

This chapter contains the following sections:

- “Electrical Characteristics”
- “Switching Characteristics”
- “I/O Timing”
- “Glossary”

## Electrical Characteristics

This chapter covers the electrical and switching characteristics for Stratix® IV devices. Electrical characteristics include operating conditions and power consumption. Switching characteristics include transceiver specifications, core, and periphery performance. This chapter also describes I/O timing, including programmable I/O element (IOE) delay and programmable output buffer delay.



For information regarding the densities and packages of devices in the Stratix IV family, refer to the *Stratix IV Device Family Overview* chapter.

## Operating Conditions

When you use Stratix IV devices, they are rated according to a set of defined parameters. To maintain the highest possible performance and reliability of the Stratix IV devices, you must consider the operating requirements described in this chapter.

Stratix IV devices are offered in commercial, industrial, and military grades. Commercial devices are offered in -2 (fastest), -2x, -3, and -4 speed grades. Industrial devices are offered in -1, -2, -3, and -4 speed grades. Military devices are offered in -3 speed grade.

### Absolute Maximum Ratings

Absolute maximum ratings define the maximum operating conditions for Stratix IV devices. The values are based on experiments conducted with the devices and theoretical modeling of breakdown and damage mechanisms. The functional operation of the device is not implied for these conditions.



Conditions other than those listed in Table 1–1, Table 1–2, and Table 1–3 may cause permanent damage to the device. Additionally, device operation at the absolute maximum ratings for extended periods of time may have adverse effects on the device.

**Table 1–1. Absolute Maximum Ratings for Stratix IV Devices**

| Symbol                | Description  | Minimum | Maximum | Unit |
|-----------------------|--|---------|---------|------|
| V <sub>CC</sub>       | Core voltage and periphery circuitry power supply                      | -0.5    | 1.35    | V    |
| V <sub>CCPT</sub>     | Power supply for programmable power technology                         | -0.5    | 1.8     | V    |
| V <sub>CCPGM</sub>    | Configuration pins power supply  | -0.5    | 3.75    | V    |
| V <sub>CCAUX</sub>    | Auxiliary supply for the programmable power technology                 | -0.5    | 3.75    | V    |
| V <sub>CCBAT</sub>    | Battery back-up power supply for design security volatile key register | -0.5    | 3.75    | V    |
| V <sub>CCPD</sub>     | I/O pre-driver power supply  | -0.5    | 3.75    | V    |
| V <sub>CGIO</sub>     | I/O power supply   | -0.5    | 3.9     | V    |
| V <sub>CC_CLKIN</sub> | Differential clock input power supply                                  | -0.5    | 3.75    | V    |
| V <sub>CCD_PLL</sub>  | PLL digital power supply   | -0.5    | 1.35    | V    |
| V <sub>CCA_PLL</sub>  | PLL analog power supply  | -0.5    | 3.75    | V    |
| V <sub>I</sub>        | DC input voltage   | -0.5    | 4.0     | V    |
| I <sub>OUT</sub>      | DC output current per pin  | -25     | 40      | mA   |
| T <sub>J</sub>        | Operating junction temperature   | -55     | 125     | °C   |
| T <sub>STG</sub>      | Storage temperature (No bias)  | -65     | 150     | °C   |

**Table 1–2. Transceiver Power Supply Absolute Maximum Ratings for Stratix IV GX Devices**

| Symbol                     | Description                                  | Minimum | Maximum | Unit |
|----------------------------|--|---------|---------|------|
| V <sub>CCA_L</sub>         | Transceiver high voltage power (left side)   | -0.5    | 3.75    | V    |
| V <sub>CCA_R</sub>         | Transceiver high voltage power (right side)  | -0.5    | 3.75    | V    |
| V <sub>CCHIP_L</sub>       | Transceiver HIP digital power (left side)    | -0.5    | 1.35    | V    |
| V <sub>CCHIP_R</sub>       | Transceiver HIP digital power (right side)   | -0.5    | 1.35    | V    |
| V <sub>CCR_L</sub>         | Receiver power (left side)                   | -0.5    | 1.35    | V    |
| V <sub>CCR_R</sub>         | Receiver power (right side)                  | -0.5    | 1.35    | V    |
| V <sub>CCT_L</sub>         | Transmitter power (left side)                | -0.5    | 1.35    | V    |
| V <sub>CCT_R</sub>         | Transmitter power (right side)               | -0.5    | 1.35    | V    |
| V <sub>CCL_GXBLn</sub> (1) | Transceiver clock power (left side)          | -0.5    | 1.35    | V    |
| V <sub>CCL_GXBRn</sub> (1) | Transceiver clock power (right side)         | -0.5    | 1.35    | V    |
| V <sub>CCH_GXBLn</sub> (1) | Transmitter output buffer power (left side)  | -0.5    | 1.8     | V    |
| V <sub>CCH_GXBRn</sub> (1) | Transmitter output buffer power (right side) | -0.5    | 1.8     | V    |

**Note to Table 1–2:**

(1) n = 0, 1, 2, or 3.

**Table 1-3. Transceiver Power Supply Absolute Maximum Ratings for Stratix IV GT Devices (Note 1)**

| Symbol               | Description                                  | Minimum | Maximum | Unit |
|----------------------|--|---------|---------|------|
| $V_{CCA\_L}$         | Transceiver high voltage power (left side)   | -0.5    | 3.75    | V    |
| $V_{CCA\_R}$         | Transceiver high voltage power (right side)  | -0.5    | 3.75    | V    |
| $V_{CCHIP\_L}$       | Transceiver HIP digital power (left side)    | -0.5    | 1.35    | V    |
| $V_{CCHIP\_R}$       | Transceiver HIP digital power (right side)   | -0.5    | 1.35    | V    |
| $V_{CCR\_L}$         | Receiver power (left side)                   | -0.5    | 1.35    | V    |
| $V_{CCR\_R}$         | Receiver power (right side)                  | -0.5    | 1.35    | V    |
| $V_{CCT\_L}$         | Transmitter power (left side)                | -0.5    | 1.35    | V    |
| $V_{CCT\_R}$         | Transmitter power (right side)               | -0.5    | 1.35    | V    |
| $V_{CCL\_GXBLn}$ (2) | Transceiver clock power (left side)          | -0.5    | 1.35    | V    |
| $V_{CCL\_GXBRn}$ (2) | Transceiver clock power (right side)         | -0.5    | 1.35    | V    |
| $V_{CCH\_GXBLn}$ (2) | Transmitter output buffer power (left side)  | -0.5    | 1.8     | V    |
| $V_{CCH\_GXBRn}$ (2) | Transmitter output buffer power (right side) | -0.5    | 1.8     | V    |

**Notes to Table 1-3:**

- (1) For the absolute maximum ratings for Stratix IV GT engineering sample (ES1) devices, contact your local Altera sales representative.
- (2)  $n = 0, 1, 2,$  or  $3$ .

**Maximum Allowed Overshoot and Undershoot Voltage**

During transitions, input signals may overshoot to the voltage shown in Table 1-4 and undershoot to  $-2.0$  V for input currents less than 100 mA and periods shorter than 20 ns.


Table 1-4 lists the maximum allowed input overshoot voltage and the duration of the overshoot voltage as a percentage of device lifetime. The maximum allowed overshoot duration is specified as a percentage of high time over the lifetime of the device. A DC signal is equivalent to 100% duty cycle. For example, a signal that overshoots to 4.3 V can only be at 4.3 V for ~5% over the lifetime of the device; for a device lifetime of 10 years, this amounts to half of a year.

**Table 1-4. Maximum Allowed Overshoot During Transitions**

| Symbol  | Description      | Condition (V) | Overshoot Duration as % of High Time | Unit |
|---------|------------------|---------------|--------------------------------------|------|
| Vi (AC) | AC input voltage | 4.0           | 100.000                              | %    |
|         |                  | 4.05          | 79.330                               | %    |
|         |                  | 4.1           | 46.270                               | %    |
|         |                  | 4.15          | 27.030                               | %    |
|         |                  | 4.2           | 15.800                               | %    |
|         |                  | 4.25          | 9.240                                | %    |
|         |                  | 4.3           | 5.410                                | %    |
|         |                  | 4.35          | 3.160                                | %    |
|         |                  | 4.4           | 1.850                                | %    |
|         |                  | 4.45          | 1.080                                | %    |
|         |                  | 4.5           | 0.630                                | %    |
|         |                  | 4.55          | 0.370                                | %    |
| 4.6     | 0.220            | %             |                                      |      |

### Recommended Operating Conditions

This section lists the functional operation limits for AC and DC parameters for Stratix IV devices. Table 1-5 lists the steady-state voltage and current values expected from Stratix IV devices. Power supply ramps must all be strictly monotonic, without plateaus.

 For power supply ripple requirements, refer to the *Device-Specific Power Delivery Network (PDN) Tool User Guide*.

**Table 1-5. Recommended Operating Conditions for Stratix IV Devices (Part 1 of 2)**

| Symbol   | Description  | Condition | Minimum | Typical | Maximum | Unit |
|--|--|-----------|---------|---------|---------|------|
| V <sub>CC</sub> (Stratix IV GX and Stratix IV E) | Core voltage and periphery circuitry power supply      | —         | 0.87    | 0.90    | 0.93    | V    |
| V <sub>CC</sub> (Stratix IV GT)                  | Core voltage and periphery circuitry power supply      | —         | 0.92    | 0.95    | 0.98    | V    |
| V <sub>CCPT</sub>                                | Power supply for programmable power technology         | —         | 1.45    | 1.5     | 1.55    | V    |
| V <sub>CCAUX</sub>                               | Auxiliary supply for the programmable power technology | —         | 2.375   | 2.5     | 2.625   | V    |
| V <sub>CCPD</sub> (2)                            | I/O pre-driver (3.0 V) power supply                    | —         | 2.85    | 3.0     | 3.15    | V    |
|  | I/O pre-driver (2.5 V) power supply                    | —         | 2.375   | 2.5     | 2.625   | V    |

**Table 1-5. Recommended Operating Conditions for Stratix IV Devices (Part 2 of 2)**

| Symbol  | Description  | Condition                | Minimum | Typical | Maximum           | Unit |
|---|--|--------------------------|---------|---------|-------------------|------|
| V <sub>CCIO</sub>   | I/O buffers (3.0 V) power supply   | —                        | 2.85    | 3.0     | 3.15              | V    |
|   | I/O buffers (2.5 V) power supply   | —                        | 2.375   | 2.5     | 2.625             | V    |
|   | I/O buffers (1.8 V) power supply   | —                        | 1.71    | 1.8     | 1.89              | V    |
|   | I/O buffers (1.5 V) power supply   | —                        | 1.425   | 1.5     | 1.575             | V    |
|   | I/O buffers (1.2 V) power supply   | —                        | 1.14    | 1.2     | 1.26              | V    |
| V <sub>CCPGM</sub>  | Configuration pins (3.0 V) power supply                                  | —                        | 2.85    | 3.0     | 3.15              | V    |
|   | Configuration pins (2.5 V) power supply                                  | —                        | 2.375   | 2.5     | 2.625             | V    |
|   | Configuration pins (1.8 V) power supply                                  | —                        | 1.71    | 1.8     | 1.89              | V    |
| V <sub>CCA_PLL</sub>  | PLL analog voltage regulator power supply                                | —                        | 2.375   | 2.5     | 2.625             | V    |
| V <sub>CCD_PLL</sub><br>(Stratix IV GX<br>and Stratix IV E) | PLL digital voltage regulator power supply                               | —                        | 0.87    | 0.90    | 0.93              | V    |
| V <sub>CCD_PLL</sub><br>(Stratix IV GT)                     | PLL digital voltage regulator power supply                               | —                        | 0.92    | 0.95    | 0.98              | V    |
| V <sub>CC_CLKIN</sub>                                       | Differential clock input power supply                                    | —                        | 2.375   | 2.5     | 2.625             | V    |
| V <sub>CCBAT</sub> (1)                                      | Battery back-up power supply (For design security volatile key register) | —                        | 1.2     | —       | 3.3               | V    |
| V <sub>I</sub>  | DC input voltage   | —                        | -0.5    | —       | 3.6               | V    |
| V <sub>O</sub>  | Output voltage   | —                        | 0       | —       | V <sub>CCIO</sub> | V    |
| T <sub>J</sub> (Stratix IV GX<br>and Stratix IV E)          | Operating junction temperature   | Commercial               | 0       | —       | 85                | °C   |
|   |  | Industrial               | -40     | —       | 100               | °C   |
|   |  | Military                 | -55     | —       | 125               | °C   |
| T <sub>J</sub> (Stratix IV GT)                              | Operating junction temperature   | Industrial               | 0       | —       | 100               | °C   |
| t <sub>RAMP</sub>   | Power supply ramp time   | Normal POR<br>(PORSEL=0) | 0.05    | —       | 100               | ms   |
|   |  | Fast POR<br>(PORSEL=1)   | 0.05    | —       | 4                 | ms   |

**Notes to Table 1-5:**

- (1) If you do not use the volatile security key, you may connect the V<sub>CCBAT</sub> to either GND or a 3.0-V power supply.
- (2) V<sub>CCPD</sub> must be 2.5 V when V<sub>CCIO</sub> is 2.5, 1.8, 1.5, or 1.2 V. V<sub>CCPD</sub> must be 3.0 V when V<sub>CCIO</sub> is 3.0 V.

Table 1-6 lists the transceiver power supply recommended operating conditions for Stratix IV GX devices.

**Table 1-6. Transceiver Power Supply Operating Conditions for Stratix IV GX Devices (Part 1 of 2) (Note 1)**

| Symbol               | Description                                 | Minimum    | Typical     | Maximum    | Unit |
|----------------------|---|------------|-------------|------------|------|
| V <sub>CCA_L</sub>   | Transceiver high voltage power (left side)  | 2.85/2.375 | 3.0/2.5 (2) | 3.15/2.625 | V    |
| V <sub>CCA_R</sub>   | Transceiver high voltage power (right side) |            |             |            |      |
| V <sub>CCHIP_L</sub> | Transceiver HIP digital power (left side)   | 0.87       | 0.9         | 0.93       | V    |
| V <sub>CCHIP_R</sub> | Transceiver HIP digital power (right side)  | 0.87       | 0.9         | 0.93       | V    |
| V <sub>CCR_L</sub>   | Receiver power (left side)                  | 1.045      | 1.1         | 1.155      | V    |
| V <sub>CCR_R</sub>   | Receiver power (right side)                 | 1.045      | 1.1         | 1.155      | V    |

**Table 1-6. Transceiver Power Supply Operating Conditions for Stratix IV GX Devices (Part 2 of 2) (Note 1)**

| Symbol                     | Description                                  | Minimum    | Typical     | Maximum    | Unit |
|----------------------------|--|------------|-------------|------------|------|
| V <sub>CCT_L</sub>         | Transmitter power (left side)                | 1.045      | 1.1         | 1.155      | V    |
| V <sub>CCT_R</sub>         | Transmitter power (right side)               | 1.045      | 1.1         | 1.155      | V    |
| V <sub>CCL_GXBLn</sub> (3) | Transceiver clock power (left side)          | 1.05       | 1.1         | 1.15       | V    |
| V <sub>CCL_GXBRn</sub> (3) | Transceiver clock power (right side)         | 1.05       | 1.1         | 1.15       | V    |
| V <sub>CCH_GXBLn</sub> (3) | Transmitter output buffer power (left side)  | 1.33/1.425 | 1.4/1.5 (4) | 1.47/1.575 | V    |
| V <sub>CCH_GXBRn</sub> (3) | Transmitter output buffer power (right side) |            |             |            |      |

**Notes to Table 1-6:**

- Transceiver power supplies do not have power-on-reset (POR) circuitry. After initial power-up, violating the transceiver power supply operating conditions could lead to unpredictable link behavior.
- V<sub>CCA\_L/R</sub> must be connected to a 3.0-V supply if the clock multiplier unit (CMU) phase-locked loop (PLL), receiver clock data recovery (CDR), or both, are configured at a base data rate > 4.25 Gbps. For data rates up to 4.25 Gbps, you can connect V<sub>CCA\_L/R</sub> to either 3.0 V or 2.5 V.
- n = 0, 1, 2, or 3.
- V<sub>CCH\_GXBL/R</sub> must be connected to a 1.4-V supply if the transmitter channel data rate is > 6.5 Gbps. For data rates up to 6.5 Gbps, you can connect V<sub>CCH\_GXBL/R</sub> to either 1.4 V or 1.5 V.

Table 1-7 lists the recommended operating conditions for the Stratix IV GT transceiver power supply.

**Table 1-7. Transceiver Power Supply Operating Conditions for Stratix IV GT Devices (Note 1), (2)**

| Symbol                     | Description                                  | Minimum | Typical | Maximum | Unit |
|----------------------------|--|---------|---------|---------|------|
| V <sub>CCA_L</sub>         | Transceiver high voltage power (left side)   | 3.17    | 3.3     | 3.43    | V    |
| V <sub>CCA_R</sub>         | Transceiver high voltage power (right side)  | 3.17    | 3.3     | 3.43    | V    |
| V <sub>CCHIP_L</sub>       | Transceiver HIP digital power (left side)    | 0.92    | 0.95    | 0.98    | V    |
| V <sub>CCHIP_R</sub>       | Transceiver HIP digital power (right side)   | 0.92    | 0.95    | 0.98    | V    |
| V <sub>CCR_L</sub>         | Receiver power (left side)                   | 1.15    | 1.2     | 1.25    | V    |
| V <sub>CCR_R</sub>         | Receiver power (right side)                  | 1.15    | 1.2     | 1.25    | V    |
| V <sub>CCT_L</sub>         | Transmitter power (left side)                | 1.15    | 1.2     | 1.25    | V    |
| V <sub>CCT_R</sub>         | Transmitter power (right side)               | 1.15    | 1.2     | 1.25    | V    |
| V <sub>CCL_GXBLn</sub> (3) | Transceiver clock power (left side)          | 1.15    | 1.2     | 1.25    | V    |
| V <sub>CCL_GXBRn</sub> (3) | Transceiver clock power (right side)         | 1.15    | 1.2     | 1.25    | V    |
| V <sub>CCH_GXBLn</sub> (3) | Transmitter output buffer power (left side)  | 1.33    | 1.4     | 1.47    | V    |
| V <sub>CCH_GXBRn</sub> (3) | Transmitter output buffer power (right side) | 1.33    | 1.4     | 1.47    | V    |

**Notes to Table 1-7:**


- For the recommended operating conditions for Stratix IV GT engineering sample (ES1) devices, contact your local Altera sales representative.
- Transceiver power supplies do not have power-on-reset circuitry. After initial power-up, violating the transceiver power supply operating conditions could lead to unpredictable link behavior.
- n = 0, 1, 2, or 3.

## DC Characteristics

This section lists the supply current, I/O pin leakage current, bus hold, on-chip termination (OCT) tolerance, input pin capacitance, and hot socketing specifications.

### Supply Current

Standby current is the current drawn from the respective power rails used for power budgeting. Use the Excel-based Early Power Estimator (EPE) to get supply current estimates for your design because these currents vary greatly with the resources you use.

 For more information about power estimation tools, refer to the *PowerPlay Early Power Estimator User Guide* and the *PowerPlay Power Analysis* chapter in the *Quartus II Handbook*.

### I/O Pin Leakage Current

Table 1-8 lists the Stratix IV I/O pin leakage current specifications.

**Table 1-8. I/O Pin Leakage Current for Stratix IV Devices (Note 1)**

| Symbol   | Description        | Conditions                  | Min | Typ | Max | Unit    |
|----------|--------------------|-----------------------------|-----|-----|-----|---------|
| $I_I$    | Input pin          | $V_I = 0V$ to $V_{CCIOMAX}$ | -20 | —   | 20  | $\mu A$ |
| $I_{OZ}$ | Tri-stated I/O pin | $V_O = 0V$ to $V_{CCIOMAX}$ | -20 | —   | 20  | $\mu A$ |

**Note to Table 1-8:**

(1)  $V_{REF}$  current refers to the input pin leakage current.

### Bus Hold Specifications

Table 1-9 lists the Stratix IV device family bus hold specifications.

**Table 1-9. Bus Hold Parameters**

| Parameter               | Symbol     | Conditions                     | $V_{CCIO}$ |      |       |      |       |      |       |      |       |      | Unit    |
|-------------------------|------------|--------------------------------|------------|------|-------|------|-------|------|-------|------|-------|------|---------|
|                         |            |                                | 1.2 V      |      | 1.5 V |      | 1.8 V |      | 2.5 V |      | 3.0 V |      |         |
|                         |            |                                | Min        | Max  | Min   | Max  | Min   | Max  | Min   | Max  | Min   | Max  |         |
| Low sustaining current  | $I_{SUSL}$ | $V_{IN} > V_{IL}$<br>(maximum) | 22.5       | —    | 25.0  | —    | 30.0  | —    | 50.0  | —    | 70.0  | —    | $\mu A$ |
| High sustaining current | $I_{SUSH}$ | $V_{IN} < V_{IH}$<br>(minimum) | -22.5      | —    | -25.0 | —    | -30.0 | —    | -50.0 | —    | -70.0 | —    | $\mu A$ |
| Low overdrive current   | $I_{ODL}$  | $0V < V_{IN} < V_{CCIO}$       | —          | 120  | —     | 160  | —     | 200  | —     | 300  | —     | 500  | $\mu A$ |
| High overdrive current  | $I_{ODH}$  | $0V < V_{IN} < V_{CCIO}$       | —          | -120 | —     | -160 | —     | -200 | —     | -300 | —     | -500 | $\mu A$ |
| Bus-hold trip point     | $V_{TRIP}$ | —                              | 0.45       | 0.95 | 0.50  | 1.00 | 0.68  | 1.07 | 0.70  | 1.70 | 0.80  | 2.00 | V       |

### On-Chip Termination (OCT) Specifications

If you enable OCT calibration, calibration is automatically performed at power-up for I/Os connected to the calibration block. Table 1-10 lists the Stratix IV OCT termination calibration accuracy specifications.

**Table 1-10. OCT Calibration Accuracy Specifications for Stratix IV Devices (Note 1)**

| Symbol   | Description   | Conditions                                    | Calibration Accuracy |           |       | Unit |
|--|---|---|----------------------|-----------|-------|------|
|  |   |   | C2                   | C3,I3, M3 | C4,I4 |      |
| 25-Ω R <sub>S</sub> (2)<br>3.0, 2.5, 1.8, 1.5, 1.2                 | Internal series termination with calibration (25-Ω setting)   | V <sub>CCIO</sub> = 3.0, 2.5, 1.8, 1.5, 1.2 V | ± 8                  | ± 8       | ± 8   | %    |
| 50-Ω R <sub>S</sub><br>3.0, 2.5, 1.8, 1.5, 1.2                     | Internal series termination with calibration (50-Ω setting)   | V <sub>CCIO</sub> = 3.0, 2.5, 1.8, 1.5, 1.2 V | ± 8                  | ± 8       | ± 8   | %    |
| 50-Ω R <sub>T</sub><br>2.5, 1.8, 1.5, 1.2                          | Internal parallel termination with calibration (50-Ω setting)   | V <sub>CCIO</sub> = 2.5, 1.8, 1.5, 1.2 V      | ± 10                 | ± 10      | ± 10  | %    |
| 20-Ω, 40-Ω, and 60-Ω R <sub>S</sub> (3)<br>3.0, 2.5, 1.8, 1.5, 1.2 | Expanded range for internal series termination with calibration (20-Ω, 40-Ω, and 60-Ω R <sub>S</sub> setting) | V <sub>CCIO</sub> = 3.0, 2.5, 1.8, 1.5, 1.2 V | ± 10                 | ± 10      | ± 10  | %    |
| 25-Ω R <sub>S_left_shift</sub><br>3.0, 2.5, 1.8, 1.5, 1.2          | Internal left shift series termination with calibration (25-Ω R <sub>S_left_shift</sub> setting)              | V <sub>CCIO</sub> = 3.0, 2.5, 1.8, 1.5, 1.2 V | ± 10                 | ± 10      | ± 10  | %    |

**Notes to Table 1-10:**

- (1) OCT calibration accuracy is valid at the time of calibration only.
- (2) 25-Ω R<sub>S</sub> is not supported for 1.5 V and 1.2 V in Row I/O.
- (3) 20-Ω R<sub>S</sub> is not supported for 1.5 V and 1.2 V in Row I/O.

The calibration accuracy for calibrated series and parallel OCTs are applicable at the moment of calibration. When process, voltage, and temperature (PVT) conditions change after calibration, the tolerance may change. Table 1-11 lists the Stratix IV OCT without calibration resistance tolerance to PVT changes.

**Table 1-11. OCT Without Calibration Resistance Tolerance Specifications for Stratix IV Devices (Part 1 of 2)**

| Symbol                             | Description  | Conditions                        | Resistance Tolerance |           |       | Unit |
|------------------------------------|--|-----------------------------------|----------------------|-----------|-------|------|
|                                    |  |                                   | C2                   | C3,I3, M3 | C4,I4 |      |
| 25-Ω R <sub>S</sub><br>3.0 and 2.5 | Internal series termination without calibration (25-Ω setting) | V <sub>CCIO</sub> = 3.0 and 2.5 V | ± 30                 | ± 40      | ± 40  | %    |
| 25-Ω R <sub>S</sub><br>1.8 and 1.5 | Internal series termination without calibration (25-Ω setting) | V <sub>CCIO</sub> = 1.8 and 1.5 V | ± 30                 | ± 40      | ± 40  | %    |
| 25-Ω R <sub>S</sub><br>1.2         | Internal series termination without calibration (25-Ω setting) | V <sub>CCIO</sub> = 1.2 V         | ± 35                 | ± 50      | ± 50  | %    |

**Table 1-11. OCT Without Calibration Resistance Tolerance Specifications for Stratix IV Devices (Part 2 of 2)**

| Symbol                             | Description  | Conditions                        | Resistance Tolerance |           |       | Unit |
|------------------------------------|--|-----------------------------------|----------------------|-----------|-------|------|
|                                    |  |                                   | C2                   | C3,I3, M3 | C4,I4 |      |
| 50-Ω R <sub>S</sub><br>3.0 and 2.5 | Internal series termination without calibration (50-Ω setting) | V <sub>CCIO</sub> = 3.0 and 2.5 V | ± 30                 | ± 40      | ± 40  | %    |
| 50-Ω R <sub>S</sub><br>1.8 and 1.5 | Internal series termination without calibration (50-Ω setting) | V <sub>CCIO</sub> = 1.8 and 1.5 V | ± 30                 | ± 40      | ± 40  | %    |
| 50-Ω R <sub>S</sub><br>1.2         | Internal series termination without calibration (50-Ω setting) | V <sub>CCIO</sub> = 1.2 V         | ± 35                 | ± 50      | ± 50  | %    |
| 100-Ω R <sub>D</sub><br>2.5        | Internal differential termination (100-Ω setting)              | V <sub>CCIO</sub> = 2.5 V         | ± 25                 | ± 25      | ± 25  | %    |

OCT calibration is automatically performed at power-up for OCT-enabled I/Os. Table 1-12 lists OCT variation with temperature and voltage after power-up calibration. Use Table 1-12 to determine the OCT variation after power-up calibration and Equation 1-1 to determine the OCT variation without re-calibration.

**Equation 1-1. OCT Variation Without Re-Calibration (Note 1), (2), (3), (4), (5), (6)**

$$R_{OCT} = R_{SCAL} \left( 1 + \left\langle \frac{dR}{dT} \times \Delta T \right\rangle \pm \left\langle \frac{dR}{dV} \times \Delta V \right\rangle \right)$$

**Notes to Equation 1-1:**

- (1) The R<sub>OCT</sub> value calculated from Equation 1-1 shows the range of OCT resistance with the variation of temperature and V<sub>CCIO</sub>.
- (2) R<sub>SCAL</sub> is the OCT resistance value at power-up.
- (3) ΔT is the variation of temperature with respect to the temperature at power-up.
- (4) ΔV is the variation of voltage with respect to the V<sub>CCIO</sub> at power-up.
- (5) dR/dT is the percentage change of R<sub>SCAL</sub> with temperature.
- (6) dR/dV is the percentage change of R<sub>SCAL</sub> with voltage.

Table 1-12 lists the OCT variation after the power-up calibration.

