Section I. HardCopy III Device Datasheet

This section provides the datasheet for the HardCopy® III device family. This section includes the following chapter:

- Chapter 1, DC and Switching Characteristics of HardCopy III Devices

Revision History

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

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1. DC and Switching Characteristics of HardCopy III Devices

HIII53001-2.0

Electrical Characteristics

This chapter provides information about the absolute maximum ratings, recommended operating conditions, DC electrical characteristics, and other specifications for HardCopy® III devices. HardCopy III devices are offered in both commercial and industrial grades.

Operating Conditions

When HardCopy III devices are implemented in a system, they are rated according to a set of defined parameters. To maintain the highest possible performance and reliability, you must consider the operating requirements described in this chapter. HardCopy III devices are not speed binned like Stratix® III devices because HardCopy III devices are designed and built to function at a target frequency based on timing constraints, and operate at either commercial or industrial temperatures.

Absolute Maximum Ratings

Absolute maximum ratings define the maximum operating conditions for HardCopy III devices. The values are based on experiments conducted with the device and theoretical modeling of breakdown and damage mechanisms. The functional operation of the device is not implied by these conditions. Conditions beyond those listed in Table 1–1 can cause permanent damage to the device. Additionally, device operation at the absolute maximum ratings for extended periods of time can have adverse effects on the device.

Table 1–1. HardCopy III Device Absolute Maximum Ratings – Preliminary (Part 1 of 2) *(Note 1)*

Symbol	Parameter	Minimum	Maximum	Unit
V_{CCL}	Core voltage power supply	–0.5	1.35	V
V_{CC}	I/O registers power supply	–0.5	1.35	V
V_{CCD_PLL}	PLL digital power supply	–0.5	1.35	V
V_{CCA_PLL}	PLL analog power supply	–0.5	3.75	V
V_{CCPT} *(2)*	Power supply for the temperature sensing diode	–0.5	3.75	V
V_{CCPGM}	Configuration pins power supply	–0.5	3.9	V
V_{CCPD}	I/O pre-driver power supply	–0.5	3.9	V
V_{CCIO}	I/O power supply	–0.5	3.9	V
V_{CC_CLKIN}	Differential clock input power supply (top and bottom I/O banks only)	–0.5	3.75	V
V_{CCBAT} *(3)*	Battery back-up power supply for design security volatile key register	—	—	V
V_I	DC input voltage	–0.5	4.0	V
T_J	Operating junction temperature	–55	125	°C
I_{OUT}	DC output current, per pin	–25	40	mA

Table 1–1. HardCopy III Device Absolute Maximum Ratings – Preliminary (Part 2 of 2) *(Note 1)*

Symbol	Parameter	Minimum	Maximum	Unit
T_{STG}	Storage temperature (no bias)	–65	150	°C

Notes to Table 1–1:

(1) Supply voltage specifications apply to voltage readings taken at the device pins and not the power supply.
(2) In Stratix III devices, this power supply is also used for programmable power technology.
(3) In HardCopy III devices, this power supply is not used.

Maximum Allowed Overshoot and Undershoot Voltage

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

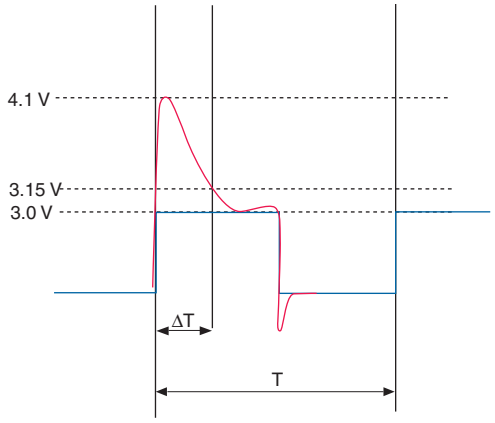
Table 1–2 lists the maximum allowed input overshoot voltage. The maximum allowed overshoot duration is specified as the percentage of high time over the lifetime of the device. A DC signal is equivalent to 100% duty cycle.

Table 1–2. Maximum Allowed Overshoot During Transitions – Preliminary

Symbol	Parameter	Condition	Overshoot Duration as % of High Time	Unit
Vi (AC)	AC Input Voltage	4	100.000	%
		4.05	79.330	%
		4.1	46.270	%
		4.15	27.030	%
		4.2	15.800	%
		4.25	9.240	%
		4.3	5.410	%
		4.35	3.160	%
		4.4	1.850	%
		4.45	1.080	%
		4.5	0.630	%
		4.55	0.370	%
		4.6	0.220	%
		4.65	0.130	%
		4.7	0.074	%
		4.75	0.043	%
		4.8	0.025	%
		4.85	0.015	%

Figure 1–1 shows the methodology to determine the overshoot duration. The overshoot voltage is displayed in red and is present at the HardCopy III pin, up to 4.1 V. From Table 1–2, for an overshoot of up to 4.1 V, the percentage of high time for overshoot > 3.15 V can be as high as 46% over an 11.4 year period. The percentage of high-time is calculated as (delta T/T) × 100. This 11.4 year period assumes the device is always turned on with 100% I/O toggle rate and 50% duty cycle signal. For lower I/O toggle rates and situations where the device is in an idle state, lifetimes are increased.

Figure 1–1. Overshoot Duration



Recommended Operating Conditions

This section lists the functional operation limits for AC and DC parameters for HardCopy III devices. The steady-state voltage and current values expected from HardCopy III devices are provided in Table 1–3. All supplies are required to monotonically reach their full-rail values within t_{RAMP} maximum. Allowed ripple on power supplies is bounded by the minimum and maximum specifications listed in Table 1–3.

Table 1–3. HardCopy III Device Recommended Operating Conditions – Preliminary (Part 1 of 2)

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{CCL} *(1)*	Core voltage power supply for internal logic and input buffers	—	0.87	0.9	0.93	V
V_{CC} *(1)*	I/O registers power supply	—	0.87	0.9	0.93	V
V_{CCD_PLL} *(1)*	PLL digital power supply	—	0.87	0.9	0.93	V
V_{CCA_PLL}	PLL analog power supply	—	2.375	2.5	2.625	V
V_{CCPT} *(2)*	Power supply for the temperature sensing diode	—	2.375	2.5	2.625	V
V_{CCPGM}	Configuration pins power supply, 3.0 V	—	2.85	3.0	3.15	V
	Configuration pins power supply, 2.5 V	—	2.375	2.5	2.625	V
	Configuration pins power supply, 1.8 V	—	1.71	1.8	1.89	V

Table 1–3. HardCopy III Device Recommended Operating Conditions – Preliminary (Part 2 of 2)

Symbol	Parameter	Conditions	Minimum	Typical	Maximum	Unit
V_{CCPD} *(3)*	I/O pre-driver power supply, 3.0 V	—	2.85	3.0	3.15	V
	I/O pre-driver power supply, 2.5 V	—	2.375	2.5	2.625	V
V_{CCIO}	I/O power supply, 3.0 V	—	2.85	3.0	3.15	V
	I/O power supply, 2.5 V	—	2.375	2.5	2.625	V
	I/O power supply, 1.8 V	—	1.71	1.8	1.89	V
	I/O power supply, 1.5 V	—	1.425	1.5	1.575	V
	I/O power supply, 1.2 V	—	1.14	1.2	1.26	V
V_{CC_CLKIN}	Differential clock input power supply (top and bottom I/O banks only)	—	2.375	2.5	2.625	V
V_{CCBAT} *(4)*	Battery back-up power supply for design security volatile key register	—	—	—	—	V
V_I	DC input voltage	—	–0.3	—	3.6	V
V_O	Output voltage	—	0	—	V_{CCIO}	V
T_J	Operating junction temperature	For commercial use	0	—	85	°C
		For industrial use	–40	—	100	°C
t_{RAMP}	Power supply ramp time	Normal POR (PORSEL=0)	50 µs	—	300 ms	—
		Fast POR (PORSEL=1)	50 µs	—	12 ms	—

Notes to Table 1–3:

(1) In Stratix III devices, V_{CCL} can also be 1.1 V, while V_{CC} and V_{CCD_PLL} are 1.1 V. In HardCopy III devices, all three supplies are 0.9 V.
(2) In Stratix III devices, this power supply is also used for programmable power technology.
(3) V_{CCPD} is either 2.5 V or 3.0 V. For a 3.0-V I/O standard, V_{CCPD} = 3.0 V. For a 2.5 V or lower I/O standard, V_{CCPD} = 2.5 V.
(4) In HardCopy III devices, this power supply is not used.

