Arria II GX Device Handbook,
Volume 3

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Contents

Chapter Revision Dates

The chapters in this book, *Arria II GX Device Handbook, Volume 3*, were revised on the following dates. Where chapters or groups of chapters are available separately, part numbers are listed.

Chapter 1 Arria II GX Device Datasheet
Revised: *July 2010*
Part Number: *AIIGX-53001*

Chapter 2 Addendum to the Arria II GX Device Handbook
Revised: *July 2010*
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Section I. Arria II GX Device Data Sheet and Addendum

This section provides information about the Arria® II GX device data sheet and addendum. This section includes the following chapters:

- Chapter 1, Arria II GX Device Datasheet
- Chapter 2, Addendum to the Arria II GX Device Handbook

Revision History

Refer to each chapter for its own specific revision history. For information on when each chapter was updated, refer to the Chapter Revision Dates section, which appears in this volume.

1. Arria II GX Device Datasheet

AIIGX53001-3.0

This chapter describes the electrical and switching characteristics of the Arria® II GX device family.

This chapter contains the following sections:

Electrical Characteristics

The following sections describe the electrical characteristics.

Operating Conditions

Arria II GX devices are rated according to a set of defined parameters. To maintain the highest possible performance and reliability of Arria II GX devices, you must consider the operating requirements described in this chapter.

Arria II GX devices are offered in both commercial and industrial grades. Commercial devices are offered in –4 (fastest), –5, and –6 (slowest) speed grades. Industrial devices are offered in –3 and –5 speed grades.

In this chapter, a prefix associated with the operating temperature range is attached to the speed grades; commercial with the "C" prefix and industrial with the "I" prefix. Commercial devices are therefore indicated as C4, C5, and C6 speed grade, and the industrial devices are indicated as I3 and I5.

Absolute Maximum Ratings

Absolute maximum ratings define the maximum operating conditions for Arria II GX devices. The values are based on experiments conducted with the device and theoretical modeling of breakdown and damage mechanisms. The functional operation of the device is not implied under these conditions. Table 1–1 lists the absolute maximum ratings for Arria II GX devices.

CAUTION

Conditions beyond those listed in Table 1–1 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 Arria II GX Devices (Part 1 of 2)

Symbol	Description	Minimum	Maximum	Unit
V_{CC}	Supplies power to the core, periphery, I/O registers, PCI Express® (PIPE) (PCIe) HIP block, and transceiver PCS	–0.5	1.35	V
V_{CCCB}	Supplies power to the configuration RAM bits	–0.5	1.8	V
V_{CCBAT}	Battery back-up power supply for design security volatile key register	–0.5	3.75	V

Table 1–1. Absolute Maximum Ratings for Arria II GX Devices (Part 2 of 2)

Symbol	Description	Minimum	Maximum	Unit
V_{CCPD}	Supplies power to the I/O pre-drivers, differential input buffers, and MSEL circuitry	–0.5	3.75	V
V_{CCIO}	Supplies power to the I/O banks	–0.5	3.9	V
V_{CCD_PLL}	Supplies power to the digital portions of the PLL	–0.5	1.35	V
V_{CCA_PLL}	Supplies power to the analog portions of the PLL and device-wide power management circuitry	–0.5	3.75	V
V_I	DC input voltage	–0.5	4.0	V
I_{OUT}	DC output current, per pin	–25	40	mA
V_{CCA}	Supplies power to the transceiver PMA regulator	—	3.75	V
V_{CCL_GXB}	Supplies power to the transceiver PMA TX, PMA RX, and clocking	—	1.21	V
V_{CCH_GXB}	Supplies power to the transceiver PMA output (TX) buffer	—	1.8	V
T_J	Operating junction temperature	–55	125	°C
T_{STG}	Storage temperature (no bias)	–65	150	°C

Maximum Allowed Overshoot and Undershoot Voltage

During transitions, input signals may overshoot to the voltage shown in Table 1–2 and undershoot to –2.0 V for magnitude of currents less than 100 mA and periods shorter than 20 ns.

Table 1–2 lists the maximum allowed input overshoot voltage and the duration of the overshoot voltage as a percentage over the 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 5.41% over the lifetime of the device; for a device lifetime of 10 years, this amounts to 5.41/10ths of a year.

Table 1–2. Maximum Allowed Overshoot During Transitions

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

Maximum Allowed I/O Operating Frequency

Table 1–3 lists the maximum allowed I/O operating frequency for I/Os using the specified I/O standards to ensure device reliability.

Table 1–3. Maximum Allowed I/O Operating Frequency

I/O Standard	I/O Frequency (MHz)
HSTL-18 and HSTL-15	333
SSTL -15	400
SSTL-18	333
2.5-V LVCMOS	260
3.3-V and 3.0-V LVTTL	250
3.3-V, 3.0-V, 1.8-V, and 1.5-V LVCMOS	
PCI and PCI-X	
SSTL-2	
1.2-V LVCMOS HSTL-12	200

Recommended Operating Conditions

This section lists the functional operation limits for AC and DC parameters for Arria II GX devices. All supplies are required to monotonically reach their full-rail values without plateaus within t_{RAMP}.

Table 1–4 lists the recommended operating conditions for Arria II GX devices.

Table 1–4. Recommended Operating Conditions for Arria II GX Devices (Part 1 of 2) *(Note 1)*

Symbol	Description	Condition	Minimum	Typical	Maximum	Unit
V_{CC}	Supplies power to the core, periphery, I/O registers, PCIe HIP block, and transceiver PCS	—	0.87	0.90	0.93	V
V_{CCCB}	Supplies power to the configuration RAM bits	—	1.425	1.50	1.575	V
V_{CCBAT} *(2)*	Battery back-up power supply for design security volatile key registers	—	1.2	—	3.3	V
V_{CCPD} *(3)*	Supplies power to the I/O pre-drivers, differential input buffers, and MSEL circuitry	—	3.135	3.3	3.465	V
		—	2.85	3.0	3.15	V
		—	2.375	2.5	2.625	V
V_{CCIO}	Supplies power to the I/O banks *(4)*	—	3.135	3.3	3.465	V
		—	2.85	3.0	3.15	V
		—	2.375	2.5	2.625	V
		—	1.71	1.8	1.89	V
		—	1.425	1.5	1.575	V
		—	1.14	1.2	1.26	V
V_{CCD_PLL}	Supplies power to the digital portions of the PLL	—	0.87	0.90	0.93	V

Table 1–4. Recommended Operating Conditions for Arria II GX Devices (Part 2 of 2) *(Note 1)*

Symbol	Description	Condition	Minimum	Typical	Maximum	Unit
V_{CCA_PLL}	Supplies power to the analog portions of the PLL and device-wide power management circuitry	—	2.375	2.5	2.625	V
V_I	DC Input voltage	—	–0.5	—	3.6	V
V_O	Output voltage	—	0	—	V_{CCIO}	V
V_{CCA}	Supplies power to the transceiver PMA regulator	—	2.375	2.5	2.625	V
V_{CCL_GXB}	Supplies power to the transceiver PMA TX, PMA RX, and clocking	—	1.045	1.1	1.155	V
V_{CCH_GXB}	Supplies power to the transceiver PMA output (TX) buffer	—	1.425	1.5	1.575	V
T_J	Operating junction temperature	Commercial	0	—	85	C
		Industrial	–40	—	100	C
t_{RAMP}	Power Supply Ramp time	Normal POR	0.05	—	100	ms
		Fast POR	0.05	—	4	ms

Notes to Table 1–4:

(1) For more information about supply pin connections, refer to the *Arria II GX Device Family Pin Connection Guidelines*.

(2) Altera recommends a 3.0-V nominal battery voltage when connecting V_{CCBAT} to a battery for volatile key backup. If you do not use the volatile security key, you may connect the V_{CCBAT} to either GND or a 3.0-V power supply.

(3) V_{CCPD} must be 2.5-V for I/O banks with 2.5-V and lower V_{CCIO}, 3.0-V for 3.0-V V_{CCIO}, and 3.3-V for 3.3-V V_{CCIO}.

(4) V_{CCIO} for 3C and 8C I/O banks where the configuration pins reside only supports 3.3-, 3.0-, 2.5-, or 1.8-V voltage levels.

DC Characteristics

This section lists the supply current, I/O pin leakage current, on-chip termination (OCT) accuracy and variation, input pin capacitance, internal weak pull-up and pull-down resistance, hot socketing, and Schmitt trigger input specifications.

Supply Current

Standby current is the current the device draws after the device is configured with no inputs or outputs toggling and no activity in the device. Because these currents vary largely with the resources used, use the Excel-based Early Power Estimator (EPE) to get supply current estimates for your design.

For more information about power estimation tools, refer to the *Arria II GX EPE User Guide* and the *PowerPlay Power Analysis* chapter.

I/O Pin Leakage Current

Table 1–5 lists the Arria II GX I/O pin leakage current specifications.

Table 1–5. I/O Pin Leakage Current for Arria II GX Devices

Symbol	Description	Conditions	Min	Typ	Max	Unit
I_I	Input pin	V_I = 0 V to $V_{CCIOMAX}$	–10	—	10	µA
I_{OZ}	Tri-stated I/O pin	V_O = 0 V to $V_{CCIOMAX}$	–10	—	10	µA

Bus Hold

Bus hold retains the last valid logic state after the source driving it either enters the high impedance state or is removed. Each I/O pin has an option to enable bus hold in user mode. Bus hold is always disabled in configuration mode.

Table 1–6 lists bus hold specifications for Arria II GX devices.

Table 1–6. Bus Hold Parameters for Arria II GX Devices *(Note 1)*

Parameter	Condition	V_{CCIO} (V)												Unit
		1.2		1.5		1.8		2.5		3.0		3.3		
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
Bus-hold low, sustaining current	$V_{IN} > V_{IL}$ (maximum)	8	—	12	—	30	—	50	—	70	—	70	—	µA
Bus-hold high, sustaining current	$V_{IN} < V_{IL}$ (minimum)	–8	—	–12	—	–30	—	–50	—	–70	—	–70	—	µA
Bus-hold low, overdrive current	$0 V < V_{IN} < V_{CCIO}$	—	125	—	175	—	200	—	300	—	500	—	500	µA
Bus-hold high, overdrive current	$0 V < V_{IN} < V_{CCIO}$	—	–125	—	–175	—	–200	—	–300	—	–500	—	–500	µA
Bus-hold trip point	—	0.3	0.9	0.375	1.125	0.68	1.07	0.7	1.7	0.8	2	0.8	2	V

Note to Table 1–6:

(1) The bus-hold trip points are based on calculated input voltages from the JEDEC standard.

OCT Specifications

Table 1–7 lists the Arria II GX series and differential OCT with and without calibration accuracy.

Table 1–7. OCT With and Without Calibration Specification for I/Os (Part 1 of 2) *(Note 1)*

Symbol	Description	Conditions	Calibration Accuracy		Unit
			Commercial	Industrial	
25-Ω R_S 3.0/2.5	25-Ω series OCT without calibration	V_{CCIO} = 3.0/2.5 V	± 30	± 40	%
50-Ω R_S 3.0/2.5	50-Ω series COT without calibration	V_{CCIO} = 3.0/2.5 V	± 30	± 40	%
25-Ω R_S 1.8	25-Ω series OCT without calibration	V_{CCIO} = 1.8 V	± 40	± 50	%
50-Ω R_S 1.8	50-Ω series OCT without calibration	V_{CCIO} = 1.8 V	± 40	± 50	%

Table 1–7. OCT With and Without Calibration Specification for I/Os (Part 2 of 2) *(Note 1)*

Symbol	Description	Conditions	Calibration Accuracy		Unit
			Commercial	Industrial	
25-Ω R_S 1.5/1.2	25-Ω series OCT without calibration	V_{CCIO} = 1.5/1.2 V	± 50	± 50	%
50-Ω R_S 1.5/1.2	50-Ω series OCT without calibration	V_{CCIO} = 1.5/1.2 V	± 50	± 50	%
25-Ω R_S 3.0/2.5/1.8/ 1.5/1.2	25-Ω series OCT with calibration	V_{CCIO} = 3.0/2.5/1.8/ 1.5/1.2 V	± 10	± 10	%
50-Ω R_S 3.0/2.5/1.8/ 1.5/1.2	50-Ω series OCT with calibration	V_{CCIO} = 3.0/2.5/1.8/ 1.5/1.2 V	± 10	± 10	%
100-Ω R_D 2.5	100-Ω differential OCT without calibration	V_{CCIO} = 2.5 V	± 30	± 30	%

Note to Table 1–7:

(1) OCT with calibration accuracy is valid at the time of calibration only.