**Table 1-12. OCT Variation after Power-Up Calibration (Note 1)**

| Symbol | Description                                       | V <sub>CCIO</sub> (V) | Typical | Unit   |
|--------|---|-----------------------|---------|--------|
| dR/dV  | OCT variation with voltage without re-calibration | 3.0                   | 0.0297  | % / mV |
|        |   | 2.5                   | 0.0344  |        |
|        |   | 1.8                   | 0.0499  |        |
|        |   | 1.5                   | 0.0744  |        |
|        |   | 1.2                   | 0.1241  |        |

**Table 1-12. OCT Variation after Power-Up Calibration (Note 1)**

| Symbol | Description   | V <sub>CCIO</sub> (V) | Typical | Unit              |
|--------|---|-----------------------|---------|-------------------|
| dR/dT  | OCT variation with temperature without re-calibration | 3.0                   | 0.189   | %/ <sup>o</sup> C |
|        |   | 2.5                   | 0.208   |                   |
|        |   | 1.8                   | 0.266   |                   |
|        |   | 1.5                   | 0.273   |                   |
|        |   | 1.2                   | 0.317   |                   |

**Note to Table 1-12:**

(1) Valid for V<sub>CCIO</sub> range of ±5% and temperature range of 0° to 85°C.

**Pin Capacitance**

Table 1-13 lists the Stratix IV device family pin capacitance.

**Table 1-13. Pin Capacitance for Stratix IV Devices**

| Symbol   | Description  | Value | Unit |
|--|--|-------|------|
| C <sub>IOTB</sub>  | Input capacitance on the top and bottom I/O pins                       | 4     | pF   |
| C <sub>IOLR</sub>  | Input capacitance on the left and right I/O pins                       | 4     | pF   |
| C <sub>CLKTB</sub>   | Input capacitance on the top and bottom non-dedicated clock input pins | 4     | pF   |
| C <sub>CLKLR</sub>   | Input capacitance on the left and right non-dedicated clock input pins | 4     | pF   |
| C <sub>OUTFB</sub>   | Input capacitance on the dual-purpose clock output and feedback pins   | 5     | pF   |
| C <sub>CLK1</sub> , C <sub>CLK3</sub> , C <sub>CLK8</sub> , and C <sub>CLK10</sub> | Input capacitance for dedicated clock input pins                       | 2     | pF   |

**Hot Socketing**

Table 1-14 lists the hot socketing specifications for Stratix IV devices.

**Table 1-14. Hot Socketing Specifications for Stratix IV Devices**

| Symbol                        | Description                       | Maximum  |
|-------------------------------|-----------------------------------|----------|
| I <sub>IOPIN</sub> (DC)       | DC current per I/O pin            | 300 μA   |
| I <sub>IOPIN</sub> (AC)       | AC current per I/O pin            | 8 mA (1) |
| I <sub>XCVR-TX</sub> (DC) (2) | DC current per transceiver TX pin | 100 mA   |
| I <sub>XCVR-RX</sub> (DC) (2) | DC current per transceiver RX pin | 50 mA    |

**Notes to Table 1-14:**

- (1) The I/O ramp rate is 10 ns or more. For ramp rates faster than 10 ns, |I<sub>IOPIN</sub>| = C dv/dt, in which C is the I/O pin capacitance and dv/dt is the slew rate.
- (2) These specifications are preliminary.

## Schmitt Trigger Input

Stratix IV devices support Schmitt trigger input on the TDI, TMS, TCK, nSTATUS, nCONFIG, nCE, CONF\_DONE, and DCLK pins. A Schmitt trigger feature introduces hysteresis to the input signal for improved noise immunity, especially for signals with slow edge rates. Table 1-15 lists the hysteresis specifications across the supported  $V_{CCIO}$  range for Schmitt trigger inputs in Stratix IV devices.

**Table 1-15. Schmitt Trigger Input Hysteresis Specifications for Stratix IV Devices**

| Symbol        | Description                          | Condition (V)    | Minimum | Unit |
|---------------|--------------------------------------|------------------|---------|------|
| $V_{Schmitt}$ | Hysteresis for Schmitt trigger input | $V_{CCIO} = 3.3$ | 220     | mV   |
|               |                                      | $V_{CCIO} = 2.5$ | 180     | mV   |
|               |                                      | $V_{CCIO} = 1.8$ | 110     | mV   |
|               |                                      | $V_{CCIO} = 1.5$ | 70      | mV   |

## Internal Weak Pull-Up Resistor

Table 1-16 lists the weak pull-up resistor values for Stratix IV devices.

**Table 1-16. Internal Weak Pull-Up Resistor for Stratix IV Devices (Note 1), (3)**

| Symbol   | Description   | Conditions (V)               | Value (4) | Unit      |
|----------|---|------------------------------|-----------|-----------|
| $R_{PU}$ | Value of the I/O pin pull-up resistor before and during configuration, as well as user mode if the programmable pull-up resistor option is enabled. | $V_{CCIO} = 3.0 \pm 5\%$ (2) | 25        | $k\Omega$ |
|          |   | $V_{CCIO} = 2.5 \pm 5\%$ (2) | 25        | $k\Omega$ |
|          |   | $V_{CCIO} = 1.8 \pm 5\%$ (2) | 25        | $k\Omega$ |
|          |   | $V_{CCIO} = 1.5 \pm 5\%$ (2) | 25        | $k\Omega$ |
|          |   | $V_{CCIO} = 1.2 \pm 5\%$ (2) | 25        | $k\Omega$ |

### Notes to Table 1-16:

- All I/O pins have an option to enable weak pull-up except configuration, test, and JTAG pins.
- Pin pull-up resistance values may be lower if an external source drives the pin higher than  $V_{CCIO}$ .
- The internal weak pull-down feature is only available for the JTAG TCK pin. The typical value for this internal weak pull-down resistor is approximately  $25 k\Omega$ .
- These specifications are valid with  $\pm 10\%$  tolerances to cover changes over PVT.

## I/O Standard Specifications

Table 1-17 through Table 1-22 list the input voltage ( $V_{IH}$  and  $V_{IL}$ ), output voltage ( $V_{OH}$  and  $V_{OL}$ ), and current drive characteristics ( $I_{OH}$  and  $I_{OL}$ ) for various I/O standards supported by Stratix IV devices. These tables also show the Stratix IV device family I/O standard specifications.  $V_{OL}$  and  $V_{OH}$  values are valid at the corresponding  $I_{OH}$  and  $I_{OL}$ , respectively.

For an explanation of terms used in Table 1-17 through Table 1-22, refer to “Glossary” on page 1-63.

**Table 1-17. Single-Ended I/O Standards (Part 1 of 2)**

| I/O Standard | $V_{CCIO}$ (V) |     |      | $V_{IL}$ (V) |     | $V_{IH}$ (V) |     | $V_{OL}$ (V) | $V_{OH}$ (V)     | $I_{OL}$ (mA) | $I_{OH}$ (mA) |
|--------------|----------------|-----|------|--------------|-----|--------------|-----|--------------|------------------|---------------|---------------|
|              | Min            | Typ | Max  | Min          | Max | Min          | Max | Max          | Min              |               |               |
| LVTTL        | 2.85           | 3   | 3.15 | -0.3         | 0.8 | 1.7          | 3.6 | 0.4          | 2.4              | 2             | -2            |
| LVC MOS      | 2.85           | 3   | 3.15 | -0.3         | 0.8 | 1.7          | 3.6 | 0.2          | $V_{CCIO} - 0.2$ | 0.1           | -0.1          |

**Table 1-17. Single-Ended I/O Standards (Part 2 of 2)**

| I/O Standard | V <sub>CCIO</sub> (V) |     |       | V <sub>IL</sub> (V) |                             | V <sub>IH</sub> (V)         |                            | V <sub>OL</sub> (V)         | V <sub>OH</sub> (V)         | I <sub>OL</sub> (mA) | I <sub>OH</sub> (mA) |
|--------------|-----------------------|-----|-------|---------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|-----------------------------|----------------------|----------------------|
|              | Min                   | Typ | Max   | Min                 | Max                         | Min                         | Max                        | Max                         | Min                         |                      |                      |
| 2.5 V        | 2.375                 | 2.5 | 2.625 | -0.3                | 0.7                         | 1.7                         | 3.6                        | 0.4                         | 2                           | 1                    | -1                   |
| 1.8 V        | 1.71                  | 1.8 | 1.89  | -0.3                | 0.35 *<br>V <sub>CCIO</sub> | 0.65 *<br>V <sub>CCIO</sub> | V <sub>CCIO</sub> +<br>0.3 | 0.45                        | V <sub>CCIO</sub> -<br>0.45 | 2                    | -2                   |
| 1.5 V        | 1.425                 | 1.5 | 1.575 | -0.3                | 0.35 *<br>V <sub>CCIO</sub> | 0.65 *<br>V <sub>CCIO</sub> | V <sub>CCIO</sub> +<br>0.3 | 0.25 *<br>V <sub>CCIO</sub> | 0.75 *<br>V <sub>CCIO</sub> | 2                    | -2                   |
| 1.2 V        | 1.14                  | 1.2 | 1.26  | -0.3                | 0.35 *<br>V <sub>CCIO</sub> | 0.65 *<br>V <sub>CCIO</sub> | V <sub>CCIO</sub> +<br>0.3 | 0.25 *<br>V <sub>CCIO</sub> | 0.75 *<br>V <sub>CCIO</sub> | 2                    | -2                   |
| 3.0-V PCI    | 2.85                  | 3   | 3.15  | —                   | 0.3 *<br>V <sub>CCIO</sub>  | 0.5 *<br>V <sub>CCIO</sub>  | 3.6                        | 0.1 *<br>V <sub>CCIO</sub>  | 0.9 * V <sub>CCIO</sub>     | 1.5                  | -0.5                 |
| 3.0-V PCI-X  | 2.85                  | 3   | 3.15  | —                   | 0.35 *<br>V <sub>CCIO</sub> | 0.5 *<br>V <sub>CCIO</sub>  | —                          | 0.1 *<br>V <sub>CCIO</sub>  | 0.9 * V <sub>CCIO</sub>     | 1.5                  | -0.5                 |

**Table 1-18. Single-Ended SSTL and HSTL I/O Reference Voltage Specifications**

| I/O Standard        | V <sub>CCIO</sub> (V) |     |       | V <sub>REF</sub> (V)        |                            |                             | V <sub>TT</sub> (V)         |                      |                             |
|---------------------|-----------------------|-----|-------|-----------------------------|----------------------------|-----------------------------|-----------------------------|----------------------|-----------------------------|
|                     | Min                   | Typ | Max   | Min                         | Typ                        | Max                         | Min                         | Typ                  | Max                         |
| SSTL-2 Class I, II  | 2.375                 | 2.5 | 2.625 | 0.49 *<br>V <sub>CCIO</sub> | 0.5 *<br>V <sub>CCIO</sub> | 0.51 *<br>V <sub>CCIO</sub> | V <sub>REF</sub> -<br>0.04  | V <sub>REF</sub>     | V <sub>REF</sub> +<br>0.04  |
| SSTL-18 Class I, II | 1.71                  | 1.8 | 1.89  | 0.833                       | 0.9                        | 0.969                       | V <sub>REF</sub> -<br>0.04  | V <sub>REF</sub>     | V <sub>REF</sub> +<br>0.04  |
| SSTL-15 Class I, II | 1.425                 | 1.5 | 1.575 | 0.47 *<br>V <sub>CCIO</sub> | 0.5 *<br>V <sub>CCIO</sub> | 0.53 *<br>V <sub>CCIO</sub> | 0.47 *<br>V <sub>CCIO</sub> | V <sub>REF</sub>     | 0.53 *<br>V <sub>CCIO</sub> |
| HSTL-18 Class I, II | 1.71                  | 1.8 | 1.89  | 0.85                        | 0.9                        | 0.95                        | —                           | V <sub>CCIO</sub> /2 | —                           |
| HSTL-15 Class I, II | 1.425                 | 1.5 | 1.575 | 0.68                        | 0.75                       | 0.9                         | —                           | V <sub>CCIO</sub> /2 | —                           |
| HSTL-12 Class I, II | 1.14                  | 1.2 | 1.26  | 0.47 *<br>V <sub>CCIO</sub> | 0.5 *<br>V <sub>CCIO</sub> | 0.53 *<br>V <sub>CCIO</sub> | —                           | V <sub>CCIO</sub> /2 | —                           |

**Table 1-19. Single-Ended SSTL and HSTL I/O Standards Signal Specifications (Part 1 of 2)**

| I/O Standard     | V <sub>IL(DC)</sub> (V) |                             | V <sub>IH(DC)</sub> (V)     |                            | V <sub>IL(AC)</sub> (V)     | V <sub>IH(AC)</sub> (V)     | V <sub>OL</sub> (V)        | V <sub>OH</sub> (V)         | I <sub>ol</sub> (mA) | I <sub>oh</sub> (mA) |
|------------------|-------------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|----------------------|----------------------|
|                  | Min                     | Max                         | Min                         | Max                        | Max                         | Min                         | Max                        | Min                         |                      |                      |
| SSTL-2 Class I   | -0.3                    | V <sub>REF</sub> -<br>0.15  | V <sub>REF</sub> +<br>0.15  | V <sub>CCIO</sub> +<br>0.3 | V <sub>REF</sub> -<br>0.31  | V <sub>REF</sub> +<br>0.31  | V <sub>TT</sub> -<br>0.57  | V <sub>TT</sub> +<br>0.57   | 8.1                  | -8.1                 |
| SSTL-2 Class II  | -0.3                    | V <sub>REF</sub> -<br>0.15  | V <sub>REF</sub> +<br>0.15  | V <sub>CCIO</sub> +<br>0.3 | V <sub>REF</sub> -<br>0.31  | V <sub>REF</sub> +<br>0.31  | V <sub>TT</sub> -<br>0.76  | V <sub>TT</sub> +<br>0.76   | 16.2                 | -16.2                |
| SSTL-18 Class I  | -0.3                    | V <sub>REF</sub> -<br>0.125 | V <sub>REF</sub> +<br>0.125 | V <sub>CCIO</sub> +<br>0.3 | V <sub>REF</sub> -<br>0.25  | V <sub>REF</sub> +<br>0.25  | V <sub>TT</sub> -<br>0.475 | V <sub>TT</sub> +<br>0.475  | 6.7                  | -6.7                 |
| SSTL-18 Class II | -0.3                    | V <sub>REF</sub> -<br>0.125 | V <sub>REF</sub> +<br>0.125 | V <sub>CCIO</sub> +<br>0.3 | V <sub>REF</sub> -<br>0.25  | V <sub>REF</sub> +<br>0.25  | 0.28                       | V <sub>CCIO</sub> -<br>0.28 | 13.4                 | -13.4                |
| SSTL-15 Class I  | —                       | V <sub>REF</sub> -<br>0.1   | V <sub>REF</sub> +<br>0.1   | —                          | V <sub>REF</sub> -<br>0.175 | V <sub>REF</sub> +<br>0.175 | 0.2 *<br>V <sub>CCIO</sub> | 0.8 *<br>V <sub>CCIO</sub>  | 8                    | -8                   |

**Table 1-19. Single-Ended SSTL and HSTL I/O Standards Signal Specifications (Part 2 of 2)**

| I/O Standard     | $V_{IL(DC)} (V)$ |                  | $V_{IH(DC)} (V)$ |                   | $V_{IL(AC)} (V)$  | $V_{IH(AC)} (V)$  | $V_{OL} (V)$      | $V_{OH} (V)$      | $I_{ol} (mA)$ | $I_{oh} (mA)$ |
|------------------|------------------|------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|---------------|---------------|
|                  | Min              | Max              | Min              | Max               | Max               | Min               | Max               | Min               |               |               |
| SSTL-15 Class II | —                | $V_{REF} - 0.1$  | $V_{REF} + 0.1$  | —                 | $V_{REF} - 0.175$ | $V_{REF} + 0.175$ | $0.2^* V_{CCIO}$  | $0.8^* V_{CCIO}$  | 16            | -16           |
| HSTL-18 Class I  | —                | $V_{REF} - 0.1$  | $V_{REF} + 0.1$  | —                 | $V_{REF} - 0.2$   | $V_{REF} + 0.2$   | 0.4               | $V_{CCIO} - 0.4$  | 8             | -8            |
| HSTL-18 Class II | —                | $V_{REF} - 0.1$  | $V_{REF} + 0.1$  | —                 | $V_{REF} - 0.2$   | $V_{REF} + 0.2$   | 0.4               | $V_{CCIO} - 0.4$  | 16            | -16           |
| HSTL-15 Class I  | —                | $V_{REF} - 0.1$  | $V_{REF} + 0.1$  | —                 | $V_{REF} - 0.2$   | $V_{REF} + 0.2$   | 0.4               | $V_{CCIO} - 0.4$  | 8             | -8            |
| HSTL-15 Class II | —                | $V_{REF} - 0.1$  | $V_{REF} + 0.1$  | —                 | $V_{REF} - 0.2$   | $V_{REF} + 0.2$   | 0.4               | $V_{CCIO} - 0.4$  | 16            | -16           |
| HSTL-12 Class I  | -0.15            | $V_{REF} - 0.08$ | $V_{REF} + 0.08$ | $V_{CCIO} + 0.15$ | $V_{REF} - 0.15$  | $V_{REF} + 0.15$  | $0.25^* V_{CCIO}$ | $0.75^* V_{CCIO}$ | 8             | -8            |
| HSTL-12 Class II | -0.15            | $V_{REF} - 0.08$ | $V_{REF} + 0.08$ | $V_{CCIO} + 0.15$ | $V_{REF} - 0.15$  | $V_{REF} + 0.15$  | $0.25^* V_{CCIO}$ | $0.75^* V_{CCIO}$ | 16            | -16           |

**Table 1-20. Differential SSTL I/O Standards**

| I/O Standard        | $V_{CCIO} (V)$ |     |       | $V_{SWING(DC)} (V)$ |                  | $V_{X(AC)} (V)$      |              |                      | $V_{SWING(AC)} (V)$ |                  | $V_{OX(AC)} (V)$     |              |                      |
|---------------------|----------------|-----|-------|---------------------|------------------|----------------------|--------------|----------------------|---------------------|------------------|----------------------|--------------|----------------------|
|                     | Min            | Typ | Max   | Min                 | Max              | Min                  | Typ          | Max                  | Min                 | Max              | Min                  | Typ          | Max                  |
| SSTL-2 Class I, II  | 2.375          | 2.5 | 2.625 | 0.3                 | $V_{CCIO} + 0.6$ | $V_{CCIO}/2 - 0.2$   | —            | $V_{CCIO}/2 + 0.2$   | 0.62                | $V_{CCIO} + 0.6$ | $V_{CCIO}/2 - 0.15$  | —            | $V_{CCIO}/2 + 0.15$  |
| SSTL-18 Class I, II | 1.71           | 1.8 | 1.89  | 0.25                | $V_{CCIO} + 0.6$ | $V_{CCIO}/2 - 0.175$ | —            | $V_{CCIO}/2 + 0.175$ | 0.5                 | $V_{CCIO} + 0.6$ | $V_{CCIO}/2 - 0.125$ | —            | $V_{CCIO}/2 + 0.125$ |
| SSTL-15 Class I, II | 1.425          | 1.5 | 1.575 | 0.2                 | —                | —                    | $V_{CCIO}/2$ | —                    | 0.35                | —                | —                    | $V_{CCIO}/2$ | —                    |

**Table 1-21. Differential HSTL I/O Standards**

| I/O Standard        | $V_{CCIO} (V)$ |     |       | $V_{DIF(DC)} (V)$ |                  | $V_{X(AC)} (V)$ |                  |      | $V_{CM(DC)} (V)$ |                  |                  | $V_{DIF(AC)} (V)$ |                   |
|---------------------|----------------|-----|-------|-------------------|------------------|-----------------|------------------|------|------------------|------------------|------------------|-------------------|-------------------|
|                     | Min            | Typ | Max   | Min               | Max              | Min             | Typ              | Max  | Min              | Typ              | Max              | Min               | Max               |
| HSTL-18 Class I     | 1.71           | 1.8 | 1.89  | 0.2               | —                | 0.78            | —                | 1.12 | 0.78             | —                | 1.12             | 0.4               | —                 |
| HSTL-15 Class I, II | 1.425          | 1.5 | 1.575 | 0.2               | —                | 0.68            | —                | 0.9  | 0.68             | —                | 0.9              | 0.4               | —                 |
| HSTL-12 Class I, II | 1.14           | 1.2 | 1.26  | 0.16              | $V_{CCIO} + 0.3$ | —               | $0.5^* V_{CCIO}$ | —    | $0.4^* V_{CCIO}$ | $0.5^* V_{CCIO}$ | $0.6^* V_{CCIO}$ | 0.3               | $V_{CCIO} + 0.48$ |

**Table 1-22. Differential I/O Standard Specifications (Note 1), (2)**

| I/O Standard     | V <sub>CCIO</sub> (V)  |     |       | V <sub>ID</sub> (mV) |                          |     | V <sub>ICM(DC)</sub> (V) |                             |          | V <sub>OD</sub> (V) (3) |     |     | V <sub>OCM</sub> (V) (3) |      |       |
|------------------|--|-----|-------|----------------------|--------------------------|-----|--------------------------|-----------------------------|----------|-------------------------|-----|-----|--------------------------|------|-------|
|                  | Min  | Typ | Max   | Min                  | Condition                | Max | Min                      | Condition                   | Max      | Min                     | Typ | Max | Min                      | Typ  | Max   |
| PCML             | Transmitter, receiver, and input reference clock pins of high-speed transceivers use PCML I/O standard. For transmitter, receiver, and reference clock I/O pin specifications, refer to Table 1-23 on page 1-15 and Table 1-24 on page 1-24. |     |       |                      |                          |     |                          |                             |          |                         |     |     |                          |      |       |
| 2.5 V LVDS (HIO) | 2.375  | 2.5 | 2.625 | 100                  | V <sub>CM</sub> = 1.25 V | —   | 0.05 (4)                 | —                           | 1.8 (4)  | 0.247                   | —   | 0.6 | 1.125                    | 1.25 | 1.375 |
|                  |  |     |       |                      |                          | —   | 1.05 (4)                 | D <sub>MAX</sub> > 700 Mbps | 1.55 (4) |                         |     |     |                          |      |       |
| 2.5 V LVDS (VIO) | 2.375  | 2.5 | 2.625 | 100                  | V <sub>CM</sub> = 1.25 V | —   | 0.05                     | —                           | 1.8      | 0.247                   | —   | 0.6 | 1                        | 1.25 | 1.5   |
|                  |  |     |       |                      |                          | —   | 1.05                     | D <sub>MAX</sub> > 700 Mbps | 1.55     |                         |     |     |                          |      |       |
| RSDS (HIO)       | 2.375  | 2.5 | 2.625 | 100                  | V <sub>CM</sub> = 1.25 V | —   | 0.3                      | —                           | 1.4      | 0.1                     | 0.2 | 0.6 | 0.5                      | 1.2  | 1.4   |
| RSDS (VIO)       | 2.375  | 2.5 | 2.625 | 100                  | V <sub>CM</sub> = 1.25 V | —   | 0.3                      | —                           | 1.4      | 0.1                     | 0.2 | 0.6 | 0.5                      | 1.2  | 1.5   |
| Mini-LVDS (HIO)  | 2.375  | 2.5 | 2.625 | 200                  | —                        | 600 | 0.4                      | —                           | 1.325    | 0.25                    | —   | 0.6 | 1                        | 1.2  | 1.4   |
| Mini-LVDS (VIO)  | 2.375  | 2.5 | 2.625 | 200                  | —                        | 600 | 0.4                      | —                           | 1.325    | 0.25                    | —   | 0.6 | 1                        | 1.2  | 1.5   |
| LVPECL           | 2.375  | 2.5 | 2.625 | 300                  | —                        | —   | 0.6 (5)                  | —                           | 1.8 (5)  | —                       | —   | —   | —                        | —    | —     |
|                  |  |     |       |                      |                          |     | 1 (5)                    | D <sub>MAX</sub> > 700 Mbps | 1.6 (5)  |                         |     |     |                          |      |       |

**Notes to Table 1-22:**

- (1) Vertical I/O (VIO) is top and bottom I/Os; horizontal I/O (HIO) is left and right I/Os.
- (2) 1.4-V/1.5-V PCML transceiver I/O standard specifications are described in “Transceiver Performance Specifications” on page 1-15.
- (3) RL range: 90 ≤ RL ≤ 110 Ω.
- (4) The receiver voltage input range for the data rate when D<sub>MAX</sub> > 700 Mbps is 1.0 V ≤ V<sub>IN</sub> ≤ 1.6 V. The receiver voltage input range for the data rate when D<sub>MAX</sub> ≤ 700 Mbps is zero V ≤ V<sub>IN</sub> ≤ 1.85 V.
- (5) The receiver voltage input range for the data rate when D<sub>MAX</sub> > 700 Mbps is 0.85 V ≤ V<sub>IN</sub> ≤ 1.75 V. The receiver voltage input range for the data rate when D<sub>MAX</sub> ≤ 700 Mbps is 0.45 V ≤ V<sub>IN</sub> ≤ 1.95 V.

## Power Consumption

Altera offers two ways to estimate power consumption for a design the Excel-based Early Power Estimator and the Quartus® II PowerPlay Power Analyzer feature.



You typically use the interactive Excel-based Early Power Estimator before designing the FPGA to get a magnitude estimate of the device power. The Quartus II PowerPlay Power Analyzer provides better quality estimates based on the specifics of the design after you complete place-and-route. The PowerPlay Power Analyzer can apply a combination of user-entered, simulation-derived, and estimated signal activities that, when combined with detailed circuit models, yields very accurate power estimates.



For more information about power estimation tools, refer to the *PowerPlay Early Power Estimator User Guide* and the *PowerPlay Power Analysis* chapter in the *Quartus II Handbook*.

## Switching Characteristics

This section provides performance characteristics of Stratix IV core and periphery blocks for commercial grade devices.

These characteristics can be designated as Preliminary or Final.

- Preliminary characteristics are created using simulation results, process data, and other known parameters. The title of these tables show the designation as “Preliminary”.
- Final numbers are based on actual silicon characterization and testing. The numbers reflect the actual performance of the device under worst-case silicon process, voltage, and junction temperature conditions. There are no designations on finalized tables.

## Transceiver Performance Specifications

This section describes transceiver performance specifications.

Table 1-23 lists the Stratix IV GX transceiver specifications.

