



Kintex UltraScale+ FPGAs Data Sheet: DC and AC Switching Characteristics (DS922)

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Summary

The AMD Kintex™ UltraScale+™ FPGAs are available in -3, -2, -1 speed grades, with -3E devices having the highest performance. The -2LE and -1LI devices can operate at a V_{CCINT} voltage at 0.85V or 0.72V and provide lower maximum static power. When operated at $V_{CCINT} = 0.85V$, using -2LE and -1LI devices, the speed specification for the L devices is the same as the -2I or -1I speed grades. When operated at $V_{CCINT} = 0.72V$, the -2LE and -1LI performance and static and dynamic power is reduced.

DC and AC characteristics are specified in extended (E), industrial (I), and military (M) temperature ranges. Except the operating temperature range or unless otherwise noted, all the DC and AC electrical parameters are the same for a particular speed grade (that is, the timing characteristics of a -1 speed grade extended device are the same as for a -1 speed grade industrial device). However, only selected speed grades and/or devices are available in each temperature range.

The XQ references in this data sheet are specific to the devices available in XQ Ruggedized packages. See the *Defense-Grade UltraScale Architecture Data Sheet: Overview (DS895)* for further information on XQ Defense-grade part numbers, packages, and ordering information. All supply voltage and junction temperature specifications are representative of worst-case conditions. The parameters included are common to popular designs and typical applications. This data sheet, part of an overall set of documentation on the Kintex UltraScale+ FPGAs, is available on the [AMD Technical Information Portal](#).

DC Characteristics

Absolute Maximum Ratings

Table: Absolute Maximum Ratings

Symbol	Description ¹	Min	Max	Units
FPGA Logic				
V_{CCINT}	Internal supply voltage	-0.500	1.000	V
V_{CCINT_IO} ²	Internal supply voltage for the I/O banks	-0.500	1.000	V
V_{CCAUX}	Auxiliary supply voltage	-0.500	2.000	V
V_{CCBRAM}	Supply voltage for the block RAM and UltraRAM	-0.500	1.000	V

Symbol	Description ¹	Min	Max	Units
V _{CCO}	Output drivers supply voltage for HD I/O banks	-0.500	3.400	V
	Output drivers supply voltage for HP I/O banks and configuration bank 0	-0.500	2.000	V
V _{CCAUX_IO} 3	Auxiliary supply voltage for the I/O banks	-0.500	2.000	V
V _{REF}	Input reference voltage for HP I/O banks	-0.500	2.000	V
V _{IN} ^{4, 5, 6, 7}	I/O input voltage for HD I/O banks	-0.550	V _{CCO} + 0.550	V
	I/O input voltage for HP I/O banks	-0.550	V _{CCO} + 0.550	V
V _{BATT}	Key memory battery backup supply	-0.500	2.000	V
I _{DC}	Available output current at the pad	-20	20	mA
I _{RMS}	Available RMS output current at the pad	-20	20	mA
GTH or GTY Transceiver ⁸				
V _{MGTAVCC}	Analog supply voltage for transceiver circuits	-0.500	1.000	V
V _{MGTAVTT}	Analog supply voltage for transceiver termination circuits	-0.500	1.300	V
V _{MGTVCCAUX}	Auxiliary analog Quad PLL (QPLL) voltage supply for transceivers	-0.500	1.900	V
V _{MGTREFCLK}	Transceiver reference clock absolute input voltage	-0.500	1.300	V
V _{MGTAVTTRCAL}	Analog supply voltage for the resistor calibration circuit of the transceiver column	-0.500	1.300	V
V _{IN}	Receiver (RXP/RXN) and transmitter (TXP/TXN) absolute input voltage	-0.500	1.200	V
I _{DCIN-FLOAT}	DC input current for receiver input pins DC coupled RX termination = floating ⁹	-	10	mA
I _{DCIN-MGTAVTT}	DC input current for receiver input pins DC coupled RX termination = V _{MGTAVTT}	-	10	mA

Symbol	Description ¹	Min	Max	Units
I _{DCIN-GND}	DC input current for receiver input pins DC coupled RX termination = GND ¹⁰	–	0	mA
I _{DCIN-PROG}	DC input current for receiver input pins DC coupled RX termination = programmable ¹¹	–	0	mA
I _{DCOUT-FLOAT}	DC output current for transmitter pins DC coupled RX termination = floating	–	6	mA
I _{DCOUT-MGTAVTT}	DC output current for transmitter pins DC coupled RX termination = V _{MGTAVTT}	–	6	mA
System Monitor				
V _{CCADC}	System Monitor supply relative to GNDADC	–0.500	2.000	V
V _{REFP}	System Monitor reference input relative to GNDADC	–0.500	2.000	V
Temperature ¹²				
T _{STG}	Storage temperature (ambient)	–65	150	°C
T _{SOL}	Maximum dry rework soldering temperature	–	260	°C
	Maximum reflow soldering temperature for SFVB784, FFVA676, and FFVB676 packages	–	250	°C
	Maximum reflow soldering temperature for FFVD900, FFVE900, FFVA1156, FFVE1517, FFVA1760, FFVE1760, FFVJ1760, and FFVB2104 packages	–	245	°C
	Maximum reflow soldering temperature for the FFRB676, SFRB784, FFRA1156, and FFRE1517 packages	–	225	°C
T _j	Maximum junction temperature	–	125	°C

1. Stresses beyond those listed under Absolute Maximum Ratings might cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those listed under Operating Conditions

Symbol	Description ¹	Min	Max	Units
	<p>is not implied. Exposure to Absolute Maximum Ratings conditions for extended periods of time might affect device reliability.</p> <ol style="list-style-type: none"> V_{CCINT_IO} must be connected to V_{CCBRAM}. V_{CCAUX_IO} must be connected to V_{CCAUX}. The lower absolute voltage specification always applies. For I/O operation, see the <i>UltraScale Architecture SelectIO Resources User Guide (UG571)</i>. When operating outside of the recommended operating conditions, refer to Table 1 and Table 2 for maximum overshoot and undershoot specifications. V_{IN} for the POR_OVERRIDE pin is unique. POR_OVERRIDE must be connected to either GND (default) or V_{CCINT}. See T_{POR} in Configuration Switching Characteristics for additional information. For more information on supported GTH or GTY transceiver terminations see the <i>UltraScale Architecture GTH Transceivers User Guide (UG576)</i> or <i>UltraScale Architecture GTY Transceivers User Guide (UG578)</i>. AC coupled operation is not supported for RX termination = floating. For GTY transceivers, DC coupled operation is not supported for RX termination = GND. DC coupled operation is not supported for RX termination = programmable. For soldering guidelines and thermal considerations, see the <i>UltraScale and UltraScale+ FPGAs Packaging and Pinouts Product Specification (UG575)</i>. 			

Recommended Operating Conditions

Table: Recommended Operating Conditions

Symbol	Description ^{1, 2}	Min	Typ	Max	Units
FPGA Logic					
V_{CCINT}	Internal supply voltage	0.825	0.850	0.876	V
	For -1LI and -2LE ($V_{CCINT} = 0.72V$) devices: internal supply voltage	0.698	0.720	0.742	V
	For -3E devices: internal supply voltage	0.873	0.900	0.927	V
V_{CCINT_IO} ³	Internal supply voltage for the I/O banks	0.825	0.850	0.876	V
	For -1LI and -2LE ($V_{CCINT} = 0.72V$) devices: internal supply voltage for the I/O banks	0.825	0.850	0.876	V

Symbol	Description ^{1, 2}	Min	Typ	Max	Units
	For -3E devices: internal supply voltage for the I/O banks	0.873	0.900	0.927	V
V _{CCBRAM}	Block RAM and UltraRAM supply voltage	0.825	0.850	0.876	V
	For -3E devices: block RAM and UltraRAM supply voltage	0.873	0.900	0.927	V
V _{CCAUX}	Auxiliary supply voltage	1.746	1.800	1.854	V
V _{CCO} ⁴	Supply voltage for HD I/O banks ⁵	1.140	–	3.400	V
	Supply voltage for HP I/O banks and configuration bank 0 ⁶	0.950	–	1.900	V
V _{CCAUX_IO} ⁷	Auxiliary I/O supply voltage	1.746	1.800	1.854	V
V _{IN} ^{8, 9}	I/O input voltage	– 0.200	–	V _{CCO} + 0.200	V
I _{IN} ¹⁰	Maximum current through any pin in a powered or unpowered bank when forward biasing the clamp diode	–	–	10	mA
V _{BATT} ¹¹	Battery voltage	1.000	–	1.890	V
GTH or GTY Transceiver					
V _{MGTAVCC} ¹²	Analog supply voltage for the GTH or GTY transceiver	0.873	0.900	0.927	V
V _{MGTAVTT} ¹²	Analog supply voltage for the GTH or GTY transmitter and receiver termination circuits	1.164	1.200	1.236	V
V _{MGTVCCAUX} ¹²	Auxiliary analog QPLL voltage supply for the transceivers	1.746	1.800	1.854	V
V _{MGTAVTTRCAL} ¹²	Analog supply voltage for the resistor calibration circuit of the GTH or GTY transceiver column	1.164	1.200	1.236	V
System Monitor					

Symbol	Description ^{1, 2}	Min	Typ	Max	Units
V _{CCADC}	System Monitor supply relative to GNDADC	1.746	1.800	1.854	V
V _{REFP}	System Monitor externally supplied reference voltage relative to GNDADC	1.200	1.250	1.300	V
Temperature					
T _j ¹³	Junction temperature operating range for extended (E) temperature devices ¹⁴	0	–	100	°C
	Junction temperature operating range for industrial (I) temperature devices	– 40	–	100	°C
	Junction temperature operating range for military (M) temperature devices	– 55	–	125	°C
	Junction temperature operating range for eFUSE programming ¹⁵	– 40	–	125	°C

1. All voltages are relative to GND, assuming supplies are present.
2. For the design of the power distribution system consult the *UltraScale Architecture PCB Design User Guide (UG583)*.
3. V_{CCINT_IO} must be connected to V_{CCBRAM}.
4. For V_{CCO_0}, the recommended nominal operating voltage is 1.5V or 1.8V, and the minimum voltage for power on and during configuration is 1.425V. After configuration, data is retained even if V_{CCO} drops to 0V.
5. Includes V_{CCO} of 1.2V, 1.35V, 1.5V, 1.8V, and 2.5V at ±5%, and 3.3V at +3/–5%.
6. Includes V_{CCO} of 1.0V, 1.2V, 1.35V, 1.5V, and 1.8V at ±5%.
7. V_{CCAUX_IO} must be connected to V_{CCAUX}.
8. The lower absolute voltage specification always applies.
9. V_{IN} for the POR_OVERRIDE pin is unique. POR_OVERRIDE must be connected to either GND (default) or V_{CCINT}. See T_{POR} in Configuration Switching Characteristics for additional information.
10. A total of 200 mA per bank should not be exceeded.
11. If battery is not used, connect V_{BATT} to either GND or V_{CCAUX}.
12. Each voltage listed requires filtering as described in the *UltraScale Architecture GTH Transceivers User Guide (UG576)* or the *UltraScale Architecture GTY Transceivers User Guide (UG578)*.
13. AMD recommends measuring the T_j of a device using the system monitor as described in the *UltraScale Architecture System Monitor User Guide (UG580)*. The system monitor temperature measurement errors (that are described in Table 1) must be accounted for

Symbol	Description ^{1, 2}	Min	Typ	Max	Units
	<p>in your design. For example, when using the system monitor with an external reference of 1.25V, and when the system monitor reports 97°C, there is a measurement error $\pm 3^\circ\text{C}$. A reading of 97°C is considered the maximum adjusted T_j ($100^\circ\text{C} - 3^\circ\text{C} = 97^\circ\text{C}$).</p> <p>14. Devices labeled with the speed/temperature grade of -2LE can operate for a limited time at a junction temperature between 100°C and 110°C. Timing parameters adhere to the same speed file at 110°C as they do below 110°C, regardless of operating voltage (nominal voltage of 0.85V or a low-voltage of 0.72V). Operation up to $T_j = 110^\circ\text{C}$ is limited to 1% of the device lifetime and can occur sequentially or at regular intervals as long as the total time does not exceed 1% of the device lifetime.</p> <p>15. Do not program eFUSE during device configuration (e.g., during configuration, during configuration readback, or when readback CRC is active).</p>				

DC Characteristics Over Recommended Operating Conditions

Table: DC Characteristics Over Recommended Operating Conditions

Symbol	Description	Min	Typ ¹	Max	Units
V_{DRINT}	Data retention V_{CCINT} voltage (below which configuration data might be lost)	0.68	–	–	V
V_{DRAUX}	Data retention V_{CCAUX} voltage (below which configuration data might be lost)	1.5	–	–	V
I_{REF}	V_{REF} leakage current per pin	–	–	15	μA
I_{L}	Input or output leakage current per pin (HD I/O and HP I/O ²) (sample-tested)	–	–	15	μA
C_{IN}^3	Die input capacitance at the pad (HP I/O)	–	–	3.1	pF
	Die input capacitance at the pad (HD I/O)	–	–	4.75	pF
I_{RPU}	Pad pull-up (when selected) at $V_{\text{IN}} = 0\text{V}$, $V_{\text{CCO}} = 3.3\text{V}$	75	–	190	μA
	Pad pull-up (when selected) at $V_{\text{IN}} = 0\text{V}$, $V_{\text{CCO}} = 2.5\text{V}$	50	–	169	μA
	Pad pull-up (when selected) at $V_{\text{IN}} = 0\text{V}$, $V_{\text{CCO}} = 1.8\text{V}$	60	–	120	μA

Symbol	Description	Min	Typ ¹	Max	Units
	Pad pull-up (when selected) at $V_{IN} = 0V$, $V_{CCO} = 1.5V$	30	–	120	μA
	Pad pull-up (when selected) at $V_{IN} = 0V$, $V_{CCO} = 1.2V$	10	–	100	μA
I_{RPD}	Pad pull-down (when selected) at $V_{IN} = 3.3V$	60	–	200	μA
	Pad pull-down (when selected) at $V_{IN} = 1.8V$	29	–	120	μA
$I_{CCADCON}$	Analog supply current for the SYSMON circuits in the power-up state	–	–	8	mA
$I_{CCADCOFF}$	Analog supply current for the SYSMON circuits in the power-down state	–	–	1.5	mA
$I_{BATT}^{4, 5}$	Battery supply current at $V_{BATT} = 1.89V$	–	–	650	nA
	Battery supply current at $V_{BATT} = 1.20V$	–	–	150	nA
I_{PFS}^6	V_{CCAUX} additional supply current during eFUSE programming	–	–	115	mA
Internal V_{REF}	50% V_{CCO}	$V_{CCO} \times$ 0.49	$V_{CCO} \times$ 0.50	$V_{CCO} \times$ 0.51	V
	70% V_{CCO}	$V_{CCO} \times$ 0.69	$V_{CCO} \times$ 0.70	$V_{CCO} \times$ 0.71	V
Differential termination	Programmable differential termination (TERM_100) for HP I/O banks	–35%	100	+35%	Ω
n	Temperature diode ideality factor	–	1.026	–	–
r	Temperature diode series resistance	–	2	–	Ω
Calibrated programmable on-die termination (DCI) in HP I/O banks ⁷ (measured per JEDEC specification)					
R^9	Thevenin equivalent resistance of programmable input termination to $V_{CCO}/2$ where $ODT = RTT_{40}$	–10% 8	40	+10% 8	Ω

Symbol	Description	Min	Typ ¹	Max	Units
	Thevenin equivalent resistance of programmable input termination to $V_{CCO}/2$ where ODT = RTT_48	-10% 8	48	+10% 8	Ω
	Thevenin equivalent resistance of programmable input termination to $V_{CCO}/2$ where ODT = RTT_60	-10% 8	60	+10% 8	Ω
	Programmable input termination to V_{CCO} where ODT = RTT_40	-10% 8	40	+10% 8	Ω
	Programmable input termination to V_{CCO} where ODT = RTT_48	-10% 8	48	+10% 8	Ω
	Programmable input termination to V_{CCO} where ODT = RTT_60	-10% 8	60	+10% 8	Ω
	Programmable input termination to V_{CCO} where ODT = RTT_120	-10% 8	120	+10% 8	Ω
	Programmable input termination to V_{CCO} where ODT = RTT_240	-10% 8	240	+10% 8	Ω
Uncalibrated programmable on-die termination in HP I/Os banks (measured per JEDEC specification)					
R ⁹	Thevenin equivalent resistance of programmable input termination to $V_{CCO}/2$ where ODT = RTT_40	-50%	40	+50%	Ω
	Thevenin equivalent resistance of programmable input termination to $V_{CCO}/2$ where ODT = RTT_48	-50%	48	+50%	Ω
	Thevenin equivalent resistance of programmable input termination to $V_{CCO}/2$ where ODT = RTT_60	-50%	60	+50%	Ω
	Programmable input termination to V_{CCO} where ODT = RTT_40	-50%	40	+50%	Ω
	Programmable input termination to V_{CCO} where ODT = RTT_48	-50%	48	+50%	Ω

Symbol	Description	Min	Typ ¹	Max	Units
	Programmable input termination to V_{CCO} where $ODT = RTT_{60}$	-50%	60	+50%	Ω
	Programmable input termination to V_{CCO} where $ODT = RTT_{120}$	-50%	120	+50%	Ω
	Programmable input termination to V_{CCO} where $ODT = RTT_{240}$	-50%	240	+50%	Ω
Uncalibrated programmable on-die termination in HD I/O banks (measured per JEDEC specification)					
R^9	Thevenin equivalent resistance of programmable input termination to $V_{CCO}/2$ where $ODT = RTT_{48}$	-50%	48	+50%	Ω

1. Typical values are specified at nominal voltage, 25°C.
2. For the HP I/O banks with a V_{CCO} of 1.8V and separated V_{CCO} and V_{CCAUX_IO} power supplies, the I_L maximum current is 70 μ A.
3. This measurement represents the die capacitance at the pad, not including the package.
4. Maximum value specified for worst case process at 25°C.
5. I_{BATT} is measured when the battery-backed RAM (BBRAM) is enabled.
6. Do not program eFUSE during device configuration (e.g., during configuration, during configuration readback, or when readback CRC is active).
7. VRP resistor tolerance is (240 Ω \pm 1%).
8. If VRP resides at a different bank (DCI cascade), the range increases to \pm 15%.
9. On-die input termination resistance, for more information see the *UltraScale Architecture SelectIO Resources User Guide (UG571)*.

VIN Maximum Allowed AC Voltage Overshoot and Undershoot

Table: V_{IN} Maximum Allowed AC Voltage Overshoot and Undershoot for HD I/O Banks

AC Voltage Overshoot ¹ of UI ² at -40°C to 100°C	% ³ Voltage Undershoot of UI ² at -40°C to 100°C
$V_{CCO} + 0.30$	100%
$V_{CCO} + 0.35$	90%

AC Voltage Overshoot	% ¹ of UI ² at –40°C to 100°C	AC Voltage Undershoot	% ¹ of UI ² at –40°C to 100°C
V _{CCO} + 0.40	100%	–0.40	78%
V _{CCO} + 0.45	100%	–0.45	40%
V _{CCO} + 0.50	100%	–0.50	24%
V _{CCO} + 0.55	100%	–0.55	18.0%
V _{CCO} + 0.60	100%	–0.60	13.0%
V _{CCO} + 0.65	100%	–0.65	10.8%
V _{CCO} + 0.70	92%	–0.70	9.0%
V _{CCO} + 0.75	92%	–0.75	7.0%
V _{CCO} + 0.80	92%	–0.80	6.0%
V _{CCO} + 0.85	92%	–0.85	5.0%
V _{CCO} + 0.90	92%	–0.90	4.0%
V _{CCO} + 0.95	92%	–0.95	2.5%

1. A total of 200 mA per bank should not be exceeded.
2. For UI smaller than 20 μs.
3. For the -1M devices, the temperature limits are –55°C to 125°C.

Table: V_{IN} Maximum Allowed AC Voltage Overshoot and Undershoot for HP I/O Banks

AC Voltage Overshoot	% ¹ of UI ² at –40°C to 100°C	AC Voltage Undershoot	% ¹ of UI ² at –40°C to 100°C
V _{CCO} + 0.30	100%	–0.30	100%
V _{CCO} + 0.35	100%	–0.35	100%
V _{CCO} + 0.40	92%	–0.40	92%
V _{CCO} + 0.45	50%	–0.45	50%
V _{CCO} + 0.50	20%	–0.50	20%
V _{CCO} + 0.55	10%	–0.55	10%
V _{CCO} + 0.60	6%	–0.60	6%

AC Voltage Overshoot ¹ of UI ² at –40°C to 100°C	% of UI ² at –40°C to 100°C	AC Voltage Undershoot ¹ of UI ² at –40°C to 100°C	% of UI ² at –40°C to 100°C
V _{CCO} + 0.65	2%	–0.65	2%
V _{CCO} + 0.70	2%	–0.70	2%

1. A total of 200 mA per bank should not be exceeded.
 2. For UI smaller than 20 μs.
 3. For the -1M devices, the temperature limits are –55°C to 125°C.

Quiescent Supply Current

Table: Typical Quiescent Supply Current

Symbol	Description ^{1, 2, 3}	Device	Speed Grade and V _{CCINT} Operating Voltages					Units
			0.90V		0.85V		0.72V	
			-3	-2	-1	-2	-1	
I _{CCINTQ}	Quiescent V _{CCINT} supply current	XCKU3P 1242	1181	1181	1037	1037	mA	
		XCKU5P 1242	1181	1181	1037	1037	mA	
		XCKU9P 1592	1523	1523	1356	1356	mA	
		XCKU11P1780	1693	1693	1486	1486	mA	
		XCKU13P1950	1864	1864	1658	1658	mA	
		XCKU15P2677	2559	2559	2275	2275	mA	
		XCKU19P6784	6480	6480	5758	5758	mA	
		XQKU5P N/A	1181	1181	N/A	1037	mA	
		XQKU15PN/A	2559	2559	N/A	2275	mA	
I _{CCINT_IOQ}	Quiescent V _{CCINT_IO} supply current	XCKU3P 61	59	59	59	59	mA	
		XCKU5P 61	59	59	59	59	mA	
		XCKU9P 61	59	59	59	59	mA	
		XCKU11P 120	115	115	115	115	mA	
		XCKU13P 61	59	59	59	59	mA	

Symbol	Description ^{1, 2, 3}	Device	Speed Grade and V _{CCINT} Operating Voltages					mA
			0.90V		0.85V		0.72V	
			-3	-2	-1	-2	-1	
		XCKU15P164	158	158	158	158	mA	
		XCKU19P234	226	226	226	226	mA	
		XQKU5P N/A	59	59	N/A	59	mA	
		XQKU15PN/A	158	158	N/A	158	mA	
I _{CCOQ}	Quiescent V _{CCO} supply current	All devices	1	1	1	1	1	mA
I _{CCAUXQ}	Quiescent V _{CCAUX} supply current	XCKU3P 153	153	153	153	153	153	mA
		XCKU5P 153	153	153	153	153	153	mA
		XCKU9P 227	227	227	227	227	227	mA
		XCKU11P 255	255	255	255	255	255	mA
		XCKU13P 266	266	266	266	266	266	mA
		XCKU15P 396	396	396	396	396	396	mA
		XCKU19P 735	735	735	735	735	735	mA
		XQKU5P N/A	153	153	N/A	153	mA	
		XQKU15PN/A	396	396	N/A	396	mA	
I _{CCAUX_IOQ}	Quiescent V _{CCAUX_IO} supply current	XCKU3P 32	32	32	32	32	32	mA
		XCKU5P 32	32	32	32	32	32	mA
		XCKU9P 33	33	33	33	33	33	mA
		XCKU11P 56	56	56	56	56	56	mA
		XCKU13P 33	33	33	33	33	33	mA
		XCKU15P 74	74	74	74	74	74	mA
		XCKU19P 100	100	100	100	100	100	mA
		XQKU5P N/A	32	32	N/A	32	mA	
		XQKU15PN/A	74	74	N/A	74	mA	

Symbol	Description ^{1, 2, 3}	Device	Speed Grade and V _{CCINT} Operating Voltages					Units
			0.90V	0.85V		0.72V		
			-3	-2	-1	-2	-1	
I _{CCBRAMQ}	Quiescent V _{CCBRAM} supply current	XCKU3P	18	17	17	17	17	mA
		XCKU5P	18	17	17	17	17	mA
		XCKU9P	25	24	24	24	24	mA
		XCKU11P	23	22	22	22	22	mA
		XCKU13P	29	28	28	28	28	mA
		XCKU15P	37	35	35	35	35	mA
		XCKU19P	66	63	63	63	63	mA
		XQKU5P	N/A	17	17	N/A	17	mA
		XQKU15P	N/A	74	74	N/A	74	mA

1. Typical values are specified at nominal voltage, 85°C junction temperatures (T_j) with single-ended SelectIO™ resources.
2. Typical values are for blank configured devices with no output current loads, no active input pull-up resistors, and all I/O pins are 3-state and floating.
3. Use the Xilinx Power Estimator (XPE) spreadsheet tool (download at www.xilinx.com/power) to estimate static power consumption for conditions or supplies other than those specified.

Power Supply Sequencing

Power-On/Off Power Supply Sequencing

The recommended power-on sequence is V_{CCINT}, V_{CCINT_IO}/V_{CCBRAM}, V_{CCAUX}/V_{CCAUX_IO}, and V_{CCO} to achieve minimum current draw and ensure that the I/Os are 3-stated at power-on. The recommended power-off sequence is the reverse of the power-on sequence. If V_{CCINT} and V_{CCINT_IO}/V_{CCBRAM} have the same recommended voltage levels, they can be powered by the same supply and ramped simultaneously. V_{CCINT_IO} must be connected to V_{CCBRAM}. If V_{CCAUX}/V_{CCAUX_IO} and V_{CCO} have the same recommended voltage levels, they can be powered by the same supply and ramped simultaneously. V_{CCAUX} and V_{CCAUX_IO} must be

connected together. V_{CCADC} and V_{REF} can be powered at any time and have no power-up sequencing requirements.

The recommended power-on sequence to achieve minimum current draw for the GTH or GTY transceivers is V_{CCINT} , $V_{MGTAVCC}$, $V_{MGTAVTT}$ OR $V_{MGTAVCC}$, V_{CCINT} , $V_{MGTAVTT}$. There is no recommended sequencing for $V_{MGTAVCCAUX}$. Both $V_{MGTAVCC}$ and V_{CCINT} can be ramped simultaneously. The recommended power-off sequence is the reverse of the power-on sequence to achieve minimum current draw. If these recommended sequences are not met, current drawn from $V_{MGTAVTT}$ can be higher than specifications during power-up and power-down.

Power Supply Requirements

Table 1 shows the minimum current, in addition to I_{CCOQ} maximum, required by each Kintex UltraScale+ FPGA for proper power-on and configuration. If these current minimums are met, the device powers on after all supplies have passed through their power-on reset threshold voltages. The device must not be configured until after V_{CCINT} is applied. Once initialized and configured, use the Xilinx Power Estimator (XPE) spreadsheet tool (download at www.amd.com/power) to estimate current drain on these supplies. XPE is also used to estimate power-on current for all supplies.

Table: Power-on Current by Device

Device	$I_{CCINTMIN}$	$I_{CCINT_IOMIN} + I_{CCBRAMMIN}$	I_{CCOMIN}	$I_{CCAUXMIN} + I_{CCAUX_IOMIN}$	Units
XCKU3P	$I_{CCINTQ} + 770$	$I_{CCBRAMQ} + I_{CCINT_IOQ} + 229$	$I_{CCOQ} + 50$	$I_{CCAUXQ} + I_{CCAUX_IOQ} + 386$	mA
XCKU5P XQKU5P	$I_{CCINTQ} + 770$	$I_{CCBRAMQ} + I_{CCINT_IOQ} + 305$	$I_{CCOQ} + 50$	$I_{CCAUXQ} + I_{CCAUX_IOQ} + 515$	mA
XCKU9P	$I_{CCINTQ} + 1800$	$I_{CCBRAMQ} + I_{CCINT_IOQ} + 600$	$I_{CCOQ} + 50$	$I_{CCAUXQ} + I_{CCAUX_IOQ} + 650$	mA
XCKU11P	$I_{CCINTQ} + 1961$	$I_{CCBRAMQ} + I_{CCINT_IOQ} + 654$	$I_{CCOQ} + 55$	$I_{CCAUXQ} + I_{CCAUX_IOQ} + 709$	mA
XCKU13P	$I_{CCINTQ} + 2242$	$I_{CCBRAMQ} + I_{CCINT_IOQ} + 748$	$I_{CCOQ} + 63$	$I_{CCAUXQ} + I_{CCAUX_IOQ} + 810$	mA
XCKU15P XQKU15P	$I_{CCINTQ} + 3433$	$I_{CCBRAMQ} + I_{CCINT_IOQ} + 1145$	$I_{CCOQ} + 96$	$I_{CCAUXQ} + I_{CCAUX_IOQ} + 1240$	mA
XCKU19P	$I_{CCINTQ} + 5225$	$I_{CCBRAMQ} + I_{CCINT_IOQ} + 1751$	$I_{CCOQ} + 131$	$I_{CCAUXQ} + I_{CCAUX_IOQ} + 915$	mA

Table: Power Supply Ramp Time

Symbol	Description	Min	Max	Units
T_{VCCINT}	Ramp time from GND to 95% of V_{CCINT}	0.2	40	ms
T_{VCCINT_IO}	Ramp time from GND to 95% of V_{CCINT_IO}	0.2	40	ms
T_{VCCO}	Ramp time from GND to 95% of V_{CCO}	0.2	40	ms
T_{VCCAUX}	Ramp time from GND to 95% of V_{CCAUX}	0.2	40	ms
$T_{VCCBRAM}$	Ramp time from GND to 95% of V_{CCBRAM}	0.2	40	ms
$T_{MGTAVCC}$	Ramp time from GND to 95% of $V_{MGTAVCC}$	0.2	40	ms
$T_{MGTAVTT}$	Ramp time from GND to 95% of $V_{MGTAVTT}$	0.2	40	ms
$T_{MGTVCCAUX}$	Ramp time from GND to 95% of $V_{MGTVCCAUX}$	0.2	40	ms

DC Input and Output Levels

Values for V_{IL} and V_{IH} are recommended input voltages. Values for I_{OL} and I_{OH} are guaranteed over the recommended operating conditions at the V_{OL} and V_{OH} test points. Only selected standards are tested. These are chosen to ensure that all standards meet their specifications. The selected standards are tested at a minimum V_{CCO} with the respective V_{OL} and V_{OH} voltage levels shown. Other standards are sample tested.

I/O Levels

Table: SelectIO DC Input and Output Levels For HD I/O Banks

I/O Standard ^{1, 2}	V_{IL}		V_{IH}		V_{OL}	V_{OH}	I_{OL}	I_{OH}
	V, Min	V, Max	V, Min	V, Max	V, Max	V, Min	mA	mA
HSTL_I	– 0.300	$V_{REF} - 0.100$	$V_{REF} + 0.100$	$V_{CCO} + 0.300$	0.400	$V_{CCO} - 0.400$	8.0	– 8.0
HSTL_I_18	– 0.300	$V_{REF} - 0.100$	$V_{REF} + 0.100$	$V_{CCO} + 0.300$	0.400	$V_{CCO} - 0.400$	8.0	– 8.0
HSUL_12	– 0.300	$V_{REF} - 0.130$	$V_{REF} + 0.130$	$V_{CCO} + 0.300$	20% V_{CCO}	80% V_{CCO}	0.1	– 0.1

I/O Standard ^{1, 2}	V _{IL}		V _{IH}		V _{OL}	V _{OH}	I _{OL}	I _{OH}
	V, Min	V, Max	V, Min	V, Max	V, Max	V, Min	mA	mA
LVC MOS12	– 0.300	35% V _{CCO}	65% V _{CCO}	V _{CCO} + 0.300 0.400	0.400	V _{CCO} – 0.400	Note 3	Note 3
LVC MOS15	– 0.300	35% V _{CCO}	65% V _{CCO}	V _{CCO} + 0.300 0.450	0.450	V _{CCO} – 0.450	Note 4	Note 4
LVC MOS18	– 0.300	35% V _{CCO}	65% V _{CCO}	V _{CCO} + 0.300 0.450	0.450	V _{CCO} – 0.450	Note 4	Note 4
LVC MOS25	– 0.300	0.700	1.700	V _{CCO} + 0.300 0.400	0.400	V _{CCO} – 0.400	Note 4	Note 4
LVC MOS33	– 0.300	0.800	2.000	3.400	0.400	V _{CCO} – 0.400	Note 4	Note 4
LVTTL	– 0.300	0.800	2.000	3.400	0.400	2.400	Note 4	Note 4
SSTL12	– 0.300	V _{REF} – 0.100	V _{REF} + 0.100	V _{CCO} + 0.300 0.150	V _{CCO} /2 – 0.150	V _{CCO} /2 + 0.150	0.150	– 14.25
SSTL135	– 0.300	V _{REF} – 0.090	V _{REF} + 0.090	V _{CCO} + 0.300 0.150	V _{CCO} /2 – 0.150	V _{CCO} /2 + 0.150	0.150	– 8.9
SSTL135_II	– 0.300	V _{REF} – 0.090	V _{REF} + 0.090	V _{CCO} + 0.300 0.150	V _{CCO} /2 – 0.150	V _{CCO} /2 + 0.150	0.150	– 13.0
SSTL15	– 0.300	V _{REF} – 0.100	V _{REF} + 0.100	V _{CCO} + 0.300 0.175	V _{CCO} /2 – 0.175	V _{CCO} /2 + 0.175	0.175	– 8.9
SSTL15_II	– 0.300	V _{REF} – 0.100	V _{REF} + 0.100	V _{CCO} + 0.300 0.175	V _{CCO} /2 – 0.175	V _{CCO} /2 + 0.175	0.175	– 13.0
SSTL18_I	– 0.300	V _{REF} – 0.125	V _{REF} + 0.125	V _{CCO} + 0.300 0.470	V _{CCO} /2 – 0.470	V _{CCO} /2 + 0.470	0.470	– 8.0
SSTL18_II	– 0.300	V _{REF} – 0.125	V _{REF} + 0.125	V _{CCO} + 0.300 0.600	V _{CCO} /2 – 0.600	V _{CCO} /2 + 0.600	0.600	– 13.4

1. Tested according to relevant specifications.
2. Standards specified using the default I/O standard configuration. For details, see the *UltraScale Architecture SelectIO Resources User Guide (UG571)*.