DC Characteristics

This section lists the input pin capacitances, on-chip termination tolerance, and hot socketing specifications.

Supply Current

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

Table 1–4 lists supply current specifications for V_{CC_CLKIN} and V_{CCPGM}. Use the EPE to get supply current estimates for the remaining power supplies.

Table 1–4. Supply Current Specifications for V_{CC_CLKIN} and V_{CCPGM} – Preliminary *(Note 1)*

Symbol	Parameter	Min	Max	Unit
I_{CLKIN}	V_{CC_CLKIN} current specifications	0	TBD	mA
I_{PGM}	V_{CCPGM} current specifications	0	TBD	mA

Note to Table 1–4:

(1) Pending silicon characterization.

I/O Pin Leakage Current

Table 1–5 defines HardCopy III I/O pin leakage current specifications.

Table 1–5. HardCopy III I/O Pin Leakage Current – Preliminary *(Note 1), (2)*

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

Notes To Table 1–5:

(1) This value is specified for normal device operation. The value may vary during power up. This applies for all V_{CCIO} settings (3.0, 2.5, 1.8, 1.5, and 1.2 V).

(2) The 10 mA I/O leakage current limit is applicable when the internal clamping diode is off. A higher current is observed when the diode is on.

On-Chip Termination (OCT) Specifications

If OCT calibration is enabled, calibration is automatically performed at power up for I/Os connected to the calibration block. Table 1–6 lists the HardCopy III OCT calibration block accuracy specifications.

Table 1–6. HardCopy III On-Chip Termination Calibration Accuracy Specifications – Preliminary (Part 1 of 2) *(Note 1)*

Symbol	Description	Conditions	Calibration Accuracy		Unit
			Commercial *(2)*	Industrial	
25–Ω R_S 3.0/2.5	Internal series termination with calibration (25-Ω setting)	V_{CCIO} = 3.0/2.5 V	TBD	—	%
50–Ω R_S 3.0/2.5	Internal series termination with calibration (50-Ω setting)	V_{CCIO} = 3.0/2.5 V	TBD	—	%
50–Ω R_T 2.5	Internal parallel termination with calibration (50-Ω setting)	V_{CCIO} = 2.5 V	TBD	—	%
25–Ω R_S 1.8	Internal series termination with calibration (25-Ω setting)	V_{CCIO} = 1.8 V	TBD	—	%
50–Ω R_S 1.8	Internal series termination with calibration (50-Ω setting)	V_{CCIO} = 1.8 V	TBD	—	%
50–Ω R_T 1.8	Internal parallel termination with calibration (50-Ω setting)	V_{CCIO} = 1.8 V	TBD	—	%
50–Ω R_S 1.5	Internal series termination with calibration (50-Ω setting)	V_{CCIO} = 1.5 V	TBD	—	%

Table 1–6. HardCopy III On-Chip Termination Calibration Accuracy Specifications – Preliminary (Part 2 of 2) *(Note 1)*

Symbol	Description	Conditions	Calibration Accuracy		Unit
			Commercial *(2)*	Industrial	
50–Ω R_T 1.5	Internal parallel termination with calibration (50-Ω setting)	V_{CCIO} = 1.5 V	TBD	—	%
50–Ω R_S 1.2	Internal series termination with calibration (50-Ω setting)	V_{CCIO} = 1.2 V	TBD	—	%
50–Ω R_T 1.2	Internal parallel termination with calibration (50-Ω setting)	V_{CCIO} = 1.2 V	TBD	—	%

Notes to Table 1–6:

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

(2) Pending silicon characterization.

The accuracy listed in Table 1–6 is valid at the time of calibration. If the voltage or temperature changes, the termination resistance value varies. Table 1–7 lists the resistance tolerance for HardCopy III on-chip termination.

Table 1–7. On-Chip Termination Resistance Tolerance Specification for I/Os – Preliminary *(Note 1)*

Symbol	Description	Resistance Tolerance		Unit
		Commercial Max	Industrial Max	
R_{OCT_UNCAL}	Internal series termination without calibration	TBD	—	%
R_{OCT_CAL}	Internal series termination with calibration	*(2)*	—	%

Notes to Table 1–7:

(1) Pending silicon characterization.

(2) For resistance tolerance after power-up calibration, refer to Table 1–8.

Table 1–8 lists OCT variation with temperature and voltage after power-up calibration. Use Table 1–8 and Equation 1–1 to determine OCT variation without re-calibration.

Equation 1–1.

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

Note that R_{CAL} is calibrated on-chip termination at power-up. ΔT and ΔV are variations in temperature and voltage (V_{CCIO}) at power-up.

Table 1–8. On-Chip Termination Variation after Power-up Calibration – Preliminary *(Note 1), (2)*

Symbol	Description	V_{CCIO} (V)	Commercial Typical	Unit
dR/dV	OCT variation with voltage without re-calibration	3.0	TBD	%/mV
		2.5	TBD	%/mV
		1.8	TBD	%/mV
		1.5	TBD	%/mV
		1.2	TBD	%/mV
dR/dT	OCT variation with temperature without re-calibration	3.0	TBD	%/°C
		2.5	TBD	%/°C
		1.8	TBD	%/°C
		1.5	TBD	%/°C
		1.2	TBD	%/°C

Note to Table 1–8:

(1) Valid for V_{CCIO} range of ± 5% and temperature range of 0° to 85° C.

(2) Pending silicon characterization.

Pin Capacitance

Table 1–9 shows the HardCopy III device family pin capacitance.

Table 1–9. HardCopy III Device Capacitance – Preliminary *(Note 1)*

Symbol	Parameter	Typical	Unit
C_{IOTB}	Input capacitance on top and bottom I/O pins	TBD	pF
C_{IOLR}	Input capacitance on left and right I/O pins	TBD	pF
C_{CLKTB}	Input capacitance on top and bottom dedicated clock input pins	TBD	pF
C_{CLKLR}	Input capacitance on left and right dedicated clock input pins	TBD	pF
C_{OUTFB}	Input capacitance on dual-purpose clock output and feedback pins	TBD	pF
C_{CLK1}, C_{CLK3}, C_{CLK8}, and C_{CLK10}	Input capacitance for dedicated clock input pins	TBD	pF

Note to Table 1–9:

(1) Pending silicon characterization.

Hot Socketing

Table 1–10 lists the hot socketing specifications for HardCopy III devices.