**Table 1-23. Transceiver Specifications for Stratix IV GX Devices (Part 1 of 9)**

| Symbol/<br>Description                              | Conditions   | -2 Commercial<br>Speed Grade |     |      | -3 Commercial/<br>Industrial/Military and<br>-2× Commercial<br>Speed Grade (1) |     |      | -4<br>Commercial/Industrial<br>Speed Grade |     |       | Unit |
|---|--|------------------------------|-----|------|--|-----|------|--|-----|-------|------|
|   |  | Min                          | Typ | Max  | Min  | Typ | Max  | Min  | Typ | Max   |      |
| <b>Reference Clock</b>                              |  |                              |     |      |  |     |      |  |     |       |      |
| Supported I/O Standards                             | 1.2 V PCML, 1.4 V PCML 1.5 V PCML, 2.5 V PCML, Differential LVPECL (3), LVDS, HCSL |                              |     |      |  |     |      |  |     |       |      |
| Input frequency from REFCLK input pins              | —  | 50                           | —   | 697  | 50   | —   | 697  | 50   | —   | 637.5 | MHz  |
| Phase frequency detector (CMU PLL and receiver CDR) | —  | 50                           | —   | 425  | 50   | —   | 325  | 50   | —   | 325   | MHz  |
| Absolute V <sub>MAX</sub> for a REFCLK pin          | —  | —                            | —   | 1.6  | —  | —   | 1.6  | —  | —   | 1.6   | V    |
| Operational V <sub>MAX</sub> for a REFCLK pin       | —  | —                            | —   | 1.5  | —  | —   | 1.5  | —  | —   | 1.5   | V    |
| Absolute V <sub>MIN</sub> for a REFCLK pin          | —  | -0.4                         | —   | —    | -0.4   | —   | —    | -0.4                                       | —   | —     | V    |
| Rise/fall time (21)                                 | —  | —                            | —   | 0.2  | —  | —   | 0.2  | —  | —   | 0.2   | UI   |
| Duty cycle  | —  | 45                           | —   | 55   | 45   | —   | 55   | 45   | —   | 55    | %    |
| Peak-to-peak differential input voltage             | —  | 200                          | —   | 1600 | 200  | —   | 1600 | 200  | —   | 1600  | mV   |
| Spread-spectrum modulating clock frequency          | PCIe   | 30                           | —   | 33   | 30   | —   | 33   | 30   | —   | 33    | kHz  |

**Table 1-23. Transceiver Specifications for Stratix IV GX Devices (Part 2 of 9)**

| Symbol/<br>Description   | Conditions  | -2 Commercial<br>Speed Grade |               |      | -3 Commercial/<br>Industrial/Military and<br>-2× Commercial<br>Speed Grade (1) |               |      | -4<br>Commercial/Industrial<br>Speed Grade |               |      | Unit   |
|--|---|------------------------------|---------------|------|--|---------------|------|--|---------------|------|--------|
|  |   | Min                          | Typ           | Max  | Min  | Typ           | Max  | Min  | Typ           | Max  |        |
| Spread-spectrum<br>downspread  | PCIe  | —                            | 0 to<br>-0.5% | —    | —  | 0 to<br>-0.5% | —    | —  | 0 to<br>-0.5% | —    | —      |
| On-chip termination<br>resistors   | —   | —                            | 100           | —    | —  | 100           | —    | —  | 100           | —    | Ω      |
| V <sub>ICM</sub> (AC coupled)  | —   | 1100 ± 10%                   |               |      | 1100 ± 10%   |               |      | 1100 ± 10%                                 |               |      | mV     |
| V <sub>ICM</sub> (DC coupled)  | HCSL I/O<br>standard for<br>PCIe reference<br>clock | 250                          | —             | 550  | 250  | —             | 550  | 250  | —             | 550  | mV     |
| Transmitter REFCLK<br>Phase Noise  | 10 Hz   | —                            | —             | -50  | —  | —             | -50  | —  | —             | -50  | dBc/Hz |
|  | 100 Hz  | —                            | —             | -80  | —  | —             | -80  | —  | —             | -80  | dBc/Hz |
|  | 1 KHz   | —                            | —             | -110 | —  | —             | -110 | —  | —             | -110 | dBc/Hz |
|  | 10 KHz  | —                            | —             | -120 | —  | —             | -120 | —  | —             | -120 | dBc/Hz |
|  | 100 KHz   | —                            | —             | -120 | —  | —             | -120 | —  | —             | -120 | dBc/Hz |
|  | ≥ 1 MHz   | —                            | —             | -130 | —  | —             | -130 | —  | —             | -130 | dBc/Hz |
| Transmitter REFCLK<br>Phase Jitter (rms)<br>for 100 MHz<br>REFCLK (2)        | 10 KHz to<br>20 MHz                                 | —                            | —             | 3    | —  | —             | 3    | —  | —             | 3    | ps     |
| R <sub>REF</sub>   | —   | —                            | 2000<br>± 1%  | —    | —  | 2000 ±<br>1%  | —    | —  | 2000<br>± 1%  | —    | Ω      |
| <b>Transceiver Clocks</b>  |   |                              |               |      |  |               |      |  |               |      |        |
| Calibration block<br>clock frequency   | —   | 10                           | —             | 125  | 10   | —             | 125  | 10   | —             | 125  | MHz    |
| fixedclk clock<br>frequency  | PCIe Receiver<br>Detect                             | —                            | 125           | —    | —  | 125           | —    | —  | 125           | —    | MHz    |
| reconfig_clk<br>clock frequency  | Dynamic<br>reconfiguration<br>clock frequency       | 2.5/<br>37.5<br>(4)          | —             | 50   | 2.5/<br>37.5<br>(4)  | —             | 50   | 2.5/<br>37.5<br>(4)                        | —             | 50   | —      |
| Delta time between<br>reconfig_clks<br>(19)                                  | —   | —                            | —             | 2    | —  | —             | 2    | —  | —             | 2    | ms     |
| Transceiver block<br>minimum<br>power-down<br>(gxb_powerdown)<br>pulse width | —   | 1                            | —             | —    | 1  | —             | —    | 1  | —             | —    | μs     |
| <b>Receiver</b>  |   |                              |               |      |  |               |      |  |               |      |        |

**Table 1-23. Transceiver Specifications for Stratix IV GX Devices (Part 3 of 9)**

| Symbol/<br>Description   | Conditions   | -2 Commercial<br>Speed Grade |     |      | -3 Commercial/<br>Industrial/Military and<br>-2× Commercial<br>Speed Grade (1) |     |      | -4<br>Commercial/Industrial<br>Speed Grade |     |              | Unit |
|--|--|------------------------------|-----|------|--|-----|------|--|-----|--------------|------|
|  |  | Min                          | Typ | Max  | Min  | Typ | Max  | Min  | Typ | Max          |      |
| Supported I/O<br>Standards   | 1.4 V PCML, 1.5 V PCML, 2.5 V PCML, LVPECL, LVDS                           |                              |     |      |  |     |      |  |     |              |      |
| Data rate (Single<br>width, non-PMA<br>Direct)   | —  | 600                          | —   | 3750 | 600  | —   | 3750 | 600  | —   | 3750         | Mbps |
| Data rate (Double<br>width, non-PMA<br>Direct)   | —  | 1000                         | —   | 8500 | 1000   | —   | 6500 | 1000                                       | —   | 6375<br>(22) | Mbps |
| Data rate (Single<br>width, PMA Direct)  | —  | 600                          | —   | 3250 | 600  | —   | 3250 | 600  | —   | 3250         | Mbps |
| Data rate (Double<br>width, PMA Direct)  | —  | 1000                         | —   | 6500 | 1000   | —   | 6500 | 1000                                       | —   | 6375         | Mbps |
| Absolute $V_{MAX}$ for a<br>receiver pin (5)   | —  | —                            | —   | 1.6  | —  | —   | 1.6  | —  | —   | 1.6          | V    |
| Operational $V_{MAX}$ for<br>a receiver pin  | —  | —                            | —   | 1.5  | —  | —   | 1.5  | —  | —   | 1.5          | V    |
| Absolute $V_{MIN}$ for a<br>receiver pin   | —  | -0.4                         | —   | —    | -0.4   | —   | —    | -0.4                                       | —   | —            | V    |
| Maximum<br>peak-to-peak<br>differential input<br>voltage $V_{ID}$ (diff p-p)<br>before device<br>configuration | —  | —                            | —   | 1.6  | —  | —   | 1.6  | —  | —   | 1.6          | V    |
| Maximum peak-to-<br>peak differential<br>input voltage $V_{ID}$<br>(diff p-p) after<br>device configuration    | $V_{ICM} = 0.82$ V<br>setting  | —                            | —   | 2.7  | —  | —   | 2.7  | —  | —   | 2.7          | V    |
|  | $V_{ICM} = 1.1$ V<br>setting (6)   | —                            | —   | 1.6  | —  | —   | 1.6  | —  | —   | 1.6          | V    |
| Minimum<br>differential eye<br>opening at receiver<br>serial input pins<br>(20)                                | Data Rate =<br>600 Mbps to<br>5 Gbps<br>Equalization = 0<br>DC gain = 0 dB | 100                          | —   | —    | 100  | —   | —    | 165  | —   | —            | mV   |
|  | Data Rate<br>> 5 Gbps<br>Equalization = 0<br>DC gain = 0 dB                | 165                          | —   | —    | 165  | —   | —    | 165  | —   | —            | mV   |
| $V_{ICM}$  | $V_{ICM} = 0.82$ V<br>setting  | 820 ± 10%                    |     |      | 820 ± 10%  |     |      | 820 ± 10%                                  |     |              | mV   |
|  | $V_{ICM} = 1.1$ V<br>setting (6)   | 1100 ± 10%                   |     |      | 1100 ± 10%   |     |      | 1100 ± 10%                                 |     |              | mV   |

**Table 1-23. Transceiver Specifications for Stratix IV GX Devices (Part 4 of 9)**

| Symbol/<br>Description  | Conditions  | -2 Commercial<br>Speed Grade   |     |      | -3 Commercial/<br>Industrial/Military and<br>-2× Commercial<br>Speed Grade (1) |     |      | -4<br>Commercial/Industrial<br>Speed Grade |     |      | Unit |     |
|---|---|--|-----|------|--|-----|------|--|-----|------|------|-----|
|   |   | Min  | Typ | Max  | Min  | Typ | Max  | Min  | Typ | Max  |      |     |
| Receiver DC<br>Coupling Support                                 | —   | For more information about receiver DC coupling support, refer to the “DC-Coupled Links” section in the <i>Transceiver Architecture in Stratix IV Devices</i> chapter. |     |      |  |     |      |  |     |      |      |     |
| Differential on-chip<br>termination<br>resistors                | 85-Ω setting  | 85 ± 20%   |     |      | 85 ± 20%   |     |      | 85 ± 20%                                   |     |      | Ω    |     |
|   | 100-Ω setting   | 100 ± 20%  |     |      | 100 ± 20%  |     |      | 100 ± 20%                                  |     |      | Ω    |     |
|   | 120-Ω setting   | 120 ± 20%  |     |      | 120 ± 20%  |     |      | 120 ± 20%                                  |     |      | Ω    |     |
|   | 150-Ω setting   | 150 ± 20%  |     |      | 150 ± 20%  |     |      | 150 ± 20%                                  |     |      | Ω    |     |
| Differential and<br>common mode<br>return loss                  | PCIe (Gen 1<br>and Gen 2),<br>XAUI,<br>HiGig+,<br>CEI SR/LR,<br>Serial RapidIO<br>SR/LR,<br>CPRI LV/HV,<br>OBSAI,<br>SATA | Compliant  |     |      |  |     |      |  |     |      |      | —   |
| Programmable PPM<br>detector (7)                                | —   | ± 62.5, 100, 125, 200,<br>250, 300, 500, 1000  |     |      |  |     |      |  |     |      |      | ppm |
| Run length  | —   | —  | —   | 200  | —  | —   | 200  | —  | —   | 200  | UI   |     |
| Programmable<br>equalization (18)                               | —   | —  | —   | 16   | —  | —   | 16   | —  | —   | 16   | dB   |     |
| t <sub>LTR</sub> (8)  | —   | —  | —   | 75   | —  | —   | 75   | —  | —   | 75   | μs   |     |
| t <sub>LTR_LTD_Manual</sub> (9)                                 | —   | 15   | —   | —    | 15   | —   | —    | 15   | —   | —    | μs   |     |
| t <sub>LTD_Manual</sub> (10)                                    | —   | —  | —   | 4000 | —  | —   | 4000 | —  | —   | 4000 | ns   |     |
| t <sub>LTD_Auto</sub> (11)                                      | —   | —  | —   | 4000 | —  | —   | 4000 | —  | —   | 4000 | ns   |     |
| Receiver CDR<br>3 dB Bandwidth in<br>lock-to-data (LTD)<br>mode | PCIe Gen1   | 20 - 35  |     |      |  |     |      |  |     |      | MHz  |     |
|   | PCIe Gen2   | 40 - 65  |     |      |  |     |      |  |     |      | MHz  |     |
|   | (OIF) CEI PHY<br>at 6.375 Gbps  | 20 - 35  |     |      |  |     |      |  |     |      | MHz  |     |
|   | XAUI  | 10 - 18  |     |      |  |     |      |  |     |      | MHz  |     |
|   | Serial RapidIO<br>1.25 Gbps   | 10 - 18  |     |      |  |     |      |  |     |      | MHz  |     |
|   | Serial RapidIO<br>2.5 Gbps  | 10 - 18  |     |      |  |     |      |  |     |      | MHz  |     |
|   | Serial RapidIO<br>3.125 Gbps  | 6 - 10   |     |      |  |     |      |  |     |      | MHz  |     |
|   | GIGE  | 6 - 10   |     |      |  |     |      |  |     |      | MHz  |     |
|   | SONET OC12  | 3 - 6  |     |      |  |     |      |  |     |      | MHz  |     |
|   | SONET OC48  | 14 - 19  |     |      |  |     |      |  |     |      | MHz  |     |

**Table 1-23. Transceiver Specifications for Stratix IV GX Devices (Part 5 of 9)**

| Symbol/<br>Description   | Conditions   | -2 Commercial<br>Speed Grade |     |           | -3 Commercial/<br>Industrial/Military and<br>-2× Commercial<br>Speed Grade (1) |     |           | -4<br>Commercial/Industrial<br>Speed Grade |     |       | Unit                           |
|--|--|------------------------------|-----|-----------|--|-----|-----------|--|-----|-------|--------------------------------|
|  |  | Min                          | Typ | Max       | Min  | Typ | Max       | Min  | Typ | Max   |                                |
| Receiver buffer and CDR offset cancellation time (per channel) | —  | —                            | —   | 1850<br>0 | —  | —   | 1850<br>0 | —  | —   | 18500 | recon<br>fig_<br>clk<br>cycles |
| Programmable DC gain   | DC Gain Setting = 0  | —                            | 0   | —         | —  | 0   | —         | —  | 0   | —     | dB                             |
|  | DC Gain Setting = 1  | —                            | 3   | —         | —  | 3   | —         | —  | 3   | —     | dB                             |
|  | DC Gain Setting = 2  | —                            | 6   | —         | —  | 6   | —         | —  | 6   | —     | dB                             |
|  | DC Gain Setting = 3  | —                            | 9   | —         | —  | 9   | —         | —  | 9   | —     | dB                             |
|  | DC Gain Setting = 4  | —                            | 12  | —         | —  | 12  | —         | —  | 12  | —     | dB                             |
| EyeQ Data Rate   | —  | 600                          | —   | 3250      | 600  | —   | 3250      | 600  | —   | 3250  | Mbps                           |
| AEQ Data Rate  | min $V_{ID}$<br>(diff p-p)<br>outer envelope<br>= 600 mV<br>8B/10B<br>encoded data | 2500                         | —   | 6500      | 2500   | —   | 6500      | —  | —   | —     | Mbps                           |
| Decision Feedback Equalizer (DFE) Data Rate                    | min $V_{ID}$<br>(diff p-p)<br>outer envelope<br>= 500 mV                           | 3125                         | —   | 6500      | 3125   | —   | 6500      | —  | —   | —     | Mbps                           |

| <b>Transmitter</b>                           |                        |      |     |      |      |     |      |      |     |              |      |
|--|------------------------|------|-----|------|------|-----|------|------|-----|--------------|------|
| Supported I/O Standards                      | 1.4 V PCML, 1.5 V PCML |      |     |      |      |     |      |      |     |              |      |
| Data rate (Single width, non-PMA Direct)     | —                      | 600  | —   | 3750 | 600  | —   | 3750 | 600  | —   | 3750         | Mbps |
| Data rate (Double width, non-PMA Direct)     | —                      | 1000 | —   | 8500 | 1000 | —   | 6500 | 1000 | —   | 6375<br>(22) | Mbps |
| Data rate (Single width, PMA Direct)         | —                      | 600  | —   | 3250 | 600  | —   | 3250 | 600  | —   | 3250         | Mbps |
| Data rate (Double width, PMA Direct)<br>(12) | —                      | 1000 | —   | 6500 | 1000 | —   | 6500 | 1000 | —   | 6375         | Mbps |
| $V_{OCM}$                                    | 0.65 V setting         | —    | 650 | —    | —    | 650 | —    | —    | 650 | —            | mV   |

**Table 1-23. Transceiver Specifications for Stratix IV GX Devices (Part 6 of 9)**

| Symbol/<br>Description   | Conditions  | -2 Commercial<br>Speed Grade |     |     | -3 Commercial/<br>Industrial/Military and<br>-2× Commercial<br>Speed Grade (1) |     |     | -4<br>Commercial/Industrial<br>Speed Grade |     |     | Unit |
|--|---|------------------------------|-----|-----|--|-----|-----|--|-----|-----|------|
|  |   | Min                          | Typ | Max | Min  | Typ | Max | Min  | Typ | Max |      |
| Differential on-chip<br>termination<br>resistors                     | 85-Ω setting  | 85 ± 15%                     |     |     | 85 ± 15%   |     |     | 85 ± 15%                                   |     |     | Ω    |
|  | 100-Ω setting   | 100 ± 15%                    |     |     | 100 ± 15%  |     |     | 100 ± 15%                                  |     |     | Ω    |
|  | 120-Ω setting   | 120 ± 15%                    |     |     | 120 ± 15%  |     |     | 120 ± 15%                                  |     |     | Ω    |
|  | 150-Ω setting   | 150 ± 15%                    |     |     | 150 ± 15%  |     |     | 150 ± 15%                                  |     |     | Ω    |
| Differential and<br>common mode<br>return loss                       | PCIe Gen1 and<br>Gen2 (TX<br>V <sub>OD</sub> =4),<br>XAUI (TX<br>V <sub>OD</sub> =6),<br>HiGig+<br>(TX V <sub>OD</sub> =6),<br>CEI SR/LR<br>(TX V <sub>OD</sub> =8),<br>Serial RapidIO<br>SR (V <sub>OD</sub> =6),<br>Serial RapidIO<br>LR (V <sub>OD</sub> =8),<br>CPRI LV<br>(V <sub>OD</sub> =6),<br>CPRI HV<br>(V <sub>OD</sub> =2),<br>OBSAI (V <sub>OD</sub> =6),<br>SATA (V <sub>OD</sub> =4), | Compliant                    |     |     |  |     |     |  |     |     | —    |
| Rise time (13)   | —   | 50                           | —   | 200 | 50   | —   | 200 | 50   | —   | 200 | ps   |
| Fall time (13)   | —   | 50                           | —   | 200 | 50   | —   | 200 | 50   | —   | 200 | ps   |
| XAUI rise time   | —   | 60                           | —   | 130 | 60   | —   | 130 | 60   | —   | 130 | ps   |
| XAUI fall time   | —   | 60                           | —   | 130 | 60   | —   | 130 | 60   | —   | 130 | ps   |
| Intra-differential pair<br>skew                                      | —   | —                            | —   | 15  | —  | —   | 15  | —  | —   | 15  | ps   |
| Intra-transceiver<br>block transmitter<br>channel-to-channel<br>skew | ×4 PMA and<br>PCS bonded<br>mode Example:<br>XAUI, PCIe ×4,<br>Basic ×4   | —                            | —   | 120 | —  | —   | 120 | —  | —   | 120 | ps   |
| Inter-transceiver<br>block transmitter<br>channel-to-channel<br>skew | ×8 PMA and<br>PCS bonded<br>mode Example:<br>PCIe ×8,<br>Basic ×8   | —                            | —   | 500 | —  | —   | 500 | —  | —   | 500 | ps   |

**Table 1-23. Transceiver Specifications for Stratix IV GX Devices (Part 7 of 9)**

| Symbol/<br>Description   | Conditions  | -2 Commercial<br>Speed Grade |     |      | -3 Commercial/<br>Industrial/Military and<br>-2× Commercial<br>Speed Grade (1) |     |      | -4<br>Commercial/Industrial<br>Speed Grade |     |      | Unit |
|--|---|------------------------------|-----|------|--|-----|------|--|-----|------|------|
|  |   | Min                          | Typ | Max  | Min  | Typ | Max  | Min  | Typ | Max  |      |
| Inter-transceiver<br>block skew in Basic<br>(PMA Direct) ×N<br>mode (14) | N < 18 channels<br>located across<br>three<br>transceiver<br>blocks with the<br>source CMU<br>PLL located in<br>the center<br>transceiver<br>block            | —                            | —   | 400  | —  | —   | 400  | —  | —   | 400  | ps   |
|  | N ≥ 18 channels<br>located across<br>four transceiver<br>blocks with the<br>source CMU<br>PLL located in<br>one of the two<br>center<br>transceiver<br>blocks | —                            | —   | 650  | —  | —   | 650  | —  | —   | 650  | ps   |
| <b>CMU0 PLL and CMU1 PLL</b>   |   |                              |     |      |  |     |      |  |     |      |      |
| Supported Data<br>Range  | —   | 600                          | —   | 8500 | 600  | —   | 6500 | 600  | —   | 6375 | Mbps |
| pll_powerdown<br>minimum pulse<br>width<br>(tpll_powerdown)              | —   | 1                            |     |      |  |     |      |  |     |      | μs   |
| CMU PLL lock time<br>from<br>pll_powerdown<br>de-assertion               | —   | —                            | —   | 100  | —  | —   | 100  | —  | —   | 100  | μs   |

**Table 1-23. Transceiver Specifications for Stratix IV GX Devices (Part 8 of 9)**

| Symbol/<br>Description                   | Conditions                     | -2 Commercial<br>Speed Grade |     |     | -3 Commercial/<br>Industrial/Military and<br>-2× Commercial<br>Speed Grade (1) |     |     | -4<br>Commercial/Industrial<br>Speed Grade |     |     | Unit |
|--|--------------------------------|------------------------------|-----|-----|--|-----|-----|--|-----|-----|------|
|  |                                | Min                          | Typ | Max | Min  | Typ | Max | Min  | Typ | Max |      |
| -3 dB Bandwidth                          | PCIe Gen1                      | 2.5 - 3.5                    |     |     |  |     |     |  |     |     | MHz  |
|  | PCIe Gen2                      | 6 - 8                        |     |     |  |     |     |  |     |     | MHz  |
|  | (OIF) CEI PHY<br>at 4.976 Gbps | 7 - 11                       |     |     |  |     |     |  |     |     | MHz  |
|  | (OIF) CEI PHY<br>at 6.375 Gbps | 5 - 10                       |     |     |  |     |     |  |     |     | MHz  |
|  | XAUI                           | 2 - 4                        |     |     |  |     |     |  |     |     | MHz  |
|  | Serial RapidIO<br>1.25 Gbps    | 3 - 5.5                      |     |     |  |     |     |  |     |     | MHz  |
|  | Serial RapidIO<br>2.5 Gbps     | 3 - 5.5                      |     |     |  |     |     |  |     |     | MHz  |
|  | Serial RapidIO<br>3.125 Gbps   | 2 - 4                        |     |     |  |     |     |  |     |     | MHz  |
|  | GIGE                           | 2.5 - 4.5                    |     |     |  |     |     |  |     |     | MHz  |
|  | SONET OC12                     | 1.5 - 2.5                    |     |     |  |     |     |  |     |     | MHz  |
|  | SONET OC48                     | 3.5 - 6                      |     |     |  |     |     |  |     |     | MHz  |
| <b>ATX PLL (6G)</b>                      |                                |                              |     |     |  |     |     |  |     |     |      |
| Supported Data<br>Range (16)             | /L = 1                         | 4800-5400 and<br>6000-6500   |     |     | 4800-5400 and<br>6000-6500   |     |     | 4800-5400 and<br>6000-6375                 |     |     | Mbps |
|  | /L = 2                         | 2400-2700 and<br>3000-3250   |     |     | 2400-2700 and<br>3000-3250   |     |     | 2400-2700 and<br>3000-3187.5               |     |     | Mbps |
|  | /L = 4                         | 1200-1350 and<br>1500-1625   |     |     | 1200-1350 and<br>1500-1625   |     |     | 1200-1350 and<br>1500-1593.75              |     |     | Mbps |
| -3 dB Bandwidth                          | PCIe Gen 2                     | 1.5                          |     |     | 1.5  |     |     | —  |     |     | MHz  |
|  | (OIF) CEI PHY<br>at 6.375 Gbps | 3 - 4.5                      |     |     | 3 - 4.5  |     |     | —  |     |     | MHz  |
| <b>Transceiver-FPGA Fabric Interface</b> |                                |                              |     |     |  |     |     |  |     |     |      |
| Interface speed<br>(non-PMA Direct)      | —                              | 25                           | —   | 325 | 25   | —   | 325 | 25   | —   | 250 | MHz  |
| Interface speed<br>(PMA Direct)          | —                              | 50                           | —   | 325 | 50   | —   | 325 | 50   | —   | 325 | MHz  |

**Table 1-23. Transceiver Specifications for Stratix IV GX Devices (Part 9 of 9)**

| Symbol/<br>Description    | Conditions | -2 Commercial<br>Speed Grade         |     |     | -3 Commercial/<br>Industrial/Military and<br>-2× Commercial<br>Speed Grade (1) |     |     | -4<br>Commercial/Industrial<br>Speed Grade |     |     | Unit |
|---------------------------|------------|--------------------------------------|-----|-----|--|-----|-----|--|-----|-----|------|
|                           |            | Min                                  | Typ | Max | Min  | Typ | Max | Min  | Typ | Max |      |
| Digital reset pulse width | —          | Minimum is two parallel clock cycles |     |     |  |     |     |  |     |     | —    |

**Notes to Table 1-23:**

- (1) The -2× speed grade is the fastest speed grade offered in the following Stratix IV GX devices: EP4SGX70DF29, EP4SGX110DF29, EP4SGX110FF35, EP4SGX230DF29, EP4SGX110FF35, EP4SGX180DF29, EP4SGX230FF35, EP4SGX290FF35, EP4SGX180FF35, EP4SGX290FH29, EP4SGX360FF35, and EP4SGX360FH29.
- (2) To calculate the REFCLK rms phase jitter requirement at reference clock frequencies other than 100 MHz, use the following formula: REFCLK rms phase jitter at f (MHz) = REFCLK rms phase jitter at 100 MHz \* 100/f.
- (3) Differential LVPECL signal levels must comply to the minimum and maximum peak-to-peak differential input voltage specified in this table.
- (4) The minimum `reconfig_clk` frequency is 2.5 MHz if the transceiver channel is configured in **Transmitter only** mode. The minimum `reconfig_clk` frequency is 37.5 MHz if the transceiver channel is configured in **Receiver only** or **Receiver and Transmitter** mode. For more information, refer to the *Dynamic Reconfiguration in Stratix IV Devices* chapter.
- (5) The device cannot tolerate prolonged operation at this absolute maximum.
- (6) You must use the 1.1-V RX  $V_{ICM}$  setting if the input serial data standard is LVDS.
- (7) The rate matcher supports only up to ± 300 parts per million (ppm).
- (8) Time taken to `rx_pll_locked` goes high from `rx_analogreset` de-assertion. Refer to [Figure 1-2 on page 1-32](#).
- (9) Time for which the CDR must be kept in lock-to-reference (LTR) mode after `rx_pll_locked` goes high and before `rx_locktodata` is asserted in manual mode. Refer to [Figure 1-2 on page 1-32](#).
- (10) Time taken to recover valid data after the `rx_locktodata` signal is asserted in manual mode. Refer to [Figure 1-2 on page 1-32](#).
- (11) Time taken to recover valid data after the `rx_freqlocked` signal goes high in automatic mode. Refer to [Figure 1-3 on page 1-32](#).
- (12) A GPLL may be required to meet the PMA-FPGA fabric interface timing above certain data rates. For more information, refer to the "Left/Right PLL Requirements in Basic (PMA Direct) Mode" section in the *Transceiver Clocking in Stratix IV Devices* chapter.
- (13) The Quartus II software automatically selects the appropriate slew rate depending on the configured data rate or functional mode.
- (14) For applications that require low transmit lane-to-lane skew, use Basic (PMA Direct) xN to achieve PMA-Only bonding across all channels in the link. You can bond all channels on one side of the device by configuring them in Basic (PMA Direct) xN mode. For more information about clocking requirements in this mode, refer to the "Basic (PMA Direct) Mode Clocking" section in the *Transceiver Clocking in Stratix IV Devices* chapter.
- (15) Pending Characterization.
- (16) The Quartus II software automatically selects the appropriate /L divider depending on the configured data.
- (17) The maximum transceiver-FPGA fabric interface speed of 265.625 MHz is allowed only in Basic low-latency PCS mode with a 32-bit interface width. For more information, refer to the "Basic Double-Width Mode Configurations" section in the *Transceiver Architecture in Stratix IV Devices* chapter.
- (18) [Figure 1-1](#) shows the AC gain curves for each of the 16 available equalization settings.
- (19) If your design uses more than one dynamic reconfiguration controller (`altgx_reconfig`) instances to control the transceiver (`altgx`) channels physically located on the same side of the device AND if you use different `reconfig_clk` sources for these `altgx_reconfig` instances, the delta time between any two of these `reconfig_clk` sources becoming stable must not exceed the maximum specification listed.
- (20) The differential eye opening specification at the receiver input pins assumes that **Receiver Equalization** is disabled. If you enable **Receiver Equalization**, the receiver circuitry can tolerate a lower minimum eye opening, depending on the equalization level. Use H-Spice simulation to derive the minimum eye opening requirement with **Receiver Equalization** enabled.
- (21) The rise and fall time transition is specified from 20% to 80%.
- (22) Stratix IV GX devices in -4 speed grade support Basic mode and deterministic latency mode transceiver configurations up to 6375 Mbps. These configurations are shown in the figures 1-90, 1-92, 1-94, 1-96, and 1-101 in the *Transceiver Architecture in Stratix IV Devices* chapter.

Figure 1-1 shows the top-to-bottom AC gain curve for equalization settings 0 to 15.

