within the media or within the transmitting component itself. See Note 2. |

**Notes:**

1. Specified at the measurement point into a timing and voltage test load as shown in [Figure 76](#) and measured over any 250 consecutive transmitter UIs.
2. The chip's SerDes transmitter does not have C<sub>TX</sub> built-in. An external AC coupling capacitor is required.
3. For recommended operating conditions, see [Table 3](#).

This table defines the PCI Express 3.0 (8 GT/s) AC specifications for the differential output at all transmitters. The parameters are specified at the component pins. The AC timing specifications do not include RefClk jitter.

**Table 75. PCI Express 8 GT/s differential transmitter output AC specifications<sup>4</sup>**

| Parameter  | Symbol                   | Min      | Typ    | Max      | Units  | Notes   |
|--|--------------------------|----------|--------|----------|--------|---|
| Unit Interval  | UI                       | 124.9625 | 125.00 | 125.0375 | ps     | Each UI is 125 ps $\pm$ 300 ppm. UI does not account for spread-spectrum clock dictated variations. |
| Transmitter uncorrelated total jitter  | T <sub>TX-UTJ</sub>      | —        | —      | 31.25    | ps p-p | —   |
| Transmitter uncorrelated deterministic jitter                                    | T <sub>TX-UDJ-DD</sub>   | —        | —      | 12       | ps p-p | —   |
| Total uncorrelated pulse width jitter (PWJ)                                      | T <sub>TX-UPW-TJ</sub>   | —        | —      | 24       | ps p-p | See Note 1, 2   |
| Deterministic data dependent jitter (DjDD) uncorrelated pulse width jitter (PWJ) | T <sub>TX-UPW-DJDD</sub> | —        | —      | 10       | ps p-p | See Note 1, 2   |

Table continues on the next page...

**Table 75. PCI Express 8 GT/s differential transmitter output AC specifications<sup>4</sup> (continued)**

| Parameter             | Symbol       | Min | Typ | Max | Units  | Notes   |
|-----------------------|--------------|-----|-----|-----|--------|---|
| Data dependent jitter | $T_{TX-DDJ}$ | —   | —   | 18  | ps p-p | See Note 2  |
| AC coupling capacitor | $C_{TX}$     | 176 | —   | 265 | nF     | All transmitters must be AC coupled. The AC coupling is required either within the media or within the transmitting component itself. See Note 3. |

**Notes:**

1. PWJ parameters shall be measured after data dependent jitter (DDJ) separation.
2. Measured with optimized preset value after de-embedding to transmitter pin.
3. The chip's SerDes transmitter does not have  $C_{TX}$  built-in. An external AC coupling capacitor is required.
4. For recommended operating conditions, see [Table 3](#).

### 3.22.4.5.2 PCI Express AC physical layer receiver specifications

This section discusses the PCI Express AC physical layer receiver specifications for 2.5 GT/s, 5 GT/s and 8 GT/s.

This table defines the AC specifications for the PCI Express 2.0 (2.5 GT/s) differential input at all receivers. The parameters are specified at the component pins. The AC timing specifications do not include RefClk jitter.

**Table 76. PCI Express 2.5 GT/s differential receiver input AC specifications<sup>4</sup>**

| Parameter   | Symbol                            | Min    | Typ    | Max    | Units | Notes   |
|---|-----------------------------------|--------|--------|--------|-------|---|
| Unit Interval   | UI                                | 399.88 | 400.00 | 400.12 | ps    | Each UI is 400 ps $\pm$ 300 ppm. UI does not account for spread-spectrum clock dictated variations.   |
| Minimum receiver eye width  | $T_{RX-EYE}$                      | 0.4    | —      | —      | UI    | The maximum interconnect media and transmitter jitter that can be tolerated by the receiver can be derived as $T_{RX-MAX-JITTER} = 1 - T_{RX-EYE} = 0.6$ UI.<br>See Notes 1 and 2.  |
| Maximum time between the jitter median and maximum deviation from the median. | $T_{RX-EYE-MEDIAN-to-MAX-JITTER}$ | —      | —      | 0.3    | UI    | Jitter is defined as the measurement variation of the crossing points ( $V_{RX-DIFFp-p} = 0$ V) in relation to a recovered transmitter UI. A recovered transmitter UI is calculated over 3500 consecutive unit intervals of sample data. Jitter is measured using all edges of the 250 consecutive UI in the center of the 3500 UI used for calculating the transmitter UI. See Notes 1, 2 and 3. |

**Notes:**

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**Table 76. PCI Express 2.5 GT/s differential receiver input AC specifications<sup>4</sup>**

| Parameter  | Symbol | Min | Typ | Max | Units | Notes |
|--|--------|-----|-----|-----|-------|-------|
| <p>1. Specified at the measurement point and measured over any 250 consecutive UIs. The test load in <a href="#">Figure 76</a> must be used as the receiver device when taking measurements. If the clocks to the receiver and transmitter are not derived from the same reference clock, the transmitter UI recovered from 3500 consecutive UI must be used as a reference for the eye diagram.</p> <p>2. A <math>T_{RX-EYE} = 0.40</math> UI provides for a total sum of 0.60 UI deterministic and random jitter budget for the transmitter and interconnect collected any 250 consecutive UIs. The TRX-EYE-MEDIAN-to-MAX-JITTER specification ensures a jitter distribution in which the median and the maximum deviation from the median is less than half of the total. UI jitter budget collected over any 250 consecutive transmitter UIs. It must be noted that the median is not the same as the mean. The jitter median describes the point in time where the number of jitter points on either side is approximately equal as opposed to the averaged time value. If the clocks to the receiver and transmitter are not derived from the same reference clock, the transmitter UI recovered from 3500 consecutive UI must be used as the reference for the eye diagram.</p> <p>3. It is recommended that the recovered transmitter UI is calculated using all edges in the 3500 consecutive UI interval with a fit algorithm using a minimization merit function. Least squares and median deviation fits have worked well with experimental and simulated data.</p> <p>4. For recommended operating conditions, see <a href="#">Table 3</a>.</p> |        |     |     |     |       |       |

This table defines the AC specifications for the PCI Express 2.0 (5 GT/s) differential input at all receivers. The parameters are specified at the component pins. The AC timing specifications do not include RefClk jitter.

**Table 77. PCI Express 5 GT/s differential receiver input AC specifications<sup>1</sup>**

| Parameter  | Symbol            | Min    | Typ    | Max    | Units | Notes   |
|--|-------------------|--------|--------|--------|-------|---|
| Unit Interval  | UI                | 199.40 | 200.00 | 200.06 | ps    | Each UI is 200 ps $\pm$ 300 ppm. UI does not account for spread-spectrum clock dictated variations. |
| Max receiver inherent timing error                                     | $T_{RX-TJ-CC}$    | —      | —      | 0.4    | UI    | The maximum inherent total timing error for common RefClk receiver architecture                     |
| Max receiver inherent deterministic timing error                       | $T_{RX-DJ-DD-CC}$ | —      | —      | 0.30   | UI    | The maximum inherent deterministic timing error for common RefClk receiver architecture             |
| <b>Note:</b>   |                   |        |        |        |       |   |
| 1. For recommended operating conditions, see <a href="#">Table 3</a> . |                   |        |        |        |       |   |

This table defines the AC specifications for the PCI Express 3.0 (8 GT/s) differential input at all receivers. The parameters are specified at the component pins. The AC timing specifications do not include RefClk jitter.

**Table 78. PCI Express 8 GT/s differential receiver input AC specifications<sup>5</sup>**

| Parameter         | Symbol         | Min      | Typ    | Max      | Units | Notes   |
|-------------------|----------------|----------|--------|----------|-------|---|
| Unit Interval     | UI             | 124.9625 | 125.00 | 125.0375 | ps    | Each UI is 125 ps $\pm$ 300 ppm. UI does not account for spread-spectrum clock dictated variations. See Note 1. |
| Eye Width at TP2P | $T_{RX-SV-8G}$ | 0.3      | —      | 0.35     | UI    | See Note 1  |

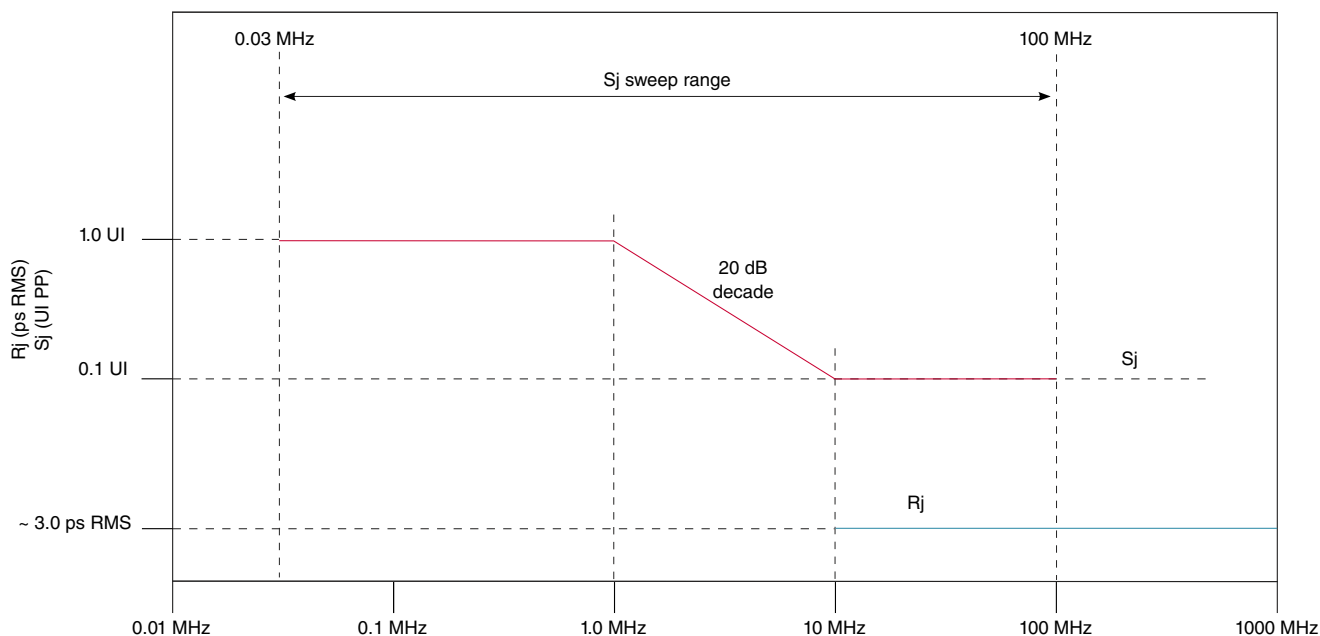
Table continues on the next page...

**Table 78. PCI Express 8 GT/s differential receiver input AC specifications<sup>5</sup> (continued)**

| Parameter                      | Symbol              | Min | Typ | Max | Units  | Notes   |
|--------------------------------|---------------------|-----|-----|-----|--------|---|
| Differential mode interference | $V_{RX-SV-DIFF-8G}$ | 14  | —   | —   | mV     | Frequency = 2.1GHz. See Note 2.                             |
| Sinusoidal Jitter at 100 MHz   | $T_{RX-SV-SJ-8G}$   | —   | —   | 0.1 | UI p-p | Fixed at 100 MHz. See Note 3.                               |
| Random Jitter                  | $T_{RX-SV-RJ-8G}$   | —   | —   | 2.0 | ps RMS | Random jitter spectrally flat before filtering. See Note 4. |

**Note:**

- $T_{RX-SV-8G}$  is referenced to TP2P and obtained after post processing data captured at TP2.  $T_{RX-SV-8G}$  includes the effects of applying the behavioral receiver model and receiver behavioral equalization.
- $V_{RX-SV-DIFF-8G}$  voltage may need to be adjusted over a wide range for the different loss calibration channels.
- The sinusoidal jitter in the total jitter tolerance may have any amplitude and frequency as shown in [Figure 75](#).
- Random jitter (Rj) is applied over the following range: The low frequency limit may be between 1.5 and 10 MHz, and the upper limit is 1.0 GHz. See [Figure 75](#) for details. Rj may be adjusted to meet the 0.3 UI value for  $T_{RX-SV-8G}$ .
- For recommended operating conditions, see [Table 3](#).