Table 1–10. HardCopy III Hot Socketing Specifications – Preliminary *(Note 1)*

Symbol	Parameter	Maximum
$I_{IOPIN(DC)}$	DC current per I/O pin	300 µA
$I_{IOPIN(AC)}$	AC current per I/O pin	8 mA for ≤ 10 ns

Note to Table 1–10:

(1) Pending silicon characterization.

Internal Weak Pull-Up Resistor

Table 1–11 lists the weak pull-up resistor values for HardCopy III devices.

Table 1–11. HardCopy III Internal Weak Pull-Up Resistor – Preliminary *(Note 1), (2)*

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
R_{PU}	Value of I/O pin pull-up resistor before and during user mode, if the pull-up resistor option is enabled	V_{CCIO} = 3.0 V ± 5% *(3)*	—	25	—	kΩ
		V_{CCIO} = 2.5 V ± 5% *(3)*	—	25	—	kΩ
		V_{CCIO} = 1.8 V ± 5% *(3)*	—	25	—	kΩ
		V_{CCIO} = 1.5 V ± 5% *(3)*	—	25	—	kΩ
		V_{CCIO} = 1.2 V ± 5% *(3)*	—	25	—	kΩ

Notes to Table 1–11:

(1) Pending silicon characterization.

(2) All I/O pins have an option to enable weak pull-up except test and JTAG pins.

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

I/O Standard Specifications

Table 1–12 through Table 1–17 list input voltage sensitivities (V_{IH} and V_{IL}), output voltage (V_{OH} and V_{OL}), and current drive characteristics (I_{OH} and I_{OL}) for all I/O standards supported by HardCopy III devices. Refer to Table 1–33 on page 1–21 for an explanation of terms used in Table 1–12 through Table 1–17. V_{OL} and V_{OH} values are valid at the corresponding I_{OL} and I_{OH}, respectively.

Table 1–12. Single-Ended I/O Standards Specifications — Preliminary

	V_{CCIO} (V)			V_{IL} (V)		V_{IH} (V)		V_{OL} (V)	V_{OH} (V)		
I/O Standard	Min	Typ	Max	Min	Max	Min	Max	Max	Min	I_{OL} (mA)	I_{OH} (mA)
3.0-V LVTTL	2.85	3	3.15	–0.3	0.8	1.7	3.6	0.4	2.4	2	–2
3.0-V LVCMOS	2.85	3	3.15	–0.3	0.8	1.7	3.6	0.2	V_{CCIO} – 0.2	0.1	–0.1
2.5V LVTTL/ LVCMOS	2.375	2.5	2.625	–0.3	0.7	1.7	3.6	0.2	2.1	0.1	–0.1
		2.5	2.625	–0.3	0.7	1.7	3.6	0.4	2	1	–1
		2.5	2.625	–0.3	0.7	1.7	3.6	0.7	1.7	2	–2
1.8V LVTTL/ LVCMOS	1.71	1.8	1.89	–0.3	0.35 × V_{CCIO}	0.65 × V_{CCIO}	V_{CCIO} + 0.3	0.45	V_{CCIO} – 0.45	2	–2
1.5 V LVTTL/ LVCMOS	1.425	1.5	1.575	–0.3	0.35 × V_{CCIO}	0.65 × V_{CCIO}	V_{CCIO} + 0.3	0.25 × V_{CCIO}	0.75 × V_{CCIO}	2	–2
1.2V LVTTL/ LVCMOS	1.14	1.2	1.26	–0.3	0.35 × V_{CCIO}	0.65 × V_{CCIO}	V_{CCIO} + 0.3	0.25 × V_{CCIO}	0.75 × V_{CCIO}	2	–2
3.0-V PCI	2.85	3	3.15	—	0.3 × V_{CCIO}	0.5 × V_{CCIO}	3.6	0.1 × V_{CCIO}	0.9 × V_{CCIO}	1.5	–0.5
3.0-V PCI-X	2.85	3	3.15	—	0.35 × V_{CCIO}	0.5 × V_{CCIO}	—	0.1 × V_{CCIO}	0.9 × V_{CCIO}	1.5	–0.5

Refer to Figure 1–6 in the row "Single-Ended Voltage Referenced I/O Standard" in Table 1–33 for an example of a voltage referenced receiver input waveform and explanation of terms used in Table 1–13.

Table 1–13. Single-Ended SSTL and HSTL I/O Reference Voltage Specifications – Preliminary

I/O Standard	V_{CCIO} (V)			V_{REF} (V)			V_{TT} (V)		
	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
SSTL-2 CLASS I, II	2.375	2.5	2.625	0.49 × V_{CCIO}	0.5 × V_{CCIO}	0.51 × V_{CCIO}	V_{REF} – 0.04	V_{REF}	V_{REF} + 0.04
SSTL-18 CLASS I, II	1.71	1.8	1.89	0.833	0.9	0.969	V_{REF} – 0.04	V_{REF}	V_{REF} + 0.04
SSTL-15 CLASS I, II	1.425	1.5	1.575	0.47 × V_{CCIO}	0.5 × V_{CCIO}	0.53 × V_{CCIO}	0.47 × V_{CCIO}	V_{REF}	0.53 × V_{CCIO}
HSTL-18 CLASS I, II	1.71	1.8	1.89	0.85	0.9	0.95	—	$V_{CCIO}/2$	—
HSTL-15 CLASS I, II	1.425	1.5	1.575	0.68	0.75	0.9	—	$V_{CCIO}/2$	—
HSTL-12 CLASS I, II	1.14	1.2	1.26	0.47 × V_{CCIO}	0.5 × V_{CCIO}	0.53 × V_{CCIO}	—	$V_{CCIO}/2$	—

Table 1–14. Single-Ended SSTL and HSTL I/O Standards Signal Specifications – Preliminary (Part 1 of 2)

I/O Standard	$V_{IL(DC)}$ (V)		$V_{IH(DC)}$ (V)		$V_{IL(AC)}$ (V)	$V_{IH(AC)}$ (V)	V_{OL} (V)	V_{OH} (V)		
	Min	Max	Min	Max	Max	Min	Max	Min	I_{OL} (mA)	I_{OH} (mA)
SSTL-2 CLASS I	–0.3	V_{REF} – 0.15	V_{REF} + 0.15	V_{CCIO} + 0.3	V_{REF} – 0.31	V_{REF} + 0.31	VTT – 0.57	VTT + 0.57	8.1	–8.1
SSTL-2 CLASS II	–0.3	V_{REF} – 0.15	V_{REF} + 0.15	V_{CCIO} + 0.3	V_{REF} – 0.31	V_{REF} + 0.31	VTT – 0.76	VTT + 0.76	16.2	–16.2
SSTL-18 CLASS I	–0.3	V_{REF} – 0.125	V_{REF} + 0.125	V_{CCIO} + 0.3	V_{REF} – 0.25	V_{REF} + 0.25	VTT – 0.475	VTT + 0.475	6.7	–6.7
SSTL-18 CLASS II	–0.3	V_{REF} – 0.125	V_{REF} + 0.125	V_{CCIO} + 0.3	V_{REF} – 0.25	V_{REF} + 0.25	0.28	V_{CCIO} – 0.28	13.4	–13.4
SSTL-15 CLASS I	–0.3	V_{REF} – 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} – 0.175	V_{REF} + 0.175	0.2 × V_{CCIO}	0.8 × V_{CCIO}	8	–8
SSTL-15 CLASS II	–0.3	V_{REF} – 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} – 0.175	V_{REF} + 0.175	0.2 × V_{CCIO}	0.8 × V_{CCIO}	16	–16
HSTL-18 CLASS I	–0.3	V_{REF} – 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} – 0.2	V_{REF} + 0.2	0.4	V_{CCIO} – 0.4	8	–8
HSTL-18 CLASS II	–0.3	V_{REF} – 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} – 0.2	V_{REF} + 0.2	0.4	V_{CCIO} – 0.4	16	–16
HSTL-15 CLASS I	–0.3	V_{REF} – 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} – 0.2	V_{REF} + 0.2	0.4	V_{CCIO} – 0.4	8	–8
HSTL-15 CLASS II	–0.3	V_{REF} – 0.1	V_{REF} + 0.1	V_{CCIO} + 0.3	V_{REF} – 0.2	V_{REF} + 0.2	0.4	V_{CCIO} – 0.4	16	–16