Figure 1-1. AC Gain Curves for Equalization Settings 0 to 15 (Bottom to Top)

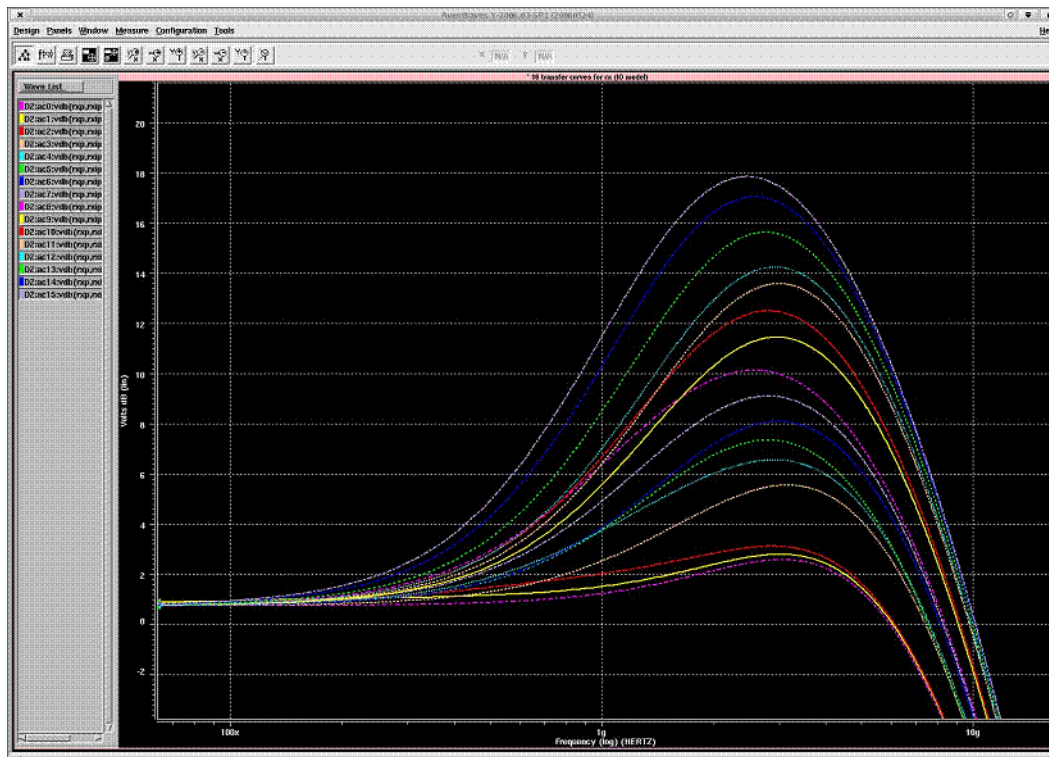


Table 1-24 lists the Stratix IV GT transceiver specifications.

Table 1-24. Transceiver Specifications for Stratix IV GT Devices (Part 1 of 8)

| Symbol/<br>Description                              | Conditions  | -1 Industrial Speed Grade |     |        | -2 Industrial Speed Grade |     |        | -3 Industrial Speed Grade |     |        | Unit |
|---|---|---------------------------|-----|--------|---------------------------|-----|--------|---------------------------|-----|--------|------|
|   |   | Min                       | Typ | Max    | Min                       | Typ | Max    | Min                       | Typ | Max    |      |
| <b>Reference Clock</b>                              |   |                           |     |        |                           |     |        |                           |     |        |      |
| Supported I/O Standards                             | 1.2 V PCML, 1.4 V PCML, 1.5 V PCML, 2.5 V PCML, Differential LVPECL (3), LVDS |                           |     |        |                           |     |        |                           |     |        |      |
| Input frequency from REFCLK input pins              | —   | 50                        | —   | 706.25 | 50                        | —   | 706.25 | 50                        | —   | 706.25 | MHz  |
| Phase frequency detector (CMU PLL and receiver CDR) | —   | 50                        | —   | 425    | 50                        | —   | 425    | 50                        | —   | 425    | MHz  |
| Absolute $V_{MAX}$ for a REFCLK pin                 | —   | —                         | —   | 1.6    | —                         | —   | 1.6    | —                         | —   | 1.6    | V    |
| Operational $V_{MAX}$ for a REFCLK pin              | —   | —                         | —   | 1.5    | —                         | —   | 1.5    | —                         | —   | 1.5    | V    |
| Absolute $V_{MIN}$ for a REFCLK pin                 | —   | -0.3                      | —   | —      | -0.3                      | —   | —      | -0.3                      | —   | —      | V    |

**Table 1-24. Transceiver Specifications for Stratix IV GT Devices (Part 2 of 8)**

| Symbol/<br>Description   | Conditions                                       | -1 Industrial Speed Grade |     |               | -2 Industrial Speed Grade |               |      | -3 Industrial Speed Grade |               |      | Unit     |
|--|--|---------------------------|-----|---------------|---------------------------|---------------|------|---------------------------|---------------|------|----------|
|  |  | Min                       | Typ | Max           | Min                       | Typ           | Max  | Min                       | Typ           | Max  |          |
| Rise/fall time   | —  | —                         | —   | 0.2           | —                         | —             | 0.2  | —                         | —             | 0.2  | UI       |
| Duty cycle   | —  | 45                        | —   | 55            | 45                        | —             | 55   | 45                        | —             | 55   | %        |
| Peak-to-peak differential input voltage                          | —  | 200                       | —   | 1200          | 200                       | —             | 1200 | 200                       | —             | 1200 | mV       |
| On-chip termination resistors                                    | —  | —                         | 100 | —             | —                         | 100           | —    | —                         | 100           | —    | $\Omega$ |
| $V_{ICM}$  | —  | 1200 $\pm$ 10%            |     |               | 1200 $\pm$ 10%            |               |      | 1200 $\pm$ 10%            |               |      | mV       |
| Transmitter REFCLK Phase Noise                                   | 10 Hz  | —                         | —   | -50           | —                         | —             | -50  | —                         | —             | -50  | dBc/Hz   |
|  | 100 Hz   | —                         | —   | -80           | —                         | —             | -80  | —                         | —             | -80  | dBc/Hz   |
|  | 1 KHz  | —                         | —   | -110          | —                         | —             | -110 | —                         | —             | -110 | dBc/Hz   |
|  | 10 KHz   | —                         | —   | -120          | —                         | —             | -120 | —                         | —             | -120 | dBc/Hz   |
|  | 100 KHz  | —                         | —   | -120          | —                         | —             | -120 | —                         | —             | -120 | dBc/Hz   |
|  | $\geq$ 1 MHz                                     | —                         | —   | -130          | —                         | —             | -130 | —                         | —             | -130 | dBc/Hz   |
| Transmitter REFCLK Phase Jitter (rms) for 100 MHz REFCLK (2)     | 10 KHz to 20 MHz                                 | —                         | —   | 3             | —                         | —             | 3    | —                         | —             | 3    | ps       |
| $R_{REF}$  | —  | —                         | —   | 2000 $\pm$ 1% | —                         | 2000 $\pm$ 1% | —    | —                         | 2000 $\pm$ 1% | —    | $\Omega$ |
| <b>Transceiver Clocks</b>  |  |                           |     |               |                           |               |      |                           |               |      |          |
| Calibration block clock frequency                                | —  | 10                        | —   | 125           | 10                        | —             | 125  | 10                        | —             | 125  | MHz      |
| reconfig_clk clock frequency                                     | Dynamic reconfiguration clock frequency          | 2.5/37.5 (1)              | —   | —             | 2.5/37.5 (1)              | —             | 50   | 2.5/37.5 (1)              | —             | 50   | MHz      |
| fixedclk clock frequency   | PCIe Receiver Detect                             | —                         | 125 | —             | —                         | 125           | —    | —                         | 125           | —    | MHz      |
| Delta time between reconfig_clks (16)                            | —  | —                         | —   | 2             | —                         | —             | 2    | —                         | —             | 2    | ms       |
| Transceiver block minimum (gxb_powerdown) power-down pulse width | —  | —                         | 1   | —             | —                         | 1             | —    | —                         | 1             | —    | $\mu$ s  |
| <b>Receiver</b>  |  |                           |     |               |                           |               |      |                           |               |      |          |
| Supported I/O Standards  | 1.4 V PCML, 1.5 V PCML, 2.5 V PCML, LVPECL, LVDS |                           |     |               |                           |               |      |                           |               |      |          |
| Data rate (Single width, non-PMA Direct)                         | —  | 600                       | —   | 3750          | 600                       | —             | 3750 | 600                       | —             | 3750 | Mbps     |

**Table 1-24. Transceiver Specifications for Stratix IV GT Devices (Part 3 of 8)**

| Symbol/<br>Description   | Conditions                             | -1 Industrial Speed Grade |      |       | -2 Industrial Speed Grade |     |         | -3 Industrial Speed Grade |     |      | Unit |
|--|--|---------------------------|------|-------|---------------------------|-----|---------|---------------------------|-----|------|------|
|  |  | Min                       | Typ  | Max   | Min                       | Typ | Max     | Min                       | Typ | Max  |      |
| Data rate (Double width, non-PMA Direct)   | —                                      | 1000                      | —    | 11300 | 1000                      | -   | 10312.5 | 1000                      | —   | 8500 | Mbps |
| Data rate (Single width, PMA Direct)   | —                                      | 600                       | -    | 3250  | 600                       | -   | 3250    | 600                       | —   | 3250 | Mbps |
| Data rate (Double width, PMA Direct)   | —                                      | 1000                      | -    | 6500  | 1000                      | -   | 6500    | 1000                      | —   | 6500 | Mbps |
| Absolute $V_{MAX}$ for a receiver pin (4)  | —                                      | —                         | —    | 1.6   | —                         | —   | 1.6     | —                         | —   | 1.6  | V    |
| Operational $V_{MAX}$ for a receiver pin   | —                                      | —                         | —    | 1.5   | —                         | —   | 1.5     | —                         | —   | 1.5  | V    |
| Absolute $V_{MIN}$ for a receiver pin  | —                                      | —                         | -0.4 | —     | -0.4                      | —   | —       | -0.4                      | —   | —    | V    |
| Maximum peak-to-peak differential input voltage $V_{ID}$ (diff p-p) before device configuration        | —                                      | —                         | —    | 1.6   | —                         | —   | 1.6     | —                         | —   | 1.6  | V    |
| Maximum peak-to-peak differential input voltage $V_{ID}$ (diff p-p) after device configuration         | $V_{ICM} = 0.82$ V setting             | —                         | —    | 2.7   | —                         | —   | 2.7     | —                         | —   | 2.7  | V    |
|  | $V_{ICM} = 1.2$ V setting (5)          | —                         | —    | 1.2   | —                         | —   | 1.2     | —                         | —   | 1.2  | V    |
| Minimum differential eye opening at the receiver serial input pins for data rates $\leq 10.3125$ Gbps. | Equalization = 0 (6)<br>DC gain = 0 dB | 85                        | —    | —     | 85                        | —   | —       | 85                        | —   | —    | mV   |
| Minimum differential eye opening at the receiver serial input pins for data rates $> 10.3125$ Gbps.    | Equalization = 0 (6)<br>DC gain = 0 dB | 165                       | —    | —     | —                         | —   | —       | —                         | —   | —    | mV   |
| $V_{ICM}$  | $V_{ICM} = 0.82$ V setting             | $820 \pm 10\%$            |      |       | $820 \pm 10\%$            |     |         | $820 \pm 10\%$            |     |      | mV   |
|  | $V_{ICM} = 1.2$ V setting (5)          | $1200 \pm 10\%$           |      |       | $1200 \pm 10\%$           |     |         | $1200 \pm 10\%$           |     |      | mV   |

**Table 1–24. Transceiver Specifications for Stratix IV GT Devices (Part 4 of 8)**

| Symbol/<br>Description   | Conditions   | –1 Industrial Speed Grade |  |       | –2 Industrial Speed Grade |     |       | –3 Industrial Speed Grade |     |       | Unit                |
|--|--|---------------------------|--|-------|---------------------------|-----|-------|---------------------------|-----|-------|---------------------|
|  |  | Min                       | Typ  | Max   | Min                       | Typ | Max   | Min                       | Typ | Max   |                     |
| Differential on-chip termination resistors                     | 85-Ω setting   | 85 ± 20%                  |  |       | 85 ± 20%                  |     |       | 85 ± 20%                  |     |       | Ω                   |
|  | 100-Ω setting  | 100 ± 20%                 |  |       | 100 ± 20%                 |     |       | 100 ± 20%                 |     |       | Ω                   |
|  | 120-Ω setting  | 120 ± 20%                 |  |       | 120 ± 20%                 |     |       | 120 ± 20%                 |     |       | Ω                   |
|  | 150-Ω setting  | 150 ± 20%                 |  |       | 150 ± 20%                 |     |       | 150 ± 20%                 |     |       | Ω                   |
| Differential and common mode return loss                       | PCIe (Gen 1 and Gen 2), XAUI, HiGig+, CEI SR/LR, Serial RapidIO SR/LR, CPRI LV/HV, OBSAI, SATA | Compliant                 |  |       |                           |     |       |                           |     |       | —                   |
| Programmable PPM detector (7)                                  | —  | —                         | ± 62.5, 100, 125, 200, 250, 300, 500, 1000 |       |                           |     |       |                           |     | ppm   |                     |
| Run length   | —  | —                         | —  | 200   | —                         | —   | 200   | —                         | —   | 200   | UI                  |
| Programmable equalization                                      | —  | —                         | —  | 16    | —                         | —   | 16    | —                         | —   | 16    | dB                  |
| t <sub>LTR</sub> (8)   | —  | —                         | —  | 75    | —                         | —   | 75    | —                         | —   | 75    | μs                  |
| t <sub>LTR_LTD_Manual</sub> (9)                                | —  | 15                        | —  | —     | 15                        | —   | —     | 15                        | —   | —     | μs                  |
| t <sub>LTD_Manual</sub> (10)                                   | —  | —                         | —  | 4000  | —                         | —   | 4000  | —                         | —   | 4000  | ns                  |
| t <sub>LTD_Auto</sub> (11)                                     | —  | —                         | —  | 4000  | —                         | —   | 4000  | —                         | —   | 4000  | ns                  |
| Receiver buffer and CDR offset cancellation time (per channel) | —  | —                         | —  | 17000 | —                         | —   | 17000 | —                         | —   | 17000 | reconfig_clk cycles |
| Programmable DC gain   | DC Gain Setting = 0  | —                         | 0  | —     | —                         | 0   | —     | —                         | 0   | —     | dB                  |
|  | DC Gain Setting = 1  | —                         | 3  | —     | —                         | 3   | —     | —                         | 3   | —     | dB                  |
|  | DC Gain Setting = 2  | —                         | 6  | —     | —                         | 6   | —     | —                         | 6   | —     | dB                  |
|  | DC Gain Setting = 3  | —                         | 9  | —     | —                         | 9   | —     | —                         | 9   | —     | dB                  |
|  | DC Gain Setting = 4  | —                         | 12   | —     | —                         | 12  | —     | —                         | 12  | —     | dB                  |
| EyeQ Max Data Rate   | —  | —                         | —  | 4.0   | —                         | —   | 4.0   | —                         | —   | 4.0   | Gbps                |

**Table 1-24. Transceiver Specifications for Stratix IV GT Devices (Part 5 of 8)**

| Symbol/<br>Description                      | Conditions  | -1 Industrial Speed Grade |     |       | -2 Industrial Speed Grade |     |         | -3 Industrial Speed Grade |     |      | Unit |
|---|---|---------------------------|-----|-------|---------------------------|-----|---------|---------------------------|-----|------|------|
|   |   | Min                       | Typ | Max   | Min                       | Typ | Max     | Min                       | Typ | Max  |      |
| AEQ Data Rate                               | min V <sub>ID</sub><br>(diff p-p)<br>outer envelope<br>= 600 mV<br>8B/10B<br>encoded data | 2500                      | —   | 6500  | 2500                      | —   | 6500    | —                         | —   | —    | Mbps |
| Decision Feedback Equalizer (DFE) Data Rate | min V <sub>ID</sub><br>(diff p-p)<br>outer envelope<br>= 600 mV                           | 3125                      | —   | 6500  | 3125                      | —   | 6500    | —                         | —   | —    | Mbps |
| <b>Transmitter</b>                          |   |                           |     |       |                           |     |         |                           |     |      |      |
| Supported I/O Standards                     | 1.4 V PCML  |                           |     |       |                           |     |         |                           |     |      |      |
| Data rate (Single width, non-PMA Direct)    | —   | 600                       | —   | 3750  | 600                       | —   | 3750    | 600                       | —   | 3750 | Mbps |
| Data rate (Double width, non-PMA Direct)    | —   | 1000                      | —   | 11300 | 1000                      | —   | 10312.5 | 1000                      | —   | 8500 | Mbps |
| Data rate (Single width, PMA Direct)        | —   | 600                       | —   | 3250  | 600                       | —   | 3250    | 600                       | —   | 3250 | Mbps |
| Data rate (Double width, PMA Direct) (12)   | —   | 1000                      | —   | 6500  | 1000                      | —   | 6500    | 1000                      | —   | 6500 | Mbps |
| V <sub>OCM</sub>                            | 0.65 V setting  | —                         | 650 | —     | —                         | 650 | —       | —                         | 650 | —    | mV   |
| Differential on-chip termination resistors  | 85-Ω setting  | 85 ± 15%                  |     |       | 85 ± 15%                  |     |         | 85 ± 15%                  |     |      | Ω    |
|   | 100-Ω setting   | 100 ± 15%                 |     |       | 100 ± 15%                 |     |         | 100 ± 15%                 |     |      | Ω    |
|   | 120-Ω setting   | 120 ± 15%                 |     |       | 120 ± 15%                 |     |         | 120 ± 15%                 |     |      | Ω    |
|   | 150-Ω setting   | 150 ± 15%                 |     |       | 150 ± 15%                 |     |         | 150 ± 15%                 |     |      | Ω    |

**Table 1-24. Transceiver Specifications for Stratix IV GT Devices (Part 6 of 8)**

| Symbol/<br>Description                                      | Conditions  | -1 Industrial Speed Grade |     |     | -2 Industrial Speed Grade |     |     | -3 Industrial Speed Grade |     |     | Unit |
|---|---|---------------------------|-----|-----|---------------------------|-----|-----|---------------------------|-----|-----|------|
|   |   | Min                       | Typ | Max | Min                       | Typ | Max | Min                       | Typ | Max |      |
| Differential and common mode return loss                    | PCIe Gen1 and Gen2 (TX V <sub>OD</sub> =4), XAUI (TX V <sub>OD</sub> =6), HiGig+ (TX V <sub>OD</sub> =6), CEI SR/LR (TX V <sub>OD</sub> =8), Serial RapidIO SR (V <sub>OD</sub> =6), Serial RapidIO LR (V <sub>OD</sub> =8), CPRI LV (V <sub>OD</sub> =6), CPRI HV (V <sub>OD</sub> =2), OBSAI (V <sub>OD</sub> =6), SATA (V <sub>OD</sub> =4), | Compliant                 |     |     |                           |     |     |                           |     |     | —    |
| Rise time (13)  | —   | 50                        | —   | 200 | 50                        | —   | 200 | 50                        | —   | 200 | ps   |
| Fall time (13)  | —   | 50                        | —   | 200 | 50                        | —   | 200 | 50                        | —   | 200 | ps   |
| XAUI rise time  | —   | 60                        | —   | 130 | 60                        | —   | 130 | 60                        | —   | 130 | ps   |
| XAUI fall time  | —   | 60                        | —   | 130 | 60                        | —   | 130 | 60                        | —   | 130 | ps   |
| Intra-differential pair skew                                | —   | —                         | —   | 15  | —                         | —   | 15  | —                         | —   | 15  | ps   |
| Intra-transceiver block transmitter channel-to-channel skew | ×4 PMA and PCS bonded mode Example: XAUI, PCIe, ×4, Basic ×4  | —                         | —   | 120 | —                         | —   | 120 | —                         | —   | 120 | ps   |
| Inter-transceiver block transmitter channel-to-channel skew | ×8 PMA and PCS bonded mode Example: PCIe ×8, Basic ×8   | —                         | —   | 500 | —                         | —   | 500 | —                         | —   | 500 | ps   |

**Table 1-24. Transceiver Specifications for Stratix IV GT Devices (Part 7 of 8)**

| Symbol/<br>Description  | Conditions   | -1 Industrial Speed Grade |     |       | -2 Industrial Speed Grade |     |         | -3 Industrial Speed Grade |     |         | Unit |
|---|--|---------------------------|-----|-------|---------------------------|-----|---------|---------------------------|-----|---------|------|
|   |  | Min                       | Typ | Max   | Min                       | Typ | Max     | Min                       | Typ | Max     |      |
| Inter-transceiver block skew in Basic (PMA Direct) xN mode (13) | N < 18 channels located across three transceiver blocks with the source CMU PLL located in the center transceiver block            | —                         | —   | 400   | —                         | —   | 400     | —                         | —   | 400     | ps   |
|   | N ≥ 18 channels located across four transceiver blocks with the source CMU PLL located in one of the two center transceiver blocks | —                         | —   | 650   | —                         | —   | 650     | —                         | —   | 650     | ps   |
| <b>CMU PLL0 and CMU PLL1</b>                                    |  |                           |     |       |                           |     |         |                           |     |         |      |
| Supported data range  | —  | 600                       | —   | 11300 | 600                       | —   | 10312.5 | 600                       | —   | 8500    | Mbps |
| CMU PLL lock time from pll_powerdown de-assertion               | —  | —                         | —   | 100   | —                         | —   | 100     | —                         | —   | 100     | μs   |
| <b>ATX PLL (6G)</b>   |  |                           |     |       |                           |     |         |                           |     |         |      |
| Supported Data Range  | /L = 1   | 4800-5400 and 6000-6500   |     |       | 4800-5400 and 6000-6500   |     |         | 4800-5400 and 6000-6500   |     |         | Mbps |
|   | /L = 2   | 2400-2700 and 3000-3250   |     |       | 2400-2700 and 3000-3250   |     |         | 2400-2700 and 3000-3250   |     |         | Mbps |
|   | /L = 4   | 1200-1350 and 1500-1625   |     |       | 1200-1350 and 1500-1625   |     |         | 1200-1350 and 1500-1625   |     |         | Mbps |
| <b>ATX PLL (10G)</b>  |  |                           |     |       |                           |     |         |                           |     |         |      |
| Supported Data Range  | —  | 9900                      | —   | 11300 | 9900                      | —   | 10312.5 | —                         |     |         | Mbps |
| <b>Transceiver-FPGA Fabric Interface</b>                        |  |                           |     |       |                           |     |         |                           |     |         |      |
| Interface speed (non-PMA Direct)                                | —  | 25                        | —   | 325   | 25                        | —   | 325     | 25                        | —   | 265.625 | MHz  |
| Interface speed (PMA Direct)                                    | —  | 50                        | —   | 325   | 50                        | —   | 325     | 50                        | —   | 325     | MHz  |


**Table 1–24. Transceiver Specifications for Stratix IV GT Devices (Part 8 of 8)**

| Symbol/<br>Description    | Conditions | –1 Industrial Speed Grade            |     |     | –2 Industrial Speed Grade |     |     | –3 Industrial Speed Grade |     |     | Unit |
|---------------------------|------------|--------------------------------------|-----|-----|---------------------------|-----|-----|---------------------------|-----|-----|------|
|                           |            | Min                                  | Typ | Max | Min                       | Typ | Max | Min                       | Typ | Max |      |
| Digital reset pulse width | —          | Minimum is two parallel clock cycles |     |     |                           |     |     |                           |     |     | —    |

**Notes to Table 1–24:**

- (1) The minimum `reconfig_clk` frequency is 2.5 MHz if the transceiver channel is configured in **Transmitter Only** mode. The minimum `reconfig_clk` frequency is 37.5 MHz if the transceiver channel is configured in **Receiver only** or **Receiver and Transmitter** mode. For more information, refer to the *Dynamic Reconfiguration in Stratix IV Devices* chapter.
- (2) To calculate the REFCLK rms phase jitter requirement at reference clock frequencies other than 100 MHz, use the following formula: REFCLK rms phase jitter at f (MHz) = REFCLK rms phase jitter at 100 MHz \* 100/f.
- (3) Differential LVPECL signal levels must comply to the minimum and maximum peak-to-peak differential input voltage specified in this table.
- (4) The device cannot tolerate prolonged operation at this absolute maximum.
- (5) You must use the 1.2-V `RXVICM` setting if the input serial data standard is LVDS.
- (6) The differential eye opening specification at the receiver input pins assumes that **Receiver Equalization** is disabled. If you enable **Receiver Equalization**, the receiver circuitry can tolerate a lower minimum eye opening, depending on the equalization level. Use H-Spice simulation to derive the minimum eye opening requirement with **Receiver Equalization** enabled.
- (7) The rate matcher supports only up to ± 300 ppm.
- (8) Time taken to `rx_pll_locked` goes high from `rx_analogreset` de-assertion. Refer to [Figure 1–2 on page 1–32](#).
- (9) Time for which the CDR must be kept in lock-to-reference mode after `rx_pll_locked` goes high and before `rx_locktodata` is asserted in manual mode. Refer to [Figure 1–2 on page 1–32](#).
- (10) Time taken to recover valid data after the `rx_locktodata` signal is asserted in manual mode. Refer to [Figure 1–2 on page 1–32](#).
- (11) Time taken to recover valid data after the `rx_freqlocked` signal goes high in automatic mode. Refer to [Figure 1–3 on page 1–32](#).
- (12) A GPLL may be required to meet the PMA-FPGA fabric interface timing above certain data rates. For more information, refer to the "Left/Right PLL Requirements in Basic (PMA Direct) Mode" section in the *Transceiver Clocking in Stratix IV Devices* chapter.
- (13) The Quartus II software automatically selects the appropriate slew rate depending on the configured data rate or functional mode.
- (14) For applications that require low transmit lane-to-lane skew, use Basic (PMA Direct) xN to achieve PMA-Only bonding across all channels in the link. You can bond all channels on one side of the device by configuring them in Basic (PMA Direct) xN mode. For more information about clocking requirements in this mode, refer to the "Basic (PMA Direct) Mode Clocking" section in the *Transceiver Clocking in Stratix IV Devices* chapter.
- (15) Pending Characterization.
- (16) If your design uses more than one dynamic reconfiguration controller (`altgx_reconfig`) instances to control the transceiver (`altgx`) channels physically located on the same side of the device AND if you use different `reconfig_clk` sources for these `altgx_reconfig` instances, the delta time between any two of these `reconfig_clk` sources becoming stable must not exceed the maximum specification listed.

Figure 1-2 shows the lock time parameters in manual mode.

 LTD = Lock-To-Data; LTR = Lock-To-Reference

**Figure 1-2. Lock Time Parameters for Manual Mode**

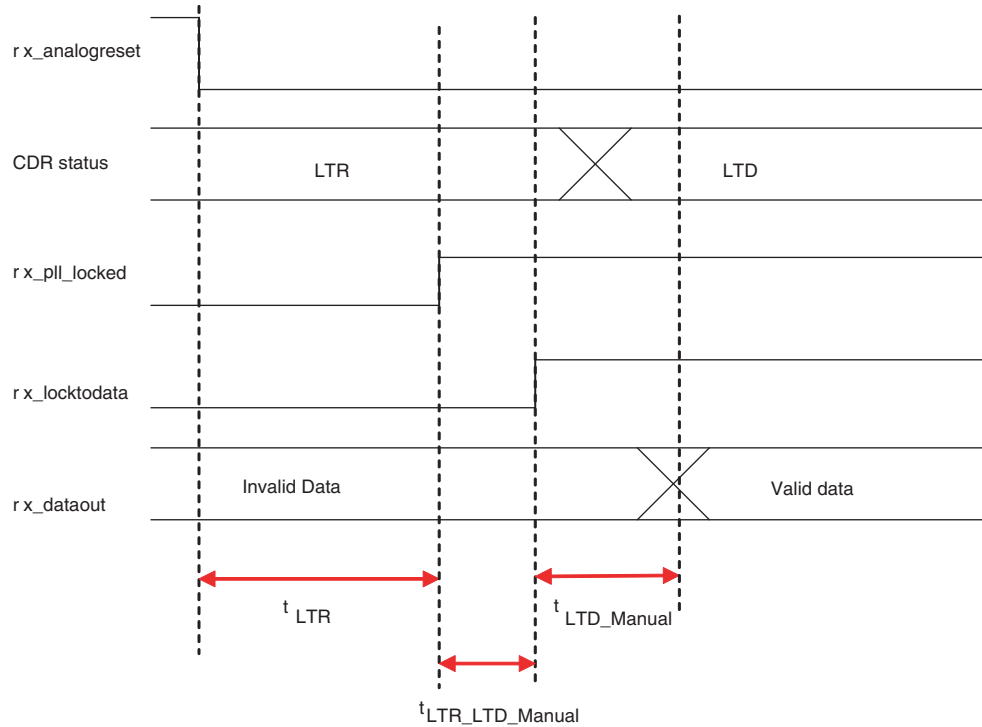


Figure 1-3 shows the lock time parameters in automatic mode.