**Figure 75. Swept sinusoidal jitter mask****3.22.4.6 Test and measurement load**

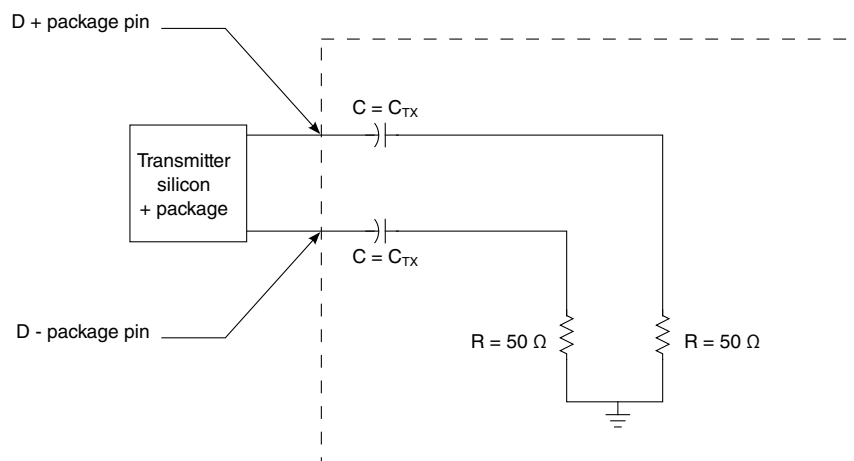
The AC timing and voltage parameters must be verified at the measurement point. The package pins of the device must be connected to the test/measurement load within 0.2 inches of that load, as shown in the following figure.

**NOTE**

The allowance of the measurement point to be within 0.2 inches of the package pins is meant to acknowledge that package/

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board routing may benefit from D+ and D- not being exactly matched in length at the package pin boundary. If the vendor does not explicitly state where the measurement point is located, the measurement point is assumed to be the D+ and D- package pins.



**Figure 76. Test/measurement load**

### 3.22.5 Serial ATA (SATA) interface

This section describes the DC and AC electrical specifications for the serial ATA (SATA) interface.

#### 3.22.5.1 SATA DC electrical characteristics

This section describes the DC electrical characteristics for SATA.

##### 3.22.5.1.1 SATA DC transmitter output characteristics

The table below provides the DC differential transmitter output DC characteristics for the SATA interface at Gen1i/1m 1.5 Gbits/s transmission.

**Table 79. Gen1i/1m 1.5G transmitter (Tx) DC specifications ( $XV_{DD} = 1.35 V$ )<sup>3</sup>**

| Parameter                               | Symbol               | Min | Typ | Max | Units    | Notes |
|---|----------------------|-----|-----|-----|----------|-------|
| Transmitter differential output voltage | $V_{SATA\_TXDIFF}$   | 400 | 500 | 600 | mV p-p   | 1     |
| Transmitter differential pair impedance | $Z_{SATA\_TXDIFFIM}$ | 85  | 100 | 115 | $\Omega$ | 2     |

**Notes:**

**Table 79. Gen1i/1m 1.5G transmitter (Tx) DC specifications ( $XV_{DD} = 1.35\text{ V}$ )<sup>3</sup>**

| Parameter  | Symbol | Min | Typ | Max | Units | Notes |
|--|--------|-----|-----|-----|-------|-------|
| 1. Terminated by 50 $\Omega$ load.                                     |        |     |     |     |       |       |
| 2. DC impedance.   |        |     |     |     |       |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a> . |        |     |     |     |       |       |

The table below provides the differential transmitter output DC characteristics for the SATA interface at Gen2i/2m 3.0 Gbits/s transmission.

**Table 80. Gen 2i/2m 3.0G transmitter (Tx) DC specifications ( $XV_{DD} = 1.35\text{ V}$ )<sup>3</sup>**

| Parameter  | Symbol               | Min | Typ | Max | Units    | Notes |
|--|----------------------|-----|-----|-----|----------|-------|
| Transmitter diff output voltage  | $V_{SATA\_TXDIFF}$   | 400 | -   | 700 | mV p-p   | 1     |
| Transmitter differential pair impedance                                | $Z_{SATA\_TXDIFFIM}$ | 85  | 100 | 115 | $\Omega$ | 2     |
| 1. Terminated by 50 $\Omega$ load.                                     |                      |     |     |     |          |       |
| 2. DC impedance.   |                      |     |     |     |          |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a> . |                      |     |     |     |          |       |

The table below provides the differential transmitter output DC characteristics for the SATA interface at Gen3i 6.0 Gbits/s transmission.

**Table 81. Gen 3i 6.0G transmitter (Tx) DC specifications ( $XV_{DD} = 1.35\text{ V}$ )<sup>3</sup>**

| Parameter  | Symbol               | Min | Typ | Max | Units    | Notes |
|--|----------------------|-----|-----|-----|----------|-------|
| Transmitter diff output voltage  | $V_{SATA\_TXDIFF}$   | 240 | -   | 900 | mV p-p   | 1     |
| Transmitter differential pair impedance                                | $Z_{SATA\_TXDIFFIM}$ | 85  | 100 | 115 | $\Omega$ | 2     |
| 1. Terminated by 50 $\Omega$ load.                                     |                      |     |     |     |          |       |
| 2. DC impedance.   |                      |     |     |     |          |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a> . |                      |     |     |     |          |       |

### 3.22.5.1.2 SATA DC receiver (Rx) input characteristics

The table below provides the Gen1i/1m 1.5Gbits/s differential receiver input DC characteristics for the SATA interface.

**Table 82. Gen1i/1m 1.5G receiver input DC specifications ( $SV_{DD} = 1.0\text{ V}$ )<sup>3</sup>**

| Parameter                             | Symbol             | Min | Typical | Max | Units    | Notes |
|---------------------------------------|--------------------|-----|---------|-----|----------|-------|
| Differential input voltage            | $V_{SATA\_RXDIFF}$ | 240 | -       | 600 | mV p-p   | 1     |
| Differential receiver input impedance | $Z_{SATA\_RXSEIM}$ | 85  | 100     | 115 | $\Omega$ | 2     |

Table continues on the next page...

**Electrical characteristics****Table 82. Gen1i/1m 1.5G receiver input DC specifications ( $SV_{DD} = 1.0 V$ )<sup>3</sup> (continued)**

| Parameter   | Symbol          | Min | Typical | Max | Units  | Notes |
|---|-----------------|-----|---------|-----|--------|-------|
| OOB signal detection threshold  | $V_{SATA\_OOB}$ | 50  | 100     | 200 | mV p-p | -     |
| 1. Voltage relative to common of either signal comprising a differential pair<br>2. DC impedance.<br>3. For recommended operating conditions, see <a href="#">Table 3</a> . |                 |     |         |     |        |       |

The table below provides the Gen2i/2m 3Gbits/s differential receiver input DC characteristics for the SATA interface.

**Table 83. Gen2i/2m 3G receiver input DC specifications ( $SV_{DD} = 1.0 V$ )<sup>3</sup>**

| Parameter   | Symbol             | Min | Typical | Max | Units    | Notes |
|---|--------------------|-----|---------|-----|----------|-------|
| Differential input voltage  | $V_{SATA\_RXDIFF}$ | 240 | -       | 750 | mV p-p   | 1     |
| Differential receiver input impedance   | $Z_{SATA\_RXSEIM}$ | 85  | 100     | 115 | $\Omega$ | 2     |
| OOB signal detection threshold  | $V_{SATA\_OOB}$    | 75  | 125     | 200 | mV p-p   | -     |
| <b>Notes:</b><br>1. Voltage relative to common of either signal comprising a differential pair<br>2. DC impedance<br>3. For recommended operating conditions, see <a href="#">Table 3</a> . |                    |     |         |     |          |       |

The table below provides the Gen3i 6Gbits/s differential receiver input DC characteristics for the SATA interface.

**Table 84. Gen3i 6G receiver input DC specifications ( $SV_{DD} = 1.0 V$ )<sup>3</sup>**

| Parameter   | Symbol             | Min | Typical | Max  | Units    | Notes |
|---|--------------------|-----|---------|------|----------|-------|
| Differential input voltage  | $V_{SATA\_RXDIFF}$ | 240 | -       | 1000 | mV p-p   | 1     |
| Differential receiver input impedance   | $Z_{SATA\_RXSEIM}$ | 85  | 100     | 115  | $\Omega$ | 2     |
| OOB signal detection threshold  | $V_{SATA\_OOB}$    | 75  | 125     | 200  | mV p-p   | -     |
| <b>Notes:</b><br>1. Voltage relative to common of either signal comprising a differential pair<br>2. DC impedance<br>3. For recommended operating conditions, see <a href="#">Table 3</a> . |                    |     |         |      |          |       |

**3.22.5.2 SATA AC timing specifications**

This section discusses the SATA AC timing specifications.

### 3.22.5.2.1 AC requirements for SATA REF\_CLK

The AC requirements for the SATA reference clock are listed in the [Table 85](#) to be guaranteed by the customer's application design.

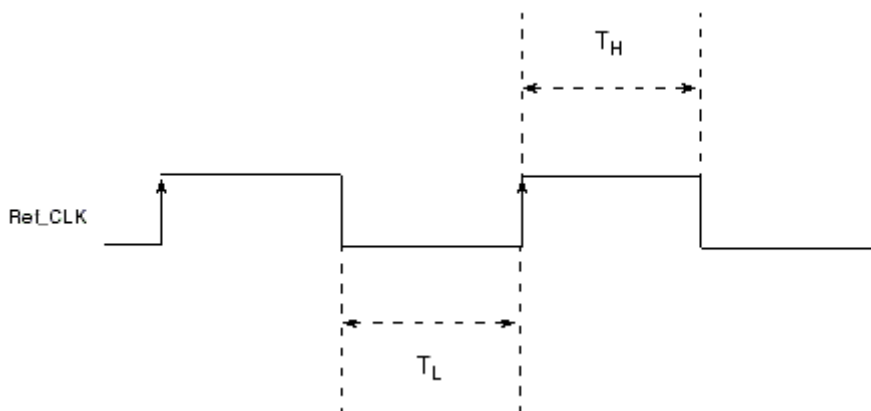
**Table 85. SATA reference clock input requirements**

| Parameter  | Symbol          | Min  | Typ     | Max  | Unit | Notes   |
|--|-----------------|------|---------|------|------|---------|
| SD_REF_CLK/SD_REF_CLK frequency range  | $t_{CLK\_REF}$  | -    | 100/125 | -    | MHz  | 1       |
| SD_REF_CLK/SD_REF_CLK clock frequency tolerance                              | $t_{CLK\_TOL}$  | -350 | -       | +350 | ppm  | -       |
| SD_REF_CLK/SD_REF_CLK reference clock duty cycle                             | $t_{CLK\_DUTY}$ | 40   | 50      | 60   | %    | -       |
| SD_REF_CLK/SD_REF_CLK cycle-to-cycle clock jitter (period jitter)            | $t_{CLK\_CJ}$   | -    | -       | 100  | ps   | 2       |
| SD_REF_CLK/SD_REF_CLK total reference clock jitter, phase jitter (peak-peak) | $t_{CLK\_PJ}$   | -50  | -       | +50  | ps   | 2, 3, 4 |

**Notes:**

- Caution:** Only 100, 125MHz have been tested. In-between values do not work correctly with the rest of the system.
- At RefClk input
- In a frequency band from 150 kHz to 15 MHz at BER of  $10^{-12}$
- Total peak-to-peak deterministic jitter should be less than or equal to 50 ps.

The figure below shows the reference clock timing waveform.



**Figure 77. Reference clock timing waveform**

### 3.22.5.2.2 AC transmitter output characteristics

The table below provides the differential transmitter output AC characteristics for the SATA interface at Gen1i/1m 1.5Gbits/s transmission. The AC timing specifications do not include RefClk jitter.

## Electrical characteristics

**Table 86. Gen1i/1m 1.5G transmitter (Tx) AC specifications ( $XV_{DD} = 1.35 V$ )<sup>2</sup>**

| Parameter                              | Symbol                | Min      | Typ      | Max      | Units  | Notes |
|--|-----------------------|----------|----------|----------|--------|-------|
| Channel speed                          | $t_{CH\_SPEED}$       | -        | 1.5      | -        | Gbps   | -     |
| Unit Interval                          | $T_{UI}$              | 666.4333 | 666.6667 | 670.2333 | ps     | -     |
| Total jitter data-data 5 UI            | $U_{SATA\_TXTJ5UI}$   | -        | -        | 0.355    | UI p-p | 1     |
| Total jitter, data-data 250 UI         | $U_{SATA\_TXTJ250UI}$ | -        | -        | 0.47     | UI p-p | 1     |
| Deterministic jitter, data-data 5 UI   | $U_{SATA\_TXDJ5UI}$   | -        | -        | 0.175    | UI p-p | 1     |
| Deterministic jitter, data-data 250 UI | $U_{SATA\_TXDJ250UI}$ | -        | -        | 0.22     | UI p-p | 1     |

1. Measured at transmitter output pins peak to peak phase variation, random data pattern  
2. For recommended operating conditions, see [Table 3](#).

The table below provides the differential transmitter output AC characteristics for the SATA interface at Gen2i/2m 3.0 Gbits/s transmission. The AC timing specifications do not include RefClk jitter.