OCT calibration is automatically performed at power up for OCT-enabled I/Os. When voltage and temperature conditions change after calibration, the resistance may change. Use Equation 1–1 and Table 1–8 to determine the OCT variation when voltage and temperature vary after power-up calibration.

Equation 1–1. OCT Variation *(Note 1)*

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

Notes to Equation 1–1:

(1) R_{OCT} value calculated from Equation 1–1shows the range of OCT resistance with the variation of temperature and V_{CCIO}.
(2) R_{SCAL} 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_{CCIO} at power up.
(5) dR/dT is the percentage change of R_{SCAL} with temperature.
(6) dR/dV is the percentage change of R_{SCAL} with voltage.

Table 1–8 lists OCT variation with temperature and voltage after power-up calibration.

Table 1–8. OCT Variation after Power-up Calibration

Nominal Voltage	dR/dT (%/°C)	dR/dV (%/mV)
3.0	0.262	0.035
2.5	0.234	0.039
1.8	0.219	0.086
1.5	0.199	0.136
1.2	0.161	0.288

Pin Capacitance

Table 1–9 lists the Arria II GX devices pin capacitance.

Table 1–9. Pin Capacitance for Arria II GX Devices

Symbol	Description	Typical	Unit
C_{IO}	Input capacitance on I/O pins, dual-purpose pins (differential I/O, clock, R_{up}, R_{dn}), and dedicated clock input pins	7	pF

Internal Weak Pull-Up and Weak Pull-Down Resistors

Table 1–10 lists the Arria II GX devices weak pull-up and pull-down resistor values.

Table 1–10. Internal Weak Pull-up and Weak Pull-Down Resistors for Arria II GX Devices *(Note 1)*

Symbol	Description	Conditions	Min	Typ	Max	Unit
R_{PU}	Value of 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} = 3.3 V ±5% *(2)*	7	25	41	kΩ
		V_{CCIO} = 3.0 V ±5% *(2)*	7	28	47	kΩ
		V_{CCIO} = 2.5 V ±5% *(2)*	8	35	61	kΩ
		V_{CCIO} = 1.8 V ±5% *(2)*	10	57	108	kΩ
		V_{CCIO} = 1.5 V ±5% *(2)*	13	82	163	kΩ
		V_{CCIO} = 1.2 V ±5% *(2)*	19	143	351	kΩ
R_{PD}	Value of TCK pin pull-down resistor	V_{CCIO} = 3.3 V ±5%	6	19	29	kΩ
		V_{CCIO} = 3.0 V ±5%	6	22	32	kΩ
		V_{CCIO} = 2.5 V ±5%	6	25	42	kΩ
		V_{CCIO} = 1.8 V ±5%	7	35	70	kΩ
		V_{CCIO} = 1.5 V ±5%	8	50	112	kΩ

Notes to Table 1–10:

(1) All I/O pins have an option to enable weak pull-up except configuration, test, and JTAG pins. The weak pull-down feature is only available for JTAG TCK.

(2) Pin pull-up resistance values may be lower if an external source drives the pin higher than V_{CCIO}.

Hot Socketing

Table 1–11 lists the hot-socketing specification for Arria II GX devices.

Table 1–11. Hot Socketing Specifications for Arria II GX Devices (Part 1 of 2)

Symbol	Description	Maximum
$I_{IIOPIN(DC)}$	DC current per I/O pin	300 µA
$I_{IOPIN(AC)}$	AC current per I/O pin	8 mA *(1)*
$I_{XCVRTX(DC)}$	DC current per transceiver TX pin	100 mA

Table 1–11. Hot Socketing Specifications for Arria II GX Devices (Part 2 of 2)

Symbol	Description	Maximum
$I_{XCVRRX(DC)}$	DC current per transceiver RX pin	50 mA

Note to Table 1–11:

(1) The I/O ramp rate is 10 ns or more. For ramp rates faster than 10 ns, |IIOPIN| = C dv/dt, in which "C" is I/O pin capacitance and "dv/dt" is slew rate.

Schmitt Trigger Input

The Arria II GX device supports 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 1–12 lists the hysteresis specifications across the supported V_{CCIO} range for Schmitt trigger inputs in Arria II GX devices.

Table 1–12. Schmitt Trigger Input Hysteresis Specifications for Arria II GX Devices

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

I/O Standard Specifications

Table 1–13 through Table 1–18 list 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 Arria II GX devices. They also show the Arria II GX 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 1–13 through Table 1–18, refer to "Glossary" on page 1–44.

Table 1–13 lists the Arria II GX single-ended I/O standards.

Table 1–13. 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		
3.3 V LVTTL	3.135	3.3	3.465	–0.3	0.8	1.7	3.6	0.45	2.4	4	–4
3.3 V LVCMOS	3.135	3.3	3.465	–0.3	0.8	1.7	3.6	0.2	V_{CCIO} -0.2	2	–2
3.0 V LVTTL	2.85	3	3.15	–0.3	0.8	1.7	V_{CCIO} + 0.3	0.45	2.4	4	–4
3.0 V LVCMOS	2.85	3	3.15	–0.3	0.8	1.7	V_{CCIO} + 0.3	0.2	V_{CCIO} - 0.2	0.1	–0.1
2.5 V LVCMOS	2.375	2.5	2.625	–0.3	0.7	1.7	V_{CCIO} + 0.3	0.4	2	1	–1
1.8 V LVCMOS	1.71	1.8	1.89	–0.3	0.35 × V_{CCIO}	0.65 × V_{CCIO}	V_{CCIO} + 0.3	0.45	V_{CCIO} - 0.45	2	–2

Table 1–13. Single-Ended I/O Standards (Part 2 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		
1.5 V LVCMOS	1.425	1.5	1.575	–0.3	0.35 × V_{CCIO}	0.65 × V_{CCIO}	V_{CCIO} + 0.3	0.25 * V_{CCIO}	0.75 × V_{CCIO}	2	–2
1.2 V LVCMOS	1.14	1.2	1.26	–0.3	0.35 × V_{CCIO}	0.65 × V_{CCIO}	V_{CCIO} + 0.3	0.25 * V_{CCIO}	0.75 × V_{CCIO}	2	–2
3.0-V PCI	2.85	3	3.15	—	0.3 × V_{CCIO}	0.5 × V_{CCIO}	V_{CCIO} + 0.3	0.1 × V_{CCIO}	0.9 × V_{CCIO}	1.5	–0.5
3.0-V PCI-X	2.85	3	3.15	—	0.35 × V_{CCIO}	0.5 × V_{CCIO}	V_{CCIO} + 0.3	0.1 × V_{CCIO}	0.9 × V_{CCIO}	1.5	–0.5

Table 1–14 lists the Arria II GX single-ended SSTL and HSTL I/O reference voltage specifications.

Table 1–14. Single-Ended SSTL and HSTL I/O Reference Voltage Specifications

I/O Standard	V_{CCIO} (V)			V_{REF} (V)			V_{TT} (V)		
	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
SSTL-2 Class I, II	2.375	2.5	2.625	0.49 × V_{CCIO}	0.5 × V_{CCIO}	0.51 × V_{CCIO}	V_{REF} - 0.04	V_{REF}	V_{REF} + 0.04
SSTL-18 Class I, II	1.71	1.8	1.89	0.833	0.9	0.969	V_{REF} - 0.04	V_{REF}	V_{REF} + 0.04
SSTL-15 Class I, II	1.425	1.5	1.575	0.47 × V_{CCIO}	0.5 × V_{CCIO}	0.53 × V_{CCIO}	0.47 × V_{CCIO}	0.5 × V_{CCIO}	0.53 × V_{CCIO}
HSTL-18 Class I, II	1.71	1.8	1.89	0.85	0.9	0.95	0.85	0.9	0.95
HSTL-15 Class I, II	1.425	1.5	1.575	0.71	0.75	0.79	0.71	0.75	0.79
HSTL-12 Class I, II	1.14	1.2	1.26	0.48 × V_{CCIO}	0.5 × V_{CCIO}	0.52 × V_{CCIO}	—	V_{CCIO}/2	—

Table 1–15 lists the Arria II GX single-ended SSTL and HSTL I/O standard signal specifications.

Table 1–15. Single-Ended SSTL and HSTL I/O Standard Signal Specifications (Part 1 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-2 Class I	–0.3	V_{REF} - 0.18	V_{REF} + 0.18	V_{CCIO} + 0.3	V_{REF} - 0.35	V_{REF} + 0.35	V_{TT} - 0.57	V_{TT} + 0.57	8.1	–8.1
SSTL-2 Class II	–0.3	V_{REF} - 0.18	V_{REF} + 0.18	V_{CCIO} + 0.3	V_{REF} - 0.35	V_{REF} + 0.35	V_{TT} - 0.76	V_{TT} + 0.76	16.4	–16.4
SSTL-18 Class I	–0.3	V_{REF} - 0.125	V_{REF} + 0.125	V_{CCIO} + 0.3	V_{REF} - 0.25	V_{REF} + 0.25	V_{TT} - 0.475	V_{TT} + 0.475	6.7	–6.7
SSTL-18 Class II	–0.3	V_{REF} - 0.125	V_{REF} + 0.125	V_{CCIO} + 0.3	V_{REF} - 0.25	V_{REF} + 0.25	0.28	V_{CCIO} - 0.28	13.4	–13.4
SSTL-15 Class I	–0.3	V_{REF} - 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} - 0.175	V_{REF} + 0.175	0.2 × V_{CCIO}	0.8 × V_{CCIO}	8	–8

Table 1–15. Single-Ended SSTL and HSTL I/O Standard 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	–0.3	V_{REF} - 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} - 0.175	V_{REF} + 0.175	0.2 × V_{CCIO}	0.8 × V_{CCIO}	16	–16
HSTL-18 Class I	–0.3	V_{REF} - 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} - 0.2	V_{REF} + 0.2	0.4	V_{CCIO} - 0.4	8	–8
HSTL-18 Class II	–0.3	V_{REF} - 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} - 0.2	V_{REF} + 0.2	0.4	V_{CCIO} - 0.4	16	–16
HSTL-15 Class I	–0.3	V_{REF} - 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} - 0.2	V_{REF} + 0.2	0.4	V_{CCIO} - 0.4	8	–8
HSTL-15 Class II	–0.3	V_{REF} - 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	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}	14	–14

Table 1–16 lists the Arria II GX differential SSTL I/O standards.

Table 1–16. 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	0.36	V_{CCIO}	$V_{CCIO}/2$ - 0.2	—	$V_{CCIO}/2$ + 0.2	0.7	V_{CCIO}	$V_{CCIO}/2$ - 0.15	—	$V_{CCIO}/2$ + 0.15
SSTL-18 Class I, II	1.71	1.8	1.89	0.25	V_{CCIO}	$V_{CCIO}/2$ - 0.175	—	$V_{CCIO}/2$ + 0.175	0.5	V_{CCIO}	$V_{CCIO}/2$ - 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 1–17 lists the Arria II GX HSTL I/O standards.

Table 1–17. 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	—	0.85	—	0.95	0.88	—	0.95	0.4	—
HSTL-15 Class I, II	1.425	1.5	1.575	0.2	—	0.71	—	0.79	0.71	—	0.79	0.4	—
HSTL-12 Class I, II	1.14	1.2	1.26	0.16	—	—	0.5 × V_{CCIO}	—	0.48 × V_{CCIO}	0.5 × V_{CCIO}	0.52 × V_{CCIO}	0.3	—

Table 1–18 lists the Arria II GX differential I/O standard specifications.