I/O Standard ^{1, 2}	V _{IL}		V _{IH}		V _{OL}	V _{OH}	I _{OL}	I _{OH}
	V, Min	V, Max	V, Min	V, Max	V, Max	V, Min	mA	mA
3. Supported drive strengths of 4, 8, or 12 mA in HD I/O banks.								
4. Supported drive strengths of 4, 8, 12, or 16 mA in HD I/O banks.								

Table: SelectIO DC Input and Output Levels for HP I/O Banks

I/O Standard ^{1, 2, 3}	V _{IL}		V _{IH}		V _{OL}	V _{OH}	I _{OL}	I _{OH}
	V, Min	V, Max	V, Min	V, Max	V, Max	V, Min	mA	mA
HSTL_I	– 0.300	V _{REF} – 0.100	V _{REF} + 0.100	V _{CCO} + 0.300	0.400	V _{CCO} – 0.400	5.8	– 5.8
HSTL_I_12	– 0.300	V _{REF} – 0.080	V _{REF} + 0.080	V _{CCO} + 0.300	0.25V _{CCO}	75% V _{CCO}	4.1	– 4.1
HSTL_I_18	– 0.300	V _{REF} – 0.100	V _{REF} + 0.100	V _{CCO} + 0.300	0.400	V _{CCO} – 0.400	6.2	– 6.2
HSUL_12	– 0.300	V _{REF} – 0.130	V _{REF} + 0.130	V _{CCO} + 0.300	0.20V _{CCO}	80% V _{CCO}	0.1	– 0.1
LVC MOS12	– 0.300	35% V _{CCO}	65% V _{CCO}	V _{CCO} + 0.300	0.400	V _{CCO} – 0.400	Note 4	Note 4
LVC MOS15	– 0.300	35% V _{CCO}	65% V _{CCO}	V _{CCO} + 0.300	0.450	V _{CCO} – 0.450	Note 5	Note 5
LVC MOS18	– 0.300	35% V _{CCO}	65% V _{CCO}	V _{CCO} + 0.300	0.450	V _{CCO} – 0.450	Note 5	Note 5
LVDCI_15	– 0.300	35% V _{CCO}	65% V _{CCO}	V _{CCO} + 0.300	0.450	V _{CCO} – 0.450	7.0	– 7.0
LVDCI_18	– 0.300	35% V _{CCO}	65% V _{CCO}	V _{CCO} + 0.300	0.450	V _{CCO} – 0.450	7.0	– 7.0
SSTL12	– 0.300	V _{REF} – 0.100	V _{REF} + 0.100	V _{CCO} + 0.300	V _{CCO} /2 – 0.150	V _{CCO} /2 + 0.150	8.5	– 8.0
SSTL135	– 0.300	V _{REF} – 0.090	V _{REF} + 0.090	V _{CCO} + 0.300	V _{CCO} /2 – 0.150	V _{CCO} /2 + 0.150	9.5	– 9.0

I/O Standard ^{1, 2, 3}	V _{IL}		V _{IH}		V _{OL}	V _{OH}	I _{OL}	I _{OH}
	V, Min	V, Max	V, Min	V, Max	V, Max	V, Min	mA	mA
SSTL15	– 0.300	V _{REF} – 0.100	V _{REF} + 0.100	V _{CCO} + 0.300	V _{CCO} /2 – 0.175	V _{CCO} /2 + 0.175	– 10.0	– 10.0
SSTL18_I	– 0.300	V _{REF} – 0.125	V _{REF} + 0.125	V _{CCO} + 0.300	V _{CCO} /2 – 0.470	V _{CCO} /2 + 0.470	– 7.0	– 7.0
MIPI_DPHY_ DCI_LP ⁶	– 0.300	0.550	0.880 ⁷	V _{CCO} + 0.300	0.050	1.100	0.01	– 0.01

1. Tested according to relevant specifications.
2. Standards specified using the default I/O standard configuration. For details, see the *UltraScale Architecture SelectIO Resources User Guide (UG571)*.
3. POD10 and POD12 DC input and output levels are shown in Table 3, Table 8, and Table 9.
4. Supported drive strengths of 2, 4, 6, or 8 mA in HP I/O banks.
5. Supported drive strengths of 2, 4, 6, 8, or 12 mA in HP I/O banks.
6. Low-power option for MIPI_DPHY_DCI.
7. When operating at data rates greater than 1500 Mb/s, the minimum V_{IH} is 0.790V. MIPI D-PHY data rates are outlined in Table 3 .

Table: DC Input Levels for Single-ended POD10 and POD12 I/O Standards

I/O Standard ^{1, 2}	V _{IL}		V _{IH}	
	V, Min	V, Max	V, Min	V, Max
POD10	–0.300	V _{REF} – 0.068	V _{REF} + 0.068	V _{CCO} + 0.300
POD12	–0.300	V _{REF} – 0.068	V _{REF} + 0.068	V _{CCO} + 0.300

1. Tested according to relevant specifications.
2. Standards specified using the default I/O standard configuration. For details, see the *UltraScale Architecture SelectIO Resources User Guide (UG571)*.

Table: Differential SelectIO DC Input and Output Levels

I/O Standard	V _{ICM} (V) ¹			V _{ID} (V) ²			V _{ILHS} ³	V _{IHHS} ³	V _{OCM} (V) ⁴			V _{OD} (V) ⁵		
	Min	Typ	Max	Min	Typ	Max	Min	Max	Min	Typ	Max	Min	Typ	Max

I/O Standard	V _{ICM} (V) ¹			V _{ID} (V) ²			V _{ILHS} ³	V _{IHHS} ³	V _{OCM} (V) ⁴			V _{OD} (V) ⁵		
	Min	Typ	Max	Min	Typ	Max	Min	Max	Min	Typ	Max	Min	Typ	Max
SUB_LVDS ⁸	0.500	0.900	1.300	0.070	–	–	–	–	0.700	0.900	1.100	1.000	1.150	1.200
LVPECL	0.300	1.200	1.425	0.100	0.350	0.600	–	–	–	–	–	–	–	–
SLVS_400_18	0.070	0.200	0.330	0.140	–	0.450	–	–	–	–	–	–	–	–
SLVS_400_25	0.070	0.200	0.330	0.140	–	0.450	–	–	–	–	–	–	–	–
MIPI_DPHY_DCI_HS ^{9, 10}	0.070	–	0.330	0.070	–	–	–	0.460	0.150	0.200	0.250	0.140	0.200	0.270

1. V_{ICM} is the input common mode voltage.
2. V_{ID} is the input differential voltage (Q – \bar{Q}).
3. V_{IHHS} and V_{ILHS} are the single-ended input high and low voltages, respectively.
4. V_{OCM} is the output common mode voltage.
5. V_{OD} is the output differential voltage (Q – \bar{Q}).
6. LVDS_25 is specified in Table 1.
7. LVDS is specified in Table 1.
8. The SUB_LVDS receiver is supported in HP I/O and HD I/O banks. The SUB_LVDS transmitter is supported only in HP I/O banks.
9. High-speed option for MIPI_DPHY_DCI. The V_{ID} maximum is aligned with the standard's specification. A higher V_{ID} is acceptable as long as the V_{IN} specification is also met.
10. When operating at data rates greater than 1500 Mb/s, the minimum V_{ID} is 0.040V. MIPI D-PHY data rates are outlined in Table 3 .

Table: Complementary Differential SelectIO DC Input and Output Levels for HD I/O Banks

I/O Standard	V _{ICM} (V) ¹			V _{ID} (V) ²		V _{OL} (V) ³	V _{OH} (V) ⁴	I _{OL}	I _{OH}
	Min	Typ	Max	Min	Max	Max	Min	mA	mA
DIFF_HSTL_I	0.300	0.750	1.125	0.100	–	0.400	V _{CC0} – 0.400	8.0	–8.0
DIFF_HSTL_I_18	0.300	0.900	1.425	0.100	–	0.400	V _{CC0} – 0.400	8.0	–8.0
DIFF_HSUL_120	0.300	0.600	0.850	0.100	–	20% V _{CC0}	80% V _{CC0}	0.1	–0.1

I/O Standard	V _{ICM} (V) ¹			V _{ID} (V) ²		V _{OL} (V) ³	V _{OH} (V) ⁴	I _{OL}	I _{OH}
	Min	Typ	Max	Min	Max	Max	Min	mA	mA
DIFF_SSTL12	0.300	0.600	0.850	0.100	–	(V _{CCO} /2) – 0.150	(V _{CCO} /2) + 0.150	4.25	– 14.25
DIFF_SSTL135	0.300	0.675	1.000	0.100	–	(V _{CCO} /2) – 0.150	(V _{CCO} /2) + 0.150	8.9	–8.9
DIFF_SSTL135_ID	0.300	0.675	1.000	0.100	–	(V _{CCO} /2) – 0.150	(V _{CCO} /2) + 0.150	13.0	–13.0
DIFF_SSTL15	0.300	0.750	1.125	0.100	–	(V _{CCO} /2) – 0.175	(V _{CCO} /2) + 0.175	8.9	–8.9
DIFF_SSTL15_ID	0.300	0.750	1.125	0.100	–	(V _{CCO} /2) – 0.175	(V _{CCO} /2) + 0.175	13.0	–13.0
DIFF_SSTL18_ID	0.300	0.900	1.425	0.100	–	(V _{CCO} /2) – 0.470	(V _{CCO} /2) + 0.470	8.0	–8.0
DIFF_SSTL18_ID	0.300	0.900	1.425	0.100	–	(V _{CCO} /2) – 0.600	(V _{CCO} /2) + 0.600	13.4	–13.4

1. V_{ICM} is the input common mode voltage.
 2. V_{ID} is the input differential voltage.
 3. V_{OL} is the single-ended low-output voltage.
 4. V_{OH} is the single-ended high-output voltage.

Table: Complementary Differential SelectIO DC Input and Output Levels for HP I/O Banks

I/O Standard	V _{ICM} (V) ²			V _{ID} (V) ³		V _{OL} (V) ⁴	V _{OH} (V) ⁵	I _{OL}	I _{OH}
	Min	Typ	Max	Min	Max	Max	Min	mA	mA
DIFF_HSTL_I	0.680	V _{CCO} /2	(V _{CCO} /2) + 0.150	0.100	–	0.400	V _{CCO} – 0.400	5.8	– 5.8
DIFF_HSTL_I	0.200 x V _{CCO}	V _{CCO} /2	0.600 x V _{CCO}	0.100	–	0.250 x V _{CCO}	0.750 x V _{CCO}	4.1	– 4.1
DIFF_HSTL_I	(V _{CCO} /2) – 0.175	V _{CCO} /2	(V _{CCO} /2) + 0.175	0.100	–	0.400	V _{CCO} – 0.400	6.2	– 6.2

I/O Standard ¹	V _{ICM} (V) ²			V _{ID} (V) ³		V _{OL} (V) ⁴	V _{OH} (V) ⁵	I _{OL}	I _{OH}
	Min	Typ	Max	Min	Max	Max	Min	mA	mA
DIFF_HSUL_10	(V _{CCO} /2) – 0.120	V _{CCO} /2	(V _{CCO} /2) + 0.120	0.000	–	20% V _{CCO}	80% V _{CCO}	0.1	– 0.1
DIFF_SSTL12	(V _{CCO} /2) – 0.150	V _{CCO} /2	(V _{CCO} /2) + 0.150	0.000	–	(V _{CCO} /2) – 0.150	(V _{CCO} /2) + 0.850	–	8.0
DIFF_SSTL13	(V _{CCO} /2) – 0.150	V _{CCO} /2	(V _{CCO} /2) + 0.150	0.000	–	(V _{CCO} /2) – 0.150	(V _{CCO} /2) + 0.850	–	9.0
DIFF_SSTL15	(V _{CCO} /2) – 0.175	V _{CCO} /2	(V _{CCO} /2) + 0.175	0.500	–	(V _{CCO} /2) – 0.175	(V _{CCO} /2) + 0.175	–	10.0
DIFF_SSTL18	(V _{CCO} /2) – 0.175	V _{CCO} /2	(V _{CCO} /2) + 0.175	0.500	–	(V _{CCO} /2) – 0.470	(V _{CCO} /2) + 0.470	–	7.0

1. DIFF_POD10 and DIFF_POD12 HP I/O bank specifications are shown in Table 7, Table 8, and Table 9.
 2. V_{ICM} is the input common mode voltage.
 3. V_{ID} is the input differential voltage.
 4. V_{OL} is the single-ended low-output voltage.
 5. V_{OH} is the single-ended high-output voltage.

Table: DC Input Levels for Differential POD10 and POD12 I/O Standards

I/O Standard ^{1, 2}	V _{ICM} (V)			V _{ID} (V)	
	Min	Typ	Max	Min	Max
DIFF_POD10	0.63	0.70	0.77	0.14	–
DIFF_POD12	0.76	0.84	0.92	0.16	–

1. Tested according to relevant specifications.
 2. Standards specified using the default I/O standard configuration. For details, see the *UltraScale Architecture SelectIO Resources User Guide (UG571)*.

Table: DC Output Levels for Single-ended and Differential POD10 and POD12 Standards

Symbol	Description ^{1, 2}	V _{OUT}	Min	Typ	Max	Units
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Symbol	Description ^{1, 2}	V _{OUT}	Min	Typ	Max	Units
R _{OL}	Pull-down resistance	V _{OM_DC} (as described in Table 9)	36	40	44	Ω
R _{OH}	Pull-up resistance	V _{OM_DC} (as described in Table 9)	36	40	44	Ω

1. Tested according to relevant specifications.
2. Standards specified using the default I/O standard configuration. For details, see the *UltraScale Architecture SelectIO Resources User Guide (UG571)*.

Table: Definitions for DC Output Levels for Single-ended and Differential POD10 and POD12 Standards

Symbol	Description	All Speed Grades	Units
V _{OM_DC}	DC output Mid measurement level (for IV curve linearity)	0.8 x V _{CCO}	V

LVDS DC Specifications (LVDS_25)

The LVDS_25 standard is available in the HD I/O banks. See the *UltraScale Architecture SelectIO Resources User Guide (UG571)* for more information.

Table: LVDS_25 DC Specifications

Symbol	DC Parameter	Min	Typ	Max	Units
V _{CCO} ¹	Supply voltage	2.375	2.500	2.625	V
V _{IDIFF}	Differential input voltage: (Q – \bar{Q}), Q = High (\bar{Q} – Q), \bar{Q} = High	100	350	600 ²	mV
V _{ICM}	Input common-mode voltage	0.300	1.200	1.425	V

1. LVDS_25 in HD I/O banks supports inputs only. LVDS_25 inputs without internal termination have no V_{CCO} requirements. Any V_{CCO} can be chosen as long as the input voltage levels do not violate the *Recommended Operating Condition* (Table 1) specification for the V_{IN} I/O pin voltage.
2. Maximum V_{IDIFF} value is specified for the maximum V_{ICM} specification. With a lower V_{ICM}, a higher V_{DIFF} is tolerated only when the recommended operating conditions and

Symbol	DC Parameter	Min	Typ	Max	Units
overshoot/undershoot V_{IN} specifications are maintained.					

LVDS DC Specifications (LVDS)

The LVDS standard is available in the HP I/O banks. See the *UltraScale Architecture SelectIO Resources User Guide (UG571)* for more information.

Table: LVDS DC Specifications

Symbol	DC Parameter	Conditions	Min	Typ	Max	Units
V_{CCO} ¹	Supply voltage		1.710	1.800	1.890	V
V_{ODIFF} ²	Differential output voltage: ($Q - \bar{Q}$), $Q = \text{High}$ ($\bar{Q} - Q$), $\bar{Q} = \text{High}$	$R_T = 100\Omega$ across Q and \bar{Q} signals	247	350	454	mV
V_{OCM} ²	Output common-mode voltage	$R_T = 100\Omega$ across Q and \bar{Q} signals	1.000	1.250	1.425	V
V_{IDIFF} ³	Differential input voltage: ($Q - \bar{Q}$), $Q = \text{High}$ ($\bar{Q} - Q$), $\bar{Q} = \text{High}$		100	350	600 ³	mV
V_{ICM_DC} ⁴	Input common-mode voltage (DC coupling)		0.300	1.200	1.425	V
V_{ICM_AC} ⁵	Input common-mode voltage (AC coupling)		0.600	–	1.100	V

1. In HP I/O banks, when LVDS is used with input-only functionality, it can be placed in a bank where the V_{CCO} levels are different from the specified level only if internal differential termination is not used. In this scenario, V_{CCO} must be chosen to ensure the input pin voltage levels do not violate the Recommended Operating Condition (Table 1) specification for the V_{IN} I/O pin voltage.
2. V_{OCM} and V_{ODIFF} values are for $LVDS_PRE_EMPHASIS = \text{FALSE}$.
3. Maximum V_{IDIFF} value is specified for the maximum V_{ICM} specification. With a lower V_{ICM} , a higher V_{DIFF} is tolerated only when the recommended operating conditions and overshoot/undershoot V_{IN} specifications are maintained.

Symbol	DC Parameter	Conditions	Min	Typ	Max	Units
	4. Input common mode voltage for DC coupled configurations. EQUALIZATION = EQ_NONE (Default). 5. External input common mode voltage specification for AC coupled configurations. EQUALIZATION = EQ_LEVEL0, EQ_LEVEL1, EQ_LEVEL2, EQ_LEVEL3, EQ_LEVEL4.					

AC Switching Characteristics

All values represented in this data sheet are based on the speed specifications in the AMD Vivado™ Design Suite as outlined in the following table.

Table: Speed Specification Version By Device

2022.1	Device
1.28	XCKU3P, XCKU5P, XCKU9P, XCKU11P, XCKU13P, and XCKU15P XQKU5P, XQKU15P
1.34	XCKU19P

Switching characteristics are specified on a per-speed-grade basis and can be designated as Advance, Preliminary, or Production. Each designation is defined as follows:

Advance Product Specification

These specifications are based on simulations only and are typically available soon after device design specifications are frozen. Although speed grades with this designation are considered relatively stable and conservative, some under-reporting might still occur.

Preliminary Product Specification

These specifications are based on complete ES (engineering sample) silicon characterization. Devices and speed grades with this designation are intended to give a better indication of the expected performance of production silicon. The probability of under-reporting delays is greatly reduced as compared to Advance data.

Product Specification

These specifications are released once enough production silicon of a particular device family member has been characterized to provide full correlation between specifications and devices over numerous production lots. There is no under-reporting of delays, and customers receive formal notification of any subsequent changes. Typically, the slowest speed grades transition to production before faster speed grades.

Testing of AC Switching Characteristics

Internal timing parameters are derived from measuring internal test patterns. All AC switching characteristics are representative of worst-case supply voltage and junction temperature conditions.

For more specific, more precise, and worst-case guaranteed data, use the values reported by the static timing analyzer and back-annotate to the simulation net list. Unless otherwise noted, values apply to all Kintex UltraScale+ FPGAs.

Speed Grade Designations

Since individual family members are produced at different times, the migration from one category to another depends completely on the status of the fabrication process for each device. Table 1 correlates the current status of the Kintex UltraScale+ FPGAs on a per speed grade basis.

Table: Speed Grade Designations by Device

Device	Speed Grade, Temperature Ranges, and V _{CCINT} Operating Voltages		
	Advance	Preliminary	Production
XCKU3P			-3E (V _{CCINT} = 0.90V) -2E (V _{CCINT} = 0.85V), -2I (V _{CCINT} = 0.85V) -1E (V _{CCINT} = 0.85V), -1I (V _{CCINT} = 0.85V) -2LE (V _{CCINT} = 0.85V) ¹ , -1LI (V _{CCINT} = 0.85V) ¹ -2LE (V _{CCINT} = 0.72V) ¹ , -1LI (V _{CCINT} = 0.72V) ¹
XCKU5P			-3E (V _{CCINT} = 0.90V) -2E (V _{CCINT} = 0.85V), -2I (V _{CCINT} = 0.85V) -1E (V _{CCINT} = 0.85V), -1I (V _{CCINT} = 0.85V) -2LE (V _{CCINT} = 0.85V) ¹ , -1LI (V _{CCINT} = 0.85V) ¹ -2LE (V _{CCINT} = 0.72V) ¹ , -1LI (V _{CCINT} = 0.72V) ¹

Device	Speed Grade, Temperature Ranges, and V _{CCINT} Operating Voltages		
	Advance	Preliminary	Production
XCKU9P			-3E (V _{CCINT} = 0.90V) -2E (V _{CCINT} = 0.85V), -2I (V _{CCINT} = 0.85V) -1E (V _{CCINT} = 0.85V), -1I (V _{CCINT} = 0.85V) -2LE (V _{CCINT} = 0.85V) ¹ , -1LI (V _{CCINT} = 0.85V) ¹ -2LE (V _{CCINT} = 0.72V) ¹ , -1LI (V _{CCINT} = 0.72V) ¹
XCKU11P			-3E (V _{CCINT} = 0.90V) -2E (V _{CCINT} = 0.85V), -2I (V _{CCINT} = 0.85V) -1E (V _{CCINT} = 0.85V), -1I (V _{CCINT} = 0.85V) -2LE (V _{CCINT} = 0.85V) ¹ , -1LI (V _{CCINT} = 0.85V) ¹ -2LE (V _{CCINT} = 0.72V) ¹ , -1LI (V _{CCINT} = 0.72V) ¹
XCKU13P			-3E (V _{CCINT} = 0.90V) -2E (V _{CCINT} = 0.85V), -2I (V _{CCINT} = 0.85V) -1E (V _{CCINT} = 0.85V), -1I (V _{CCINT} = 0.85V) -2LE (V _{CCINT} = 0.85V) ¹ , -1LI (V _{CCINT} = 0.85V) ¹ -2LE (V _{CCINT} = 0.72V) ¹ , -1LI (V _{CCINT} = 0.72V) ¹
XCKU15P			-3E (V _{CCINT} = 0.90V) -2E (V _{CCINT} = 0.85V), -2I (V _{CCINT} = 0.85V) -1E (V _{CCINT} = 0.85V), -1I (V _{CCINT} = 0.85V)

Device	Speed Grade, Temperature Ranges, and V _{CCINT} Operating Voltages		
	Advance	Preliminary	Production
			-2LE (V _{CCINT} = 0.85V) ¹ , -1LI (V _{CCINT} = 0.85V) ¹ -2LE (V _{CCINT} = 0.72V) ¹ , -1LI (V _{CCINT} = 0.72V) ¹
XCKU19P			-3E (V _{CCINT} = 0.90V) -2E (V _{CCINT} = 0.85V), -2I (V _{CCINT} = 0.85V) -1E (V _{CCINT} = 0.85V), -1I (V _{CCINT} = 0.85V) -2LE (V _{CCINT} = 0.85V) ¹ , -1LI (V _{CCINT} = 0.85V) ¹ -2LE (V _{CCINT} = 0.72V) ¹ , -1LI (V _{CCINT} = 0.72V) ¹
XQKU5P			-2I (V _{CCINT} = 0.85V) -1I (V _{CCINT} = 0.85V), -1M (V _{CCINT} = 0.85V) -1LI (V _{CCINT} = 0.85V) ¹ , -1LI (V _{CCINT} = 0.72V) ¹
XQKU15P			-2I (V _{CCINT} = 0.85V) -1I (V _{CCINT} = 0.85V), -1M (V _{CCINT} = 0.85V) -1LI (V _{CCINT} = 0.85V) ¹ , -1LI (V _{CCINT} = 0.72V) ¹

1. The lowest power -1L and -2L devices, where V_{CCINT} = 0.72V, are listed in the Vivado Design Suite as -1LV and -2LV, respectively. Otherwise, the -1L and -2L devices, where V_{CCINT} = 0.85V, are listed in the Vivado Design Suite as -1L and -2L, respectively.

Production Silicon and Software Status

In some cases, a particular family member (and speed grade) is released to production before a speed specification is released with the correct label (Advance, Preliminary, Production). Any

labeling discrepancies are corrected in subsequent speed specification releases.

Table 1 lists the production released Kintex UltraScale+ FPGA, speed grade, and the minimum corresponding supported speed specification version and Vivado software revisions. The Vivado software and speed specifications listed are the minimum releases required for production. All subsequent releases of software and speed specifications are valid.

Table: Kintex UltraScale+ FPGA Device Production Software and Speed Specification Release

Device	Speed Grade and V _{CCINT} Operating Voltages ¹						
	0.90V	0.85V				0.72V	
	-3	-2	-1	-2L	-1L	-2L	-1L
XCKU3P	Vivado tools 2018.1 v1.19	Vivado tools 2017.1 v1.10		Vivado tools 2017.4 v1.17			
XCKU5P	Vivado tools 2018.1 v1.19	Vivado tools 2017.1 v1.10		Vivado tools 2017.4 v1.17			
XCKU9P	Vivado tools 2018.2.1 v1.21	Vivado tools 2017.1 v1.10		Vivado tools 2017.3.1 v1.16			
XCKU11P	Vivado tools 2018.1 v1.19	Vivado tools 2017.3 v1.14		Vivado tools 2017.4.1 v1.18			
XCKU13P	Vivado tools 2018.1 v1.19	Vivado tools 2017.2 v1.12		Vivado tools 2017.3.1 v1.16			
XCKU15P	Vivado tools 2018.1 v1.19	Vivado tools 2017.2.1 v1.13		Vivado tools 2017.4 v1.17			
XCKU19P	Vivado tools 2020.2.2 v1.32	Vivado tools 2020.2.2 v1.32		Vivado tools 2020.2.2 v1.32			
XQKU5P	N/A	Vivado tools 2018.3.1 v1.23		N/A	Vivado tools 2018.3.1 v1.23	N/A	Vivado tools 2018.3.1 v1.23
XQKU15P	N/A	Vivado tools 2018.3.1 v1.23		N/A	Vivado tools 2018.3.1 v1.23	N/A	Vivado tools 2018.3.1 v1.23

1. Blank entries indicate a device and/or speed grade in Advance or Preliminary status.

FPGA Logic Performance Characteristics

This section provides the performance characteristics of some common functions and designs implemented in the Kintex UltraScale+ FPGAs. These values are subject to the same guidelines as the AC Switching Characteristics section.

In each of the following LVDS performance tables, the I/O bank type is either high performance (HP) or high density (HD).

In LVDS component mode:

- For the input/output registers in HP I/O banks, the Vivado tools limit clock frequencies to 312.9 MHz for all speed grades.
- For IDDR in HP I/O banks, Vivado tools limit clock frequencies to 625.0 MHz for all speed grades.
- For ODDR in HP I/O banks, Vivado tools limit clock frequencies to 625.0 MHz for all speed grades.

Table: LVDS Component Mode Performance

Description	I/O Bank Type	Speed Grade and V _{CCINT} Operating Voltages									Units	
		0.90V			0.85V			0.72V				
		-3			-2			-1				
		Min	Max	0	Min	Max	0	Min	Max	0		
LVDS TX DDR (OSERDES 4:1, 8:1)	HP	0	1250	0	1250	0	1250	0	1250	0	1250	Mb/s
LVDS TX SDR (OSERDES 2:1, 4:1)	HP	0	625	0	625	0	625	0	625	0	625	Mb/s
LVDS RX DDR (ISERDES 1:4, 1:8) ¹	HP	0	1250	0	1250	0	1250	0	1250	0	1250	Mb/s
LVDS RX DDR	HD	0	250	0	250	0	250	0	250	0	250	Mb/s
LVDS RX SDR (ISERDES 1:2, 1:4) ¹	HP	0	625	0	625	0	625	0	625	0	625	Mb/s
LVDS RX SDR	HD	0	125	0	125	0	125	0	125	0	125	Mb/s

1. LVDS receivers are typically bounded with certain applications to achieve maximum performance. Package skews are not included and should be removed through PCB routing.

Table: LVDS Native Mode Performance

Description ^{1, 2}	DATA_WIDTH	I/O Bank	Speed Grade and V _{CCINT} Operating Voltages										Units		
			0.90V		0.85V				0.72V						
			-3		-2		-1		-2		-1				
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max			
LVDS TX DDR (TX_BITSLICE)	4	HP	375	1600	375	1600	375	1600	375	1600	375	1400	375	1260	Mb/s
	8		375	1600	375	1600	375	1600	375	1600	375	1600	375	1600	
LVDS TX SDR (TX_BITSLICE)	4	HP	187.5800	187.5800	187.5800	187.5800	187.5800	187.5800	187.5700	187.5630					Mb/s
	8		187.5800	187.5800	187.5800	187.5800	187.5800	187.5800	187.5800	187.5800	187.5800				Mb/s
LVDS RX DDR (RX_BITSLICE)	4	HP	375	1600	375	1600	375	1600	375	1600	375	1400	375	1260	Mb/s
	8		375	1600	375	1600	375	1600	375	1600	375	1600	375	1600	
LVDS RX SDR (RX_BITSLICE)	4	HP	187.5800	187.5800	187.5800	187.5800	187.5800	187.5800	187.5700	187.5630					Mb/s
	8		187.5800	187.5800	187.5800	187.5800	187.5800	187.5800	187.5800	187.5800	187.5800				Mb/s

1. Native mode is supported through the **High-Speed SelectIO Interface Wizard** available with the Vivado Design Suite. The performance values assume a source-synchronous interface.
2. PLL settings can restrict the minimum allowable data rate. For example, when using the PLL with CLKOUTPHY_MODE = VCO_HALF the minimum frequency is PLL_F_{VCOMIN}/2.
3. LVDS receivers are typically bounded with certain applications to achieve maximum performance. Package skews are not included and should be removed through PCB routing.
4. Asynchronous receiver performance is limited to 1300 Mb/s for -3/-2 speed grades and to 1250 Mb/s for -1 speed grades.

Table: MIPI D-PHY Performance

Description	I/O Bank Type	Conditions ¹	Speed Grade and V _{CCINT} Operating Voltages					Rates
			0.90V	0.85V		0.72V		
			-3	-2	-1	-2	-1	
Maximum MIPI D-PHY transmitter or receiver data rate per lane	HP	XC devices using Vivado tools 2019.2.2 or later	2500	2500	2500	2500	1260	Mb/s
		XC devices using Vivado tools 2019.1.1 through 2019.2.1	2500	2500	1260	2500	1260	Mb/s
		XC devices using Vivado tools 2019.1 or earlier	1500	1500	1260	1260	1260	Mb/s
		XQ devices	N/A	1500	1260	N/A	1260	Mb/s

1. For applicable conditions, the lower maximum data rate applies.

Table: LVDS Native-Mode 1000BASE-X Support

Description	I/O Bank Type	Speed Grade and V _{CCINT} Operating Voltages				
		0.90V	0.85V		0.72V	
		-3	-2	-1	-2	-1
1000BASE-X	HP	Yes				

1. 1000BASE-X support is based on the *IEEE Standard for CSMA/CD Access Method and Physical Layer Specifications* (IEEE Std 802.3-2008).

The following table provides the maximum data rates for applicable memory standards using the Kintex UltraScale+ FPGA memory PHY. Refer to [Memory Solutions](#) for the complete list of memory interface standards supported and detailed specifications. The final performance of the memory interface is determined through a complete design implemented in the Vivado Design Suite, following guidelines in the *UltraScale Architecture PCB Design User Guide (UG583)*, electrical analysis, and characterization of the system.