**Table 87. Gen 2i/2m 3G transmitter (Tx) AC specifications ( $XV_{DD} = 1.35 V$ )<sup>2</sup>**

| Parameter   | Symbol                  | Min      | Typ      | Max      | Units  | Notes |
|---|-------------------------|----------|----------|----------|--------|-------|
| Channel speed   | $t_{CH\_SPEED}$         | -        | 3.0      | -        | Gbps   | -     |
| Unit Interval   | $T_{UI}$                | 333.2167 | 333.3333 | 335.1167 | ps     | -     |
| Total jitter $f_{C3dB} = f_{BAUD} \div 10$            | $U_{SATA\_TXTJfB/10}$   | -        | -        | 0.3      | UI p-p | 1     |
| Total jitter $f_{C3dB} = f_{BAUD} \div 500$           | $U_{SATA\_TXTJfB/500}$  | -        | -        | 0.37     | UI p-p | 1     |
| Total jitter $f_{C3dB} = f_{BAUD} \div 1667$          | $U_{SATA\_TXTJfB/1667}$ | -        | -        | 0.55     | UI p-p | 1     |
| Deterministic jitter, $f_{C3dB} = f_{BAUD} \div 10$   | $U_{SATA\_TXDJfB/10}$   | -        | -        | 0.17     | UI p-p | 1     |
| Deterministic jitter, $f_{C3dB} = f_{BAUD} \div 500$  | $U_{SATA\_TXDJfB/500}$  | -        | -        | 0.19     | UI p-p | 1     |
| Deterministic jitter, $f_{C3dB} = f_{BAUD} \div 1667$ | $U_{SATA\_TXDJfB/1667}$ | -        | -        | 0.35     | UI p-p | 1     |

1. Measured at transmitter output pins peak-to-peak phase variation, random data pattern  
2. For recommended operating conditions, see [Table 3](#).

The table below provides the differential transmitter output AC characteristics for the SATA interface at Gen3i 6.0 Gbits/s transmission. The AC timing specifications do not include RefClk jitter.

**Table 88. Gen 3i 6G transmitter (Tx) AC specifications ( $XV_{DD} = 1.35 V$ )<sup>2</sup>**

| Parameter   | Symbol   | Min      | Typ      | Max      | Units  | Notes |
|---|----------|----------|----------|----------|--------|-------|
| Unit Interval   | $T_{UI}$ | 166.6083 | 166.6667 | 167.5583 | ps     | -     |
| Total jitter before and after compliance interconnect channel | JT       | -        | -        | 0.52     | UI p-p | 1     |

Table continues on the next page...

**Table 88. Gen 3i 6G transmitter (Tx) AC specifications ( $V_{DD} = 1.35 V$ )<sup>2</sup> (continued)**

| Parameter  | Symbol | Min | Typ | Max  | Units  | Notes |
|--|--------|-----|-----|------|--------|-------|
| Random jitter before compliance interconnect channel | JR     | -   | -   | 0.18 | UI p-p | 1     |

1. Measured at transmitter output pins peak-to-peak phase variation, random data pattern  
2. For recommended operating conditions, see [Table 3](#).

**3.22.5.2.3 AC differential receiver input characteristics**

The table below provides the Gen1i/1m or 1.5Gbits/s differential receiver input AC characteristics for the SATA interface.

**Table 89. Gen 1i/1m 1.5G receiver (Rx) AC specifications ( $V_{DD} = 1.0 V$ )<sup>3</sup>**

| Parameter                              | Symbol                | Min      | Typical  | Max      | Units  | Notes |
|--|-----------------------|----------|----------|----------|--------|-------|
| Unit Interval                          | $T_{UI}$              | 666.4333 | 666.6667 | 670.2333 | ps     | -     |
| Total jitter data-data 5 UI            | $U_{SATA\_TXTJ5UI}$   | -        | -        | 0.43     | UI p-p | 1     |
| Total jitter, data-data 250 UI         | $U_{SATA\_TXTJ250UI}$ | -        | -        | 0.60     | UI p-p | 1     |
| Deterministic jitter, data-data 5 UI   | $U_{SATA\_TXDJ5UI}$   | -        | -        | 0.25     | UI p-p | 1     |
| Deterministic jitter, data-data 250 UI | $U_{SATA\_TXDJ250UI}$ | -        | -        | 0.35     | UI p-p | 1     |

1. Measured at receiver.  
2. The AC timing specifications do not include RefClk jitter.  
3. For recommended operating conditions, see [Table 3](#).

The table below provides the differential receiver input AC characteristics for the SATA interface at Gen2i/2m 3.0 Gbits/s transmission.

**Table 90. Gen 2i/2m 3G receiver (Rx) AC specifications ( $V_{DD} = 1.0 V$ )<sup>3</sup>**

| Parameter   | Symbol                  | Min      | Typical  | Max      | Units  | Notes |
|---|-------------------------|----------|----------|----------|--------|-------|
| Unit Interval   | $T_{UI}$                | 333.2167 | 333.3333 | 335.1167 | ps     | -     |
| Total jitter $f_{C3dB} = f_{BAUD} \div 10$            | $U_{SATA\_TXTJfB/10}$   | -        | -        | 0.46     | UI p-p | 1     |
| Total jitter $f_{C3dB} = f_{BAUD} \div 500$           | $U_{SATA\_TXTJfB/500}$  | -        | -        | 0.60     | UI p-p | 1     |
| Total jitter $f_{C3dB} = f_{BAUD} \div 1667$          | $U_{SATA\_TXTJfB/1667}$ | -        | -        | 0.65     | UI p-p | 1     |
| Deterministic jitter, $f_{C3dB} = f_{BAUD} \div 10$   | $U_{SATA\_TXDJfB/10}$   | -        | -        | 0.35     | UI p-p | 1     |
| Deterministic jitter, $f_{C3dB} = f_{BAUD} \div 500$  | $U_{SATA\_TXDJfB/500}$  | -        | -        | 0.42     | UI p-p | 1     |
| Deterministic jitter, $f_{C3dB} = f_{BAUD} \div 1667$ | $U_{SATA\_TXDJfB/1667}$ | -        | -        | 0.35     | UI p-p | 1     |

1. Measured at receiver.  
2. The AC timing specifications do not include RefClk jitter.  
3. For recommended operating conditions, see [Table 3](#).

## Electrical characteristics

The table below provides the Gen3i 6.0Gbits/s differential receiver input AC characteristics for the SATA interface.

**Table 91. Gen 3i 6.0G receiver (Rx) AC specifications ( $SV_{DD} = 1.0 V$ )<sup>3</sup>**

| Parameter   | Symbol   | Min      | Typical  | Max      | Units  | Notes |
|---|----------|----------|----------|----------|--------|-------|
| Unit Interval   | $T_{UI}$ | 166.6083 | 166.6667 | 167.5583 | ps     | -     |
| Total jitter after compliance interconnect channel  | $J_T$    | -        | -        | 0.60     | UI p-p | 1     |
| Random jitter before compliance interconnect channel  | $J_R$    | -        | -        | 0.18     | UI p-p | 1     |
| 1. Measured at receiver.<br>2. The AC timing specifications do not include RefClk jitter.<br>3. For recommended operating conditions, see <a href="#">Table 3</a> . |          |          |          |          |        |       |

### 3.22.6 SGMII interface

Each SGMII port features a 4-wire AC-coupled serial link from the SerDes interface of the chip, as shown in [Figure 78](#), where  $C_{TX}$  is the external (on board) AC-coupled capacitor. Each SerDes transmitter differential pair features 100- $\Omega$  output impedance. Each input of the SerDes receiver differential pair features 50- $\Omega$  on-die termination to SD\_GND. The reference circuit of the SerDes transmitter and receiver is shown in [Figure 74](#).

#### 3.22.6.1 SGMII clocking requirements for

When operating in SGMII mode, a SerDes reference clock is required on SDn\_REF\_CLK[1:2]\_P and SDn\_REF\_CLK[1:2]\_Npins. Both SerDes 1 and SerDes 2 may be used for SGMII configurations based on the RCW Configuration field SRDS\_PRTCL.

For more information on these specifications, see [SerDes reference clocks](#).

#### 3.22.6.2 SGMII DC electrical characteristics

This section discusses the electrical characteristics for the SGMII interface.

### 3.22.6.2.1 SGMII and SGMII 2.5x transmit DC characteristics

This table describes the SGMII SerDes transmitter AC-coupled DC electrical characteristics. Transmitter DC characteristics are measured at the transmitter outputs ( $SDn\_TXn\_P$  and  $SDn\_TXn\_N$ ) as shown in [Figure 79](#).

**Table 92. SGMII DC transmitter electrical characteristics ( $XV_{DD} = 1.35\text{ V}$ )<sup>4</sup>**

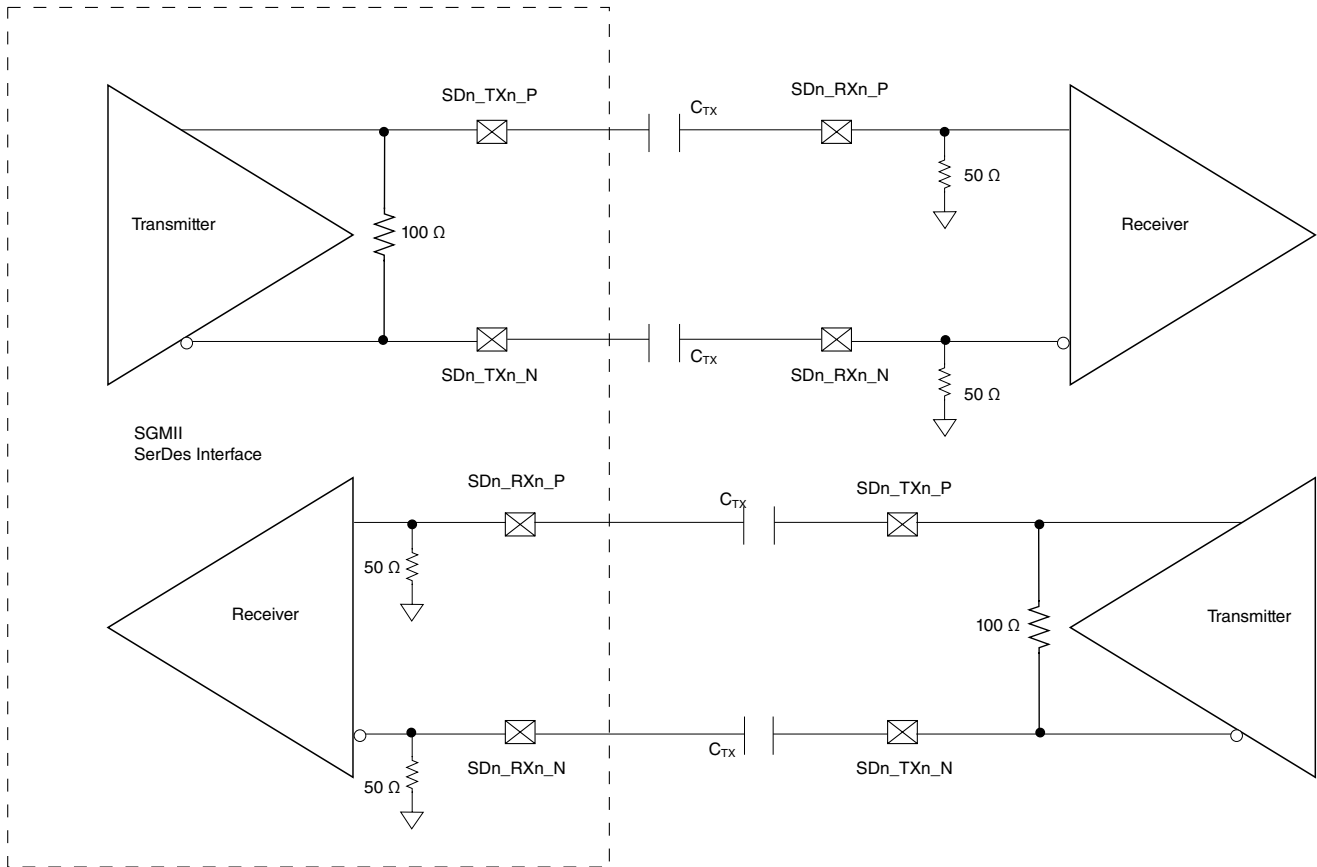
| Parameter   | Symbol     | Min                 | Typ   | Max                          | Unit     | Notes |
|---|------------|---------------------|-------|------------------------------|----------|-------|
| Output high voltage   | $V_{OH}$   | —                   | —     | $1.5 \times  V_{OD} _{-max}$ | mV       | 1     |
| Output low voltage  | $V_{OL}$   | $ V_{OD} _{-min}/2$ | —     | —                            | mV       | 1     |
| Output differential voltage <sup>2, 3</sup><br>( $XV_{DD-Typ}$ at 1.35 V) | $ V_{OD} $ | 320                 | 500.0 | 725.0                        | mV       | —     |
|   |            | 293.8               | 459.0 | 665.6                        |          | —     |
|   |            | 266.9               | 417.0 | 604.7                        |          | —     |
|   |            | 240.6               | 376.0 | 545.2                        |          | —     |
|   |            | 213.1               | 333.0 | 482.9                        |          | —     |
|   |            | 186.9               | 292.0 | 423.4                        |          | —     |
|   |            | 160.0               | 250.0 | 362.5                        |          | —     |
| Output impedance (differential)   | $R_O$      | 80                  | 100   | 120                          | $\Omega$ | —     |

**Notes:**

1. This does not align to DC-coupled SGMII.
2.  $|V_{OD}| = |V_{SD\_TXn\_P} - V_{SD\_TXn\_N}|$ .  $|V_{OD}|$  is also referred to as output differential peak voltage.  $V_{TX-DIFFp-p} = 2 \times |V_{OD}|$ .
3. The  $|V_{OD}|$  value shown in the Typ column is based on the condition of  $XVDD\_SRDSn-Typ = 1.35\text{ V}$ , no common mode offset variation. SerDes transmitter is terminated with 100- $\Omega$  differential load between  $SDn\_TXn\_P$  and  $SDn\_TXn\_N$ .
4. For recommended operating conditions, see [Table 3](#).