**Figure 1-3. Lock Time Parameters for Automatic Mode**

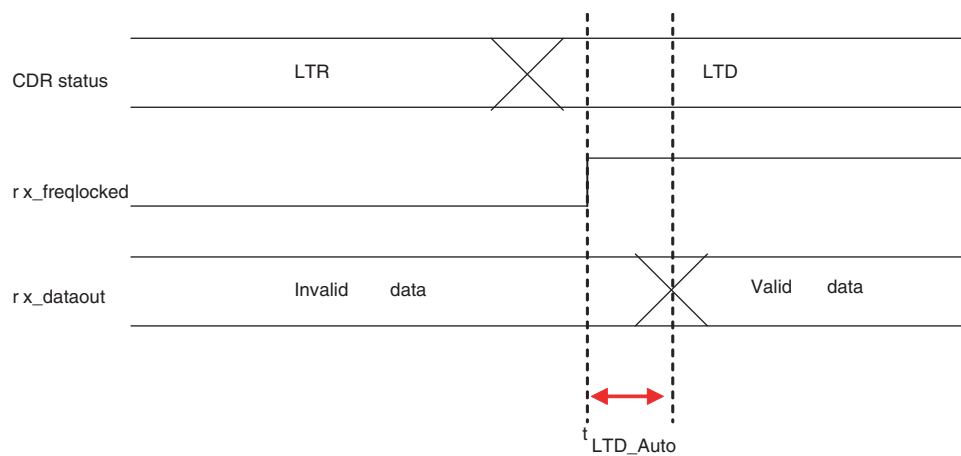


Table 1-25 through Table 1-28 lists the typical differential  $V_{OD}$  termination settings for Stratix IV GX and GT devices.

**Table 1-25. Typical  $V_{OD}$  Setting, TX Term = 85  $\Omega$**

| Symbol  | $V_{OD}$ Setting (mV) |               |               |               |               |               |               |                |
|---|-----------------------|---------------|---------------|---------------|---------------|---------------|---------------|----------------|
|   | 0                     | 1             | 2             | 3             | 4             | 5             | 6             | 7              |
| $V_{OD}$ differential peak-to-peak Typical (mV) | 170 $\pm$ 20%         | 340 $\pm$ 20% | 510 $\pm$ 20% | 595 $\pm$ 20% | 680 $\pm$ 20% | 765 $\pm$ 20% | 850 $\pm$ 20% | 1020 $\pm$ 20% |

**Table 1-26. Typical  $V_{OD}$  Setting, TX Term = 100  $\Omega$**

| Symbol  | $V_{OD}$ Setting (mV) |               |               |               |               |               |                |                |
|---|-----------------------|---------------|---------------|---------------|---------------|---------------|----------------|----------------|
|   | 0                     | 1             | 2             | 3             | 4             | 5             | 6              | 7              |
| $V_{OD}$ differential peak-to-peak Typical (mV) | 200 $\pm$ 20%         | 400 $\pm$ 20% | 600 $\pm$ 20% | 700 $\pm$ 20% | 800 $\pm$ 20% | 900 $\pm$ 20% | 1000 $\pm$ 20% | 1200 $\pm$ 20% |

**Table 1-27. Typical  $V_{OD}$  Setting, TX Term = 120  $\Omega$**

| Symbol  | $V_{OD}$ Setting (mV) |               |               |               |               |                |                |
|---|-----------------------|---------------|---------------|---------------|---------------|----------------|----------------|
|   | 0                     | 1             | 2             | 3             | 4             | 5              | 6              |
| $V_{OD}$ differential peak-to-peak Typical (mV) | 240 $\pm$ 20%         | 480 $\pm$ 20% | 720 $\pm$ 20% | 840 $\pm$ 20% | 960 $\pm$ 20% | 1080 $\pm$ 20% | 1200 $\pm$ 20% |

**Table 1-28. Typical  $V_{OD}$  Setting, TX Term = 150  $\Omega$**

| Symbol  | $V_{OD}$ Setting (mV) |               |               |                |                |                |
|---|-----------------------|---------------|---------------|----------------|----------------|----------------|
|   | 0                     | 1             | 2             | 3              | 4              | 5              |
| $V_{OD}$ differential peak-to-peak Typical (mV) | 300 $\pm$ 20%         | 600 $\pm$ 20% | 900 $\pm$ 20% | 1050 $\pm$ 20% | 1200 $\pm$ 20% | 1350 $\pm$ 20% |

Table 1-29 lists typical transmitter pre-emphasis levels in dB for the first post tap under the following conditions (low-frequency data pattern [five 1s and five 0s] at 6.25 Gbps). The levels listed in Table 1-29 are a representation of possible pre-emphasis levels under the specified conditions only and that the pre-emphasis levels may change with data pattern and data rate.



To predict the pre-emphasis level for your specific data rate and pattern, run simulations using the [Stratix IV HSSI HSPICE](#) models.

**Table 1-29. Transmitter Pre-Emphasis Levels for Stratix IV Devices (Part 1 of 2)**

| Pre-Emphasis 1st Post-Tap Setting | $V_{OD}$ Setting |     |     |   |   |   |   |   |
|-----------------------------------|------------------|-----|-----|---|---|---|---|---|
|                                   | 0                | 1   | 2   | 3 | 4 | 5 | 6 | 7 |
| 0                                 | 0                | 0   | 0   | 0 | 0 | 0 | 0 | 0 |
| 1                                 | N/A              | 0.7 | 0   | 0 | 0 | 0 | 0 | 0 |
| 2                                 | N/A              | 1   | 0.3 | 0 | 0 | 0 | 0 | 0 |
| 3                                 | N/A              | 1.5 | 0.6 | 0 | 0 | 0 | 0 | 0 |

**Table 1-29. Transmitter Pre-Emphasis Levels for Stratix IV Devices (Part 2 of 2)**

| Pre-Emphasis 1st Post-Tap Setting | V <sub>OD</sub> Setting |     |      |      |      |     |     |     |
|-----------------------------------|-------------------------|-----|------|------|------|-----|-----|-----|
|                                   | 0                       | 1   | 2    | 3    | 4    | 5   | 6   | 7   |
| 4                                 | N/A                     | 2   | 0.7  | 0.3  | 0    | 0   | 0   | 0   |
| 5                                 | N/A                     | 2.7 | 1.2  | 0.5  | 0.3  | 0   | 0   | 0   |
| 6                                 | N/A                     | 3.1 | 1.3  | 0.8  | 0.5  | 0.2 | 0   | 0   |
| 7                                 | N/A                     | 3.7 | 1.8  | 1.1  | 0.7  | 0.4 | 0.2 | 0   |
| 8                                 | N/A                     | 4.2 | 2.1  | 1.3  | 0.9  | 0.6 | 0.3 | 0   |
| 9                                 | N/A                     | 4.9 | 2.4  | 1.6  | 1.2  | 0.8 | 0.5 | 0.2 |
| 10                                | N/A                     | 5.4 | 2.8  | 1.9  | 1.4  | 1   | 0.7 | 0.3 |
| 11                                | N/A                     | 6   | 3.2  | 2.2  | 1.7  | 1.2 | 0.9 | 0.4 |
| 12                                | N/A                     | 6.8 | 3.5  | 2.6  | 1.9  | 1.4 | 1.1 | 0.6 |
| 13                                | N/A                     | 7.5 | 3.8  | 2.8  | 2.1  | 1.6 | 1.2 | 0.6 |
| 14                                | N/A                     | 8.1 | 4.2  | 3.1  | 2.3  | 1.7 | 1.3 | 0.7 |
| 15                                | N/A                     | 8.8 | 4.5  | 3.4  | 2.6  | 1.9 | 1.5 | 0.8 |
| 16                                | N/A                     | N/A | 4.9  | 3.7  | 2.9  | 2.2 | 1.7 | 0.9 |
| 17                                | N/A                     | N/A | 5.3  | 4    | 3.1  | 2.4 | 1.8 | 1.1 |
| 18                                | N/A                     | N/A | 5.7  | 4.4  | 3.4  | 2.6 | 2   | 1.2 |
| 19                                | N/A                     | N/A | 6.1  | 4.7  | 3.6  | 2.8 | 2.2 | 1.4 |
| 20                                | N/A                     | N/A | 6.6  | 5.1  | 4    | 3.1 | 2.4 | 1.5 |
| 21                                | N/A                     | N/A | 7    | 5.4  | 4.3  | 3.3 | 2.7 | 1.7 |
| 22                                | N/A                     | N/A | 8    | 6.1  | 4.8  | 3.8 | 3   | 2   |
| 23                                | N/A                     | N/A | 9    | 6.8  | 5.4  | 4.3 | 3.4 | 2.3 |
| 24                                | N/A                     | N/A | 10   | 7.6  | 6    | 4.8 | 3.9 | 2.6 |
| 25                                | N/A                     | N/A | 11.4 | 8.4  | 6.8  | 5.4 | 4.4 | 3   |
| 26                                | N/A                     | N/A | 12.6 | 9.4  | 7.4  | 5.9 | 4.9 | 3.3 |
| 27                                | N/A                     | N/A | N/A  | 10.3 | 8.1  | 6.4 | 5.3 | 3.6 |
| 28                                | N/A                     | N/A | N/A  | 11.3 | 8.8  | 7.1 | 5.8 | 4   |
| 29                                | N/A                     | N/A | N/A  | 12.5 | 9.6  | 7.7 | 6.3 | 4.3 |
| 30                                | N/A                     | N/A | N/A  | N/A  | 11.4 | 9   | 7.4 | N/A |
| 31                                | N/A                     | N/A | N/A  | N/A  | 12.9 | 10  | 8.2 | N/A |

Table 1-30 lists the Stratix IV GX transceiver jitter specifications for all supported protocols. For protocols supported by Stratix IV GT industrial speed grade devices, refer to the Stratix IV GX -2 commercial speed grade column in Table 1-30.

**Table 1-30. Transceiver Block Jitter Specifications for Stratix IV GX Devices (Note 1), (2) (Part 1 of 9)**

| Symbol/<br>Description                                    | Conditions                                      | -2 Commercial<br>Speed Grade |     |      | -3 Commercial/<br>Industrial/Military<br>and -2× Commercial<br>Speed Grade |     |      | -4 Commercial/<br>Industrial Speed<br>Grade |     |      | Unit |
|---|---|------------------------------|-----|------|--|-----|------|---|-----|------|------|
|   |   | Min                          | Typ | Max  | Min  | Typ | Max  | Min   | Typ | Max  |      |
| <b>SONET/SDH Transmit Jitter Generation (3)</b>           |   |                              |     |      |  |     |      |   |     |      |      |
| Peak-to-peak jitter at 622.08 Mbps                        | Pattern = PRBS15                                | —                            | —   | 0.1  | —  | —   | 0.1  | —   | —   | 0.1  | UI   |
| RMS jitter at 622.08 Mbps                                 | Pattern = PRBS15                                | —                            | —   | 0.01 | —  | —   | 0.01 | —   | —   | 0.01 | UI   |
| Peak-to-peak jitter at 2488.32 Mbps                       | Pattern = PRBS15                                | —                            | —   | 0.1  | —  | —   | 0.1  | —   | —   | 0.1  | UI   |
| RMS jitter at 2488.32 Mbps                                | Pattern = PRBS15                                | —                            | —   | 0.01 | —  | —   | 0.01 | —   | —   | 0.01 | UI   |
| <b>SONET/SDH Receiver Jitter Tolerance (3)</b>            |   |                              |     |      |  |     |      |   |     |      |      |
| Jitter tolerance at 622.08 Mbps                           | Jitter frequency = 0.03 KHz<br>Pattern = PRBS15 | > 15                         |     |      | > 15   |     |      | > 15  |     |      | UI   |
|   | Jitter frequency = 25 KHz<br>Pattern = PRBS15   | > 1.5                        |     |      | > 1.5  |     |      | > 1.5                                       |     |      | UI   |
|   | Jitter frequency = 250 KHz<br>Pattern = PRBS15  | > 0.15                       |     |      | > 0.15   |     |      | > 0.15                                      |     |      | UI   |
| Jitter tolerance at 2488.32 Mbps                          | Jitter frequency = 0.06 KHz<br>Pattern = PRBS15 | > 15                         |     |      | > 15   |     |      | > 15  |     |      | UI   |
|   | Jitter frequency = 100 KHz<br>Pattern = PRBS15  | > 1.5                        |     |      | > 1.5  |     |      | > 1.5                                       |     |      | UI   |
|   | Jitter frequency = 1 MHz<br>Pattern = PRBS15    | > 0.15                       |     |      | > 0.15   |     |      | > 0.15                                      |     |      | UI   |
|   | Jitter frequency = 10 MHz<br>Pattern = PRBS15   | > 0.15                       |     |      | > 0.15   |     |      | > 0.15                                      |     |      | UI   |
| <b>Fibre Channel Transmit Jitter Generation (4), (12)</b> |   |                              |     |      |  |     |      |   |     |      |      |
| Total jitter FC-1   | Pattern = CRPAT                                 | —                            | —   | 0.23 | —  | —   | 0.23 | —   | —   | 0.23 | UI   |
| Deterministic jitter FC-1                                 | Pattern = CRPAT                                 | —                            | —   | 0.11 | —  | —   | 0.11 | —   | —   | 0.11 | UI   |
| Total jitter FC-2   | Pattern = CRPAT                                 | —                            | —   | 0.33 | —  | —   | 0.33 | —   | —   | 0.33 | UI   |
| Deterministic jitter FC-2                                 | Pattern = CRPAT                                 | —                            | —   | 0.2  | —  | —   | 0.2  | —   | —   | 0.2  | UI   |

**Table 1-30. Transceiver Block Jitter Specifications for Stratix IV GX Devices (Note 1), (2) (Part 2 of 9)**

| Symbol/<br>Description                                   | Conditions                      | -2 Commercial<br>Speed Grade |     |      | -3 Commercial/<br>Industrial/Military<br>and -2× Commercial<br>Speed Grade |     |      | -4 Commercial/<br>Industrial Speed<br>Grade |     |      | Unit |
|--|---------------------------------|------------------------------|-----|------|--|-----|------|---|-----|------|------|
|  |                                 | Min                          | Typ | Max  | Min  | Typ | Max  | Min   | Typ | Max  |      |
| Total jitter FC-4  | Pattern = CRPAT                 | —                            | —   | 0.52 | —  | —   | 0.52 | —   | —   | 0.52 | UI   |
| Deterministic jitter FC-4                                | Pattern = CRPAT                 | —                            | —   | 0.33 | —  | —   | 0.33 | —   | —   | 0.33 | UI   |
| <b>Fibre Channel Receiver Jitter Tolerance (4), (13)</b> |                                 |                              |     |      |  |     |      |   |     |      |      |
| Deterministic jitter FC-1                                | Pattern = CJTPAT                | > 0.37                       |     |      | > 0.37   |     |      | > 0.37                                      |     |      | UI   |
| Random jitter FC-1                                       | Pattern = CJTPAT                | > 0.31                       |     |      | > 0.31   |     |      | > 0.31                                      |     |      | UI   |
| Sinusoidal jitter FC-1                                   | Fc/25000                        | > 1.5                        |     |      | > 1.5  |     |      | > 1.5                                       |     |      | UI   |
|  | Fc/1667                         | > 0.1                        |     |      | > 0.1  |     |      | > 0.1                                       |     |      | UI   |
| Deterministic jitter FC-2                                | Pattern = CJTPAT                | > 0.33                       |     |      | > 0.33   |     |      | > 0.33                                      |     |      | UI   |
| Random jitter FC-2                                       | Pattern = CJTPAT                | > 0.29                       |     |      | > 0.29   |     |      | > 0.29                                      |     |      | UI   |
| Sinusoidal jitter FC-2                                   | Fc/25000                        | > 1.5                        |     |      | > 1.5  |     |      | > 1.5                                       |     |      | UI   |
|  | Fc/1667                         | > 0.1                        |     |      | > 0.1  |     |      | > 0.1                                       |     |      | UI   |
| Deterministic jitter FC-4                                | Pattern = CJTPAT                | > 0.33                       |     |      | > 0.33   |     |      | > 0.33                                      |     |      | UI   |
| Random jitter FC-4                                       | Pattern = CJTPAT                | > 0.29                       |     |      | > 0.29   |     |      | > 0.29                                      |     |      | UI   |
| Sinusoidal jitter FC-4                                   | Fc/25000                        | > 1.5                        |     |      | > 1.5  |     |      | > 1.5                                       |     |      | UI   |
|  | Fc/1667                         | > 0.1                        |     |      | > 0.1  |     |      | > 0.1                                       |     |      | UI   |
| <b>XAUI Transmit Jitter Generation (5)</b>               |                                 |                              |     |      |  |     |      |   |     |      |      |
| Total jitter at 3.125 Gbps                               | Pattern = CJPAT                 | —                            | —   | 0.3  | —  | —   | 0.3  | —   | —   | 0.3  | UI   |
| Deterministic jitter at 3.125 Gbps                       | Pattern = CJPAT                 | —                            | —   | 0.17 | —  | —   | 0.17 | —   | —   | 0.17 | UI   |
| <b>XAUI Receiver Jitter Tolerance (5)</b>                |                                 |                              |     |      |  |     |      |   |     |      |      |
| Total jitter   | —                               | > 0.65                       |     |      | > 0.65   |     |      | > 0.65                                      |     |      | UI   |
| Deterministic jitter                                     | —                               | > 0.37                       |     |      | > 0.37   |     |      | > 0.37                                      |     |      | UI   |
| Peak-to-peak jitter                                      | Jitter frequency =<br>22.1 KHz  | > 8.5                        |     |      | > 8.5  |     |      | > 8.5                                       |     |      | UI   |
| Peak-to-peak jitter                                      | Jitter frequency =<br>1.875 MHz | > 0.1                        |     |      | > 0.1  |     |      | > 0.1                                       |     |      | UI   |
| Peak-to-peak jitter                                      | Jitter frequency =<br>20 MHz    | > 0.1                        |     |      | > 0.1  |     |      | > 0.1                                       |     |      | UI   |
| <b>PCIe Transmit Jitter Generation (6)</b>               |                                 |                              |     |      |  |     |      |   |     |      |      |
| Total jitter at 2.5 Gbps (Gen1)                          | Compliance pattern              | —                            | —   | 0.25 | —  | —   | 0.25 | —   | —   | 0.25 | UI   |
| Total jitter at 5 Gbps (Gen2) (14)                       | Compliance pattern              | —                            | —   | 0.25 | —  | —   | 0.25 | —   | —   | —    | UI   |
| <b>PCIe Receiver Jitter Tolerance (6)</b>                |                                 |                              |     |      |  |     |      |   |     |      |      |
| Total jitter at 2.5 Gbps (Gen1)                          | Compliance pattern              | > 0.6                        |     |      | > 0.6  |     |      | > 0.6                                       |     |      | UI   |

**Table 1–30. Transceiver Block Jitter Specifications for Stratix IV GX Devices (Note 1), (2) (Part 3 of 9)**

| Symbol/<br>Description  | Conditions   | –2 Commercial<br>Speed Grade |     |       | –3 Commercial/<br>Industrial/Military<br>and –2× Commercial<br>Speed Grade |     |       | –4 Commercial/<br>Industrial Speed<br>Grade |     |       | Unit |
|---|--|------------------------------|-----|-------|--|-----|-------|---|-----|-------|------|
|   |  | Min                          | Typ | Max   | Min  | Typ | Max   | Min   | Typ | Max   |      |
| Total jitter at 5 Gbps<br>(Gen2)  | Compliance pattern   | Compliant                    |     |       | Compliant  |     |       | —   |     |       | UI   |
| <b>PCIe (Gen 1) Electrical Idle Detect Threshold</b>                    |  |                              |     |       |  |     |       |   |     |       |      |
| $V_{RX-IDLE-DETDIFFp-p}$ (15)   | Compliance pattern   | 65                           | —   | 175   | 65   | —   | 175   | 65  | —   | 175   | UI   |
| <b>Serial RapidIO Transmit Jitter Generation (7)</b>                    |  |                              |     |       |  |     |       |   |     |       |      |
| Deterministic jitter<br>(peak-to-peak)                                  | Data Rate = 1.25, 2.5,<br>3.125 Gbps<br>Pattern = CJPAT                                    | —                            | —   | 0.17  | —  | —   | 0.17  | —   | —   | 0.17  | UI   |
| Total jitter<br>(peak-to-peak)  | Data Rate = 1.25, 2.5,<br>3.125 Gbps<br>Pattern = CJPAT                                    | —                            | —   | 0.35  | —  | —   | 0.35  | —   | —   | 0.35  | UI   |
| <b>Serial RapidIO Receiver Jitter Tolerance (7)</b>                     |  |                              |     |       |  |     |       |   |     |       |      |
| Deterministic jitter<br>tolerance (peak-to-peak)                        | Data Rate = 1.25, 2.5,<br>3.125 Gbps<br>Pattern = CJPAT                                    | > 0.37                       |     |       | > 0.37   |     |       | > 0.37                                      |     |       | UI   |
| Combined deterministic<br>and random jitter<br>tolerance (peak-to-peak) | Data Rate = 1.25, 2.5,<br>3.125 Gbps<br>Pattern = CJPAT                                    | > 0.55                       |     |       | > 0.55   |     |       | > 0.55                                      |     |       | UI   |
| Sinusoidal jitter<br>tolerance (peak-to-peak)                           | Jitter Frequency = 22.1<br>KHz Data Rate = 1.25,<br>2.5, 3.125 Gbps<br>Pattern = CJPAT     | > 8.5                        |     |       | > 8.5  |     |       | > 8.5                                       |     |       | UI   |
|   | Jitter Frequency = 1.875<br>MHz<br>Data Rate = 1.25, 2.5,<br>3.125 Gbps<br>Pattern = CJPAT | > 0.1                        |     |       | > 0.1  |     |       | > 0.1                                       |     |       | UI   |
|   | Jitter Frequency =<br>20 MHz<br>Data Rate = 1.25, 2.5,<br>3.125 Gbps<br>Pattern = CJPAT    | > 0.1                        |     |       | > 0.1  |     |       | > 0.1                                       |     |       | UI   |
| <b>GIGE Transmit Jitter Generation (8)</b>                              |  |                              |     |       |  |     |       |   |     |       |      |
| Deterministic jitter<br>(peak-to-peak)                                  | Pattern = CRPAT  | —                            | —   | 0.14  | —  | —   | 0.14  | —   | —   | 0.14  | UI   |
| Total jitter<br>(peak-to-peak)  | Pattern = CRPAT  | —                            | —   | 0.279 | —  | —   | 0.279 | —   | —   | 0.279 | UI   |

**Table 1-30. Transceiver Block Jitter Specifications for Stratix IV GX Devices (Note 1), (2) (Part 4 of 9)**

| Symbol/<br>Description  | Conditions  | -2 Commercial<br>Speed Grade |     |      | -3 Commercial/<br>Industrial/Military<br>and -2× Commercial<br>Speed Grade |     |     | -4 Commercial/<br>Industrial Speed<br>Grade |     |        | Unit |
|---|---|------------------------------|-----|------|--|-----|-----|---|-----|--------|------|
|   |   | Min                          | Typ | Max  | Min  | Typ | Max | Min   | Typ | Max    |      |
| <b>GIGE Receiver Jitter Tolerance (8)</b>                         |   |                              |     |      |  |     |     |   |     |        |      |
| Deterministic jitter tolerance (peak-to-peak)                     | Pattern = CJPAT   | > 0.4                        |     |      | > 0.4  |     |     | > 0.4                                       |     |        | UI   |
| Combined deterministic and random jitter tolerance (peak-to-peak) | Pattern = CJPAT   | > 0.66                       |     |      | > 0.66   |     |     | > 0.66                                      |     |        | UI   |
| <b>HiGig Transmit Jitter Generation (9)</b>                       |   |                              |     |      |  |     |     |   |     |        |      |
| Deterministic jitter (peak-to-peak)                               | Data Rate = 3.75 Gbps<br>Pattern = CJPAT                                | —                            | —   | 0.17 | —  | —   | —   | —   | —   | —      | UI   |
| Total jitter (peak-to-peak)                                       | Data Rate = 3.75 Gbps<br>Pattern = CJPAT                                | —                            | —   | 0.35 | —  | —   | —   | —   | —   | —      | UI   |
| <b>HiGig Receiver Jitter Tolerance (9)</b>                        |   |                              |     |      |  |     |     |   |     |        |      |
| Deterministic jitter tolerance (peak-to-peak)                     | Data Rate = 3.75 Gbps<br>Pattern = CJPAT                                | > 0.37                       |     |      | —  | —   | —   | —   | —   | —      | UI   |
| Combined deterministic and random jitter tolerance (peak-to-peak) | Data Rate = 3.75 Gbps<br>Pattern = CJPAT                                | > 0.65                       |     |      | —  | —   | —   | —   | —   | —      | UI   |
| Sinusoidal jitter tolerance (peak-to-peak)                        | Jitter Frequency = 22.1 KHz<br>Data Rate = 3.75 Gbps<br>Pattern = CJPAT | > 8.5                        |     |      | —  | —   | —   | —   | —   | —      | UI   |
|   | Jitter Frequency = 1.875MHz<br>Data Rate = 3.75 Gbps<br>Pattern = CJPAT | > 0.1                        |     |      | —  | —   | —   | —   | —   | —      | UI   |
|   | Jitter Frequency = 20 MHz<br>Data Rate = 3.75 Gbps<br>Pattern = CJPAT   | > 0.1                        |     |      | —  | —   | —   | —   | —   | —      | UI   |
| <b>(OIF) CEI Transmitter Jitter Generation (10)</b>               |   |                              |     |      |  |     |     |   |     |        |      |
| Total jitter (peak-to-peak)                                       | Data Rate = 6.375 Gbps<br>Pattern = PRBS15 BER = 10 <sup>-12</sup>      | —                            | —   | 0.3  | —  | —   | 0.3 | —   | —   | 0.3    | UI   |
| <b>(OIF) CEI Receiver Jitter Tolerance (10)</b>                   |   |                              |     |      |  |     |     |   |     |        |      |
| Deterministic jitter tolerance (peak-to-peak)                     | Data Rate = 6.375 Gbps<br>Pattern = PRBS31 BER = 10 <sup>-12</sup>      | > 0.675                      |     |      | > 0.675  |     |     | —   | —   | >0.675 | UI   |

**Table 1-30. Transceiver Block Jitter Specifications for Stratix IV GX Devices (Note 1), (2) (Part 5 of 9)**

| Symbol/<br>Description  | Conditions  | -2 Commercial<br>Speed Grade |     |     | -3 Commercial/<br>Industrial/Military<br>and -2× Commercial<br>Speed Grade |     |     | -4 Commercial/<br>Industrial Speed<br>Grade |     |        | Unit |
|---|---|------------------------------|-----|-----|--|-----|-----|---|-----|--------|------|
|   |   | Min                          | Typ | Max | Min  | Typ | Max | Min   | Typ | Max    |      |
| Combined deterministic and random jitter tolerance (peak-to-peak) | Data Rate = 6.375 Gbps<br>Pattern=PRBS31<br>BER = 10 <sup>-12</sup>                               | > 0.988                      |     |     | > 0.988  |     |     | —   | —   | >0.988 | UI   |
| Sinusoidal jitter tolerance (peak-to-peak)                        | Jitter Frequency = 38.2 KHz<br>Data Rate = 6.375 Gbps<br>Pattern = PRBS31 BER = 10 <sup>-12</sup> | > 5                          |     |     | > 5  |     |     | —   | —   | > 5    | UI   |
|   | Jitter Frequency = 3.82 MHz<br>Data Rate = 6.375 Gbps<br>Pattern = PRBS31 BER = 10 <sup>-12</sup> | > 0.05                       |     |     | > 0.05   |     |     | —   | —   | > 0.05 | UI   |
|   | Jitter Frequency = 20 MHz<br>Data Rate= 6.375 Gbps<br>Pattern = PRBS31 BER = 10 <sup>-12</sup>    | > 0.05                       |     |     | > 0.05   |     |     | —   | —   | > 0.05 | UI   |
| <b>SDI Transmitter Jitter Generation (11)</b>                     |   |                              |     |     |  |     |     |   |     |        |      |
| Alignment jitter (peak-to-peak)                                   | Data Rate = 1.485 Gbps (HD) Pattern = Color Bar Low-Frequency Roll-Off = 100 KHz                  | 0.2                          | —   | —   | 0.2  | —   | —   | 0.2   | —   | —      | UI   |
|   | Data Rate = 2.97 Gbps (3G) Pattern = Color Bar Low-Frequency Roll-Off = 100 KHz                   | 0.3                          | —   | —   | 0.3  | —   | —   | 0.3   | —   | —      | UI   |