Table: Maximum Physical Interface (PHY) Rate for Memory Interfaces

Memory	Standard Packages	DRAM Type	Speed Grade and V _{CCINT} Operating Voltages						
			0.90V	0.85V		0.72V			
			-3	-2	-1	-2	-1		
DDR4	All FFV and FFR packages	Single rank component	2666	2666	2400	2400	2133	Mb/s	
		1 rank DIMM ^{1, 2, 3}	2400	2400	2133	2133	1866	Mb/s	
		2 rank DIMM ^{1, 4}	2133	2133	1866	1866	1600	Mb/s	
		4 rank DIMM ^{1, 5}	1600	1600	1333	1333	N/A	Mb/s	
	SFVB784 and SFRB784	Single rank component	2400	2400	2133	2133	1866	Mb/s	
		1 rank DIMM ^{1, 2}	2133	2133	1866	1866	1600	Mb/s	
		2 rank DIMM ^{1, 4}	1866	1866	1600	1600	1600	Mb/s	
	DDR3	All FFV and FFR packages	Single rank component	2133	2133	2133	2133	1866	Mb/s
			1 rank DIMM ^{1, 2}	1866	1866	1866	1866	1600	Mb/s
2 rank DIMM ^{1, 4}			1600	1600	1600	1600	1333	Mb/s	
4 rank DIMM ^{1, 5}			1066	1066	1066	1066	800	Mb/s	
SFVB784 and SFRB784		Single rank component	1866	1866	1866	1866	1600	Mb/s	
		1 rank DIMM ^{1, 2}	1600	1600	1600	1600	1600	Mb/s	
		2 rank DIMM ^{1, 4}	1600	1600	1600	1600	1333	Mb/s	
		4 rank DIMM ^{1, 5}	1066	1066	1066	1066	800	Mb/s	
DDR3L		All FFV and FFR packages	Single rank component	1866	1866	1866	1866	1600	Mb/s
			1 rank DIMM ^{1, 2}	1600	1600	1600	1600	1333	Mb/s
	2 rank DIMM ^{1, 4}		1333	1333	1333	1333	1066	Mb/s	
	4 rank DIMM ^{1, 5}		800	800	800	800	606	Mb/s	

Memory	Standards Packages	DRAM Type	Speed Grade and V _{CCINT} Operating Voltages					Mb/s
			0.90V		0.85V		0.72V	
			-3	-2	-1	-2	-1	
	SFVB784 and SFRB784	Single rank component	1600	1600	1600	1600	1600	Mb/s
		1 rank DIMM ^{1, 2}	1600	1600	1600	1600	1333	Mb/s
		2 rank DIMM ^{1, 4}	1333	1333	1333	1333	1066	Mb/s
		4 rank DIMM ^{1, 5}	800	800	800	800	606	Mb/s
QDR II+	All	Single rank component ⁶	633	633	600	600	550	MHz
RLDRAM 3	All FFV and FFR packages	Single rank component	1200	1200	1066	1066	933	MHz
	SFVB784 and SFRB784	Single rank component	1066	1066	933	933	800	MHz
QDR IV XP	All	Single rank component	1066	1066	1066	933	933	MHz
LPDDR3	All	Single rank component	1600	1600	1600	1600	1600	Mb/s

1. Dual in-line memory module (DIMM) includes RDIMM, SODIMM, UDIMM, and LRDIMM.
2. Includes: 1 rank 1 slot, DDP 2 rank, LRDIMM 2 or 4 rank 1 slot.
3. For the DDR4 DDP components at -3 and -2 (V_{CCINT} = 0.85V) speed grades, the maximum data rate is 2133 Mb/s for six or more DDP devices. For five or less DDP devices, use the single rank DIMM data rates for the -3 and -2 (V_{CCINT} = 0.85V) speed grades.
4. Includes: 2 rank 1 slot, 1 rank 2 slot, LRDIMM 2 rank 2 slot.
5. Includes: 2 rank 2 slot, 4 rank 1 slot.
6. The QDRII+ performance specifications are for burst-length 4 (BL = 4) implementations.

FPGA Logic Switching Characteristics

The following IOB high-density (HD) and IOB high-performance (HP) tables summarize the values of standard-specific data input delay adjustments, output delays terminating at pads (based on standard) and 3-state delays.

- $T_{INBUF_DELAY_PAD_I}$ is the delay from IOB pad through the input buffer to the I-pin of an IOB pad. The delay varies depending on the capability of the SelectIO input buffer.
- $T_{OUTBUF_DELAY_O_PAD}$ is the delay from the O pin to the IOB pad through the output buffer of an IOB pad. The delay varies depending on the capability of the SelectIO output buffer.
- $T_{OUTBUF_DELAY_TD_PAD}$ is the delay from the T pin to the IOB pad through the output buffer of an IOB pad, when 3-state is disabled. The delay varies depending on the SelectIO capability of the output buffer. In HP I/O banks, the internal DCI termination turn-on time is always faster than $T_{OUTBUF_DELAY_TD_PAD}$ when the DCITERMDISABLE pin is used. In HD I/O banks, the on-die termination turn-on time is always faster than $T_{OUTBUF_DELAY_TD_PAD}$ when the INTERMDISABLE pin is used.

IOB High Density (HD) Switching Characteristics

Table: IOB High Density (HD) Switching Characteristics

I/O Standards	$T_{INBUF_DELAY_PAD_I}$					$T_{OUTBUF_DELAY_O_PAD}$					$T_{OUTBUF_DELAY_TD_PAD}$					Units
	0.90V			0.85V		0.72V		0.90V			0.85V		0.72V			
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
DIFF_HSTL_I_1088F30	0.978	0.978	0.978	0.978	0.978	0.510	1.574	1.718	1.962	1.101	1.160	1.160	1.271	1.515	1.544	ns
DIFF_HSTL_I_1088F30	0.978	0.978	0.978	0.978	0.978	0.742	1.805	1.952	2.192	2.333	3.748	1.748	1.862	2.102	2.104	ns
DIFF_HSTL_I_108730	0.978	0.978	0.978	0.978	0.978	0.563	1.611	1.762	2.002	2.145	3.313	1.313	1.417	1.668	1.668	ns
DIFF_HSTL_I_108730	0.978	0.978	0.978	0.978	0.978	0.696	1.798	1.912	2.192	2.296	3.630	1.630	1.780	1.985	1.986	ns
DIFF_HSUL_120F960	0.910	0.970	0.910	0.970	0.970	1.493	1.573	1.703	1.962	2.086	2.221	2.221	2.335	3.577	1.578	ns
DIFF_HSUL_120F960	0.910	0.970	0.910	0.970	0.970	1.653	1.711	1.864	2.102	2.247	3.536	1.536	1.665	1.891	1.891	ns
DIFF_SSTL12_0.7960	0.906	0.970	0.906	0.970	0.970	1.577	1.643	1.792	2.032	2.175	3.285	1.285	1.423	1.640	1.640	ns
DIFF_SSTL12_0.7960	0.906	0.970	0.906	0.970	0.970	1.726	1.784	1.942	2.172	2.331	3.567	1.567	1.706	1.922	1.922	ns
DIFF_SSTL1350B070	0.920	0.995	0.920	0.995	0.995	1.558	1.625	1.762	2.012	2.148	3.341	1.341	1.458	1.696	1.696	ns
DIFF_SSTL1350B070	0.920	0.995	0.920	0.995	0.995	1.560	1.623	1.772	2.012	2.153	3.325	1.325	1.470	1.680	1.689	ns
DIFF_SSTL1350B070	0.920	0.995	0.920	0.995	0.995	1.694	1.768	1.912	2.162	2.299	3.722	1.722	1.912	2.072	2.078	ns
DIFF_SSTL1350B070	0.920	0.995	0.920	0.995	0.995	1.796	1.862	2.022	2.262	2.408	3.814	1.814	1.972	2.162	2.169	ns
DIFF_SSTL15_0.8400	0.928	0.928	0.928	0.928	0.928	1.559	1.628	1.772	2.022	2.154	3.374	1.374	1.483	1.729	1.729	ns
DIFF_SSTL15_0.8400	0.928	0.928	0.928	0.928	0.928	1.574	1.622	1.772	2.012	2.161	3.356	1.356	1.442	1.711	1.712	ns

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units	
	0.90V			0.85V		0.72V			0.90V		0.85V		0.72V				
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1		
DIFF_SSTL15_0.8	0.84	0.92	1.02	0.92	1.02	0.76	0.82	1.19	0.82	1.21	2.37	0.89	1.89	2.04	2.25	2.25	ns
DIFF_SSTL15_0.84	0.92	1.02	1.02	0.92	1.02	0.75	1.82	4.97	2.21	2.36	0.74	3.17	4.39	2.09	2.09	8	ns
DIFF_SSTL18_0.87	30.96	1.03	1.03	0.96	1.03	0.67	2.17	2.98	2.12	2.26	3.37	1.37	7.49	2.73	2.73	2	ns
DIFF_SSTL18_0.87	30.96	1.03	1.03	0.96	1.03	0.74	1.79	6.96	2.18	2.34	0.61	1.61	6.80	0.97	1.97	2	ns
DIFF_SSTL18_0.87	30.96	1.03	1.03	0.96	1.03	0.53	1.60	9.75	2.00	2.13	0.22	0.22	0.31	3.57	3.57	5	ns
DIFF_SSTL18_0.87	30.96	1.03	1.03	0.96	1.03	0.72	1.78	6.94	2.17	2.32	0.67	1.67	7.83	2.03	2.03	3	ns
HSTL_I_18_F	0.85	0.94	1.02	0.94	1.02	1.51	1.57	4.71	1.96	2.10	1.16	0.16	0.27	1.51	1.54	4	ns
HSTL_I_18_S	0.85	0.94	1.02	0.94	1.02	1.74	2.80	5.95	2.19	2.33	3.74	1.74	8.86	2.10	2.10	4	ns
HSTL_I_F	0.74	0.85	0.90	0.85	0.90	0.56	3.16	11.76	2.00	2.14	0.31	0.31	0.41	1.66	1.66	8	ns
HSTL_I_S	0.74	0.85	0.90	0.85	0.90	0.69	6.17	9.91	2.19	2.29	0.63	0.63	0.78	0.98	0.98	6	ns
HSUL_12_F	0.71	0.78	0.86	0.78	0.86	1.49	3.15	7.03	1.96	2.08	0.22	0.22	0.33	1.57	1.57	8	ns
HSUL_12_S	0.71	0.78	0.86	0.78	0.86	1.65	3.17	11.86	2.10	2.24	0.53	0.53	0.66	1.89	1.89	11	ns
LVC MOS12_F_0.7	610.91	0.97	0.91	0.97	0.91	0.65	2.16	9.85	2.08	2.23	0.20	0.20	0.31	1.55	1.55	7	ns
LVC MOS12_F_0.7	610.91	0.97	0.91	0.97	0.91	0.71	4.17	4.21	2.13	2.30	0.35	0.35	0.47	1.70	1.70	8	ns
LVC MOS12_F_0.8	610.91	0.97	0.91	0.97	0.91	0.66	8.17	4.87	2.10	2.26	0.29	0.29	0.43	1.64	1.64	7	ns
LVC MOS12_S_0.7	610.91	0.97	0.91	0.97	0.91	0.20	1.92	0.73	2.24	2.46	0.53	0.58	1.17	1.93	1.93	7	ns
LVC MOS12_S_0.7	610.91	0.97	0.91	0.97	0.91	0.97	9.19	1.97	2.18	2.37	0.56	0.63	3.16	3.77	3.98	11	ns
LVC MOS12_S_0.8	610.91	0.97	0.91	0.97	0.91	0.13	2.20	2.40	2.59	2.78	0.76	0.71	0.92	2.12	2.12	13	ns
LVC MOS15_F_0.7	750.90	0.95	0.90	0.95	0.90	0.69	1.17	3.89	2.10	2.27	0.27	0.27	0.42	1.63	1.63	10	ns
LVC MOS15_F_0.7	750.90	0.95	0.90	0.95	0.90	0.66	5.17	2.88	2.11	2.26	0.40	0.40	0.57	1.61	1.61	15	ns
LVC MOS15_F_0.8	750.90	0.95	0.90	0.95	0.90	0.74	7.18	2.95	2.21	2.34	0.45	0.45	0.57	1.80	1.80	15	ns
LVC MOS15_F_0.8	750.90	0.95	0.90	0.95	0.90	0.72	1.17	7.93	2.17	2.31	0.37	0.37	0.45	1.73	1.73	13	ns
LVC MOS15_S_0.7	750.90	0.95	0.90	0.95	0.90	0.93	6.19	2.13	2.38	2.52	0.51	0.61	0.64	1.87	1.87	11	ns

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units					
	0.90V		0.85V			0.72V		0.90V			0.85V		0.72V		0.90V		0.85V		0.72V		
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1		-3	-2	-1	-2	-1
LVC MOS15_S_0	750.90	5.95	0.90	5.95	2.17	2.17	2.38	2.56	2.77	2.70	1.70	1.70	1.88	2.06	2.06	ns					
LVC MOS15_S_4	750.90	5.95	0.90	5.95	2.27	4.31	3.48	3.70	3.86	1.95	2.12	2.30	2.30	7ns							
LVC MOS15_S_8	750.90	5.95	0.90	5.95	2.17	2.17	2.40	2.56	2.78	3.81	1.81	1.81	1.98	2.17	2.17	ns					
LVC MOS18_F_0	100.91	5.95	0.91	5.95	1.74	1.80	1.96	2.19	2.34	1.38	1.38	1.47	1.73	1.73	ns						
LVC MOS18_F_0	100.91	5.95	0.91	5.95	1.69	1.78	1.91	2.17	2.30	1.33	1.33	1.44	1.69	1.69	ns						
LVC MOS18_F_4	100.91	5.95	0.91	5.95	1.81	1.86	2.01	2.26	2.39	1.47	1.47	1.59	1.82	1.83	ns						
LVC MOS18_F_8	100.91	5.95	0.91	5.95	1.78	1.79	1.97	2.18	2.36	1.38	1.38	1.48	1.73	1.73	ns						
LVC MOS18_S_0	100.91	5.95	0.91	5.95	2.16	3.20	2.40	2.59	2.79	1.76	2.17	2.62	2.89	2.11	2.11	ns					
LVC MOS18_S_0	100.91	5.95	0.91	5.95	2.10	2.17	2.36	2.56	2.74	1.70	2.17	2.83	2.05	2.05	ns						
LVC MOS18_S_4	100.91	5.95	0.91	5.95	2.34	2.34	2.56	2.73	2.95	1.95	1.95	2.09	2.30	2.30	ns						
LVC MOS18_S_8	100.91	5.95	0.91	5.95	2.27	2.29	2.51	2.68	2.89	1.84	1.84	2.00	2.20	2.20	ns						
LVC MOS25_F_0	630.98	8.04	0.98	8.04	2.15	3.15	2.45	2.54	2.83	1.69	2.19	2.85	2.04	2.04	ns						
LVC MOS25_F_0	630.98	8.04	0.98	8.04	2.10	2.10	2.40	2.49	2.78	1.62	1.62	1.78	1.97	1.97	ns						
LVC MOS25_F_4	630.98	8.04	0.98	8.04	2.31	2.34	2.55	2.73	2.93	1.84	2.18	2.03	2.19	2.19	ns						
LVC MOS25_F_8	630.98	8.04	0.98	8.04	2.18	2.18	2.51	2.57	2.89	1.72	1.72	1.91	2.08	2.08	ns						
LVC MOS25_S_0	630.98	8.04	0.98	8.04	2.55	2.55	2.84	2.95	3.22	1.97	1.97	2.19	2.32	2.32	ns						
LVC MOS25_S_0	630.98	8.04	0.98	8.04	2.44	2.44	2.74	2.84	3.12	1.85	2.18	2.06	2.20	2.20	ns						
LVC MOS25_S_4	630.98	8.04	0.98	8.04	2.77	2.77	3.06	3.16	3.44	2.22	2.22	2.45	2.57	2.57	ns						
LVC MOS25_S_8	630.98	8.04	0.98	8.04	2.66	2.66	2.96	3.05	3.34	2.09	2.09	2.37	2.44	2.44	ns						
LVC MOS33_F_1	541.15	4.21	3.15	4.21	3.41	5.24	3.65	2.80	3.03	1.75	4.17	5.41	3.91	2.10	2.10	ns					
LVC MOS33_F_1	541.15	4.21	3.15	4.21	3.38	3.38	3.60	3.77	3.98	1.73	4.17	5.41	3.86	2.08	2.08	ns					
LVC MOS33_F_4	541.15	4.21	3.15	4.21	3.54	3.54	3.76	3.93	4.18	1.93	2.13	2.13	2.28	2.28	ns						
LVC MOS33_F_8	541.15	4.21	3.15	4.21	3.60	3.60	3.82	3.99	4.20	1.93	2.13	2.13	2.29	2.29	ns						

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units
	0.90V			0.85V		0.72V			0.90V		0.85V		0.72V			
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
LVC MOS33_S_12	541.154	213.154	213.154	213.154	213.154	2.705	2.705	3.047	3.097	3.430	2.049	2.049	2.312	2.402	2.404	ns
LVC MOS33_S_16	541.154	213.154	213.154	213.154	213.154	2.714	2.714	3.024	3.103	3.407	2.028	2.028	2.232	2.383	2.383	ns
LVC MOS33_S_4	1541.154	213.154	213.154	213.154	213.154	2.999	2.999	3.343	3.393	3.723	2.320	2.320	2.610	2.675	2.675	ns
LVC MOS33_S_8	1541.154	213.154	213.154	213.154	213.154	2.929	2.929	3.263	3.323	3.643	2.260	2.260	2.532	2.615	2.616	ns
LVDS_25	0.980	1.003	1.116	1.003	1.116	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ns
LVPECL	0.980	1.003	1.116	1.003	1.116	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ns
LVTTL_F_12	1.164	1.164	2.223	1.164	2.223	2.415	2.415	2.652	2.807	3.034	1.754	1.754	1.915	2.102	2.109	ns
LVTTL_F_16	1.164	1.164	2.223	1.164	2.223	2.464	2.464	2.732	2.853	3.115	1.750	1.750	1.980	2.102	2.117	ns
LVTTL_F_4	1.164	1.164	2.223	1.164	2.223	2.541	2.541	2.762	2.933	3.148	1.932	1.932	2.135	2.287	2.287	ns
LVTTL_F_8	1.164	1.164	2.223	1.164	2.223	2.582	2.582	2.782	2.974	3.170	1.910	1.910	2.063	2.265	2.265	ns
LVTTL_S_12	1.164	1.164	2.223	1.164	2.223	2.731	2.731	3.073	3.123	3.452	2.072	2.072	2.342	2.427	2.427	ns
LVTTL_S_16	1.164	1.164	2.223	1.164	2.223	2.714	2.714	3.024	3.103	3.407	2.028	2.028	2.232	2.383	2.383	ns
LVTTL_S_4	1.164	1.164	2.223	1.164	2.223	2.999	2.999	3.343	3.393	3.723	2.320	2.320	2.610	2.675	2.675	ns
LVTTL_S_8	1.164	1.164	2.223	1.164	2.223	2.929	2.929	3.263	3.323	3.643	2.260	2.260	2.532	2.615	2.616	ns
SLVS_400_25	0.998	1.020	1.136	1.020	1.136	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ns
SSTL12_F	0.712	0.780	0.867	0.780	0.867	1.577	1.643	1.792	2.032	2.173	1.285	1.285	1.423	1.640	1.640	ns
SSTL12_S	0.712	0.780	0.867	0.780	0.867	1.726	1.784	1.942	2.172	2.331	1.567	1.567	1.706	1.922	1.922	ns
SSTL135_F	0.731	0.790	0.880	0.790	0.880	1.558	1.625	1.762	2.012	2.148	1.341	1.341	1.458	1.696	1.696	ns
SSTL135_II_F	0.731	0.790	0.880	0.790	0.880	1.574	1.623	1.770	2.012	2.153	1.325	1.325	1.470	1.680	1.689	ns
SSTL135_II_S	0.731	0.790	0.880	0.790	0.880	1.694	1.768	1.912	2.162	2.299	1.722	1.722	1.912	2.072	2.078	ns
SSTL135_S	0.731	0.790	0.880	0.790	0.880	1.796	1.862	2.022	2.262	2.408	1.814	1.814	1.972	2.169	2.169	ns
SSTL15_F	0.731	0.830	0.880	0.830	0.880	1.544	1.612	1.752	2.002	2.137	1.357	1.357	1.464	1.712	1.713	ns
SSTL15_II_F	0.731	0.830	0.880	0.830	0.880	1.588	1.622	1.772	2.012	2.161	1.356	1.356	1.442	1.711	1.712	ns

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units	
	0.90V0.85V			0.72V		0.90V0.85V			0.72V		0.90V0.85V			0.72V			
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1		
SSTL15_II_S	0.73	1.08	3.08	0.83	0.88	0.76	0.91	1.82	1.98	2.21	3.37	0.89	1.89	2.04	2.25	2.25	ns
SSTL15_S	0.73	1.08	3.08	0.83	0.88	0.75	1.82	4.97	2.21	2.36	0.74	3.17	4.31	3.90	2.09	2.09	ns
SSTL18_II_F	0.85	4.94	7.02	1.04	7.02	1.69	9.17	2.91	8.82	1.12	2.26	3.37	7.13	7.49	2.73	2.73	ns
SSTL18_II_S	0.85	4.94	7.02	1.04	7.02	1.74	8.17	6.96	2.18	2.34	8.61	6.16	1.61	6.80	0.97	1.97	ns
SSTL18_I_F	0.85	4.94	7.02	1.04	7.02	1.56	6.10	9.75	2.00	2.13	8.22	0.12	0.31	3.57	5.57	5.57	ns
SSTL18_I_S	0.85	4.94	7.02	1.04	7.02	1.74	5.17	6.94	2.17	2.32	5.67	7.16	7.83	2.03	2.03	ns	
SUB_LVDS	0.87	1.10	2.03	6.00	2.03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ns

IOB High Performance (HP) Switching Characteristics

Table: IOB High Performance (HP) Switching Characteristics

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units
	0.90V0.85V			0.72V		0.90V0.85V			0.72V		0.90V0.85V			0.72V		
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
DIFF_HSTL_I_10_2	8.80	3.94	4.40	2.39	4.40	2.41	10.42	3.44	3.42	3.44	3.51	4.05	3.58	2.55	3.58	ns
DIFF_HSTL_I_10_2	8.80	3.94	4.40	2.39	4.40	2.55	2.55	2.58	3.55	2.58	3.63	2.64	0.67	0.64	0.67	ns
DIFF_HSTL_I_10_2	8.80	3.94	4.40	2.39	4.40	2.75	2.75	2.80	0.75	2.80	0.81	3.81	3.86	3.81	3.86	ns
DIFF_HSTL_I_18_2	5.90	3.19	3.33	3.31	3.33	3.43	9.45	6.47	4.45	6.47	4.54	9.05	6.60	6.57	6.60	ns
DIFF_HSTL_I_18_2	5.90	3.19	3.33	3.31	3.33	3.56	3.57	0.60	3.57	0.60	3.63	6.65	3.69	2.65	3.69	ns
DIFF_HSTL_I_18_2	5.90	3.19	3.33	3.31	3.33	3.78	2.78	2.83	4.78	2.83	4.81	6.81	6.87	0.81	6.87	ns
DIFF_HSTL_I_DC28	8.80	3.94	4.40	2.39	4.40	2.39	3.40	6.42	0.40	6.42	0.50	2.53	4.56	4.53	4.56	ns
DIFF_HSTL_I_DC28	8.80	3.94	4.40	2.39	4.40	2.54	6.55	0.58	0.55	0.58	0.63	6.65	3.69	4.65	3.69	ns
DIFF_HSTL_I_DC28	8.80	3.94	4.40	2.39	4.40	2.75	5.75	5.80	6.75	5.80	6.84	2.84	2.90	0.84	2.90	ns
DIFF_HSTL_I_DC25	9.80	3.23	3.33	3.32	3.33	3.42	2.44	5.46	1.44	5.46	1.50	9.05	6.59	5.56	6.59	ns
DIFF_HSTL_I_DC25	9.80	3.23	3.33	3.32	3.33	3.54	6.55	5.58	6.55	5.58	6.62	6.64	3.68	4.64	3.68	ns

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units
	0.90V0.85V			0.72V		0.90V0.85V			0.72V		0.90V0.85V			0.72V		
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
DIFF_HSTL_I_DC2500	3.33	3.32	3.33	3.33	3.33	0.76	2.76	2.81	0.76	2.81	0.83	6.83	6.90	0.83	6.90	ns
DIFF_HSTL_I_DC350	3.39	3.41	3.39	3.41	3.41	0.40	7.43	0.44	5.43	0.44	5.51	7.55	0.57	5.55	5.57	ns
DIFF_HSTL_I_DC350	3.39	3.41	3.39	3.41	3.41	0.54	9.55	0.58	3.55	0.58	3.63	4.64	0.68	4.64	4.68	ns
DIFF_HSTL_I_DC350	3.39	3.41	3.39	3.41	3.41	0.76	7.76	0.82	3.76	0.82	3.84	8.84	0.91	2.84	0.91	ns
DIFF_HSTL_I_F0.30	4.40	4.41	4.41	4.41	4.41	0.40	9.42	0.44	3.42	0.44	3.51	4.54	0.58	0.54	0.58	ns
DIFF_HSTL_I_M0.30	4.40	4.41	4.41	4.41	4.41	0.54	9.55	0.58	6.55	0.58	6.62	4.64	0.67	7.64	0.67	ns
DIFF_HSTL_I_S0.30	4.40	4.41	4.41	4.41	4.41	0.76	7.76	0.81	0.76	0.81	0.81	11.81	0.81	10.86	0.81	ns
DIFF_HSUL_1200	3.38	3.40	3.38	3.40	3.40	0.41	10.42	0.44	3.42	0.44	3.52	0.55	0.58	0.55	0.58	ns
DIFF_HSUL_1200	3.38	3.40	3.38	3.40	3.40	0.54	6.55	0.58	7.55	0.58	7.63	6.65	0.69	4.65	0.69	ns
DIFF_HSUL_1200	3.38	3.40	3.38	3.40	3.40	0.73	7.73	0.78	7.73	0.78	7.82	2.82	0.88	5.82	2.88	ns
DIFF_HSUL_1200	3.39	3.40	3.39	3.40	3.40	0.41	2.43	0.41	2.43	0.41	2.49	4.53	0.56	0.53	0.56	ns
DIFF_HSUL_1200	3.39	3.40	3.39	3.40	3.40	0.55	2.55	0.58	3.55	0.58	3.63	2.64	0.67	0.64	0.67	ns
DIFF_HSUL_1200	3.39	3.40	3.39	3.40	3.40	0.75	2.75	0.80	0.75	0.80	0.81	3.81	0.86	0.81	0.86	ns
DIFF_POD10_DC250	3.41	3.43	3.41	3.43	3.43	0.40	7.42	0.44	4.42	0.44	4.51	2.55	0.58	4.55	0.58	ns
DIFF_POD10_DC250	3.41	3.43	3.41	3.43	3.43	0.53	3.54	0.57	0.54	0.57	0.61	8.64	0.68	0.64	0.68	ns
DIFF_POD10_DC250	3.41	3.43	3.41	3.43	3.43	0.75	4.75	0.81	0.75	0.81	0.85	0.85	0.91	7.85	0.91	ns
DIFF_POD10_F0.28	3.41	3.43	3.41	3.43	3.43	0.42	5.43	0.45	0.43	0.45	0.53	1.56	0.60	0.56	0.60	ns
DIFF_POD10_M0.28	3.41	3.43	3.41	3.43	3.43	0.51	9.53	0.56	0.53	0.56	0.58	9.63	0.66	7.63	0.66	ns
DIFF_POD10_S0.28	3.41	3.43	3.41	3.43	3.43	0.75	2.76	0.82	0.76	0.82	0.82	11.83	0.89	4.83	0.89	ns
DIFF_POD12_DC250	3.40	3.42	3.40	3.42	3.42	0.41	10.42	0.44	3.42	0.44	3.51	9.55	0.58	0.55	0.58	ns
DIFF_POD12_DC250	3.40	3.42	3.40	3.42	3.42	0.51	6.54	0.57	2.54	0.57	2.60	2.63	0.67	0.63	0.67	ns
DIFF_POD12_DC250	3.40	3.42	3.40	3.42	3.42	0.74	0.77	0.82	0.77	0.82	0.83	3.86	0.92	0.86	0.92	ns
DIFF_POD12_F0.30	3.40	3.43	3.40	3.43	3.43	0.43	8.45	0.47	6.45	0.47	6.54	9.59	0.62	6.59	0.62	ns

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units
	0.90V0.85V			0.72V		0.90V0.85V			0.72V		0.90V0.85V			0.72V		
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
DIFF_POD12_M	0.30	0.40	0.43	0.40	0.43	0.55	1.05	0.58	0.55	0.58	0.63	2.06	0.67	0.64	0.67	ns
DIFF_POD12_S	0.30	0.40	0.43	0.40	0.43	0.74	0.90	0.81	0.76	0.81	0.81	1.80	0.83	0.88	0.83	ns
DIFF_SSTL12_DC30	0.38	0.40	0.38	0.40	0.41	0.42	0.54	0.42	0.42	0.44	0.52	0.60	0.58	0.55	0.58	ns
DIFF_SSTL12_DC30M	0.38	0.40	0.38	0.40	0.54	0.55	0.58	0.55	0.58	0.64	0.30	0.65	0.69	0.65	0.69	ns
DIFF_SSTL12_DC30S	0.38	0.40	0.38	0.40	0.75	0.40	0.75	0.80	0.75	0.80	0.84	2.08	0.90	0.84	0.90	ns
DIFF_SSTL12_F0.28	0.39	0.40	0.39	0.40	0.39	0.41	0.43	0.41	0.43	0.49	0.40	0.53	0.56	0.53	0.56	ns
DIFF_SSTL12_M0.28	0.39	0.40	0.39	0.40	0.55	0.58	0.55	0.58	0.58	0.63	0.00	0.64	0.67	0.64	0.67	ns
DIFF_SSTL12_S0.28	0.39	0.40	0.39	0.40	0.75	0.80	0.75	0.80	0.82	0.82	0.82	3.08	0.87	0.82	0.87	ns
DIFF_SSTL135_DC30	0.37	0.40	0.37	0.40	0.39	0.41	0.42	0.41	0.42	0.49	0.40	0.53	0.56	0.53	0.56	ns
DIFF_SSTL135_DC30M	0.37	0.40	0.37	0.40	0.55	1.05	0.58	0.55	0.58	0.64	0.30	0.64	0.68	0.64	0.68	ns
DIFF_SSTL135_DC30S	0.37	0.40	0.37	0.40	0.74	0.60	0.79	0.74	0.79	0.82	0.90	0.82	0.89	0.82	0.89	ns
DIFF_SSTL135_F2890	0.37	0.40	0.37	0.40	0.39	0.40	0.42	0.40	0.42	0.49	0.10	0.52	0.56	0.52	0.56	ns
DIFF_SSTL135_M2890	0.37	0.40	0.37	0.40	0.54	0.80	0.55	0.58	0.55	0.58	0.62	1.06	0.64	0.67	0.64	ns
DIFF_SSTL135_S2890	0.37	0.40	0.37	0.40	0.77	0.72	0.82	0.77	0.82	0.82	0.70	0.82	0.87	0.82	0.87	ns
DIFF_SSTL15_DC33	0.39	0.41	0.39	0.41	0.39	0.41	0.42	0.41	0.42	0.49	0.70	0.53	0.56	0.53	0.56	ns
DIFF_SSTL15_DC33M	0.39	0.41	0.39	0.41	0.54	0.90	0.55	0.58	0.55	0.58	0.63	2.06	0.64	0.68	0.64	ns
DIFF_SSTL15_DC33S	0.39	0.41	0.39	0.41	0.76	0.80	0.82	0.76	0.82	0.84	0.70	0.84	0.91	0.84	0.91	ns
DIFF_SSTL15_F0.30	0.40	0.41	0.40	0.41	0.40	0.42	0.44	0.42	0.44	0.51	0.30	0.55	0.57	0.55	0.57	ns
DIFF_SSTL15_M0.30	0.40	0.41	0.40	0.41	0.54	0.70	0.55	0.58	0.55	0.58	0.62	4.06	0.63	0.67	0.63	ns
DIFF_SSTL15_S0.30	0.40	0.41	0.40	0.41	0.76	0.70	0.81	0.76	0.81	0.81	0.30	0.81	0.86	0.81	0.86	ns
DIFF_SSTL18_I0266	0.32	0.33	0.32	0.33	0.42	0.20	0.44	0.46	0.44	0.46	0.54	0.00	0.56	0.59	0.56	ns
DIFF_SSTL18_I0266M	0.32	0.33	0.32	0.33	0.55	0.20	0.55	0.54	0.58	0.62	0.90	0.64	0.68	0.64	0.68	ns
DIFF_SSTL18_I0266S	0.32	0.33	0.32	0.33	0.76	0.20	0.76	0.81	0.76	0.81	0.83	0.70	0.83	0.89	0.83	ns