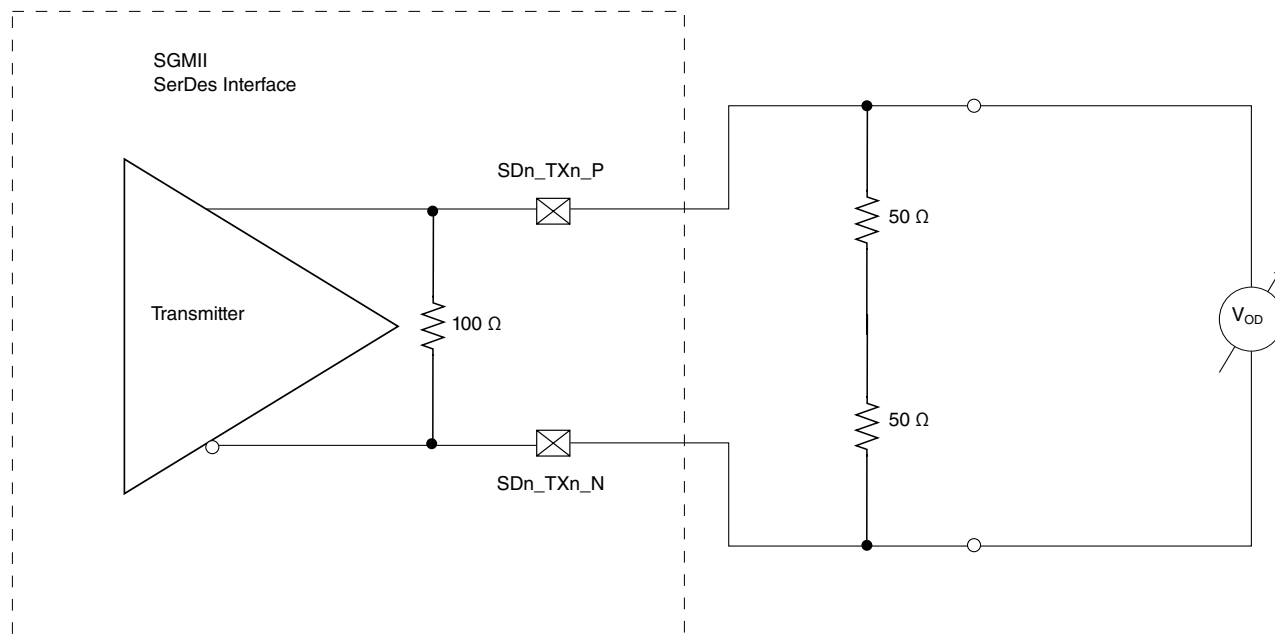
This figure shows an example of a 4-wire AC-coupled SGMII serial link connection.

## Electrical characteristics



**Figure 78. 4-wire AC-coupled SGMII serial link connection example**

This figure shows the SGMII transmitter DC measurement circuit.



**Figure 79. SGMII transmitter DC measurement circuit**

This table defines the SGMII 2.5x transmitter DC electrical characteristics for 3.125 GBaud.

**Table 93. SGMII 2.5x transmitter DC electrical characteristics ( $XV_{DD} = 1.35\text{ V}$ )<sup>1</sup>**

| Parameter                       | Symbol     | Min | Typical | Max | Unit     | Notes |
|---------------------------------|------------|-----|---------|-----|----------|-------|
| Output differential voltage     | $ V_{OD} $ | 400 | —       | 600 | mV       | —     |
| Output impedance (differential) | $R_O$      | 80  | 100     | 120 | $\Omega$ | —     |

**Notes:**

1. For recommended operating conditions, see [Table 3](#).

### 3.22.6.2.2 SGMII and SGMII 2.5x DC receiver electrical characteristics

This table lists the SGMII DC receiver electrical characteristics. Source synchronous clocking is not supported. Clock is recovered from the data.

**Table 94. SGMII DC receiver electrical characteristics ( $SV_{DD} = 1.0\text{V}$ )<sup>4</sup>**

| Parameter                  | Symbol            | Min | Typ | Max  | Unit | Notes |
|----------------------------|-------------------|-----|-----|------|------|-------|
| DC input voltage range     | —                 | N/A |     |      | —    | 1     |
| Input differential voltage | $V_{RX\_DIFFp-p}$ | 100 | —   | 1200 | mV   | 2     |
|                            |                   | 175 | —   |      |      |       |
| Loss of signal threshold   | $V_{LOS}$         | 30  | —   | 100  | mV   | 3     |
|                            |                   | 65  | —   | 175  |      |       |

Table continues on the next page...

## Electrical characteristics

**Table 94. SGMII DC receiver electrical characteristics ( $SV_{DD} = 1.0V$ )<sup>4</sup> (continued)**

| Parameter   | Symbol         | Min | Typ | Max | Unit     | Notes |
|---|----------------|-----|-----|-----|----------|-------|
| Receiver differential input impedance   | $Z_{RX\_DIFF}$ | 80  | —   | 120 | $\Omega$ | —     |
| <b>Notes:</b>   |                |     |     |     |          |       |
| 1. Input must be externally AC coupled.   |                |     |     |     |          |       |
| 2. $V_{RX\_DIFFp-p}$ is also referred to as peak-to-peak input differential voltage.  |                |     |     |     |          |       |
| 3. The concept of this parameter is equivalent to the electrical idle detect threshold parameter in PCI Express. See <a href="#">PCI Express DC physical layer receiver specifications</a> , and <a href="#">PCI Express AC physical layer receiver specifications</a> , for further explanation. |                |     |     |     |          |       |
| 4. For recommended operating conditions, see <a href="#">Table 3</a> .  |                |     |     |     |          |       |

This table defines the SGMII 2.5x receiver DC electrical characteristics for 3.125 GBaud.

**Table 95. SGMII 2.5x receiver DC timing specifications ( $SV_{DD} = 1.0V$ )<sup>1</sup>**

| Parameter  | Symbol            | Min | Typical | Max  | Unit     | Notes |
|--|-------------------|-----|---------|------|----------|-------|
| Input differential voltage   | $V_{RX\_DIFFp-p}$ | 200 | —       | 1200 | mV       | —     |
| Loss of signal threshold   | $V_{LOS}$         | 75  | —       | 200  | mV       | —     |
| Receiver differential input impedance                                  | $Z_{RX\_DIFF}$    | 80  | —       | 120  | $\Omega$ | —     |
| <b>Note:</b>   |                   |     |         |      |          |       |
| 1. For recommended operating conditions, see <a href="#">Table 3</a> . |                   |     |         |      |          |       |

**3.22.6.3 SGMII AC timing specifications**

This section discusses the AC timing specifications for the SGMII interface.

**3.22.6.3.1 SGMII and SGMII 2.5x transmit AC timing specifications**

This table provides the SGMII and SGMII 2.5x transmit AC timing specifications. A source synchronous clock is not supported. The AC timing specifications do not include RefClk jitter.

**Table 96. SGMII transmit AC timing specifications<sup>3</sup>**

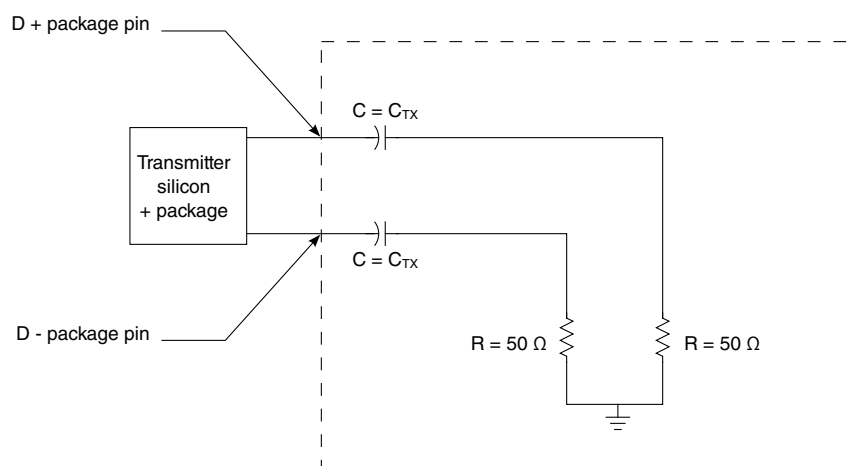
| Parameter   | Symbol   | Min           | Typ | Max           | Unit   | Notes |
|---|----------|---------------|-----|---------------|--------|-------|
| Deterministic jitter  | JD       | —             | —   | 0.17          | UI p-p | —     |
| Total jitter  | JT       | —             | —   | 0.35          | UI p-p | —     |
| Unit Interval: 1.25 GBaud (SGMII)                           | UI       | 800 - 100 ppm | 800 | 800 + 100 ppm | ps     | 1     |
| Unit Interval: 3.125 GBaud (2.5x SGMII)                     | UI       | 320 - 100 ppm | 320 | 320 + 100 ppm | ps     | 1     |
| AC coupling capacitor                                       | $C_{TX}$ | 10            | —   | 200           | nF     | 2     |
| <b>Notes:</b>   |          |               |     |               |        |       |
| 1. Each UI is 800 ps $\pm$ 100 ppm or 320 ps $\pm$ 100 ppm. |          |               |     |               |        |       |

**Table 96. SGMII transmit AC timing specifications<sup>3</sup>**

| Parameter   | Symbol | Min | Typ | Max | Unit | Notes |
|---|--------|-----|-----|-----|------|-------|
| 2. The external AC coupling capacitor is required. It is recommended that it be placed near the device transmitter outputs. |        |     |     |     |      |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a> .  |        |     |     |     |      |       |

### 3.22.6.3.2 SGMII AC measurement details

Transmitter and receiver AC specifications are measured at the transmitter outputs ( $\_TXn\_P$  and  $\_TXn\_N$ ) or at the receiver inputs ( $\_RXn\_P$  and  $\_RXn\_N$ ) respectively, as depicted in this figure.

**Figure 80. SGMII AC test/measurement load**

### 3.22.6.3.3 SGMII and SGMII 2.5x receiver AC timing specification

This table provides the SGMII and SGMII 2.5x receiver AC timing specifications. The AC timing specifications do not include RefClk jitter. Source synchronous clocking is not supported. The clock is recovered from the data.

**Table 97. SGMII receiver AC timing specifications<sup>3</sup>**

| Parameter  | Symbol   | Min           | Typ | Max           | Unit   | Notes |
|--|----------|---------------|-----|---------------|--------|-------|
| Deterministic jitter tolerance                     | $J_D$    | —             | —   | 0.37          | UI p-p | 1     |
| Combined deterministic and random jitter tolerance | $J_{DR}$ | —             | —   | 0.55          | UI p-p | 1     |
| Total jitter tolerance                             | $J_T$    | —             | —   | 0.65          | UI p-p | 1, 2  |
| Bit error ratio                                    | BER      | —             | —   | $10^{-12}$    | —      | —     |
| Unit Interval: 1.25 GBaud (SGMII)                  | UI       | 800 - 100 ppm | 800 | 800 + 100 ppm | ps     | 1     |
| Unit Interval: 3.125 GBaud (2.5x SGMII)            | UI       | 320 - 100 ppm | 320 | 320 + 100 ppm | ps     | 1     |

**Notes:**

## Electrical characteristics

**Table 97. SGMII receiver AC timing specifications<sup>3</sup>**

| Parameter  | Symbol | Min | Typ | Max | Unit | Notes |
|--|--------|-----|-----|-----|------|-------|
| 1. Measured at receiver  |        |     |     |     |      |       |
| 2. Total jitter is composed of three components: deterministic jitter, random jitter, and single frequency sinusoidal jitter. The sinusoidal jitter component is included to ensure margin for low frequency jitter, wander, noise, crosstalk and other variable system effects. |        |     |     |     |      |       |
| 3. For recommended operating conditions, see <a href="#">Table 3</a> .   |        |     |     |     |      |       |

**3.22.7 QSGMII interface**

This section describes the QSGMII clocking and its DC and AC electrical characteristics.