**Table 1-30. Transceiver Block Jitter Specifications for Stratix IV GX Devices (Note 1), (2) (Part 6 of 9)**

| Symbol/<br>Description                        | Conditions   | -2 Commercial<br>Speed Grade |       |      | -3 Commercial/<br>Industrial/Military<br>and -2× Commercial<br>Speed Grade |     |       | -4 Commercial/<br>Industrial Speed<br>Grade |     |      | Unit |
|---|--|------------------------------|-------|------|--|-----|-------|---|-----|------|------|
|   |  | Min                          | Typ   | Max  | Min  | Typ | Max   | Min   | Typ | Max  |      |
| <b>SDI Receiver Jitter Tolerance (11)</b>     |  |                              |       |      |  |     |       |   |     |      |      |
| Sinusoidal jitter<br>tolerance (peak-to-peak) | Jitter Frequency =<br>15 KHz<br>Data Rate = 2.97 Gbps<br>(3G) Pattern = Single<br>Line Scramble Color Bar    |                              | > 2   |      | > 2  |     | > 2   |   |     | UI   |      |
|   | Jitter Frequency =<br>100 KHz<br>Data Rate = 2.97 Gbps<br>(3G) Pattern = Single<br>Line Scramble Color Bar   |                              | > 0.3 |      | > 0.3  |     | > 0.3 |   |     | UI   |      |
|   | Jitter Frequency =<br>148.5 MHz<br>Data Rate = 2.97 Gbps<br>(3G) Pattern = Single<br>Line Scramble Color Bar |                              | > 0.3 |      | > 0.3  |     | > 0.3 |   |     | UI   |      |
| Sinusoidal jitter<br>tolerance (peak-to-peak) | Jitter Frequency =<br>20 KHz<br>Data Rate = 1.485 Gbps<br>(HD) Pattern = 75%<br>Color Bar                    |                              | > 1   |      | > 1  |     | > 1   |   |     | UI   |      |
|   | Jitter Frequency = 100<br>KHz Data Rate = 1.485<br>Gbps (HD) Pattern =<br>75% Color Bar                      |                              | > 0.2 |      | > 0.2  |     | > 0.2 |   |     | UI   |      |
|   | Jitter Frequency = 148.5<br>MHz<br>Data Rate = 1.485 Gbps<br>(HD) Pattern = 75%<br>Color Bar                 |                              | > 0.2 |      | > 0.2  |     | > 0.2 |   |     | UI   |      |
| <b>SAS Transmit Jitter Generation (16)</b>    |  |                              |       |      |  |     |       |   |     |      |      |
| Total jitter at 1.5 Gbps<br>(G1)              | Pattern = CJPAT  | —                            | —     | 0.55 | —  | —   | 0.55  | —   | —   | 0.55 | UI   |
| Deterministic jitter at<br>1.5 Gbps (G1)      | Pattern = CJPAT  | —                            | —     | 0.35 | —  | —   | 0.35  | —   | —   | 0.35 | UI   |
| Total jitter at 3.0 Gbps<br>(G2)              | Pattern = CJPAT  | —                            | —     | 0.55 | —  | —   | 0.55  | —   | —   | 0.55 | UI   |
| Deterministic jitter at<br>3.0 Gbps (G2)      | Pattern = CJPAT  | —                            | —     | 0.35 | —  | —   | 0.35  | —   | —   | 0.35 | UI   |
| Total jitter at 6.0 Gbps<br>(G3)              | Pattern = CJPAT  | —                            | —     | 0.25 | —  | —   | 0.25  | —   | —   | 0.25 | UI   |

**Table 1–30. Transceiver Block Jitter Specifications for Stratix IV GX Devices (Note 1), (2) (Part 7 of 9)**

| Symbol/<br>Description                                   | Conditions  | –2 Commercial<br>Speed Grade |     |       | –3 Commercial/<br>Industrial/Military<br>and –2× Commercial<br>Speed Grade |     |       | –4 Commercial/<br>Industrial Speed<br>Grade |     |       | Unit |
|--|---|------------------------------|-----|-------|--|-----|-------|---|-----|-------|------|
|  |   | Min                          | Typ | Max   | Min  | Typ | Max   | Min   | Typ | Max   |      |
| Random jitter at<br>6.0 Gbps (G3)                        | Pattern = CJPAT   | —                            | —   | 0.15  | —  | —   | 0.15  | —   | —   | 0.15  | UI   |
| <b>SAS Receiver Jitter Tolerance (16)</b>                |   |                              |     |       |  |     |       |   |     |       |      |
| Total Jitter tolerance at<br>1.5 Gbps (G1)               | Pattern = CJPAT   | > 0.65                       |     |       | > 0.65   |     |       | > 0.65                                      |     |       | UI   |
| Deterministic Jitter<br>tolerance at 1.5 Gbps<br>(G1)    | Pattern = CJPAT   | > 0.35                       |     |       | > 0.35   |     |       | > 0.35                                      |     |       | UI   |
| Sinusoidal Jitter<br>tolerance at 1.5 Gbps<br>(G1)       | Jitter Frequency = 900<br>KHz to 5 MHz<br>Pattern = CJTPAT BER =<br>1E-12 | > 0.1                        |     |       | > 0.1  |     |       | > 0.1                                       |     |       | UI   |
| <b>CPRI Transmit Jitter Generation (17)</b>              |   |                              |     |       |  |     |       |   |     |       |      |
| Total Jitter   | E.6.HV, E.12.HV<br>Pattern = CJPAT  | —                            | —   | 0.279 | —  | —   | 0.279 | —   | —   | 0.279 | UI   |
|  | E.6.LV, E.12.LV, E.24.LV,<br>E.30.LV<br>Pattern = CJTPAT                  | —                            | —   | 0.35  | —  | —   | 0.35  | —   | —   | 0.35  | UI   |
| Deterministic Jitter                                     | E.6.HV, E.12.HV<br>Pattern = CJPAT  | —                            | —   | 0.14  | —  | —   | 0.14  | —   | —   | 0.14  | UI   |
|  | E.6.LV, E.12.LV, E.24.LV,<br>E.30.LV<br>Pattern = CJTPAT                  | —                            | —   | 0.17  | —  | —   | 0.17  | —   | —   | 0.17  | UI   |
| <b>CPRI Receiver Jitter Tolerance (17)</b>               |   |                              |     |       |  |     |       |   |     |       |      |
| Total jitter tolerance                                   | E.6.HV, E.12.HV<br>Pattern = CJPAT  | > 0.66                       |     |       | > 0.66   |     |       | > 0.66                                      |     |       | UI   |
| Deterministic jitter<br>tolerance                        | E.6.HV, E.12.HV<br>Pattern = CJPAT  | > 0.4                        |     |       | > 0.4  |     |       | > 0.4                                       |     |       | UI   |
| Total jitter tolerance                                   | E.6.LV, E.12.LV, E.24.LV,<br>E.30.LV<br>Pattern = CJTPAT                  | > 0.65                       |     |       | > 0.65   |     |       | > 0.65                                      |     |       | UI   |
| Deterministic jitter<br>tolerance                        | E.6.LV, E.12.LV, E.24.LV,<br>E.30.LV<br>Pattern = CJTPAT                  | > 0.37                       |     |       | > 0.37   |     |       | > 0.37                                      |     |       | UI   |
| Combined deterministic<br>and random jitter<br>tolerance | E.6.LV, E.12.LV, E.24.LV,<br>E.30.LV<br>Pattern = CJTPAT                  | > 0.55                       |     |       | > 0.55   |     |       | > 0.55                                      |     |       | UI   |

**Table 1-30. Transceiver Block Jitter Specifications for Stratix IV GX Devices (Note 1), (2) (Part 8 of 9)**

| Symbol/<br>Description   | Conditions  | -2 Commercial<br>Speed Grade |     |      | -3 Commercial/<br>Industrial/Military<br>and -2× Commercial<br>Speed Grade |     |      | -4 Commercial/<br>Industrial Speed<br>Grade |     |      | Unit |
|--|---|------------------------------|-----|------|--|-----|------|---|-----|------|------|
|  |   | Min                          | Typ | Max  | Min  | Typ | Max  | Min   | Typ | Max  |      |
| <b>OBSAI Transmit Jitter Generation (18)</b>   |   |                              |     |      |  |     |      |   |     |      |      |
| Total jitter at 768 Mbps, 1536 Mbps, and 3072 Mbps                                       | REFCLK = 153.6MHz<br>Pattern = CJPAT                      | —                            | —   | 0.35 | —  | —   | 0.35 | —   | —   | 0.35 | UI   |
| Deterministic jitter at 768 Mbps, 1536 Mbps, and 3072 Mbps                               | REFCLK = 153.6MHz<br>Pattern = CJPAT                      | —                            | —   | 0.17 | —  | —   | 0.17 | —   | —   | 0.17 | UI   |
| <b>OBSAI Receiver Jitter Tolerance (18)</b>  |   |                              |     |      |  |     |      |   |     |      |      |
| Deterministic jitter tolerance at 768 Mbps, 1536 Mbps, and 3072 Mbps                     | Pattern = CJPAT   | > 0.37                       |     |      | > 0.37   |     |      | > 0.37                                      |     |      | UI   |
| Combined deterministic and random jitter tolerance at 768 Mbps, 1536 Mbps, and 3072 Mbps | Pattern = CJPAT   | > 0.55                       |     |      | > 0.55   |     |      | > 0.55                                      |     |      | UI   |
| Sinusoidal Jitter tolerance at 768 Mbps  | Jitter Frequency = 5.4 KHz<br>Pattern = CJPAT             | > 8.5                        |     |      | > 8.5  |     |      | > 8.5                                       |     |      | UI   |
|  | Jitter Frequency = 460 MHz to 20 MHz<br>Pattern = CJPAT   | > 0.1                        |     |      | > 0.1  |     |      | > 0.1                                       |     |      | UI   |
| Sinusoidal Jitter tolerance at 1536 Mbps   | Jitter Frequency = 10.9 KHz<br>Pattern = CJPAT            | > 8.5                        |     |      | > 8.5  |     |      | > 8.5                                       |     |      | UI   |
|  | Jitter Frequency = 921.6 MHz to 20 MHz<br>Pattern = CJPAT | > 0.1                        |     |      | > 0.1  |     |      | > 0.1                                       |     |      | UI   |

**Table 1-30. Transceiver Block Jitter Specifications for Stratix IV GX Devices (Note 1), (2) (Part 9 of 9)**

| Symbol/<br>Description                      | Conditions  | -2 Commercial<br>Speed Grade |     |     | -3 Commercial/<br>Industrial/Military<br>and -2× Commercial<br>Speed Grade |     |     | -4 Commercial/<br>Industrial Speed<br>Grade |     |     | Unit |
|---|---|------------------------------|-----|-----|--|-----|-----|---|-----|-----|------|
|   |   | Min                          | Typ | Max | Min  | Typ | Max | Min   | Typ | Max |      |
| Sinusoidal Jitter<br>tolerance at 3072 Mbps | Jitter Frequency = 21.8<br>KHz<br>Pattern = CJPAT             | > 8.5                        |     |     | > 8.5  |     |     | > 8.5                                       |     |     | UI   |
|   | Jitter Frequency =<br>1843.2 MHz to 20 MHz<br>Pattern = CJPAT | > 0.1                        |     |     | > 0.1  |     |     | > 0.1                                       |     |     | UI   |

**Notes to Table 1-30:**

- (1) Dedicated `refclk` pins were used to drive the input reference clocks.
- (2) The Jitter numbers are valid for the stated conditions only.
- (3) The jitter numbers for SONET/SDH are compliant to the GR-253-CORE Issue 3 Specification.
- (4) The jitter numbers for Fibre Channel are compliant to the FC-PI-4 Specification revision 6.10.
- (5) The jitter numbers for XAUI are compliant to the IEEE802.3ae-2002 Specification.
- (6) The jitter numbers for PCI Express (PIPE) (PCIe) are compliant to the PCIe Base Specification 2.0.
- (7) The jitter numbers for Serial RapidIO are compliant to the RapidIO Specification 1.3.
- (8) The jitter numbers for GIGE are compliant to the IEEE802.3-2002 Specification.
- (9) The jitter numbers for HiGig are compliant to the IEEE802.3ae-2002 Specification.
- (10) The jitter numbers for (OIF) CEI are compliant to the OIF-CEI-02.0 Specification.
- (11) The HD-SDI and 3G-SDI jitter numbers are compliant to the SMPTE292M and SMPTE424M Specifications.
- (12) The fibre channel transmitter jitter generation numbers are compliant to the specification at  $\delta_T$  interoperability point.
- (13) The fibre channel receiver jitter tolerance numbers are compliant to the specification at  $\delta_R$  interoperability point.
- (14) You must use the ATX PLL adjacent to the transceiver channels to meet the transmitter jitter generation compliance in PCIe Gen2 ×8 modes.
- (15) Stratix IV PCIe receivers are compliant to this specification provided the  $V_{TX-CM-DC-ACTIVEIDLE-DELTA}$  of the upstream transmitter is less than 50mV.
- (16) The jitter numbers for Serial Attached SCSI (SAS) are compliant to the SAS-2.1 Specification.
- (17) The jitter numbers for CPRI are compliant to the CPRI Specification V3.0.
- (18) The jitter numbers for OBSAI are compliant to the OBSAI RP3 Specification V4.1.

Table 1-31 lists the transceiver jitter specifications for protocols supported by Stratix IV GT devices.

**Table 1-31. Transceiver Jitter Specifications for Protocols by Stratix IV GT Devices (Part 1 of 2)**

| Symbol/<br>Description                                | Conditions  | -1 Industrial Speed Grade |     |      | -2 Industrial Speed Grade |     |      | -3 Industrial Speed Grade |     |      | Unit |
|---|---|---------------------------|-----|------|---------------------------|-----|------|---------------------------|-----|------|------|
|   |   | Min                       | Typ | Max  | Min                       | Typ | Max  | Min                       | Typ | Max  |      |
| <b>XLAUI/CAUI Transmit Jitter Generation (1), (3)</b> |   |                           |     |      |                           |     |      |                           |     |      |      |
| Total Jitter  | Pattern = PRBS-31   | —                         | —   | 0.30 | —                         | —   | 0.30 | —                         | —   | 0.30 | UI   |
| Deterministic Jitter                                  | V <sub>OD</sub> = 800 mV<br>REFCLK = 644.53 MHz<br>4 (XLAUI)/<br>10 (CAUI) channels in<br>Basic ×1 mode | —                         | —   | 0.17 | —                         | —   | 0.17 | —                         | —   | 0.17 | UI   |
| <b>XLAUI/CAUI Receiver Jitter Tolerance (1)</b>       |   |                           |     |      |                           |     |      |                           |     |      |      |
| Total Jitter tolerance                                | Pattern = PRBS-31   | > 0.62                    |     |      | > 0.62                    |     |      | —                         |     |      | UI   |
| Sinusoidal Jitter tolerance                           | Jitter Frequency = 40 KHz<br>Pattern = PRBS-31<br>Equalization = Disabled<br>BER = 1E-12                | > 5                       |     |      | > 5                       |     |      | —                         |     |      | UI   |
|   | Jitter Frequency ≥ 4 MHz<br>Pattern = PRBS-31<br>Equalization = Disabled<br>BER = 1E-12                 | > 0.05                    |     |      | > 0.05                    |     |      | —                         |     |      | UI   |
| <b>XFI Transmitter Jitter Generation (2), (3)</b>     |   |                           |     |      |                           |     |      |                           |     |      |      |
| Total jitter at 10.3125 Gbps                          | Pattern = PRBS-31<br>V <sub>od</sub> = 800 mV<br>REFCLK = 644.53 MHz<br>10 channels in Basic ×1 mode    | —                         | —   | 0.3  | —                         | —   | 0.3  | —                         | —   | —    | UI   |
| <b>OTL 4.10 (1), (3)</b>                              |   |                           |     |      |                           |     |      |                           |     |      |      |
| Total Jitter at 11.18 Gbps                            | Pattern = PRBS-31<br>V <sub>OD</sub> = 800 mV   | —                         | —   | 0.30 | —                         | —   | 0.30 | —                         | —   | 0.30 | UI   |
| Deterministic Jitter                                  | REFCLK = 698.75 MHz   | —                         | —   | 0.17 | —                         | —   | 0.17 | —                         | —   | 0.17 | UI   |

**Table 1-31. Transceiver Jitter Specifications for Protocols by Stratix IV GT Devices (Part 2 of 2)**

| Symbol/<br>Description      | Conditions   | -1 Industrial Speed Grade |     |     | -2 Industrial Speed Grade |     |     | -3 Industrial Speed Grade |     |     | Unit |
|-----------------------------|--|---------------------------|-----|-----|---------------------------|-----|-----|---------------------------|-----|-----|------|
|                             |  | Min                       | Typ | Max | Min                       | Typ | Max | Min                       | Typ | Max |      |
| Sinusoidal Jitter tolerance | Jitter Frequency = 40 KHz<br>Pattern = PRBS-31<br>Equalization = Disabled<br>BER = 1E-12 | > 5                       |     |     | > 5                       |     |     | —                         |     |     | UI   |
|                             | Jitter Frequency ≥ 4 MHz<br>Pattern = PRBS-31<br>Equalization = Disabled<br>BER = 1E-12  | > 0.05                    |     |     | > 0.05                    |     |     | —                         |     |     | UI   |

**Notes to Table 1-31:**

- (1) The jitter numbers for XLAUI/CAUI are compliant to the IEEE P802.3ba specification.
- (2) Stratix IV GT transceivers are compliant to the XFI datacom transmitter jitter specifications in Table 9 of XFP Revision 4.1.
- (3) Contact Altera for board and link best practices at BER = 1E-15.

Table 1-32 lists the SFI-S transmitter jitter specifications for Stratix IV GT devices.

**Table 1-32. SFI-S Transmitter Jitter Specifications for Stratix IV GT Devices (Note 1), (2)**

| Symbol/Description                        | Conditions   | -1 Industrial Speed Grade | -2 Industrial Speed Grade | -3 Industrial Speed Grade | Unit |
|---|--|---------------------------|---------------------------|---------------------------|------|
|   |  | Mean                      | Mean                      | Mean                      |      |
| Total Transmitter jitter at 11.3 Gbps (4) | Pattern = PRBS-31<br>Vod = 800 mV<br>REFCLK = 706.25 MHz<br>12 channels in Basic ×1 mode | 0.23 UI (3)               | —                         | —                         | UI   |

**Notes to Table 1-32:**

- (1) Dedicated `refclk` pins were used to drive the input reference clocks.
- (2) The jitter numbers are valid for stated conditions only.
- (3) Two hundred channels were characterized to derive the mean transmitter jitter specification of 0.23 UI. The maximum jitter across the 200 units characterized was 0.30 UI.
- (4) Contact Altera for board and link best practices at BER = 1E-15.

## Transceiver Datapath PCS Latency



For more information about:

- Basic mode PCS latency, refer to Figure 1-90 through Figure 1-97 in the *Transceiver Architecture in Stratix IV Devices* chapter.
- PCIe mode PCS latency, refer to Figure 1-102 in the *Transceiver Architecture in Stratix IV Devices* chapter.
- XAUI mode PCS latency, refer to Figure 1-119 in the *Transceiver Architecture in Stratix IV Devices* chapter.
- GIGE mode PCS latency, refer to Figure 1-128 in the *Transceiver Architecture in Stratix IV Devices* chapter.
- SONET/SDH mode PCS latency, refer to Figure 1-136 in the *Transceiver Architecture in Stratix IV Devices* chapter.
- SDI mode PCS latency, refer to Figure 1-141 in the *Transceiver Architecture in Stratix IV Devices* chapter.
- (OIF) CEI PHY mode PCS latency, refer to Figure 1-143 in the *Transceiver Architecture in Stratix IV Devices* chapter.

## Core Performance Specifications

This section describes the clock tree, phase-locked loop (PLL), digital signal processing (DSP), TriMatrix, configuration, JTAG, and chip-wide reset (Dev\_CLRn) specifications.

### Clock Tree Specifications

Table 1-33 lists the clock tree specifications for Stratix IV devices.

**Table 1-33. Clock Tree Performance for Stratix IV Devices—Preliminary**

| Symbol                          | Performance        |                |                | Unit |
|---------------------------------|--------------------|----------------|----------------|------|
|                                 | -2/-2× Speed Grade | -3 Speed Grade | -4 Speed Grade |      |
| Global clock and Regional clock | 800                | 700            | 500            | MHz  |
| Periphery clock                 | 550                | 500            | 450            | MHz  |



For the Stratix IV GT -1 and -2 speed grade specifications, refer to the -2/-2× speed grade column. For the Stratix IV GT -3 speed grade specification, refer to the -3 speed grade column.

## PLL Specifications

Table 1-34 lists the Stratix IV PLL specifications when operating in the commercial (0° to 85°C), industrial (-40° to 100°C), and military (-55°C to 125°C) junction temperature ranges.

**Table 1-34. PLL Specifications for Stratix IV Devices (Part 1 of 2)—Preliminary**

| Symbol                      | Parameter  | Min | Typ | Max     | Unit           |
|-----------------------------|--|-----|-----|---------|----------------|
| f <sub>IN</sub>             | Input clock frequency (-2/-2x speed grade)   | 5   | —   | 800 (1) | MHz            |
|                             | Input clock frequency (-3 speed grade)   | 5   | —   | 717 (1) | MHz            |
|                             | Input clock frequency (-4 speed grade)   | 5   | —   | 717 (1) | MHz            |
| f <sub>INPFD</sub>          | Input frequency to the PFD   | 5   | —   | 325     | MHz            |
| f <sub>VCO</sub> (2)        | PLL VCO operating range (-2 speed grade)   | 600 | —   | 1600    | MHz            |
|                             | PLL VCO operating range (-3 speed grade)   | 600 | —   | 1300    | MHz            |
|                             | PLL VCO operating range (-4 speed grade)   | 600 | —   | 1300    | MHz            |
| t <sub>EINDUTY</sub>        | Input clock or external feedback clock input duty cycle  | 40  | —   | 60      | %              |
| f <sub>OUT</sub>            | Output frequency for internal global or regional clock (-2/-2x speed grade)                              | —   | —   | 800 (3) | MHz            |
|                             | Output frequency for internal global or regional clock (-3 speed grade)                                  | —   | —   | 717 (3) | MHz            |
|                             | Output frequency for internal global or regional clock (-4 speed grade)                                  | —   | —   | 717 (3) | MHz            |
| f <sub>OUT_EXT</sub>        | Output frequency for external clock output (-2 speed grade)  | —   | —   | 800 (3) | MHz            |
|                             | Output frequency for external clock output (-3 speed grade)  | —   | —   | 717 (3) | MHz            |
|                             | Output frequency for external clock output (-4 speed grade)  | —   | —   | 717 (3) | MHz            |
| t <sub>OUTDUTY</sub>        | Duty cycle for external clock output (when set to 50%)   | 45  | 50  | 55      | %              |
| t <sub>FCOMP</sub>          | External feedback clock compensation time  | —   | —   | 10      | ns             |
| t <sub>CONFIGPLL</sub>      | Time required to reconfigure scan chain  | —   | 3.5 | —       | scanclk cycles |
| t <sub>CONFIGPHASE</sub>    | Time required to reconfigure phase shift   | —   | 1   | —       | scanclk cycles |
| f <sub>SCANCLK</sub>        | scanclk frequency  | —   | —   | 100     | MHz            |
| t <sub>LOCK</sub>           | Time required to lock from end-of-device configuration or de-assertion of areset                         | —   | —   | 1       | ms             |
| t <sub>DLOCK</sub>          | Time required to lock dynamically (after switchover or reconfiguring any non-post-scale counters/delays) | —   | —   | 1       | ms             |
| f <sub>CLBW</sub>           | PLL closed-loop low bandwidth  | —   | 0.3 | —       | MHz            |
|                             | PLL closed-loop medium bandwidth   | —   | 1.5 | —       | MHz            |
|                             | PLL closed-loop high bandwidth (8)   | —   | 4   | —       | MHz            |
| t <sub>PLL_PSERR</sub>      | Accuracy of PLL phase shift  | —   | —   | ±50     | ps             |
| t <sub>ARESET</sub>         | Minimum pulse width on the areset signal   | 10  | —   | —       | ns             |
| t <sub>INCCJ</sub> (4), (5) | Input clock cycle to cycle jitter (F <sub>REF</sub> ≥ 100 MHz)   | —   | —   | 0.15    | UI (p-p)       |
|                             | Input clock cycle to cycle jitter (F <sub>REF</sub> < 100 MHz)   | —   | —   | ±750    | ps (p-p)       |
| t <sub>OUTPJ_DC</sub> (6)   | Period Jitter for dedicated clock output (F <sub>OUT</sub> ≥ 100 MHz)                                    | —   | —   | 175     | ps (p-p)       |
|                             | Period Jitter for dedicated clock output (F <sub>OUT</sub> < 100 MHz)                                    | —   | —   | 17.5    | mUI (p-p)      |

**Table 1-34. PLL Specifications for Stratix IV Devices (Part 2 of 2)—Preliminary**

| Symbol                                | Parameter  | Min | Typ | Max      | Unit      |
|---------------------------------------|--|-----|-----|----------|-----------|
| $t_{\text{OUTCCJ\_DC}}$ (6)           | Cycle to Cycle Jitter for dedicated clock output ( $F_{\text{OUT}} \geq 100$ MHz)          | —   | —   | 175      | ps (p-p)  |
|                                       | Cycle to Cycle Jitter for dedicated clock output ( $F_{\text{OUT}} < 100$ MHz)             | —   | —   | 17.5     | mUI (p-p) |
| $t_{\text{OUTPJ\_IO}}$ (6), (9)       | Period Jitter for clock output on regular I/O ( $F_{\text{OUT}} \geq 100$ MHz)             | —   | —   | 600      | ps (p-p)  |
|                                       | Period Jitter for clock output on regular I/O ( $F_{\text{OUT}} < 100$ MHz)                | —   | —   | 60       | mUI (p-p) |
| $t_{\text{OUTCCJ\_IO}}$ (6), (9)      | Cycle to Cycle Jitter for clock output on regular I/O ( $F_{\text{OUT}} \geq 100$ MHz)     | —   | —   | 600      | ps (p-p)  |
|                                       | Cycle to Cycle Jitter for clock output on regular I/O ( $F_{\text{OUT}} < 100$ MHz)        | —   | —   | 60       | mUI (p-p) |
| $t_{\text{CASC\_OUTPJ\_DC}}$ (6), (7) | Period Jitter for dedicated clock output in cascaded PLLs ( $F_{\text{OUT}} \geq 100$ MHz) | —   | —   | 250      | ps (p-p)  |
|                                       | Period Jitter for dedicated clock output in cascaded PLLs ( $F_{\text{OUT}} < 100$ MHz)    | —   | —   | 25       | mUI (p-p) |
| $f_{\text{DRIFT}}$                    | Frequency drift after PFDENA is disabled for duration of 100 $\mu$ s                       | —   | —   | $\pm 10$ | %         |

**Notes to Table 1-34:**

- (1) This specification is limited in the Quartus II software by the I/O maximum frequency. The maximum I/O frequency is different for each I/O standard.
- (2) The VCO frequency reported by the Quartus II software in the PLL summary section of the compilation report takes into consideration the VCO post-scale counter K value. Therefore, if the counter K has a value of 2, the frequency reported can be lower than the  $f_{\text{VCO}}$  specification.
- (3) This specification is limited by the lower of the two: I/O  $F_{\text{MAX}}$  or  $F_{\text{OUT}}$  of the PLL.
- (4) A high input jitter directly affects the PLL output jitter. To have low PLL output clock jitter, you must provide a clean clock source that is less than 120 ps.
- (5)  $F_{\text{REF}}$  is  $f_{\text{IN}}/N$  when  $N = 1$ .
- (6) Peak-to-peak jitter with a probability level of  $10^{-12}$  (14 sigma, 99.9999999974404% confidence level). The output jitter specification applies to the intrinsic jitter of the PLL, when an input jitter of 30 ps is applied. The external memory interface clock output jitter specifications use a different measurement method and are available in [Table 1-50 on page 1-61](#).
- (7) The cascaded PLL specification is only applicable with the following condition:
  - A. Upstream PLL:  $0.59\text{MHz} \leq \text{Upstream PLL BW} < 1$  MHz
  - B. Downstream PLL: Downstream PLL BW  $> 2$  MHz
- (8) High bandwidth PLL settings are not supported in external feedback mode.
- (9) External memory interface clock output jitter specifications use a different measurement method, which is available in [Table 1-48 on page 1-60](#).

## DSP Block Specifications

Table 1-35 lists the Stratix IV DSP block performance specifications.