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units
	0.90V0.85V			0.72V		0.90V0.85V			0.72V		0.90V0.85V			0.72V		
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
DIFF_SSTL18_I0	2560.31	16.33	16.31	16.33	16.43	90.45	40.47	40.45	40.47	60.54	90.57	60.60	60.57	60.60	ns	
DIFF_SSTL18_I0M	2560.31	16.33	16.31	16.33	16.56	70.57	10.60	10.57	10.60	10.53	50.65	20.69	20.65	20.69	ns	
DIFF_SSTL18_I0S	2560.31	16.33	16.31	16.33	16.78	20.78	20.83	20.78	20.83	30.81	60.81	60.87	60.81	60.87	ns	
HSLVDCI_15_F	0.33	60.39	30.41	30.39	30.41	50.40	70.42	50.44	50.42	50.44	30.51	30.54	30.57	30.54	ns	
HSLVDCI_15_M	0.33	60.39	30.41	30.39	30.41	50.54	80.55	20.58	10.55	20.58	10.63	50.64	40.68	40.64	ns	
HSLVDCI_15_S	0.33	60.39	30.41	30.39	30.41	50.74	80.74	80.80	20.74	80.80	20.82	70.82	70.89	20.82	ns	
HSLVDCI_18_F	0.36	70.42	40.44	40.42	40.44	40.42	40.44	50.46	10.44	50.46	10.54	10.56	60.59	50.56	ns	
HSLVDCI_18_M	0.36	70.42	40.44	40.42	40.44	40.56	30.56	70.59	30.56	70.59	30.64	70.65	30.69	30.65	ns	
HSLVDCI_18_S	0.36	70.42	40.44	40.42	40.44	40.76	10.76	10.81	10.76	10.81	10.83	60.83	60.90	30.83	ns	
HSTL_I_12_F	0.32	20.37	30.39	30.37	30.39	40.41	0.42	30.44	30.42	30.44	30.51	40.55	30.58	20.55	ns	
HSTL_I_12_M	0.32	20.37	30.39	30.37	30.39	40.55	10.55	10.58	20.55	10.58	20.63	20.64	20.67	20.64	ns	
HSTL_I_12_S	0.32	20.37	30.39	30.37	30.39	40.75	0.75	0.79	0.75	0.79	0.81	30.81	30.86	30.81	ns	
HSTL_I_18_F	0.25	80.32	20.33	20.32	20.33	40.39	90.45	60.47	60.45	60.47	50.54	90.57	60.60	60.57	ns	
HSTL_I_18_M	0.25	80.32	20.33	20.32	20.33	40.56	20.56	0.60	20.56	0.60	20.63	70.65	30.69	20.65	ns	
HSTL_I_18_S	0.25	80.32	20.33	20.32	20.33	40.78	10.78	10.83	20.78	10.83	30.81	60.81	60.87	30.81	ns	
HSTL_I_DCI_120_F	220.37	30.39	30.37	30.39	30.39	30.40	60.42	0.40	60.42	0.50	20.53	40.56	40.53	40.56	ns	
HSTL_I_DCI_120_M	220.37	30.39	30.37	30.39	30.39	40.55	10.55	60.58	60.55	60.58	60.64	40.65	40.69	40.65	ns	
HSTL_I_DCI_120_S	220.37	30.39	30.37	30.39	30.39	40.75	40.75	40.80	30.75	40.80	30.84	20.84	20.90	20.84	ns	
HSTL_I_DCI_180_F	2580.32	10.33	10.32	10.33	10.42	20.44	50.46	10.44	50.46	10.50	90.56	60.59	50.56	50.59	ns	
HSTL_I_DCI_180_M	2580.32	10.33	10.32	10.33	10.55	10.55	40.58	50.55	40.58	50.63	40.64	30.68	40.64	30.68	ns	
HSTL_I_DCI_180_S	2580.32	10.33	10.32	10.33	10.76	10.76	10.81	10.76	10.81	10.83	60.83	60.90	30.83	60.90	ns	
HSTL_I_DCI_F	0.28	80.39	30.41	30.39	30.41	40.70	40.43	10.44	40.43	10.44	50.51	70.55	50.57	50.55	ns	
HSTL_I_DCI_M	0.28	80.39	30.41	30.39	30.41	40.54	80.55	20.58	10.55	20.58	10.63	50.64	40.68	40.64	ns	

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units
	0.90V0.85V			0.72V		0.90V0.85V			0.72V		0.90V0.85V			0.72V		
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
HSTL_I_DCI_S	0.28	0.39	0.41	0.39	0.41	0.76	0.76	0.82	0.76	0.82	0.84	0.84	0.91	0.84	0.91	ns
HSTL_I_F	0.32	0.37	0.39	0.37	0.39	0.40	0.42	0.44	0.42	0.44	0.51	0.54	0.58	0.54	0.58	ns
HSTL_I_M	0.32	0.37	0.39	0.37	0.39	0.54	0.55	0.58	0.55	0.58	0.62	0.64	0.67	0.64	0.67	ns
HSTL_I_S	0.32	0.37	0.39	0.37	0.39	0.76	0.76	0.81	0.76	0.81	0.81	0.81	0.86	0.81	0.86	ns
HSUL_12_DCI_B	0.31	0.37	0.39	0.37	0.39	0.41	0.42	0.44	0.42	0.44	0.52	0.55	0.58	0.55	0.58	ns
HSUL_12_DCI_M	0.31	0.37	0.39	0.37	0.39	0.55	0.55	0.58	0.55	0.58	0.64	0.65	0.69	0.65	0.69	ns
HSUL_12_DCI_S	0.31	0.37	0.39	0.37	0.39	0.73	0.73	0.78	0.73	0.78	0.82	0.82	0.88	0.82	0.88	ns
HSUL_12_F	0.30	0.37	0.39	0.37	0.39	0.39	0.41	0.43	0.41	0.43	0.49	0.53	0.56	0.53	0.56	ns
HSUL_12_M	0.30	0.37	0.39	0.37	0.39	0.55	0.55	0.58	0.55	0.58	0.63	0.64	0.67	0.64	0.67	ns
HSUL_12_S	0.30	0.37	0.39	0.37	0.39	0.75	0.75	0.79	0.75	0.79	0.81	0.81	0.86	0.81	0.86	ns
LVC MOS12_F_2	0.44	0.51	0.55	0.51	0.55	0.65	0.67	0.69	0.67	0.69	0.86	0.89	0.92	0.89	0.92	ns
LVC MOS12_F_4	0.44	0.51	0.55	0.51	0.55	0.48	0.50	0.52	0.50	0.52	0.64	0.66	0.69	0.66	0.69	ns
LVC MOS12_F_6	0.44	0.51	0.55	0.51	0.55	0.46	0.48	0.50	0.48	0.50	0.58	0.63	0.66	0.63	0.66	ns
LVC MOS12_F_8	0.44	0.51	0.55	0.51	0.55	0.45	0.46	0.48	0.46	0.48	0.59	0.61	0.66	0.61	0.66	ns
LVC MOS12_M_2	0.44	0.51	0.55	0.51	0.55	0.68	0.70	0.72	0.70	0.72	0.88	0.91	0.94	0.91	0.94	ns
LVC MOS12_M_4	0.44	0.51	0.55	0.51	0.55	0.53	0.55	0.57	0.55	0.57	0.62	0.64	0.69	0.64	0.69	ns
LVC MOS12_M_6	0.44	0.51	0.55	0.51	0.55	0.52	0.52	0.54	0.52	0.54	0.60	0.62	0.65	0.62	0.65	ns
LVC MOS12_M_8	0.44	0.51	0.55	0.51	0.55	0.53	0.54	0.57	0.54	0.57	0.60	0.61	0.64	0.61	0.64	ns
LVC MOS12_S_2	0.44	0.51	0.55	0.51	0.55	0.76	0.76	0.80	0.76	0.80	0.98	1.02	1.02	1.02	1.02	ns
LVC MOS12_S_4	0.44	0.51	0.55	0.51	0.55	0.66	0.66	0.70	0.66	0.70	0.80	0.80	0.84	0.80	0.84	ns
LVC MOS12_S_6	0.44	0.51	0.55	0.51	0.55	0.65	0.65	0.69	0.65	0.69	0.73	0.73	0.77	0.73	0.77	ns
LVC MOS12_S_8	0.44	0.51	0.55	0.51	0.55	0.70	0.70	0.76	0.70	0.76	0.74	0.74	0.79	0.74	0.79	ns
LVC MOS15_F_12	0.36	0.41	0.44	0.41	0.44	0.48	0.50	0.52	0.50	0.52	0.58	0.64	0.68	0.64	0.68	ns

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units
	0.90V0.85V			0.72V		0.90V0.85V			0.72V		0.90V0.85V			0.72V		
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
LVC MOS15_F_2	3.68	0.41	0.44	0.41	0.44	5.68	6.70	7.22	7.70	7.22	7.89	3.91	0.94	0.91	0.94	ns
LVC MOS15_F_4	3.68	0.41	0.44	0.41	0.44	5.56	7.05	7.60	7.60	7.27	7.75	5.78	0.75	0.78	0.78	ns
LVC MOS15_F_6	3.68	0.41	0.44	0.41	0.44	5.53	3.54	7.56	7.56	7.68	4.71	1.74	2.71	1.74	ns	
LVC MOS15_F_8	3.68	0.41	0.44	0.41	0.44	5.50	0.51	8.53	8.53	8.53	6.35	0.68	0.70	0.68	0.70	ns
LVC MOS15_M_02	3.68	0.41	0.44	0.41	0.44	5.60	7.07	7.64	7.64	7.63	7.63	7.67	0.63	7.67	0.63	ns
LVC MOS15_M_2	3.68	0.41	0.44	0.41	0.44	5.73	6.74	7.77	7.74	7.77	9.29	0.93	0.96	2.93	0.96	ns
LVC MOS15_M_4	3.68	0.41	0.44	0.41	0.44	5.61	0.62	8.65	8.65	8.65	7.33	0.75	4.78	0.75	4.78	ns
LVC MOS15_M_6	3.68	0.41	0.44	0.41	0.44	5.56	4.05	8.60	8.60	8.65	5.67	4.71	0.67	4.71	ns	
LVC MOS15_M_8	3.68	0.41	0.44	0.41	0.44	5.56	0.56	8.60	8.60	8.63	4.63	0.68	0.63	0.68	ns	
LVC MOS15_S_12	3.68	0.41	0.44	0.41	0.44	5.78	8.78	8.85	8.78	8.85	5.69	5.69	5.73	0.69	5.73	ns
LVC MOS15_S_2	3.68	0.41	0.44	0.41	0.44	5.82	9.82	9.86	9.82	9.86	4.03	8.10	9.07	9.03	9.07	ns
LVC MOS15_S_4	3.68	0.41	0.44	0.41	0.44	5.68	7.68	7.72	7.68	7.72	5.81	3.81	8.85	0.81	8.85	ns
LVC MOS15_S_6	3.68	0.41	0.44	0.41	0.44	5.67	1.67	7.71	7.71	7.72	6.72	0.76	7.72	0.76	ns	
LVC MOS15_S_8	3.68	0.41	0.44	0.41	0.44	5.70	4.70	7.75	7.75	7.21	0.72	8.72	0.75	8.75	ns	
LVC MOS18_F_12	3.52	0.41	0.44	0.41	0.44	5.56	4.05	7.60	7.60	6.96	0.73	1.76	0.73	1.76	ns	
LVC MOS18_F_2	3.52	0.41	0.44	0.41	0.44	5.72	3.73	9.76	9.73	9.76	0.91	8.94	0.97	0.94	ns	
LVC MOS18_F_4	3.52	0.41	0.44	0.41	0.44	5.59	8.60	9.63	9.63	7.49	0.77	8.80	2.77	8.80	ns	
LVC MOS18_F_6	3.52	0.41	0.44	0.41	0.44	5.59	8.60	9.63	9.63	7.81	0.78	8.80	0.78	8.80	ns	
LVC MOS18_F_8	3.52	0.41	0.44	0.41	0.44	5.56	7.05	7.60	7.60	7.12	0.73	7.76	7.73	7.76	ns	
LVC MOS18_M_02	3.52	0.41	0.44	0.41	0.44	5.64	0.64	7.67	7.64	7.67	0.67	0.67	0.70	0.67	ns	
LVC MOS18_M_2	3.52	0.41	0.44	0.41	0.44	5.78	5.79	8.82	8.79	8.82	9.86	0.99	1.01	0.99	ns	
LVC MOS18_M_4	3.52	0.41	0.44	0.41	0.44	5.58	0.66	7.69	7.66	7.69	7.86	0.79	8.83	0.79	8.83	ns
LVC MOS18_M_6	3.52	0.41	0.44	0.41	0.44	5.62	0.62	7.66	7.62	7.66	7.27	0.73	7.75	7.75	ns	

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units
	0.90V0.85V			0.72V		0.90V0.85V			0.72V		0.90V0.85V			0.72V		
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
LVC MOS18_M	0.35	0.41	0.44	0.41	0.44	0.62	0.62	0.66	0.62	0.66	0.70	0.70	0.74	0.70	0.74	ns
LVC MOS18_S	0.35	0.41	0.44	0.41	0.44	0.79	0.79	0.86	0.79	0.86	0.68	0.68	0.72	0.68	0.72	ns
LVC MOS18_S_2	0.35	0.41	0.44	0.41	0.44	0.86	0.86	0.89	0.86	0.89	1.06	1.07	1.09	1.07	1.09	ns
LVC MOS18_S_4	0.35	0.41	0.44	0.41	0.44	0.71	0.71	0.75	0.71	0.75	0.82	0.82	0.87	0.82	0.87	ns
LVC MOS18_S_6	0.35	0.41	0.44	0.41	0.44	0.68	0.68	0.72	0.68	0.72	0.74	0.74	0.76	0.74	0.76	ns
LVC MOS18_S_8	0.35	0.41	0.44	0.41	0.44	0.70	0.70	0.76	0.70	0.76	0.70	0.70	0.74	0.70	0.74	ns
LVDCI_15_F	0.36	0.42	0.46	0.42	0.46	0.40	0.42	0.44	0.42	0.44	0.51	0.54	0.58	0.54	0.58	ns
LVDCI_15_M	0.36	0.42	0.46	0.42	0.46	0.54	0.55	0.58	0.55	0.58	0.63	0.64	0.68	0.64	0.68	ns
LVDCI_15_S	0.36	0.42	0.46	0.42	0.46	0.74	0.74	0.80	0.74	0.80	0.82	0.82	0.89	0.82	0.89	ns
LVDCI_18_F	0.36	0.41	0.44	0.41	0.44	0.42	0.44	0.45	0.44	0.45	0.54	0.56	0.58	0.56	0.58	ns
LVDCI_18_M	0.36	0.41	0.44	0.41	0.44	0.54	0.55	0.58	0.55	0.58	0.62	0.64	0.68	0.64	0.68	ns
LVDCI_18_S	0.36	0.41	0.44	0.41	0.44	0.76	0.76	0.81	0.76	0.81	0.83	0.83	0.89	0.83	0.89	ns
LVDS	0.50	0.53	0.62	0.53	0.62	0.62	0.62	0.66	0.62	0.66	960.447					ns
MIPI_DPHY_DCI_15	0.30	0.38	0.41	0.38	0.41	0.48	0.50	0.52	0.50	0.52	N/A					ns
MIPI_DPHY_DCI_18	0.41	0.43	0.48	0.43	0.48	0.89	0.91	0.93	0.91	0.93	N/A					ns
POD10_DCI_F	0.33	0.40	0.43	0.40	0.43	0.40	0.42	0.44	0.42	0.44	0.51	0.55	0.58	0.55	0.58	ns
POD10_DCI_M	0.33	0.40	0.43	0.40	0.43	0.53	0.54	0.57	0.54	0.57	0.61	0.64	0.68	0.64	0.68	ns
POD10_DCI_S	0.33	0.40	0.43	0.40	0.43	0.72	0.75	0.81	0.75	0.81	0.81	0.85	0.91	0.85	0.91	ns
POD10_F	0.33	0.40	0.43	0.40	0.43	0.42	0.43	0.45	0.43	0.45	0.53	0.56	0.60	0.56	0.60	ns
POD10_M	0.33	0.40	0.43	0.40	0.43	0.51	0.53	0.56	0.53	0.56	0.58	0.63	0.66	0.63	0.66	ns
POD10_S	0.33	0.40	0.43	0.40	0.43	0.75	0.76	0.82	0.76	0.82	0.82	0.83	0.89	0.83	0.89	ns
POD12_DCI_F	0.33	0.40	0.43	0.40	0.43	0.41	0.42	0.44	0.42	0.44	0.51	0.55	0.58	0.55	0.58	ns
POD12_DCI_M	0.33	0.40	0.43	0.40	0.43	0.51	0.54	0.57	0.54	0.57	0.60	0.63	0.67	0.63	0.67	ns

I/O Standards	T _{INBUF_DELAY_PAD_I}					T _{OUTBUF_DELAY_O_PAD}					T _{OUTBUF_DELAY_TD_PAD}					Units
	0.90V0.85V			0.72V		0.90V0.85V			0.72V		0.90V0.85V			0.72V		
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
POD12_DCI_S	0.33	0.40	0.43	0.40	0.43	0.74	0.77	0.82	0.77	0.82	0.83	0.86	0.92	0.86	0.92	ns
POD12_F	0.33	0.40	0.43	0.40	0.43	0.43	0.45	0.47	0.45	0.47	0.54	0.59	0.62	0.59	0.62	ns
POD12_M	0.33	0.40	0.43	0.40	0.43	0.55	0.55	0.58	0.55	0.58	0.63	0.64	0.67	0.64	0.67	ns
POD12_S	0.33	0.40	0.43	0.40	0.43	0.74	0.76	0.81	0.76	0.81	0.81	0.83	0.88	0.83	0.88	ns
SLVS_400_18	0.49	0.53	0.62	0.53	0.62	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ns
SSTL12_DCI_F	0.33	0.38	0.39	0.38	0.39	0.41	0.42	0.44	0.42	0.44	0.52	0.55	0.58	0.55	0.58	ns
SSTL12_DCI_M	0.33	0.38	0.39	0.38	0.39	0.54	0.55	0.58	0.55	0.58	0.64	0.65	0.69	0.65	0.69	ns
SSTL12_DCI_S	0.33	0.38	0.39	0.38	0.39	0.75	0.75	0.80	0.75	0.80	0.84	0.84	0.90	0.84	0.90	ns
SSTL12_F	0.32	0.40	0.40	0.40	0.40	0.39	0.41	0.43	0.41	0.43	0.49	0.53	0.56	0.53	0.56	ns
SSTL12_M	0.32	0.40	0.40	0.40	0.40	0.55	0.55	0.58	0.55	0.58	0.63	0.64	0.67	0.64	0.67	ns
SSTL12_S	0.32	0.40	0.40	0.40	0.40	0.75	0.75	0.80	0.75	0.80	0.82	0.82	0.87	0.82	0.87	ns
SSTL135_DCI_F	0.34	0.36	0.39	0.36	0.39	0.39	0.41	0.42	0.41	0.42	0.49	0.53	0.56	0.53	0.56	ns
SSTL135_DCI_M	0.34	0.36	0.39	0.36	0.39	0.55	0.55	0.58	0.55	0.58	0.64	0.64	0.68	0.64	0.68	ns
SSTL135_DCI_S	0.34	0.36	0.39	0.36	0.39	0.74	0.74	0.79	0.74	0.79	0.82	0.82	0.89	0.82	0.89	ns
SSTL135_F	0.32	0.37	0.39	0.37	0.39	0.39	0.40	0.42	0.40	0.42	0.49	0.52	0.56	0.52	0.56	ns
SSTL135_M	0.32	0.37	0.39	0.37	0.39	0.54	0.55	0.58	0.55	0.58	0.62	0.64	0.67	0.64	0.67	ns
SSTL135_S	0.32	0.37	0.39	0.37	0.39	0.77	0.77	0.82	0.77	0.82	0.82	0.82	0.87	0.82	0.87	ns
SSTL15_DCI_F	0.31	0.40	0.41	0.40	0.41	0.39	0.41	0.42	0.41	0.42	0.49	0.53	0.56	0.53	0.56	ns
SSTL15_DCI_M	0.31	0.40	0.41	0.40	0.41	0.54	0.55	0.58	0.55	0.58	0.63	0.64	0.68	0.64	0.68	ns
SSTL15_DCI_S	0.31	0.40	0.41	0.40	0.41	0.76	0.76	0.82	0.76	0.82	0.84	0.84	0.91	0.84	0.91	ns
SSTL15_F	0.32	0.37	0.40	0.37	0.40	0.39	0.40	0.42	0.40	0.42	0.49	0.53	0.55	0.53	0.55	ns
SSTL15_M	0.32	0.37	0.40	0.37	0.40	0.54	0.55	0.58	0.55	0.58	0.62	0.63	0.67	0.63	0.67	ns
SSTL15_S	0.32	0.37	0.40	0.37	0.40	0.76	0.76	0.81	0.76	0.81	0.81	0.81	0.86	0.81	0.86	ns

I/O Standards	$T_{INBUF_DELAY_PAD_I}$					$T_{OUTBUF_DELAY_O_PAD}$					$T_{OUTBUF_DELAY_TD_PAD}$					Units
	0.90V			0.85V		0.72V		0.90V			0.85V		0.72V			
	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	-3	-2	-1	-2	-1	
SSTL18_I_DCI	0.25	0.32	0.33	0.32	0.33	0.42	0.44	0.46	0.44	0.46	0.54	0.56	0.59	0.56	0.59	ns
SSTL18_I_DCI	0.25	0.32	0.33	0.32	0.33	0.55	0.55	0.58	0.55	0.58	0.62	0.64	0.68	0.64	0.68	ns
SSTL18_I_DCI	0.25	0.32	0.33	0.32	0.33	0.76	0.76	0.81	0.76	0.81	0.83	0.83	0.89	0.83	0.89	ns
SSTL18_I_F	0.25	0.31	0.33	0.31	0.33	0.43	0.45	0.47	0.45	0.47	0.54	0.57	0.60	0.57	0.60	ns
SSTL18_I_M	0.25	0.31	0.33	0.31	0.33	0.56	0.57	0.60	0.57	0.60	0.53	0.65	0.69	0.65	0.69	ns
SSTL18_I_S	0.25	0.31	0.33	0.31	0.33	0.78	0.78	0.83	0.78	0.83	0.81	0.81	0.87	0.81	0.87	ns
SUB_LVDS	0.50	0.53	0.62	0.53	0.62	0.65	0.66	0.69	0.66	0.69	0.7	0.7	0.7	0.7	0.7	ns

IOB 3-state Output Switching Characteristics

Table 1 specifies the values of $T_{OUTBUF_DELAY_TE_PAD}$ and $T_{INBUF_DELAY_IBUFDIS_O}$.

- $T_{OUTBUF_DELAY_TE_PAD}$ is the delay from the T pin to the IOB pad through the output buffer of an IOB pad, when 3-state is enabled (i.e., a high impedance state).
- $T_{INBUF_DELAY_IBUFDIS_O}$ is the IOB delay from IBUFDISABLE to O output.
- In HP I/O banks, the internal DCI termination turn-off time is always faster than $T_{OUTBUF_DELAY_TE_PAD}$ when the DCITERMDISABLE pin is used.
- In HD I/O banks, the internal IN_TERM termination turn-off time is always faster than $T_{OUTBUF_DELAY_TE_PAD}$ when the INTERMDISABLE pin is used.

Table: IOB 3-state Output Switching Characteristics

Symbol	Description	Speed Grade and V_{CCINT} Operating Voltage					Units
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
$T_{OUTBUF_DELAY_TE_PAD}$	T input to pad high-impedance for HD I/O banks	6.167	6.318	6.369	6.699	6.752	ns
	T input to pad high-impedance for HP I/O banks	5.330	5.330	5.341	5.330	5.341	ns

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V	0.85V		0.72V		
		-3	-2	-1	-2	-1	
T _{IBUF_DELAY_IBUFDIS_O}	IBUF turn-on time from IBUFDISABLE to O output for HD I/O banks	2.266	2.266	2.430	2.266	2.430	ns
	IBUF turn-on time from IBUFDISABLE to O output for HP I/O banks	0.873	0.936	1.037	0.936	1.037	ns

Input Delay Measurement Methodology

The following table shows the test setup parameters used for measuring input delay.

Table: Input Delay Measurement Methodology

Description	I/O Standard Attribute ^{1, 2}	V _L ^{1, 2}	V _H ^{1, 2}	V _{MEAS} ^{1, 4}	V _{REF} ^{1, 3, 5}
LVC MOS, 1.2V	LVC MOS12	0.1	1.1	0.6	–
LVC MOS, LVDCI, HSLVDCI, 1.5V	LVC MOS15, LVDCI_15, HSLVDCI_15	0.1	1.4	0.75	–
LVC MOS, LVDCI, HSLVDCI, 1.8V	LVC MOS18, LVDCI_18, HSLVDCI_18	0.1	1.7	0.9	–
LVC MOS, 2.5V	LVC MOS25	0.1	2.4	1.25	–
LVC MOS, 3.3V	LVC MOS33	0.1	3.2	1.65	–
LVTTL, 3.3V	LVTTL	0.1	3.2	1.65	–
HSTL (high-speed transceiver logic), class I, 1.2V	HSTL_I_12	V _{REF} – 0.25	V _{REF} + 0.25	V _{REF}	0.6
HSTL, class I, 1.5V	HSTL_I	V _{REF} – 0.325	V _{REF} + 0.325	V _{REF}	0.75
HSTL, class I, 1.8V	HSTL_I_18	V _{REF} – 0.4	V _{REF} + 0.4	V _{REF}	0.9

Description	I/O Standard Attribute	$V_L^{1,2}$	$V_H^{1,2}$	$V_{MEAS}^{1,3,5}$	$V_{REF}^{1,3,5}$
HSUL (high-speed unterminated logic), 1.2V	HSUL_12	$V_{REF} - 0.25$	$V_{REF} + 0.25$	V_{REF}	0.6
SSTL12 (stub series terminated logic), 1.2V	SSTL12	$V_{REF} - 0.25$	$V_{REF} + 0.25$	V_{REF}	0.6
SSTL135 and SSTL135 class II, 1.35V	SSTL135, SSTL135_II	$V_{REF} - 0.2875$	$V_{REF} + 0.2875$	V_{REF}	0.675
SSTL15 and SSTL15 class II, 1.5V	SSTL15, SSTL15_II	$V_{REF} - 0.325$	$V_{REF} + 0.325$	V_{REF}	0.75
SSTL18, class I and II, 1.8V	SSTL18_I, SSTL18_II	$V_{REF} - 0.4$	$V_{REF} + 0.4$	V_{REF}	0.9
POD10, 1.0V	POD10	$V_{REF} - 0.2$	$V_{REF} + 0.2$	V_{REF}	0.7
POD12, 1.2V	POD12	$V_{REF} - 0.24$	$V_{REF} + 0.24$	V_{REF}	0.84
DIFF_HSTL, class I, 1.2V	DIFF_HSTL_I_12	$0.6 - 0.25$	$0.6 + 0.25$	0^6	–
DIFF_HSTL, class I, 1.5V	DIFF_HSTL_I	$0.75 - 0.325$	$0.75 + 0.325$	0^6	–
DIFF_HSTL, class I, 1.8V	DIFF_HSTL_I_18	$0.9 - 0.4$	$0.9 + 0.4$	0^6	–
DIFF_HSUL, 1.2V	DIFF_HSUL_12	$0.6 - 0.25$	$0.6 + 0.25$	0^6	–
DIFF_SSTL, 1.2V	DIFF_SSTL12	$0.6 - 0.25$	$0.6 + 0.25$	0^6	–
DIFF_SSTL135 and DIFF_SSTL135 class II, 1.35V	DIFF_SSTL135, DIFF_SSTL135_II	$0.675 - 0.2875$	$0.675 + 0.2875$	0^6	–
DIFF_SSTL15 and DIFF_SSTL15 class II, 1.5V	DIFF_SSTL15, DIFF_SSTL15_II	$0.75 - 0.325$	$0.75 + 0.325$	0^6	–
DIFF_SSTL18_I, DIFF_SSTL18_II, 1.8V	DIFF_SSTL18_I, DIFF_SSTL18_II	$0.9 - 0.4$	$0.9 + 0.4$	0^6	–
DIFF_POD10, 1.0V	DIFF_POD10	$0.5 - 0.2$	$0.5 + 0.2$	0^6	–

Description	I/O Standard Attribute	$V_L^{1, 2}$	$V_H^{1, 2}$	$V_{MEAS}^{1, 3, 5}$	$V_{REF}^{1, 3, 5}$
DIFF_POD12, 1.2V	DIFF_POD12	0.6 – 0.25	0.6 + 0.25	0 ⁶	–
LVDS (low-voltage differential signaling), 1.8V	LVDS	0.9 – 0.125	0.9 + 0.125	0 ⁶	–
LVDS_25, 2.5V	LVDS_25	1.25 – 0.125	1.25 + 0.125	0 ⁶	–
SUB_LVDS, 1.8V	SUB_LVDS	0.9 – 0.125	0.9 + 0.125	0 ⁶	–
SLVS, 1.8V	SLVS_400_18	0.9 – 0.125	0.9 + 0.125	0 ⁶	–
SLVS, 2.5V	SLVS_400_25	1.25 – 0.125	1.25 + 0.125	0 ⁶	–
LVPECL, 2.5V	LVPECL	1.25 – 0.125	1.25 + 0.125	0 ⁶	–
MIPI D-PHY (high speed) 1.2V	MIPI_DPHY_DCI_HS	0.2 – 0.125	0.2 + 0.125	0 ⁶	–
MIPI D-PHY (low power) 1.2V	MIPI_DPHY_DCI_LP	0.715 – 0.2	0.715 + 0.2	0 ⁶	–

1. The input delay measurement methodology parameters for LVDCI/HSLVDCI are the same for LVCMOS standards of the same voltage. Parameters for all other DCI standards are the same for the corresponding non-DCI standards.
2. Input waveform switches between V_L and V_H .
3. Measurements are made at typical, minimum, and maximum V_{REF} values. Reported delays reflect worst case of these measurements. V_{REF} values listed are typical.
4. Input voltage level from which measurement starts.
5. This is an input voltage reference that bears no relation to the V_{REF}/V_{MEAS} parameters found in IBIS models and/or noted in Figure 1.
6. The value given is the differential input voltage.

Output Delay Measurement Methodology

Output delays are measured with short output traces. Standard termination was used for all testing. The propagation delay of the trace is characterized separately and subtracted from the

final measurement, and is therefore not included in the generalized test setups shown in Figure 1 and Figure 2.

Figure: Single-Ended Test Setup

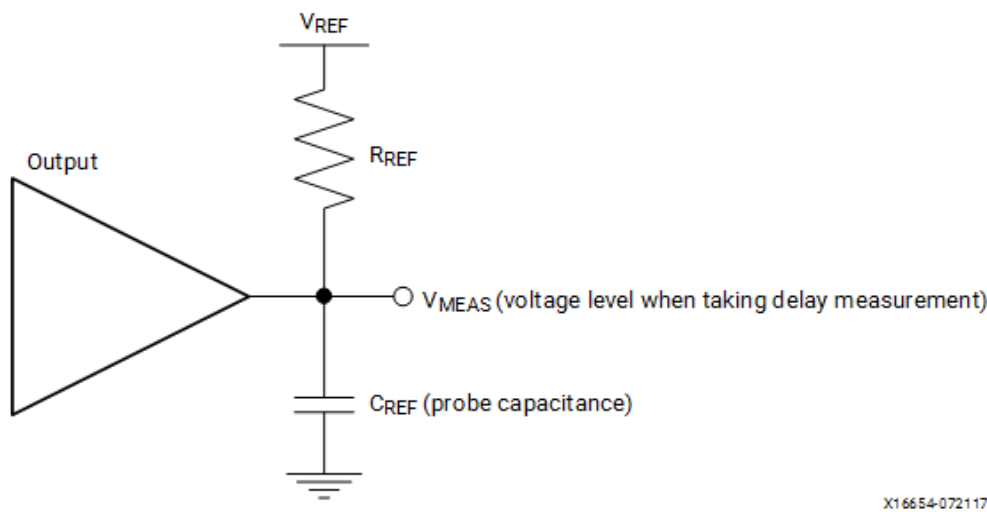
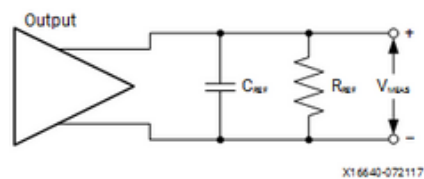


Figure: Differential Test Setup



Parameters V_{REF} , R_{REF} , C_{REF} , and V_{MEAS} fully describe the test conditions for each I/O standard. The most accurate prediction of propagation delay in any given application can be obtained through IBIS simulation, using this method:

1. Simulate the output driver of choice into the generalized test setup using values from Table 1.
2. Record the time to V_{MEAS} .
3. Simulate the output driver of choice into the actual PCB trace and load using the appropriate IBIS model or capacitance value to represent the load.
4. Record the time to V_{MEAS} .
5. Compare the results of step 2 and step 4. The increase or decrease in delay yields the actual propagation delay of the PCB trace.