Table 1–18. Differential I/O Standard Specifications *(Note 1)*

I/O Standard	V_{CCIO} (V)			V_{TH} (mV)			V_{ICM} (V) *(2)*			V_{OD} (V) *(3)*			V_{OS} (V)		
	Min	Typ	Max	Min	Cond.	Max	Min	Cond.	Max	Min	Typ	Max	Min	Typ	Max
2.5V LVDS	2.375	2.5	2.625	100	V_{CM} = 1.25 V	—	0.05	D_{max} <= 700 Mbps	1.80	0.247	—	0.6	1.125	1.25	1.375
						—	1.05	D_{max} > 700 Mbps	1.55						
RSDS *(4)*	2.375	2.5	2.625	—	—	—	—	—	—	0.1	0.2	0.6	0.5	1.2	1.4
Mini-LVDS *(4)*	2.375	2.5	2.625	—	—	—	—	—	—	0.25	—	0.6	1	1.2	1.4
LVPECL *(5)*	2.375	2.5	2.625	300	—	—	0.6	D_{max} <= 700 Mbps	1.8	—	—	—	—	—	—
							1.0	D_{max} > 700 Mbps	1.6						

Notes to Table 1–18:

(1) The 1.5 V PCML transceiver I/O standard specifications are described in "Transceiver Performance Specifications" on page 1–13.
(2) V_{IN} range: 0 <= V_{IN} <= 1.85 V.
(3) R_L range: 90 <= RL <= 110 Ω.
(4) The RSDS and mini-LVDS I/O standards are only supported for differential outputs.
(5) The LVPECL input standard is supported at the dedicated clock input pins (GCLK) only.

Power Consumption for Arria II GX Devices

Altera offers two ways to estimate power for a design:

- Using the Excel-based Early Power Estimator
- Using the Quartus® II PowerPlay Power Analyzer feature

The interactive Excel-based Early Power Estimator is typically used prior to designing the FPGA in order 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 place-and-route is complete. The PowerPlay Power Analyzer can apply a combination of user-entered, simulation-derived, and estimated signal activities which, when combined with detailed circuit models, can yield very accurate power estimates.

For more information about power estimation tools, refer to the *Arria II GX EPE User Guide* and the *PowerPlay Power Analysis* chapter.

Switching Characteristics

This section provides performance characteristics of the Arria II GX 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.
- Final characteristics are based on actual silicon characterization and testing. These 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

Table 1–19 lists the Arria II GX transceiver specifications.

Table 1–19. Transceiver Specifications for Arria II GX Devices (Part 1 of 6) *(Note 1)*

Symbol/ Description	Condition	C4			I3			C5 and I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Reference Clock														
Input frequency from REFCLK input pins	—	50	—	622.08	50	—	622.08	50	—	622.08	50	—	622.08	MHz
Input frequency from PLD input	—	50	—	200	50	—	200	50	—	200	50	—	200	MHz
Absolute V_{MAX} for a REFCLK pin	—	—	—	2.2	—	—	2.2	—	—	2.2	—	—	2.2	V
Absolute V_{MIN} for a REFCLK pin	—	–0.3	—	—	–0.3	—	—	–0.3	—	—	–0.3	—	—	V
Rise/fall time *(9)*	—	—	—	0.2	—	—	0.2	—	—	0.2	—	—	0.2	UI
Duty cycle	—	45	—	55	45	—	55	45	—	55	45	—	55	%
Peak-to-peak differential input voltage	—	200	—	2000	200	—	2000	200	—	2000	200	—	2000	mV
Spread-spectrum modulating clock frequency	PCIe	30	—	33	30	—	33	30	—	33	30	—	33	kHz
Spread-spectrum downspread	PCIe	—	0 to –0.5%	—	—	0 to –0.5%	—	—	0 to –0.5%	—	—	0 to –0.5%	—	—
On-chip termination resistors	—	—	100	—	—	100	—	—	100	—	—	100	—	Ω
V_{ICM} (AC coupled)	—	1100 ± 5%			1100 ± 5%			1100 ± 5%			1100 ± 5%			mV

Table 1–19. Transceiver Specifications for Arria II GX Devices (Part 2 of 6) *(Note 1)*

Symbol/ Description	Condition	C4			I3			C5 and I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_{ICM} (DC coupled)	HCSL I/O standard for PCIe reference clock	250	—	550	250	—	550	250	—	550	250	—	550	mV
Transmitter REFCLK Phase Noise	10 Hz	—	—	-50	—	—	-50	—	—	-50	—	—	-50	dBc/Hz
	100 Hz	—	—	-80	—	—	-80	—	—	-80	—	—	-80	dBc/Hz
	1 KHz	—	—	-110	—	—	-110	—	—	-110	—	—	-110	dBc/Hz
	10 KHz	—	—	-120	—	—	-120	—	—	-120	—	—	-120	dBc/Hz
	100 KHz	—	—	-120	—	—	-120	—	—	-120	—	—	-120	dBc/Hz
	≥ 1 MHz	—	—	-130	—	—	-130	—	—	-130	—	—	-130	dBc/Hz
R_{ref}	—	—	2000 ± 1%	—	—	2000 ± 1%	—	—	2000 ± 1%	—	—	2000 ± 1%	—	Ω
Transceiver Clocks														
Calibration block clock frequency	—	10	—	125	10	—	125	10	—	125	10	—	125	MHz
`fixedclk` clock frequency	PCIe Receiver Detect	—	125	—	—	125	—	—	125	—	—	125	—	MHz
`reconfig_clk` clock frequency	Dynamic reconfig. clock frequency	2.5/ 37.5 *(10)*	—	50	2.5/ 37.5 *(10)*	—	50	2.5/ 37.5 *(10)*	—	50	2.5/ 37.5 *(10)*	—	50	—
Delta time between `reconfig_clks` *(11)*	—	—	—	2	—	—	2	—	—	2	—	—	2	ms
Transceiver block minimum power-down pulse width	—	—	1	—	—	1	—	—	1	—	—	1	—	µs

Table 1–19. Transceiver Specifications for Arria II GX Devices (Part 3 of 6) *(Note 1)*

Symbol/ Description	Condition	C4			I3			C5 and I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Receiver														
Data rate	—	600	—	3750	600	—	6375	600	—	3750	600	—	3125	Mbps
Absolute V_{MAX} for a receiver pin *(2)*	—	—	—	1.5	—	—	1.5	—	—	1.5	—	—	1.5	V
Absolute V_{MIN} for a receiver pin	—	-0.4	—	—	-0.4	—	—	-0.4	—	—	-0.4	—	—	V
Maximum peak-to-peak differential input voltage V_{ID} (diff p-p)	V_{ICM} = 0.82 V setting	—	—	2.7	—	—	2.7	—	—	2.7	—	—	2.7	V
	V_{ICM} =1.1 V setting *(3)*	—	—	1.6	—	—	1.6	—	—	1.6	—	—	1.6	V
Minimum peak-to-peak differential input voltage V_{ID} (diff p-p)	Data Rate = 600 Mbps to 3.75 Gbps	100	—	—	100	—	—	100	—	—	100	—	—	mV
V_{ICM}	V_{ICM} = 0.82 V setting	—	820	—	—	820	—	—	820	—	—	820	—	mV
	V_{ICM} =1.1 V setting *(3)*	—	1100	—	—	1100	—	—	1100	—	—	1100	—	mV
Differential on-chip termination resistors	100-Ω setting	—	100	—	—	100	—	—	100	—	—	100	—	Ω
Return loss differential mode	PCIe	50 MHz to 1.25 GHz: –10dB												
	XAUI	100 MHz to 2.5 GHz: –10dB												
Return loss common mode	PCIe	50 MHz to 1.25 GHz: –6dB												
	XAUI	100 MHz to 2.5 GHz: –6dB												
Programmable PPM detector *(4)*	—	± 62.5, 100, 125, 200, 250, 300, 500, 1000												ppm
Run length	—	—	80	—	—	80	—	—	80	—	—	80	—	UI

Table 1–19. Transceiver Specifications for Arria II GX Devices (Part 4 of 6) *(Note 1)*

Symbol/ Description	Condition	C4			I3			C5 and I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Programmable equalization	—	—	—	7	—	—	7	—	—	7	—	—	7	dB
Signal detect/loss threshold	PCIe Mode	65	—	175	65	—	175	65	—	175	65	—	175	mV
CDR LTR time *(5)*	—	—	—	75	—	—	75	—	—	75	—	—	75	µs
CDR minimum T1b *(6)*	—	15	—		15	—	—	15	—	—	15	—	—	µs
LTD lock time *(7)*	—	0	100	4000	0	100	4000	0	100	4000	0	100	4000	ns
Data lock time from `rx_freqlocked` *(8)*	—	—	—	4000	—	—	4000	—	—	4000	—	—	4000	ns
Programmable DC gain	DC Gain Setting = 0	—	0	—	—	0	—	—	0	—	—	0	—	dB
	DC Gain Setting = 1	—	3	—	—	3	—	—	3	—	—	3	—	dB
	DC Gain Setting = 2	—	6	—	—	6	—	—	6	—	—	6	—	dB
Transmitter														
Data rate	—	600	—	3750	600	—	6375	600	—	3750	600	—	3125	Mbps
V_{OCM}	0.65 V setting	—	650	—	—	650	—	—	650	—	—	650	—	mV
Differential on-chip termination resistors	100-Ω setting	—	100	—	—	100	—	—	100	—	—	100	—	Ω
Return loss differential mode	PCIe	50 MHz to 1.25 GHz: –10dB												
	XAUI	312 MHz to 625 MHz: –10dB 625 MHz to 3.125 GHz: –10dB/decade slope												
Return loss common mode	PCIe	50 MHz to 1.25 GHz: –6dB												
Rise time *(9)*	—	50	—	200	50	—	200	50	—	200	50	—	200	ps
Fall time	—	50	—	200	50	—	200	50	—	200	50	—	200	ps

Table 1–19. Transceiver Specifications for Arria II GX Devices (Part 5 of 6) *(Note 1)*

Symbol/ Description	Condition	C4			I3			C5 and I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Intra-differential pair skew	—	—	—	15	—	—	15	—	—	15	—	—	15	ps
Intra-transceiver block skew	PCIe ×4	—	—	120	—	—	120	—	—	120	—	—	120	ps
Inter-transceiver block skew	PCIe ×8	—	—	300	—	—	300	—	—	300	—	—	300	ps
CMU PLL0 and CMU PLL1														
CMU PLL lock time from `CMUPLL_reset` deassertion	—	—	—	100	—	—	100	—	—	100	—	—	100	µs
PLD-Transceiver Interface														
Interface speed	—	25	—	240	25	—	320	25	—	240	25	—	200	MHz

Table 1–19. Transceiver Specifications for Arria II GX Devices (Part 6 of 6) *(Note 1)*

Symbol/ Description	Condition	C4			I3			C5 and I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Digital reset pulse width	—	Minimum is 2 parallel clock cycles												

Notes to Table 1–19:

(1) For AC-coupled links, the on-chip biasing circuit is switched off before and during configuration. Ensure that input specifications are not violated during this period.

(2) The device cannot tolerate prolonged operation at this absolute maximum.

(3) You must use the 1.1-V RX V_{ICM} setting if the input serial data standard is LVDS and the link is DC-coupled.

(4) The rate matcher supports only up to ±300 parts per million (ppm).

(5) Time taken to `rx_pll_locked` goes high from `rx_analogreset` de-assertion. Refer to Figure 1–1.

(6) The time in 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 1–1.

(7) The time taken to recover valid data after the `rx_locktodata` signal is asserted in manual mode. Refer to Figure 1–1.

(8) The time taken to recover valid data after the `rx_freqlocked` signal goes high in automatic mode. Refer to Figure 1–2.

(9) The rise/fall time is specified from 20% to 80%.

(10) 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 *AN 558: Implementing Dynamic Reconfiguration in Arria II GX Devices*.

(11) If your design uses more than one dynamic reconfiguration controller instances (`altgx_reconfig`) to control the transceiver channels (`altgx`) 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 1–1 shows the lock time parameters in manual mode.

LTD = lock-to-data. LTR = lock-to-reference.