Table 1–14. Single-Ended SSTL and HSTL I/O Standards Signal Specifications – Preliminary (Part 2 of 2)

I/O Standard	$V_{IL(DC)}$ (V)		$V_{IH(DC)}$ (V)		$V_{IL(AC)}$ (V)	$V_{IH(AC)}$ (V)	V_{OL} (V)	V_{OH} (V)	I_{OL} (mA)	I_{OH} (mA)
	Min	Max	Min	Max	Max	Min	Max	Min		
HSTL-12 CLASS I	–0.15	V_{REF} – 0.08	V_{REF} + 0.08	V_{CCIO} + 0.15	V_{REF} – 0.15	V_{REF} + 0.15	0.25 × V_{CCIO}	0.75 × V_{CCIO}	8	–8
HSTL-12 CLASS II	–0.15	V_{REF} – 0.08	V_{REF} + 0.08	V_{CCIO} + 0.15	V_{REF} – 0.15	V_{REF} + 0.15	0.25 × V_{CCIO}	0.75 × V_{CCIO}	16	–16

Refer to Figure 1–2 in the row "Differential I/O Standards" in Table 1–33 for receiver input and transmitter output waveforms, and for all differential I/O standards (LVDS, mini-LVDS, RSDS). V_{CC_CLKIN} is the power supply for differential column clock input pins. V_{CCPD} is the power supply for row I/Os and all other column I/Os.

Table 1–15. Differential SSTL I/O Standard Specifications – Preliminary

I/O Standard	V_{CCIO} (V)			$V_{SWING\ (DC)}$ (V)		$V_{X\ (AC)}$ (V)			$V_{SWING\ (AC)}$ (V)		$V_{OX\ (AC)}$ (V)		
	Min	Typ	Max	Min	Max	Min	Typ	Max	Min	Max	Min	Typ	Max
SSTL-2 CLASS I, CLASS II	2.375	2.5	2.625	0.3	V_{CCIO} + 0.6	V_{CCIO}/2 – 0.2	—	V_{CCIO}/2 + 0.2	0.6	V_{CCIO} + 0.6	V_{CCIO}/2 – 0.15	—	V_{CCIO}/2 + 0.15
SSTL-18 CLASS I, CLASS II	1.71	1.8	1.89	0.3	V_{CCIO} + 0.6	V_{CCIO}/2 – 0.175	—	V_{CCIO}/2 + 0.175	0.5	V_{CCIO} + 0.6	V_{CCIO}/2 – 0.125	—	V_{CCIO}/2 + 0.125
SSTL-15 CLASS I, CLASS II	1.425	1.5	1.575	0.2	—	—	V_{CCIO}/2	—	0.4	—	—	V_{CCIO}/2	—

Table 1–16. Differential HSTL I/O Standards Specifications – Preliminary

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

Table 1–17. Differential I/O Standard Specifications – Preliminary (Part 1 of 2)

I/O Standard	V_{CCIO} (V)			V_{ID} (mV)			$V_{ICM(DC)}$ (V)			V_{OD} (V) *(1)*			V_{OCM} (V) *(1)*		
	Min	Typ	Max	Min	Condition	Max	Min	Condition	Max	Min	Typ	Max	Min	Typ	Max
2.5V LVDS (Row I/O)	2.375	2.5	2.625	100	V_{CM} = 1.25V	—	0.05 *(2)*	*Dmax* ≤ 700 Mbps	1.8 *(2)*	0.247	—	0.6	1.125	1.25	1.375
	2.375	2.5	2.625	100	V_{CM} = 1.25V	—	1.05 *(2)*	*Dmax* > 700 Mbps	1.55 *(2)*	—	—	—	—	—	—

Table 1–17. Differential I/O Standard Specifications – Preliminary (Part 2 of 2)

I/O Standard	V_{CCIO} (V)			V_{ID} (mV)			$V_{ICM(DC)}$ (V)			V_{OD} (V) *(1)*			V_{OCM} (V) *(1)*		
	Min	Typ	Max	Min	Condition	Max	Min	Condition	Max	Min	Typ	Max	Min	Typ	Max
2.5V LVDS (Column I/O)	2.375	2.5	2.625	100	V_{CM} = 1.25V	—	0.05 *(2)*	*Dmax* ≤ 700 Mbps	1.8 *(2)*	0.247	—	0.6	1.0	1.25	1.5
	2.375	2.5	2.625	100	V_{CM} = 1.25V	—	1.05 *(2)*	*Dmax* > 700 Mbps	1.55 *(2)*	—	—	—	—	—	1.5
RSDS (Row I/O)	2.375	2.5	2.625	100	V_{CM} = 1.25V	—	0.3	—	1.4	0.1	0.2	0.6	0.5	1.2	1.4
RSDS (Column I/O)	2.375	2.5	2.625	100	V_{CM} = 1.25V	—	0.3	—	1.4	0.1	0.2	0.6	0.5	1.2	1.5
Mini-LVDS (Row I/O)	2.375	2.5	2.625	200	—	600	0.4	—	1.325	0.25	—	0.6	0.5	1.2	1.4
Mini-LVDS (Column I/O)	2.375	2.5	2.625	200	—	600	0.4	—	1.325	0.25	—	0.6	0.5	1.2	1.5
LVPECL *(3)*	2.375 *(4)*	2.5 *(4)*	2.625 *(4)*	300	—	—	0.6	*Dmax* ≤ 700 Mbps	1.8 *(5)*	—	—	—	—	—	—
	—	—	—	—	—	—	0.6	*Dmax* ≤ 700 Mbps	1.6 *(5)*	—	—	—	—	—	—

Notes to Table 1–17:

(1) R_L range: 90 ≤ R_L ≤ 110 Ω .

(2) For data rate: D_{max} > 700 Mbps, the minimum input voltage is 1.0 V, the maximum input voltage is 1.6 V. For D_{max} ≤ 700 Mbps, the minimum input voltage is 0 V, the maximum input voltage is 1.85 V.

(3) Column and Row I/O banks support LVPECL I/O standards for input operation only on dedicated clock input pins. Differential clock inputs in column I/O use V_{CC_CLKIN} which should be powered by 2.5 V. Differential clock inputs in row I/Os are powered by V_{CCPD}.

(4) Power supply for column I/O LVPECL differential clock input buffer is V_{CC_CLKIN}.

(5) For data rate D_{max} > 700 Mbps, the minimum input voltage is 0.85 V, and the maximum input voltage is 1.75 V. For data rate D_{max} ≤ 700 Mbps, the minimum input voltage is 0.45 V, and the maximum input voltage is 1.95 V.