Table: Output Delay Measurement Methodology

Description	I/O Standard Attribute	R_{REF} (Ω)	C_{REF} (pF)	V_{MEAS} (V)	V_{REF} (V)
LVC MOS, 1.2V	LVC MOS12	1M	0	0.6	0

Description	I/O Standard Attribute	R_{REF} (Ω)	C_{REF} (pF)	V_{REF} (V)	V_{REF} (V)
LVC MOS, 1.5V	LVC MOS15	1M	0	0.75	0
LVC MOS, 1.8V	LVC MOS18	1M	0	0.9	0
LVC MOS, 2.5V	LVC MOS25	1M	0	1.25	0
LVC MOS, 3.3V	LVC MOS33	1M	0	1.65	0
LVTTL, 3.3V	LVTTL	1M	0	1.65	0
LVDCI, HSLVDCI, 1.5V	LVDCI_15, HSLVDCI_15	50	0	V_{REF}	0.75
LVDCI, HSLVDCI, 1.8V	LVDCI_15, HSLVDCI_18	50	0	V_{REF}	0.9
HSTL (high-speed transceiver logic), class I, 1.2V	HSTL_I_12	50	0	V_{REF}	0.6
HSTL, class I, 1.5V	HSTL_I	50	0	V_{REF}	0.75
HSTL, class I, 1.8V	HSTL_I_18	50	0	V_{REF}	0.9
HSUL (high-speed unterminated logic), 1.2V	HSUL_12	50	0	V_{REF}	0.6
SSTL12 (stub series terminated logic), 1.2V	SSTL12	50	0	V_{REF}	0.6
SSTL135 and SSTL135 class II, 1.35V	SSTL135, SSTL135_II	50	0	V_{REF}	0.675
SSTL15 and SSTL15 class II, 1.5V	SSTL15, SSTL15_II	50	0	V_{REF}	0.75
SSTL18, class I and class II, 1.8V	SSTL18_I, SSTL18_II	50	0	V_{REF}	0.9
POD10, 1.0V	POD10	50	0	V_{REF}	1.0
POD12, 1.2V	POD12	50	0	V_{REF}	1.2
DIFF_HSTL, class I, 1.2V	DIFF_HSTL_I_12	50	0	V_{REF}	0.6
DIFF_HSTL, class I, 1.5V	DIFF_HSTL_I	50	0	V_{REF}	0.75
DIFF_HSTL, class I, 1.8V	DIFF_HSTL_I_18	50	0	V_{REF}	0.9

Description	I/O Standard Attribute	R _{REF} (Ω)		V _{REF} (V)	
		0	1	0	1
DIFF_HSUL, 1.2V	DIFF_HSUL_12	50	0	V _{REF}	0.6
DIFF_SSTL12, 1.2V	DIFF_SSTL12	50	0	V _{REF}	0.6
DIFF_SSTL135 and DIFF_SSTL135 class II, 1.35V	DIFF_SSTL135, DIFF_SSTL135_II	50	0	V _{REF}	0.675
DIFF_SSTL15 and DIFF_SSTL15 class II, 1.5V	DIFF_SSTL15, DIFF_SSTL15_II	50	0	V _{REF}	0.75
DIFF_SSTL18, class I and II, 1.8V	DIFF_SSTL18_I, DIFF_SSTL18_II	50	0	V _{REF}	0.9
DIFF_POD10, 1.0V	DIFF_POD10	50	0	V _{REF}	1.0
DIFF_POD12, 1.2V	DIFF_POD12	50	0	V _{REF}	1.2
LVDS (low-voltage differential signaling), 1.8V	LVDS	100	0	0 ²	0
SUB_LVDS, 1.8V	SUB_LVDS	100	0	0 ²	0
MIPI D-PHY (high speed) 1.2V	MIPI_DPHY_DCI_HS	100	0	0 ²	0
MIPI D-PHY (low power) 1.2V	MIPI_DPHY_DCI_LP	1M	0	0.6	0

1. C_{REF} is the capacitance of the probe, nominally 0 pF.
 2. The value given is the differential output voltage.

Block RAM and FIFO Switching Characteristics

Table: Block RAM and FIFO Switching Characteristics

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
Maximum Frequency							
F _{MAX_WF_NO}	Block RAM (WRITE_FIRST and NO_CHANGE modes)	825	738	645	585	516	MHz

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
F _{MAX_RF}	Block RAM (READ_FIRST mode)	718	637	575	510	460	MHz
F _{MAX_FIFO}	FIFO in all modes without ECC	825	738	645	585	516	MHz
F _{MAX_ECC}	Block RAM and FIFO in ECC configuration without PIPELINE	718	637	575	510	460	MHz
	Block RAM and FIFO in ECC configuration with PIPELINE and Block RAM in WRITE_FIRST or NO_CHANGE mode	825	738	645	585	516	MHz
T _{PW} ¹	Minimum pulse width	495	542	543	577	578	ps
Block RAM and FIFO Clock-to-Out Delays							
T _{RCKO_DO}	Clock CLK to DOUT output (without output register)	0.91	1.02	1.11	1.46	1.53	ns, Max
T _{RCKO_DO_REG}	Clock CLK to DOUT output (with output register)	0.27	0.29	0.30	0.42	0.44	ns, Max
1. The MMCM and PLL DUTY_CYCLE attribute should be set to 50% to meet the pulse-width requirements at the higher frequencies.							

UltraRAM Switching Characteristics

The *UltraScale Architecture and Product Data Sheet: Overview (DS890)* lists the Kintex UltraScale+ FPGAs that include this memory.

Table: UltraRAM Switching Characteristics

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
Maximum Frequency							

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V	0.85V		0.72V		
		-3	-2	-1	-2	-1	
F _{MAX}	UltraRAM maximum frequency with OREG_B = True	650	600	575	500	481	MHz
F _{MAX_ECC_NOPIPELINE}	UltraRAM maximum frequency with OREG_B = False and EN_ECC_RD_B = True	435	400	386	312	303	MHz
F _{MAX_NOPIPELINE}	UltraRAM maximum frequency with OREG_B = False and EN_ECC_RD_B = False	528	500	478	404	389	MHz
T _{PW} ¹	Minimum pulse width	650	700	730	800	832	ps
T _{RSTPW}	Asynchronous reset minimum pulse width. One cycle required	1 clock cycle					

1. The MMCM and PLL DUTY_CYCLE attribute should be set to 50% to meet the pulse-width requirements at the higher frequencies.

Input/Output Delay Switching Characteristics

Table: Input/Output Delay Switching Characteristics

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V	0.85V		0.72V		
		-3	-2	-1	-2	-1	
F _{REFCLK}	Reference clock frequency for IDELAYCTRL (component mode)	300 to 800					MHz
	Reference clock frequency when using BITSlice_CONTROL with REFCLK (in native mode (for RX_BITSLICE only))	300 to 800					MHz

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V	0.85V		0.72V		
		-3	-2	-1	-2	-1	
	Reference clock frequency for BITSlice_CONTROL with PLL_CLK (in native mode) ¹	300 to 2666.67	300 to 2666.67	300 to 2400	300 to 2400	300 to 2133	MHz
T _{MINPER_CLK}	Minimum period for IODELAY clock	3.195	3.195	3.195	3.195	3.195	ns
T _{MINPER_RST}	Minimum reset pulse width	52.00					ns
T _{IDELAY_RESOLUTION} T _{ODELAY_RESOLUTION}	IDELAY/ODELAY chain resolution	2.1 to 12					ps
1. PLL settings could restrict the minimum allowable data rate. For example, when using a PLL with CLKOUTPHY_MODE = VCO_HALF, the minimum frequency is PLL_F _{VCOMIN} /2.							

DSP48 Slice Switching Characteristics

Table: DSP48 Slice Switching Characteristics

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V	0.85V		0.72V ¹		
		-3	-2	-1	-2	-1	
Maximum Frequency							
F _{MAX}	With all registers used	891	775	645	644	600	MHz
F _{MAX_PATDET}	With pattern detector	794	687	571	562	524	MHz
F _{MAX_MULT_NOMREG}	Two register multiply without MREG	635	544	456	440	413	MHz
F _{MAX_MULT_NOMREG_PATDET}	Two register multiply without MREG with pattern detect	577	492	410	395	371	MHz

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					
		0.90V		0.85V		0.72V ¹	
		-3	-2	-1	-2	-1	
F _{MAX_PREADD_NOADREG}	Without ADREG	655	565	468	453	423	MHz
F _{MAX_NOPIPELINEREG}	Without pipeline registers (MREG, ADREG)	483	410	338	323	304	MHz
F _{MAX_NOPIPELINEREG_PATTERN}	Without pipeline registers (MREG, ADREG) with pattern detect	448	379	314	299	280	MHz

1. For devices operating at the lower power V_{CCINT} = 0.72V voltages, DSP cascades that cross the clock region center might operate below the specified F_{MAX}.

Clock Buffers and Networks

Table: Clock Buffers Switching Characteristics

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
Global Clock Switching Characteristics (Including BUFGCTRL)							
F _{MAX}	Maximum frequency of a global clock tree (BUFG)	891	775	667	725	667	MHz
Global Clock Buffer with Input Divide Capability (BUFGCE_DIV)							
F _{MAX}	Maximum frequency of a global clock buffer with input divide capability (BUFGCE_DIV)	891	775	667	725	667	MHz
Global Clock Buffer with Clock Enable (BUFGCE)							
F _{MAX}	Maximum frequency of a global clock buffer with clock enable (BUFGCE)	891	775	667	725	667	MHz

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
Leaf Clock Buffer with Clock Enable (BUFCE_LEAF)							
F _{MAX}	Maximum frequency of a leaf clock buffer with clock enable (BUFCE_LEAF)	891	775	667	725	667	MHz
GTH or GTY Clock Buffer with Clock Enable and Clock Input Divide Capability (BUFG_GT)							
F _{MAX}	Maximum frequency of a serial transceiver clock buffer with clock enable and clock input divide capability	512	512	512	512	512	MHz

MMCM Switching Characteristics

Table: MMCM Specification

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
MMCM_F _{INMAX}	Maximum input clock frequency	1066	933	800	933	800	MHz
MMCM_F _{INMIN}	Minimum input clock frequency	10	10	10	10	10	MHz
MMCM_F _{INJITTER}	Maximum input clock period jitter	< 20% of clock input period or 1 ns Max					
MMCM_F _{INDUTY}	Input duty cycle range: 10–49 MHz	25–75					%
	Input duty cycle range: 50–199 MHz	30–70					%
	Input duty cycle range: 200–399 MHz	35–65					%

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
	Input duty cycle range: 400–499 MHz	40–60					%
	Input duty cycle range: >500 MHz	45–55					%
MMCM_F _{MIN_PCLK}	Minimum dynamic phase shift clock frequency	0.01	0.01	0.01	0.01	0.01	MHz
MMCM_F _{MAX_PCLK}	Maximum dynamic phase shift clock frequency	550	500	450	500	450	MHz
MMCM_F _{VCOMIN}	Minimum MMCM VCO frequency	800	800	800	800	800	MHz
MMCM_F _{VCOMAX}	Maximum MMCM VCO frequency	1600	1600	1600	1600	1600	MHz
MMCM_F _{BANDWIDTH}	Low MMCM bandwidth at typical ¹	1.00	1.00	1.00	1.00	1.00	MHz
	High MMCM bandwidth at typical ¹	4.00	4.00	4.00	4.00	4.00	MHz
MMCM_T _{STATPHASOFPSET}	Static phase offset of the MMCM outputs ²	0.12	0.12	0.12	0.12	0.12	ns
MMCM_T _{OUTJITTER}	MMCM output jitter.	Note 3					
MMCM_T _{OUTDUTY}	MMCM output clock duty cycle precision ⁴	0.165	0.20	0.20	0.20	0.20	ns
MMCM_T _{LOCKMAX}	MMCM maximum lock time for MMCM_F _{PFDMIN}	100	100	100	100	100	μs
MMCM_F _{OUTMAX}	MMCM maximum output frequency	891	775	667	725	667	MHz
MMCM_F _{OUTMIN}	MMCM minimum output frequency ^{4, 5}	6.25	6.25	6.25	6.25	6.25	MHz

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
MMCM_T _{EXTFDVAR}	External clock feedback variation	< 20% of clock input period or 1 ns Max					
MMCM_RST _{MINPULSE}	Minimum reset pulse width	5.00	5.00	5.00	5.00	5.00	ns
MMCM_F _{PFDMAX}	Maximum frequency at the phase frequency detector	550	500	450	500	450	MHz
MMCM_F _{PFDMIN}	Minimum frequency at the phase frequency detector	10	10	10	10	10	MHz
MMCM_T _{FBDELAY}	Maximum delay in the feedback path	5 ns Max or one clock cycle					
MMCM_F _{DPRCLK_MAX}	Maximum DRP clock frequency	250	250	250	250	250	MHz
<ol style="list-style-type: none"> 1. The MMCM does not filter typical spread-spectrum input clocks because they are usually far below the bandwidth filter frequencies. 2. The static offset is measured between any MMCM outputs with identical phase. 3. Values for this parameter are available in the Clocking Wizard. 4. Includes global clock buffer. 5. Calculated as F_{VCO}/128 assuming output duty cycle is 50%. 							

PLL Switching Characteristics

Table: PLL Specification

Symbol	Description ¹	Speed Grade and V _{CCINT} Operating Voltages					
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
PLL_F _{INMAX}	Maximum input clock frequency	1066	933	800	933	800	MHz
PLL_F _{INMIN}	Minimum input clock frequency	70	70	70	70	70	MHz

Symbol	Description ¹	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
PLL_F _{INJITTER}	Maximum input clock period jitter	< 20% of clock input period or 1 ns Max					
PLL_F _{INDUTY}	Input duty cycle range: 70–399 MHz	35–65					%
	Input duty cycle range: 400–499 MHz	40–60					%
	Input duty cycle range: >500 MHz	45–55					%
PLL_F _{VCOMIN}	Minimum PLL VCO frequency	750	750	750	750	750	MHz
PLL_F _{VCOMAX}	Maximum PLL VCO frequency	1500	1500	1500	1500	1500	MHz
PLL_T _{STATPHASESET}	Static phase offset of the PLL outputs ²	0.12	0.12	0.12	0.12	0.12	ns
PLL_T _{OUTJITTER}	PLL output jitter.	Note 3					
PLL_T _{OUTDUTY}	PLL CLKOUT0, CLKOUT0B, CLKOUT1, CLKOUT1B duty-cycle precision ⁴	0.165	0.20	0.20	0.20	0.20	ns
PLL_T _{LOCKMAX}	PLL maximum lock time	100					µs
PLL_F _{OUTMAX}	PLL maximum output frequency at CLKOUT0, CLKOUT0B, CLKOUT1, CLKOUT1B	891	775	667	725	667	MHz
	PLL maximum output frequency at CLKOUTPHY	2667	2667	2400	2400	2133	MHz
PLL_F _{OUTMIN}	PLL minimum output frequency at CLKOUT0, CLKOUT0B, CLKOUT1, CLKOUT1B ⁵	5.86	5.86	5.86	5.86	5.86	MHz
	PLL minimum output frequency at CLKOUTPHY	2 x VCO mode: 1500, 1 x VCO mode: 750, 0.5 x VCO mode: 375					MHz

Symbol	Description ¹	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
PLL_RST_MINPULSE	Minimum reset pulse width	5.00	5.00	5.00	5.00	5.00	ns
PLL_F_PFD_MAX	Maximum frequency at the phase frequency detector	667.5	667.5	667.5	667.5	667.5	MHz
PLL_F_PFD_MIN	Minimum frequency at the phase frequency detector	70	70	70	70	70	MHz
PLL_F_BANDWIDTH_T	PLL bandwidth at typical	14	14	14	14	14	MHz
PLL_F_DPRCLK_MAX	Maximum DRP clock frequency	250	250	250	250	250	MHz

1. The PLL does not filter typical spread-spectrum input clocks because they are usually far below the loop filter frequencies.
2. The static offset is measured between any PLL outputs with identical phase.
3. Values for this parameter are available in the Clocking Wizard.
4. Includes global clock buffer.
5. Calculated as $F_{VCO}/128$ assuming output duty cycle is 50%.

Device Pin-to-Pin Output Parameter Guidelines

The pin-to-pin numbers in the following tables are based on the clock root placement in the center of the device. The actual pin-to-pin values will vary if the root placement selected is different. Consult the Vivado Design Suite timing report for the actual pin-to-pin values.

Table: Global Clock Input to Output Delay Without MMCM (Near Clock Region)

Symbol	Description ¹	Device	Speed Grade and V _{CCINT} Operating Voltages					Units
			0.90V		0.85V		0.72V	
			-3	-2	-1	-2	-1	
SSTL15 Global Clock Input to Output Delay using Output Flip-Flop, Fast Slew Rate, <i>without</i> MMCM								

Symbol	Description ¹	Device	Speed Grade and V _{CCINT} Operating Voltages				
			0.90V		0.85V		0.72V
			-3	-2	-1	-2	-1
T _{ICKOF}	Global clock input and output flip-flop <i>without</i> MMCM (near clock region)	XCKU3P4.65	5.09	5.48	6.37	6.84	ns
		XCKU5P4.65	5.09	5.48	6.37	6.84	ns
		XCKU9P5.42	5.91	6.35	7.48	8.03	ns
		XCKU11B.92	6.49	6.96	8.16	8.91	ns
		XCKU13B.58	6.09	6.55	7.75	8.33	ns
		XCKU15B.29	6.90	7.40	8.68	9.32	ns
		XCKU19B.85	6.43	6.91	8.09	8.72	ns
		XQKU5PN/A	5.09	5.48	N/A	6.84	ns
		XQKU15N/A	6.90	7.40	N/A	9.32	ns

1. This table lists representative values where one global clock input drives one vertical clock line in each accessible column, and where all accessible I/O and CLB flip-flops are clocked by the global clock net.

Table: Global Clock Input to Output Delay Without MMCM (Far Clock Region)

Symbol	Description ¹	Device	Speed Grade and V _{CCINT} Operating Voltages				
			0.90V		0.85V		0.72V
			-3	-2	-1	-2	-1
SSTL15 Global Clock Input to Output Delay using Output Flip-Flop, Fast Slew Rate, <i>without</i> MMCM							
T _{ICKOF_FAR}	Global clock input and output flip-flop <i>without</i> MMCM (far clock region)	XCKU3P4.84	5.30	5.70	6.64	7.14	ns
		XCKU5P4.84	5.30	5.70	6.64	7.14	ns
		XCKU9P5.91	6.49	6.97	8.16	8.76	ns
		XCKU11B.29	6.91	7.41	8.72	9.52	ns
		XCKU13B.90	6.49	6.96	8.16	8.77	ns

Symbol	Description ¹	Device	Speed Grade and V _{CCINT} Operating Voltages				
			0.90V	0.85V		0.72V	
			-3	-2	-1	-2	-1
		XCKU15P.84	7.53	8.07	9.52	10.23	ns
		XCKU19P.23	6.86	7.35	8.65	9.33	ns
		XQKU5PN/A	5.30	5.70	N/A	7.14	ns
		XQKU15P/A	7.53	8.07	N/A	10.23	ns

1. This table lists representative values where one global clock input drives one vertical clock line in each accessible column, and where all accessible I/O and CLB flip-flops are clocked by the global clock net.

Table: Global Clock Input to Output Delay With MMCM

Symbol	Description ^{1, 2}	Device	Speed Grade and V _{CCINT} Operating Voltages				
			0.90V	0.85V		0.72V	
			-3	-2	-1	-2	-1
SSTL15 Global Clock Input to Output Delay using Output Flip-Flop, Fast Slew Rate, <i>with</i> MMCM							
T _{ICKOFFMMCM}	Global clock input and output flip-flop <i>with</i> MMCM	XCKU3P.67	1.98	2.17	2.59	2.74	ns
		XCKU5P.67	1.98	2.17	2.59	2.74	ns
		XCKU9P.83	2.15	2.36	2.80	2.95	ns
		XCKU11P.96	2.30	2.51	2.99	3.20	ns
		XCKU13P.85	2.18	2.38	2.82	2.98	ns
		XCKU15P.08	2.44	2.66	3.15	3.33	ns
		XCKU19P.82	2.18	2.39	2.86	3.04	ns
		XQKU5PN/A	1.98	2.17	N/A	2.74	ns
		XQKU15P/A	2.44	2.66	N/A	3.33	ns

1. This table lists representative values where one global clock input drives one vertical clock line in each accessible column, and where all accessible I/O and CLB flip-flops are

Symbol	Description ^{1, 2}	Device	Speed Grade and V _{CCINT} Operating Voltages				
			0.90V		0.85V		0.72V
			-3	-2	-1	-2	-1
clocked by the global clock net. 2. MMCM output jitter is already included in the timing calculation.							

Table: Source Synchronous Output Characteristics (Component Mode)

Description	Speed Grade and V _{CCINT} Operating Voltages					Units
	0.90V		0.85V		0.72V	
	-3	-2	-1	-2	-1	
T _{OUTPUT_LOGIC_DELAY_VARIATION} 1	80					ps
1. Delay mismatch across a transmit bus when using component mode output logic (ODDRE1, OSERDESE3) within a bank.						

Device Pin-to-Pin Input Parameter Guidelines

The pin-to-pin numbers in the following tables are based on the clock root placement in the center of the device. The actual pin-to-pin values will vary if the root placement selected is different. Consult the Vivado Design Suite timing report for the actual pin-to-pin values.

Table: Global Clock Input Setup and Hold With 3.3V HD I/O Without MMCM

Symbol	Description	Device	Speed Grade and V _{CCINT} Operating Voltages					
			0.90V		0.85V		0.72V	
			-3	-2	-1	-2	-1	
Input Setup and Hold Time Relative to Global Clock Input Signal using SSTL15 Standard. ^{1, 2, 3}								
T _{PSFD_KU3P}	Global clock input and input flip-flop (or latch) <i>without</i> MMCM	Setup	XCKU3P1.98	2.28	2.38	3.55	3.83	ns
T _{PHFD_KU3P}		Hold	– 0.36	– 0.36	– 0.36	– 1.04	– 1.04	ns

Symbol	Description	Device	Speed Grade and V _{CCINT} Operating Voltages					Unit
			0.90V		0.85V		0.72V	
			-3	-2	-1	-2	-1	
T _{PSFD_KU5P}	Setup	XCKU5P1.98	2.28	2.38	3.55	3.83	ns	
T _{PHFD_KU5P}	Hold		– 0.36	– 0.36	– 0.36	– 1.04	– 1.04	ns
T _{PSFD_KU9P}	Setup	XCKU9P1.51	1.79	1.86	2.85	3.06	ns	
T _{PHFD_KU9P}	Hold		– 0.05	– 0.05	– 0.05	– 0.60	– 0.60	ns
T _{PSFD_KU11P}	Setup	XCKU11P.99	2.28	2.38	3.54	3.79	ns	
T _{PHFD_KU11P}	Hold		– 0.38	– 0.38	– 0.38	– 1.05	– 1.05	ns
T _{PSFD_KU13P}	Setup	XCKU13P.51	1.79	1.85	2.84	3.05	ns	
T _{PHFD_KU13P}	Hold		– 0.04	– 0.04	– 0.04	– 0.60	– 0.60	ns
T _{PSFD_KU15P}	Setup	XCKU15P.00	2.29	2.38	3.56	3.83	ns	
T _{PHFD_KU15P}	Hold		– 0.38	– 0.38	– 0.38	– 1.08	– 1.08	ns
T _{PSFD_KU19P}	Setup	XCKU19P.88	1.03	1.04	1.99	2.13	ns	
T _{PHFD_KU19P}	Hold		0.51	0.51	0.51	– 0.03	– 0.03	ns
T _{PSFD_XQKU5P}	Setup	XQKU5PN/A	2.28	2.38	N/A	3.83	ns	
T _{PHFD_XQKU5P}	Hold		N/A	– 0.36	– 0.36	N/A	– 1.04	ns
T _{PSFD_XQKU15P}	Setup	XQKU15PN/A	2.29	2.38	N/A	3.83	ns	
T _{PHFD_XQKU15P}	Hold		N/A	– 0.38	– 0.38	N/A	– 1.08	ns

1. Setup and hold times are measured over worst case conditions (process, voltage, temperature). Setup time is measured relative to the global clock input signal using the

Symbol	Description	Device	Speed Grade and V _{CCINT} Operating Voltages				
			0.90V		0.85V		0.72V
			-3	-2	-1	-2	-1
slowest process, slowest temperature, and slowest voltage. Hold time is measured relative to the global clock input signal using the fastest process, fastest temperature, and fastest voltage.							
2. This table lists representative values where one global clock input drives one vertical clock line in each accessible column, and where all accessible I/O and CLB flip-flops are clocked by the global clock net.							
3. Use IBIS to determine any duty-cycle distortion incurred using various standards.							

Table: Global Clock Input Setup and Hold With MMCM

Symbol	Description	Device	Speed Grade and V _{CCINT} Operating Voltages						
			0.90V		0.85V		0.72V		
			-3	-2	-1	-2	-1		
Input Setup and Hold Time Relative to Global Clock Input Signal using SSTL15 Standard. ^{1, 2, 3}									
T _{PSMMCMCC_KU3P}	Global clock input and input flip-flop (with MMCM)	Setup	XCKU3P	2.04	2.04	2.16	2.04	2.16	ns
T _{PHMMCMCC_KU3P}		Hold		–	–	–	–	–	ns
				0.17	0.17	0.17	0.23	0.23	
T _{PSMMCMCC_KU5P}		Setup	XCKU5P	2.04	2.04	2.16	2.04	2.16	ns
T _{PHMMCMCC_KU5P}		Hold		–	–	–	–	–	ns
				0.17	0.17	0.17	0.23	0.23	
T _{PSMMCMCC_KU9P}		Setup	XCKU9P	2.00	2.00	2.12	2.00	2.12	ns
T _{PHMMCMCC_KU9P}		Hold		–	–	–	–	–	ns
				0.11	0.11	0.11	0.18	0.18	
T _{PSMMCMCC_KU11P}		Setup	XCKU11P	1.89	1.89	2.02	1.89	2.02	ns
T _{PHMMCMCC_KU11P}		Hold		–	–	–	–	–	ns
				0.20	0.20	0.20	0.25	0.25	
T _{PSMMCMCC_KU13P}		Setup	XCKU13P	1.99	1.99	2.12	1.99	2.12	ns

Symbol	Description	Device	Speed Grade and V _{CCINT} Operating Voltages					Units
			0.90V		0.85V		0.72V	
			-3	-2	-1	-2	-1	
T _{PHMMCMCC_KU13P}	Hold		– 0.10	– 0.10	– 0.10	– 0.16	– 0.16	ns
T _{PSMMCMCC_KU15P}	Setup	XCKU15P	1.89	1.89	2.03	1.89	2.03	ns
T _{PHMMCMCC_KU15P}	Hold		– 0.16	– 0.16	– 0.16	– 0.23	– 0.23	ns
T _{PSMMCMCC_KU19P}	Setup	XCKU19P	2.01	2.02	2.13	2.02	2.13	ns
T _{PHMMCMCC_KU19P}	Hold		– 0.09	– 0.09	– 0.09	– 0.18	– 0.18	ns
T _{PSMMCMCC_XQKU5P}	Setup	XQKU5P	N/A	2.04	2.16	N/A	2.16	ns
T _{PHMMCMCC_XQKU5P}	Hold		N/A	– 0.17	– 0.17	N/A	– 0.23	ns
T _{PSMMCMCC_XQKU15P}	Setup	XQKU15P	N/A	1.89	2.03	N/A	2.03	ns
T _{PHMMCMCC_XQKU15P}	Hold		N/A	– 0.16	– 0.16	N/A	– 0.23	ns

1. Setup and hold times are measured over worst case conditions (process, voltage, temperature). Setup time is measured relative to the global clock input signal using the slowest process, slowest temperature, and slowest voltage. Hold time is measured relative to the global clock input signal using the fastest process, fastest temperature, and fastest voltage.
2. This table lists representative values where one global clock input drives one vertical clock line in each accessible column, and where all accessible I/O and CLB flip-flops are clocked by the global clock net.
3. Use IBIS to determine any duty-cycle distortion incurred using various standards.

Table: Sampling Window

Description	Speed Grade and V _{CCINT} Operating Voltages					Units
	0.90V		0.85V		0.72V	
	-3	-2	-1	-2	-1	

Description	Speed Grade and V _{CCINT} Operating Voltages					Units
	0.90V	0.85V		0.72V		
	-3	-2	-1	-2	-1	
T _{SAMP_BUFG} ¹	510	610	610	610	610	ps
T _{SAMP_NATIVE_DPA} ²	100	100	125	125	150	ps
T _{SAMP_NATIVE_BISC} ³	60	60	85	85	110	ps

1. This parameter indicates the total sampling error of the Kintex UltraScale+ FPGA DDR input registers, measured across voltage, temperature, and process. The characterization methodology uses the MMCM to capture the DDR input registers' edges of operation. These measurements include: CLK0 MMCM jitter, MMCM accuracy (phase offset), and MMCM phase shift resolution. These measurements do not include package or clock tree skew.
2. This parameter is the receive sampling error for RX_BITSLICE when using dynamic phase alignment.
3. This parameter is the receive sampling error for RX_BITSLICE when using built-in self-calibration (BISC).

Table: Input Logic Characteristics for Dynamic Phase Aligned Applications (Component Mode)

Description	Speed Grade and V _{CCINT} Operating Voltages					Units
	0.90V	0.85V		0.72V		
	-3	-2	-1	-2	-1	
T _{INPUT_LOGIC_UNCERTAINTY} ¹	40					ps
T _{CAL_ERROR} ²	24					ps

1. Input_logic_uncertainty accounts for the setup/hold and any pattern dependent jitter for the input logic (input register, IDDRE1, or ISERDESE3).
2. Calibration error associated with quantization effects based on the IDELAY resolution. Calibration must be performed for each input pin to ensure optimal performance.

Package Parameter Guidelines

The parameters in this section provide the necessary values for calculating timing budgets for clock transmitter and receiver data-valid windows.

Table: Package Skew

Symbol	Description	Device	Package	Value	Units
PKGSKEW	Package Skew ^{1, 2}	XCKU3P	SFVB784	75	ps
			FFVA676	136	ps
			FFVB676	69	ps
			FFVD900	179	ps
		XCKU5P	SFVB784	75	ps
			FFVA676	136	ps
			FFVB676	69	ps
			FFVD900	179	ps
		XCKU9P	FFVE900	212	ps
		XCKU11P	FFVD900	146	ps
			FFVA1156	170	ps
			FFVE1517	178	ps
		XCKU13P	FFVE900	197	ps
		XCKU15P	FFVA1156	203	ps
			FFVE1517	167	ps
			FFVA1760	191	ps
			FFVE1760	172	ps
		XCKU19P	FFVJ1760	187	ps
			FFVB2104	196	ps
		XQKU5P	FFRB676	70	ps
SFRB784	75		ps		
XQKU15P	FFRA1156	201	ps		

Symbol	Description	Device	Package	Value	Units
			FFRE1517	161	ps

1. These values represent the worst-case skew between any two SelectIO resources in the package: shortest delay to longest delay from die pad to ball.
 2. Package delay information is available for these device/package combinations. This information can be used to deskew the package.

GTH Transceiver Specifications

The *UltraScale Architecture and Product Data Sheet: Overview* (DS890) lists the Kintex UltraScale+ FPGAs that include the GTH transceivers.

GTH Transceiver DC Input and Output Levels

The following table summarizes the DC specifications of the GTH transceivers in Kintex UltraScale+ FPGAs. Consult the *UltraScale Architecture GTH Transceivers User Guide* (UG576) for further details.