Figure 1–1. Lock Time Parameters for Manual Mode

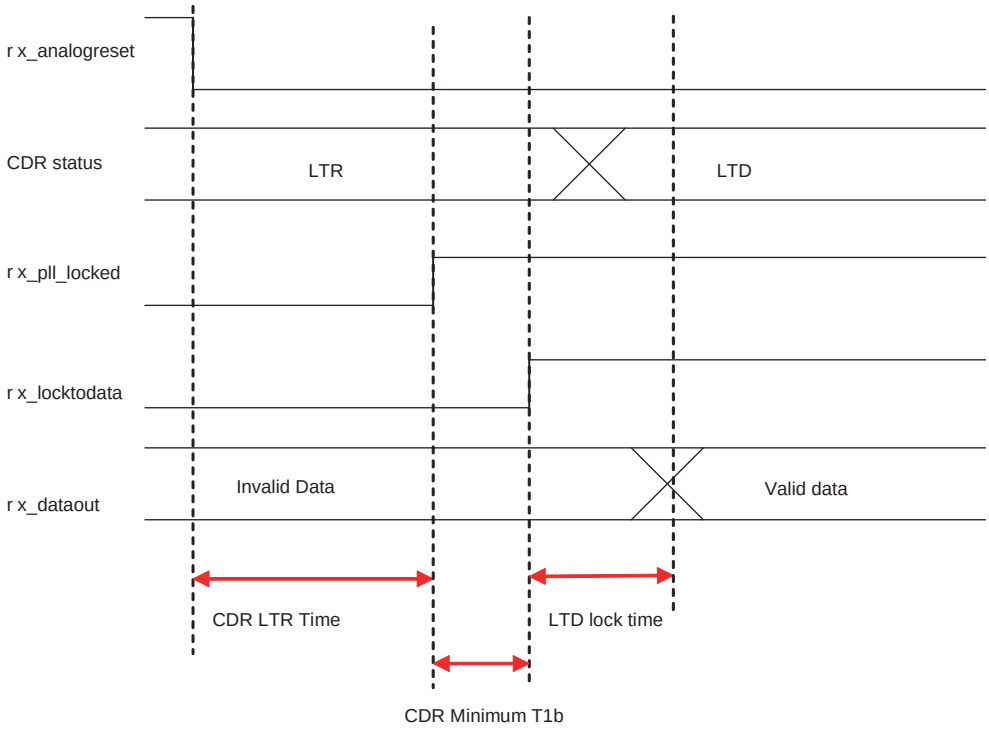


Figure 1–2 shows the lock time parameters in automatic mode.

Figure 1–2. Lock Time Parameters for Automatic Mode

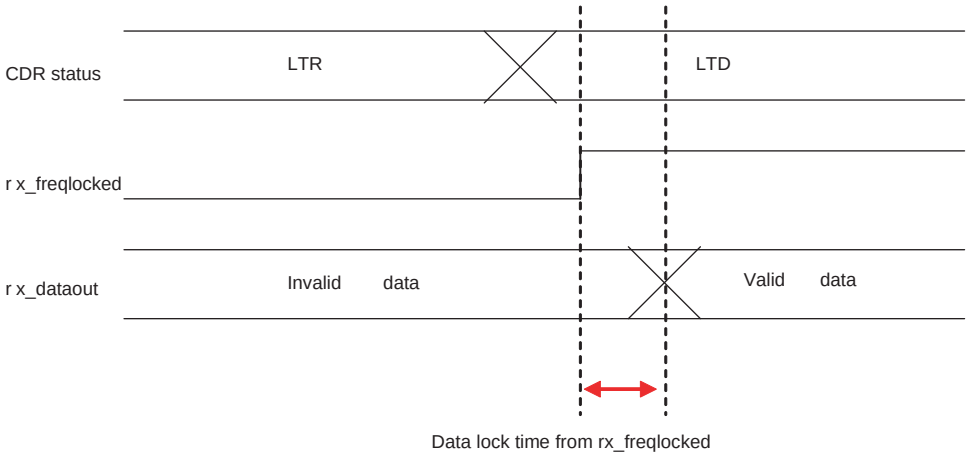


Figure 1–3 shows the differential receiver input waveform.

Figure 1–3. Receiver Input Waveform

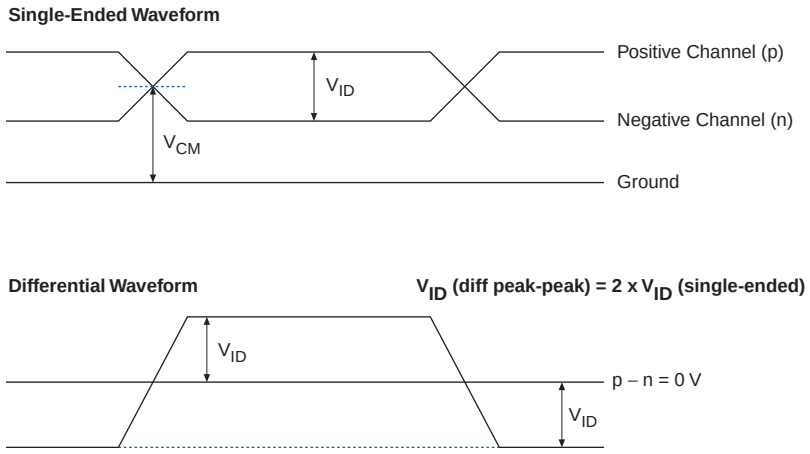


Figure 1–4 shows the transmitter output waveform.

Figure 1–4. Transmitter Output Waveform

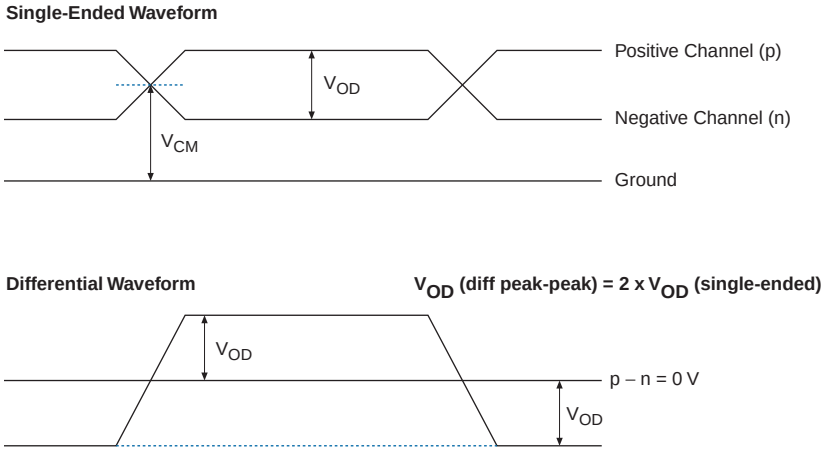


Table 1–20 lists the typical V_{OD} for TX term that equals 100 Ω .

Table 1–20. Typical V_{OD} Setting, TX Termination = 100 Ω

Quartus II Setting	V_{OD} Setting (mV)
1	400
2	600
4	800
5	900
6	1000
7	1200

Table 1–21 lists the Arria II GX transceiver block AC specifications.