**3.22.7.1 QSGMII clocking requirements for SD<sub>n</sub>\_REF\_CLK<sub>n</sub>\_P and SD<sub>n</sub>\_REF\_CLK<sub>n</sub>\_N**

For more information on these specifications, see [SerDes reference clocks](#).

**3.22.7.2 QSGMII DC electrical characteristics**

This section discusses the electrical characteristics for the SGMII interface.

**3.22.7.2.1 QSGMII transmitter DC characteristics**

This table describes the QSGMII SerDes transmitter AC-coupled DC electrical characteristics. Transmitter DC characteristics are measured at the transmitter outputs (SD<sub>n</sub>\_TX<sub>n</sub>\_P and SD<sub>n</sub>\_TX<sub>n</sub>\_N).

**Table 98. QSGMII DC transmitter electrical characteristics (XV<sub>DD</sub> = 1.35 V)<sup>1</sup>**

| Characteristic   | Symbol            | Min | Typ | Max | Unit | Notes |
|--|-------------------|-----|-----|-----|------|-------|
| Output differential voltage  | V <sub>DIFF</sub> | 400 | —   | 900 | mV   | —     |
| Differential resistance  | T <sub>RD</sub>   | 80  | 100 | 120 | Ω    | —     |
| <b>Note:</b>   |                   |     |     |     |      |       |
| 1. For recommended operating conditions, see <a href="#">Table 3</a> . |                   |     |     |     |      |       |

**3.22.7.2.2 QSGMII DC receiver electrical characteristics**

This table defines the QSGMII receiver DC electrical characteristics.

**Table 99. QSGMII receiver DC timing specifications ( $SV_{DD} = 1.0V$ )<sup>1</sup>**

| Parameter                  | Symbol     | Min | Typical | Max | Unit     | Notes |
|----------------------------|------------|-----|---------|-----|----------|-------|
| Input differential voltage | $V_{DIFF}$ | 100 | —       | 900 | mV       | —     |
| Differential resistance    | $R_{RDIN}$ | 80  | 100     | 120 | $\Omega$ | —     |

**Notes:**

1. For recommended operating conditions, see [Table 3](#).

### 3.22.7.3 QSGMII AC timing specifications

This section discusses the AC timing specifications for the QSGMII interface.

#### 3.22.7.3.1 QSGMII transmitter AC timing specifications

This table provides the QSGMII transmitter AC timing specifications.

**Table 100. QSGMII transmitter AC timing specifications<sup>1</sup>**

| Parameter                            | Symbol     | Min             | Typ   | Max             | Unit   | Notes |
|--------------------------------------|------------|-----------------|-------|-----------------|--------|-------|
| Transmitter baud rate                | $T_{BAUD}$ | 5.000 - 100 ppm | 5.000 | 5.000 + 100 ppm | Gb/s   | —     |
| Uncorrelated high probability jitter | $T_{UHPJ}$ | —               | —     | 0.15            | UI p-p | —     |
| Total jitter tolerance               | $J_T$      | —               | —     | 0.30            | UI p-p | —     |

**Notes:**

1. For recommended operating conditions, see [Table 3](#).

#### 3.22.7.3.2 QSGMII receiver AC timing Specification

This table provides the QSGMII receiver AC timing specifications.

**Table 101. QSGMII receiver AC timing specifications<sup>2</sup>**

| Parameter   | Symbol       | Min             | Typ   | Max             | Unit   | Notes |
|---|--------------|-----------------|-------|-----------------|--------|-------|
| Receiver baud rate                                | $R_{BAUD}$   | 5.000 - 100 ppm | 5.000 | 5.000 + 100 ppm | Gb/s   | —     |
| Uncorrelated bounded high probability jitter      | $R_{DJ}$     | —               | —     | 0.15            | UI p-p | —     |
| Correlated bounded high probability jitter        | $R_{CBHPJ}$  | —               | —     | 0.30            | UI p-p | 1     |
| Bounded high probability jitter                   | $R_{BHPJ}$   | —               | —     | 0.45            | UI p-p | —     |
| Sinusoidal jitter, maximum                        | $R_{SJ-max}$ | —               | —     | 5.00            | UI p-p | —     |
| Sinusoidal jitter, high frequency                 | $R_{SJ-hf}$  | —               | —     | 0.05            | UI p-p | —     |
| Total jitter (does not include sinusoidal jitter) | $R_{Tj}$     | —               | —     | 0.60            | UI p-p | —     |

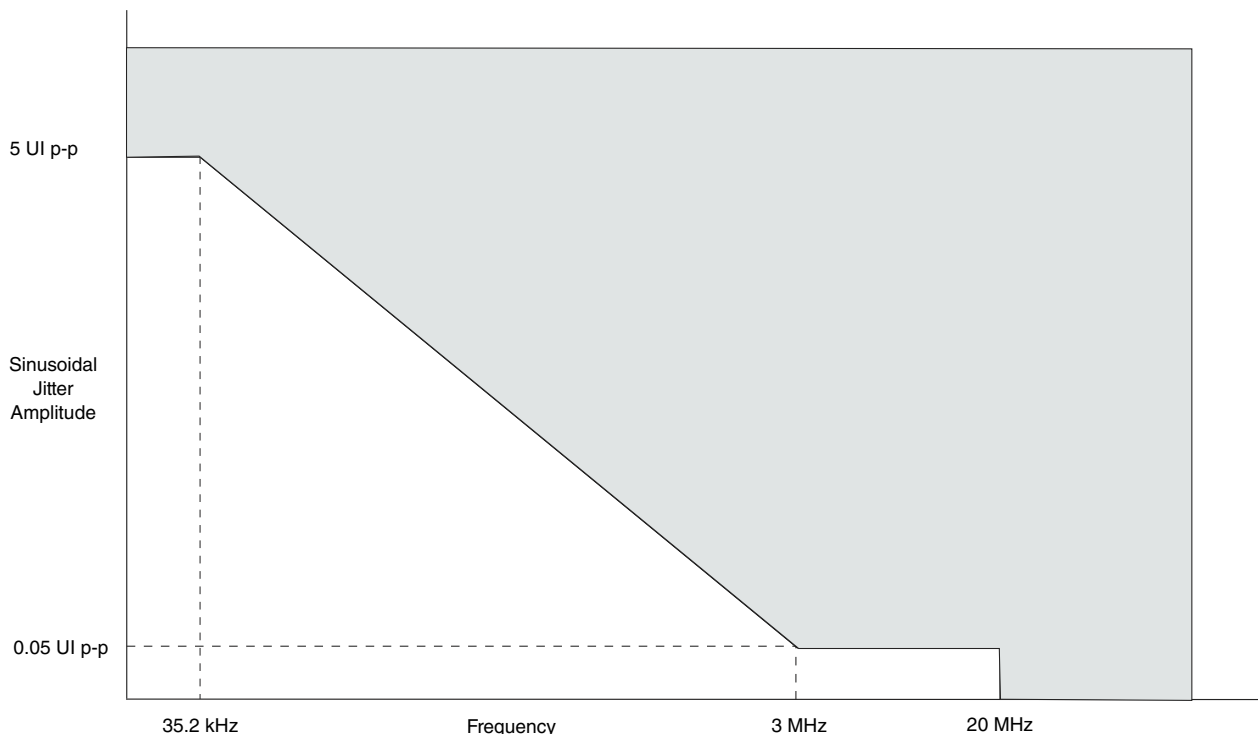
**Notes:**

1. The jitter ( $R_{CBHPJ}$ ) and amplitude have to be correlated, for example, by a PCB trace.

2. For recommended operating conditions, see [Table 3](#).

## Electrical characteristics

The sinusoidal jitter may have any amplitude and frequency in the unshaded region of this figure.



**Figure 81. QSGMII single-frequency sinusoidal jitter limits**

### 3.22.8 XFI interface

This section describes the XFI clocking requirements and its DC and AC electrical characteristics.

#### 3.22.8.1 XFI clocking requirements for SD1\_REF\_CLK $n$ \_P and SD1\_REF\_CLK $n$ \_N

Only SerDes 1 (SD1\_REF\_CLK[1:2]\_P and SD1\_REF\_CLK[1:2]\_N) may be used for SerDes XFI configurations based on the RCW Configuration field SRDS\_PRTCL.

For more information on these specifications, see [SerDes reference clocks](#).

#### 3.22.8.2 XFI DC electrical characteristics

This section describes the DC electrical characteristics for XFI.

### 3.22.8.2.1 XFI transmitter DC electrical characteristics

This table defines the XFI transmitter DC electrical characteristics.

**Table 102. XFI transmitter DC electrical characteristics ( $V_{DD} = 1.35\text{ V}$ )<sup>1</sup>**

| Parameter   | Symbol                           | Min | Typical | Max | Unit     | Notes |
|---|----------------------------------|-----|---------|-----|----------|-------|
| Output differential voltage                                 | $V_{TX-DIFF}$                    | 360 | —       | 770 | mV       | 2     |
| De-emphasized differential output voltage (ratio at 1.14dB) | $V_{TX-DE-RATIO-1.14\text{ dB}}$ | 0.6 | 1.1     | 1.6 | dB       | 3     |
| De-emphasized differential output voltage (ratio at 3.5dB)  | $V_{TX-DE-RATIO-3.5\text{ dB}}$  | 3   | 3.5     | 4   | dB       | 4     |
| De-emphasized differential output voltage (ratio at 4.66dB) | $V_{TX-DE-RATIO-4.66\text{ dB}}$ | 4.1 | 4.6     | 5.1 | dB       | 5     |
| De-emphasized differential output voltage (ratio at 6.0dB)  | $V_{TX-DE-RATIO-6.0\text{ dB}}$  | 5.5 | 6.0     | 6.5 | dB       | 6     |
| De-emphasized differential output voltage (ratio at 9.5dB)  | $V_{TX-DE-RATIO-9.5\text{ dB}}$  | 9   | 9.5     | 10  | dB       | 7     |
| Differential resistance                                     | $T_{RD}$                         | 80  | 100     | 120 | $\Omega$ | —     |

**Notes:**

- For recommended operating conditions, see [Table 3](#).
- LNmTECR0[EQ\_AMP\_RED] = 000111
- LNmTECR0[EQ\_POST1Q] = 00011
- LNmTECR0[EQ\_POST1Q] = 01000
- LNmTECR0[EQ\_POST1Q] = 01010
- LNmTECR0[EQ\_POST1Q] = 01100
- LNmTECR0[EQ\_POST1Q] = 10000

### 3.22.8.2.2 XFI receiver DC electrical characteristics

This table defines the XFI receiver DC electrical characteristics.

**Table 103. XFI receiver DC electrical characteristics ( $S_{V_{DD}} = 1.0\text{V}$ )<sup>2</sup>**

| Parameter                  | Symbol        | Min | Typical | Max  | Unit     | Notes |
|----------------------------|---------------|-----|---------|------|----------|-------|
| Input differential voltage | $V_{RX-DIFF}$ | 110 | —       | 1050 | mV       | 1     |
| Differential resistance    | $R_{RD}$      | 80  | 100     | 120  | $\Omega$ | —     |

- Measured at receiver
- For recommended operating conditions, see [Table 3](#).

## Electrical characteristics

**3.22.8.3 XFI AC timing specifications**

This section describes the AC timing specifications for XFI.

**3.22.8.3.1 XFI transmitter AC timing specifications**

This table defines the XFI transmitter AC timing specifications. RefClk jitter is not included.

**Table 104. XFI transmitter AC timing specifications<sup>1</sup>**

| Parameter             | Symbol            | Min              | Typical | Max              | Unit   |
|-----------------------|-------------------|------------------|---------|------------------|--------|
| Transmitter baud rate | $T_{\text{BAUD}}$ | 10.3125 - 100ppm | 10.3125 | 10.3125 + 100ppm | Gb/s   |
| Unit Interval         | UI                | —                | 96.96   | —                | ps     |
| Deterministic jitter  | $D_J$             | —                | —       | 0.15             | UI p-p |
| Total jitter          | $T_J$             | —                | —       | 0.30             | UI p-p |

**Notes:**

1. For recommended operating conditions, see [Table 3](#).

**3.22.8.3.2 XFI receiver AC timing specifications**

This table defines the XFI receiver AC timing specifications. RefClk jitter is not included.