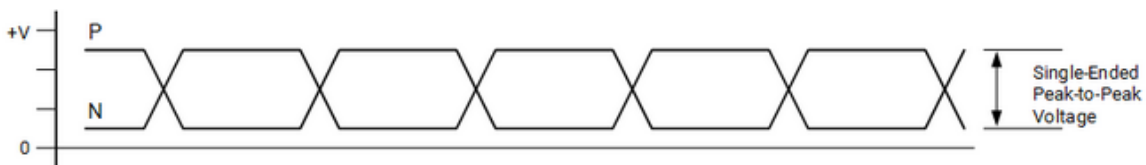
Table: GTH Transceiver DC Specifications

Symbol	DC Parameter	Conditions	Min	Typ	Max	Units
DV _{PPIN}	Differential peak-to-peak input voltage (external AC coupled)	>10.3125 Gb/s	150	–	1250	mV
		6.6 Gb/s to 10.3125 Gb/s	150	–	1250	mV
		≤ 6.6 Gb/s	150	–	2000	mV
V _{IN}	Single-ended input voltage. Voltage measured at the pin referenced to GND	DC coupled V _{MGTAVTT} = 1.2V	–400	–	V _{MGTAVTT}	mV
V _{CMIN}	Common mode input voltage	DC coupled V _{MGTAVTT} = 1.2V	–	2/3 V _{MGTAVTT}	–	mV
DV _{PPOUT}	Differential peak-to-peak output voltage ¹	Transmitter output swing is set to 11111	800	–	–	mV

Symbol	DC Parameter	Conditions	Min	Typ	Max	Units
$V_{CMOUTDC}$	Common mode output voltage: DC coupled (equation based)	When remote RX is terminated to GND	$V_{MGTAVTT}/2 - D_{VPPOUT}/4$			mV
		When remote RX termination is floating	$V_{MGTAVTT} - D_{VPPOUT}/2$			mV
		When remote RX is terminated to V_{RX_TERM} ²	$V_{MGTAVTT} - \frac{D_{VPPOUT}}{4} - \left(\frac{V_{MGTAVTT} - V_{RX_TERM}}{2} \right)$			mV
$V_{CMOUTAC}$	Common mode output voltage: AC coupled (equation based)		$V_{MGTAVTT} - D_{VPPOUT}/2$			mV
R_{IN}	Differential input resistance		–	100	–	Ω
R_{OUT}	Differential output resistance		–	100	–	Ω
T_{OSKEW}	Transmitter output pair (TXP and TXN) intra-pair skew (all packages)		–	–	10	ps
C_{EXT}	Recommended external AC coupling capacitor ³		–	100	–	nF

1. The output swing and pre-emphasis levels are programmable using the attributes discussed in the *UltraScale Architecture GTH Transceivers User Guide (UG576)*, and can result in values lower than reported in this table.
2. V_{RX_TERM} is the remote RX termination voltage.
3. Other values can be used as appropriate to conform to specific protocols and standards.

Figure: Single-Ended Peak-to-Peak Voltage



X16658-072117

Figure: Differential Peak-to-Peak Voltage

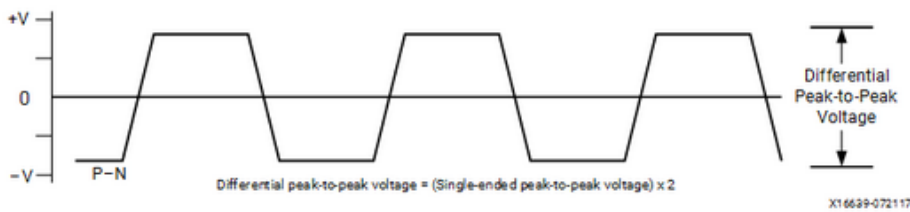


Table 2 and Table 3 summarize the DC specifications of the GTH transceivers input and output clocks in Kintex UltraScale+ FPGAs. Consult the *UltraScale Architecture GTH Transceivers User Guide (UG576)* for further details.

Table: GTH Transceiver Clock Input Level Specification

Symbol	DC Parameter	Min	Typ	Max	Units
V_{IDIFF}	Differential peak-to-peak input voltage	250	–	2000	mV
R_{IN}	Differential input resistance	–	100	–	Ω
C_{EXT}	Required external AC coupling capacitor	–	10	–	nF

Table: GTH Transceiver Clock Output Level Specification

Symbol	Description	Conditions	Min	Typ	Max	Units
V_{OL}	Output Low voltage for P and N	$R_T = 100\Omega$ across P and N signals	100	–	330	mV
V_{OH}	Output High voltage for P and N	$R_T = 100\Omega$ across P and N signals	500	–	700	mV
V_{DDOUT}	Differential output voltage (P–N), P = High (N–P), N = High	$R_T = 100\Omega$ across P and N signals	300	–	430	mV
V_{CMOUT}	Common mode voltage	$R_T = 100\Omega$ across P and N signals	300	–	500	mV

GTH Transceiver Switching Characteristics

Consult the *UltraScale Architecture GTH Transceivers User Guide (UG576)* for further information.

Table: GTH Transceiver Performance

Symbol	Description	Output Divisor	Speed Grade and V _{CCINT} Operating Voltages										Units
			0.90V		0.85V			0.72V					
			-3	-2	-1	-2	-1	-2	-1	-2	-1		
F _{GTHMAX}	GTH maximum line rate		16.375	16.375	12.5	12.5	10.3125						Gb/s
F _{GTHMIN}	GTH minimum line rate		0.5	0.5	0.5	0.5	0.5						Gb/s
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
F _{GTHCRANGE}	CPLL line rate range ¹	1	4	12.5	4	12.5	4	8.5	4	8.5	4	8.5	Gb/s
		2	2	6.25	2	6.25	2	4.25	2	4.25	2	4.25	Gb/s
		4	1	3.125	1	3.125	1	2.125	1	2.125	1	2.125	Gb/s
		8	0.5	1.5625	0.5	1.5625	0.5	1.0625	0.5	1.0625	0.5	1.0625	Gb/s
		16	N/A										Gb/s
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
F _{GTHQRANGE1}	CPLL0 line rate range ²	1	9.8	16.375	9.8	16.375	9.8	12.5	9.8	12.5	9.8	10.3125	Gb/s
		2	4.9	8.1875	4.9	8.1875	4.9	8.15	4.9	8.1875	4.9	8.15	Gb/s
		4	2.45	4.09375	2.45	4.09375	2.45	4.075	2.45	4.09375	2.45	4.075	Gb/s
		8	1.225	2.046875	1.225	2.046875	1.225	2.0375	1.225	2.046875	1.225	2.0375	Gb/s
		16	0.6125	1.0234375	0.6125	1.0234375	0.6125	1.01875	0.6125	1.0234375	0.6125	1.01875	Gb/s
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
F _{GTHQRANGE2}	CPLL1 line rate range ³	1	8.0	13.0	8.0	13.0	8.0	12.5	8.0	12.5	8.0	10.3125	Gb/s
		2	4.0	6.5	4.0	6.5	4.0	6.5	4.0	6.5	4.0	6.5	Gb/s
		4	2.0	3.25	2.0	3.25	2.0	3.25	2.0	3.25	2.0	3.25	Gb/s
		8	1.0	1.625	1.0	1.625	1.0	1.625	1.0	1.625	1.0	1.625	Gb/s
		16	0.5	0.8125	0.5	0.8125	0.5	0.8125	0.5	0.8125	0.5	0.8125	Gb/s
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
F _{CPLL}	CPLL frequency range		2	6.25	2	6.25	2	4.25	2	4.25	2	4.25	GHz

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages										Units		
		0.90V		0.85V			0.72V							
		-3	-2	-1	-2	-1	-2	-1	-2	-1				
F _{QPLL0RANGE}	QPLL0 frequency range	9.8	16.375	9.8	16.375	9.8	16.375	9.8	16.375	9.8	16.375	9.8	16.375	GHz
F _{QPLL1RANGE}	QPLL1 frequency range	8	13	8	13	8	13	8	13	8	13	8	13	GHz

1. The values listed are the rounded results of the calculated equation $(2 \times \text{CPLL_Frequency})/\text{Output_Divider}$.

2. The values listed are the rounded results of the calculated equation $(\text{QPLL0_Frequency})/\text{Output_Divider}$.

3. The values listed are the rounded results of the calculated equation $(\text{QPLL1_Frequency})/\text{Output_Divider}$.

Table: GTH Transceiver Dynamic Reconfiguration Port (DRP) Switching Characteristics

Symbol	Description	All Speed Grades	Units
F _{GTHDRPCLK}	GTHDRPCLK maximum frequency	250	MHz

Table: GTH Transceiver Reference Clock Switching Characteristics

Symbol	Description	Conditions	All Speed Grades			Units
			Min	Typ	Max	
F _{GCLK}	Reference clock frequency range		60	–	820	MHz
T _{RCLK}	Reference clock rise time	20% – 80%	–	200	–	ps
T _{FCLK}	Reference clock fall time	80% – 20%	–	200	–	ps
T _{DCREF}	Reference clock duty cycle	Transceiver PLL only	40	50	60	%

Table: GTH Transceiver Reference Clock Oscillator Selection Phase Noise Mask

Symbol	Description	Offset Frequency	Typ	Max	Units
QPLL _{REFCLKMASK} 1, 2	QPLL0/QPLL1 reference clock select phase noise mask at	10 kHz	–	–105	dBc/Hz
		100 kHz	–	–124	

Symbol	Description	Offset Frequency	Min	Typ	Max	Units
	REFCLK frequency = 312.5 MHz	1 MHz	–	–	–130	
CPLL _{REFCLK} MASK 1, 2	CPLL reference clock select phase noise mask at REFCLK frequency = 312.5 MHz	10 kHz	–	–	–105	dBc/Hz
		100 kHz	–	–	–124	
		1 MHz	–	–	–130	
		50 MHz	–	–	–140	

1. For reference clock frequencies other than 312.5 MHz, adjust the phase-noise mask values by $20 \times \text{Log}(N/312.5)$ where N is the new reference clock frequency in MHz.
2. This reference clock phase-noise mask is superseded by any reference clock phase-noise mask that is specified in a supported protocol, e.g., PCIe.

Table: GTH Transceiver PLL/Lock Time Adaptation

Symbol	Description	Conditions	All Speed Grades			Units
			Min	Typ	Max	
T _{LOCK}	Initial PLL lock		–	–	1	ms
T _{DLOCK}	Clock recovery phase acquisition and adaptation time for decision feedback equalizer (DFE)	After the PLL is locked to the reference clock, this is the time it takes to lock the clock data recovery (CDR) to the data present at the input.	–	50,000	37 x 10 ⁶	UI
	Clock recovery phase acquisition and adaptation time for low-power mode (LPM) when the DFE is disabled		–	50,000	2.3 x 10 ⁶	UI

Table: GTH Transceiver User Clock Switching Characteristics

Symbol	Description	Data Width Conditions		Speed Grade and V _{CCINT} Operating Voltages				Units	
				0.90V		0.85V			0.72V
		Internal Logic	connect Logic	-2, 3	-1, 4, 5	-2, 3	-1, 5		
F _{TXOUTPMA}	TXOUTCLK maximum frequency sourced from OUTCLKPMA			511.719	511.719	390.625	390.625	322.266	MHz

Symbol	Description	Data Width Conditions (Bit)		Speed Grade and V _{CCINT} Operating Voltages					
				0.90V		0.85V		0.72V	
		Internal Logic	Logic connect Logic	-2 ^{2, 3}	-1 ^{4, 5}	-2 ³	-1 ⁵		
F _{RXOUTPMA}	RXOUTCLK maximum frequency sourced from OUTCLKPMA			511.719	511.719	390.625	390.625	322.266	MHz
F _{TXOUTPROGDIV}	TXOUTCLK maximum frequency sourced from TXPROGDIVCLK			511.719	511.719	511.719	511.719	511.719	MHz
F _{RXOUTPROGDIV}	RXOUTCLK maximum frequency sourced from RXPROGDIVCLK			511.719	511.719	511.719	511.719	511.719	MHz
F _{TXIN}	TXUSRCLK ₆ maximum frequency	16	16, 32	511.719	511.719	390.625	390.625	322.266	MHz
		32	32, 64	511.719	511.719	390.625	390.625	322.266	MHz
		20	20, 40	409.375	409.375	312.500	312.500	257.813	MHz
		40	40, 80	409.375	409.375	312.500	312.500	257.813	MHz
F _{RXIN}	RXUSRCLK ₆ maximum frequency	16	16, 32	511.719	511.719	390.625	390.625	322.266	MHz
		32	32, 64	511.719	511.719	390.625	390.625	322.266	MHz
		20	20, 40	409.375	409.375	312.500	312.500	257.813	MHz
		40	40, 80	409.375	409.375	312.500	312.500	257.813	MHz
F _{TXIN2}	TXUSRCLK ₂₆ maximum frequency	16	16	511.719	511.719	390.625	390.625	322.266	MHz
		16	32	255.859	255.859	195.313	195.313	161.133	MHz
		32	32	511.719	511.719	390.625	390.625	322.266	MHz
		32	64	255.859	255.859	195.313	195.313	161.133	MHz
		20	20	409.375	409.375	312.500	312.500	257.813	MHz
		20	40	204.688	204.688	156.250	156.250	128.906	MHz
		40	40	409.375	409.375	312.500	312.500	257.813	MHz
		40	80	204.688	204.688	156.250	156.250	128.906	MHz

Symbol	Description	Data Width Conditions (Bit)		Speed Grade and V _{CCINT} Operating Voltages					
				0.90V		0.85V		0.72V	
		Internal Logic	Connect Logic	-2 ^{2,3}	-1 ^{4,5}	-2 ³	-1 ⁵		
F _{RXIN2}	RXUSRCLK2 6 maximum frequency	16	16	511.719	511.719	390.625	390.625	322.266	MHz
		16	32	255.859	255.859	195.313	195.313	161.133	MHz
		32	32	511.719	511.719	390.625	390.625	322.266	MHz
		32	64	255.859	255.859	195.313	195.313	161.133	MHz
		20	20	409.375	409.375	312.500	312.500	257.813	MHz
		20	40	204.688	204.688	156.250	156.250	128.906	MHz
		40	40	409.375	409.375	312.500	312.500	257.813	MHz
		40	80	204.688	204.688	156.250	156.250	128.906	MHz

1. Clocking must be implemented as described in *UltraScale Architecture GTH Transceivers User Guide (UG576)*.
2. For speed grades -3E, -2E, and -2I, a 16-bit and 20-bit internal data path can only be used for line rates less than 8.1875 Gb/s.
3. For speed grade -2LE, a 16-bit and 20-bit internal data path can only be used for line rates less than 8.1875 Gb/s when V_{CCINT} = 0.85V or 6.25 Gb/s when V_{CCINT} = 0.72V.
4. For speed grades -1E, -1I, and -1M, a 16-bit and 20-bit internal data path can only be used for line rates less than 6.25 Gb/s.
5. For speed grade -1LI, a 16-bit and 20-bit internal data path can only be used for line rates less than 6.25 Gb/s when V_{CCINT} = 0.85V or 5.15625 Gb/s when V_{CCINT} = 0.72V.
6. When the gearbox is used, these maximums refer to the XCLK. For more information, see the *UltraScale Architecture GTH Transceivers User Guide (UG576)*.

Table: GTH Transceiver Transmitter Switching Characteristics

Symbol	Description	Condition	Min	Typ	Max	Units
F _{GTHTX}	Serial data rate range		0.500	–	F _{GTHMAX}	Gb/s
T _{RTX}	TX rise time	20%– 80%	–	21	–	ps
T _{FTX}	TX fall time	80%– 20%	–	21	–	ps

Symbol	Description	Condition	Min	Typ	Max	Units
T _{LLSKEW}	TX lane-to-lane skew ¹		–	–	500.00	ps
T _{J16.375}	Total jitter ^{2, 4}	16.375 Gb/s	–	–	0.28	UI
D _{J16.375}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J15.0}	Total jitter ^{2, 4}	15.0 Gb/s	–	–	0.28	UI
D _{J15.0}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J14.1}	Total jitter ^{2, 4}	14.1 Gb/s	–	–	0.28	UI
D _{J14.1}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J14.1}	Total jitter ^{2, 4}	14.025 Gb/s	–	–	0.28	UI
D _{J14.1}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J13.1}	Total jitter ^{2, 4}	13.1 Gb/s	–	–	0.28	UI
D _{J13.1}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J12.5_QPLL}	Total jitter ^{2, 4}	12.5 Gb/s	–	–	0.28	UI
D _{J12.5_QPLL}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J12.5_CPLL}	Total jitter ^{3, 4}	12.5 Gb/s	–	–	0.33	UI
D _{J12.5_CPLL}	Deterministic jitter ^{3, 4}		–	–	0.17	UI
T _{J11.3_QPLL}	Total jitter ^{2, 4}	11.3 Gb/s	–	–	0.28	UI
D _{J11.3_QPLL}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J10.3125_QPLL}	Total jitter ^{2, 4}	10.3125 Gb/s	–	–	0.28	UI
D _{J10.3125_QPLL}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J10.3125_CPLL}	Total jitter ^{3, 4}	10.3125 Gb/s	–	–	0.33	UI
D _{J10.3125_CPLL}	Deterministic jitter ^{3, 4}		–	–	0.17	UI
T _{J9.953_QPLL}	Total jitter ^{2, 4}	9.953 Gb/s	–	–	0.28	UI
D _{J9.953_QPLL}	Deterministic jitter ^{2, 4}		–	–	0.17	UI

Symbol	Description	Condition	Min	Typ	Max	Units
T _{J9.953_CPLL}	Total jitter ^{3, 4}	9.953 Gb/s	–	–	0.33	UI
D _{J9.953_CPLL}	Deterministic jitter ^{3, 4}		–	–	0.17	UI
T _{J8.0}	Total jitter ^{3, 4}	8.0 Gb/s	–	–	0.32	UI
D _{J8.0}	Deterministic jitter ^{3, 4}		–	–	0.17	UI
T _{J6.6}	Total jitter ^{3, 4}	6.6 Gb/s	–	–	0.30	UI
D _{J6.6}	Deterministic jitter ^{3, 4}		–	–	0.15	UI
T _{J5.0}	Total jitter ^{3, 4}	5.0 Gb/s	–	–	0.30	UI
D _{J5.0}	Deterministic jitter ^{3, 4}		–	–	0.15	UI
T _{J4.25}	Total jitter ^{3, 4}	4.25 Gb/s	–	–	0.30	UI
D _{J4.25}	Deterministic jitter ^{3, 4}		–	–	0.15	UI
T _{J4.0}	Total jitter ^{3, 4}	4.0 Gb/s	–	–	0.32	UI
D _{J4.0}	Deterministic jitter ^{3, 4}		–	–	0.16	UI
T _{J3.20}	Total jitter ^{3, 4}	3.20 Gb/s ⁵	–	–	0.20	UI
D _{J3.20}	Deterministic jitter ^{3, 4}		–	–	0.10	UI
T _{J2.5}	Total jitter ^{3, 4}	2.5 Gb/s ⁶	–	–	0.20	UI
D _{J2.5}	Deterministic jitter ^{3, 4}		–	–	0.10	UI
T _{J1.25}	Total jitter ^{3, 4}	1.25 Gb/s ⁷	–	–	0.15	UI
D _{J1.25}	Deterministic jitter ^{3, 4}		–	–	0.06	UI
T _{J500}	Total jitter ^{3, 4}	500 Mb/s ⁸	–	–	0.10	UI
D _{J500}	Deterministic jitter ^{3, 4}		–	–	0.03	UI

1. Using same REFCLK input with TX phase alignment enabled for up to four consecutive transmitters (one fully populated GTH Quad) at the maximum line rate.
2. Using QPLL_FBDIV = 40, 20-bit internal data width. These values are NOT intended for protocol specific compliance determinations.

Symbol	Description	Condition	Min	Typ	Max	Units
3. Using CPLL_FBDIV = 2, 20-bit internal data width. These values are NOT intended for protocol specific compliance determinations. 4. All jitter values are based on a bit-error ratio of 10^{-12} . 5. CPLL frequency at 3.2 GHz and TXOUT_DIV = 2. 6. CPLL frequency at 2.5 GHz and TXOUT_DIV = 2. 7. CPLL frequency at 2.5 GHz and TXOUT_DIV = 4. 8. CPLL frequency at 2.0 GHz and TXOUT_DIV = 8.						

Table: GTH Transceiver Receiver Switching Characteristics

Symbol	Description	Condition	Min	Typ	Max	Units
F_{GTHRX}	Serial data rate		0.500	–	F_{GTHMAX}	Gb/s
R_{XSST}	Receiver spread-spectrum tracking ¹	Modulated at 33 kHz	– 5000	–	0	ppm
R_{XRL}	Run length (CID)		–	–	256	UI
$R_{XPPMTOL}$	Data/REFCLK PPM offset tolerance	Bit rates ≤ 6.6 Gb/s	– 1250	–	1250	ppm
		Bit rates > 6.6 Gb/s and ≤ 8.0 Gb/s	–700	–	700	ppm
		Bit rates > 8.0 Gb/s	–200	–	200	ppm
SJ Jitter Tolerance ²						
$J_{T_SJ16.375}$	Sinusoidal jitter (QPLL) ³	16.375 Gb/s	0.30	–	–	UI
$J_{T_SJ15.0}$	Sinusoidal jitter (QPLL) ³	15.0 Gb/s	0.30	–	–	UI
$J_{T_SJ14.1}$	Sinusoidal jitter (QPLL) ³	14.1 Gb/s	0.30	–	–	UI
$J_{T_SJ13.1}$	Sinusoidal jitter (QPLL) ³	13.1 Gb/s	0.30	–	–	UI
$J_{T_SJ12.5}$	Sinusoidal jitter (QPLL) ³	12.5 Gb/s	0.30	–	–	UI
$J_{T_SJ11.3}$	Sinusoidal jitter (QPLL) ³	11.3 Gb/s	0.30	–	–	UI
$J_{T_SJ10.32_QPLL}$	Sinusoidal jitter (QPLL) ³	10.32 Gb/s	0.30	–	–	UI

Symbol	Description	Condition	Min	Typ	Max	Units
J _{T_SJ} 10.32_CPLL	Sinusoidal jitter (CPLL) ³	10.32 Gb/s	0.30	–	–	UI
J _{T_SJ} 9.953_QPLL	Sinusoidal jitter (QPLL) ³	9.953 Gb/s	0.30	–	–	UI
J _{T_SJ} 9.953_CPLL	Sinusoidal jitter (CPLL) ³	9.953 Gb/s	0.30	–	–	UI
J _{T_SJ} 8.0	Sinusoidal jitter (QPLL) ³	8.0 Gb/s	0.42	–	–	UI
J _{T_SJ} 6.6_CPLL	Sinusoidal jitter (CPLL) ³	6.6 Gb/s	0.44	–	–	UI
J _{T_SJ} 5.0	Sinusoidal jitter (CPLL) ³	5.0 Gb/s	0.44	–	–	UI
J _{T_SJ} 4.25	Sinusoidal jitter (CPLL) ³	4.25 Gb/s	0.44	–	–	UI
J _{T_SJ} 3.2	Sinusoidal jitter (CPLL) ³	3.2 Gb/s ⁴	0.45	–	–	UI
J _{T_SJ} 2.5	Sinusoidal jitter (CPLL) ³	2.5 Gb/s ⁵	0.30	–	–	UI
J _{T_SJ} 1.25	Sinusoidal jitter (CPLL) ³	1.25 Gb/s ⁶	0.30	–	–	UI
J _{T_SJ} 500	Sinusoidal jitter (CPLL) ³	500 Mb/s ⁷	0.30	–	–	UI
SJ Jitter Tolerance with Stressed Eye ²						
J _{T_TJSE} 3.2	Total jitter with stressed eye ⁸	3.2 Gb/s	0.70	–	–	UI
J _{T_TJSE} 6.6		6.6 Gb/s	0.70	–	–	UI
J _{T_SJSE} 3.2	Sinusoidal jitter with stressed eye ⁸	3.2 Gb/s	0.10	–	–	UI
J _{T_SJSE} 6.6		6.6 Gb/s	0.10	–	–	UI
<ol style="list-style-type: none"> 1. Using RXOUT_DIV = 1, 2, and 4. 2. All jitter values are based on a bit error ratio of 10⁻¹². 3. The frequency of the injected sinusoidal jitter is 80 MHz. 4. CPLL frequency at 3.2 GHz and RXOUT_DIV = 2. 5. CPLL frequency at 2.5 GHz and RXOUT_DIV = 2. 6. CPLL frequency at 2.5 GHz and RXOUT_DIV = 4. 7. CPLL frequency at 2.0 GHz and RXOUT_DIV = 8. 8. Composite jitter with RX equalizer enabled. DFE disabled. 						

GTH Transceiver Electrical Compliance

The *UltraScale Architecture GTH Transceivers User Guide (UG576)* contains recommended use modes that ensure compliance for the protocols listed in the following table. The transceiver wizard provides the recommended settings for those use cases and for protocol specific characteristics.

Table: GTH Transceiver Protocol List

Protocol	Specification	Serial Rate (Gb/s)	Electrical Compliance
CAUI-10	IEEE 802.3-2012	10.3125	Compliant
nPPI	IEEE 802.3-2012	10.3125	Compliant
10GBASE-KR ¹	IEEE 802.3-2012	10.3125	Compliant
40GBASE-KR	IEEE 802.3-2012	10.3125	Compliant
SFP+	SFF-8431 (SR and LR)	9.95328–11.10	Compliant
XFP	INF-8077i, revision 4.5	10.3125	Compliant
RXAUI	CEI-6G-SR	6.25	Compliant
XAUI	IEEE 802.3-2012	3.125	Compliant
1000BASE-X	IEEE 802.3-2012	1.25	Compliant
5.0G Ethernet	IEEE 802.3bx (PAR)	5	Compliant
2.5G Ethernet	IEEE 802.3bx (PAR)	2.5	Compliant
HiGig, HiGig+, HiGig2	IEEE 802.3-2012	3.74, 6.6	Compliant
OTU2	ITU G.8251	10.709225	Compliant
OTU4 (OTL4.10)	OIF-CEI-11G-SR	11.180997	Compliant
OC-3/12/48/192	GR-253-CORE	0.1555–9.956	Compliant
TFI-5	OIF-TFI5-0.1.0	2.488	Compliant
Interlaken	OIF-CEI-6G, OIF-CEI-11G-SR	4.25–12.5	Compliant
PCIe Gen1, 2, 3, 4 ²	PCI Express base 4.0	2.5, 5.0, 8.0, and 16.0	Compliant
SDI ³	SMPTE 424M-2006	0.27–2.97	Compliant

Protocol	Specification	Serial Rate (Gb/s)	Electrical Compliance
UHD-SDI ³	SMPTE ST-2081 6G, SMPTE ST-2082 12G	6 and 12	Compliant
Hybrid memory cube (HMC)	HMC-15G-SR	10, 12.5, and 15.0	Compliant
MoSys Bandwidth Engine	CEI-11-SR and CEI-11-SR (overclocked)	10.3125, 15.5	Compliant
CPRI	CPRI_v_6_1_2014-07-01	0.6144–12.165	Compliant
HDMI ³	HDMI 2.0	All	Compliant
Passive optical network (PON)	10G-EPON, 1G-EPON, NG-PON2, XG-PON, and 2.5G-PON	0.155–10.3125	Compliant
JESD204a/b	OIF-CEI-6G, OIF-CEI-11G	3.125–12.5	Compliant
Serial RapidIO	RapidIO specification 3.1	1.25–10.3125	Compliant
DisplayPort ³	DP 1.2B CTS	1.62–5.4	Compliant
Fibre channel	FC-P1-4	1.0625–14.025	Compliant
SATA Gen1, 2, 3	Serial ATA revision 3.0 specification	1.5, 3.0, and 6.0	Compliant
SAS Gen1, 2, 3	T10/BSR INCITS 519	3.0, 6.0, and 12.0	Compliant
SFI-5	OIF-SFI5-01.0	0.625–12.5	Compliant
Aurora	CEI-6G, CEI-11G-LR	up to 11.180997	Compliant

1. The transition time of the transmitter is faster than the IEEE Std 802.3-2012 specification.
2. For PCIe operating modes supported in each device package including PCIe Gen4 compatibility mode refer to *UltraScale+ Devices Integrated Block for PCI Express LogiCORE IP Product Guide (PG213)*.
3. This protocol requires external circuitry to achieve compliance.

GTY Transceiver Specifications

The *UltraScale Architecture and Product Data Sheet: Overview* (DS890) lists the Kintex UltraScale+ FPGAs that include the GTY transceivers.

GTY Transceiver DC Input and Output Levels

Table 1 summarizes the DC specifications of the GTY transceivers in Kintex UltraScale+ FPGAs. Consult the *UltraScale Architecture GTY Transceivers User Guide* (UG578) for further details.

Table: GTY Transceiver DC Specifications

Symbol	DC Parameter	Conditions	Min	Typ	Max	Units
DV _{PPIN}	Differential peak-to-peak input voltage (external AC coupled)	>10.3125 Gb/s	150	–	1250	mV
		6.6 Gb/s to 10.3125 Gb/s	150	–	1250	mV
		≤ 6.6 Gb/s	150	–	2000	mV
V _{IN}	Single-ended input voltage. Voltage measured at the pin referenced to GND.	DC coupled V _{MGTAVTT} = 1.2V	–400	–	V _{MGTAVTT}	mV
V _{CMIN}	Common mode input voltage	DC coupled V _{MGTAVTT} = 1.2V	–	2/3 V _{MGTAVTT}	–	mV
DV _{PPOUT}	Differential peak-to-peak output voltage ¹	Transmitter output swing is set to 11111	800	–	–	mV
V _{CMOUTDC}	Common mode output voltage: DC coupled (equation based)	When remote RX is terminated to GND	$V_{MGTAVTT}/2 - D_{VPPOUT}/4$			mV
		When remote RX termination is floating	$V_{MGTAVTT} - D_{VPPOUT}/2$			mV
		When remote RX is terminated to V _{RX_TERM} ²	$V_{MGTAVTT} - \frac{D_{VPPOUT}}{4} - \left(\frac{V_{MGTAVTT} - V_{RX_TERM}}{2} \right)$			mV
V _{CMOUTAC}	Common mode output voltage: AC coupled	Equation based	$V_{MGTAVTT} - D_{VPPOUT}/2$			mV

Symbol	DC Parameter	Conditions	Min	Typ	Max	Units
R _{IN}	Differential input resistance		–	100	–	Ω
R _{OUT}	Differential output resistance		–	100	–	Ω
T _{OSKEW}	Transmitter output pair (TXP and TXN) intra-pair skew		–	–	10	ps
C _{EXT}	Recommended external AC coupling capacitor ³		–	100	–	nF

1. The output swing and pre-emphasis levels are programmable using the GTY transceiver attributes discussed in the *UltraScale Architecture GTY Transceivers User Guide (UG578)* and can result in values lower than reported in this table.
2. V_{RX_TERM} is the remote RX termination voltage.
3. Other values can be used as appropriate to conform to specific protocols and standards.

Figure: Single-Ended Peak-to-Peak Voltage

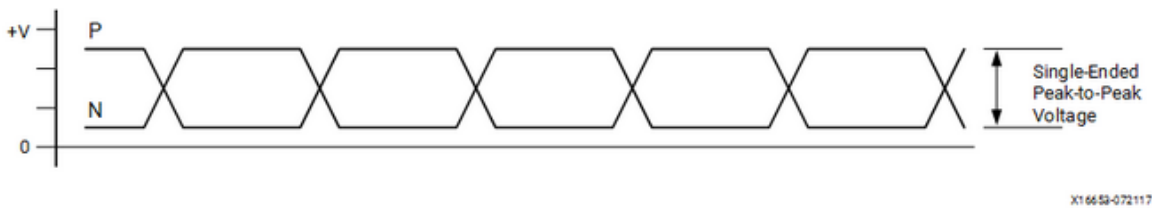
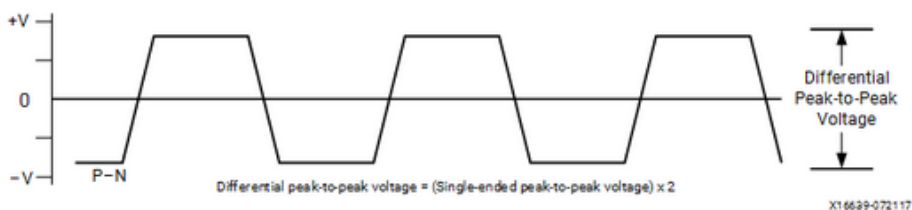


Figure: Differential Peak-to-Peak Voltage



The following tables summarize the DC specifications of the clock input/output levels of the GTY transceivers in Kintex UltraScale+ FPGAs. Consult the *UltraScale Architecture GTY Transceivers User Guide (UG578)* for further details.