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 1 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
SONET/SDH Transmit Jitter Generation *(2)*														
Peak-to-peak jitter at 622.08 Mbps	Pattern = PRBS15	—	—	0.1	—	—	0.1	—	—	0.1	—	—	0.1	UI
RMS jitter at 622.08 Mbps	Pattern = PRBS15	—	—	0.01	—	—	0.01	—	—	0.01	—	—	0.01	UI
Peak-to-peak jitter at 2488.32 Mbps	Pattern = PRBS15	—	—	0.1	—	—	0.1	—	—	0.1	—	—	0.1	UI
RMS jitter at 2488.32 Mbps	Pattern = PRBS15	—	—	0.01	—	—	0.01	—	—	0.01	—	—	0.01	UI
SONET/SDH Receiver Jitter Tolerance *(2)*														
Jitter tolerance at 622.08 Mbps	Jitter frequency = 0.03 KHz Pattern = PRBS15	> 15			> 15			> 15			> 15			UI
	Jitter frequency = 25 KHZ Pattern = PRBS15	> 1.5			> 1.5			> 1.5			> 1.5			UI
	Jitter frequency = 250 KHz Pattern = PRBS15	> 0.15			> 0.15			> 0.15			> 0.15			UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 2 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Jitter tolerance at 2488.32 Mbps	Jitter frequency = 0.06 KHz Pattern = PRBS15	> 15			> 15			> 15			> 15			UI
	Jitter frequency = 100 KHZ Pattern = PRBS15	> 1.5			> 1.5			> 1.5			> 1.5			UI
	Jitter frequency = 1 MHz Pattern = PRBS15	> 0.15			> 0.15			> 0.15			> 0.15			UI
	Jitter frequency = 10 MHz Pattern = PRBS15	> 0.15			> 0.15			> 0.15			> 0.15			UI
Fibre Channel Transmit Jitter Generation *(3)*, *(10)*														
Total jitter FC-1	Pattern = CRPAT	—	—	0.23	—	—	0.23	—	—	0.23	—	—	0.23	UI
Deterministic jitter FC-1	Pattern = CRPAT	—	—	0.11	—	—	0.11	—	—	0.11	—	—	0.11	UI
Total jitter FC-2	Pattern = CRPAT	—	—	0.33	—	—	0.33	—	—	0.33	—	—	0.33	UI
Deterministic jitter FC-2	Pattern = CRPAT	—	—	0.2	—	—	0.2	—	—	0.2	—	—	0.2	UI
Fibre Channel Receiver Jitter Tolerance *(3)*, *(11)*														
Deterministic jitter FC-1	Pattern = CJTPAT	> 0.37			> 0.37			> 0.37			> 0.37			UI
Random jitter FC-1	Pattern = CJTPAT	> 0.31			> 0.31			> 0.31			> 0.31			UI
Sinusoidal jitter FC-1	Fc/25000	> 1.5			> 1.5			> 1.5			> 1.5			UI
	Fc/1667	> 0.1			> 0.1			> 0.1			> 0.1			UI
Deterministic jitter FC-2	Pattern = CJTPAT	> 0.33			> 0.33			> 0.33			> 0.33			UI
Random jitter FC-2	Pattern = CJTPAT	> 0.29			> 0.29			> 0.29			> 0.29			UI
Sinusoidal jitter FC-2	Fc/25000	> 1.5			> 1.5			> 1.5			> 1.5			UI
	Fc/1667	> 0.1			> 0.1			> 0.1			> 0.1			UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 3 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
XAUI Transmit Jitter Generation *(4)*														
Total jitter at 3.125 Gbps	Pattern = CJPAT	—	—	0.3	—	—	0.3	—	—	0.3	—	—	0.3	UI
Deterministic jitter at 3.125 Gbps	Pattern = CJPAT	—	—	0.17	—	—	0.17	—	—	0.17	—	—	0.17	UI
XAUI Receiver Jitter Tolerance *(4)*														
Total jitter	—	> 0.65			> 0.65			> 0.65			> 0.65			UI
Deterministic jitter	—	> 0.37			> 0.37			> 0.37			> 0.37			UI
Peak-to-peak jitter	Jitter frequency = 22.1 KHz	> 8.5			> 8.5			> 8.5			> 8.5			UI
Peak-to-peak jitter	Jitter frequency = 1.875 MHz	> 0.1			> 0.1			> 0.1			> 0.1			UI
Peak-to-peak jitter	Jitter frequency = 20 MHz	> 0.1			> 0.1			> 0.1			> 0.1			UI
PCIe Transmit Jitter Generation *(5)*														
Total jitter at 2.5 Gbps (Gen1)	Compliance pattern	—	—	0.25	—	—	0.25	—	—	0.25	—	—	0.25	UI
PCIe Receiver Jitter Tolerance *(5)*														
Total jitter at 2.5 Gbps (Gen1)	Compliance pattern	> 0.6			> 0.6			> 0.6			> 0.6			UI
PCIe (Gen 1) Electrical Idle Detect Threshold *(12)*														
VRX-IDLE-DETDIFF (p-p)	Compliance pattern	65	—	175	65	—	175	65	—	175	65	—	175	mV
Serial RapidIO® Transmit Jitter Generation *(6)*														
Deterministic jitter (peak-to-peak)	Data Rate = 1.25, 2.5, 3.125 Gbps Pattern = CJPAT	—	—	0.17	—	—	0.17	—	—	0.17	—	—	0.17	UI
Total jitter (peak-to-peak)	Data Rate = 1.25, 2.5, 3.125 Gbps Pattern = CJPAT	—	—	0.35	—	—	0.35	—	—	0.35	—	—	0.35	UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 4 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Serial RapidIO Receiver Jitter Tolerance *(6)*														
Deterministic jitter tolerance (peak-to-peak)	Data Rate = 1.25, 2.5, 3.125 Gbps Pattern = CJPAT	> 0.37			> 0.37			> 0.37			> 0.37			UI
Combined deterministic and random jitter tolerance (peak-to-peak)	Data Rate = 1.25, 2.5, 3.125 Gbps Pattern = CJPAT	> 0.55			> 0.55			> 0.55			> 0.55			UI
Sinusoidal jitter tolerance (peak-to-peak)	Jitter Frequency = 22.1 KHz Data Rate = 1.25, 2.5, 3.125 Gbps Pattern = CJPAT	> 8.5			> 8.5			> 8.5			> 8.5			UI
	Jitter Frequency = 1.875 MHz Data Rate = 1.25, 2.5, 3.125 Gbps Pattern = CJPAT	> 0.1			> 0.1			> 0.1			> 0.1			UI
	Jitter Frequency = 20 MHz Data Rate = 1.25, 2.5, 3.125 Gbps Pattern = CJPAT	> 0.1			> 0.1			> 0.1			> 0.1			UI
GIGE Transmit Jitter Generation *(7)*														
Deterministic jitter (peak-to-peak)	Pattern = CRPAT	—	—	0.14	—	—	0.14	—	—	0.14	—	—	0.14	UI
Total jitter (peak-to-peak)	Pattern = CRPAT	—	—	0.279	—	—	0.279	—	—	0.279	—	—	0.279	UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 5 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
GIGE Receiver Jitter Tolerance *(7)*														
Deterministic jitter tolerance (peak-to-peak)	Pattern = CJPAT	> 0.4			> 0.4			> 0.4			> 0.4			UI
Combined deterministic and random jitter tolerance (peak-to-peak)	Pattern = CJPAT	> 0.66			> 0.66			> 0.66			> 0.66			UI
HiGig Transmit Jitter Generation *(8)*														
Deterministic jitter (peak-to-peak)	Data Rate = 3.75 Gbps Pattern = CJPAT	—	—	0.17	—	—	0.17	—	—	—	—	—	—	UI
Total jitter (peak-to-peak)	Data Rate = 3.75 Gbps Pattern = CJPAT	—	—	0.35	—	—	0.35	—	—	—	—	—	—	UI
HiGig Receiver Jitter Tolerance *(8)*														
Deterministic jitter tolerance (peak-to-peak)	Data Rate = 3.75 Gbps Pattern = CJPAT	> 0.37			> 0.37			—	—	—	—	—	—	UI
Combined deterministic and random jitter tolerance (peak-to-peak)	Data Rate = 3.75 Gbps Pattern = CJPAT	> 0.65			> 0.65			—	—	—	—	—	—	UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 6 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Sinusoidal jitter tolerance (peak-to-peak)	Jitter Frequency = 22.1 KHz Data Rate = 3.75 Gbps Pattern = CJPAT	> 8.5			> 8.5			—	—	—	—	—	—	UI
	Jitter Frequency = 1.875MHz Data Rate = 3.75 Gbps Pattern = CJPAT	> 0.1			> 0.1			—	—	—	—	—	—	UI
	Jitter Frequency = 20 MHz Data Rate = 3.75 Gbps Pattern = CJPAT	> 0.1			> 0.1			—	—	—	—	—	—	UI
SDI Transmitter Jitter Generation *(9)*														
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	—	—	0.2	—	—	UI
	Data Rate = 2.97 Gbps (3G) Pattern = Color Bar Low-Frequency Roll-Off = 100 KHz	0.3	—	—	0.3	—	—	0.3	—	—	0.3	—	—	UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 7 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
SDI Receiver Jitter Tolerance *(9)*														
Sinusoidal jitter tolerance (peak-to-peak)	Jitter Frequency = 15 KHz Data Rate = 2.97 Gbps (3G) Pattern = Single Line Scramble Color Bar	> 2			> 2			> 2			> 2			UI
	Jitter Frequency = 100 KHz Data Rate = 2.97 Gbps (3G) Pattern = Single Line Scramble Color Bar	> 0.3			> 0.3			> 0.3			> 0.3			UI
	Jitter Frequency = 148.5 MHz Data Rate = 2.97 Gbps (3G) Pattern = Single Line Scramble Color Bar	> 0.3			> 0.3			> 0.3			> 0.3			UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 8 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Sinusoidal Jitter Tolerance (peak-to-peak)	Jitter Frequency = 20 KHz Data Rate = 1.485 Gbps (HD) Pattern = 75% Color Bar	> 1			> 1			> 1			> 1			UI
	Jitter Frequency = 100 KHz Data Rate = 1.485 Gbps (HD) Pattern = 75% Color Bar	> 0.2			> 0.2			> 0.2			> 0.2			UI
	Jitter Frequency = 148.5 MHz Data Rate = 1.485 Gbps (HD) Pattern =75% Color Bar	> 0.2			> 0.2			> 0.2			> 0.2			UI
SATA Transmit Jitter Generation *(13)*														
Total jitter at 1.5 Gbps (G1)	Compliance pattern	—	—	0.55	—	—	0.55	—	—	0.55	—	—	0.55	UI
Deterministic jitter at 1.5 Gbps (G1)	Compliance pattern	—	—	0.35	—	—	0.35	—	—	0.35	—	—	0.35	UI
Total jitter at 3.0 Gbps (G2)	Compliance pattern	—	—	0.55	—	—	0.55	—	—	0.55	—	—	0.55	UI
Deterministic jitter at 3.0 Gbps (G2)	Compliance pattern	—	—	0.35	—	—	0.35	—	—	0.35	—	—	0.35	UI
Total jitter at 6.0 Gbps (G3)	Compliance pattern	—	—	0.52	—	—	—	—	—	—	—	—	—	UI
Random jitter at 6.0 Gbps (G3)	Compliance pattern	—	—	0.18	—	—	—	—	—	—	—	—	—	UI
SATA Receiver Jitter Tolerance *(13)*														
Total jitter tolerance at 1.5 Gbps (G1)	Compliance pattern	> 0.65			> 0.65			> 0.65			> 0.65			UI
Deterministic jitter tolerance at 1.5 Gbps (G1)	Compliance pattern	> 0.35			> 0.35			> 0.35			> 0.35			UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 9 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
SSC Modulation Frequency at 1.5 Gbps (G1)	Compliance pattern		33			33			33			33		kHz
SSC Modulation Deviation at 1.5 Gbps (G1)	Compliance pattern		5700			5700			5700			5700		ppm
RX Differential Skew at 1.5 Gbps (G1)	Compliance pattern		80			80			80			80		ps
RX AC Common Mode Voltage at 1.5 Gbps (G1)	Compliance pattern		150			150			150			150		mV
Total jitter tolerance at 3.0 Gbps (G2)	Compliance pattern		> 0.65			> 0.65			> 0.65			> 0.65		UI
Deterministic Jitter tolerance at 3.0 Gbps (G2)	Compliance pattern		> 0.35			> 0.35			> 0.35			> 0.35		UI
SSC Modulation Frequency at 3.0 Gbps (G2)	Compliance pattern		33			33			33			33		kHz
SSC Modulation Deviation at 3.0 Gbps (G2)	Compliance pattern		5700			5700			5700			5700		ppm
RX Differential Skew at 3.0 Gbps (G2)	Compliance pattern		75			75			75			75		ps
RX AC Common Mode Voltage at 3.0 Gbps (G2)	Compliance pattern		150			150			150			150		mV
Total Jitter tolerance at 6.0 Gbps (G3)	Compliance pattern		> 0.60			> 0.60			> 0.60			> 0.60		UI
Random Jitter tolerance at 6.0 Gbps (G3)	Compliance pattern		> 0.18			> 0.18			> 0.18			> 0.18		UI
SSC Modulation Frequency at 6.0 Gbps (G3)	Compliance pattern		33			33			33			33		kHz
SSC Modulation Deviation at 6.0 Gbps (G3)	Compliance pattern		5700			5700			5700			5700		ppm
RX Differential Skew at 6.0 Gbps (G3)	Compliance pattern		30			30			30			30		ps

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 10 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
RX AC Common Mode Voltage at 6.0 Gbps (G3)	Compliance pattern		100			100			100			100		mV
CPRI Transmit Jitter Generation *(14)*														
Total jitter	E.6.HV, E.12.HV Pattern = CJPAT	—	—	0.279	—	—	0.279	—	—	0.279	—	—	0.279	UI
	E.6.LV, E.12.LV, E.24.LV, E.30.LV Pattern = CJTPAT	—	—	0.35	—	—	0.35	—	—	0.35	—	—	0.35	UI
Deterministic jitter	E.6.HV, E.12.HV Pattern = CJPAT	—	—	0.14	—	—	0.14	—	—	0.14	—	—	0.14	UI
	E.6.LV, E.12.LV, E.24.LV, E.30.LV Pattern = CJTPAT	—	—	0.17	—	—	0.17	—	—	0.17	—	—	0.17	UI
CPRI Receiver Jitter Tolerance *(14)*														
Total jitter tolerance	E.6.HV, E.12.HV Pattern = CJPAT		> 0.66			> 0.66			> 0.66			> 0.66		UI
Deterministic jitter tolerance	E.6.HV, E.12.HV Pattern = CJPAT		> 0.4			> 0.4			> 0.4			> 0.4		UI
Total jitter tolerance	E.6.LV, E.12.LV, E.24.LV, E.30.LV Pattern = CJTPAT		> 0.65			> 0.65			> 0.65			> 0.65		UI
	E.60.LV Pattern = PRBS31		> 0.6			—			—			—		UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 11 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Deterministic jitter tolerance	E.6.LV, E.12.LV, E.24.LV, E.30.LV Pattern = CJTPAT		> 0.37			> 0.37			> 0.37			> 0.37		UI
	E.60.LV Pattern = PRBS31		> 0.45			—			—			—		UI
Combined deterministic and random jitter tolerance	E.6.LV, E.12.LV, E.24.LV, E.30.LV Pattern = CJTPAT		> 0.55			> 0.55			> 0.55			> 0.55		UI
OBSAI Transmit Jitter Generation *(15)*														
Total jitter at 768 Mbps, 1536 Mbps, and 3072 Mbps	REFCLK = 153.6 MHz Pattern = CJPAT	—	—	0.35	—	—	0.35	—	—	0.35	—	—	0.35	UI
Deterministic jitter at 768 Mbps, 1536 Mbps, and 3072 Mbps	REFCLK = 153.6 MHz Pattern = CJPAT	—	—	0.17	—	—	0.17	—	—	0.17	—	—	0.17	UI
OBSAI Receiver Jitter Tolerance *(15)*														
Deterministic jitter tolerance at 768 Mbps, 1536 Mbps, and 3072 Mbps	Pattern = CJPAT		> 0.37			> 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			> 0.55		UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 12 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Sinusoidal Jitter tolerance at 768 Mbps	Jitter Frequency = 5.4 KHz Pattern = CJPAT	> 8.5			> 8.5			> 8.5			> 8.5			UI
	Jitter Frequency = 460.8 KHz to 20 MHz Pattern = CJPAT	> 0.1			> 0.1			> 0.1			> 0.1			UI
Sinusoidal Jitter tolerance at 1536 Mbps	Jitter Frequency = 10.9 KHz Pattern = CJPAT	> 8.5			> 8.5			> 8.5			> 8.5			UI
	Jitter Frequency = 921.6 KHz to 20 MHz Pattern = CJPAT	> 0.1			> 0.1			> 0.1			> 0.1			UI

Table 1–21. Transceiver Block AC Specifications for Arria II GX Devices *(Note 1)* (Part 13 of 13)

Symbol/ Description	Conditions	I3			C4			C5, I5			C6			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Sinusoidal Jitter tolerance at 3072 Mbps	Jitter Frequency = 21.8 KHz Pattern = CJPAT		> 8.5			> 8.5			> 8.5			> 8.5		UI
	Jitter Frequency = 1843.2 KHz to 20 MHz Pattern = CJPAT		> 0.1			> 0.1			> 0.1			> 0.1		UI

Notes to Table 1–21:

(1) Dedicated `refclk` pins are used to drive the input reference clocks. The jitter numbers are valid for the stated conditions only.
(2) The jitter numbers for SONET/SDH are compliant to the GR-253-CORE Issue 3 Specification.
(3) The jitter numbers for Fibre Channel are compliant to the FC-PI-4 Specification revision 6.10.
(4) The jitter numbers for XAUI are compliant to the IEEE802.3ae-2002 Specification.
(5) The jitter numbers for PCIe are compliant to the PCIe Base Specification 2.0.
(6) The jitter numbers for Serial RapidIO® are compliant to the RapidIO Specification 1.3.
(7) The jitter numbers for GIGE are compliant to the IEEE802.3-2002 Specification.
(8) The jitter numbers for HiGig are compliant to the IEEE802.3ae-2002 Specification.
(9) The HD-SDI and 3G-SDI jitter numbers are compliant to the SMPTE292M and SMPTE424M Specifications.
(10) The Fibre Channel transmitter jitter generation numbers are compliant to the specification at the δ_T inter operability point.
(11) The Fibre Channel receiver jitter tolerance numbers are compliant to the specification at the δ_R interpretability point.
(12) Arria II PCIe receivers are compliant to this specification provided the VTX_CM-DC-ACTIVEIDLE-DELTA of the upstream transmitter is less than 50 mV.
(13) The jitter numbers for Serial Advanced Technology Attachment (SATA) are compliant to the Serial ATA Revision 3.0 Specification.
(14) The jitter numbers for Common Public Radio Interface (CPRI) are compliant to the CPRI Specification V3.0.
(15) The jitter numbers for Open Base Station Architecture Initiative (OBSAI) are compliant to the OBSAI RP3 Specification V4.1.