Power Consumption

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

Use the interactive Excel-based Early Power Estimator prior to designing in order to get a magnitude estimate of the device power. The Quartus II PowerPlay Power Analyzer provides better quality estimates based on the specifics of the design after the place-and-route is complete. The PowerPlay Power Analyzer can apply a combination of user-entered, simulation-derived, and estimated signal activities which, combined with detailed circuit models, can yield very accurate power estimates.

See Table 1–4 on page 1–5 for supply current estimates for V_{CCPGM} and V_{CC_CLKIN}. Use the EPE and PowerPlay Power Analyzer for current estimates of the remaining power supplies.

For more information about power estimation tools, refer to the *Power Play Early Power Estimator User Guide* and the *PowerPlay Power Analysis* chapter in volume 3 of the *Quartus II Device Handbook*.

Switching Characteristics

This section provides performance characteristics of HardCopy III core and periphery blocks for commercial grade devices. HardCopy III devices are designed to meet, at minimum, the –3 speed grade of the Stratix III devices. Silicon characterization determines the actual performance of the HardCopy III devices. These characteristics can be designated as **Preliminary** or **Final,** as defined below.

- **Preliminary**—Preliminary characteristics are created using simulation results, process data, and other known parameters.
- **Final**—Final numbers are based on actual silicon characterization and testing. These numbers reflect the actual performance of the device under worst-case silicon process, voltage, and junction temperature conditions.

Core Performance Specifications

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

Clock Tree Specifications

Table 1–18 lists clock tree performance specifications for the logic array, DSP blocks, and TriMatrix Memory blocks for HardCopy III devices.

Table 1–18. HardCopy III Clock Tree Performance – Preliminary *(Note 1)*

Device	Commercial Grade (MHz)	Unit
HC311	500	MHz
HC321	500	MHz
HC322	500	MHz
HC331	500	MHz
HC332	500	MHz
HC351	500	MHz
HC352	500	MHz
HC361	500	MHz
HC362	500	MHz
HC372	500	MHz

Note to Table 1–18:

(1) Pending silicon characterization.

PLL Specifications

Table 1–19 describes the HardCopy III PLL specifications when operating in both the commercial junction temperature range (0° to 85° C) and the industrial junction temperature range (–40° to 100°C). Refer to Figure 1–4 in the "PLL Specifications" row in Table 1–33 for a PLL block diagram.

Table 1–19. HardCopy III PLL Specifications – Preliminary (Part 1 of 2) *(Note 1)*

Symbol	Parameter	Min	Typ	Max	Unit
f_{IN}	Input clock frequency	5	—	717 *(2)*	MHz
f_{INPFD}	Input frequency to the PFD	5	—	325	MHz
f_{VCO}	PLL VCO operating range	600	—	1300	MHz
$t_{EINDUTY}$	Input clock or external feedback clock input duty cycle	40	—	60	%
f_{OUT}	Output frequency for internal global or regional clock	—	—	717 *(3)*	MHz
f_{OUT_EXT}	Output frequency for external clock output	—	—	717 *(3)*	MHz
$t_{OUTDUTY}$	Duty cycle for external clock output (when set to 50%)	45	50	55	%
t_{FCOMP}	External feedback clock compensation time	—	—	10	ns
$t_{CONFIGPLL}$	Time required to reconfigure PLL scan chain	—	—	—	scanclk cycles
$t_{CONFIGPHASE}$	Time required to reconfigure phase shift	—	—	—	scanclk cycles
$f_{SCANCLK}$	`scanclk` frequency	—	—	100	MHz
t_{LOCK}	Time required to lock from end of device power up *(4)*	—	—	—	ms
t_{DLOCK}	Time required to lock dynamically (after switchover or reconfiguring any non-post-scale counters/delays)	—	—	—	ms
f_{CLBW}	PLL closed-loop low bandwidth	—	—	—	MHz
	PLL closed-loop medium bandwidth	—	—	—	MHz
	PLL closed-loop high bandwidth *(5)*	—	—	—	MHz
t_{PLL_PSERR}	Accuracy of PLL phase shift	—	—	—	ps
t_{ARESET}	Minimum pulse width on *areset* signal	10	—	—	ns
t_{INCCJ} *(4)*	Input clock cycle to cycle jitter ($F_{REF} \geq 100$ MHz)	—	—	—	UI (p–p)
	Input clock cycle to cycle jitter ($F_{REF} < 100$ MHz)	—	—	—	ps (p–p)
t_{OUTPJ_DC} *(6)*	Period jitter for dedicated clock output ($F_{OUT} \geq 100$ MHz)	—	—	—	ps (p–p)
	Period jitter for dedicate clock output ($F_{OUT} < 100$ MHz)	—	—	—	mUI (p–p)
t_{OUTCCJ_DC} *(6)*	Cycle to cycle jitter for dedicated clock output ($F_{OUT} \geq 100$ MHz)	—	—	—	ps (p–p)
	Cycle to cycle jitter for dedicated clock output ($F_{OUT} < 100$ MHz)	—	—	—	mUI (p–p)
t_{OUTPJ_IO} *(6)*	Period jitter for clock output on regular I/O ($F_{OUT} \geq 100$ MHz)	—	—	—	ps (p–p)
	Period jitter for clock output on regular I/O ($F_{OUT} < 100$ MHz)	—	—	—	mUI (p–p)
t_{OUTCCJ_IO} *(6)*	Cycle to cycle jitter for clock output on regular I/O ($F_{OUT} \geq$ 100 MHz)	—	—	—	ps (p–p)
	Cycle to cycle jitter for clock output on regular I/O ($F_{OUT} <$ 100 MHz)	—	—	—	mUI (p–p)

Table 1–19. HardCopy III PLL Specifications – Preliminary (Part 2 of 2) *(Note 1)*

Symbol	Parameter	Min	Typ	Max	Unit
f_{DRIFT}	Frequency drift after PFDENA is disabled for duration of 100 ms	—	—	—	%

Notes to Table 1–19:

(1) Pending silicon characterization.

(2) This specification is limited in the Quartus II software by the I/O maximum frequency. The maximum I/O frequency is different for each I/O standard.

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

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

(5) High bandwidth PLL settings are not supported in external feedback mode.

(6) Peak-to-peak jitter with a probability level of 10^{-12}(14 sigma, 99.99999999974404% confidence level). The output jitter specification applies to the intrinsic jitter of the PLL, when an input jitter of 30 ps is applied.

DSP Block Specifications

Table 1–20 describes the HardCopy III DSP performance specifications.

Table 1–20. HardCopy III DSP Block Performance Specifications – Preliminary *(Note 1)*, *(2)*

Mode	Number of Multipliers	Max	Unit
9 × 9-bit multiplier (a, c, e, g) *(3)*	1	365	MHz
9 × 9-bit multiplier (b, d, f, h) *(3)*	1	410	MHz
12 × 12-bit multiplier (a, e) *(4)*	1	365	MHz
12 × 12-bit multiplier (b, d, f, h) *(4)*	1	410	MHz
18 × 18-bit multiplier	1	495	MHz
36 × 36-bit multiplier	1	365	MHz
Double mode	1	365	MHz
18 × 18-bit multiply adder	2	405	MHz
18 × 18-bit multiply adder	4	405	MHz
18 × 18-bit multiply adder with loop back *(5)*	2	405	MHz
18 × 18-bit multiply accumulator	4	390	MHz
18 × 18-bit multiply adder with chainout	4	390	MHz
Input Cascade Independent output of 4 18 × 18 bit multiplier	4	455	MHz
36-bit shift (32 bit data)	1	390	MHz

Notes to Table 1–20:

(1) Maximum is for fully pipelined block with **round** and **saturation** disabled.