Table: GTY Transceiver Clock DC Input Level Specification

Symbol	DC Parameter	Min	Typ	Max	Units
V _{IDIFF}	Differential peak-to-peak input voltage	250	–	2000	mV
R _{IN}	Differential input resistance	–	100	–	Ω

Symbol	DC Parameter	Min	Typ	Max	Units
C _{EXT}	Required external AC coupling capacitor	–	10	–	nF

Table: GTY Transceiver Clock Output Level Specification

Symbol	Description	Conditions	Min	Typ	Max	Units
V _{OL}	Output Low voltage for P and N	R _T = 100Ω across P and N signals	100	–	330	mV
V _{OH}	Output High voltage for P and N	R _T = 100Ω across P and N signals	500	–	700	mV
V _{DDOUT}	Differential output voltage (P–N), P = High (N–P), N = High	R _T = 100Ω across P and N signals	300	–	430	mV
V _{CMOUT}	Common mode voltage	R _T = 100Ω across P and N signals	300	–	500	mV

GTY Transceiver Switching Characteristics

Consult the *UltraScale Architecture GTY Transceivers User Guide* ([UG578](#)) for further information.

Table: GTY Transceiver Performance

Symbol	Description	Output Divisor	Speed Grade and V _{CCINT} Operating Voltages										Units				
			0.90V		0.85V			0.72V									
			-3	-2	-1	-2	-1										
F _{GTymax}	GTY maximum line rate		32.75 ¹		28.21 ¹			25.785 ¹					28.21 ¹		12.5		Gb/s
F _{GTymin}	GTY minimum line rate		0.5		0.5			0.5					0.5		0.5		Gb/s
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max			
F _{GTyCRANGE}	CPPLL line rate range ²	1	4.0	12.5	4.0	12.5	4.0	8.5	4.0	12.5	4.0	8.5	4.0	8.5	Gb/s		
		2	2.0	6.25	2.0	6.25	2.0	4.25	2.0	6.25	2.0	4.25	2.0	4.25	Gb/s		
		4	1.0	3.125	1.0	3.125	1.0	2.125	1.0	3.125	1.0	2.125	1.0	2.125	Gb/s		

Symbol	Description	Output Divisor	Speed Grade and V _{CCINT} Operating Voltages										Units
			0.90V		0.85V			0.72V					
			-3	-2	-1	-2	-1						
		8	0.5	1.5625	0.5	1.5625	0.5	1.0625	0.5	1.5625	0.5	1.0625	Gb/s
		16	N/A										Gb/s
		32	N/A										Gb/s
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
F _{GTYQRANGE1}	QPLL0 line rate range ³	1	19.6	32.75	19.6	28.21	19.6	25.785	19.6	28.21	N/A		Gb/s
		1	9.8	16.375	9.8	16.375	9.8	16.375	9.8	16.375	9.8	12.5	Gb/s
		2	4.9	8.1875	4.9	8.1875	4.9	8.1875	4.9	8.1875	4.9	8.1875	Gb/s
		4	2.45	4.0938	2.45	4.0938	2.45	4.0938	2.45	4.0938	2.45	4.0938	Gb/s
		8	1.225	2.0469	1.225	2.0469	1.225	2.0469	1.225	2.0469	1.225	2.0469	Gb/s
		16	0.6125	1.0234	0.6125	1.0234	0.6125	1.0234	0.6125	1.0234	0.6125	1.0234	Gb/s
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
F _{GTYQRANGE2}	QPLL1 line rate range ⁴	1	16.0	26.0	16.0	26.0	16.0	25.785	16.0	26.0	N/A		Gb/s
		1	8.0	13.0	8.0	13.0	8.0	12.5	8.0	13.0	8.0	12.5	Gb/s
		2	4.0	6.5	4.0	6.5	4.0	6.5	4.0	6.5	4.0	6.5	Gb/s
		4	2.0	3.25	2.0	3.25	2.0	3.25	2.0	3.25	2.0	3.25	Gb/s
		8	1.0	1.625	1.0	1.625	1.0	1.625	1.0	1.625	1.0	1.625	Gb/s
		16	0.5	0.8125	0.5	0.8125	0.5	0.8125	0.5	0.8125	0.5	0.8125	Gb/s
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
F _{CPLL} RANGE	QPLL frequency range		2.0	6.25	2.0	6.25	2.0	4.25	2.0	6.25	2.0	4.25	GHz
F _{QPLL0} RANGE	QPLL0 frequency range		9.8	16.375	9.8	16.375	9.8	16.375	9.8	16.375	9.8	16.375	GHz

Symbol	Description	Output Divider	Speed Grade and V _{CCINT} Operating Voltages										Units		
			0.90V		0.85V				0.72V						
			-3		-2		-1		-2		-1				
F _{QPLL1RANGE}	QPLL1 frequency range		8.0	13.0	8.0	13.0	8.0	13.0	8.0	13.0	8.0	13.0	8.0	13.0	GHz

1. GTY transceiver line rates are package limited: SFVB784 and SFRB784 to 12.5 Gb/s; FFVA676, FFVD900, FFVA1156, and FFRA1156 to 16.3 Gb/s.
2. The values listed are the rounded results of the calculated equation $(2 \times \text{CPLL_Frequency}) / \text{Output_Divider}$.
3. The values listed are the rounded results of the calculated equation $(\text{QPLL0_Frequency} \times \text{RATE}) / \text{Output_Divider}$ where RATE is 1 when QPLL0_CLKOUT_RATE is set to HALF and 2 if QPLL0_CLKOUT_RATE is set to FULL.
4. The values listed are the rounded results of the calculated equation $(\text{QPLL1_Frequency} \times \text{RATE}) / \text{Output_Divider}$ where RATE is 1 when QPLL1_CLKOUT_RATE is set to HALF and 2 if QPLL1_CLKOUT_RATE is set to FULL.

Table: GTY Transceiver Dynamic Reconfiguration Port (DRP) Switching Characteristics

Symbol	Description	All Speed Grades	Units
F _{GTYDRPCLK}	GTYDRPCLK maximum frequency	250	MHz

Table: GTY Transceiver Reference Clock Switching Characteristics

Symbol	Description	Conditions	All Speed Grades			Units
			Min	Typ	Max	
F _{GCLK}	Reference clock frequency range		60	–	820	MHz
T _{RCLK}	Reference clock rise time	20% – 80%	–	200	–	ps
T _{FCLK}	Reference clock fall time	80% – 20%	–	200	–	ps
T _{DCREF}	Reference clock duty cycle	Transceiver PLL only	40	50	60	%

Table: GTY Transceiver Reference Clock Oscillator Selection Phase Noise Mask

Symbol	Description ^{1, 2}	Offset Frequency	Typ	Max	Units
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Symbol	Description ^{1, 2}	Offset Frequency	Typ	Max	Units	
QPLL _{REFCLKMASK}	QPLL0/QPLL1 reference clock select phase noise mask at REFCLK frequency = 156.25 MHz	10 kHz	–	–	–112	dBc/Hz
		100 kHz	–	–	–128	
		1 MHz	–	–	–145	
	QPLL0/QPLL1 reference clock select phase noise mask at REFCLK frequency = 312.5 MHz	10 kHz	–	–	–103	dBc/Hz
		100 kHz	–	–	–123	
		1 MHz	–	–	–143	
	QPLL0/QPLL1 reference clock select phase noise mask at REFCLK frequency = 625 MHz	10 kHz	–	–	–98	dBc/Hz
		100 kHz	–	–	–117	
		1 MHz	–	–	–140	
CPLL _{REFCLKMASK}	CPLL reference clock select phase noise mask at REFCLK frequency = 156.25 MHz	10 kHz	–	–	–112	dBc/Hz
		100 kHz	–	–	–128	
		1 MHz	–	–	–145	
		50 MHz	–	–	–145	
	CPLL reference clock select phase noise mask at REFCLK frequency = 312.5 MHz	10 kHz	–	–	–103	dBc/Hz
		100 kHz	–	–	–123	
		1 MHz	–	–	–143	
		50 MHz	–	–	–145	
	CPLL reference clock select phase noise mask at REFCLK frequency = 625 MHz	10 kHz	–	–	–98	dBc/Hz
		100 kHz	–	–	–117	
		1 MHz	–	–	–140	
		50 MHz	–	–	–144	

1. For reference clock frequencies not in this table, use the phase-noise mask for the nearest reference clock frequency.
2. This reference clock phase-noise mask is superseded by any reference clock phase-noise mask that is specified in a supported protocol, e.g., PCIe.

Table: GTY Transceiver PLL/Lock Time Adaptation

Symbol	Description	Conditions	All Speed Grades			Units
			Min	Typ	Max	
T _{LOCK}	Initial PLL lock.		–	–	1	ms
T _{DLOCK}	Clock recovery phase acquisition and adaptation time for decision feedback equalizer (DFE)	After the PLL is locked to the reference clock, this is the time it takes to lock the clock data recovery (CDR) to the data present at the input.	–	50,000	37 x 10 ⁶	UI
	Clock recovery phase acquisition and adaptation time for low-power mode (LPM) when the DFE is disabled		–	50,000	2.3 x 10 ⁶	UI

Table: GTY Transceiver User Clock Switching Characteristics

Symbol	Description	Data Width Conditions (bits)		Speed Grade and V _{CCINT} Operating Voltages				Units	
				0.90V		0.85V			0.72V
		Internal Logic	Connect Logic	-2 ^{2,3}	-1 ^{4,5,6}	-2 ³	-1 ⁵		
F _{TXOUTPMA}	TXOUTCLK maximum frequency sourced from OUTCLKPMA			511.719	511.719	402.891	402.832	322.266	MHz
F _{RXOUTPMA}	RXOUTCLK maximum frequency sourced from OUTCLKPMA			511.719	511.719	402.891	402.832	322.266	MHz
F _{TXOUTPROGDIV}	TXOUTCLK maximum frequency sourced from TXPROGDIVCLK			511.719	511.719	511.719	511.719	511.719	MHz
F _{RXOUTPROGDIV}	RXOUTCLK maximum frequency sourced from RXPROGDIVCLK			511.719	511.719	511.719	511.719	511.719	MHz
F _{TXIN}	TXUSRCLK ₇ maximum frequency	16	16, 32	511.719	511.719	390.625	390.625	322.266	MHz
		32	32, 64	511.719	511.719	390.625	390.625	322.266	MHz
		64	64, 128	511.719	440.781	402.891	402.832	195.313	MHz
		20	20, 40	409.375	409.375	312.500	312.500	257.813	MHz

Symbol	Description	Data Width Conditions (Bit)		Speed Grade and V _{CCINT} Operating Voltages					
				0.90V	0.85V		0.72V		
		Internal Logic	Interconnect Logic	-2 ^{2, 3}	-1 ^{4, 5, 6}	-2 ³	-1 ⁵		
		40	40, 80	409.375	409.375	312.500	350.000	257.813	MHz
		80	80, 160	409.375	352.625	322.313	352.625	156.250	MHz
F _{RXIN}	RXUSRCLK ₇ maximum frequency	16	16, 32	511.719	511.719	390.625	390.625	322.266	MHz
		32	32, 64	511.719	511.719	390.625	390.625	322.266	MHz
		64	64, 128	511.719	440.781	402.891	402.832	195.313	MHz
		20	20, 40	409.375	409.375	312.500	312.500	257.813	MHz
		40	40, 80	409.375	409.375	312.500	350.000	257.813	MHz
		80	80, 160	409.375	352.625	322.313	352.625	156.250	MHz
F _{TXIN2}	TXUSRCLK ₂₇ maximum frequency	16	16	511.719	511.719	390.625	390.625	322.266	MHz
		16	32	255.859	255.859	195.313	195.313	161.133	MHz
		32	32	511.719	511.719	390.625	390.625	322.266	MHz
		32	64	255.859	255.859	195.313	195.313	161.133	MHz
		64	64	511.719	440.781	402.891	402.832	195.313	MHz
		64	128	255.859	220.391	201.445	201.416	97.656	MHz
		20	20	409.375	409.375	312.500	312.500	257.813	MHz
		20	40	204.688	204.688	156.250	156.250	128.906	MHz
		40	40	409.375	409.375	312.500	350.000	257.813	MHz
		40	80	204.688	204.688	156.250	175.000	128.906	MHz
		80	80	409.375	352.625	322.313	352.625	156.250	MHz
		80	160	204.688	176.313	161.156	176.313	78.125	MHz
F _{RXIN2}	RXUSRCLK ₂₇ maximum frequency	16	16	511.719	511.719	390.625	390.625	322.266	MHz
		16	32	255.859	255.859	195.313	195.313	161.133	MHz
		32	32	511.719	511.719	390.625	390.625	322.266	MHz

Symbol	Description	Data Width Conditions (Bit)		Speed Grade and V _{CCINT} Operating Voltages			Units		
		Internal	Logic	0.90V	0.85V	0.72V			
				-2 ^{2, 3}	-1 ^{4, 5, 6}	-2 ³		-1 ⁵	
		32	64	255.859	255.859	195.313	195.313	161.133	MHz
		64	64	511.719	440.781	402.891	402.832	195.313	MHz
		64	128	255.859	220.391	201.445	201.416	97.656	MHz
		20	20	409.375	409.375	312.500	312.500	257.813	MHz
		20	40	204.688	204.688	156.250	156.250	128.906	MHz
		40	40	409.375	409.375	312.500	350.000	257.813	MHz
		40	80	204.688	204.688	156.250	175.000	128.906	MHz
		80	80	409.375	352.625	322.313	352.625	156.250	MHz
		80	160	204.688	176.313	161.156	176.313	78.125	MHz

1. Clocking must be implemented as described in the *UltraScale Architecture GTY Transceivers User Guide (UG578)*.
2. For speed grades -3E, -2E, and -2I, a 16-bit and 20-bit internal data path can only be used for line rates less than 8.1875 Gb/s.
3. For speed grade -2LE, a 16-bit and 20-bit internal data path can only be used for line rates less than 8.1875 Gb/s when V_{CCINT} = 0.85V or 6.25 Gb/s when V_{CCINT} = 0.72V.
4. For speed grades -1E, -1I, and -1M, a 16-bit and 20-bit internal data path can only be used for line rates less than 6.25 Gb/s.
5. For speed grade -1LI, a 16-bit and 20-bit internal data path can only be used for line rates less than 6.25 Gb/s when V_{CCINT} = 0.85V or 5.15625 Gb/s when V_{CCINT} = 0.72V.
6. For the speed grades -1E, -1I, and -1M, only a 64- or 80-bit internal data path can be used for line rates above 12.5 Gb/s.
7. When the gearbox is used, these maximums refer to the XCLK. For more information, see the Valid Data Width Combinations for TX Asynchronous Gearbox table in the *UltraScale Architecture GTY Transceivers User Guide (UG578)*.

Table: GTY Transceiver Transmitter Switching Characteristics

Symbol	Description	Condition	Min	Typ	Max	Units
F _{GTYTX}	Serial data rate range		0.500	–	F _{GTYMAX}	Gb/s

Symbol	Description	Condition	Min	Typ	Max	Units
T _{RTX}	TX rise time	20%–80%	–	21	–	ps
T _{FTX}	TX fall time	80%–20%	–	21	–	ps
T _{LLSKEW}	TX lane-to-lane skew ¹		–	–	500.00	ps
T _{J32.75}	Total jitter ^{2, 4}	32.75 Gb/s	–	–	0.35	UI
D _{J32.75}	Deterministic jitter ^{2, 4}		–	–	0.19	UI
T _{J28.21}	Total jitter ^{2, 4}	28.21 Gb/s	–	–	0.28	UI
D _{J28.21}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J16.375}	Total jitter ^{2, 4}	16.375 Gb/s	–	–	0.28	UI
D _{J16.375}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J15.0}	Total jitter ^{2, 4}	15.0 Gb/s	–	–	0.28	UI
D _{J15.0}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J14.1}	Total jitter ^{2, 4}	14.1 Gb/s	–	–	0.28	UI
D _{J14.1}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J14.1}	Total jitter ^{2, 4}	14.025 Gb/s	–	–	0.28	UI
D _{J14.1}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J13.1}	Total jitter ^{2, 4}	13.1 Gb/s	–	–	0.28	UI
D _{J13.1}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J12.5_QPLL}	Total jitter ^{2, 4}	12.5 Gb/s	–	–	0.28	UI
D _{J12.5_QPLL}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J12.5_CPLL}	Total jitter ^{3, 4}	12.5 Gb/s	–	–	0.33	UI
D _{J12.5_CPLL}	Deterministic jitter ^{3, 4}		–	–	0.17	UI
T _{J11.3_QPLL}	Total jitter ^{2, 4}	11.3 Gb/s	–	–	0.28	UI

Symbol	Description	Condition	Min	Typ	Max	Units
D _{J11.3_QPLL}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J10.3125_QPLL}	Total jitter ^{2, 4}	10.3125 Gb/s	–	–	0.28	UI
D _{J10.3125_QPLL}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J10.3125_CPLL}	Total jitter ^{3, 4}	10.3125 Gb/s	–	–	0.33	UI
D _{J10.3125_CPLL}	Deterministic jitter ^{3, 4}		–	–	0.17	UI
T _{J9.953_QPLL}	Total jitter ^{2, 4}	9.953 Gb/s	–	–	0.28	UI
D _{J9.953_QPLL}	Deterministic jitter ^{2, 4}		–	–	0.17	UI
T _{J9.953_CPLL}	Total jitter ^{3, 4}	9.953 Gb/s	–	–	0.33	UI
D _{J9.953_CPLL}	Deterministic jitter ^{3, 4}		–	–	0.17	UI
T _{J8.0}	Total jitter ^{3, 4}	8.0 Gb/s	–	–	0.32	UI
D _{J8.0}	Deterministic jitter ^{3, 4}		–	–	0.17	UI
T _{J6.6}	Total jitter ^{3, 4}	6.6 Gb/s	–	–	0.30	UI
D _{J6.6}	Deterministic jitter ^{3, 4}		–	–	0.15	UI
T _{J5.0}	Total jitter ^{3, 4}	5.0 Gb/s	–	–	0.30	UI
D _{J5.0}	Deterministic jitter ^{3, 4}		–	–	0.15	UI
T _{J4.25}	Total jitter ^{3, 4}	4.25 Gb/s	–	–	0.30	UI
D _{J4.25}	Deterministic jitter ^{3, 4}		–	–	0.15	UI
T _{J3.20}	Total jitter ^{3, 4}	3.20 Gb/s 5	–	–	0.20	UI
D _{J3.20}	Deterministic jitter ^{3, 4}		–	–	0.10	UI
T _{J2.5}	Total jitter ^{3, 4}	2.5 Gb/s 6	–	–	0.20	UI
D _{J2.5}	Deterministic jitter ^{3, 4}		–	–	0.10	UI
T _{J1.25}	Total jitter ^{3, 4}	1.25 Gb/s 7	–	–	0.15	UI
D _{J1.25}	Deterministic jitter ^{3, 4}		–	–	0.06	UI

Symbol	Description	Condition	Min	Typ	Max	Units
T _{J500}	Total jitter ^{3, 4}	500 Mb/s 8	–	–	0.10	UI
D _{J500}	Deterministic jitter ^{3, 4}		–	–	0.03	UI

1. Using same REFCLK input with TX phase alignment enabled for up to four consecutive transmitters (one fully populated GTY Quad) at maximum line rate.
2. Using QPLL_FBDIV = 40, 20-bit internal data width. These values are NOT intended for protocol specific compliance determinations.
3. Using CPLL_FBDIV = 2, 20-bit internal data width. These values are NOT intended for protocol specific compliance determinations.
4. All jitter values are based on a bit-error ratio of 10⁻¹².
5. CPLL frequency at 3.2 GHz and TXOUT_DIV = 2.
6. CPLL frequency at 2.5 GHz and TXOUT_DIV = 2.
7. CPLL frequency at 2.5 GHz and TXOUT_DIV = 4.
8. CPLL frequency at 2.0 GHz and TXOUT_DIV = 8.

Table: GTY Transceiver Receiver Switching Characteristics

Symbol	Description	Condition	Min	Typ	Max	Units
F _{GTYRX}	Serial data rate		0.500	–	F _{GTYMAX}	Gb/s
R _{XSST}	Receiver spread-spectrum tracking ¹	Modulated at 33 kHz	– 5000	–	0	ppm
R _{XRL}	Run length (CID)		–	–	256	UI
R _{XPPMTOL}	Data/REFCLK PPM offset tolerance	Bit rates ≤ 6.6 Gb/s	– 1250	–	1250	ppm
		Bit rates > 6.6 Gb/s and ≤ 8.0 Gb/s	–700	–	700	ppm
		Bit rates > 8.0 Gb/s	–200	–	200	ppm
SJ Jitter Tolerance ²						
J _{T_SJ32.75}	Sinusoidal jitter (QPLL) ³	32.75 Gb/s	0.25	–	–	UI
J _{T_SJ28.21}	Sinusoidal jitter (QPLL) ³	28.21 Gb/s	0.30	–	–	UI

Symbol	Description	Condition	Min	Typ	Max	Units
J _{T_SJ16.375}	Sinusoidal jitter (QPLL) ³	16.375 Gb/s	0.30	–	–	UI
J _{T_SJ15.0}	Sinusoidal jitter (QPLL) ³	15.0 Gb/s	0.30	–	–	UI
J _{T_SJ14.1}	Sinusoidal jitter (QPLL) ³	14.1 Gb/s	0.30	–	–	UI
J _{T_SJ13.1}	Sinusoidal jitter (QPLL) ³	13.1 Gb/s	0.30	–	–	UI
J _{T_SJ12.5}	Sinusoidal jitter (QPLL) ³	12.5 Gb/s	0.30	–	–	UI
J _{T_SJ11.3}	Sinusoidal jitter (QPLL) ³	11.3 Gb/s	0.30	–	–	UI
J _{T_SJ10.32_QPLL}	Sinusoidal jitter (QPLL) ³	10.32 Gb/s	0.30	–	–	UI
J _{T_SJ10.32_CPLL}	Sinusoidal jitter (CPLL) ³	10.32 Gb/s	0.30	–	–	UI
J _{T_SJ9.953_QPLL}	Sinusoidal jitter (QPLL) ³	9.953 Gb/s	0.30	–	–	UI
J _{T_SJ9.953_CPLL}	Sinusoidal jitter (CPLL) ³	9.953 Gb/s	0.30	–	–	UI
J _{T_SJ8.0}	Sinusoidal jitter (CPLL) ³	8.0 Gb/s	0.42	–	–	UI
J _{T_SJ6.6}	Sinusoidal jitter (CPLL) ³	6.6 Gb/s	0.44	–	–	UI
J _{T_SJ5.0}	Sinusoidal jitter (CPLL) ³	5.0 Gb/s	0.44	–	–	UI
J _{T_SJ4.25}	Sinusoidal jitter (CPLL) ³	4.25 Gb/s	0.44	–	–	UI
J _{T_SJ3.2}	Sinusoidal jitter (CPLL) ³	3.2 Gb/s ⁴	0.45	–	–	UI
J _{T_SJ2.5}	Sinusoidal jitter (CPLL) ³	2.5 Gb/s ⁵	0.30	–	–	UI
J _{T_SJ1.25}	Sinusoidal jitter (CPLL) ³	1.25 Gb/s ⁶	0.30	–	–	UI
J _{T_SJ500}	Sinusoidal jitter (CPLL) ³	500 Mb/s ⁷	0.30	–	–	UI
SJ Jitter Tolerance with Stressed Eye ²						
J _{T_TJSE3.2}	Total jitter with stressed eye ⁸	3.2 Gb/s	0.70	–	–	UI
J _{T_TJSE6.6}		6.6 Gb/s	0.70	–	–	UI
J _{T_SJSE3.2}	Sinusoidal jitter with stressed eye ⁸	3.2 Gb/s	0.10	–	–	UI
J _{T_SJSE6.6}		6.6 Gb/s	0.10	–	–	UI

Symbol	Description	Condition	Min	Typ	Max	Units
<ol style="list-style-type: none"> 1. Using RXOUT_DIV = 1, 2, and 4. 2. All jitter values are based on a bit error ratio of 10^{-12}. 3. The frequency of the injected sinusoidal jitter is 80 MHz. 4. CPLL frequency at 3.2 GHz and RXOUT_DIV = 2. 5. CPLL frequency at 2.5 GHz and RXOUT_DIV = 2. 6. CPLL frequency at 2.5 GHz and RXOUT_DIV = 4. 7. CPLL frequency at 2.0 GHz and RXOUT_DIV = 8. 8. Composite jitter with RX equalizer enabled. DFE disabled. 						

GTY Transceiver Electrical Compliance

The *UltraScale Architecture GTY Transceivers User Guide (UG578)* contains recommended use modes that ensure compliance for the protocols listed in the following table. The transceiver wizard provides the recommended settings for those use cases and for protocol specific characteristics.

Table: GTY Transceiver Protocol List

Protocol	Specification	Serial Rate (Gb/s)	Electrical Compliance
CAUI-4	IEEE 802.3-2012	25.78125	Compliant
28 Gb/s backplane	CEI-25G-LR	25–28.05	Compliant
Interlaken	OIF-CEI-6G, OIF-CEI-11GSR, OIF-CEI-28G-MR	4.25–25.78125	Compliant
100GBASE-KR4	IEEE 802.3bj-2014, CEI-25G-LR	25.78125	Compliant 1
100GBASE-CR4	IEEE 802.3bj-2014, CEI-25G-LR	25.78125	Compliant 1
50GBASE-KR4	IEEE 802.3by-2014, CEI-25G-LR	25.78125	Compliant 1
50GBASE-CR4	IEEE 802.3by-2014, CEI-25G-LR	25.78125	Compliant 1
25GBASE-KR4	IEEE 802.3by-2014, CEI-25G-LR	25.78125	Compliant 1

Protocol	Specification	Serial Rate (Gb/s)	Electrical Compliance
25GBASE-CR4	IEEE 802.3by-2014, CEI-25G-LR	25.78125	Compliant 1
OTU4 (OTL4.4) CFP2	OIF-CEI-28G-VSR	27.952493–32.75	Compliant
OTU4 (OTL4.4) CFP	OIF-CEI-11G-MR	11.18–13.1	Compliant
CAUI-10	IEEE 802.3-2012	10.3125	Compliant
nPPI	IEEE 802.3-2012	10.3125	Compliant
10GBASE-KR ²	IEEE 802.3-2012	10.3125	Compliant
SFP+	SFF-8431 (SR and LR)	9.95328–11.10	Compliant
XFP	INF-8077i, revision 4.5	10.3125	Compliant
RXAUI	CEI-6G-SR	6.25	Compliant
XAUI	IEEE 802.3-2012	3.125	Compliant
1000BASE-X	IEEE 802.3-2012	1.25	Compliant
5.0G Ethernet	IEEE 802.3bx (PAR)	5	Compliant
2.5G Ethernet	IEEE 802.3bx (PAR)	2.5	Compliant
HiGig, HiGig+, HiGig2	IEEE 802.3-2012	3.74, 6.6	Compliant
QSGMII	QSGMII v1.2 (Cisco System, ENG-46158)	5	Compliant
OTU2	ITU G.8251	10.709225	Compliant
OTU4 (OTL4.10)	OIF-CEI-11G-SR	11.180997	Compliant
OC-3/12/48/192	GR-253-CORE	0.1555–9.956	Compliant
PCIe Gen1, 2, 3, 4	PCI Express base 4.0	2.5, 5.0, 8.0 and 16.0	Compliant
SDI ³	SMPTE 424M-2006	0.27–2.97	Compliant
UHD-SDI ³	SMPTE ST-2081 6G, SMPTE ST-2082 12G	6 and 12	Compliant
Hybrid memory cube (HMC)	HMC-15G-SR	10, 12.5, and 15.0	Compliant

Protocol	Specification	Serial Rate (Gb/s)	Electrical Compliance
MoSys bandwidth engine	CEI-11-SR and CEI-11-SR (overclocked)	10.3125, 15.5	Compliant
CPRI	CPRI_v_6_1_2014-07-01	0.6144–12.165	Compliant
Passive optical network (PON)	10G-EPON, 1G-EPON, NG-PON2, XG-PON, and 2.5G-PON	0.155–10.3125	Compliant
JESD204a/b	OIF-CEI-6G, OIF-CEI-11G	3.125–12.5	Compliant
Serial RapidIO	RapidIO specification 3.1	1.25–10.3125	Compliant
DisplayPort	DP 1.2B CTS	1.62–5.4	Compliant 3
Fibre channel	FC-PI-4	1.0625–14.025	Compliant
SATA Gen1, 2, 3	Serial ATA revision 3.0 specification	1.5, 3.0, and 6.0	Compliant
SAS Gen1, 2, 3	T10/BSR INCITS 519	3.0, 6.0, and 12.0	Compliant
SFI-5	OIF-SFI5-01.0	0.625 - 12.5	Compliant
Aurora	CEI-6G, CEI-11G-LR	All rates	Compliant

1. 25 dB loss at Nyquist without FEC.
2. The transition time of the transmitter is faster than the IEEE Std 802.3-2012 specification.
3. This protocol requires external circuitry to achieve compliance.

Integrated Interface Block for Interlaken

More information and documentation on solutions using the integrated interface block for Interlaken can be found at [UltraScale+ Interlaken](#) . The *UltraScale Architecture and Product Data Sheet: Overview (DS890)* lists how many blocks are in each Kintex UltraScale+ FPGA. This section describes the following Interlaken configurations.

- 12 x 12.5 Gb/s protocol and lane logic mode (Table 1) .
- 6 x 25.78125 Gb/s and 6 x 28.21 Gb/s protocol and lane logic mode (Table 2) .
- 12 x 25.78125 Gb/s lane logic only mode (Table 3) .

Kintex UltraScale+ FPGAs in the SFVB784, SFRB784, FFVA676, FFVD900, FFVA1156, and FFRA1156 packages are only supported using the 12 x 12.5 Gb/s Interlaken configuration. See the F_{GTMAX} maximum line rates.

Table: Maximum Performance for Interlaken 12 x 12.5 Gb/s Protocol and Lane Logic Mode Designs

Symbol	Description	Speed Grade and V_{CCINT} Operating Voltages										Units
		0.90V		0.85V			0.72V					
		-3		-2		-1	-2		-1			
$F_{RX_SERDES_CLK}$	Receive serializer/deserializer clock	195.32		195.32			195.32					MHz
$F_{TX_SERDES_CLK}$	Transmit serializer/deserializer clock	195.32		195.32			195.32					MHz
F_{DRP_CLK}	Dynamic reconfiguration port clock	250.00		250.00			250.00					MHz
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
F_{CORE_CLK}	Interlaken core clock	300.00	322.27	300.00	322.27	300.00	322.27	300.00	322.27	300.00	322.27	MHz
F_{LBUS_CLK}	Interlaken local bus clock	300.00	322.27	300.00	322.27	300.00	322.27	300.00	322.27	300.00	322.27	MHz
1. These are the minimum clock frequencies at the maximum lane performance.												

Table: Maximum Performance for Interlaken 6 x 25.78125 Gb/s and 6 x 28.21 Gb/s Protocol and Lane Logic Mode Designs

Symbol	Description	Speed Grade and V_{CCINT} Operating Voltages					Units
		0.90V		0.85V		0.72V	
		-3 ¹		-2 ¹		-1	

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages										Units	
		0.90V		0.85V			0.72V						
		-3 ¹		-2 ¹		-1	-2		-1				
F _{RX_SERDES_CLK}	Receive serializer/deserializer clock	440.79		440.79			N/A	402.84		N/A			MHz
F _{TX_SERDES_CLK}	Transmit serializer/deserializer clock	440.79		440.79			N/A	402.84		N/A			MHz
F _{DRP_CLK}	Dynamic reconfiguration port clock	250.00		250.00			N/A	250.00		N/A			MHz
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max		
		2		2				2					
F _{CORE_CLK}	Interlaken core clock	412.50	479.20	412.50	479.20	N/A		412.50	429.69	N/A		MHz	
		3		3									
F _{LBUS_CLK}	Interlaken local bus clock	300.00	349.52	300.00	349.52	N/A		300.00	349.52	N/A		MHz	
		4		4									
<p>1. 6 x 28.21 mode is only supported in the -2 (V_{CCINT} = 0.85V) and -3 (V_{CCINT} = 0.90V) speed grades.</p> <p>2. These are the minimum clock frequencies at the maximum lane performance.</p> <p>3. The minimum value for CORE_CLK is 451.36 MHz for the 6 x 28.21 Gb/s protocol.</p> <p>4. The minimum value for LBUS_CLK is 330.00 MHz for the 6 x 28.21 Gb/s protocol.</p>													

Table: Maximum Performance for Interlaken 12 x 25.78125 Gb/s Lane Logic Only Mode Designs

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V		0.85V		0.72V	
		-3		-2	-1	-2	

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
F _{RX_SERDES_CLK}	Receive serializer/deserializer clock	402.84	402.84	N/A	N/A	N/A	MHz
F _{TX_SERDES_CLK}	Transmit serializer/deserializer clock	402.84	402.84	N/A	N/A	N/A	MHz
F _{DRP_CLK}	Dynamic reconfiguration port clock	250.00	250.00	N/A	N/A	N/A	MHz
F _{CORE_CLK}	Interlaken core clock	412.50	412.50	N/A	N/A	N/A	MHz
F _{LBUS_CLK}	Interlaken local bus clock	349.52	349.52	N/A	N/A	N/A	MHz

Integrated Interface Block for 100G Ethernet MAC and PCS

More information and documentation on solutions using the integrated 100 Gb/s Ethernet block can be found at [UltraScale+ Integrated 100G Ethernet MAC/PCS](#). The *UltraScale Architecture and Product Data Sheet: Overview (DS890)* lists how many blocks are in each Kintex UltraScale+ FPGA.