**Table 105. XFI receiver AC timing specifications<sup>3</sup>**

| Parameter              | Symbol               | Min              | Typical | Max              | Unit   | Notes |
|------------------------|----------------------|------------------|---------|------------------|--------|-------|
| Receiver baud rate     | $R_{\text{BAUD}}$    | 10.3125 - 100ppm | 10.3125 | 10.3125 + 100ppm | Gb/s   | —     |
| Unit Interval          | UI                   | —                | 96.96   | —                | ps     | —     |
| Total non-EQJ jitter   | $T_{\text{NON-EQJ}}$ | —                | —       | 0.45             | UI p-p | 1     |
| Total jitter tolerance | $T_J$                | —                | —       | 0.65             | UI p-p | 1, 2  |

1. The total jitter ( $T_J$ ) consists of Random Jitter ( $R_J$ ), Duty Cycle Distortion (DCD), Periodic Jitter ( $P_J$ ), and Inter symbol Interference (ISI). Non-EQJ jitter can include duty cycle distortion (DCD), random jitter ( $R_J$ ), and periodic jitter ( $P_J$ ). Non-EQJ jitter is uncorrelated to the primary data stream with exception of the DCD and so cannot be equalized by the receiver under test. It can exhibit a wide spectrum. Non - EQJ =  $T_J - \text{ISI} = R_J + \text{DCD} + P_J$

2. The XFI channel has a loss budget of 9.6 dB @5.5GHz. The channel loss including connector @ 5.5GHz is 6dB. The channel crosstalk and reflection margin is 3.6dB. Manual tuning of transmitter equalization and amplitude is required for performance optimization.

3. For recommended operating conditions, see [Table 3](#).

This figure shows the sinusoidal jitter tolerance of XFI receiver.

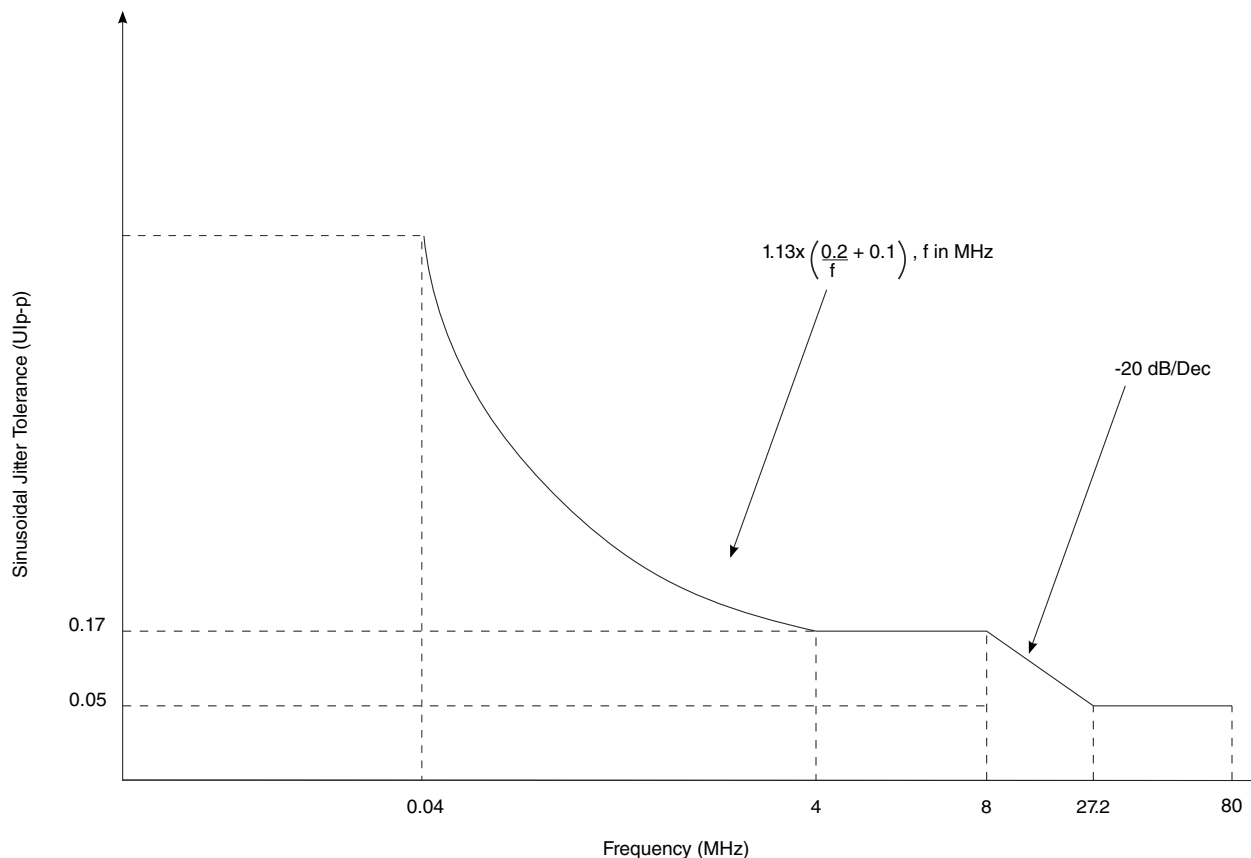


Figure 82. XFI host receiver input sinusoidal jitter tolerance

### 3.22.9 XAUI interface

This section describes the DC and AC electrical specifications for the XAUI bus.

#### 3.22.9.1 XAUI DC electrical characteristics

This section discusses the XAUI DC electrical characteristics for the clocking signals, transmitter, and receiver.

##### 3.22.9.1.1 DC requirements for XAUI SD<sub>n</sub>\_REF\_CLK<sub>n</sub>\_P and SD<sub>n</sub>\_REF\_CLK<sub>n</sub>\_N

Only SerDes 1 (SD1\_REF\_CLK[1:2]\_P and SD1\_REF\_CLK[1:2]\_N) may be used for various SerDes XAUI configurations based on the RCW Configuration field SRDS\_PRTCL.

For more information on these specifications, see [SerDes reference clocks](#).

## Electrical characteristics

**3.22.9.1.2 XAUI transmitter DC electrical characteristics**

This table defines the XAUI transmitter DC electrical characteristics.

**Table 106. XAUI transmitter DC electrical characteristics ( $V_{DD} = 1.35\text{ V}$ )<sup>1</sup>**

| Parameter                             | Symbol           | Min   | Typical | Max  | Unit     | Notes |
|---------------------------------------|------------------|-------|---------|------|----------|-------|
| Output voltage                        | $V_O$            | -0.40 | —       | 2.30 | V        | 2     |
| Differential output voltage           | $V_{DIFFPP}$     | 800   | 1000    | 1600 | mV p-p   | —     |
| DC Differential transmitter impedance | $Z_{TX-DIFF-DC}$ | 80    | 100     | 120  | $\Omega$ | 3     |

**Notes:**

1. For recommended operating conditions, see [Table 3](#).
2. Absolute output voltage limit
3. Transmitter DC differential impedance

**3.22.9.1.3 XAUI receiver DC electrical characteristics**

This table defines the XAUI receiver DC electrical characteristics.

**Table 107. XAUI receiver DC timing specifications ( $S_{V_{DD}} = 1.0\text{ V}$ )<sup>1</sup>**

| Parameter                                | Symbol           | Min | Typical | Max  | Unit     | Notes |
|--|------------------|-----|---------|------|----------|-------|
| Differential input voltage               | $V_{IN}$         | 200 | —       | 1600 | mV p-p   | 2     |
| DC Differential receiver input impedance | $Z_{RX-DIFF-DC}$ | 80  | 100     | 120  | $\Omega$ | 3     |

**Notes:**

1. For recommended operating conditions, see [Table 3](#).
2. Measured at the receiver
3. Receiver DC differential impedance

**3.22.9.2 XAUI AC timing specifications**

This section explains the AC requirements for the XAUI interface.

**3.22.9.2.1 XAUI transmitter AC timing specifications**

This table defines the XAUI transmitter AC timing specifications. RefClk jitter is not included.

**Table 108. XAUI transmitter AC timing specifications<sup>1</sup>**

| Parameter                  | Symbol         | Min           | Typical | Max           | Unit   |
|----------------------------|----------------|---------------|---------|---------------|--------|
| Deterministic jitter       | J <sub>D</sub> | —             | —       | 0.17          | UI p-p |
| Total jitter               | J <sub>T</sub> | —             | —       | 0.35          | UI p-p |
| Unit Interval: 3.125 GBaud | UI             | 320 - 100 ppm | 320     | 320 + 100 ppm | ps     |

**Notes:**

- For recommended operating conditions, see [Table 3](#).

### 3.22.9.2.2 XAUI receiver AC timing specifications

This table defines the receiver AC specifications for XAUI. RefClk jitter is not included.

**Table 109. XAUI receiver AC timing specifications<sup>1</sup>**

| Parameter  | Symbol          | Min           | Typical | Max               | Unit   | Notes |
|--|-----------------|---------------|---------|-------------------|--------|-------|
| Deterministic jitter tolerance                     | J <sub>D</sub>  | —             | —       | 0.37              | UI p-p | 2     |
| Combined deterministic and random jitter tolerance | J <sub>DR</sub> | —             | —       | 0.55              | UI p-p | 2     |
| Total jitter tolerance                             | J <sub>T</sub>  | —             | —       | 0.65              | UI p-p | 2, 3  |
| Bit error rate                                     | BER             | —             | —       | 10 <sup>-12</sup> | —      | —     |
| Unit Interval: 3.125 GBaud                         | UI              | 320 - 100 ppm | 320     | 320 + 100 ppm     | ps     | —     |

**Notes:**

- For recommended operating conditions, see [Table 3](#).
- Measured at receiver
- Total jitter is composed of three components: deterministic jitter, random jitter, and single frequency sinusoidal jitter. The sinusoidal jitter component is included to ensure margin for low frequency jitter, wander, noise, crosstalk, and other variable system effects.

## 3.22.10 10GBase-KR interface

This section describes the 10GBase-KR clocking requirements and its DC and AC electrical characteristics.

### 3.22.10.1 10GBase-KR clocking requirements for SD1\_REF\_CLK<sub>n</sub> and SD1\_REF\_CLK<sub>n</sub>\_B

Only SerDes 1 (SD1\_REF\_CLK[1:2] and SD1\_REF\_CLK[1:2]\_B) may be used for SerDes 10GBase-KR configurations based on the RCW Configuration field SRDS\_PRTCL.

For more information on these specifications, see [SerDes reference clocks](#).

## Electrical characteristics

## 3.22.10.2 10GBase-KR DC electrical characteristics

This section describes the DC electrical characteristics for 10GBase-KR.

## 3.22.10.2.1 10GBase-KR transmitter DC electrical characteristics

This table defines the 10GBase-KR transmitter DC electrical characteristics.

**Table 110. 10GBaseKR transmitter DC electrical characteristics ( $XV_{DD} = 1.35V$ )<sup>1</sup>**

| Parameter   | Symbol                   | Min | Typical | Max  | Unit     | Notes |
|---|--------------------------|-----|---------|------|----------|-------|
| Output differential voltage                                 | $V_{TX-DIFF}$            | 800 | -       | 1200 | mV       | 2     |
| De-emphasized differential output voltage (ratio at 1.14dB) | $V_{TX-DE-RATIO-1.14dB}$ | 0.6 | 1.1     | 1.6  | dB       | 3     |
| De-emphasized differential output voltage (ratio at 3.5dB)  | $V_{TX-DE-RATIO-3.5dB}$  | 3   | 3.5     | 4    | dB       | 4     |
| De-emphasized differential output voltage (ratio at 4.66dB) | $V_{TX-DE-RATIO-4.66dB}$ | 4.1 | 4.6     | 5.1  | dB       | 5     |
| De-emphasized differential output voltage (ratio at 6.0dB)  | $V_{TX-DE-RATIO-6.0dB}$  | 5.5 | 6.0     | 6.5  | dB       | 6     |
| De-emphasized differential output voltage (ratio at 9.5dB)  | $V_{TX-DE-RATIO-9.5dB}$  | 9   | 9.5     | 10   | dB       | 7     |
| Differential resistance                                     | $T_{RD}$                 | 80  | 100     | 120  | $\Omega$ | -     |

1. For recommended operating conditions, see [Table 3](#).

2. LNmTECR0[EQ\_AMP\_RED] = 000000

3. LNmTECR0[EQ\_POST1Q] = 00011

4. LNmTECR0[EQ\_POST1Q] = 01000

5. LNmTECR0[EQ\_POST1Q] = 01010

6. LNmTECR0[EQ\_POST1Q] = 01100

7. LNmTECR0[EQ\_POST1Q] = 10000

## 3.22.10.2.2 10GBase-KR receiver DC electrical characteristics

This table defines the 10GBase-KR receiver DC electrical characteristics.