**Table 1-35. Block Performance Specifications for Stratix IV DSP Devices (Note 1)—Preliminary**

| Mode   | Resources Used        | Performance        |                |                | Unit |
|--|-----------------------|--------------------|----------------|----------------|------|
|  | Number of Multipliers | -2/-2× Speed Grade | -3 Speed Grade | -4 Speed Grade |      |
| 9×9-bit multiplier                             | 1                     | 520                | 460            | 400            | MHz  |
| 12×12-bit multiplier                           | 1                     | 540                | 500            | 440            | MHz  |
| 18×18-bit multiplier                           | 1                     | 600                | 550            | 480            | MHz  |
| 36×36-bit multiplier                           | 1                     | 480                | 440            | 380            | MHz  |
| 18×18-bit multiply accumulator                 | 4                     | 490                | 440            | 380            | MHz  |
| 18×18-bit multiply adder                       | 4                     | 510                | 470            | 410            | MHz  |
| 18×18-bit multiply adder-signed full precision | 2                     | 490                | 450            | 390            | MHz  |
| 18×18-bit multiply adder with loopback (2)     | 2                     | 390                | 350            | 310            | MHz  |
| 36-bit shift (32-bit data)                     | 1                     | 490                | 440            | 380            | MHz  |
| Double mode                                    | 1                     | 480                | 440            | 380            | MHz  |

**Notes to Table 1-35:**

- (1) Maximum is for fully pipelined block with **Round** and **Saturation** disabled.
- (2) Maximum for loopback input registers disabled, **Round** and **Saturation** disabled, and pipeline and output registers enabled.

## TriMatrix Memory Block Specifications

Table 1-36 lists the Stratix IV TriMatrix memory block specifications.

**Table 1-36. TriMatrix Memory Block Performance Specifications for Stratix IV Devices—Preliminary (Note 1) (Part 1 of 3)**

| Memory   | Mode                   | Resources Used |                  | Performance                                |   |                                       |   |                               | Unit |
|----------|------------------------|----------------|------------------|--|---|---------------------------------------|---|-------------------------------|------|
|          |                        | ALUTs          | TriMatrix Memory | -2 /-2× Commercial/ Industrial Speed Grade | -3 Commercial/ Industrial/ Military Speed Grade | -4 Commercial/ Industrial Speed Grade | -3 Industrial/ Military Speed Grade (2) | -4 Industrial Speed Grade (2) |      |
| MLAB (3) | Single port 64×10      | 0              | 1                | 600  | 500   | 450                                   | 500                                     | 450                           | MHz  |
|          | Simple dual-port 32×20 | 0              | 1                | 600  | 500   | 450                                   | 500                                     | 450                           | MHz  |
|          | Simple dual-port 64×10 | 0              | 1                | 600  | 500   | 450                                   | 500                                     | 450                           | MHz  |
|          | ROM 64×10              | 0              | 1                | 600  | 500   | 450                                   | 500                                     | 450                           | MHz  |
|          | ROM 32×20              | 0              | 1                | 600  | 500   | 450                                   | 500                                     | 450                           | MHz  |

**Table 1-36. TriMatrix Memory Block Performance Specifications for Stratix IV Devices—Preliminary (Note 1) (Part 2 of 3)**


| Memory        | Mode  | Resources Used |                  | Performance                               |   |                                      |  |                               | Unit |
|---------------|---|----------------|------------------|---|---|--------------------------------------|--|-------------------------------|------|
|               |   | ALUTs          | TriMatrix Memory | -2 /-2× Commercial/Industrial Speed Grade | -3 Commercial/Industrial/Military Speed Grade | -4 Commercial/Industrial Speed Grade | -3 Industrial/Military Speed Grade (2) | -4 Industrial Speed Grade (2) |      |
| M9K Block (3) | Single-port 256×36  | 0              | 1                | 600                                       | 540   | 475                                  | 540                                    | 475                           | MHz  |
|               | Simple dual-port 256×36   | 0              | 1                | 550                                       | 490   | 420                                  | 490                                    | 420                           | MHz  |
|               | Simple dual-port 256×36, with the read-during-write option set to <b>Old Data</b> | 0              | 1                | 375                                       | 340   | 300                                  | 340                                    | 300                           | MHz  |
|               | True dual port 512×18   | 0              | 1                | 490                                       | 430   | 370                                  | 430                                    | 370                           | MHz  |
|               | True dual-port 512×18, with the read-during-write option set to <b>Old Data</b>   | 0              | 1                | 375                                       | 335   | 290                                  | 335                                    | 290                           | MHz  |
|               | ROM 1 Port  | 0              | 1                | 600                                       | 540   | 475                                  | 540                                    | 475                           | MHz  |
|               | ROM 2 Port  | 0              | 1                | 600                                       | 540   | 475                                  | 540                                    | 475                           | MHz  |
|               | Min Pulse Width (clock high time)   | —              | —                | 750                                       | 800   | 850                                  | 800                                    | 850                           | ps   |
|               | Min Pulse Width (clock low time)  | —              | —                | 500                                       | 625   | 690                                  | 625                                    | 690                           | ps   |

**Table 1-36. TriMatrix Memory Block Performance Specifications for Stratix IV Devices—Preliminary (Note 1) (Part 3 of 3)**

| Memory          | Mode   | Resources Used |                  | Performance                               |   |                                      |  |                               | Unit |
|-----------------|--|----------------|------------------|---|---|--------------------------------------|--|-------------------------------|------|
|                 |  | ALUTs          | TriMatrix Memory | -2 /-2× Commercial/Industrial Speed Grade | -3 Commercial/Industrial/Military Speed Grade | -4 Commercial/Industrial Speed Grade | -3 Industrial/Military Speed Grade (2) | -4 Industrial Speed Grade (2) |      |
| M144K Block (3) | Single-port 2K×72  | 0              | 1                | 475                                       | 440   | 380                                  | 400                                    | 350                           | MHz  |
|                 | Simple dual-port 2K×72   | 0              | 1                | 465                                       | 435   | 385                                  | 375                                    | 325                           | MHz  |
|                 | Simple dual-port 2K×72, with the read-during-write option set to <b>Old Data</b> | 0              | 1                | 260                                       | 240   | 205                                  | 225                                    | 200                           | MHz  |
|                 | Simple dual-port 2K×64 (with ECC)  | 0              | 1                | 335                                       | 300   | 255                                  | 295                                    | 250                           | MHz  |
|                 | True dual-port 4K×36   | 0              | 1                | 400                                       | 375   | 330                                  | 350                                    | 310                           | MHz  |
|                 | True dual-port 4K×36, with the read-during-write option set to <b>Old Data</b>   | 0              | 1                | 245                                       | 230   | 205                                  | 225                                    | 200                           | MHz  |
|                 | ROM 1 Port   | 0              | 1                | 540                                       | 500   | 435                                  | 450                                    | 420                           | MHz  |
|                 | ROM 2 Port   | 0              | 1                | 500                                       | 465   | 400                                  | 425                                    | 400                           | MHz  |
|                 | Min Pulse Width (clock high time)  | —              | —                | 700                                       | 755   | 860                                  | 860                                    | 950                           | ps   |
|                 | Min Pulse Width (clock low time)   | —              | —                | 500                                       | 625   | 690                                  | 690                                    | 690                           | ps   |

**Notes to Table 1-36:**

- (1) To achieve the maximum memory block performance, use a memory block clock that comes through global clock routing from an on-chip PLL set to 50% output duty cycle. Use the Quartus II software to report timing for this and other memory block clocking schemes.
- (2) This is only applicable to the Stratix IV E and GX devices.
- (3) When you use the error detection CRC feature, there is no degradation in  $F_{MAX}$ .

 For the Stratix IV GT -1 and -2 speed grade specifications, refer to the -2/-2× speed grade column. For the Stratix IV GT -3 speed grade specification, refer to the -3 speed grade column.

## Configuration and JTAG Specifications

Table 1-37 lists the Stratix IV configuration mode specifications.

**Table 1-37. Configuration Mode Specifications for Stratix IV Devices—Preliminary**

| Programming Mode                   | DCLK F <sub>MAX</sub> |     |     | Unit |
|------------------------------------|-----------------------|-----|-----|------|
|                                    | Min                   | Typ | Max |      |
| Passive serial                     | —                     | —   | 125 | MHz  |
| Fast passive parallel (1)          | —                     | —   | 125 | MHz  |
| Fast active serial                 | 17                    | 26  | 40  | MHz  |
| Remote update only in fast AS mode | 4.3                   | 5.3 | 10  | MHz  |

**Note to Table 1-37:**

- (1) This denotes the maximum frequency supported in the FPP configuration scheme. The frequency supported for each device may vary depending on device density. For more information, refer to the *Configuration, Design Security, and Remote System Upgrades in Stratix IV Devices* chapter.

Table 1-38 lists the JTAG timing parameters and values for Stratix IV devices.

**Table 1-38. JTAG Timing Parameters and Values for Stratix IV Devices—Preliminary**

| Symbol                  | Description                              | Min | Max    | Unit |
|-------------------------|--|-----|--------|------|
| t <sub>JCP</sub>        | TCK clock period                         | 30  | —      | ns   |
| t <sub>JCH</sub>        | TCK clock high time                      | 14  | —      | ns   |
| t <sub>JCL</sub>        | TCK clock low time                       | 14  | —      | ns   |
| t <sub>JPSU (TDI)</sub> | TDI JTAG port setup time                 | 1   | —      | ns   |
| t <sub>JPSU (TMS)</sub> | TMS JTAG port setup time                 | 3   | —      | ns   |
| t <sub>JPH</sub>        | JTAG port hold time                      | 5   | —      | ns   |
| t <sub>JPCO</sub>       | JTAG port clock to output                | —   | 11 (1) | ns   |
| t <sub>JPZX</sub>       | JTAG port high impedance to valid output | —   | 14 (1) | ns   |
| t <sub>JPXZ</sub>       | JTAG port valid output to high impedance | —   | 14 (1) | ns   |

**Note to Table 1-38:**

- (1) A 1 ns adder is required for each V<sub>CCIO</sub> voltage step down from 3.0 V. For example, t<sub>JPCO</sub> = 12 ns if V<sub>CCIO</sub> of the TDO I/O bank = 2.5 V, or 13 ns if it equals 1.8 V.

## Temperature Sensing Diode Specifications

Table 1-39 lists the specifications for the Stratix IV temperature sensing diode.

**Table 1-39. External Temperature Sensing Diode Specifications—Preliminary**

| Description                              | Min | Typ | Max   | Unit |
|--|-----|-----|-------|------|
| I <sub>bias</sub> , diode source current | 8   | —   | 500   | μA   |
| V <sub>bias</sub> , voltage across diode | 0.3 | —   | 0.9   | V    |
| Series resistance                        | —   | —   | < 5   | Ω    |
| Diode ideality factor                    | —   | —   | 1.030 | —    |

## Chip-Wide Reset (Dev\_CLRn) Specifications

Table 1-40 lists the specifications for the Stratix IV chip-wide reset (Dev\_CLRn).

**Table 1-40. Chip-Wide Reset (DEV\_CLRn) Specifications**

| Description | Min | Typ | Max | Unit |
|-------------|-----|-----|-----|------|
| Dev_CLRn    | 500 | —   | —   | μS   |

## Periphery Performance

This section describes periphery performance, including high-speed I/O and external memory interface.

I/O performance supports several system interfaces, such as the LVDS high-speed I/O interface, external memory interface, and the PCI/PCI-X bus interface.

General-purpose I/O standards such as 3.3-, 2.5-, 1.8-, and 1.5-LVTTL/LVCMOS are capable of typical 167 MHz and 1.2 LVCMOS at 100 MHz interfacing frequency with 10 pF load.



Actual achievable frequency depends on design- and system-specific factors. You must perform HSPICE/IBIS simulations based on your specific design and system setup to determine the maximum achievable frequency in your system.

## High-Speed I/O Specification

Table 1-41 lists the high-speed I/O timing for Stratix IV devices.

**Table 1-41. High-Speed I/O Specifications (Note 1), (2), (10) (Part 1 of 3)—Preliminary**

| Symbol   | Conditions                            | -2/-2x Speed Grade |     |            | -3 Speed Grade |     |            | -4 Speed Grade |     |            | Unit |
|--|---------------------------------------|--------------------|-----|------------|----------------|-----|------------|----------------|-----|------------|------|
|  |                                       | Min                | Typ | Max        | Min            | Typ | Max        | Min            | Typ | Max        |      |
| f <sub>HSCLK_in</sub> (input clock frequency)<br>True Differential I/O Standards | Clock boost factor W = 1 to 40<br>(3) | 5                  | —   | 800        | 5              | —   | 717        | 5              | —   | 717        | MHz  |
| f <sub>HSCLK_in</sub> (input clock frequency)<br>Single Ended I/O Standards (9)  | Clock boost factor W = 1 to 40<br>(3) | 5                  | —   | 800        | 5              | —   | 717        | 5              | —   | 717        | MHz  |
| f <sub>HSCLK_in</sub> (input clock frequency)<br>Single Ended I/O Standards (10) | Clock boost factor W = 1 to 40<br>(3) | 5                  | —   | 520        | 5              | —   | 420        | 5              | —   | 420        | MHz  |
| f <sub>HSCLK_OUT</sub> (output clock frequency)                                  | —                                     | 5                  | —   | 800<br>(7) | 5              | —   | 717<br>(7) | 5              | —   | 717<br>(7) | MHz  |

**Table 1-41. High-Speed I/O Specifications (Note 1), (2), (10) (Part 2 of 3)—Preliminary**

| Symbol   | Conditions   | -2/-2x Speed Grade |     |       | -3 Speed Grade |     |      | -4 Speed Grade |     |      | Unit |
|--|--|--------------------|-----|-------|----------------|-----|------|----------------|-----|------|------|
|  |  | Min                | Typ | Max   | Min            | Typ | Max  | Min            | Typ | Max  |      |
| <b>Transmitter</b>   |  |                    |     |       |                |     |      |                |     |      |      |
| True Differential I/O Standards - $f_{\text{HSDR}}$ (data rate)  | SERDES factor J = 3 to 10 (8)  | (4)                | —   | 1600  | (4)            | —   | 1250 | (4)            | —   | 1250 | Mbps |
|  | SERDES factor J = 2, Uses DDR Registers  | (4)                | —   | (4)   | (4)            | —   | (4)  | (4)            | —   | (4)  | Mbps |
|  | SERDES factor J = 1, Uses an SDR Register  | (4)                | —   | (4)   | (4)            | —   | (4)  | (4)            | —   | (4)  | Mbps |
| Emulated Differential I/O Standards with Three External Output Resistor Networks - $f_{\text{HSDR}}$ (data rate) (5) | SERDES factor J = 4 to 10  | (4)                | —   | 1250  | (4)            | —   | 1152 | (4)            | —   | 800  | Mbps |
| Emulated Differential I/O Standards with One External Output Resistor - $f_{\text{HSDR}}$ (data rate)                |  | (4)                | —   | 311   | (4)            | —   | 200  | (4)            | —   | 200  | Mbps |
| $t_{\text{x Jitter}}$ - True Differential I/O Standards  | Total Jitter for Data Rate, 600 Mbps to 1.6 Gbps                                 | —                  | —   | 160   | —              | —   | 160  | —              | —   | 160  | ps   |
|  | Total Jitter for Data Rate, < 600 Mbps   | —                  | —   | 0.1   | —              | —   | 0.1  | —              | —   | 0.1  | UI   |
| $t_{\text{x Jitter}}$ - Emulated Differential I/O Standards with Three External Output Resistor Network              | Total Jitter for Data Rate, 600 Mbps to 1.25 Gbps                                | —                  | —   | 300   | —              | —   | 300  | —              | —   | 325  | ps   |
|  | Total Jitter for Data Rate < 600 Mbps  | —                  | —   | 0.2   | —              | —   | 0.2  | —              | —   | 0.25 | UI   |
| $t_{\text{x Jitter}}$ - Emulated Differential I/O Standards with One External Output Resistor Network                | —  | —                  | —   | 0.125 | —              | —   | 0.15 | —              | —   | 0.15 | UI   |
| $t_{\text{DUTY}}$  | Tx output clock duty cycle for both True and Emulated Differential I/O Standards | 45                 | 50  | 55    | 45             | 50  | 55   | 45             | 50  | 55   | %    |
| $t_{\text{RISE}}$ & $t_{\text{FALL}}$  | True Differential I/O Standards  | —                  | —   | 160   | —              | —   | 200  | —              | —   | 200  | ps   |
|  | Emulated Differential I/O Standards with Three External Output Resistor Networks | —                  | —   | 250   | —              | —   | 250  | —              | —   | 300  | ps   |
|  | Emulated Differential I/O Standards with One External Output Resistor            | —                  | —   | 460   | —              | —   | 500  | —              | —   | 500  | ps   |

**Table 1-41. High-Speed I/O Specifications (Note 1), (2), (10) (Part 3 of 3)—Preliminary**

| Symbol   | Conditions                                | -2/-2× Speed Grade |     |       | -3 Speed Grade |     |       | -4 Speed Grade |     |       | Unit  |
|--|---|--------------------|-----|-------|----------------|-----|-------|----------------|-----|-------|-------|
|  |   | Min                | Typ | Max   | Min            | Typ | Max   | Min            | Typ | Max   |       |
| TCCS   | True Differential I/O Standards           | —                  | —   | 100   | —              | —   | 100   | —              | —   | 100   | ps    |
|  | Emulated Differential I/O Standards       | —                  | —   | 250   | —              | —   | 250   | —              | —   | 250   | ps    |
| <b>Receiver</b>  |   |                    |     |       |                |     |       |                |     |       |       |
| True Differential I/O Standards - $f_{HSDRPA}$ (data rate) | SERDES factor J = 3 to 10                 | 150                | —   | 1600  | 150            | —   | 1250  | 150            | —   | 1250  | Mbps  |
| $f_{HSDR}$ (data rate)                                     | SERDES factor J = 3 to 10                 | (4)                | —   | (4)   | (4)            | —   | (4)   | (4)            | —   | (4)   | Mbps  |
|  | SERDES factor J = 2, Uses DDR Registers   | (4)                | —   | (4)   | (4)            | —   | (4)   | (4)            | —   | (4)   | Mbps  |
|  | SERDES factor J = 1, Uses an SDR Register | (4)                | —   | (4)   | (4)            | —   | (4)   | (4)            | —   | (4)   | Mbps  |
| <b>DPA Mode</b>  |   |                    |     |       |                |     |       |                |     |       |       |
| DPA run length   | —   | —                  | —   | 10000 | —              | —   | 10000 | —              | —   | 10000 | UI    |
| <b>Soft CDR mode</b>                                       |   |                    |     |       |                |     |       |                |     |       |       |
| Soft-CDR PPM tolerance                                     | —   | —                  | —   | 300   | —              | —   | 300   | —              | —   | 300   | ± PPM |
| <b>Non DPA Mode</b>  |   |                    |     |       |                |     |       |                |     |       |       |
| Sampling Window  | —   | —                  | —   | 300   | —              | —   | 300   | —              | —   | 300   | ps    |

**Notes to Table 1-41:**

- (1) When J = 3 to 10, use the serializer/deserializer (SERDES) block.
- (2) When J = 1 or 2, bypass the SERDES block.
- (3) Clock Boost Factor (W) is the ratio between input data rate to the input clock rate.
- (4) The maximum ideal frequency is the SERDES factor (J) x the PLL maximum output frequency ( $f_{OUT}$ ) provided you can close the design timing and the signal integrity simulation is clean.
- (5) You must calculate the leftover timing margin in the receiver by performing link timing closure analysis. You must consider the board skew margin, transmitter channel-to-channel skew, and receiver sampling margin to determine leftover timing margin.
- (6) You can estimate the achievable maximum data rate for non-DPA mode by performing link timing closure analysis. You must consider the board skew margin, transmitter delay margin, and the receiver sampling margin to determine the maximum data rate supported.
- (7) This is achieved by using the LVDS and DPA clock network.
- (8) If the receiver with DPA enabled and transmitter are using shared PLLs, the minimum data rate is 150 Mbps.
- (9) This only applies to DPA and soft-CDR modes.
- (10) This only applies to LVDS source synchronous mode.



For the Stratix IV GT -1 and -2 speed grade specifications, refer to the -2/-2× speed grade column. For the Stratix IV GT -3 speed grade specification, refer to the -3 speed grade column.

Table 1-42 lists the DPA lock time specifications for Stratix IV ES devices.

**Table 1-42. DPA Lock Time Specifications—Stratix IV ES Devices Only** (Note 1), (2), (3)

| Standard           | Training Pattern     | Number of Data Transitions in one repetition of training pattern | Number of repetitions per 256 data transitions (4) | Condition                   | Maximum   |
|--------------------|----------------------|--|--|-----------------------------|---|
| SPI-4              | 00000000001111111111 | 2  | 128  | without DPA PLL calibration | 256 data transitions                                |
|                    |                      |  |  | with DPA PLL calibration    | 3x256 data transitions + 2x96 slow clock cycles (5) |
| Parallel Rapid I/O | 00001111             | 2  | 128  | without DPA PLL calibration | 256 data transitions                                |
|                    |                      |  |  | with DPA PLL calibration    | 3x256 data transitions + 2x96 slow clock cycles (5) |
|                    | 10010000             | 4  | 64   | without DPA PLL calibration | 256 data transitions                                |
|                    |                      |  |  | with DPA PLL calibration    | 3x256 data transitions + 2x96 slow clock cycles (5) |
| Miscellaneous      | 10101010             | 8  | 32   | without DPA PLL calibration | 256 data transitions                                |
|                    |                      |  |  | with DPA PLL calibration    | 3x256 data transitions + 2x96 slow clock cycles (5) |
|                    | 01010101             | 8  | 32   | without DPA PLL calibration | 256 data transitions                                |
|                    |                      |  |  | with DPA PLL calibration    | 3x256 data transitions + 2x96 slow clock cycles (5) |

**Notes to Table 1-42:**

- (1) The DPA lock time is for one channel.
- (2) One data transition is defined as a 0-to-1 or 1-to-0 transition.
- (3) The DPA lock time applies to commercial, industrial, and military speed grades.
- (4) This is the number of repetition for the stated training pattern to achieve 256 data transitions.
- (5) Slow clock = Data rate (Mbps)/Deserialization factor.

Figure 1-4 shows the DPA lock time specifications with DPA PLL calibration enabled.

**Figure 1-4. DPA Lock Time Specification with DPA PLL Calibration Enabled**

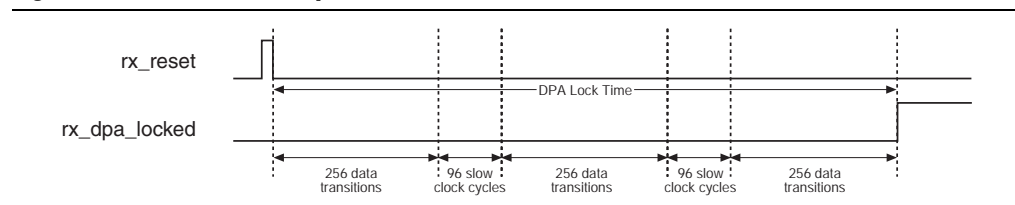


Table 1-43 lists the DPA lock time specifications for Stratix IV GX and GT devices.

**Table 1-43. DPA Lock Time Specifications—Stratix IV GX and GT Devices Only** (Note 1), (2), (3)

| Standard           | Training Pattern     | Number of Data Transitions in One Repetition of the Training Pattern | Number of Repetitions per 256 Data Transitions (4) | Maximum              |
|--------------------|----------------------|--|--|----------------------|
| SPI-4              | 00000000001111111111 | 2  | 128  | 640 data transitions |
| Parallel Rapid I/O | 00001111             | 2  | 128  | 640 data transitions |
|                    | 10010000             | 4  | 64   | 640 data transitions |
| Miscellaneous      | 10101010             | 8  | 32   | 640 data transitions |
|                    | 01010101             | 8  | 32   | 640 data transitions |

**Notes to Table 1-43:**

- (1) The DPA lock time is for one channel.
- (2) One data transition is defined as a 0-to-1 or 1-to-0 transition.
- (3) The DPA lock time stated in the table applies to commercial, industrial, and military speed grades.
- (4) This is the number of repetitions for the stated training pattern to achieve the 256 data transitions.

Figure 1-5 shows the LVDS soft-CDR/DPA sinusoidal jitter tolerance specification for a data rate equal to or higher than 1.25 Gbps. Table 1-44 lists this information in table form.

**Figure 1-5. LVDS Soft-CDR/DPA Sinusoidal Jitter Tolerance Specification for a Data Rate Equal to or Higher Than 1.25 Gbps**

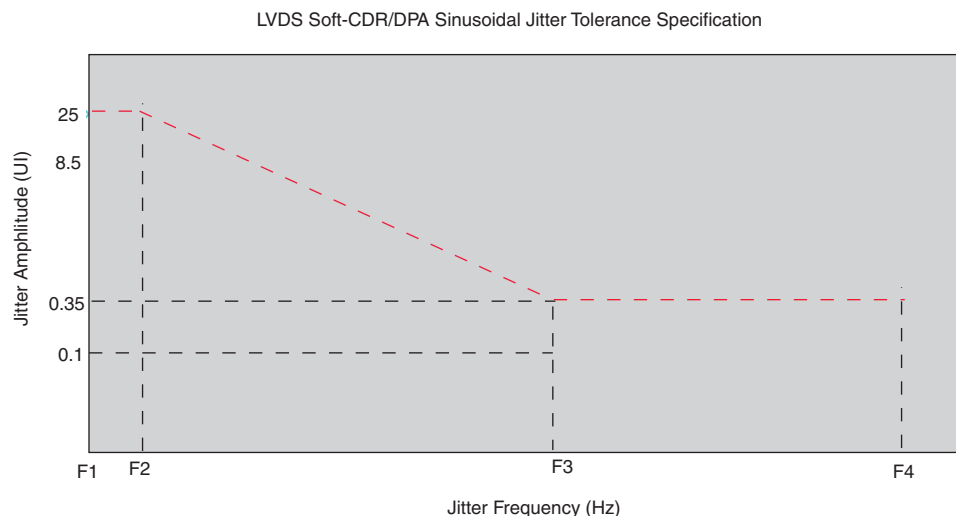


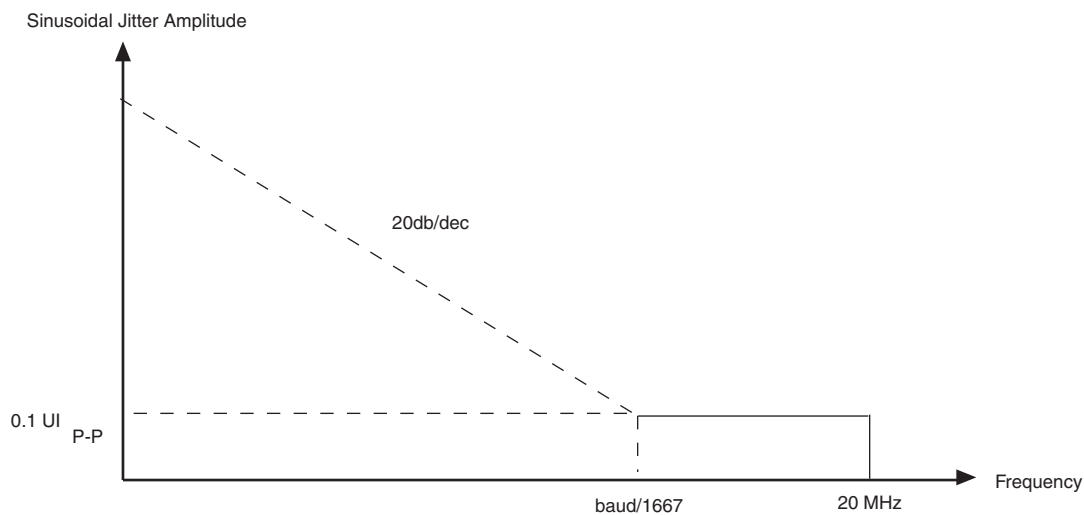
Table 1-44 lists the LVDS soft-CDR/DPA sinusoidal jitter tolerance specification for a data rate equal to or higher than 1.25 Gbps.

**Table 1-44. LVDS Soft-CDR/DPA Sinusoidal Jitter Mask Values for a Data Rate Equal to or Higher than 1.25 Gbps**

| Jitter Frequency (Hz) |            | Sinusoidal Jitter (UI) |
|-----------------------|------------|------------------------|
| F1                    | 10,000     | 25.000                 |
| F2                    | 17,565     | 25.000                 |
| F3                    | 1,493,000  | 0.350                  |
| F4                    | 50,000,000 | 0.350                  |

Figure 1-6 shows the LVDS soft-CDR/DPA sinusoidal jitter tolerance specification for a data rate less than 1.25 Gbps.

**Figure 1-6. LVDS Soft-CDR/DPA Sinusoidal Jitter Tolerance Specification for a Data Rate Less than 1.25 Gbps**



### DLL and DQS Logic Block Specifications

Table 1-45 lists the DLL frequency range specifications for Stratix IV devices.