Core Performance Specifications for Arria II GX Devices

This section describes the clock tree, phase-locked loop (PLL), digital signal processing (DSP), embedded memory, configuration, and JTAG specifications.

Clock Tree Specifications

Table 1–22 lists the clock tree specifications for Arria II GX devices.

Table 1–22. Clock Tree Performance for Arria II GX Devices

Clock Network	Performance			Unit
	I3, C4	C5,I5	C6	
GCLK and RCLK	500	500	400	MHz
PCLK	420	350	280	MHz

PLL Specifications

Table 1–23 lists the PLL specifications for Arria II GX devices.

Table 1–23. PLL Specifications for Arria II GX Devices (Part 1 of 2)

Symbol	Description	Min	Typ	Max	Unit
f_{IN}	Input clock frequency (from clock input pins residing in right/top/bottom banks) (–4 Speed Grade)	5	—	670 *(1)*	MHz
	Input clock frequency (from clock input pins residing in right/top/bottom banks) (–5 Speed Grade)	5	—	622 *(1)*	MHz
	Input clock frequency (from clock input pins residing in right/top/bottom banks) (–6 Speed Grade)	5	—	500 *(1)*	MHz
f_{INPFD}	Input frequency to the PFD	5	—	325	MHz
f_{VCO}	PLL VCO operating Range *(2)*	600	—	1,300	MHz
f_{INDUTY}	Input clock duty cycle	40	—	60	%
$f_{EINDUTY}$	External feedback clock input duty cycle	40	—	60	%
t_{INCCJ} *(3)*, *(4)*	Input clock cycle-to-cycle jitter (Frequency ≥ 100 MHz)	—	—	0.15	UI (p–p)
	Input clock cycle-to-cycle jitter (Frequency ≤100 MHz)	—	—	±750	ps (p–p)
f_{OUT}	Output frequency for internal global or regional clock (–4 Speed Grade)	—	—	500	MHz
	Output frequency for internal global or regional clock (–5 Speed Grade)	—	—	500	MHz
	Output frequency for internal global or regional clock (–6 Speed Grade)	—	—	400	MHz
f_{OUT_EXT}	Output frequency for external clock output (–4 Speed Grade)	—	—	670 *(5)*	MHz
	Output frequency for external clock output (–5 Speed Grade)	—	—	622 *(5)*	MHz
	Output frequency for external clock output (–6 Speed Grade)	—	—	500 *(5)*	MHz
$t_{OUTDUTY}$	Duty cycle for external clock output (when set to 50%)	45	50	55	%
t_{OUTPJ_DC}	Dedicated clock output period jitter (f_{OUT} ≥ 100 MHz)	—	—	300	ps (p–p)
	Dedicated clock output period jitter (f_{OUT} < 100 MHz)	—	—	30	mUI (p–p)
t_{OUTCCJ_DC}	Dedicated clock output cycle-to-cycle jitter (f_{OUT} ≥ 100 MHz)	—	—	300	ps (p–p)
	Dedicated clock output cycle-to-cycle jitter (f_{OUT} < 100 MHz)	—	—	30	mUI (p–p)
f_{OUTPJ_IO}	Regular I/O clock output period jitter (f_{OUT} ≥ 100 MHz)	—	—	650	ps (p–p)
	Regular I/O clock output period jitter (f_{OUT} < 100 MHz)	—	—	65	mUI (p–p)
f_{OUTCCJ_IO}	Regular I/O clock output cycle-to-cycle jitter (f_{OUT} ≥ 100 MHz)	—	—	650	ps (p–p)
	Regular I/O clock output cycle-to-cycle jitter (f_{OUT} < 100 MHz)	—	—	65	mUI (p–p)
$t_{CONFIGPLL}$	Time required to reconfigure PLL scan chains	—	3.5	—	SCANCLK cycles
$t_{CONFIGPHASE}$	Time required to reconfigure phase shift	—	1	—	SCANCLK cycles
$f_{SCANCLK}$	SCANCLK frequency	—	—	100	MHz
t_{LOCK}	Time required to lock from end of device configuration	—	—	1	ms
t_{DLOCK}	Time required to lock dynamically (after switchover or reconfiguring any non-post-scale counters/delays)	—	—	1	ms

Table 1–23. PLL Specifications for Arria II GX Devices (Part 2 of 2)

Symbol	Description	Min	Typ	Max	Unit
f_{CLBW}	PLL closed-loop low bandwidth	—	0.3	—	MHz
	PLL closed-loop medium bandwidth	—	1.5	—	MHz
	PLL closed-loop high bandwidth	—	4	—	MHz
t_{PLL_PSERR}	Accuracy of PLL phase shift	—	—	±50	ps
t_{ARESET}	Minimum pulse width on `areset` signal	10	—	—	ns

Notes to Table 1–23:

(1) f_{IN} is limited by the I/O f_{MAX}.

(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_{VCO} specification.

(3) A high-input jitter directly affects the PLL output jitter. To have low PLL output clock jitter, you must provide a clean-clock source, which is less than 200 ps.

(4) F_{REF} is fIN/N when N = 1.

(5) This specification is limited by the lower of the two: I/O f_{MAX} or f_{OUT} of the PLL.

DSP Block Specifications

Table 1–24 lists the Arria II GX DSP block performance specifications.

Table 1–24. DSP Block Performance Specifications for Arria II GX Devices *(Note 1)*

Mode	Resources Used	Performance				Unit
	Number of Multipliers	C4	I3	C5,I5	C6	
9 × 9-bit multiplier	1	380	310	300	250	MHz
12 × 12-bit multiplier	1	380	310	300	250	MHz
18 × 18-bit multiplier	1	380	310	300	250	MHz
36 × 36-bit multiplier	1	350	270	270	220	MHz
18 × 36-bit high-precision multiplier adder mode	1	350	270	270	220	MHz
18 × 18-bit multiply accumulator	4	380	310	300	250	MHz
18 × 18-bit multiply adder	4	380	310	300	250	MHz
18 × 18-bit multiply adder-signed full precision	2	380	310	300	250	MHz
18 × 18-bit multiply adder with loopback *(2)*	2	275	220	220	180	MHz
36-bit shift (32-bit data)	1	350	270	270	220	MHz
Double mode	1	350	270	270	220	MHz

Notes to Table 1–24:

(1) Maximum is for a fully-pipelined block with **Round** and **Saturation** disabled.

(2) Maximum is for loopback input registers disabled, **Round** and **Saturation** disabled, pipeline and output registers enabled.

Embedded Memory Block Specifications

Table 1–25 lists the Arria II GX embedded memory block specifications.

Table 1–25. Embedded Memory Block Performance Specifications for Arria II GX Devices

Memory	Mode	Resources Used		Performance				Unit
		ALUTs	Embedded Memory	C4	I3	C5,I5	C6	
Memory Logic Array Block (MLAB)	Single port 64 × 10	0	1	500	450	450	378	MHz
	Simple dual-port 32 × 20 single clock	0	1	500	270	450	378	MHz
	Simple dual-port 64 × 10 single clock	0	1	500	428	450	378	MHz
M9K Block	Single-port 256 × 36	0	1	400	360	360	310	MHz
	Single-port 256 × 36, with the **read-during-write** option set to **Old Data**	0	1	280	250	250	210	MHz
	Simple dual-port 256 × 36 single CLK	0	1	400	360	360	310	MHz
	Single-port 256 × 36 single CLK, with the **read-during-write** option set to **Old Data**	0	1	280	250	250	210	MHz
	True dual port 512 × 18 single CLK	0	1	400	360	360	310	MHz
	True dual-port 512 × 18 single CLK, with the **read-during-write** option set to **Old Data**	0	1	280	250	250	210	MHz
	Min Pulse Width (clock high time)	—	—	850	900	950	1130	ps
	Min Pulse Width (clock low time)	—	—	690	730	770	920	ps

Configuration

Table 1–26 lists the Arria II GX configuration mode specifications.

Table 1–26. Configuration Mode Specifications for Arria II GX Devices

Programming Mode	DCLK Frequency			Unit
	Min	Typ	Max	
Passive Serial	—	—	125	MHz
Fast Passive Parallel	—	—	125	MHz
Fast Active Serial (fast clock)	17	26	40	MHz
Fast Active Serial (slow clock)	8.5	13	20	MHz
Remote Update only in Fast AS mode	—	—	10	MHz

Configuration Times for Fast Passive Parallel Mode

Table 1–27 lists the typical Arria II GX configuration time for fast passive parallel mode at 125 MHz.

Table 1–27. Typical Configuration Times for Arria II GX Devices Configured with Fast Passive Parallel Mode *(1)*

Device	Time (ms)
EP2AGX45	24
EP2AGX65	35
EP2AGX95	35
EP2AGX125	48
EP2AGX190	48
EP2AGX260	79

Note to Table 1–27:

(1) Pending characterization.

JTAG Specifications

Table 1–28 lists the JTAG timing parameters and values for Arria II GX devices.

Table 1–28. JTAG Timing Parameters and Values for Arria II GX Devices

Symbol	Description	Min	Max	Unit
t_{JCP}	TCK clock period	30	—	ns
t_{JCH}	TCK clock high time	14	—	ns
t_{JCL}	TCK clock low time	14	—	ns
$t_{JPSU\ (TDI)}$	TDI JTAG port setup time	1	—	ns
$t_{JPSU\ (TMS)}$	TMS JTAG port setup time	3	—	ns
t_{JPH}	JTAG port hold time	5	—	ns
t_{JPCO}	JTAG port clock to output	—	11 *(1)*	ns
t_{JPZX}	JTAG port high impedance to valid output	—	14 *(1)*	ns
t_{JPXZ}	JTAG port valid output to high impedance	—	14 *(1)*	ns

Note to Table 1–28:

(1) A 1-ns adder is required for each V_{CCIO} voltage step down from 3.3 V. For example, t_{JPCO} = 12 ns if V_{CCIO} of the TDO I/O bank = 2.5 V, or 13 ns if it equals to 1.8 V.

Chip-Wide Reset (Dev_CLRn) Specifications

Table 1–29 lists the specifications for the Arria II GX chip-wide reset (Dev_CLRn).

Table 1–29. 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, external memory interface, and IOE programmable delay.

I/O performance supports several system interfaces, for example the high-speed I/O interface, external memory interface, and the PCI/PCI-X bus interface. I/O using SSTL-18 Class I termination standard can achieve up to the stated DDR2 SDRAM interfacing speed with typical DDR2 SDRAM memory interface setup. I/O using general purpose I/O (GPIO) standards such as 3.0, 2.5, 1.8, or 1.5 LVTTL/LVCMOS are capable of typical 200 MHz interfacing frequency with 10pF load.