Table: Maximum Performance for 100G Ethernet Designs

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
CAUI-10 Mode							
F _{TX_CLK}	Transmit clock	390.625	390.625	322.266	322.266	322.266	MHz
F _{RX_CLK}	Receive clock	390.625	390.625	322.266	322.266	322.266	MHz
F _{RX_SERDES_CLK}	Receive serializer/deserializer	390.625	390.625	322.266	322.266	322.266	MHz

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V	0.85V		0.72V		
		-3	-2	-1	-2	-1	
	clock						
F _{DRP_CLK}	Dynamic reconfiguration port clock	250.00	250.00	250.00	250.00	250.00	MHz
CAUI-4, CAUI-4 + RS-FEC, and RS-FEC Transcode Bypass Modes							
F _{TX_CLK}	Transmit clock	390.625	322.266	322.266	322.266	N/A	MHz
F _{RX_CLK}	Receive clock	390.625	322.266	322.266	322.266	N/A	MHz
F _{RX_SERDES_CLK}	Receive serializer/deserializer clock	390.625	322.266	322.266	322.266	N/A	MHz
F _{DRP_CLK}	Dynamic reconfiguration port clock	250.00	250.00	250.00	250.00	N/A	MHz

Integrated Interface Block for PCI Express Designs

More information and documentation on solutions for PCI Express® designs can be found at [PCI Express](#). The *UltraScale Architecture and Product Data Sheet: Overview (DS890)* lists how many PCIe4 or PCIe4C blocks are in each Kintex UltraScale+ FPGA. The PCIe4C blocks are augmented with support for the CCIX protocol. For supported modes, link widths, and link speeds, see the *UltraScale+ Devices Integrated Block for PCI Express LogiCORE IP Product Guide (PG213)*.

Table: Maximum Performance for PCIe4-based PCI Express Designs

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V	0.85V		0.72V		
		-3	-2	-1	-2	-1	
F _{PIPECLK}	Pipe clock maximum frequency	250.00	250.00	250.00	250.00	250.00	MHz
F _{CORECLK}	Core clock maximum frequency	500.00	500.00	500.00	250.00	250.00	MHz

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V	0.85V		0.72V		
		-3	-2	-1	-2	-1	
F _{DRPCLK}	DRP clock maximum frequency	250.00	250.00	250.00	250.00	250.00	MHz
F _{MCAPCLK}	MCAP clock maximum frequency	125.00	125.00	125.00	125.00	125.00	MHz

Table: Maximum Performance for PCIe4C-based PCI Express and CCIX Designs

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					Units
		0.90V	0.85V		0.72V		
		-3	-2	-1	-2	-1	
F _{PIPECLK}	Pipe clock maximum frequency	250.00	250.00	250.00	250.00	250.00	MHz
F _{CORECLK}	Core clock maximum frequency	500.00	500.00	500.00	500.00	250.00	MHz
F _{CORECLKCCIX}	CCIX TL interface clock maximum frequency	500.00	500.00	500.00	N/A	N/A	MHz
F _{DRPCLK}	DRP clock maximum frequency	250.00	250.00	250.00	250.00	250.00	MHz
F _{MCAPCLK}	MCAP clock maximum frequency ¹	125.00	125.00	125.00	125.00	125.00	MHz

1. The XCKU19P device does not support tandem PCIe.

System Monitor Specifications

Table: System Monitor Specifications

Parameter	Symbol	Comments/Conditions	Min	Typ	Max	Units
V _{CCADC} = 1.8V ±3%, V _{REFP} = 1.25V, V _{REFN} = 0V, ADCCLK = 5.2 MHz, T _j = -40°C to 100°C, typical values at T _j = 40°C						

Parameter	Symbol	Comments/Conditions	Min	Typ	Max	Units
ADC Accuracy ¹						
Resolution			10	–	–	Bits
Integral nonlinearity ²	INL		–	–	±1.5	LSBs
Differential nonlinearity	DNL	No missing codes, guaranteed monotonic	–	–	±1	LSBs
Offset error		Offset calibration enabled	–	–	±2	LSBs
Gain error			–	–	±0.4	%
Sample rate			–	–	0.2	MS/s
RMS code noise		External 1.25V reference	–	–	1	LSBs
		On-chip reference	–	1	–	LSBs
ADC Accuracy at Extended Temperatures						
Resolution		T _j = –55°C to 125°C	10	–	–	Bits
Integral nonlinearity ²	INL	T _j = –55°C to 125°C	–	–	±1.5	LSBs
Differential nonlinearity	DNL	No missing codes, guaranteed monotonic T _j = –55°C to 125°C	–	–	±1	LSBs
Analog Inputs ²						
ADC input ranges		Unipolar operation	0	–	1	V
		Bipolar operation	– 0.5	–	+0.5	V
		Unipolar common mode range (FS input)	0	–	+0.5	V
		Bipolar common mode range (FS input)	+0.5	–	+0.6	V
Maximum external channel input ranges		Adjacent channels set within these ranges should not corrupt	– 0.1	–	V _{CCADC}	V

Parameter	Symbol	Comments/Conditions	Min	Typ	Max	Units
		measurements on adjacent channels				
On-Chip Sensor Accuracy						
Temperature sensor error ^{1, 3}		$T_j = -55^{\circ}\text{C}$ to 125°C (with external REF)	–	–	± 3	$^{\circ}\text{C}$
		$T_j = -55^{\circ}\text{C}$ to 110°C (with internal REF)	–	–	± 3.5	$^{\circ}\text{C}$
		$T_j = 110^{\circ}\text{C}$ to 125°C (with internal REF)	–	–	± 5	$^{\circ}\text{C}$
Supply sensor error ⁴		Supply voltages 0.72V to 1.2V, $T_j = -40^{\circ}\text{C}$ to 100°C (with external REF)	–	–	± 0.5	%
		Supply voltages 0.72V to 1.2V, $T_j = -55^{\circ}\text{C}$ to 125°C (with external REF)	–	–	± 1.0	%
		All other supply voltages, $T_j = -40^{\circ}\text{C}$ to 100°C (with external REF)	–	–	± 1.0	%
		All other supply voltages, $T_j = -55^{\circ}\text{C}$ to 125°C (with external REF)	–	–	± 2.0	%
		Supply voltages 0.72V to 1.2V, $T_j = -40^{\circ}\text{C}$ to 100°C (with internal REF)	–	–	± 1.0	%
		Supply voltages 0.72V to 1.2V, $T_j = -55^{\circ}\text{C}$ to 125°C (with internal REF)	–	–	± 2.0	%
		All other supply voltages, $T_j = -40^{\circ}\text{C}$ to 100°C (with internal REF)	–	–	± 1.5	%
		All other supply voltages, $T_j = -55^{\circ}\text{C}$ to 125°C (with internal REF)	–	–	± 2.5	%

Parameter	Symbol	Comments/Conditions	Min	Typ	Max	Units
Conversion Rate ⁵						
Conversion time— continuous	t _{CONV}	Number of ADCCLK cycles	26	–	32	Cycles
Conversion time— event	t _{CONV}	Number of ADCCLK cycles	–	–	21	Cycles
DRP clock frequency	DCLK	DRP clock frequency	8	–	250	MHz
ADC clock frequency	ADCCLK	Derived from DCLK	1	–	5.2	MHz
DCLK duty cycle			40	–	60	%
SYSMON Reference ⁶						
External reference	V _{REFP}	Externally supplied reference voltage	1.20	1.25	1.30	V
On-chip reference		Ground V _{REFP} pin to AGND, T _j = –40°C to 100°C	1.2375	1.25	1.2625	V
		Ground V _{REFP} pin to AGND, T _j = –55°C to 125°C	1.225	1.25	1.275	V

1. ADC offset errors are removed by enabling the ADC automatic offset calibration feature. The values are specified for when this feature is enabled.
2. See the Analog Input section in the *UltraScale Architecture System Monitor User Guide (UG580)*.
3. When reading temperature values directly from the PMBus interface, the SYSMON has a +4°C offset due to the transfer function used by the PMBus application. For example, the external REF temperature sensor error's range of ±3°C becomes +1°C to +7°C when the temperature is read through the PMBus interface.
4. Supply sensor offset and gain errors are removed by enabling the automatic offset and gain calibration feature. The values are specified for when this feature is enabled.
5. See the Adjusting the Acquisition Settling Time section in the *UltraScale Architecture System Monitor User Guide (UG580)*.
6. Any variation in the reference voltage from the nominal V_{REFP} = 1.25V and V_{REFN} = 0V will result in a deviation from the ideal transfer function. This also impacts the accuracy of the internal sensor measurements (i.e., temperature and power supply). However, for external ratiometric type applications allowing reference to vary by ±4% is permitted.

SYSMON I2C/PMBus Interfaces

Table: SYSMON I2C Fast Mode Interface Switching Characteristics

Symbol	Description ¹	Min	Max	Units
T _{SMFCKL}	SCL Low time	1.3	–	µs
T _{SMFCKH}	SCL High time	0.6	–	µs
T _{SMFCKO}	SDAO clock-to-out delay	–	900	ns
T _{SMFDCK}	SDAI setup time	100	–	ns
F _{SMFCLK}	SCL clock frequency	–	400	kHz

1. The test conditions are configured to the LVCMOS 1.8V I/O standard.

Table: SYSMON I2C Standard Mode Interface Switching Characteristics

Symbol	Description ¹	Min	Max	Units
T _{SMSCKL}	SCL Low time	4.7	–	µs
T _{SMSCKH}	SCL High time	4.0	–	µs
T _{SMSCKO}	SDAO clock-to-out delay	–	3450	ns
T _{SMSDCK}	SDAI setup time	250	–	ns
F _{SMSCLK}	SCL clock frequency	–	100	kHz

1. The test conditions are configured to the LVCMOS 1.8V I/O standard.

Configuration Switching Characteristics

Table: Configuration Switching Characteristics

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages				
		0.90V		0.85V		0.72V
		-3	-2	-1	-2	-1

Symbol	Description		Speed Grade and V _{CCINT} Operating Voltages					
			0.90V	0.85V		0.72V		
			-3	-2	-1	-2	-1	
Power-up Timing Characteristics								
T _{PL}	Program latency	XCKU19P	8.5	8.5	8.5	8.5	8.5	ms, Max
		All other devices	7.5	7.5	7.5	7.5	7.5	ms, Max
T _{POR} ^{1, 2}	Power-on reset (40 ms maximum ramp rate)		65	65	65	65	65	ms, Max
			0	0	0	0	0	ms, Min
	Power-on reset with POR override (2 ms maximum ramp rate)		15	15	15	15	15	ms, Max
			5	5	5	5	5	ms, Min
T _{PROGRAM}	Program pulse width		250	250	250	250	250	ns, Min
CCLK Output (Master Mode)								
T _{ICCK}	Master CCLK output delay from INIT_B		150	150	150	150	150	ns, Min
T _{MCCKL} ³	Master CCLK clock Low time duty cycle		40/60	40/60	40/60	40/60	40/60	%, Min/Max
T _{MCCKH}	Master CCLK clock High time duty cycle		40/60	40/60	40/60	40/60	40/60	%, Min/Max
F _{MCCK}	Master SPI (x1/x2/x4) CCLK frequency	XCKU3P, XCKU5P, XQKU5P	125	125	125	60	60	MHz, Max
		XCKU19P	125	125	125	100	100	
		All other devices	150	150	150	125	125	

Symbol	Description		Speed Grade and V _{CCINT} Operating Voltages					
			0.90V	0.85V		0.72V		
			-3	-2	-1	-2	-1	
	Master SPI (x8) or Master BPI (x8/x16) ⁴ CCLK frequency	XCKU3P, XCKU5P, XQKU5P	125	125	125	60	60	
		XCKU19P	100	100	100	60	60	
		All other devices	150	150	150	125	125	
F _{MCCK_START}	Master CCLK frequency at start of configuration		2.70	2.70	2.70	2.70	2.70	MHz, Typ
F _{MCCKTOL}	Frequency tolerance, master mode with respect to nominal CCLK		±15	±15	±15	±15	±15	%, Max
CCLK Input (Slave Mode)								
T _{SCCKL}	Slave CCLK clock minimum Low time		2.5	2.5	2.5	2.5	2.5	ns, Min
T _{SCCKH}	Slave CCLK clock minimum High time		2.5	2.5	2.5	2.5	2.5	ns, Min
F _{SCCK}	Slave serial CCLK frequency	XCKU3P, XCKU5P, XQKU5P	125	125	125	60	60	MHz, Max
		XCKU19P	125	125	125	100	100	
		All other devices	125	125	125	125	125	
	Slave SelectMAP CCLK frequency	XCKU3P, XCKU5P, XQKU5P	125	125	125	60	60	
		XCKU19P	100	100	100	60	60	
		All other devices	125	125	125	125	125	
EMCCLK Input (Master Mode)								

Symbol	Description		Speed Grade and V _{CCINT} Operating Voltages						
			0.90V	0.85V		0.72V			
			-3	-2	-1	-2	-1		
T _{EMCCKL}	External master CCLK Low time		2.5	2.5	2.5	2.5	2.5	ns, Min	
T _{EMCCKH}	External master CCLK High time		2.5	2.5	2.5	2.5	2.5	ns, Min	
F _{EMCCK}	External master CCLK frequency with Master SPI x1/x2/x4	XCKU3P, XCKU5P, XQKU5P	125	125	125	60	60	MHz, Max	
		XCKU19P	125	125	125	100	100		
		All other devices	150	150	150	125	125		
	External master CCLK frequency with Master SPI x8 or Master BPI x8/x16 ⁴	XCKU3P, XCKU5P, XQKU5P	125	125	125	60	60		
		XCKU19P	100	100	100	60	60		
		All other devices	150	150	150	125	125		
Internal Configuration Access Port									
F _{ICAPCK}	Internal configuration access port (ICAPE3)		200	200	200	150	150	MHz, Max	
Slave Serial Mode Programming Switching									
T _{DCCK} /T _{CCKD}	D _{IN} setup/hold		3.0/0	3.0/0	3.0/0	4.0/0	4.0/0	ns, Min	
T _{CCO}	D _{OUT} clock to out		8.0	8.0	8.0	9.0	9.0	ns, Max	
SelectMAP Mode Programming Switching									
T _{SMDCCK} /T _{SMECKD}	D[31:00] setup/hold		XCKU3P, XCKU5P, XQKU5P	4.5/0	4.5/0	4.5/0	8.0/0	8.0/0	ns, Min

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages						
		0.90V	0.85V		0.72V			
		-3	-2	-1	-2	-1		
		XCKU19P	5.5/0	5.5/0	5.5/0	8.5/0	8.5/0	
		All other devices	3.5/0	3.5/0	3.5/0	4.5/0	4.5/0	
T _{SMCSCCK} /T _{SMCCKES}	CSL_B setup/hold	XCKU3P, XCKU5P, XQKU5P	4.5/0	4.5/0	4.5/0	7.0/0	7.0/0	ns, Min
		XCKU19P	5.0/0	5.0/0	5.0/0	8.5/0	8.5/0	
		All other devices	4.0/0	4.0/0	4.0/0	5.0/0	5.0/0	
T _{SMWCK} /T _{SMCKW}	RDWR_B setup/hold	XCKU3P, XCKU5P, XQKU5P	10.0/0	10.0/0	10.0/0	17.0/0	17.0/0	ns, Min
		XCKU19P	11.0/0	11.0/0	11.0/0	17.5/0	17.5/0	
		All other devices	10.0/0	10.0/0	10.0/0	11.0/0	11.0/0	
T _{SMCKCSO}	CSO_B clock to out (330Ω pull-up resistor required)	XCKU3P, XCKU5P, XQKU5P	7.0	7.0	7.0	10.0	10.0	ns, Max
		XCKU19P	7.0	7.0	7.0	10.0	10.0	
		All other devices	7.0	7.0	7.0	7.0	7.0	
T _{SMCO}	D[31:00] clock to out in readback	XCKU3P, XCKU5P, XQKU5P	8.0	8.0	8.0	10.0	10.0	ns, Max
		XCKU19P	8.0	8.0	8.0	10.0	10.0	
		All other devices	8.0	8.0	8.0	8.0	8.0	
F _{RBCK}	Readback frequency	XCKU3P, XCKU5P,	125	125	125	60	60	MHz, Max

Symbol	Description		Speed Grade and V _{CCINT} Operating Voltages					
			0.90V	0.85V		0.72V		
			-3	-2	-1	-2	-1	
		XQKU5P						
		XCKU19P	100	100	100	60	60	
		All other devices	125	125	125	125	125	
Boundary-Scan Port Timing Specifications								
T _{TAPTCK} /T _{TCKTAP}	TMS and TDI setup/hold		3.0/2.0	3.0/2.0	3.0/2.0	3.0/2.0	3.0/2.0	ns, Min
T _{TCKTDO}	TCK falling edge to TDO output		7.0	7.0	7.0	7.0	7.0	ns, Max
F _{TCK}	TCK frequency	XCKU15P, XQKU15P, XCKU19P	66	66	66	50	50	MHz, Max
		All other devices	66	66	66	66	66	
BPI Master Flash Mode Programming Switching								
T _{BPICCO}	A[28:00], RS[1:0], FCS_B, FOE_B, FWE_B, ADV_B clock to out		10	10	10	10	10	ns, Max
T _{BPIDCC} /T _{BPICCD}	D[15:00] setup/hold	XCKU3P, XCKU5P, XQKU5P	4.5/0	4.5/0	4.5/0	8.0/0	8.0/0	ns, Min
		XCKU19P	5.5/0	5.5/0	5.5/0	8.5/0	8.5/0	
		All other devices	3.5/0	3.5/0	3.5/0	4.5/0	4.5/0	
SPI Master Flash Mode Programming Switching								
T _{SPIDCC} /T _{SPICCD}	D[03:00] setup/hold		3.0/0	3.0/0	3.0/0	4.0/0	4.0/0	ns, Min
T _{SPIDCC} /T _{SPICCD}	D[07:04] setup/hold		4.5/0	4.5/0	4.5/0	8.0/0	8.0/0	ns, Min

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
	XQKU5P						
	XCKU19P	5.5/0	5.5/0	5.5/0	8.5/0	8.5/0	
	All other devices	3.5/0	3.5/0	3.5/0	4.5/0	4.5/0	
T _{SPICCM}	MOSI clock to out	8.0	8.0	8.0	8.0	8.0	ns, Max
T _{SPICCM2}	D[04] clock to out	10.0	10.0	10.0	10.0	10.0	ns, Max
T _{SPICCF}	FCS_B clock to out	8.0	8.0	8.0	8.0	8.0	ns, Max
T _{SPICCF2}	FCS2_B clock to out	10.0	10.0	10.0	10.0	10.0	ns, Max
DNA Port Switching							
F _{DNACK}	DNA port frequency	200	200	200	175	175	MHz, Max
STARTUPE3 Ports							
T _{USRCCLKO}	STARTUPE3 USRCCLKO input port to CCLK pin output delay	0.25/6.00	0.25/6.50	0.25/7.50	0.25/9.00	0.25/9.00	ns, Min/Max
T _{DO}	DO[3:0] ports to D03-D00 pins output delay	0.25/6.70	0.25/7.70	0.25/8.40	0.25/10.00	0.25/10.00	ns, Min/Max
T _{DTS}	DTS[3:0] ports to D03-D00 pins 3-state delays	0.25/6.70	0.25/7.70	0.25/8.40	0.25/10.00	0.25/10.00	ns, Min/Max
T _{FCSBO}	FCSBO port to FCS_B pin output delay	0.25/6.90	0.25/7.50	0.25/8.40	0.25/9.80	0.25/9.80	ns, Min/Max
T _{FCSBTS}	FCSBTS port to FCS_B pin 3-state delay	0.25/6.90	0.25/7.50	0.25/8.40	0.25/9.80	0.25/9.80	ns, Min/Max
T _{USRDONEO}	USRDONEO port to DONE pin output delay	0.25/8.60	0.25/9.40	0.25/10.50	0.25/12.10	0.25/12.10	ns, Min/Max

Symbol	Description	Speed Grade and V _{CCINT} Operating Voltages					
		0.90V		0.85V		0.72V	
		-3	-2	-1	-2	-1	
T _{USRDONETS}	USRDONETS port to DONE pin 3-state delay	0.25/8.6	0.25/9.4	0.25/10.5	0.25/12.1	0.25/12.1	ns, Min/Max
T _{DI}	D03-D00 pins to DI[3:0] ports input delay	0.5/2.6	0.5/3.1	0.5/3.5	0.5/4.0	0.5/4.0	ns, Min/Max
F _{CFGMCLK}	STARTUPE3 CFGMCLK output frequency	50	50	50	50	50	MHz, Typ
F _{CFGMCLKTOL}	STARTUPE3 CFGMCLK output frequency tolerance	±15	±15	±15	±15	±15	%, Max
T _{DCI_MATCH}	Specifies a stall in the startup cycle until the digitally controlled impedance (DCI) match signals are asserted	4	4	4	4	4	ms, Max

1. The T_{POR} specification begins when the last of the monitored supplies (V_{CCINT}, V_{CCBRAM}, V_{CCAUX}, V_{CCO_0}) reaches 95% of its recommended operating condition voltage.
2. The T_{POR} time is determined by the POR_OVERRIDE input pin which must be tied to V_{CCINT} or GND. The POR_OVERRIDE pin can be tied to V_{CCINT} for POR override only when the monitored supplies ramp within the specified 2 ms maximum ramp rate. Otherwise, POR_OVERRIDE must be tied to GND.
3. When the CCLK is sourced from the EMCCLK pin with a divide-by-one setting, the external EMCCLK must meet this duty-cycle requirement.
4. SPI mode is recommended for master mode configuration from flash memory because of the higher configuration rates and low configuration interface pin counts. Due to the obsolescence of synchronous read-mode flash devices, BPI mode performance is limited. For system configuration rates with SPI flash and parallel NOR flash in BPI asynchronous read mode see the *UltraScale Architecture Configuration User Guide (UG570)*.

Revision History

Date	Version	Description of Revisions
08/09/2024	1.18	<p>Added note about V_{IN} for POR_OVERRIDE pin to Table 1 and Table 1.</p> <p>For clarity, moved the location of the specifications for internal V_{REF}, differential termination, and temperature diode (ideality factor and series resistance) in Table 1.</p> <p>In Table 1, updated notes 1 and 4, and expanded V_{CCO} table note into notes 5 and 6.</p> <p>Updated note 7 in Table 2.</p> <p>Updated note 8 and note 10 in Table 4.</p> <p>Revised the Production Specification speed file version for XCKU19P in Table 1 to Vivado Design Suite from 2020.2.2 v1.32 to 2022.1 v1.34.</p> <p>Updated MIPI D-PHY data rate per lane for XQ devices in -3 and -2 (0.72V) speed grades in Table 3.</p> <p>Updated to PCIe Gen1, 2, 3, 4 protocol in Table 1 and Table 1.</p> <p>Added notes 1 and 2 to Table 1.</p>
2/16/2021	1.17	<p>Updated Table 1, Table 1, and Table 1 to production release the XCKU19P devices in Vivado Design Suite 2020.2.2 v1.32.</p> <p>Revised some of the XCKU19P speed files in Table 1, Table 2, Table 3, Table 1, and Table 2.</p> <p>For the KU19P device only, added PCIE4C support in Table 2.</p>
12/08/2020	1.16	<p>Added the XCKU19P device to Table 1, Table 1, and Table 1 in Vivado Design Suite 2020.2 v1.04, and where applicable in other sections of this data sheet.</p> <p>Added Note 10 to Table 4.</p> <p>Updated the Table 3 table with Vivado tools specific conditions.</p> <p>Increased the maximum line rate of the QPLL0 -1 ($V_{CCINT} = 0.85V$) output divider 1 in Table 1 and updated Notes 3 and 4.</p> <p>Added Note 4 to the Configuration Switching Characteristics table.</p>
7/12/2019	1.15	<p>Added Note 7 to Table 2. Added the capability for XC devices designed using Vivado Design Suite v2019.1.1 or later to increase the performance of the MIPI PHY transmitter/receiver in Table 3.</p>
4/09/2019	1.14	<p>Added the XQKU5P and XQKU15P devices in -1M temperature grade throughout this version including updates to Table 1, Table 1, and Table 1 in Vivado Design Suite 2018.3.1 v1.23. This version also</p>

Date	Version	Description of Revisions
		added the ruggedized FFRB676, SFRB784, FFRA1156, and FFRE1517 packages. Added LVDS component mode notes to FPGA Logic Performance Characteristics. Removed PCI Express Gen4 support in Integrated Interface Block for PCI Express Designs and Note 1, Note 2, and Note 3.
8/01/2018	1.13	Updated Table 1, Table 1, and Table 1 to production release the XCKU9P devices in the -3E speed/temperature grade in Vivado Design Suite 2018.2.1 v1.21. In Table 2, added Note 4 to the LVDS RX DDR maximum data. In Table 1, revised the calculated values from 322.223 to 322.266.
6/18/2018	1.12	Revised the speed grade -1 ($V_{CCINT} = 0.85$) F_{GTMAX} in Table 1, which also revised values in Table 6 and added Note 6.
4/09/2018	1.11	Updated Table 1, Table 1, and Table 1 to production release the XCKU3P, XCKU5P, XCKU11P, XCKU13P, and XCKU15P devices in the -3E speed/temperature grade in Vivado Design Suite 2018.1 v1.19. Added Table 4 and Table 4. Added Note 2 and 3 to Table 3. Revised Table 1 to add specific mode specifications and remove Notes 1 and 2.
2/07/2018	1.10	Updated Table 1, Table 1, and Table 1 to production release the XCKU11P with -2LE and -1LI speed/temperature grades in Vivado Design Suite 2017.4.1. Revised some of the -3E and -1LI/-2LE ($V_{CCINT} = 0.72V$) speed files in Table 1, Table 1, Table 2, Table 3, Table 1, and Table 2.
12/22/2017	1.9	Revised Table 1 and Table 1 to production release the XCKU15P -1L, -2L, -1LV, and -2LV speed/temperature grades in Vivado Design Suite 2017.4.
11/28/2017	1.8	Updated Table 1, Table 1, and Table 1 to production release the following devices/speed/temperature grades in Vivado Design Suite 2017.4. XCKU3P: -2LE, -1LI XCKU5P: -2LE, -1LI Revised the F_{REFCLK} descriptions in Table 1. Revised the $F_{GTQRANGE2}$ -1 speed grade minimum in Table 1. Added $T_{SPICCM2}$ and $T_{SPICFC2}$ to Table 1.

Date	Version	Description of Revisions
11/17/2017	1.7	<p>In Table 1, corrected the minimum voltage for the System Monitor section.</p> <p>Updated Table 1, Table 1, and Table 1 to production release the following devices/speed/temperature grades in Vivado Design Suite 2017.3.1.</p> <p>XCKU9P: -2LE, -1LI</p> <p>XCKU13P: -2LE, -1LI</p> <p>Updated speed file data for this release in Table 1, Table 2, Table 3, and Table 1. Updated the notes for F_{GTYMAX} in Table 1.</p>
10/05/2017	1.6	<p>In Table 1, because the voltages are covered in Table 1, removed the note on V_{IN} for I/O input voltage for HD I/O banks. Updated T_{SOL} by package in Table 1. Added Note 2 to Table 1.</p> <p>Updated Table 1, Table 1, and Table 1 the XCKU11P: -2E, -2I, -1E, -1I (all $V_{CCINT} = 0.85V$) to production in Vivado Design Suite 2017.3 v1.14. Also updated speed file data for this release in Table 1, Table 2, Table 3, Table 1, and Table 2.</p>
8/29/2017	1.5	<p>Updated Table 1, Table 1, and Table 1 to production release the following devices/speed/temperature grades in Vivado Design Suite 2017.2.1.</p> <p>XCKU15P: -2E, -2I, -1E, -1I (all $V_{CCINT} = 0.85V$)</p> <p>In Table 1, revised the $T_{OUTBUF_DELAY_O_PAD -2}$ ($V_{CCINT} = 0.85V$) values for DIFF_SSTL135_S, DIFF_SSTL15_DCI_S, DIFF_SSTL15_S, DIFF_SSTL18_I_DCI_S, and DIFF_SSTL18_I_S. Revised some of the -3E and -1LI/-2LE ($V_{CCINT} = 0.72V$) speed files in Table 1, Table 1, Table 1, Table 1, Table 2, Table 3, Table 1, and Table 2.</p>
6/26/2017	1.4	<p>Updated Table 1, Table 1, and Table 1 to production release the following devices/speed/temperature grades in Vivado Design Suite 2017.2.</p> <p>XCKU13P: -2E, -2I, -1E, -1I (all $V_{CCINT} = 0.85V$)</p> <p>Updated Note 11 in Table 1 for clarity. Revised the -3E and -1LI/-2LE ($V_{CCINT} = 0.72V$) speed files in Table 1, Table 1, Table 1, Table 1, Table 2, Table 3, Table 1, and Table 2. Updated the F_{MAX} symbol names and values in Table 1. Added Note 1 to Table 1. Added Note 3 to Table 1.</p>
5/08/2017	1.3	<p>Updated Table 1 and Table 1 to production release the following devices/speed/temperature grades in Vivado Design Suite 2017.1.</p> <p>XCKU9P: -2E, -2I, -1E, -1I</p>

Date	Version	Description of Revisions
		<p>Removed the MIPI_DPHY_DCI_LP standard from Table 1 (HD I/O banks never supported DCI). Revised the minimum 32.75 Gb/s sinusoidal jitter in Table 8.</p>
4/11/2017	1.2	<p>Updated the Summary description. In Table 1, updated and added data, and updated Note 6, added Note 7, Note 8, and Note 9. Updated and added data to Table 1, revised Note 11 and added Note 12 and Note 13. Updated Table 1 and added Note 6. Added specifications to Table 1 though Table 1. Updated maximum V_{ICM} and Note 1 in Table 1. Updated the maximum V_{ODIFF} in Table 1. Updated Table 1, Table 1, and Table 1 to production release the following devices/speed/temperature grades in Vivado Design Suite 2017.1.</p> <p>XCKU3P: -2E, -2I, -1E, -1I XCKU5P: -2E, -2I, -1E, -1I</p> <p>Added Note 1 to Table 1. Updated Table 1. Updated Table 2 and added Note 2. Added Table 3. Updated Table 5 and added Note 3. Many revisions to the speed specifications in Table 1, Table 1, Table 1, Table 1, Table 1, Table 1, Table 1, Table 2, Table 3, Table 1, Table 2, and Table 3. Updated V_L and V_H values in Table 1. In Table 1, added T_{MINPER_CLK} and Note 1, and revised F_{REFCLK}. Added $MMCM_FDPRCLK_MAX$ to Table 1 and $PLL_FDPRCLK_MAX$ to Table 1. Updated Table 1. Revised the GTH Transceiver Specifications and GTY Transceiver Specifications sections. Revised the Integrated Interface Block for Interlaken and Integrated Interface Block for 100G Ethernet MAC and PCS sections. Updated the System Monitor Specifications section including On-Chip Sensor Accuracy and adding Note 3 to Table 1. Removed timing diagrams from the SYSMON I2C/PMBus Interfaces section. Updated the Configuration Switching Characteristics section. Removed the eFUSE Programming Conditions table and added the specifications to Table 1 and Table 1. Updated Table 1. Updated the Automotive Applications Disclaimer.</p>
5/09/2016	1.1	<p>In Table 1 revised V_{IN} for HP I/O banks. Updated Note 5 in Table 1. Added values to Table 1. Added MIPI_DPHY_DCI to Table 1, Table 2, and Table 4. Updated and added notes in Table 1 and Table 1. Updated Table 1 speed specifications for Vivado Design Suite 2016.1. Removed Table 23, Video Codec Unit Performance. Updated Table 2. Expanded and updated Table 5. Updated Table 1 and Table 1. Updated Table 1 and Table 1 with MIPI D-PHY values. Updated Table 1 and Table 1. In Table 1, added the Block RAM and</p>

Date	Version	Description of Revisions
		FIFO Clock-to-Out Delays section. Updated Table 1 to Table 2. Revised the symbol names in Table 1. Revised typical values in Table 2. Updated the -2 (0.72V) and -1 (0.72V) values in Table 1. Added Table 4 and Table 4. Added Note 2 to Table 1. Revised Table 6. Revised data and added notes to Table 1, Table 1, and Table 1. Revised INL in Table 1. Added notes to Table 1 and Table 2. Many revised sections in Table 1.
11/24/2015	1.0	Initial AMD release.

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