(2) Pending silicon characterization.

(3) The DSP block implements eight independent 9 × 9-bit multipliers using a, b, c, and d for the top half of the DSP block and e, f, g, and h for the bottom DSP half block multipliers.

(4) The DSP block implements six independent 12 × 12-bit multipliers using a, b, and d for the top half of the DSP half block and e, f, and h for the bottom DSP half block multipliers.

(5) Maximum for non-pipelined block with loopback input registers disabled with **round** and **saturation** disabled.

TriMatrix Memory Block Specifications

Table 1–21 describes the HardCopy III TriMatrix memory block specifications.

Table 1–21. HardCopy III TriMatrix Memory Block Performance Specifications – Preliminary (Part 1 of 2) *(Note 1)*

Memory Block Type	Mode	TriMatrix Memory	Max	Unit
MLAB	Single port 16 × 10	1	500	MHz
	Simple dual-port 16 × 20 single clock	1	500	MHz
	ROM 64 × 10	1	500	MHz
	ROM 32 × 20	1	500	MHz
M9K	Single-port 8K × 1	1	465	MHz
	Single-port 4K × 2 or 2K × 4	1	485	MHz
	Single-port 1K × 9, 512 × 18, or 256 × 36	1	475	MHz
	Simple dual-port, 8K × 1 single clock	1	460	MHz
	Simple dual-port, 4K × 2 or 2K × 4, single clock	1	480	MHz
	Simple dual-port, 1K × 9, 512 × 18, or 256 × 36, single clock	1	475	MHz
	Simple dual-port, 8K × 1, 4K × 2, or 2K × 4 single clock, with the read-during-write option set to “Old Data”	1	312	MHz
	Simple dual-port, 1K × 9, 512 × 18, or 256 × 36, single clock, with the read-during-write option set to “Old Data”	1	312	MHz
	True dual-port, 8K × 1 single clock	1	440	MHz
	True dual-port, 4K × 2 or 2K × 4, single clock	1	480	MHz
	True dual-port, 1K × 9 or 512 × 18, single clock	1	460	MHz
	True dual-port, 8K × 1, 4K × 2, or 2K × 4, single clock, with the read-during-write option set to “Old Data”	1	295	MHz
	True dual-port, 1K × 9 or 512 × 18, single clock, with the read-during-write option set to “Old Data”	1	285	MHz
	ROM 1P, 8K × 1, 4K × 2, or 2K × 4, single clock, with the read-during-write option set to “Old Data”	1	485	MHz
	ROM 1P, 1K × 9, 512 × 18, single clock, with the read-during-write option set to “Old Data”	1	485	MHz
	ROM 2P, 8K × 1, 4K × 2, or 2K × 4	1	485	MHz
	ROM 2P, 1K × 9, or 512 × 18	1	485	MHz
	Min Pulse Width (Clock High Time)	—	800	ps

Table 1–21. HardCopy III TriMatrix Memory Block Performance Specifications – Preliminary (Part 2 of 2) *(Note 1)*

Memory Block Type	Mode	TriMatrix Memory	Max	Unit
M144K	True dual-port 16K × 9 or 8K × 18, dual clock	1	300	MHz
	True dual-port 4K × 36 dual clock	1	430	MHz
	Simple dual-port 16K × 9 or 8K × 18, dual clock	1	300	MHz
	Simple dual-port 4K × 36 or 2K × 72, dual clock	1	470	MHz
	ROM 1 Port	1	500	MHz
	ROM 2 Port	1	450	MHz
	Single-port 16K × 9 or 8K × 18	1	330	MHz
	Single-port 4K × 36	1	500	MHz
	True dual-port 16K × 9, 8K × 18, or 4K × 36, dual clock with the read-during-write option set to "Old Data"	1	270	MHz
	Simple dual-port 16K × 9, 8K × 18, 4K × 36, or 2K × 72, dual clock with the read-during-write option set to "Old Data"	1	292	MHz
	Simple dual-port 2K × 64 dual clock (with ECC)	1	210	MHz
	Min Pulse Width (Clock High Time)	—	1000	ps

Note to Table 1–21:

(1) Pending silicon characterization.

JTAG Specifications

Table 1–22 shows the JTAG timing parameters and values for HardCopy III devices. Refer to Figure 1–3 in the "HIGH-SPEED I/O Block" row in Table 1–33 for JTAG timing requirements.

Table 1–22. HardCopy III JTAG Timing Parameters and Values – Preliminary

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

Periphery Performance

This section describes the periphery performance, including high-speed I/O, external memory interface, and OCT calibration block specifications.

High-Speed I/O Specifications

Refer to Table 1–33 for definitions of high-speed timing specifications.

Table 1–23 shows the high-speed I/O timing for HardCopy III devices.

Table 1–23. High Speed I/O Specifications – Preliminary *(Note 1), (2), (3)*

Symbol	Conditions	Min	Typ	Max	Unit
f_{HSCLK} (input clock frequency)	Clock boost factor W = 2 to 32 *(4)*	5	—	625	MHz
	Clock boost factor W = 1 (SERDES bypassed)	5	—	600	MHz
	Clock boost factor W = 1 (SERDES used)	150	—	717	MHz
Dedicate LVDS-f_{HSDR} (data rate)	SERDES factor J = 3 to 10	150	—	1250	Mbps
	SERDES factor J = 2, uses DDR registers	—	—	TBD *(5)*	Mbps
	SERDES factor J = 1, uses SDR register	—	—	TBD *(5)*	Mbps
Dedicated LVDS-$f_{HSDRDPA}$ (data rate)	—	150	—	1250	Mbps
LVDS_E_3R-f_{HSDR}	—	—	—	340	Mbps
LVDS_E_1R-f_{HSDR} (data rate)	—	—	—	200	Mbps
Transmitter					
t_X jitter	Total jitter for data rate, 600 Mbps - 1.25 Gbps	—	—	160	ps
	Total jitter for data rate, < 600 Mbps	—	—	0.1	UI
Dedicated LVDS Output t_{RISE} and t_{FALL}	All differential I/O standards	—	—	200	ps
t_{DUTY}	TX output clock duty cycle	45	50	55	%
TCCS	All differential I/O standards	—	—	100	ps
DPA mode					
DPA run length	—	—	—	*(5)*	UI
Soft CDR mode					
Soft CDR jitter tolerance	—	—	—	*(5)*	ps
Soft CDR run length	—	—	—	*(5)*	UI
Soft-CDR PPM tolerance	—	—	—	*(5)*	PPM
Non DPA mode					
Sampling window	All differential I/O standards	—	—	*(5)*	ps

Notes to Table 1–23:

(1) When J = 3 to 10, the serializer/deserializer (SERDES) block is used.

(2) When J = 1 or 2, the SERDES block is bypassed.

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

(4) The input clock frequency and the W factor must satisfy the following Left and Right PLL output frequency specification: 150 MHz input clock frequency × W ≤ 1250 MHz.

(5) Pending silicon characterization.

Table 1–24. DPA Lock Time Specifications – Preliminary *(Note 1)*

Standard	Training Pattern	Transition Density	Min	Typ	Max	Unit
SPI-4	00000000001111111111	10%	TBD	—	—	Number of repetitions
Parallel Rapid I/O	00001111	25%	TBD	—	—	Number of repetitions
	10010000	50%	TBD	—	—	Number of repetitions
Miscellaneous	10101010	100%	TBD	—	—	Number of repetitions
	01010101	100%	TBD	—	—	Number of repetitions

Note to Table 1–24:

(1) Pending silicon characterization.