Actual achievable frequency depends on design- and system-specific factors. You should 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 1–30 lists the high-speed I/O timing for Arria II GX devices.

Table 1–30. High-Speed I/O Specifications for Arria II GX Devices (Part 1 of 3)

Symbol	Conditions	C4		I3		C5,I5		C6		Unit
		Min	Max	Min	Max	Min	Max	Min	Max	
Clock										
f_{HSCLK_IN} (input clock frequency)–Row I/O	Clock boost factor, W = 1 to 40 *(1)*	5	670	5	670	5	622	5	500	MHz
f_{HSCLK_IN} (input clock frequency)–Column I/O	Clock boost factor, W = 1 to 40 *(1)*	5	500	5	500	5	472.5	5	472.5	MHz
f_{HSCLK_OUT} (output clock frequency)–Row I/O	—	5	670	5	670	5	622	5	500	MHz
f_{HSCLK_OUT} (output clock frequency)–Column I/O	—	5	500	5	500	5	472.5	5	472.5	MHz
Transmitter										
f_{HSDR_TX} (true LVDS output data rate)	SERDES factor, J = 3 to 10 (using dedicated SERDES)	150	1250 *(2)*	150	1250 *(2)*	150	1050 *(2)*	150	840	Mbps

Table 1–30. High-Speed I/O Specifications for Arria II GX Devices (Part 2 of 3)

Symbol	Conditions	C4		I3		C5,I5		C6		Unit
		Min	Max	Min	Max	Min	Max	Min	Max	
f_{HSDR_TX} (true LVDS output data rate)	SERDES factor, J = 4 to 10 (using logic elements as SERDES)	*(3)*	945	*(3)*	945	*(3)*	840	*(3)*	740	Mbps
	SERDES factor, J = 2 (using DDR registers) and J = 1 (using SDR register)	*(3)*	*(3)*	*(3)*	*(3)*	*(3)*	*(3)*	*(3)*	*(3)*	Mbps
$f_{HSDR\_TX\_E3R}$ (emulated LVDS_E_3R output data rate) *(7)*	SERDES factor, J = 4 to 10	*(3)*	945	*(3)*	945	*(3)*	840	*(3)*	740	Mbps
t_{TX_JITTER} *(4)*	True LVDS with dedicated SERDES (data rate 600–1,250 Mbps)	—	175	—	175	—	225	—	300	ps
	True LVDS with dedicated SERDES (data rate < 600 Mbps)	—	0.105	—	0.105	—	0.135	—	0.18	UI
	True LVDS and Emulated LVDS_E_3R with logic elements as SERDES (data rate 600–945 Mbps)	—	260	—	260	—	300	—	350	ps
	True LVDS and Emulated LVDS_E_3R with logic elements as SERDES (data rate < 600 Mbps)	—	0.16	—	0.16	—	0.18	—	0.21	UI
t_{TX_DCD}	True LVDS and Emulated LVDS_E_3R	45	55	45	55	45	55	45	55	%
t_{RISE} and t_{FALL}	True LVDS and Emulated LVDS_E_3R	—	200	—	200	—	225	—	250	ps
TCCS	True LVDS *(5)*	—	150	—	150	—	175	—	200	ps
	Emulated LVDS_E_3R	—	200	—	200	—	250	—	300	ps

Table 1–30. High-Speed I/O Specifications for Arria II GX Devices (Part 3 of 3)

Symbol	Conditions	C4		I3		C5,I5		C6		Unit
		Min	Max	Min	Max	Min	Max	Min	Max	
Receiver *(6)*										
True Differential I/O Standards - $f_{HSDRDPA}$ (data rate)	SERDES factor J = 3 to 10	150	1250	150	1250	150	1050	150	840	Mbps
f_{HSDR} (data rate)	SERDES factor J = 3 to 10	*(3)*	945 *(7)*	*(3)*	945 *(7)*	*(3)*	740 *(7)*	*(3)*	640 *(7)*	Mbps
	SERDES factor J = 2 (using DDR registers)	*(3)*	*(7)*	*(3)*	*(7)*	*(3)*	*(7)*	*(3)*	*(7)*	Mbps
	SERDES factor J = 1 (using SDR registers)	*(3)*	*(7)*	*(3)*	*(7)*	*(3)*	*(7)*	*(3)*	*(7)*	Mbps
Soft-CDR PPM tolerance	Soft-CDR mode	—	300	—	300	—	300	—	300	±PPM
DPA run length	DPA mode	—	10,000	—	10,000	—	10,000	—	10,000	UI
SW	Non-DPA mode *(5)*	—	300	—	300	—	350	—	400	ps

Notes to Table 1–30:

(1) $f_{HSCLK\_IN} = f_{HSDR} / W$. Use W to determine the supported selection of input reference clock frequencies for the desired data rate.

(2) This applies to interfacing with DPA receivers. For interfacing with non-DPA receivers, the maximum supported data rate is 945 Mbps. Beyond 840 Mbps, PCB trace compensation is required. PCB trace compensation refers to the adjustment of the PCB trace length for LVDS channels to improve channel-to-channel skews and is required to support date rates beyond 840 Mbps.

(3) The minimum and maximum specification depends on the clock source (for example, PLL and clock pin) and the clock routing resource you use (global, regional, or local). The I/O differential buffer and input register do not have a minimum toggle rate.

(4) The specification is only applicable under the influence of core noise.

(5) Specification is only applicable for true LVDS using dedicated SERDES.

(6) Dedicated SERDES and DPA features are only available on the right banks.

(7) You are required to 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 the receiver sampling margin to determine the leftover timing margin.

Table 1–31 lists DPA lock time specifications for Arria II GX devices.

Table 1–31. DPA Lock Time Specifications for Arria II GX Devices *(Note 1)*, *(2)*, *(3)*

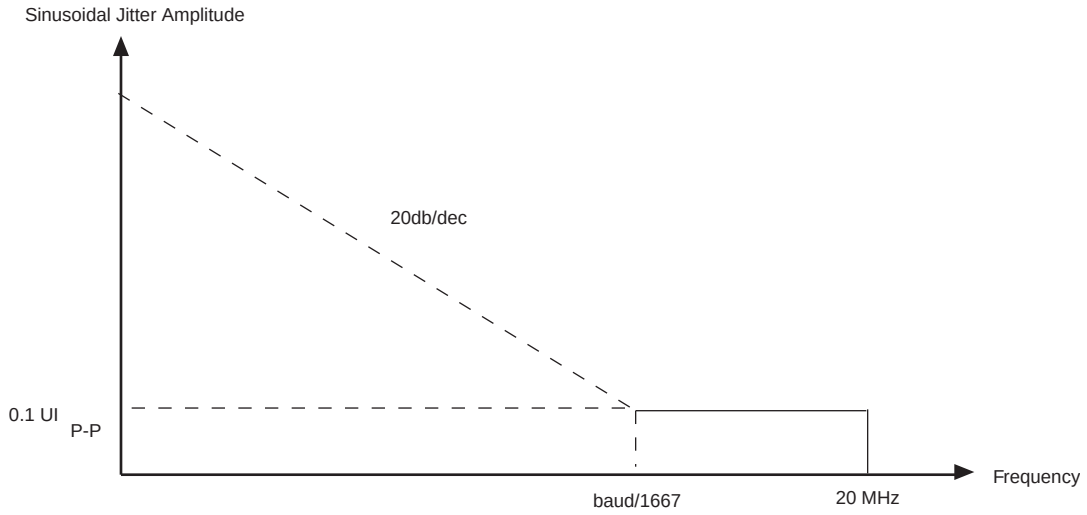
Standard	Training Pattern	Number of Data Transitions in One Repetition of the Training Pattern	Number of Repetitions per 256 Data Transitions *(4)*	Maximum
SPI-4	00000000001111111111	2	128	640 data transitions
Parallel Rapid I/O	00001111	2	128	640 data transitions
	10010000	4	64	640 data transitions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

Notes to Table 1–31:

(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 both commercial and industrial grade.
(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.

Figure 1–5. LVDS Soft-CDR/DPA Sinusoidal Jitter Tolerance Specification



External Memory Interface Specifications

For the maximum clock rate supported for Arria II GX device family, refer to the *External Memory Interface System Specifications*.

Table 1–32 lists DLL frequency range specifications for Arria II GX devices.

Table 1–32. DLL Frequency Range Specifications for Arria II GX Devices

Frequency Mode	Frequency Range (MHz)			Resolution (°)
	C4	I3, C5, I5	C6	
0	60–140	60–130	60–110	22.5
1	80–180	80–170	80–150	30
2	100–220	100–210	100–180	36
3	120–270	120–260	120–220	45
4	160–340	160–310	160–270	30
5	190–410	190–380	190–320	36

Table 1–33 lists the DQS phase offset delay per stage for Arria II GX devices.

Table 1–33. DQS Phase Offset Delay Per Setting for Arria II GX Devices *(Note 1)*, *(2)*, *(3)*

Speed Grade	Min	Max	Unit
C4	7.0	13.0	ps
I3, C5, I5	7.0	15.0	ps
C6	8.5	18.0	ps

Notes to Table 1–33:

(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 5.

(2) The typical value equals the average of the minimum and maximum values.

(3) The delay settings are linear.

Duty Cycle Distortion (DCD) Specifications

Table 1–34 lists the worst-case DCD specifications for Arria II GX devices.

Table 1–34. Duty Cycle Distortion on Arria II GX I/O Pins *(Note 1)*

Symbol	C4		I3, C5, I5		C6		Unit
	Min	Max	Min	Max	Min	Max	
Output Duty Cycle	45	55	45	55	45	55	%

Note to Table 1–34:

(1) The DCD specification applies to clock outputs from the PLL, global clock tree, and IOE driving dedicated as well as general purpose I/O pins.

IOE Programmable Delay

Table 1–35 lists the delay associated with each supported IOE programmable delay chain.

Table 1–35. IOE Programmable Delay for Arria II GX Devices

Parameter	Available Settings *(1)*	Minimum Offset *(2)*	Maximum Offset								Unit
			Fast Model			Slow Model					
			I3	I5	C4	C4	C5	C6	I3	I5	
Output Enable Pin delay	7	0	0.413	0.413	0.442	0.713	0.796	0.873	0.814	0.801	ns
Delay from Output Register to Output pin	7	0	0.339	0.339	0.362	0.585	0.654	0.722	0.671	0.661	ns
Input Delay from Pin to Internal Cell	52	0	1.494	1.494	1.607	2.520	2.733	2.944	2.895	2.775	ns
Input Delay from Pin to Input Register	52	0	1.493	1.493	1.607	2.503	2.732	2.944	2.896	2.774	ns
DQS Bus to Input Register Delay	4	0	0.074	0.074	0.076	0.124	0.147	0.167	0.140	0.147	ns

Notes to Table 1–35:

(1) The available setting for every delay chain starts with zero and ends with the specified maximum number of settings.

(2) The minimum offset represented in the table does not include intrinsic delay.

I/O Timing

Altera offers two ways to determine I/O timing:

- Using the Excel-based I/O Timing.
- Using the Quartus II Timing Analyzer.

The 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 place-and-route is complete.

The Excel-based I/O Timing spreadsheet is downloadable from the Arria II GX Devices Literature webpage.

Glossary

Table 1–36 lists the glossary for this chapter.