**Table 111. 10GBase-KR receiver DC electrical characteristics ( $SV_{DD} = 1.0V$ )<sup>1</sup>**

| Parameter                  | Symbol        | Min | Typical | Max  | Unit     | Notes |
|----------------------------|---------------|-----|---------|------|----------|-------|
| Input differential voltage | $V_{RX-DIFF}$ | -   | -       | 1200 | mV       | -     |
| Differential resistance    | $R_{RD}$      | 80  | -       | 120  | $\Omega$ | -     |

1. For recommended operating conditions, see [Table 3](#).

### 3.22.10.3 10GBase-KR AC timing specifications

This section describes the AC timing specifications for 10GBase-KR.

#### 3.22.10.3.1 10GBase-KR transmitter AC timing specifications

This table defines the 10GBase-KR transmitter AC timing specifications. RefClk jitter is not included.

**Table 112. 10GBase-KR transmitter AC timing specifications<sup>1</sup>**

| Parameter  | Symbol              | Min               | Typical | Max               | Unit   |
|--|---------------------|-------------------|---------|-------------------|--------|
| Transmitter baud rate                              | T <sub>BAUD</sub>   | 10.3125 - 100 ppm | 10.3125 | 10.3125 + 100 ppm | Gb/s   |
| Uncorrelated high probability jitter/Random jitter | U <sub>HPJ/RJ</sub> | -                 | -       | 0.15              | UI p-p |
| Deterministic jitter                               | D <sub>J</sub>      | -                 | -       | 0.15              | UI p-p |
| Total jitter                                       | T <sub>J</sub>      | -                 | -       | 0.30              | UI p-p |

1. For recommended operating conditions, see [Table 3](#).

#### 3.22.10.3.2 10GBase-KR receiver AC timing specifications

This table defines the 10GBase-KR receiver AC timing specifications. RefClk jitter is not included.

**Table 113. 10GBase-KR receiver AC timing specifications<sup>2</sup>**

| Parameter                  | Symbol             | Min               | Typical | Max               | Unit   | Notes |
|----------------------------|--------------------|-------------------|---------|-------------------|--------|-------|
| Receiver baud rate         | R <sub>BAUD</sub>  | 10.3125 - 100 ppm | 10.3125 | 10.3125 + 100 ppm | Gb/s   | -     |
| Random jitter              | R <sub>J</sub>     | -                 | -       | 0.130             | UI p-p | -     |
| Sinusoidal jitter, maximum | S <sub>J-max</sub> | -                 | -       | 0.115             | UI p-p | -     |
| Duty cycle distortion      | D <sub>CD</sub>    | -                 | -       | 0.035             | UI p-p | -     |
| Total jitter               | T <sub>J</sub>     | -                 | -       | See Note 1        | UI p-p | 1     |

1. The total jitter (T<sub>J</sub>) is per Interference tolerance test IEEE Standard 802.3ap-2007 specified in Annex 69A.  
2. For recommended operating conditions, see [Table 3](#).

### 3.22.11 1000Base-KX interface

This section discusses the electrical characteristics for the 1000Base-KX. Only AC-coupled operation is supported.

## Electrical characteristics

**3.22.11.1 1000Base-KX DC electrical characteristics****3.22.11.1.1 1000Base-KX transmitter DC specifications**

This table describes the 1000Base-KX SerDes transmitter DC specification at TP1 per IEEE Std 802.3ap-2007. Transmitter DC characteristics are measured at the transmitter outputs ( \_TXn\_P and \_TXn\_N).

**Table 114. 1000Base-KX transmitter DC specifications**

| Parameter                   | Symbols          | Min | Typ | Max  | Units    | Notes |
|-----------------------------|------------------|-----|-----|------|----------|-------|
| Output differential voltage | $V_{TX-DIFFp-p}$ | 800 | —   | 1600 | mV       | 1     |
| Differential resistance     | $T_{RD}$         | 80  | 100 | 120  | $\Omega$ | —     |

Notes:

- SRDSxLNmTECR0[AMP\_RED]=00\_0000.
- For recommended operating conditions, see [Table 3](#).

**3.22.11.1.2 1000Base-KX receiver DC specifications**

Table below provides the 1000Base-KX receiver DC timing specifications.

**Table 115. 1000Base-KX receiver DC specifications**

| Parameter                  | Symbols          | Min | Typical | Max  | Units    | Notes |
|----------------------------|------------------|-----|---------|------|----------|-------|
| Input differential voltage | $V_{RX-DIFFp-p}$ | —   | —       | 1600 | mV       | 1     |
| Differential resistance    | $T_{RDIN}$       | 80  | —       | 120  | $\Omega$ | —     |

Notes:

- For recommended operating conditions, see [Table 3](#).

**3.22.11.2 1000Base-KX AC electrical characteristics****3.22.11.2.1 1000Base-KX transmitter AC specifications**

Table below provides the 1000Base-KX transmitter AC specification.

**Table 116. 1000Base-KX transmitter AC specifications**

| Parameter | Symbols    | Min           | Typical | Max           | Units | Notes |
|-----------|------------|---------------|---------|---------------|-------|-------|
| Baud rate | $T_{BAUD}$ | 1.25 - 100ppm | 1.25    | 1.25 + 100ppm | Gb/s  | —     |

*Table continues on the next page...*

**Table 116. 1000Base-KX transmitter AC specifications (continued)**

| Parameter  | Symbols       | Min | Typical | Max  | Units  | Notes |
|--|---------------|-----|---------|------|--------|-------|
| Uncorrelated high probability jitter/<br>random jitter | $T_{UHPJTRJ}$ | —   | —       | 0.15 | UI p-p | —     |
| Deterministic jitter                                   | $T_{DJ}$      | —   | —       | 0.10 | UI p-p | —     |
| Total jitter   | $T_{TJ}$      | —   | —       | 0.25 | UI p-p | 1     |

Notes:

- Total jitter is specified at a BER of  $10^{-12}$ .
- For recommended operating conditions, see [Table 3](#).

### 3.22.11.2.2 1000Base-KX receiver AC specifications

Table below provides the 1000Base-KX receiver AC specification with parameters guided by IEEE Std 802.3ap-2007.

**Table 117. 1000Base-KX receiver AC specifications**

| Parameter                     | Symbols      | Min           | Typical | Max              | Units  | Notes |
|-------------------------------|--------------|---------------|---------|------------------|--------|-------|
| Receiver baud rate            | $R_{BAUD}$   | 1.25 - 100ppm | 1.25    | 1.25 +<br>100ppm | Gb/s   | —     |
| Random jitter                 | $R_{RJ}$     | —             | —       | 0.15             | UI p-p | 1     |
| Sinusoidal jitter,<br>maximum | $R_{SJ-max}$ | —             | —       | 0.10             | UI p-p | 2     |
| Total jitter                  | $R_{TJ}$     | —             | —       | See Note 3       | UI p-p | 2     |

Notes:

- Random jitter is specified at a BER of  $10^{-12}$ .
- The receiver interference tolerance level of this parameter shall be measured as described in Annex 69A of the IEEE Std 802.3ap-2007.
- Per IEEE 802.3ap-clause 70.
- The AC specifications do not include Refclk jitter.
- For recommended operating conditions, see [Table 3](#).

## 4 Hardware design considerations

### 4.1 Clock ranges

This table provides the clocking specifications for the processor core, platform, memory, and integrated flash controller.

## Hardware design considerations

**Table 118. Processor, platform, and memory clocking specifications**

| Characteristic                            | Maximum processor core frequency |      |          |      |                  |      |                  |      |          |      | Unit | Notes |
|---|----------------------------------|------|----------|------|------------------|------|------------------|------|----------|------|------|-------|
|   | 1600 MHz                         |      | 1800 MHz |      | 2000 MHz/800 MHz |      | 2000 MHz/700 MHz |      | 2100 MHz |      |      |       |
|   | Min                              | Max  | Min      | Max  | Min              | Max  | Min              | Max  | Min      | Max  |      |       |
| Core frequency                            | 800                              | 1600 | 800      | 1800 | 800              | 2100 | 800              | 2000 | 800      | 2100 | MHz  | 1     |
| Coherency Domain frequency                | 1000                             | 1200 | 1000     | 1400 | 1000             | 1600 | 1000             | 1400 | 1000     | 1600 | MHz  |       |
| Platform clock frequency                  | 500                              | 600  | 500      | 700  | 500              | 800  | 500              | 700  | 500      | 800  | MHz  | 1     |
| Memory bus clock frequency (DDRC1, DDRC2) | 625                              | 800  | 625      | 933  | 625              | 1066 | 625              | 1066 | 625      | 1066 | MHz  | 1, 2  |
| IFC clock frequency                       | -                                | 100  | -        | 100  | -                | 100  | -                | 100  | -        | 100  | MHz  | 3     |
| WRIOP                                     | 500                              | 600  | 500      | 700  | 500              | 800  | 500              | 700  | 500      | 800  | MHz  |       |

**Notes:**

- Caution:** The coherency domain clock to SYSCLK ratio and core to SYSCLK ratio settings must be chosen such that the resulting SYSCLK frequency, core frequency, coherency domain and platform clock frequency do not exceed their respective maximum or minimum operating frequencies.
- The memory bus clock speed is half the DDR4 data rate.
- The integrated flash controller (IFC) clock speed on IFC\_CLK[0:1] is determined by half of the platform clock frequency divided by the IFC ratio programmed in CCR[CLKDIV]. See the chip reference manual for more information.

## 4.2 Power supply design

For additional details on the power supply design, see AN4977, *QorIQ LS2088A Family Design Checklist*.

### 4.2.1 Voltage ID (VID) controllable supply

To guarantee performance and power specifications, a specific method of selecting the optimum voltage-level must be implemented when the chip is used. As part of the chip's boot process, software must read the VID efuse values stored in the Fuse Status register (FUSESR) and then configure the external voltage regulator based on this information. This method requires a point of load voltage regulator for each chip.  $V_{DD}$  supply should be separated from the SerDes 1.0 V supply  $SV_{DD}$ . It is required in order to control the  $V_{DD}$  supply only.

#### NOTE

During the power-on reset process, the fuse values are read and stored in the FUSESR. It is expected that the chip's boot code reads the FUSESR value very early in the boot sequence and updates the regulator accordingly.

The default voltage regulator setting that is safe for the system to boot is the recommended operating  $V_{DD}$  at initial start-up of 1.05 V. It is highly recommended to select a regulator with a  $V_{out}$  range of at least 0.875 V to 1.1 V, with a resolution of 12.5 mV or better, when implementing a VID solution.

The table below lists the valid VID efuse values that will be programmed at the factory for this chip.

**Table 119. Fuse Status Register (DCFG\_CCSR\_FUSESR)**

| Binary value of DA_V / DA_ALT_V | $V_{DD}$ voltage |
|---------------------------------|------------------|
| 00000                           | default (1.05 V) |
| 00010                           | 0.9750 V         |
| 01000                           | 0.9000 V         |
| 10000                           | 1.0000 V         |
| 10010                           | 1.0250 V         |
| All other values                | Reserved         |

For additional information on VID, see the chip reference manual.

## 5 Thermal

This table shows the thermal characteristics for the chip. Note that these numbers are based on design estimates and are preliminary.

**Table 120. Package thermal characteristics<sup>1</sup>**

| Rating                                  | Board                   | Symbol             | Value | Unit | Notes |
|---|-------------------------|--------------------|-------|------|-------|
| Junction to ambient, natural convection | Single-layer board (1s) | $R_{\theta JA}$    | 13    | °C/W |       |
| Junction to ambient, natural convection | Four-layer board (2s2p) | $R_{\theta JA}$    | 10    | °C/W |       |
| Junction to ambient (at 200 ft./min.)   | Single-layer board (1s) | $R_{\theta JMA}$   | 8     | °C/W |       |
| Junction to ambient (at 200 ft./min.)   | Four-layer board (2s2p) | $R_{\theta JMA}$   | 6     | °C/W |       |
| Junction to board                       | —                       | $R_{\theta JB}$    | 3     | °C/W |       |
| Junction to case top                    | —                       | $R_{\theta JCtop}$ | 0.3   | °C/W |       |
| Junction to Lid top                     | —                       | $R_{\theta JLtop}$ | 0.1   | °C/W |       |

**Notes:**

1. See "Thermal management information" in the design checklist for additional details.
2. Junction temperature is a function of die size, on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance.
3. Junction-to-Ambient Thermal Resistance determined per JEDEC JESD51-3 and JESD51-6. Thermal test board meets JEDEC specification for this package.