External Memory Interface Specifications

Table 1–25 through Table 1–30 list the external memory interface specifications for the HardCopy III device family. Use these tables to perform memory interface timing analysis.

Table 1–25. HardCopy III Maximum Clock Rate Support for External Memory Interfaces with Half-Rate Controller – Preliminary *(Note 1)*

Memory Standards	(MHz)	
	Top and Bottom I/O Banks	Left and Right I/O Banks
DDR3 SDRAM	TBD	TBD
DDR2 SDRAM	TBD	TBD
DDR SDRAM	TBD	TBD
QDRII+ SRAM	TBD	TBD
QDRII SRAM	TBD	TBD
RLDRAM II	TBD	TBD

Note to Table 1–25:

(1) Pending silicon characterization.

Table 1–26. HardCopy III Maximum Clock Rate Support for External Memory Interfaces with Full-Rate Controller – Preliminary *(Note 1)*

Memory Standards	(MHz)	
	Top and Bottom I/O Banks	Left and Right I/O Banks
DDR2 SDRAM	TBD	TBD
DDR SDRAM	TBD	TBD

Note to Table 1–26:

(1) Pending silicon characterization.

External Memory I/O Timing Specifications

Table 1–27 and Table 1–28 list HardCopy III device timing uncertainties on the read and write data paths. Use these specifications to determine timing margins for source synchronous paths between the HardCopy III FPGA and the external memory device. Refer to Figure 1–5 in the "SW (sampling window)" row in Table 1–33.

Table 1–27. Sampling Window (SW), Read Side – Preliminary *(Note 1)*

Location *(2)*	Memory Type	Sampling Window (ps)	
		Setup	Hold
VIO	DDR3	TBD	TBD
VIO	DDR2	TBD	TBD
VIO	DDR1	TBD	TBD
VIO	QDRII / II +	TBD	TBD
VIO	RLDRAM II	TBD	TBD
HIO	DDR3	TBD	TBD
HIO	DDR2	TBD	TBD
HIO	DDR1	TBD	TBD
HIO	QDRII / II +	TBD	TBD
HIO	RLDRAM	TBD	TBD

Notes to Table 1–27:

(1) Pending silicon characterization.

(2) VIO (vertical I/O) refers to I/Os in the top and bottom banks; HIO (horizontal I/O) refers to I/Os in the left and right banks.

Table 1–28. Transmitter Channel-to-Channel Skew (TCCS), Write Side – Preliminary *(Note 1)*

Location *(2)*	Memory Type	TCCS (ps)	
		Lead	Lag
VIO	DDR3	TBD	TBD
VIO	DDR2	TBD	TBD
VIO	DDR1	TBD	TBD
VIO	QDRII / II +	TBD	TBD
VIO	RLDRAM II	TBD	TBD
HIO	DDR3	TBD	TBD
HIO	DDR2	TBD	TBD
HIO	DDR1	TBD	TBD
HIO	QDRII / II +	TBD	TBD
HIO	RLDRAM II	TBD	TBD

Notes to Table 1–28:

(1) Pending silicon characterization.

(2) VIO (vertical I/O) refers to I/Os in the top and bottom banks; HIO (horizontal I/O) refers to I/Os in the left and right banks.

DLL and DQS Logic Block Specifications

Table 1–29 describes the delay-locked loop (DLL) frequency range specifications for HardCopy III devices.

Table 1–29. HardCopy III DLL Frequency Range Specifications – Preliminary *(Note 1)*

Frequency Mode	Frequency Range (MHz)	Resolution (Degrees)
0	TBD	22.5
1	TBD	30
2	TBD	36
3	TBD	45
4	TBD	30
5	TBD	36
6	TBD	45

Note to Table 1–29:

(1) Pending silicon characterization.

Table 1–30 describes the DQS phase offset delay per setting for HardCopy III devices.

Table 1–30. Average DQS Phase Offset Delay per Setting – Preliminary *(Note 1)*, *(2)*, *(3)*, *(4)*

Min	Typ	Max	Unit
7	11	15	ps

Notes to Table 1–30:

(1) The valid settings for phase offset are –64 to +63 for frequency modes 0 to 3 and –32 to +31 for frequency modes 4 to 6.

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

(3) The delay settings are linear with a cumulative delay variation of ±20ps for all speed grades.

(4) Pending silicon characterization.

OCT Calibration Block Specifications

Table 1–31 shows the on-chip termination calibration block specifications for HardCopy III devices.

Table 1–31. On-Chip Termination Calibration Block Specification – Preliminary

Symbol	Description	Min	Typical	Max	Unit
OCTUSRCLK	Clock required by OCT calibration blocks	—	—	20	MHz
t_{OCTCAL}	Number of OCTUSRCLK clock cycles required for OCT RS and RT calibration	—	1000	—	cycles
$t_{OCTSHIFT}$	Number of OCTUSRCLK clock cycles required for OCT code to shift out per OCT calibration block	—	28	—	cycles
t_{RS_RT}	Time required to dynamically switch from R_S to R_T	—	2.5	—	ns

Duty Cycle Distortion (DCD) Specifications

Table 1–32 lists the worst case DCD for HardCopy III devices. Detailed information on duty cycle distortion are published after characterization.

Table 1–32. Duty Cycle Distortion on HardCopy III I/O Pins – Preliminary *(Note 1)*, *(2)*

Symbol	Min	Max	Unit
Output Duty Cycle	45	55	%

Notes to Table 1–32:

(1) Preliminary DCD specification applies to clock outputs from PLLs, global clock tree, IOE driving dedicated, and general purpose I/O pins.

(2) Detailed DCD specifications pending silicon characterization.

I/O Timing Model

The I/O timing specifications for HardCopy III devices will be available in a future revision of the *DC and Switching Characteristics* chapter in volume 3 of the *HardCopy III Device Handbook*.

Glossary

Table 1–33 shows the glossary for this chapter.

Table 1–33. Glossary Table

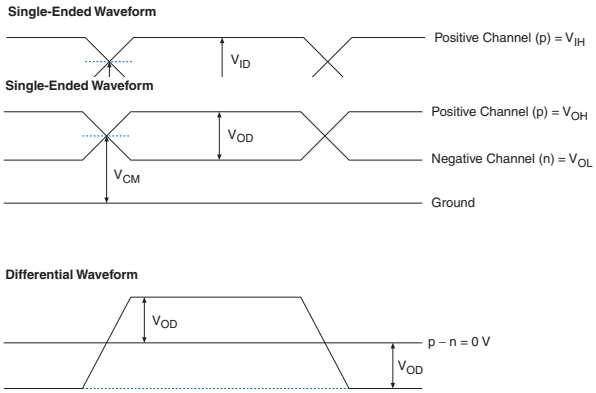
Letter	Subject	Definitions
A	—	—
B	—	—
C	—	—
D	Differential I/O Standards	**Figure 1–2.** Receiver Input Waveforms 
E	—	—
F	f_{HSCLK}	HIGH-SPEED I/O Block: High-speed receiver/transmitter input and output clock frequency.
	f_{HSDR}	HIGH-SPEED I/O Block: Maximum/minimum LVDS data transfer rate (f_{HSDR} = 1/TUI), non-DPA.
	$f_{HSDRDPA}$	HIGH-SPEED I/O Block: Maximum/minimum LVDS data transfer rate ($f_{HSDRDPA}$ = 1/TUI), DPA.
G	—	—
H	—	—