Table 1–36. Glossary (Part 1 of 4)

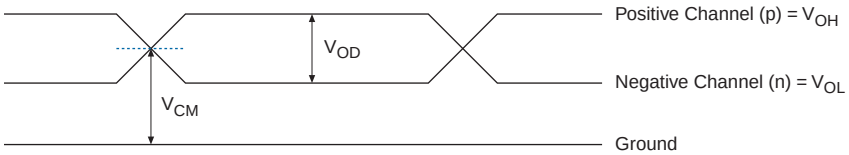
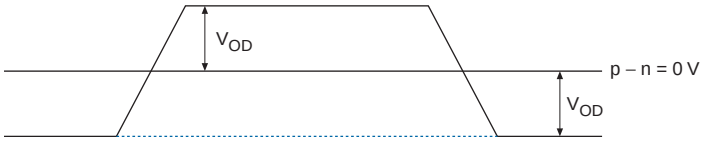
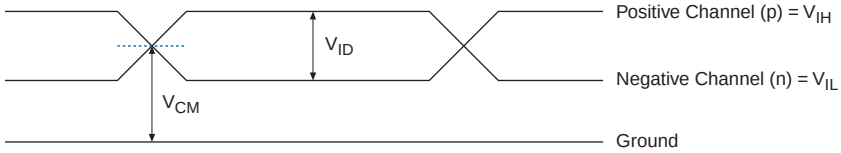
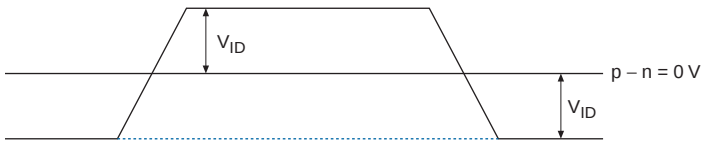
Letter	Subject	Definitions
A	—	—
B	—	—
C	—	—
D	Differential I/O Standards	*Receiver Input Waveforms* **Single-Ended Waveform**  **Differential Waveform**  *Transmitter Output Waveforms* **Single-Ended Waveform**  **Differential Waveform** 
E	—	—
F	f_{HSCLK}	Left/Right PLL input clock frequency.
	f_{HSDR}	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.

Table 1–36. Glossary (Part 2 of 4)

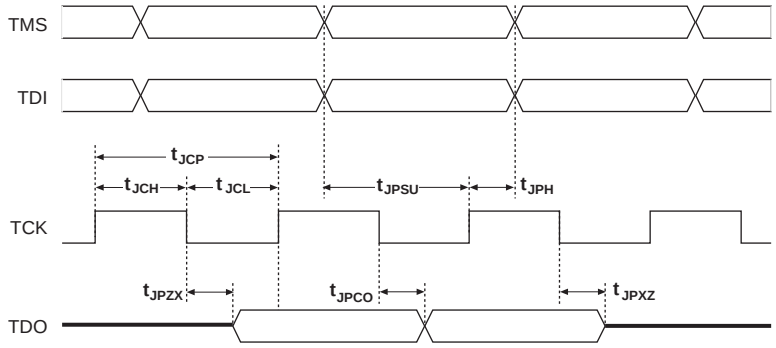
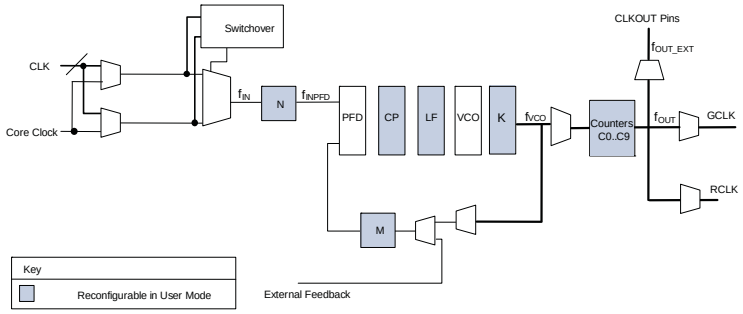
Letter	Subject	Definitions
G	—	—
H	—	—
I	—	—
J	J	High-speed I/O block: Deserialization factor (width of parallel data bus).
	JTAG Timing Specifications	JTAG Timing Specifications: 
K	—	—
L	—	—
M	—	—
N	—	—
O	—	—
P	PLL Specifications	PLL Specification parameters: **Diagram of PLL Specifications (1)**  **Note:** (1) CoreClock can only be fed by dedicated clock input pins or PLL outputs.
Q	—	—
R	R_L	Receiver differential input discrete resistor (external to the Arria II GX device).

Table 1–36. Glossary (Part 3 of 4)

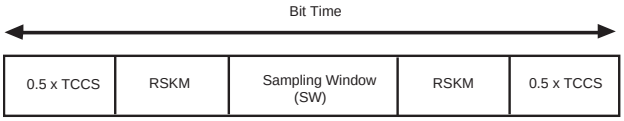
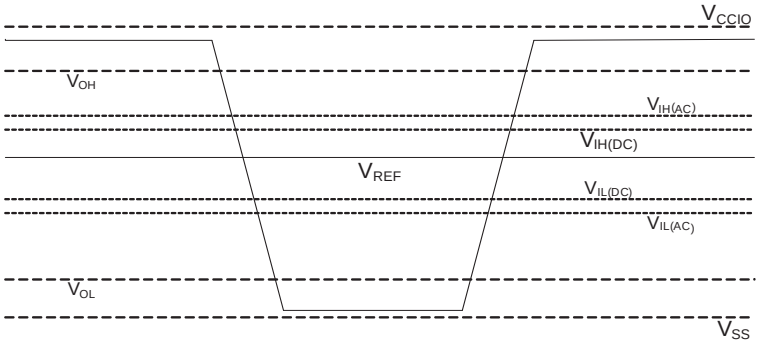
Letter	Subject	Definitions
S	SW (sampling window)	The period of time during which the data must be valid in order to capture it correctly. The setup and hold times determine the ideal strobe position within the sampling window: *Timing Diagram* 
	Single-ended Voltage Referenced I/O Standard	The JEDEC standard for SSTL and HSTL I/O standards define 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. 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: *Single-Ended Voltage Referenced I/O Standard* 
T	t_C	High-speed receiver and transmitter input and output clock period.
	TCCS (channel-to-channel-skew)	The timing difference between the fastest and slowest output edges, including t_{CO} variation and clock skew, across channels driven by the same PLL. The clock is included in the TCCS measurement (refer to the *Timing Diagram* figure under **S** in this table).
	t_{DUTY}	High-speed I/O block: Duty cycle on the high-speed transmitter output clock.
		Timing Unit Interval (TUI) 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 1–36. Glossary (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.
W	W	High-speed I/O block: The clock boost factor.
X	—	—
Y	—	—
Z	—	—

Document Revision History

Table 1–37 lists the revision history for this chapter.

Table 1–37. Document Revision History

Date	Version	Changes Made
July 2010	3.0	■ Updated Table 1–1, Table 1–4, Table 1–16, Table 1–19, Table 1–21, Table 1–23, Table 1–25, Table 1–26, Table 1–30, and Table 1–35 ■ Added Table 1–27 and Table 1–29. ■ Added I3 speed grade information to Table 1–19, Table 1–21, Table 1–22, Table 1–24, Table 1–25, Table 1–30, Table 1–32, Table 1–33, Table 1–34, and Table 1–35. ■ Updated the "Operating Conditions" section. ■ Removed "Preliminary" from Table 1–19, Table 1–21, Table 1–22, Table 1–23, Table 1–24, Table 1–25, Table 1–26, Table 1–28, Table 1–30, Table 1–32, Table 1–33, Table 1–34, and Figure 1–4. ■ Minor text edits.
March 2010	2.3	Updated for the Quartus II version 9.1 SP2 release: ■ Updated Table 1–3, Table 1–7, Table 1–19, Table 1–21, Table 1–22, Table 1–24, Table 1–25 and Table 1–33. ■ Updated "Recommended Operating Conditions" section. ■ Minor text edits.
February 2010	2.2	Updated Table 1–19.
February 2010	2.1	Updated for Arria II GX v9.1 SP1 release: ■ Updated Table 1–19, Table 1–23, Table 1–28, Table 1–30, and Table 1–33. ■ Added Figure 1–5. ■ Minor text edits.
November 2009	2.0	Updated for Arria II GX v9.1 release: ■ Updated Table 1–1, Table 1–4, Table 1–13, Table 1–14, Table 1–19, Table 1–15, Table 1–22, Table 1–24, and Table 1–28. ■ Added Table 1–6 and Table 1–33. ■ Added "Bus Hold" on page 1–5. ■ Added "IOE Programmable Delay" section. ■ Minor text edit.
June 2009	1.2	■ Updated Table 1–1, Table 1–3, Table 1–7, Table 1–8, Table 1–18, Table 1–23, Table 1–25, Table 1–26, Table 1–29, Table 1–30, Table 1–31, Table 1–32, and Table 1–33. ■ Added Table 1–32. ■ Updated Equation 1–1.
March 2009	1.1	Added "I/O Timing" section.
February 2009	1.0	Initial release.

2. Addendum to the Arria II GX Device Handbook

AIIGX53002-1.2

This chapter describes changes to the published version of the *Arria II GX Device Handbook*. All changes from Revision 1.1 of this chapter are now incorporated in the main handbook chapters.

Highlights

This information is now located in the *Arria II GX Device Family Overview* chapter.

High-Speed LVDS I/O with DPA and Soft CDR

This information is now located in the *Arria II GX Device Family Overview* chapter.

Auto-Calibrating External Memory Interfaces

This information is now located in the *Arria II GX Device Family Overview* chapter.

Guidelines for Connecting Serial Configuration Device to Arria II GX Device Family on AS Interface

This information is now located in the *Configuration, Design Security, and Remote System Upgrades in Arria II GX Devices* chapter.

Document Revision History

Table 2–1 lists the revision history for this chapter.

Table 2–1. Document Revision History

Date	Document Version	Changes Made
July 2010	1.2	■ Moved the "Highlights", "High-Speed LVDS I/O with DPA and Soft CDR", and "Auto-Calibrating External Memory Interfaces" sections to the *Arria II GX Device Family Overview* chapter. ■ Moved the "Guidelines for Connecting Serial Configuration Device to Arria II GX Device Family on AS Interface" section to the *Configuration, Design Security, and Remote System Upgrades in Arria II GX Devices* chapter
March 2010	1.1	Added "Guidelines for Connecting Serial Configuration Device to Arria II GX Device Family on AS Interface"
February 2010	1.0	Initial release.

About this Handbook

This handbook provides comprehensive information about the Altera Arria II GX family of devices.

How to Contact Altera

For the most up-to-date information about Altera products, see the following table.

Contact *(Note 1)*	Contact Method	Address
Technical support	Website	www.altera.com/support
Technical training	Website	www.altera.com/training
	Email	custrain@altera.com
Product literature	Website	www.altera.com/literature
Non-technical support (General)	Email	nacomp@altera.com
(Software Licensing)	Email	authorization@altera.com

Note:

(1) You can also contact your local Altera sales office or sales representative.

Typographic Conventions

The following table shows the typographic conventions that this document uses.

Visual Cue	Meaning
Bold Type with Initial Capital Letters	Indicates command names and dialog box titles. For example, **Save As** dialog box.
bold type	Indicates directory names, project names, disk drive names, file names, file name extensions, dialog box options, software utility names, and other GUI labels. For example, **\qdesigns** directory, **d:** drive, and **chiptrip.gdf** file.
Italic Type with Initial Capital Letters	Indicates document titles. For example, *AN 519: Stratix IV Design Guidelines.*
Italic type	Indicates variables. For example, *n* + 1. Variable names are enclosed in angle brackets (< >). For example, *<file name>* and *<project name>***.pof** file.
Initial Capital Letters	Indicates keyboard keys and menu names. For example, Delete key and the Options menu.
"Subheading Title"	Quotation marks indicate references to sections within a document and titles of Quartus II Help topics. For example, "Typographic Conventions."

Visual Cue	Meaning
`Courier type`	Indicates signal, port, register, bit, block, and primitive names. For example, `data1`, `tdi`, and `input`. Active-low signals are denoted by suffix n. For example, `resetn`. Indicates command line commands and anything that must be typed exactly as it appears. For example, `c:\qdesigns\tutorial\chiptrip.gdf`. Also indicates sections of an actual file, such as a Report File, references to parts of files (for example, the AHDL keyword `SUBDESIGN`), and logic function names (for example, `TRI`).
1., 2., 3., and a., b., c., and so on.	Numbered steps indicate a list of items when the sequence of the items is important, such as the steps listed in a procedure.
■ ■	Bullets indicate a list of items when the sequence of the items is not important.
	The hand points to information that requires special attention.
	A caution calls attention to a condition or possible situation that can damage or destroy the product or your work.
	A warning calls attention to a condition or possible situation that can cause you injury.
↵	The angled arrow instructs you to press **Enter**.
	The feet direct you to more information about a particular topic.