**Package information****Table 120. Package thermal characteristics<sup>1</sup>**

| Rating   | Board | Symbol | Value | Unit | Notes |
|--|-------|--------|-------|------|-------|
| 4. Junction-to-Board thermal resistance determined per JEDEC JESD51-8. Thermal test board meets JEDEC specification for the specified package.   |       |        |       |      |       |
| 5. Junction-to-Case at the top of the package determined using MIL-STD 883 Method 1012.1. The cold plate temperature is used for the case temperature. Reported value includes the thermal resistance of the interface layer.  |       |        |       |      |       |
| 6. Junction-to-Lid-Top thermal resistance determined using the using MIL-STD 883 Method 1012.1. However, instead of the cold plate, the lid top temperature is used here for the reference case temperature. Reported value does not include the thermal resistance of the interface layer between the package and cold plate. |       |        |       |      |       |

## 5.1 Temperature diode

The chip has a temperature diode that can be used to monitor its temperature by using some external temperature monitoring devices (such as Analog Devices, ADT7481A). For more information, see AN4787.

The followings are the specifications of the chip temperature diode:

- Operating range: 10 - 230  $\mu$ A
- Ideality factor over temperature range 85°C - 105°C,  $n = 1.006 \pm 0.003$ , with approximate error  $\pm 1$  °C and error under  $\pm 3$  °C for temperature range 0 °C to 85 °C.

## 6 Package information

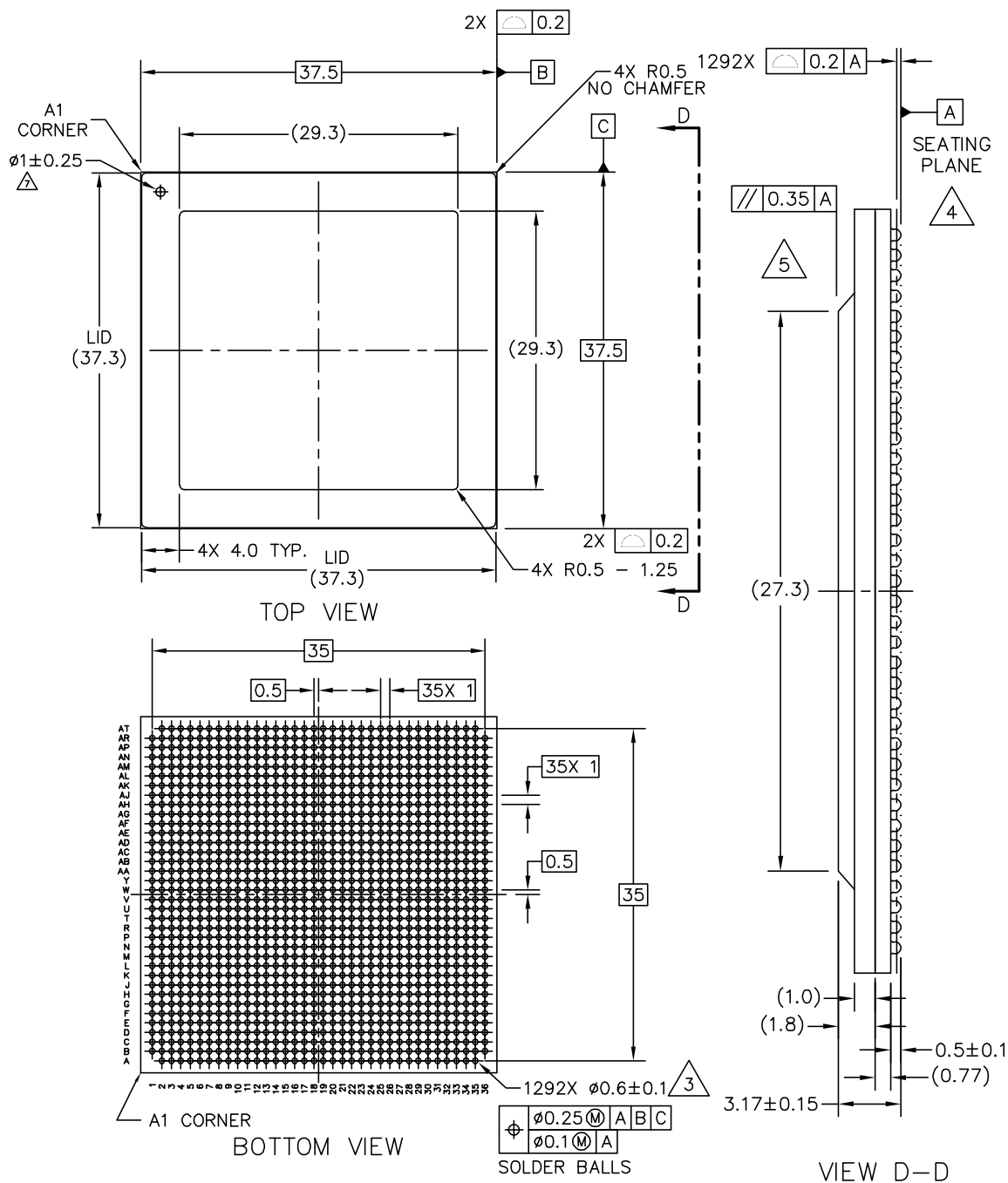
### 6.1 Package parameters for the FC-PBGA

The package parameters are as provided in the following list. The package type is 37.5 mm x 37.5 mm, 1292 flip-chip plastic lidded ball grid array (FC-PBGA).

- Package outline—37.5 mm x 37.5 mm
- Interconnects—1292
- Ball Pitch—1 mm
- Ball Diameter (typical)—0.6 mm
- Solder Balls—96.5% Sn, 3% Ag, 0.5% Cu
- Module height—3.02 mm (minimum), 3.17 mm (typical), 3.32 mm (maximum)

### 6.2 Mechanical dimensions of the FC-PBGA

This figure shows the mechanical dimensions and bottom surface nomenclature of the chip.



|  |                          |                            |
|--|--------------------------|----------------------------|
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| TITLE: FC PBGA, WITH LID,<br>37.5 X 37.5 X 3.17 PKG,<br>1 MM PITCH, 1292 I/O | DOCUMENT NO: 98ASA00618D | REV: 0                     |
|  | STANDARD: NON-JEDEC      |                            |
| 19 MAY 2014  |                          |                            |

Figure 83. Mechanical dimensions of the FC-PBGA with full lid

**Security fuse processor****NOTES:**

1. All dimensions are in millimeters.
2. Dimensions and tolerances per ASME Y14.5M-1994.
3. Maximum solder ball diameter measured parallel to datum A.
4. Datum A, the seating plane, is determined by the spherical crowns of the solder balls.
5. Parallelism measurement shall exclude any effect of mark on top surface of package.
6. All dimensions are symmetric across the package center lines, unless dimensioned otherwise.
7. Pin 1 thru hole shall be centered within foot area.
8. 37.7 mm maximum package assembly (lid + laminate) X and Y.

## 7 Security fuse processor

This chip implements the QorIQ platform's trust architecture, supporting capabilities such as secure boot. Use of the trust architecture features is dependent on programming fuses in the Security Fuse Processor (SFP). The details of the trust architecture and SFP can be found in the chip reference manual.

To program SFP fuses, the user is required to supply 1.80 V to the TA\_PROG\_SFP pin per [Power sequencing](#). TA\_PROG\_SFP should only be powered for the duration of the fuse programming cycle, with a per device limit of two fuse programming cycles. All other times TA\_PROG\_SFP should be connected to GND. The sequencing requirements for raising and lowering TA\_PROG\_SFP are shown in [Figure 8](#). To ensure device reliability, fuse programming must be performed within the recommended fuse programming temperature range per [Table 3](#).

**NOTE**

Users not implementing the QorIQ platform's trust architecture features should connect TA\_PROG\_SFP to GND.

## 8 Ordering information

Contact your local NXP sales office or regional marketing team for order information.

### 8.1 Part numbering nomenclature

This table provides the NXP Layerscape platform part numbering nomenclature.

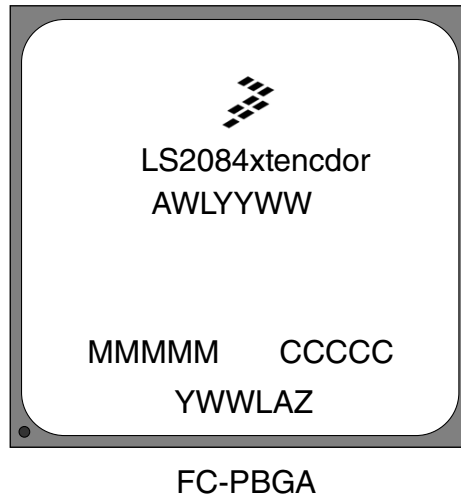
Table 121. Part numbering nomenclature

| <i>q</i>  | <i>p</i>           | <i>g</i>          | <i>c</i>        | <i>u</i>     | <i>c</i>  | <i>t</i>   | <i>e</i>  | <i>n</i>    | <i>c</i>   | <i>d</i>                                    | <i>o</i>  | <i>r</i>    |
|---|--------------------|-------------------|-----------------|--------------|-----------|--|---|-------------|--|---|---|-------------|
| Qual Status   | Product Generation | Performance Level | Number of Cores | Unique ID    | Core Type | Temperature Range                                    | Encryption  | Package     | Top Core Freq  | DDR Freq                                    | Option Code   | Revision    |
| (blank)<br>= Qualified<br>P = Pre-qual<br>S = Special | LS = Layerscape    | 2                 | 08<br>04        | 4 = AIOP off | A = Arm   | S = 0–105°C<br>X = -40–105°C<br>C = AEC-Q100 Grade 3 | E = Export controlled crypto hardware enabled<br>N = Export controlled crypto hardware disabled | 7 = FC-PBGA | Q = 1.6 GHz<br>T = 1.8 GHz<br>V = 2.0 GHz<br>1 = 2.1 GHz | Q = 1.6 GHz<br>T = 1.86 GHz<br>1 = 2.13 GHz | Blank = Standard device<br>7 = Platform speed limited to 700 MHz. Only available for 2GHz core. | B = Rev 1.1 |

## 8.2 Part marking

Parts are marked as in the example shown in this figure.

## Revision history



**Legend:**

LS2084xtencdor is the part marking on the die. See the corresponding orderable part number in the table above.

AWLYYWW is the test traceability code.

MMMMM is the mask number.

WLSQXXXXXX is the lot number.

CCCCC is the country code.

YWWLAZ is the assembly traceability code.

**Figure 84. Part marking for FC-PBGA chip**

## 9 Revision history

This table summarizes revisions to this document.

**Table 122. Revision history**

| Revision | Date    | Description  |
|----------|---------|--|
| 4        | 05/2021 | <ul style="list-style-type: none"> <li>Changed the min and max value of I/O leakage current in <a href="#">Table 20</a></li> <li>Added a new row "Required assertion time of PORESET_B after stable SYSCLK" in <a href="#">Table 19</a></li> <li>Updated the figure in <a href="#">Part marking</a></li> </ul>   |
| 3        | 09/2020 | <ul style="list-style-type: none"> <li>Changed the value of Cryptography acceleration from 10 Gbps to 20 Gbps in <a href="#">Features</a></li> <li>Updated <a href="#">Power characteristics</a>, added a new row for 2000/700 MHz core speed</li> <li>Added 2000/700 MHz core speed to <a href="#">Clock ranges</a></li> <li>Added the option code in <a href="#">Part numbering nomenclature</a></li> </ul>  |
| 2        | 05/2020 | <ul style="list-style-type: none"> <li>In the pinout list, added a new note 29 to D1_MALERT_B/D2_MALERT_B</li> <li>Updated <a href="#">Table 23</a></li> <li>Corrected table reference in <a href="#">DDR4 SDRAM interface output AC timing specifications</a></li> <li>In <a href="#">Table 121</a>, updated the unique ID</li> </ul>   |
| 1        | 11/2018 | <ul style="list-style-type: none"> <li>Added "Automotive AEC-Q100 Grade 3 qualified (105°C Tj)" to <a href="#">Features</a></li> <li>Updated <a href="#">Overview</a></li> <li>Added "AEC-Q100 Grade 3 temperature" row in <a href="#">Recommended operating conditions</a></li> <li>Added notes 7 and 8 in <a href="#">Recommended operating conditions</a></li> <li>Updated <a href="#">Figure 12</a></li> <li>Added note 3 in <a href="#">Table 45</a></li> </ul> |

*Table continues on the next page...*

**Table 122. Revision history (continued)**

| Revision | Date    | Description   |
|----------|---------|---|
|          |         | <ul style="list-style-type: none"><li>• Added <a href="#">Temperature diode</a></li><li>• Added "C = AEC-Q100 Grade 3" in <a href="#">Table 121</a></li></ul> |
| 0        | 04/2018 | Initial release   |

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