Table 1–33. Glossary Table

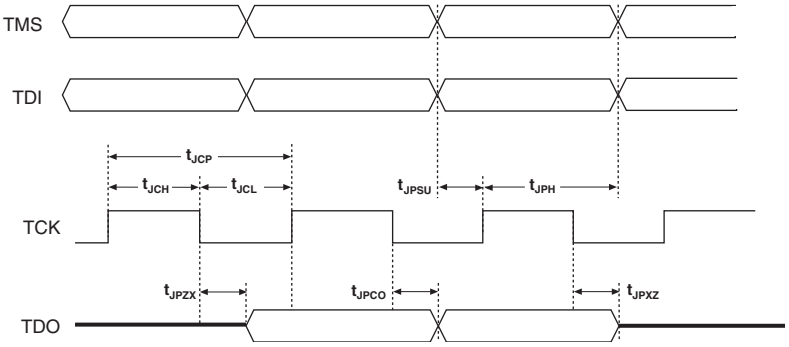
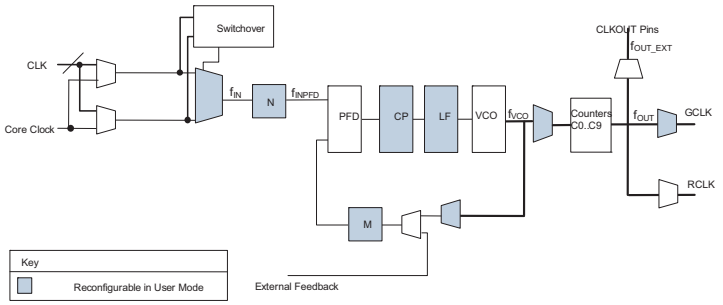
Letter	Subject	Definitions
I	—	—
J	J	HIGH-SPEED I/O Block: Deserialization factor (width of parallel data bus).
	JTAG Timing Specifications	**Figure 1–3.** JTAG Timing Specifications 
K	—	—
L	—	—
M	—	—
N	—	—
O	—	—
P	PLL Specifications	The block diagram shown in the following figure highlights the PLL Specification parameters: **Figure 1–4.** Diagram of PLL Specifications *(Note 1)*  **Note:** (1) Core Clock can only be fed by dedicated clock input pins or PLL outputs.
Q	—	—
R	R_L	Receiver differential input discrete resistor (external to HardCopy III device).

Table 1–33. Glossary Table

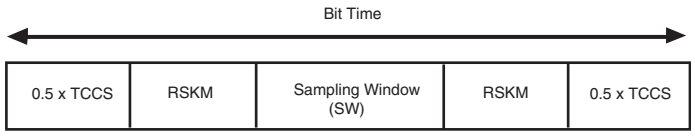
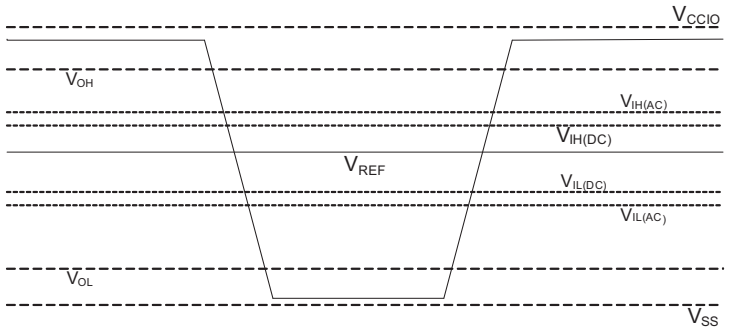
Letter	Subject	Definitions
S	SW (sampling window)	The period of time during which the data must be valid in order to capture it correctly. The setup and hold times determine the ideal strobe position within the sampling window. **Figure 1–5.** Timing Diagram 
	Single-ended Voltage Referenced I/O Standard	The JEDEC standard for SSTI and HSTL I/O standards defines both the AC and DC input signal values. The AC values indicate the voltage levels at which the receiver must meet its timing specifications. The DC values indicate the voltage levels at which the final logic state of the receiver is unambiguously defined. Once the receiver input has crossed the AC value, the receiver is changed to the new logic state. The new logic state is maintained as long as the input stays beyond the DC threshold. This approach is intended to provide predictable receiver timing in the presence of input waveform ringing. **Figure 1–6.** Single-Ended Voltage Referenced I/O Standard 
T	t_C	High-speed receiver and transmitter input and output clock period.
	TCCS (channel-to-channel-skew)	The timing difference between the fastest and the slowest output edges, including t_{CO} variation and clock skew, across channels driven by the same PLL. The clock is included in the TCCS measurement (refer to Figure 1–5 under **S** in this table).
	t_{DUTY}	HIGH-SPEED I/O Block: Duty cycle on high-speed transmitter output clock. Timing Unit Interval (TUI) The timing budget allowed for skew, propagation delays, and data sampling window. (TUI = 1/(Receiver Input Clock Frequency Multiplication Factor) = t_c/w)
	t_{FALL}	Signal high-to-low transition time (80-20%)
	t_{INCCJ}	Cycle-to-cycle jitter tolerance on PLL clock input
	t_{OUTPJ_IO}	Period jitter on general purpose I/O driven by a PLL
	t_{OUTPJ_DC}	Period jitter on dedicated clock output driven by a PLL
	t_{RISE}	Signal low-to-high transition time (20–80%)
U	—	—

Table 1–33. Glossary Table

Letter	Subject	Definitions
V	$V_{CM(DC)}$	DC common mode input voltage.
	V_{ICM}	Input common mode voltage: The common mode of the differential signal at the receiver.
	V_{ID}	Input differential voltage swing: The difference in voltage between the positive and complementary conductors of a differential transmission at the receiver.
	$V_{DIF(AC)}$	AC differential input voltage: Minimum AC input differential voltage required for switching.
	$V_{DIF(DC)}$	DC differential input voltage: Minimum DC input differential voltage required for switching.
	V_{IH}	Voltage input high: The minimum positive voltage applied to the input that will be accepted by the device as a logic high.
	$V_{IH(AC)}$	High-level AC input voltage
	$V_{IH(DC)}$	High-level DC input voltage
	V_{IL}	Voltage input low: The maximum positive voltage applied to the input that will be accepted by the device as a logic low.
	$V_{IL(AC)}$	Low-level AC input voltage
	$V_{IL(DC)}$	Low-level DC input voltage
	V_{OCM}	Output common mode voltage: The common mode of the differential signal at the transmitter.
	V_{OD}	Output differential voltage swing: The difference in voltage between the positive and complementary conductors of a differential transmission at the transmitter.
W	W	HIGH-SPEED I/O BLOCK: Clock boost factor
X	—	—
Y	—	—
Z	—	—

Referenced Documents

This chapter references the following documents:

- *Power Play Early Power Estimator User Guide*
- *PowerPlay Power Analysis* chapter in volume 3 of the *Quartus II Device Handbook*

Document Revision History

Table 1–34 shows the revision history for this document.

Table 1–34. Document Revision History

Date and Document Version	Changes Made	Summary of Changes
December 2008, v2.0	■ Updated Table 1–3. ■ Updated Table 1–19. ■ Updated Table 1–23. ■ Made minor editorial changes.	—
May 2008, v1.0	Initial release.	—