**Table 1-45. DLL Frequency Range Specifications for Stratix IV Devices—Preliminary (Part 1 of 2)**

| Frequency Mode | Frequency Range (MHz) |                |                | Available Phase Shift  | DQS Delay Buffer Mode (1) | Number of Delay Chains |
|----------------|-----------------------|----------------|----------------|------------------------|---------------------------|------------------------|
|                | -2/-2x Speed Grade    | -3 Speed Grade | -4 Speed Grade |                        |                           |                        |
| 0              | 90-140                | 90-130         | 90-120         | 22.5°, 45°, 67.5°, 90° | Low                       | 16                     |
| 1              | 120-180               | 120-170        | 120-160        | 30°, 60°, 90°, 120°    | Low                       | 12                     |
| 2              | 150-220               | 150-210        | 150-200        | 36°, 72°, 108°, 144°   | Low                       | 10                     |
| 3              | 180-280               | 180-260        | 180-240        | 45°, 90°, 135°, 180°   | Low                       | 8                      |
| 4              | 240-350               | 240-320        | 240-290        | 30°, 60°, 90°, 120°    | High                      | 12                     |
| 5              | 290-430               | 290-380        | 290-360        | 36°, 72°, 108°, 144°   | High                      | 10                     |
| 6              | 360-540               | 360-450        | 360-450        | 45°, 90°, 135°, 180°   | High                      | 8                      |

**Table 1-45. DLL Frequency Range Specifications for Stratix IV Devices—Preliminary (Part 2 of 2)**

| Frequency Mode | Frequency Range (MHz) |                |                | Available Phase Shift | DQS Delay Buffer Mode (1) | Number of Delay Chains |
|----------------|-----------------------|----------------|----------------|-----------------------|---------------------------|------------------------|
|                | -2/-2x Speed Grade    | -3 Speed Grade | -4 Speed Grade |                       |                           |                        |
| 7              | 470-700               | 470-630        | 470-590        | 60°, 120°, 180°, 240° | High                      | 6                      |

Note to Table 1-45:

(1) Low indicates a 6-bit DQS delay setting; high indicates a 5-bit DQS delay setting.


 For the Stratix IV GT -1 and -2 speed grade specifications, refer to the -2/-2x speed grade column. For the Stratix IV GT -3 speed grade specification, refer to the -3 speed grade column.

Table 1-46 lists the DQS phase offset delay per stage for Stratix IV devices.

**Table 1-46. DQS Phase Offset Delay Per Setting for Stratix IV Devices (Note 1), (2), (3)**

| Speed Grade | Min | Max | Unit |
|-------------|-----|-----|------|
| -2/-2x      | 7   | 13  | ps   |
| -3          | 7   | 15  | ps   |
| -4          | 7   | 16  | ps   |

Notes to Table 1-46:

- (1) The valid settings for phase offset are -64 to +63 for frequency modes 0 to 3 and -32 to +31 for frequency modes 4 to 6.
- (2) The typical value equals the average of the minimum and maximum values.
- (3) The delay settings are linear, with a cumulative delay variation of 40 ps for all speed grades. For example, when using a -2 speed grade and applying a 10 phase offset settings to a 90° phase shift at 400 MHz, the expected average cumulative delay is  $[625 \text{ ps} + (10 \times 10.5 \text{ ps}) \pm 20 \text{ ps}] = 730 \text{ ps} \pm 20 \text{ ps}$ .


 For the Stratix IV GT -1 and -2 speed grade specifications, refer to the -2/-2x speed grade column. For the Stratix IV GT -3 speed grade specification, refer to the -3 speed grade column.

Table 1-47 lists the DQS phase shift error for Stratix IV devices.

**Table 1-47. DQS Phase Shift Error Specification for DLL-Delayed Clock ( $t_{DQS\_PSEERR}$ ) for Stratix IV Devices (Note 1)**

| Number of DQS Delay Buffer | -2/-2X Speed Grade | -3 Speed Grade | -4 Speed Grade | Unit |
|----------------------------|--------------------|----------------|----------------|------|
| 1                          | 26                 | 28             | 30             | ps   |
| 2                          | 52                 | 56             | 60             | ps   |
| 3                          | 78                 | 84             | 90             | ps   |
| 4                          | 104                | 112            | 120            | ps   |

Note to Table 1-47:

- (1) This error specification is the absolute maximum and minimum error. For example, skew on three DQS delay buffers in a -2/-2x speed grade is  $\pm 78 \text{ ps}$  or  $\pm 39 \text{ ps}$ .


 For the Stratix IV GT -1 and -2 speed grade specifications, refer to the -2/-2x speed grade column. For the Stratix IV GT -3 speed grade specification, refer to the -3 speed grade column.


Table 1-48 lists the memory output clock jitter specifications for Stratix IV devices.

**Table 1-48. Memory Output Clock Jitter Specification for Stratix IV Devices (Note 1), (2), (3)**

| Parameter                    | Clock Network | Symbol                 | -2/-2X Speed Grade |     | -3 Speed Grade |      | -4 Speed Grade |      | Unit |
|------------------------------|---------------|------------------------|--------------------|-----|----------------|------|----------------|------|------|
|                              |               |                        | Min                | Max | Min            | Max  | Min            | Max  |      |
| Clock period jitter          | Regional      | $t_{\text{JIT(per)}}$  | -50                | 50  | -55            | 55   | -55            | 55   | ps   |
| Cycle-to-cycle period jitter | Regional      | $t_{\text{JIT(cc)}}$   | -100               | 100 | -110           | 110  | -110           | 110  | ps   |
| Duty cycle jitter            | Regional      | $t_{\text{JIT(duty)}}$ | -50                | 50  | -82.5          | 82.5 | -82.5          | 82.5 | ps   |
| Clock period jitter          | Global        | $t_{\text{JIT(per)}}$  | -75                | 75  | -82.5          | 82.5 | -82.5          | 82.5 | ps   |
| Cycle-to-cycle period jitter | Global        | $t_{\text{JIT(cc)}}$   | -150               | 150 | -165           | 165  | -165           | 165  | ps   |
| Duty cycle jitter            | Global        | $t_{\text{JIT(duty)}}$ | -75                | 75  | -90            | 90   | -90            | 90   | ps   |

**Notes to Table 1-48:**

- (1) The memory output clock jitter measurements are for 200 consecutive clock cycles, as specified in the JEDEC DDR2/DDR3 SDRAM standard.
- (2) The clock jitter specification applies to memory output clock pins generated using differential signal-splitter and DDIO circuits clocked by a PLL output routed on a regional or global clock network as specified. Altera recommends using regional clock networks whenever possible.
- (3) The memory output clock jitter stated in Table 1-48 is applicable when an input jitter of 30 ps is applied.

 For the Stratix IV GT -1 and -2 speed grade specifications, refer to the -2/-2x speed grade column. For the Stratix IV GT -3 speed grade specification, refer to the -3 speed grade column.

## OCT Calibration Block Specifications

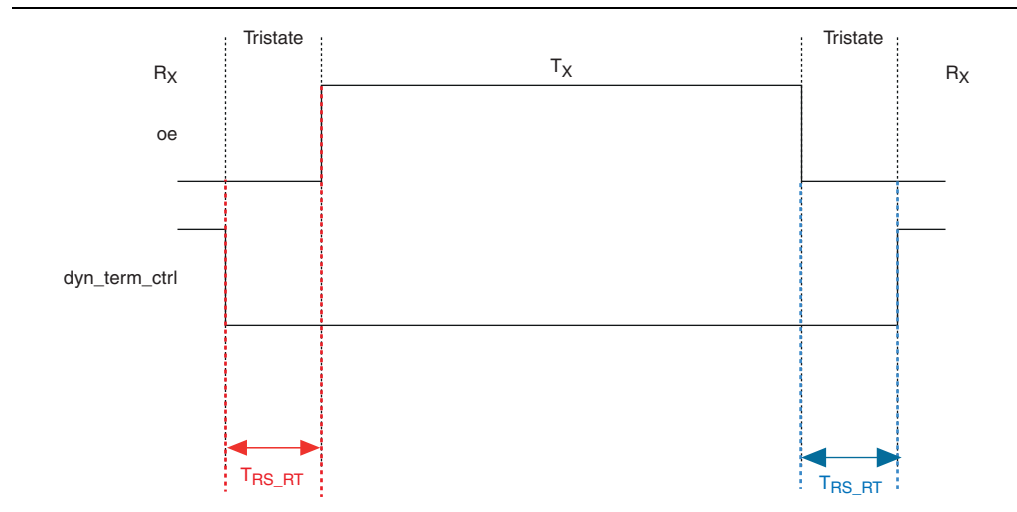
Table 1-49 lists the OCT calibration block specifications for Stratix IV devices.

**Table 1-49. OCT Calibration Block Specifications for Stratix IV Devices**

| Symbol                | Description   | Min | Typ  | Max | Unit   |
|-----------------------|---|-----|------|-----|--------|
| OCTUSRCLK             | Clock required by OCT calibration blocks  | —   | —    | 20  | MHz    |
| $T_{\text{OCTCAL}}$   | Number of OCTUSRCLK clock cycles required for OCT $R_S/R_T$ calibration   | —   | 1000 | —   | Cycles |
| $T_{\text{OCTSHIFT}}$ | Number of OCTUSRCLK clock cycles required for OCT code to shift out   | —   | 28   | —   | Cycles |
| $T_{\text{RS_RT}}$    | Time required between the <code>dyn_term_ctrl</code> and <code>oe</code> signal transitions in a bidirectional I/O buffer to dynamically switch between OCT $R_S$ and $R_T$ | —   | 2.5  | —   | ns     |

Figure 1-7 shows the timing diagram for the oe and dyn\_term\_ctrl signals.

**Figure 1-7. Timing Diagram for the oe and dyn\_term\_ctrl Signals**



### Duty Cycle Distortion (DCD) Specifications

Table 1-50 lists the worst-case DCD for Stratix IV devices.

**Table 1-50. Worst-Case DCD on Stratix IV I/O Pins**

| Symbol            | -2/-2x<br>Speed Grade |     | -3<br>Speed Grade |     | -4<br>Speed Grade |     | Unit |
|-------------------|-----------------------|-----|-------------------|-----|-------------------|-----|------|
|                   | Min                   | Max | Min               | Max | Min               | Max |      |
| Output Duty Cycle | 45                    | 55  | 45                | 55  | 45                | 55  | %    |

## I/O Timing

Altera offers two ways to determine I/O timing—the Excel-based I/O Timing and the Quartus II Timing Analyzer.

Excel-based I/O Timing provides pin timing performance for each device density and speed grade. The data is typically used prior to designing the FPGA to get an estimate of the timing budget as part of the link timing analysis. The Quartus II Timing Analyzer provides a more accurate and precise I/O timing data based on the specifics of the design after you complete place-and-route.

- The Excel-based I/O Timing spreadsheet is downloadable from the [Literature: Stratix IV Devices](#) webpage.

## Programmable IOE Delay

Table 1-51 lists the Stratix IV IOE programmable delay settings.

**Table 1-51. IOE Programmable Delay for Stratix IV Devices**

| Parameter<br>(1) | Available<br>Settings | Min Offset<br>(2) | Fast Model              |                   | Slow Model |       |       |       |       | Unit |
|------------------|-----------------------|-------------------|-------------------------|-------------------|------------|-------|-------|-------|-------|------|
|                  |                       |                   | Industrial/<br>Military | Commercial<br>(3) | C2 (3)     | C3    | C4    | I3/M3 | I4    |      |
| D1               | 16                    | 0                 | 0.462                   | 0.505             | 0.732      | 0.795 | 0.857 | 0.801 | 0.864 | ns   |
| D2               | 8                     | 0                 | 0.234                   | 0.232             | 0.337      | 0.372 | 0.407 | 0.371 | 0.405 | ns   |
| D3               | 8                     | 0                 | 1.700                   | 1.769             | 2.695      | 2.927 | 3.157 | 2.948 | 3.178 | ns   |
| D4               | 16                    | 0                 | 0.508                   | 0.554             | 0.813      | 0.882 | 0.952 | 0.889 | 0.959 | ns   |
| D5               | 16                    | 0                 | 0.472                   | 0.500             | 0.747      | 0.799 | 0.875 | 0.817 | 0.882 | ns   |
| D6               | 8                     | 0                 | 0.186                   | 0.195             | 0.294      | 0.319 | 0.345 | 0.321 | 0.347 | ns   |

**Notes to Table 1-51:**

- (1) You can set this value in the Quartus II software by selecting **D1**, **D2**, **D3**, **D4**, **D5**, and **D6** in the **Assignment Name** column.
- (2) Minimum offset does not include the intrinsic delay.
- (3) For the EP4SGX530 device density, the IOE programmable delays have an additional 5% maximum offset.

## Programmable Output Buffer Delay

Table 1-52 lists the delay chain settings that control the rising and falling edge delays of the output buffer. The default delay is 0 ps.

**Table 1-52. Programmable Output Buffer Delay (Note 1)**

| Symbol              | Parameter                        | Typical     | Unit |
|---------------------|----------------------------------|-------------|------|
| D <sub>OUTBUF</sub> | Rising and/or falling edge delay | 0 (default) | ps   |
|                     |                                  | 50          | ps   |
|                     |                                  | 100         | ps   |
|                     |                                  | 150         | ps   |

**Note to Table 1-52:**

- (1) You can set the programmable output buffer delay in the Quartus II software by setting the **Output Buffer Delay Control** assignment to either positive, negative, or both edges, with the specific values stated here (in ps) for the **Output Buffer Delay** assignment.

# Glossary

Table 1-53 lists the glossary for this chapter.

Table 1-53. Glossary Table (Part 1 of 4)

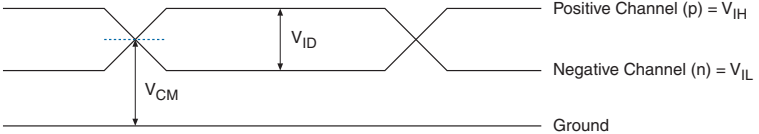
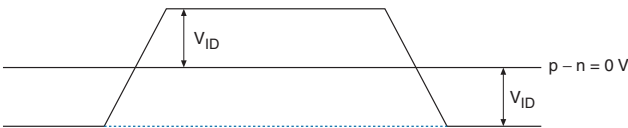
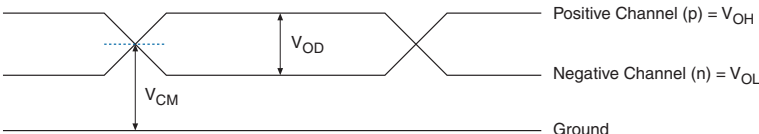
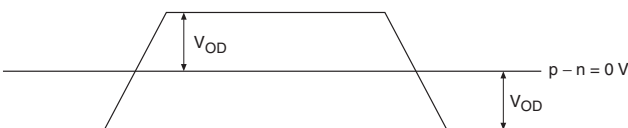
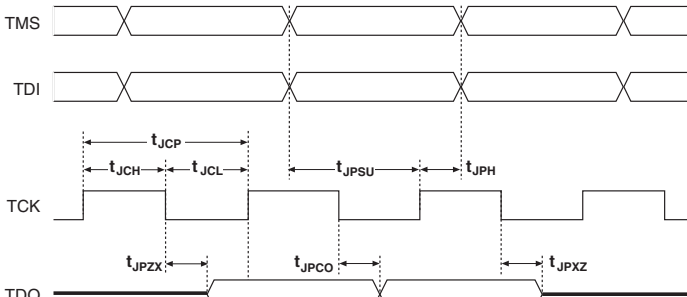
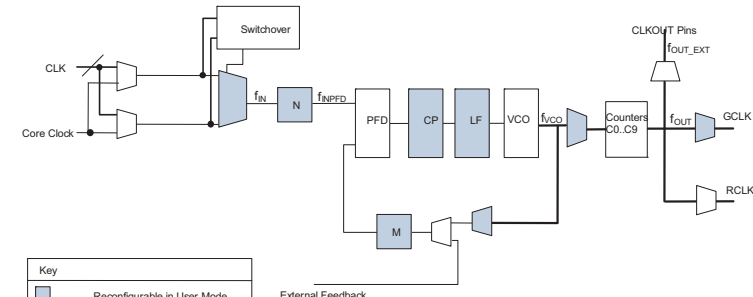
| Letter  | Subject                    | Definitions  |
|---------|----------------------------|--|
| A, B, C | —                          | —  |
| D       | Differential I/O Standards | <p><i>Receiver Input Waveforms</i></p> <p><b>Single-Ended Waveform</b></p>  <p>Positive Channel (p) = <math>V_{IH}</math><br/>Negative Channel (n) = <math>V_{IL}</math><br/>Ground</p> <p><b>Differential Waveform</b></p>  <p><math>p - n = 0\text{ V}</math><br/><math>V_{ID}</math></p> <p><i>Transmitter Output Waveforms</i></p> <p><b>Single-Ended Waveform</b></p>  <p>Positive Channel (p) = <math>V_{OH}</math><br/>Negative Channel (n) = <math>V_{OL}</math><br/>Ground</p> <p><b>Differential Waveform</b></p>  <p><math>p - n = 0\text{ V}</math><br/><math>V_{OD}</math></p> |
| E       | —                          | —  |
| F       | $f_{HSCLK}$                | Left/right PLL input clock frequency.  |
|         | $f_{HSDR}$                 | High-speed I/O block: Maximum/minimum LVDS data transfer rate ( $f_{HSDR} = 1/TUI$ ), non-DPA.   |
|         | $f_{HSDRDPA}$              | High-speed I/O block: Maximum/minimum LVDS data transfer rate ( $f_{HSDRDPA} = 1/TUI$ ), DPA.  |
| G, H, I | —                          | —  |

Table 1-53. Glossary Table (Part 2 of 4)

| Letter        | Subject                    | Definitions  |
|---------------|----------------------------|--|
| J             | J                          | High-speed I/O block: Deserialization factor (width of parallel data bus).   |
|               | JTAG Timing Specifications | <p>JTAG Timing Specifications:</p>   |
| K, L, M, N, O | —                          | —  |
| P             | PLL Specifications         | <p><b>Diagram of PLL Specifications (1)</b></p>  <p><b>Note:</b><br/>(1) Core Clock can only be fed by dedicated clock input pins or PLL outputs.</p> |
| Q             | —                          | —  |
| R             | R <sub>L</sub>             | Receiver differential input discrete resistor (external to Stratix IV device).   |

**Table 1-53. Glossary Table (Part 3 of 4)**

| Letter     | Subject                                      | Definitions  |
|------------|--|--|
| S          | SW (sampling window)                         | <p>Timing Diagram—the period of time during which the data must be valid in order to capture it correctly. The setup and hold times determine the ideal strobe position within the sampling window, as shown:</p>  |
|            | Single-ended voltage referenced I/O standard | <p>The JEDEC standard for SSTI and HSTL I/O defines both the AC and DC input signal values. The AC values indicate the voltage levels at which the receiver must meet its timing specifications. The DC values indicate the voltage levels at which the final logic state of the receiver is unambiguously defined. After the receiver input has crossed the AC value, the receiver changes to the new logic state.</p> <p>The new logic state is then maintained as long as the input stays beyond the AC threshold. This approach is intended to provide predictable receiver timing in the presence of input waveform ringing, as shown:</p> <p><i>Single-Ended Voltage Referenced I/O Standard</i></p> |
| T          | $t_c$  | High-speed receiver/transmitter input and output clock period.   |
|            | <b>TCCS (channel-to-channel-skew)</b>        | The timing difference between the fastest and slowest output edges, including $t_{c0}$ variation and clock skew, across channels driven by the same PLL. The clock is included in the TCCS measurement (refer to the <i>Timing Diagram</i> figure under <b>SW</b> in this table).  |
|            | $t_{DUTY}$                                   | High-speed I/O block: Duty cycle on high-speed transmitter output clock.<br><b>Timing Unit Interval (TUI)</b><br>The timing budget allowed for skew, propagation delays, and data sampling window. (TUI = 1/(Receiver Input Clock Frequency Multiplication Factor) = $t_c/w$ )   |
|            | $t_{FALL}$                                   | Signal high-to-low transition time (80-20%)  |
|            | $t_{INCCJ}$                                  | Cycle-to-cycle jitter tolerance on the PLL clock input   |
|            | $t_{OUTPJ\_IO}$                              | Period jitter on the general purpose I/O driven by a PLL   |
|            | $t_{OUTPJ\_DC}$                              | Period jitter on the dedicated clock output driven by a PLL  |
| $t_{RISE}$ | Signal low-to-high transition time (20-80%)  |  |
| U          | —  | —  |

**Table 1-53. Glossary Table (Part 4 of 4)**

| Letter   | Subject                                 | Definitions  |
|----------|---|--|
| V        | $V_{CM(DC)}$                            | DC Common mode input voltage.  |
|          | $V_{ICM}$                               | Input Common mode voltage—The common mode of the differential signal at the receiver.  |
|          | $V_{ID}$                                | Input differential voltage swing—The difference in voltage between the positive and complementary conductors of a differential transmission at the receiver.     |
|          | $V_{DIF(AC)}$                           | AC differential input voltage—Minimum AC input differential voltage required for switching.  |
|          | $V_{DIF(DC)}$                           | DC differential input voltage— Minimum DC input differential voltage required for switching.   |
|          | $V_{IH}$                                | Voltage input high—The minimum positive voltage applied to the input which is accepted by the device as a logic high.  |
|          | $V_{IH(AC)}$                            | High-level AC input voltage  |
|          | $V_{IH(DC)}$                            | High-level DC input voltage  |
|          | $V_{IL}$                                | Voltage input low—The maximum positive voltage applied to the input which is accepted by the device as a logic low.  |
|          | $V_{IL(AC)}$                            | Low-level AC input voltage   |
|          | $V_{IL(DC)}$                            | Low-level DC input voltage   |
|          | $V_{OCM}$                               | Output Common mode voltage—The common mode of the differential signal at the transmitter.  |
|          | $V_{OD}$                                | Output differential voltage swing—The difference in voltage between the positive and complementary conductors of a differential transmission at the transmitter. |
|          | $V_{SWING}$                             | Differential input voltage   |
| $V_X$    | Input differential cross point voltage  |  |
| $V_{OX}$ | Output differential cross point voltage |  |
| W        | W                                       | High-speed I/O block: Clock Boost Factor   |
| X, Y, Z  | —                                       | —  |

## Document Revision History

Table 1-54 lists the revision history for this chapter.

**Table 1-54. Document Revision History (Part 1 of 3)**

| Date          | Version | Changes  |
|---------------|---------|--|
| December 2011 | 5.2     | <ul style="list-style-type: none"> <li>■ Added Figure 1-7.</li> <li>■ Updated Table 1-22 and Table 1-41.</li> </ul>  |
| June 2011     | 5.1     | <ul style="list-style-type: none"> <li>■ Added military speed grade information.</li> <li>■ Updated Table 1-1 and Table 1-30.</li> <li>■ Updated (Note 3) in Table 1-42 and (Note 3) in Table 1-43.</li> <li>■ Added military speed grade to Table 1-5, Table 1-10, Table 1-11, Table 1-23, Table 1-30, Table 1-36, and Table 1-51.</li> </ul> |
| April 2011    | 5.0     | <ul style="list-style-type: none"> <li>■ Updated Table 1-1, Table 1-5, Table 1-6, Table 1-13, Table 1-16, Table 1-23, and Table 1-24.</li> </ul>   |
| March 2011    | 4.9     | <ul style="list-style-type: none"> <li>■ Updated Table 1-24.</li> </ul>  |
| March 2011    | 4.8     | <ul style="list-style-type: none"> <li>■ Removed (Note 17) in Table 1-24.</li> </ul>   |
| February 2011 | 4.7     | <ul style="list-style-type: none"> <li>■ Added (Note 17) to Table 1-24.</li> </ul>   |

**Table 1-54. Document Revision History (Part 2 of 3)**

| Date           | Version | Changes   |
|----------------|---------|---|
| February 2011  | 4.6     | <ul style="list-style-type: none"> <li>■ Updated Table 1-1, Table 1-5, Table 1-23, Table 1-24, Table 1-30, Table 1-31, Table 1-32, Table 1-34, Table 1-37, Table 1-41, and Table 1-51.</li> <li>■ Updated the “Recommended Operating Conditions” section.</li> <li>■ Added the “Schmitt Trigger Input” section.</li> <li>■ Minor text edits.</li> </ul>   |
| November 2010  | 4.5     | <ul style="list-style-type: none"> <li>■ Updated Table 1-29.</li> <li>■ Updated chapter title.</li> <li>■ Minor text edits.</li> </ul>  |
| September 2010 | 4.4     | <ul style="list-style-type: none"> <li>■ Applied new template.</li> <li>■ Updated Table 1-1 and Table 1-5.</li> </ul>   |
| July 2010      | 4.3     | <ul style="list-style-type: none"> <li>■ Updated Table 1-7, Table 1-22, Table 1-23, Table 1-33, Table 1-35, Table 1-36, and Table 1-40.</li> <li>■ Added Table 1-39.</li> <li>■ Changed “PCI Express” to “PCIe” throughout.</li> <li>■ Minor text edits</li> </ul>  |
| March 2010     | 4.2     | <ul style="list-style-type: none"> <li>■ Updated Table 1-22, Table 1-23, Table 1-30, Table 1-46, and Table 1-49.</li> <li>■ Added Table 1-31.</li> <li>■ Minor text edits.</li> </ul>   |
| February 2010  | 4.1     | <ul style="list-style-type: none"> <li>■ Updated Table 1-11, Table 1-22, Table 1-23, Table 1-24, Table 1-25, Table 1-26, Table 1-27, Table 1-29, Table 1-32, Table 1-33, Table 1-34, Table 1-35, Table 1-39, Table 1-40, Table 1-43, Table 1-46, and Table 1-49.</li> <li>■ Added Stratix IV GT speed grade note to Table 1-32, Table 1-35, Table 1-39, Table 1-43, Table 1-44, Table 1-45, and Table 1-46.</li> <li>■ Added Table 1-28 and Table 1-30.</li> <li>■ Minor text edits.</li> </ul>   |
| November 2009  | 4.0     | <ul style="list-style-type: none"> <li>■ Added Table 1-9, Table 1-15, Table 1-38, and Table 1-39.</li> <li>■ Added Figure 1-5 and Figure 1-6.</li> <li>■ Added the “Transceiver Datapath PCS Latency” section.</li> <li>■ Updated the “Electrical Characteristics”, “Operating Conditions”, and “I/O Timing” sections.</li> <li>■ All tables updated except Table 1-16, Table 1-24, Table 1-25, Table 1-26, Table 1-27, Table 1-33, Table 1-34, and Table 1-45.</li> <li>■ Updated Figure 1-2 and Figure 1-3.</li> <li>■ Updated Equation 1-1.</li> <li>■ Deleted Table 1-28, Table 1-29, Table 1-30, Table 1-42, Table 1-43, and Table 1-44.</li> <li>■ Minor text edits.</li> </ul> |
| June 2009      | 3.1     | <ul style="list-style-type: none"> <li>■ Added “Preliminary Specifications” to the footer of each page.</li> <li>■ Updated Table 1-1, Table 1-2, Table 1-7, Table 1-10, Table 1-11, Table 1-12, Table 1-21, Table 1-22, Table 1-23, Table 1-25, Table 1-37, Table 1-38, Table 1-39, Table 1-40, and Table 1-44.</li> <li>■ Minor text edits.</li> </ul>   |

**Table 1-54. Document Revision History (Part 3 of 3)**

| Date          | Version | Changes  |
|---------------|---------|--|
| March 2009    | 3.0     | <ul style="list-style-type: none"> <li>■ Replaced Table 1-31 and Table 1-37.</li> <li>■ Updated Table 1-1, Table 1-2, Table 1-5, Table 1-19, Table 1-41, Table 1-44, Table 1-45, Table 1-49, and Table 1-51.</li> <li>■ Added Table 1-21, Table 1-46, and Table 1-47</li> <li>■ Added Figure 1-3.</li> <li>■ Removed “Timing Model”, “Preliminary and Final Timing”, “I/O Timing Measurement Methodology”, “I/O Default Capacitive Loading”, and “Referenced Documents” sections.</li> </ul> |
| December 2008 | 2.1     | Minor changes.   |
| November 2008 | 2.0     | <ul style="list-style-type: none"> <li>■ Minor text edits.</li> <li>■ Updated Table 1-19, Table 1-32, Table 1-34 - Table 1-39.</li> <li>■ Minor text edits.</li> </ul>   |
| August 2008   | 1.1     | <ul style="list-style-type: none"> <li>■ Updated Table 1-1, Table 1-2, Table 1-4, Table 1-5, and Table 1-26.</li> <li>■ Removed figures from “Transceiver Performance Specifications” on page 1-10 that are repeated in the glossary.</li> <li>■ Minor text edits and an additional note to Table 1-26.</li> </ul>   |
| May 2008      | 1.0     | Initial release.   |